# Phase 2 Stream Geomorphic Assessment
# Black River Watershed
# Rutland & Windsor Counties, Vermont
# July 2009



*Prepared by* *Prepared under contract to*

South Mountain Research & Consulting
2852 South 116 Road, Bristol, VT 05443
802-453-3076

Southern Windsor County
Regional Planning Commission
P.O. Box 320
Ascutney, VT 05030

# TABLE OF CONTENTS

**ACKNOWLEDGEMENTS** ..... II

**EXECUTIVE SUMMARY** ..... III

**1.0 INTRODUCTION** ..... 1

**2.0 BACKGROUND** ..... 1

2.1 GEOGRAPHIC SETTING ..... 1
2.2 REGIONAL GEOLOGIC SETTING ..... 4
2.3 GEOMORPHIC SETTING ..... 7
2.4 HYDROLOGY ..... 11
2.5 FLOOD HISTORY ..... 12
2.6 LAND USE ..... 15

**3.0 ASSESSMENT METHODOLOGY** ..... 15

3.1 PHASE 2 STREAM GEOMORPHIC ASSESSMENT ..... 16
3.2 PHASE 1 UPDATES ..... 16
3.3 QUALITY ASSURANCE / QUALITY CONTROL ..... 16

**4.0 PHASE 2 ASSESSMENT RESULTS** ..... 18

4.1 BLACK RIVER MAIN STEM – UPSTREAM OF CAVENDISH GORGE: LUDLOW, CAVENDISH ..... 19
4.2 BLACK RIVER MAIN STEM – DOWNSTREAM OF CAVENDISH GORGE ..... 22
4.3 TWENTYMILE STREAM – READING, CAVENDISH ..... 25
4.4 NORTH BRANCH – READING, CAVENDISH, WEATHERSFIELD ..... 28

**5.0 DEPARTURE ANALYSIS, STRESSOR IDENTIFICATION & SENSITIVITY** ..... 31

5.1 DEPARTURE ANALYSIS ..... 31
*5.1.1 Watershed Scale Hydrologic and Sediment Regime Stressors* ..... *32*
*5.1.2 Sediment Regime Stressors (Watershed and Reach Scale)* ..... *43*
*5.1.3 Reach Scale Modifiers* ..... *46*
*5.1.4 Sediment Regime Departure, Constraints to Sediment Transport & Attenuation* ..... *48*
5.2 SENSITIVITY ANALYSIS ..... 63

**6.0 PRELIMINARY PROJECT IDENTIFICATION (REACH & CORRIDOR SCALE)** ..... 68

6.1 PROTECTING RIVER CORRIDORS ..... 69
6.2 PLANTING STREAM BUFFERS ..... 72
6.3 STABILIZING STREAM BANKS ..... 72
6.4 ARRESTING HEAD CUTS AND NICK POINTS ..... 73
6.5 REMOVING BERMS / OTHER CONSTRAINTS TO FLOOD & SEDIMENT LOAD ATTENUATION ..... 74
6.6 REMOVING / REPLACING STRUCTURES ..... 74
*6.6.1 Bridge and Culvert Crossings* ..... *75*
*6.6.2 Other constrictions* ..... *78*
*6.6.2 Other constrictions* ..... *79*
6.7 RESTORING INCISED REACHES ..... 80
6.8 RESTORING AGGRADED REACHES ..... 81
6.9 MITIGATING POINT SOURCES OF INCREASED STORMWATER AND SEDIMENT LOADING ..... 83
6.10 RESTORATION OF CHANNEL-CONTIGUOUS WETLANDS ..... 84

**7.0 WATERSHED-LEVEL MANAGEMENT STRATEGIES** ..... 85

7.1 TOWN PLANNING INCORPORATING RIVER CORRIDORS ..... 85
7.2 BUFFERS FOR WATERWAYS NOT COVERED BY PHASE 2 ASSESSMENTS ..... 89
7.3 ADDITIONAL PLANNING / ZONING STRATEGIES TO MITIGATE STORMWATER / SEDIMENT IMPACTS ..... 89
7.4 MAINTENANCE AND REPLACEMENT OF CROSSING STRUCTURES ..... 90

**8.0 REFERENCES ..... 91**

## APPENDICES

A. Phase 2 Stream Geomorphic Assessment Reach Summary Reports
B. Bridge & Culvert Assessment Reports
C. Quality Assurance Documentation
D. Reach Segmentation
E. Reach Narratives
F. Stressor Tables, Reach-Scale
G. Departure Analysis Tables
H. Valley Wall Updates

### ACKNOWLEDGEMENTS

This study was made possible through funding received from: (1) the State of Vermont Department of Environmental Conservation, Division of Water Quality (River Corridor Grant); and (2) the State of Vermont Emergency Management, coordinated through the Lamoille County Planning Commission (Pre-Disaster Mitigation Funds). Grants were administered by the Southern Windsor County Regional Planning Commission. Technical assistance was provided by the VT Department of Environmental Conservation, River Management Program.

Field work was conducted with the cooperation of Reading, Cavendish, Weathersfield, and Ludlow landowners who granted permission to cross their property to access the river.

## EXECUTIVE SUMMARY

Phase 2 geomorphic assessments were completed in 2007 and 2008 on 27 reaches (23.5 river miles) of the Black River and major tributaries following protocols published by the Vermont Agency of Natural Resources. Field investigations and limited historical reviews have identified various watershed and channel disturbances that have impacted these reaches of the Black River network, including:

Watershed-scale Modifiers:

- Historic deforestation and subsequent reforestation from the mid-1800s through the early 1900s;
- Significant flood events in 1927, 1936, 1938, and 1973;
- Historic impoundments and flow diversions associated with industrial and manufacturing interests in Ludlow, Proctorsville, Cavendish and Felchville in the 1800s; and
- Upstream erosion and tributary sources of sediment.

Reach-scale Modifiers:

- Channelization (straightening) especially associated with development in village centers, bridge and culvert crossings, historic impoundments, and agricultural uses;
- Reported gravel extraction, dredging and windrowing of the channel in response to the flood events of 1927, 1936 / 1938 and 1973, particularly along the Black River main stem through Ludlow and Cavendish;
- Berming along stream banks;
- Streambank armoring (rip-rap) and retaining walls;
- Floodplain encroachment by roads and residential and commercial development;
- Undersized public and private bridges and in-stream culverts, serving as flow constrictors at bankfull flow or higher-magnitude flood events; and
- Stormwater runoff from roads.

The Black River and tributary channels are adjusting in response to these past and present watershed and channel disturbances. Adjustments have occurred to varying degrees, depending on many factors, including the magnitude and timing of past disturbances, the erosion resistance of sediment types in the channel bed and banks, the type and density of vegetative cover along stream banks, and presence of grade controls such as exposed bedrock. Broadly speaking, the assessed reaches can be grouped into two categories:

- In Regime (Dynamic Equilibrium) – Some of the assessed river segments were in regime, showing an expected (natural) level of change or adjustment, exhibiting connection to the surrounding floodplain, and maintaining average channel dimensions, planform, and profile, over time (dynamic equilibrium). This category includes two sub-groupings:
    - Semi-confined and bedrock-channel reaches/segments, which are afforded greater stability by the surrounding bedrock and resistant boundary conditions, and are less susceptible to lateral and vertical adjustments:
        - bedrock falls on the North Branch of the Black River located in Felchville (Reading) above the Route 106 bridge crossing;

- a short length of the Black River main stem downstream of the Dug Road bridge crossing above Ludlow village, closely confined by bedrock-controlled valley wall;
- a 900-ft section of the Twentymile Stream in northern Cavendish which is closely confined by bedrock walls and has two exposures of channel-spanning bedrock.

- Unconfined reaches/segments in minor adjustment. In some cases, the inferred dynamic-equilibrium condition is associated with a relative lack of channel or watershed stressors. In other cases, the equilibrium condition exists despite the presence of channel and watershed disturbances, suggesting that boundary conditions offer sufficient resistance to stressors and/or stressors are low in magnitude or extent. Most of these segments are identified as key attenuation assets in the watershed, providing for attenuation of sediment and flows:

  - A short section of the Black River main stem upstream of the Branch Brook confluence;
  - Along the Twentymile Stream, a half-mile section between Meadowbrook Farm Rd crossing and Twentymile Stream Rd crossing, as well as a 2.5-mile section from Quent Phalen Rd intersection with Twentymile Rd downstream to the Davis Road bridge crossing; and
  - Along the North Branch Rd, a 1.5-mile section upstream of Amsden Falls, and a 0.75-mile section below the falls and above Stoughton Pond.

- Incised / Entrenched - In contrast, many of the assessed main stem and tributary reaches have become disconnected from their surrounding floodplain to varying degrees. Channel incision and entrenchment has generally followed from historic channel manipulations (especially during flood recovery efforts) to protect and restore adjacent development, roads, and support impoundments to supply water-power to industries – or has resulted from channelization/ ditching to accommodate farming in the floodplain. Often channel entrenchment was exacerbated by floodplain encroachments such as berms, railroad or road bed materials, and building foundations. Through historic channel manipulations, these channel segments have been converted from unconfined, meandering channels with opportunities for overbank and point bar sediment deposition to entrenched, linear, more transport-dominated channels. The modified channel would be expected to have enhanced sediment transport capacity as a result of the increased slope and increased stream power. Dominant adjustment processes observed in these reaches were planform adjustment, aggradation and widening; none of the segments exhibited signs of active, system-wide incision. Nevertheless, these channel segments remain highly susceptible to catastrophic channel adjustments and associated fluvial erosion losses in future flood events, given their entrenched status. Also, they tend to translate erosive energies and sediment loads to downstream reaches. These incised and entrenched segments can be further categorized in terms of the nature of the channel bed and banks and their relative resistance to erosion:

  - Moderate Boundary Resistance - At present, enhanced erosive energies of some incised / entrenched segments appear to be balanced by the resisting forces of the channel margins (e.g., streambank revetments, armored beds, bedrock walls, forested buffers). The coarseness or cohesiveness of materials in the stream bed and banks has moderated the potential for lateral channel adjustments. In typical seasonal to annual flows, these reaches are generally not a significant a source of sediment to downstream reaches as a result of streambank and bed erosion. During floods, however, these reaches would be susceptible to catastrophic erosion, due to their partially incised or entrenched status. The majority of the assessed reaches/segments are in this category and include:

- The short section of Branch Brook at the confluence with Black River.
- The Black River main stem from the Okemo Marketplace in Ludlow downstream to Fletcher Fields in Cavendish; from Proctorsville downstream to the Mill Street bridge in Cavendish; from Cavendish Gorge downstream to Whitesville; and downstream of the covered bridge on Upper Falls Road in Weathersfield.
- The short section of Twentymile Stream at the confluence with Black River in Whiteville, as well as upstream sections of this tributary along Twentymile Stream Road spanning the Reading / Cavendish boundary.
- The North Branch from Felchville downstream to Ascutney Basin Road.

- Limited Boundary Resistance – Other incised/ entrenched segments are generally more prone to lateral adjustments, given: (1) the relative lack of armoring, extensive berms or encroachments, (2) the presence of more erodible sediments in the channel boundaries; and/or (3) the lack of forested buffers (along one or both banks). These segments are actively adjusting and in the process are building a new floodplain at a somewhat lower elevation than the floodplain which was abandoned during historic incision (or as a result of channel manipulations). Assessed reaches/segments in this category include:

  - Portions of the Black River main stem downstream of Lake Pauline in Ludlow, downstream of Winery Road crossing in Cavendish (to Proctorsville); and upstream of Perkinsville in Weathersfield.
  - Sections of the Twentymile Stream upstream of Meadowbrook Farm Rd and downstream of the Twentymile Stream Road culvert crossing.
  - The North Branch Black River between Ascutney Basin Road and Little Ascutney Road.

Opportunities for river restoration and conservation have been identified based on the Phase 2 geomorphic assessment results. A preliminary project listing forms the basis for follow-on project development and planning activities which can be carried out by watershed stakeholders.

# 1.0 INTRODUCTION

Phase 2 geomorphic assessments were completed in 2007 and 2008 on 27 reaches (23.5 river miles) of the Black River and major tributaries following protocols published by the Vermont Agency of Natural Resources (VTANR, 2007a). Objectives of the Phase 2 assessments were to:

- determine the geomorphic condition of targeted reaches, and identify active vertical and lateral adjustment processes;
- identify current and historic disturbances to the channel at the reach and watershed levels; and
- evaluate the sensitivity of reaches to future channel and watershed stressors given their current geomorphic condition and inherent vulnerability (e.g., valley setting, slope, streambed and streambank sediments, vegetative buffer conditions).

Assessment data have been entered into the online Data Management System (DMS), a custom database of geomorphic data developed and maintained by the Vermont Agency of Natural Resources. Assessment results will be used by landowners and other watershed stakeholders to:

- identify restoration and conservation projects intended to improve water quality and enhance a return to a more balanced condition of the channel;
- plan for future development which is compatible with adjusting river channels; and
- reduce fluvial erosion hazards.

This summary report has been prepared by South Mountain Research & Consulting (SMRC) of Bristol, Vermont under contract to the Southern Windsor County Regional Planning Commission (SWCRPC).

# 2.0 BACKGROUND

Phase 2 assessments in the Black River watershed were undertaken to provide a geologic and geomorphic context for the erosion and water quality issues documented in these tributaries over the past several years. These field-based assessments build on results of a Phase 1 Stream Geomorphic Assessment completed in 2007 (SMRC).

## 2.1 Geographic Setting

The Black River watershed in southeastern Vermont contains approximately 204 square miles of land area. This tributary watershed of the Connecticut River spans portions of two counties. Approximately 90% (183 square miles) of the catchment is located in Windsor County, while 10% (21 square miles) is located in Rutland County (see Figure 1).

Portions of twelve towns are contained in the watershed (see Figure 2). Five towns occupy a majority of the land area: Plymouth, Ludlow, Cavendish, Weathersfield and Springfield.

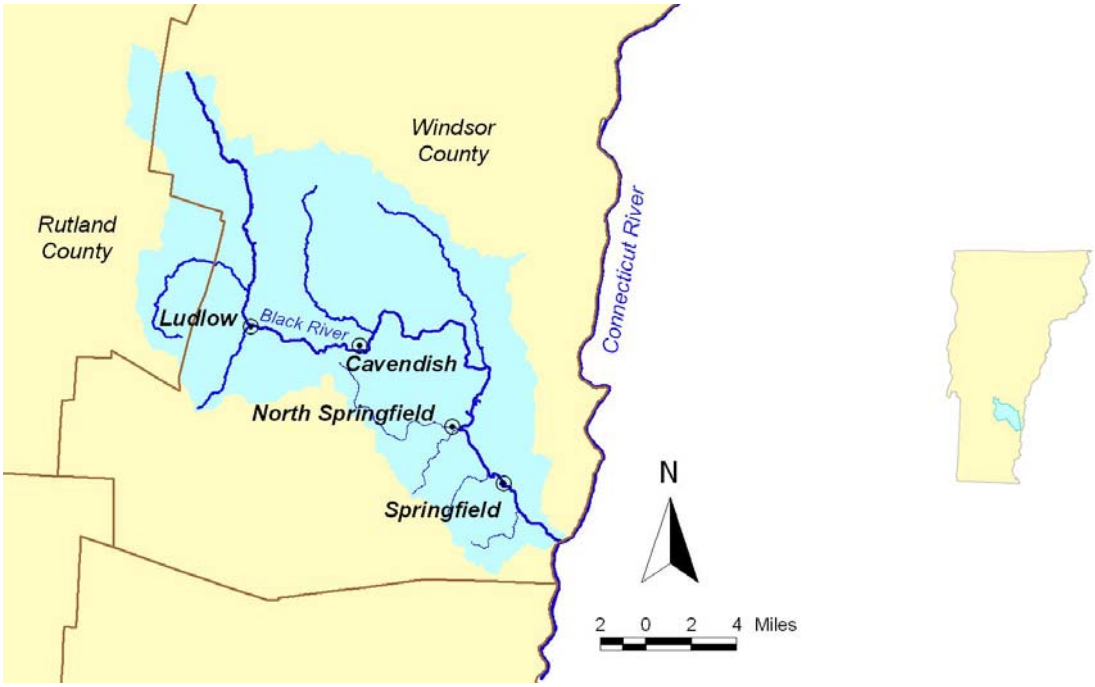



***Figure 1. Black River Watershed Location within Windsor & Rutland Counties, Vermont.***




***Figure 2. Location of Black River watershed within towns of Rutland and Windsor Counties, VT.***

This study focused on portions of the Black River main stem and three major tributaries (Figure 3):

- 8.6 miles (8 reaches) of the **Black River main stem upstream of Cavendish Gorge**, from Lake Pauline downstream through Ludlow village and Proctorsville, to the Mill Street bridge crossing in Cavendish;
- 2.6 miles (3 reaches) of the **Black River main stem downstream of Cavendish Gorge**, including a 1.1-mile section from the base of the gorge to just below Whitesville in the town of Cavendish, and a 1.5-mile section below the Upper Falls Covered Bridge extending to Perkinsville in the town of Weathersfield;
- 0.6 mile (1 reach) of the **Branch Brook** tributary in Ludlow at the confluence with the Black River main stem;
- 5.9 miles (7 reaches) of the **Twentymile Stream** tributary extending from just north of the Reading town line downstream through the town of Cavendish to the Davis Road crossing, and including a short 0.2-mile section of this tributary immediately upstream of the confluence with the Black River main stem at Whitesville; and
- 5.8 miles (8 reaches) of the **North Branch Black River** tributary extending from Felchville in Reading downstream through the northeast corner of Cavendish, into Weathersfield ending just above Amsden Falls, and including a one-mile section of this tributary below the falls and upstream of Stoughton Pond.

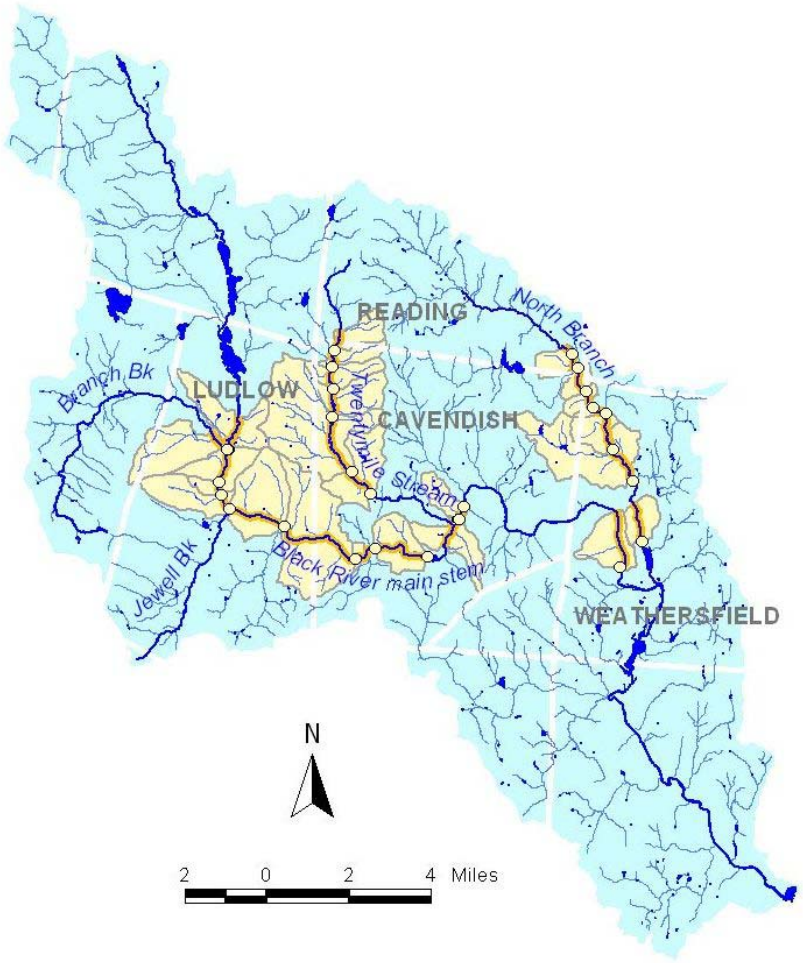



***Figure 3. Location of reaches assessed in 2007 and 2008, Black River watershed.***

*Yellow highlighting identified land areas which directly drain to the study reaches.*

## 2.2 Regional Geologic Setting

The headwaters of the Black River in the western and northwestern extents of the watershed are located in the Southern Green Mountain physiographic province, while the eastern portion of the watershed is located in the Southern Vermont Piedmont (Stewart & MacClintock, 1969).

The Green Mountains and the Vermont Piedmont formed during the Grenville, Taconic and Acadian mountain-building events from more than 1 billion years ago to 380 million years ago. Bedrock underlying the watershed is complexly folded and faulted. The oldest Grenvillian basement rocks (comprised generally of gneisses, schists, and amphibolite) are located at the core of the Green Mountains – for example, Burnt Mountain and the Coolidge Range in the town of Plymouth and South Mountain and Ludlow Mountain in the town of Mount Holly. Grenvillian basement rocks are also exposed at the core of a dome-like structure in the mid-section of the Black River watershed known as the Chester Dome. These basement complex rocks are surrounded and overlain by thrust sheets of younger rocks (generally, schists, quartzites, conglomerates, dolomites). These younger rock sequences were emplaced and subsequently uplifted during later mountain-building episodes. Under compressional forces of these mountain-building events, the rock sequences were folded and faulted (Karabinos & Thompson, 1997; Ratcliffe, Armstrong, & Aleinikoff, 1997; Stewart, 1975).

The topography of the Black River watershed is largely controlled by the characteristics of the underlying bedrock. The western half of the watershed is marked by several north-south trending faults. In the upper extent of the Black River valley from Plymouth to the village of Ludlow, the planform of the river valley - including Amherst Lake, Echo Lake, Lake Rescue and Lake Pauline - is controlled by the Black River fault (Walsh *et al.*, 1994; Walsh & Ratcliffe, 1994). The mid-portion of the Black River main stem from Proctorsville to Springfield flows through a landscape underlain by bedrock of the Chester Dome (Ratcliffe, 1996, Ratcliffe, 1995a; Ratcliffe, 1995b). Bedrock is exposed in the bed and banks of the Black River and tributaries in several locations, often constraining the planform and profile of the river network.

In more recent geologic time (from 24,000+ to 13,500 years before present; Ridge, 2003) the landscape of Vermont was occupied by advancing and retreating glaciers, with ice up to a mile or more in thickness above the present land surface (Stewart & MacClintock, 1969). Glacial tills now blanket much of the upper bedrock-controlled slopes and headwaters of the watershed. As the global climate warmed, the glaciers melted and receded. Kame terrace deposits formed as outwash sediments accumulated along the margins of ice which persisted in the river valleys. Kame terraces and moraines are preserved along the Black River valley particularly upstream of Cavendish (Stewart, 1975; Stewart, 1972; Stewart & MacClintock, 1969).

As the glacial front retreated further northward, a large fresh-water lake inundated the Connecticut River valley – commonly referred to as Glacial Lake Hitchcock. This lake was initially impounded behind large deposits of sand and gravel outwash left by the glaciers near Rocky Hill, Connecticut. Later, water levels dropped slowly and were subsequently controlled by a natural spillway carved through glacial till to reach bedrock at New Brittain, Connecticut. At its highest stage, Glacial Lake Hitchcock's shoreline extended from the vicinity of Rocky Hill northward to St. Johnsbury, Vermont. Glacial Lake Hitchcock is thought to have persisted from approximately 15,000 to 12,000 years ago or more (Rittenour, T. M., 2007; Ridge, 2003; Koteff & Larsen, 1989; Stewart & MacClintock, 1969).

Along the margins of the Connecticut River valley, Glacial Lake Hitchcock waters backed up into tributaries, including the Black River. As sediments were carried by the Black River into Lake Hitchcock, large deltas or fan-like deposits of sediments formed and prograded out into the lake. A very large, well-preserved, Glacial Lake Hitchcock delta sequence exists within the Black River valley to the north and west of North Springfield (Stewart & MacClintock, 1969) at an approximate elevation of 590 feet. Similar ice-contact delta deposits which formed at a "High Stage" of Glacial Lake Hitchcock are found along

Connecticut River tributaries in New Hampshire (e.g., the Little Sugar River Valley at North Charlestown (Ridge, 2001).

Following glacial retreat, the landscape was dissected by the Black River network, driven in part by dropping base levels in the Connecticut River valley. Channel incision was also driven by isostatic rebound of the land surface in the late Pleistocene and early Holocene (Koteff and Larsen, 1989). The surface of the delta at North Springfield was dissected by the Black River and its major tributaries which were graded to lower lake stages in the Connecticut River valley. Delta deposits at the mouth of the Black River were "deposited in the Cold River stage [of Glacial Lake Hitchcock] by meteoric runoff from the Black River Valley" (Ridge, 2001). The Connecticut River subsequently incised through these Pleistocene delta deposits as base levels continued to drop and isostatic rebound progressed through the early Holocene.

Absence of vegetation on the recently-deglaciated hillslopes probably contributed to floodplain aggradation in the late Pleistocene. Sedimentation rates would have declined as the landscape became revegetated and forests matured, and floodplain incision may have begun to dominate. Rates of sedimentation on alluvial fan surfaces and in ponds were relatively high during the early Holocene based on research from Northwestern Vermont (Bierman *et al*, 1997). Bierman *et al* (1997) note that "early Holocene hillslope erosion may have been driven by episodic large storms in a drier [but stormier] climate than today. Late Holocene erosion and aggradation were also event driven, but greater ambient levels of soil saturation [in a cooler, moister climate] may have allowed smaller storms to trigger similar landscape responses." In historic times (<200 years ago), hillslope erosion and floodplain aggradation increased substantially as a result of wide-spread deforestation by the early- to mid-1800s (Brakenridge *et al*, 1988; Severson, 1991; Thomas, 1985). These trends may have again reversed themselves when most hillslopes became reforested in the late 1880s and early 1900s.

Glacial and postglacial activity has influenced the surficial sediments and soil types which are present in the Black River watershed today. Soils are summarized by parent material for the Black River watershed in Figure 4. Bedrock-controlled upland slopes are dominated by a veneer of glacial tills, while more erodible sands, gravels and cobbles of glacial outwash and more recent alluvial origin tend to be concentrated in the bedrock-controlled valleys of the Black River and its major tributaries. At a watershed scale, the distribution of soil parent materials illustrated in Figure 4 is largely consistent with available surficial geologic mapping (Stewart & MacClintock, 1969; Stewart, 1975).

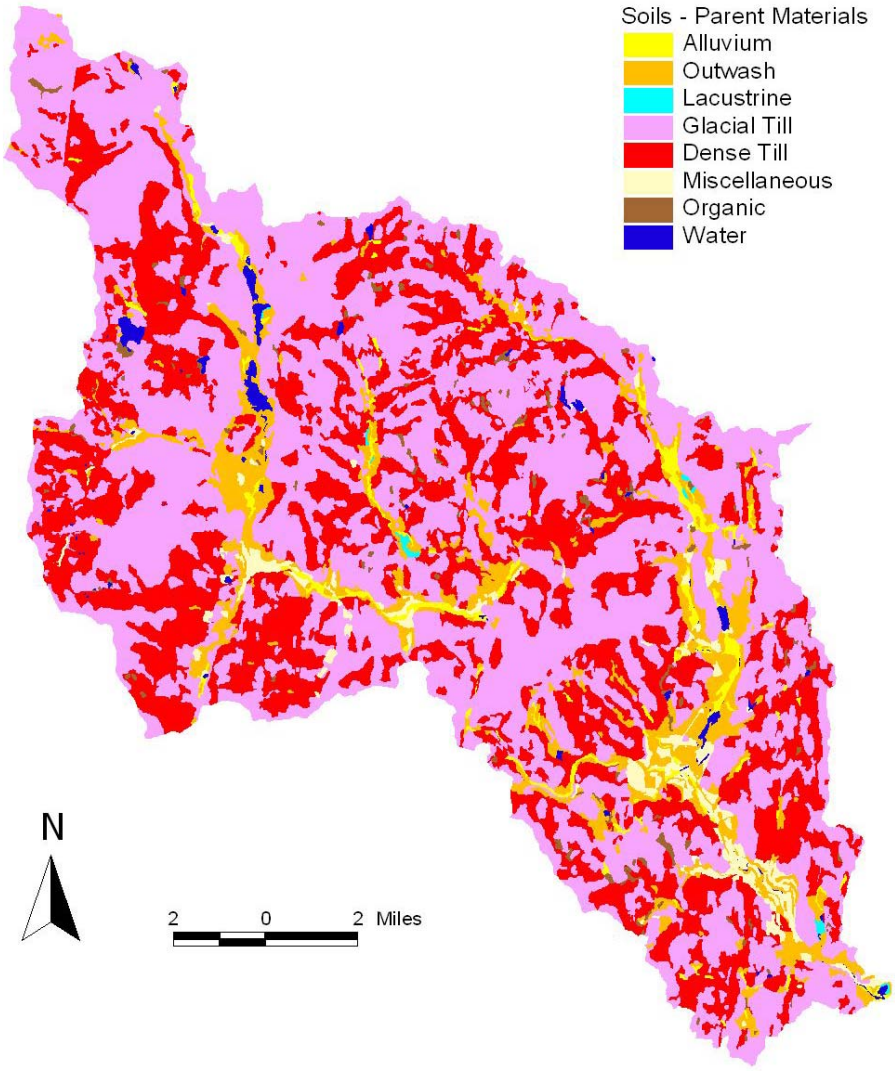



***Figure 4. Generalized map of soil parent material in the Black River watershed (NRCS Soil Survey mapping).***

## 2.3 Geomorphic Setting

Surface waters of the Black River watershed were delineated into a total of 341 reaches in a previously-completed Phase 1 Stream Geomorphic Assessment (SMRC, 2007). Reach lengths ranged from approximately 440 feet (0.08 mile) to 12,000 feet (2.3 miles), with an average length of 3,310 feet (0.6 mile). Geomorphic reaches were defined based on variation in valley confinement, gradient, and sinuosity, as well as tributary influence (see protocols for further background). The reader is referred to the Phase 1 summary report for details of the assessment.

By convention expressed in VTANR protocols, tributaries contributing 10% or more of the upstream watershed area at their point of confluence with the main stem are considered Major Tributaries and are recommended for reach delineation like the main stem. Eight (8) Major Tributaries of the Black River were identified (see Figure 5, Table 1). Each reach was assigned a unique alphanumeric identification. Reaches along the main stem of the Black River were prefixed with a capital "M". Major tributary reaches were denoted with a capital "T"; minor tributaries with a capital "S". Further details of the reach-labeling procedure are outlined in VTANR protocols.

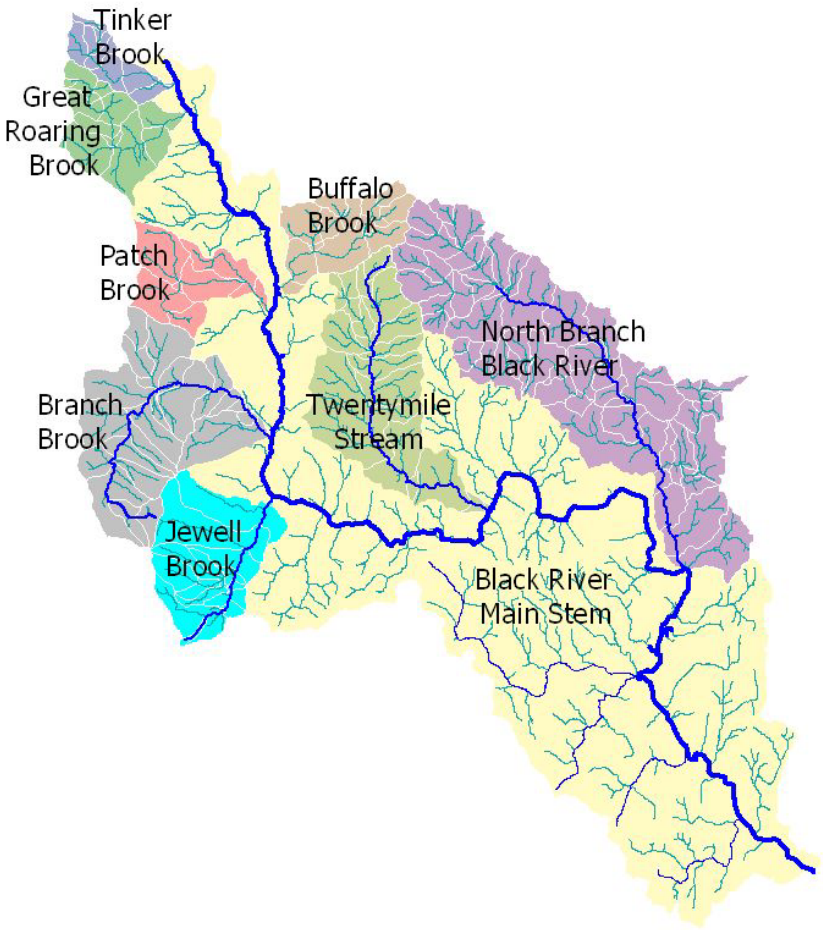



***Figure 5. Major Sub-watersheds Delineated in the Black River Watershed***

***Table 1. Phase 1 Tributary Delineation in the Black River Watershed.***

| Tributary Identification | Name | Drainage Area (sq mi) | Channel Length (mi) | Number Reaches |
|---|---|---|---|---|
| M | Black River main stem | 204.0 | 41.4 | 49 |
| ***Major Tributaries*** | | | | |
| M15T1 | North Branch Black River | 32.0 | 14.4 | 20 |
| M26T2 | Twentymile Stream | 15.0 | 10.7 | 14 |
| M33T3 | Jewell Brook | 9.4 | 4.9 | 10 |
| M36T4 | Branch Brook | 15.9 | 9.5 | 15 |
| M40T5 | Patch Brook | 5.4 | 5.0 | 4 |
| M41T6 | Buffalo Brook | 5.7 | 3.4 | 6 |
| M47T7 | Great Roaring Brook | 6.0 | 5.3 | 11 |
| M48T8 | Tinker Brook | 2.5 | 3.9 | 6 |

Based on the channel and watershed stressors identified through remote sensing, windshield surveys and limited historical research during the Phase 1 Geomorphic Assessment, several reaches along the main stem and major tributaries were prioritized for Phase 2 Stream Geomorphic Assessments in 2007 and 2008 (see Table 2, Figure 6, next pages).

***Table 2. Reaches selected for Phase 2 Stream Geomorphic Assessments on Black River main stem and tributaries, 2007 - 2008.***

| Tributary | Towns | Reach Number | Reach Length (ft) | Reach Length (miles) | Year Assessed |
|---|---|---|---|---|---|
| **Black River** | Ludlow | **M37** | 5,311 | 1.0 | 2008 |
| **Main Stem** | Ludlow | **M36** | 4,713 | 0.9 | 2007 |
| | Ludlow | **M35** | 1,713 | 0.3 | 2007 |
| | Ludlow | **M34** | 2,161 | 0.4 | 2007 |
| | Ludlow | **M33** | 7,849 | 1.5 | 2007 |
| | Ludlow, Cavendish | **M32** | 12,000 | 2.3 | 2007 |
| | Cavendish | **M31** | 3,741 | 0.7 | 2007 |
| | Cavendish | **M30** | 8,101 | 1.5 | 2007 |
| | Cavendish | **M27** | 3,999 | 0.8 | 2008 |
| | Cavendish | **M26** | 1,815 | 0.3 | 2008 |
| | Weathersfield | **M19** | 7,697 | 1.5 | 2008 |
| **Branch Brook** | Ludlow | **M36T4.01** | 3,228 | 0.6 | 2008 |
| **Twentymile Stream** | Cavendish, Reading | **M26T2.10** | 3,132 | 0.6 | 2008 |
| | Cavendish | **M26T2.09** | 2,851 | 0.5 | 2008 |
| | Cavendish | **M26T2.08** | 3,634 | 0.7 | 2008 |
| | Cavendish | **M26T2.07** | 4,926 | 0.9 | 2008 |
| | Cavendish | **M26T2.06** | 9,808 | 1.9 | 2008 |
| | Cavendish | **M26T2.05** | 5,400 | 1.0 | 2008 |
| | Cavendish | **M26T2.01** | 1,138 | 0.2 | 2008 |
| **North Branch** | Reading | **M15T1.11** | 1,138 | 0.2 | 2008 |
| | Reading | **M15T1.10** | 2,400 | 0.5 | 2008 |
| | Reading, Cavendish, Weathersfield | **M15T1.09** | 3,664 | 0.7 | 2008 |
| | Weathersfield | **M15T1.08** | 2,488 | 0.5 | 2008 |
| | Weathersfield | **M15T1.07** | 2,740 | 0.5 | 2008 |
| | Weathersfield | **M15T1.06** | 6,547 | 1.2 | 2008 |
| | Weathersfield | **M15T1.05** | 6,365 | 1.2 | 2008 |
| | Weathersfield | **M15T1.03** | 5,488 | 1.0 | 2008 |
| | | ***Total:*** | **124,047** | **23.5** | |

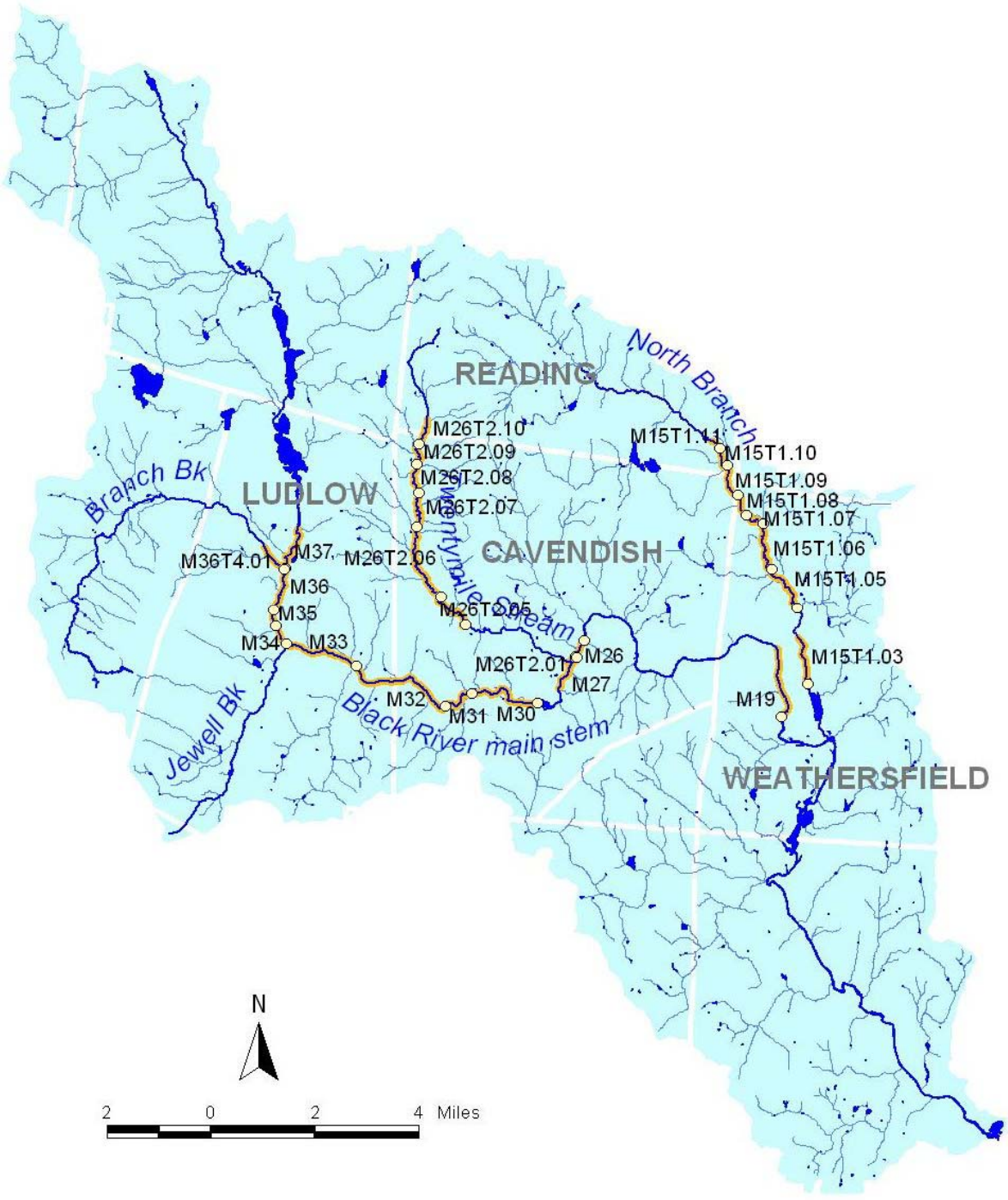



***Figure 6. Location of reaches assessed in 2007 – 2008.***

## 2.4 Hydrology

To characterize the hydrology of the Black River watershed, available records were reviewed for a current United States Geological Survey (USGS) gage on the Black River main stem at North Springfield. This gage is located approximately 600 feet upstream of the River Street (Route 106) bridge crossing. The upstream drainage area of the Black River at this point is approximately 158 square miles (USGS, 2008). This is a real-time monitoring station with flow records available on the internet. This gage has been operational since 1930 (http://waterdata.usgs.gov/vt/nwis). There are approximately 30 years of gaging records available prior to the 1960 completion of the North Springfield dam, and approximately 47 years of available record for the flow-regulated condition of the river, post-1960.

The USGS (Olson, 2002) has estimated the approximate magnitude of peak flows for the Black River during the 30-year period (pre-1960) unaffected by flow regulation at the North Springfield Reservoir and dam (Table 3).

***Table 3. Estimated flood magnitudes on the Black River for unregulated (pre-1960) conditions.***

| | |
|---|---|
| *USGS Stn #* | 01153000 |
| *USGS Description* | Black River at North Springfield, VT |
| *USGS Period of Record* | 1930 - 1960; 1973 |
| *Upstream Dr. Area (sq mi)* | 158 |
| *Geomorphic Reach* | M12 |

| Magnitude | Data Source | Discharge (cfs) |
|---|---|---|
| $Q_{1.5}$ | *(VTDEC, 2001)* | 3,980 |
| $Q_2$ | *(Olson, 2002)* | 5,590 |
| $Q_5$ | | 8,920 |
| $Q_{10}$ | | 11,600 |
| $Q_{25}$ | | 15,600 |
| $Q_{50}$ | | 19,100 |
| $Q_{100}$ | | 23,000 |
| $Q_{500}$ | | 34,100 |

Figure 7 illustrates peak discharge measured at the gage over the full period of available record from 1930 to present. Flood peaks have been essentially eliminated in the 8.7 miles of the Black River downstream of the North Springfield dam since this store-and-release flood control structure was placed into operation circa 1960. Flow regulation has contributed to significant reductions in flood damages for downstream communities along the Black River (Springfield) and the Connecticut River (ACOE, 2007).

At the same time, flow regulation has reduced the frequency and magnitude of low-flow events (see Figure 7; USGS, 2007). The post-impoundment bankfull discharge is now lower than the pre-impoundment bankfull discharge (Magilligan & Nislow, 2001).

The dam on the Black River at North Springfield Reservoir is operated as a store-and-release facility for flood control purposes. "Water discharge from the dam generally matches upstream flows, maintaining a relatively constant reservoir, except during large precipitation events and spring snowmelt…[when] storage behind the dam is temporarily increased to prevent downstream flooding" (Salant *et al*, 2006). Given the large size of the North Springfield Reservoir, sediment transported by the Black River is

effectively trapped at the upstream end of the reservoir. In the short term following construction of the dam, the average bed elevation of the Black River channel downstream of the dam (near the USGS gaging station) decreased somewhat (i.e., the channel incised) and the variability of the bed elevation decreased (i.e., channel bed stabilized). Sediment transport modeling performed by Salant *et al* (2006) suggests that the "combined effect of reduced large discharges coupled with a reduction in sediment supply by the dam and the rapid flushing of sand from the bed results in an almost instantaneous decrease in bed mobility and bed elevation variability" [downstream of the dam].

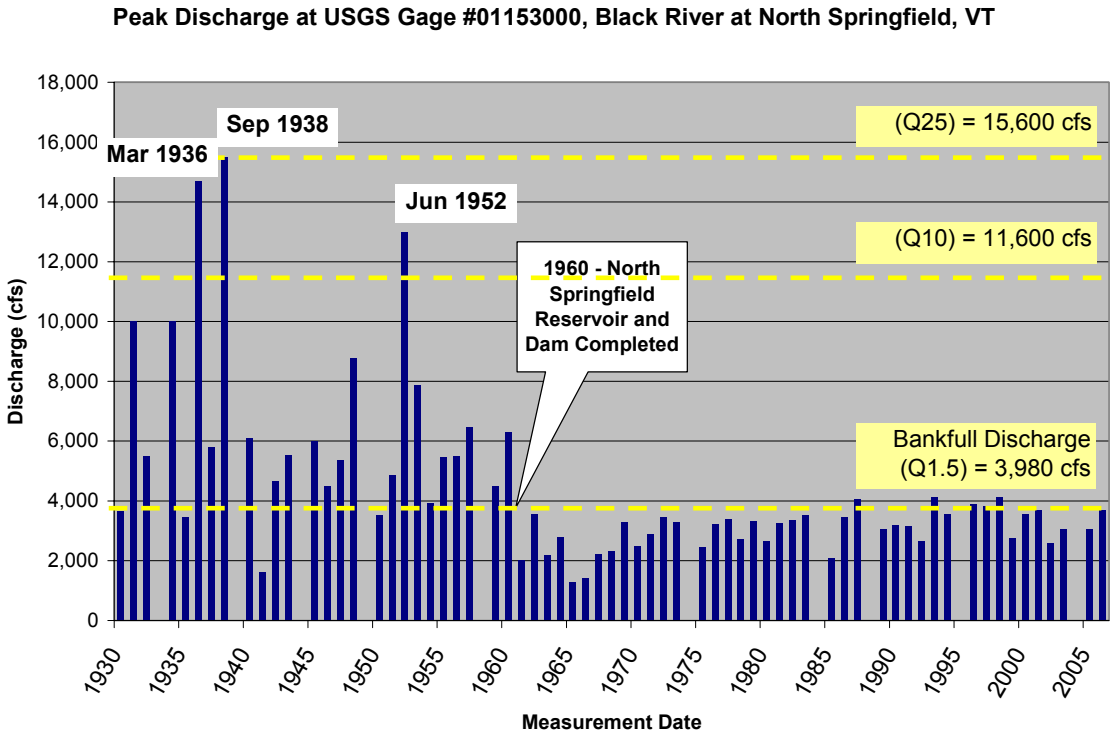



***Figure 7. Peak Discharges for USGS Gage Station #01153000, Black River at North Springfield, VT.*** *(Data obtained from USGS on-line surface water data, <http://waterdata.usgs.gov/vt/nwis> annotated with estimated bankfull discharge after VTDEC WQD, 2001, and pre-regulated flood peaks after Olson, 2002).*

Given the high relief of the Black River watershed, as well as the predominance of low-permeability glacial till and bedrock, flows in this mountainous basin watershed can be quite flashy. Snowmelt events in the late winter and early spring months can contribute to relatively high discharges. Periodic ice jams may locally enhance flood stages and lead to catastrophic erosion in break-out events. Occasional blow outs of beaver dams in the upper reaches and tributaries can also increase flood stages.

## 2.5 Flood History

Flood events can serve as a stressor to river networks, leading to localized or systemic channel adjustments. Online USGS discharge records and readily-available historic data were reviewed to identify flood events of significance in previous decades in the Black River watershed (Table 4). This limited historical review included town history books, state-wide flood publications, an online flood database maintained by the National Climatic Data Center (NCDC), and historic photodocumentation reviewed on the UVM Perkins Landscape Change Program website.

While the North Springfield dam (on the Black River main stem) and the Stoughton Pond dam (on the North Branch Black River) have controlled flood-event impacts on the downstream 9 miles of the Black River main stem since 1960, the upper main stem and tributaries of the Black River have been impacted to varying degrees by floods, before and after construction of the dam.

***Table 4. Notable flood events in the Black River watershed.***

| Flood Date(s) | Description | Data Source |
|---|---|---|
| 1996, July 13 | "dirt roads around Ludlow, Vermont were washed out"; "remnants of Tropical Storm Bertha". | NCDC, 2007 |
| 1996, May 14 | "flooding and minor washouts on several roads in …Ludlow…Proctorsville" | NCDC, 2007 |
| 1987, April | Largest flood since completion of the North Springfield Dam; reservoir was at 82% of its maximum 16.6 billion gallon capacity. | ACOE, 2007 |
| 1976, August | Flood impacting Southern Vermont | VTDEC WQD, 1999 |
| **1973, June** | Damages in Ludlow;<br>Cavendish WWTF destroyed;<br>Flood flows at historic gaging sites on North Branch Black River at Felchville, VT and Black River at Covered Bridge at Weathersfield, VT (each upstream of the North Springfield Lake). | USGS, 1990<br>VTDEC WQD, 1976<br><br>USGS, 2008 |
| 1952, June | Estimated 15-year storm (see Figure 3) | USGS, 2008 |
| **1938, September** | Estimated 25-year storm (see Figure 3) | USGS, 2008 |
| **1936, March** | Estimated 20-year storm (see Figure 3) | USGS, 2008 |
| **1927, Nov 3-7** | Largest flood on record in Vermont.<br>Significant damages in Ludlow.<br>A quarter-mile long channel avulsion bypassing the Cavendish Gorge eroded approximately 2 million tons of sediment down to bedrock leaving a channel 150 feet deep and 600 feet wide. Several buildings and a long section of the road were washed away. In Springfield, mill buildings and several bridges incurred damages. | USGS, 1990<br>Harris, 1949<br>Minsinger, W. E., 2002;<br>Perkins Landscape Change Program images, 2008; |
| 1913 | Springfield flood damages | Perkins Landscape Change Program images, 2008 |
| 1869, October | Tropical storm;<br>Springfield flood damages: washouts of the Springfield Railroad, Gould's Mill dam. | USGS, 1990;<br>Perkins Landscape Change Program images, 2008;<br>Lyndes & Menard, 1927 |
| 1850 | Damages along Jewell Brook and in Ludlow | Harris, 1949. |

The 1927 flood (November 3) was particularly destructive in the Black River valley. Approximately 7.5 inches of rain fell in a 24-hour period (Wheeler, 1952; Minsinger, 2002; National Weather Service, 2008). Reportedly, an earthen dam at Lake Rescue was breached by the floodwaters and sent a flood wave downstream to Ludlow (Gay, 1927). The "electric light dams on Lake Rescue and Lake Pauline were washed out" (Black River Tribune, 1991). Water was two feet deep in the streets of Ludlow village, and the flood waters destroyed four bridges in town (Minsinger, 2002; Harris, 1949), and undermined "the bank near the school building opposite Black River Academy" (Gay, 1927). Several dams and mills along the main stem suffered damages. Mills in Proctorsville were inundated with flood waters and tenement houses were undermined (Wheeler, 1952). In Cavendish, the Gay Brothers Woolen Mill (site of current

Mack Molding plant) was "flooded with 3 feet of water" (Wheeler, 1952). And just downstream of this site, a massive avulsion of the Black River channel bypassed the Cavendish gorge and eroded a very wide and deep channel which undermined portions of the Cavendish village (Gay, 1927; see more detailed description in Appendix E under reach heading, M29/M28).



***Figure 8. 1927 flood waters in Ludlow village.*** *View downstream of Depot Street crossing. Flow over the dam is visible in the close foreground. Inundated buildings of the former Ludlow Woolen Mill are visible at picture right.*

*Source: UVM Perkins Landscape Change Program.*

## 2.6 Land Use

Current (1993) land use / land cover within the Black River watershed (SMRC, 2007) is summarized for the overall Black River watershed, as well as four of the major tributaries (Table 5).

***Table 5. Land cover/ land use in Black River watershed and select Major Tributaries.***

| Watershed | Drainage Area (sq mi) | Commercial / Industrial | Residential | Agricultural | Forest / Shrub | Water / Wetland |
|---|---|---|---|---|---|---|
| Black River | 204.0 | 0% | 7% | 4% | 80% | 4% |
| North Branch Black River | 32.0 | 0% | 5% | 3% | 83% | 5% |
| Twentymile Stream | 15.0 | 0% | 5% | 3% | 82% | 4% |
| Jewell Brook | 9.4 | 0% | 7% | 1% | 84% | 4% |
| Branch Brook | 15.9 | 0% | 4% | 2% | 85% | 4% |

*(Note: Due to rounding preferences established in the Data Management System, the sum of the land cover / land use classifications does not equal 100%. Values noted as 0% are actually a fraction of a percent, i.e., less than 1%).*

While agricultural and developed uses comprise a relatively small percentage of the overall watershed area, these activities tend to be concentrated along the valleys of the Black River main stem and major tributaries. Development centers in vicinity of the assessed reaches currently include the villages of Ludlow, Proctorsville, Cavendish, Felchville, Whitesville and Perkinsville.

Historically, these village areas were centers of more intensive industrial and manufacturing activities (Beers, 1869; Child, 1884). Several dams were present on the Black River and tributaries to provide power to these manufacturing interests. Many of these dams are no longer present, having been breached or destroyed in past floods. Remnants of a few of these dams are visible in the river channel. Some dams persist in close vicinity of the assessed reaches, and are further discussed in Section 5.1.1.

Widespread deforestation of Vermont's landscape occurred by the early- to mid-1880s to support subsistence and sheep farming and lumber industries. Forest cover in the highlands began to regenerate in the late 1800s and early 1900s, during the industrial age when upland farms and sawmills were commonly abandoned (Thompson & Sorensen, 2000).

# 3.0 ASSESSMENT METHODOLOGY

Phase 2 Stream Geomorphic Assessments and Bridge and Culvert Assessments conducted on the Black River main stem and tributary reaches utilized protocols published by the Vermont Agency of Natural Resources (2007a) and available at: http://www.vtwaterquality.org/rivers/htm/rv_geoassesspro.htm. Reference is made to these protocols for a description of specific methods.

## 3.1 Phase 2 Stream Geomorphic Assessment

Phase 2 Stream Geomorphic Assessment protocols are field procedures for geomorphic and habitat assessment. Reach-specific and cross-section data gathered during Phase 2 characterize the present geomorphic condition of the river reach and the dominant process(es) of adjustment (i.e., degradation, widening, aggradation and/or planform adjustment). Phase 2 results, along with Phase 1 assessment results, define the natural and human disturbances to the watershed and channel over time and the composite response or adjustment of the channel to these stressors.

The Black River and tributary reaches were assessed between 1 October and 8 November 2007 and between 11 June and 23 September in 2008. Specific features and channel positions were located using either a Garmin™ eTrex VISTA model (2007) or a Garmin™ 76CSx model (2008) global positioning system (GPS) unit. Pictures were recorded with a digital camera.

In accordance with protocols, select features were digitized in ArcView© 3.x and referenced to the Vermont Hydrography Dataset (VHD), using the Feature Indexing Tool, a component of the Stream Geomorphic Assessment Tool (SGAT, v. 4.57). Certain parameters documented during the original Phase 1 Stream Geomorphic Assessment were updated based on field observations in Phase 2 (see Section 3.2). Phase 2 assessment data were entered into the online Data Management System (DMS, v.4.56) maintained by the VTANR. Phase 2 reach summary reports are compiled in Appendix A.

Thirty-four bridge and culvert crossings were encountered during Phase 2 assessments. Spans, clearance and width measurements were conducted at each structure. The span of each crossing was compared to measured or predicted bankfull widths (VTDEC WQD, 2006) to determine if the structure was a constrictor of flows at the bankfull stage or the flood-prone-width elevation (10-year to 50-year flood). Appendix B of this report provides a summary of the bridge and culvert assessments completed for these bridge crossings in accordance with Appendix G of the VTANR protocols (April 2008). Bridge and culvert data were entered into the Structures portion of the DMS (under the "Black River" database).

## 3.2 Phase 1 Updates

Original Phase 1 assessment data (SMRC, 2007) for the 27 main stem and tributary reaches were reviewed and verified during field work as per VTANR protocols. Necessary corrections or updates were documented on Phase 1 summary sheets for each reach. As appropriate, GIS shape files were corrected or updated (using the Feature Indexing Tool). Phase 1 data in the DMS was updated, and the metadata for each Phase 1 step in the database were reviewed and updated (where necessary) to reflect that data were supported by field observations. Phase 1 reach summary reports are presented in Appendix A.

The position of the reference (Phase 1) valley walls was updated, based on field observations and following clarifications to valley wall delineation procedures articulated in protocol updates between 2007 and 2009. Also, a shape file of the modified (Phase 2) valley wall was generated; typically, this Phase 2 valley wall represents artificial fill for semi-permanent structures such as major roads and railroads. Updated valley wall shape files are contained on the Project CD. Further discussion of valley wall updates is found in the Quality Assurance documentation (Appendix C) and in Appendix H.

## 3.3 Quality Assurance / Quality Control

Phase 2 data were reviewed against standard DMS Phase 2 quality control checks (X.1 through X.4), and then submitted to the River Management Section for a quality assurance review. Quality assurance documentation is contained in Appendix C.

The following considerations and limitations apply to the Phase 2 data for the Black River main stem and tributary reaches:

- Where applicable, reaches were segmented using the Segmentation Tool contained in SGAT (v. 4.57). Segmentation was necessary to:
    - Capture subreaches of a stream type (after Montgomery & Buffington, 1997; and Rosgen, 1996) that was different than the reference stream type of the overall reach;
    - Identify sections of a reach that were of distinctly different geomorphic condition;
    - Identify sections of a reach undergoing a different channel management or land use;
    - Delineate wetland-dominated or beaver-impounded reach sections; and
    - Define bedrock channel sections, defined as "gorges" by protocols.

- The Segmentation Tool within SGAT automates the calculation of segment lengths. Elevation data for the downstream and upstream segment breaks were interpolated from USGS 7.5-Minute topographic maps. Segment lengths and elevations are presented in Appendix D, along with channel gradients calculated for each segment. Segment slopes were factored into the stream-type designation for each segment. Occasionally, a subreach of alternate stream type was identified based on the calculation of segment slopes.

- Select Phase 2 features (including, grade control locations, stormwater inputs, streambank erosion, revetment locations, and more) were geo-located using the Feature Indexing Tool (FIT) in SGAT. Using FIT, these features are indexed to the available Vermont Hydrography Dataset (VHD) for the Black River. In some cases, surface waters depicted on the VHD were significantly offset from their actual position on 1994 orthophotos available for the study area. In some cases, the actual channel position has moved from its 1994 position as a result of natural channel migrations. These cases were revealed by comparison of the 1994 orthophotos with the 2003 aerial imagery (NAIP, 2003), or by review of 2007 or 2008 channel positions recorded with a hand-held GPS receiver. Thus, locations and lengths of features indexed to the VHD should be considered approximate.

# 4.0 PHASE 2 ASSESSMENT RESULTS

Geomorphic and habitat assessments were completed on 27 reaches (23.5 river miles) of the Black River and major tributaries. Phase 2 assessment results are discussed below for the main stem reaches upstream and downstream of the Cavendish Gorge (Sections 4.1 and 4.2, respectively) and Twentymile Stream and North Branch tributary reaches (Sections 4.3 and 4.4). Reach and segment reports are provided in Appendix A. Detailed reach summaries are provided in Appendix E.

A reference stream type (Phase 1) and an existing stream type (Phase 2) have been classified for each reach. Stream type designations are based on Rosgen (1996) and Montgomery & Buffington (1997). A sensitivity classification was also assigned to each reach based on the Phase 2 stream geomorphic assessment data. The sensitivity classification is intended to identify "the degree or likelihood that vertical and lateral adjustments (erosion) will occur, as driven by natural and/or human-induced fluvial processes" (VTANR, 2007b). Inherent in the stream sensitivity rating are:

- the natural sensitivity of the reach given the topographic setting (confinement, gradient) and geologic boundary conditions (sediment sizes) – as reflected in the reference stream type classification; and

- the enhanced sensitivity of the reach given by the degree of departure from reference (or dynamic equilibrium) condition – as reflected in the existing stream type classification and the condition (Reference, Good, Fair to Poor) rating of the Rapid Geomorphic Assessment).

Abbreviations used in the sections below include the following (see protocols for further description):

- Left Bank, facing downstream (abbreviated, "LB")
- Right Bank, facing downstream (RB).
- Incision Ratio (IR) = Low Bank Height / Bankfull Max Depth
    - $IR_{RAF}$ = Recently Abandoned Floodplain Incision Ratio
    - $IR_{HEF}$ = Human-Elevated Floodplain Incision Ratio
- Entrenchment Ratio (ER) = Flood Prone Width / Bankfull Width
- Width / Depth Ratio (W/D) = Bankfull Width / Mean Depth
- Flood Prone Width (FPW) – estimated as the 10- to 50-year flood event
- Stream Type Departure (STD)
- Large Woody Debris (LWD)
- Debris Jams (DJs)
- Rapid Geomorphic Assessment (RGA)
- Rapid Habitat Assessment (RHA)
- Vermont Hydrography Dataset (VHD)
- National Wetlands Inventory (NWI)
- Vermont Significant Wetlands Inventory (VSWI)

## 4.1 Black River main stem – Upstream of Cavendish Gorge: Ludlow, Cavendish

Eight reaches (8.6 miles) of the Black River main stem upstream of Cavendish Gorge in the towns of Ludlow and Cavendish were assessed in 2007 and 2008 (Figure 9). These eight reaches have upstream drainage areas ranging from 39.4 to 82.8 square miles. Assessment results for one short tributary reach at the confluence with the main stem are also presented in this section: the downstream-most reach of Branch Brook (M36T4.01) which has an upstream drainage area of 15.9 square miles. Results are summarized below in Table 6. Detailed reach narratives are presented in Appendix E.

This section of the Black River extends from Lake Pauline downstream through the village areas of Ludlow, Proctorsville and Cavendish to the Mill Street bridge crossing in Cavendish, just above the impoundment at Cavendish Gorge. Generally, the main-stem channel in this section has a relatively low gradient (0.2 to 0.4%) and is unconfined (Broad to Very Broad valley); one short reach upstream of Ludlow village (M35) is semi-confined by close bedrock-controlled valley walls, but still has a low gradient (0.2%). The Branch Brook tributary joins the Black River near the upstream end of this section (between reaches M37 and M36). The downstream reach of Branch Brook (M36T4.01) has a somewhat steeper gradient (0.9%) and is transitional between the upstream steeper-gradient, confined reaches of this tributary and the broader, low-gradient Black River valley. As such, it was classified as an "alluvial fan" reach by VTANR protocols, (although surficial geologic mapping to confirm this classification is beyond the scope of a Phase 2 geomorphic assessment).

The Black River channel flows through sediments of alluvial and glaciofluvial origin; occasionally, the channel impinges on a terrace of glacial till sediments. Often, a degree of cohesiveness in streambank soils was noted, due to a moderate silt content. Channel-spanning bedrock was observed in the Branch Brook channel upstream of the confluence with Black River. Bedrock was occasionally noted along the banks of the Black River (M37-B, M32-C, M32-B).

Over recent centuries, residential, commercial, industrial and municipal development has encroached within the floodplain of the Black River near the village centers of Ludlow, Proctorsville, and Cavendish. At least five dams and three diversion channels operated along this section of the river in the mid- to late-1800s (Beers, 1896; Child, 1884; Harris, 1949; see Section 5.1.1 Table 12, and Appendix E). Railroad construction in the Ludlow area began in 1848 and was finished by 1850 (Harris, 1949); this railroad encroaches along 2.4 miles of the Black River, reducing the available floodplain (e.g., reaches M32, M31 and M30). Historic channelization is inferred along approximately 7.2 miles (or 84%) of this 8.6-mile section, due to the linear planform and extensive streambank armoring and frequent berms. Historic straightening is also evident along Branch Brook reach M36T4.01 for approximately 80% of its length. In some cases, this channelization is evident from comparison of historic aerial photographs (e.g., above the Jewell Brook confluence in reach M34 post-1939; at the Ludlow wastewater treatment facility in Segment M33-A, post-1939; and near the Winery Road intersection with Route 103 in segment M32-B, post-1980). Berms were observed on one or both banks along 0.8 mile of channel, or 9% of this 8.6-mile section (i.e., portions of reaches M37, M34, M33, M32, and M30). Streambank armoring (rip-rap, concrete wall, or stone walls) was indexed on one or both banks along 3.8 miles or channel, or 44% of this 8.6-mile section.

A limited review of historical resources indicated a long history of channel management (dredging, windrowing, armoring, berming) in the Black River, particularly following the major floods of 1927, 1936, 1938 and 1973. Occasionally, encroachments and channel management have resulted in a channel cross section that is undersized – much narrower and sometimes deeper than would be natural for this valley setting (e.g., through Ludlow village in reach M34 and segment M33-B and at the Ludlow wastewater treatment facility in segment M33-A).

With the exception of reaches M36 and M35, each of the reaches in this section has incurred some degree of historic incision. Six of the reaches/segments (including Branch Brook reach M36T4.01) have undergone a vertical stream type departure (from a C-to-F or C-to-Bc stream type), losing connection to

the surrounding floodplain as a result of historic incision, channel management and human encroachments. Sensitivities range from High to Extreme, indicating the strong propensity for future adjustment. Most reaches/segments persist in a partially to fully entrenched condition, and are presently dominated by minor to moderate (often localized) aggradation, widening and planform adjustment.

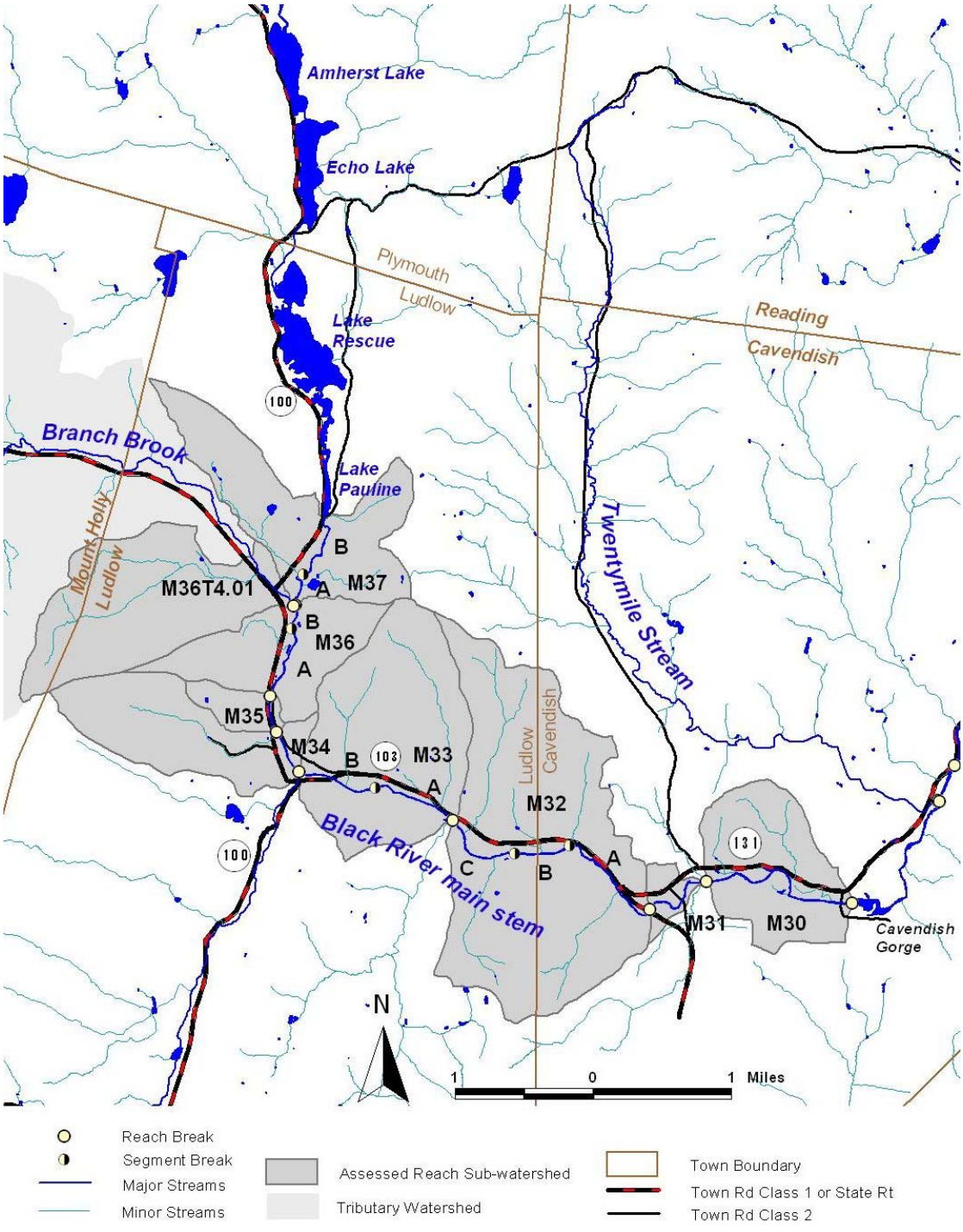



***Figure 9. Location of Black River main stem reaches upstream of Cavendish Gorge, assessed in 2007 – 2008.***

***Table 6. Results of Phase 2 Geomorphic Assessments, in 2007-2008.***
***Black River main stem Upstream of Cavendish Gorge – Ludlow, Cavendish***

| Reach | Seg-ment | Channel Length (ft) | Channel Slope (%) | Drainage Area (sq mi) | Stream Type | Incision Ratio | Width Depth Ratio | RHA Condition | RGA Condition | Active Adjustment Process | Channel Evolution Stage | Stream Type Departure? | Sensitivity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M37 | B | 3,469 | ***0.3*** | | B4c-R/P | 1.47 [RAF] | 30.4 | 0.67 Good | 0.48 Fair | Moderate PF | II [F] | C to Bc | Very High |
| | A | 1,842 | ***0.4*** | 39.4 | Not Assessed - Wetland-Dominated | | | | | | | | |
| M36T4.01 | -- | 3,228 | 0.93 | 15.9 | F3-PB | 3.2 [RAF] | 28.6 | 0.56 Fair | 0.49 Fair | Moderate Aggr, PF | II [F] | C to F | Extreme |
| M36 | B | 1,217 | ***0.4*** | | Not Assessed - portion flow pirated by Branch Brook tributary | | | | | | | | |
| | A | 3,496 | ***0.3*** | 56.5 | C4-R/P | 1.0 [RAF] | 34.9 | 0.63 Fair | 0.69 Good | Moderate PF | IIc [D] | No | High |
| M35 | -- | 1,713 | 0.23 | 56.8 | B4c-PB | 1.0 [RAF] | 36.4 | 0.49 Fair | 0.65 Good | Mod Aggr, Min Wid | I [F] | No | High |
| M34 | -- | 2,161 | 0.23 | 58.1 | F3-R/P | 2.3 [RAF] | 26.8 | 0.56 Fair | 0.55 Fair | Minor Wid, Aggr | II [F] | C to F | Extreme |
| M33 | B | 3,796 | ***0.2*** | | F3-PB | 2.0 [RAF] | 18.9 | 0.51 Fair | 0.65 Good | None | II [F] | C to F | Extreme |
| | A | 4,053 | ***0.4*** | 69.8 | C3-PB | 1.3 [RAF] | 19.6 | 0.50 Fair | 0.64 Fair | Moderate Aggr (local) | II [F] | No | Very High |
| M32 | C | 3,945 | ***0.3*** | | B3c-R/P | 1.7 [RAF] | 27.0 | 0.64 Fair | 0.55 Fair | Mod Wid (local) | II [F] | C to Bc | High |
| | B | 2,626 | ***0.3*** | | C4-R/P | 1.7 [HEF] | 33.7 | 0.62 Fair | 0.56 Fair | Mod Wid (local) | II [F] | No | Very High |
| | A | 5,429 | ***0.3*** | 78.8 | B3c-R/P | 2.1 [RAF] | 73.2 | 0.55 Fair | 0.39 Fair | Mod Aggr, Wid, PF | III [F] | C to Bc | High |
| M31 | -- | 3,741 | 0.32 | 79.0 | C4-R/P | 1.3 [RAF] | 22.4 | 0.60 Fair | 0.73 Good | Min Aggr, Wid, PF | II [F] | No | High |
| M30 | -- | 8,101 | 0.38 | 82.8 | C3-R/P | 1.4 [RAF] | 21.4 | 0.58 Fair | 0.64 Fair | Min Aggr, PF (local) | II [F] | No | High |
| Impoundment Above Dam at Cavendish Gorge | | | | | | | | | | | | | |

***Notes / Abbreviations:***

Channel Slope: Values in italic bold have been updated since the Phase 1 SGA, due to field-truthing and/or segmentation.

Stream Type: S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Br = Braided; Casc = Cascade; Ref = Reference

Incision Ratio: RAF = Recently Abandoned Floodplain; HEF = Human-elevated Floodplain (following protocols, VTANR, 2007).

Condition: RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTANR, 2007).

Adjustment: PF = Planform Adjustment; Aggr = Aggradation; Wid = Widening; Deg = Degradation; NM = Not Measured.

Channel Evolution Stage: F = F-stage model; D = D-stage model (see Appendix C of protocols, VTANR, May 2007).

* Subreach of alternate reference stream type.

## 4.2 Black River main stem – Downstream of Cavendish Gorge

Three reaches (2.6 miles) of the Black River main stem downstream of the Cavendish Gorge in the towns of Cavendish and Weathersfield were assessed in 2008: reaches M27, M26 and M19 (Figure 10). These three reaches have upstream drainage areas ranging from 84.7 to 117 square miles. Assessment results for one short tributary reach at the confluence with the main stem in this section are also presented: the downstream-most reach of Twentymile Stream (M26T2.01) which has an upstream drainage area of 15.0 square miles. Results are summarized below in Table 7. Detailed reach narratives are presented in Appendix E.

Generally, the Black River channel in these sections has a relatively low gradient (0.2 to 0.6%) with an Unconfined setting (Broad to Very Broad valley). The narrowly-confined reach of Twentymile Stream (M26T2.01) has a somewhat steeper gradient (1.3%) and joins the Black River between reaches M27 and M26. This reach of the Twentymile Stream is transitional between the upstream steeper-gradient, confined reaches of this tributary and the broader, low-gradient Black River valley. As such, it was classified as an "alluvial fan" reach by VTANR protocols, (although surficial geologic mapping to confirm this classification is beyond the scope of a Phase 2 geomorphic assessment).

In these sections, the Black River channel flows through sediments of alluvial and glaciofluvial origin; occasionally, the channel impinges on a terrace of glacial till sediments. A degree of cohesiveness in streambank soils was noted, due to a moderate silt content. In contrast, streambank sediments in the Twentymile Stream reach M26T2.01 were non-cohesive ranging from gravel to cobble in size. Channel-spanning bedrock was observed in the Black River channel upstream of the Twentymile Stream confluence at the falls below Carlton Road. Bedrock was occasionally noted along the banks of the Black River in this reach (M27) and in reach M19 and Twentymile Stream reach M26T2.01.

Residential and commercial encroachments are present along reaches M27 and M26 in vicinity of the Twentymile Stream confluence (Whitesville). Historically, this was a small industrial center with a grist mill and saw mill (Beers, 1869). Channelization is inferred along approximately 0.8 mile (or 75%) of this 1.1-mile section of the Black River, due to the linear planform and occasional berms. Historical accounts describe tons of sediment eroded by the Cavendish avulsion during the 1927 flood accumulating in the Black River channel down to Whitesville (Minsinger, 2002). Extensive "stream cleaning" was reportedly undertaken. The mostly linear planform of the reach is indicative of channelization and inferred dredging in response to the 1927 flood (and possibly the floods of 1936, 1938 and/or 1973). Channelization is also inferred along approximately 97% of the 1138-foot length of Twentymile Stream reach M26T2.01 which has been channelized and armored along Whitesville Road and Route 131.

Sparse residential development and sand and gravel quarries are evident along reach M19 above Perkinsville (town of Weathersfield); hay and crop fields are also concentrated along this valley. Historic accounts and aerial photographs record extensive channelization and berming along the upper end of reach M19 in Weathersfield, following the 1973 flood (see Appendix E). Historically, straightening is inferred along nearly the full length of this 1.5-mile reach of the Black River. A dam ("Soapstone") was present at Perkinsville approximately 1,150 ft downstream of M19 (Beers, 1869). Today, only remnants of the dam are visible amidst exposures of channel-spanning bedrock. The extent of upstream impoundment effects of the Soapstone Dam (when it was intact) is unknown. Beginning in 1960, the Black River was impounded at the North Springfield flood control reservoir approximately 4.2 miles downstream of reach M19.

Each of the reaches in this section downstream of Cavendish Gorge has incurred some degree of historic incision. Two of the reaches/segments (M26 and M19-B) have undergone a vertical stream type departure (from a C-to-F stream type), losing connection to the surrounding floodplain as a result of

historic incision, channel management, and berming (M19-B). Sensitivities range from High to Extreme, indicating the strong propensity for future adjustment. These reaches/segments persist in a partially to fully entrenched condition, and are presently dominated by minor (often localized) aggradation, widening and/or planform adjustment.

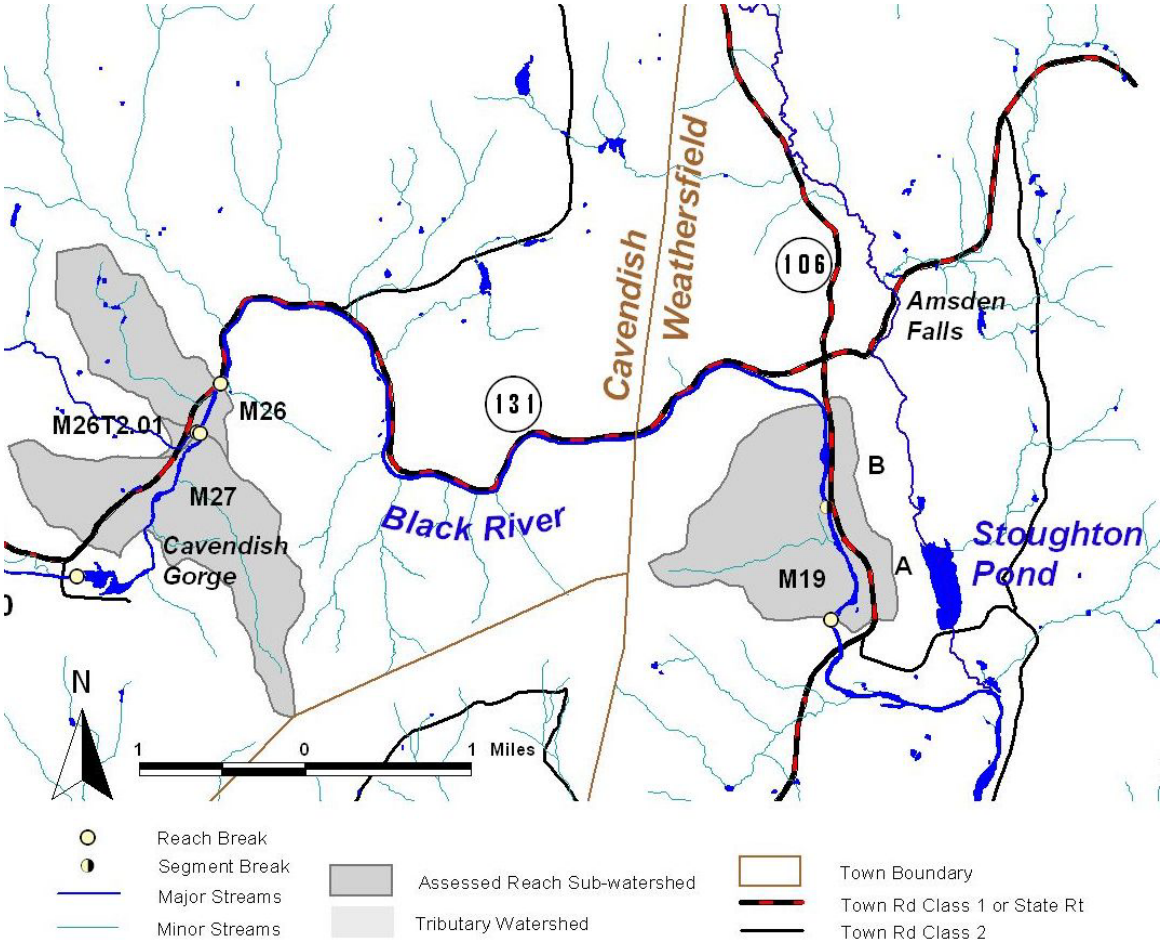



***Figure 10. Location of Black River main stem reaches downstream of Cavendish Gorge, assessed in 2007 – 2008.***

***Table 7. Results of Phase 2 Geomorphic Assessments, in 2007-2008.***
***Black River main stem Downstream of Cavendish Gorge – Cavendish, Weathersfield***

| Reach | Seg-ment | Channel Length (ft) | Channel Slope (%) | Drainage Area (sq mi) | Stream Type | Incision Ratio | Width Depth Ratio | RHA Condition | RGA Condition | Active Adjustment Process | Channel Evolution Stage | Stream Type Departure? | Sensitivity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M27 | -- | 3,999 | 0.50 | 84.7 | C3-R/P | 1.8 [RAF] | 23.9 | 0.77 Good | 0.59 Fair | Min Aggr, PF; Wid (local) | II [F] | No | High |
| M26T2.01 | -- | 1,138 | 1.32 | 15.0 | C3-PB | 1.6 [RAF] | 12.2 | 0.50 Fair | 0.63 Fair | Min Aggr; Wid (local) | II [F] | No | High |
| M26 | -- | 1,815 | 0.55 | 100 | F4-PB | 2.3 [RAF] | 42.7 | 0.52 Fair | 0.49 Fair | None (minor) | II [F] | C to F | Extreme |
| Reaches M25 - M20 (5.4 miles) through a semi-confined, bedrock-controlled valley along Route 131 | | | | | | | | | | | | | |
| M19 | B | 3,454 | ***0.6*** | | F3-R/P | 2.2 [RAF] | 48.1 | 0.62 Fair | 0.55 Fair | Min Aggr, PF | II [F] | C to F | Extreme |
| | A | 4,243 | ***0.2*** | 117 | C4-R/P | 1.7 [RAF] | 42.1 | 0.56 Fair | 0.46 Fair | Mod PF, Wid; Min Aggr | III [F] | No | Very High |

***Notes / Abbreviations:***

Channel Slope: Values in italic bold have been updated since the Phase 1 SGA, due to field-truthing and/or segmentation.

Stream Type: S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Br = Braided; Casc = Cascade; Ref = Reference

Incision Ratio: RAF = Recently Abandoned Floodplain; HEF = Human-elevated Floodplain (following protocols, VTANR, 2007).

Condition: RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTANR, 2007).

Adjustment: PF = Planform Adjustment; Aggr = Aggradation; Wid = Widening; Deg = Degradation; NM = Not Measured.

Channel Evolution Stage: F = F-stage model; D = D-stage model (see Appendix C of protocols, VTANR, May 2007).

* Subreach of alternate reference stream type.

## 4.3 Twentymile Stream – Reading, Cavendish

Twentymile Stream drains a 15.0-square-mile area in the north-central region of the Black River watershed. This tributary joins the Black River in Whitesville, just downstream of the Cavendish Gorge, at the upstream end of reach M26. A total of 7 reaches (5.9 miles) of the Twentymile Stream were assessed in 2008 (Figure 11). Results are summarized below in Table 8. Detailed reach narratives are presented in Appendix E. Results for the downstream-most reach of this tributary (M26T2.01) were discussed in Section 4.1 since this short reach is relevant to the conditions of main stem reaches M26 and M27, and since intermediate reaches (M26T2.02 – M26T2.04) were not assessed as part of this study.

The assessed portion of Twentymile Stream extends from just north of the Reading town line downstream through the town of Cavendish to the Davis Road crossing. Generally speaking, the gradient of this channel decreases along the length of study, from 3.9% in the middle segment of M26T2.10 to 0.5% in reach M26T2.06 above a valley pinch point which marks the start of reach M26T2.05. In the upstream, steeper portions of this section (M26T2.10-B) the channel is semi-confined and bedrock is exposed in the channel bed and banks. Similar, bedrock-controlled, valley pinch points are evident in Segments M26T2.08-B, M26T2.06-B and M26T2.05. Elsewhere, along this studied portion of Twentymile Stream, the valley confinement ranged from Broad to Very Broad and channel gradients were low.

This portion of the Twentymile Stream flows through sediments of alluvial and glaciofluvial origin; occasionally, the channel impinges on a terrace of glacial till sediments. Generally, the grain size of sediments in the bed and banks decreases with distance downstream, and the cohesiveness increases, to the point where a low width/depth cross section (e.g. reference E stream type) dominates the channel in lower reaches (M26T2.06). Hydric soils and riparian wetlands (NWI) are frequently mapped along this section of the Twentymile Stream (outside of the steeper-gradient and/or more-confined segments). Channel-spanning bedrock was observed in Segments M26T2.10-C, M26T2.10-B and M26T2.06-B. Bedrock was also noted along the banks of these segments, and in Segment M26T2.05.

Sparse residential development has encroached within the floodplain of the Twentymile Stream, generally near the periphery of the valley. Much of the floodplain (in the lower-gradient, broadly unconfined sections) has been converted to agricultural uses including pasture (generally fallow), hay fields, and crop fields (less common). Historic channelization is inferred along approximately 1.9 miles (or 33%) of this 5.7-mile section (excluding M26T2.01), given the linear planform, frequent streambank armoring (15%), and occasional berms. Where tributary channels cross the Twentymile Stream valley through agricultural fields, they generally appear to have been channelized or ditched (through areas of hydric soils).

In the upstream portion of the study area (reaches/segments M26T2.10, M26T2.09 and M26T2.08-A, excluding M26T2.08-B), the channel has undergone varying degrees of historic incision, with incision ratios ranging from 1.3 to 2.3. One of the segments (M26T2.10-A) has undergone a vertical stream type departure (from Cb to Fb stream type). In contrast, in downstream segments (M26T2.06-B, M26T2.06-A and M26T2.05), incision is minor to negligible and the Twentymile Stream has reasonable access to the floodplain. It is likely that periodic exposures of channel-spanning bedrock (in M26T2.06-B, and M26T2.10-B) have limited the extent of incision along the Twentymile Stream channel.

The bedrock-influenced reaches / segments with narrower confinement and/or channel-spanning bedrock exposures (e.g., M26T2.10-B, M26T2.08-B, M26T2.06-B, M26T2.05) are fairly stable, have good access to the floodplain, and have forested buffers that moderate lateral adjustments. Between these segments, most reaches/segments persist in a partially- to fully-entrenched condition, and are presently dominated by minor to moderate aggradation and planform adjustment. Sensitivities generally range from High to Extreme, indicating the strong likelihood for future adjustment. One exception to this generalization is segment M26T2.06-A (High sensitivity) which is only slightly entrenched with good floodplain access. While some planform adjustment is evident (flood chutes, meander extension), widening and incision

appear to have been moderated by the low gradient and cohesive sediments. Beaver activity is widespread in the study section of Twentymile Stream, contributing to localized aggradation and lateral adjustments of the channel (e.g., reaches M26T2.09, M26T2.07, M26T2.06).

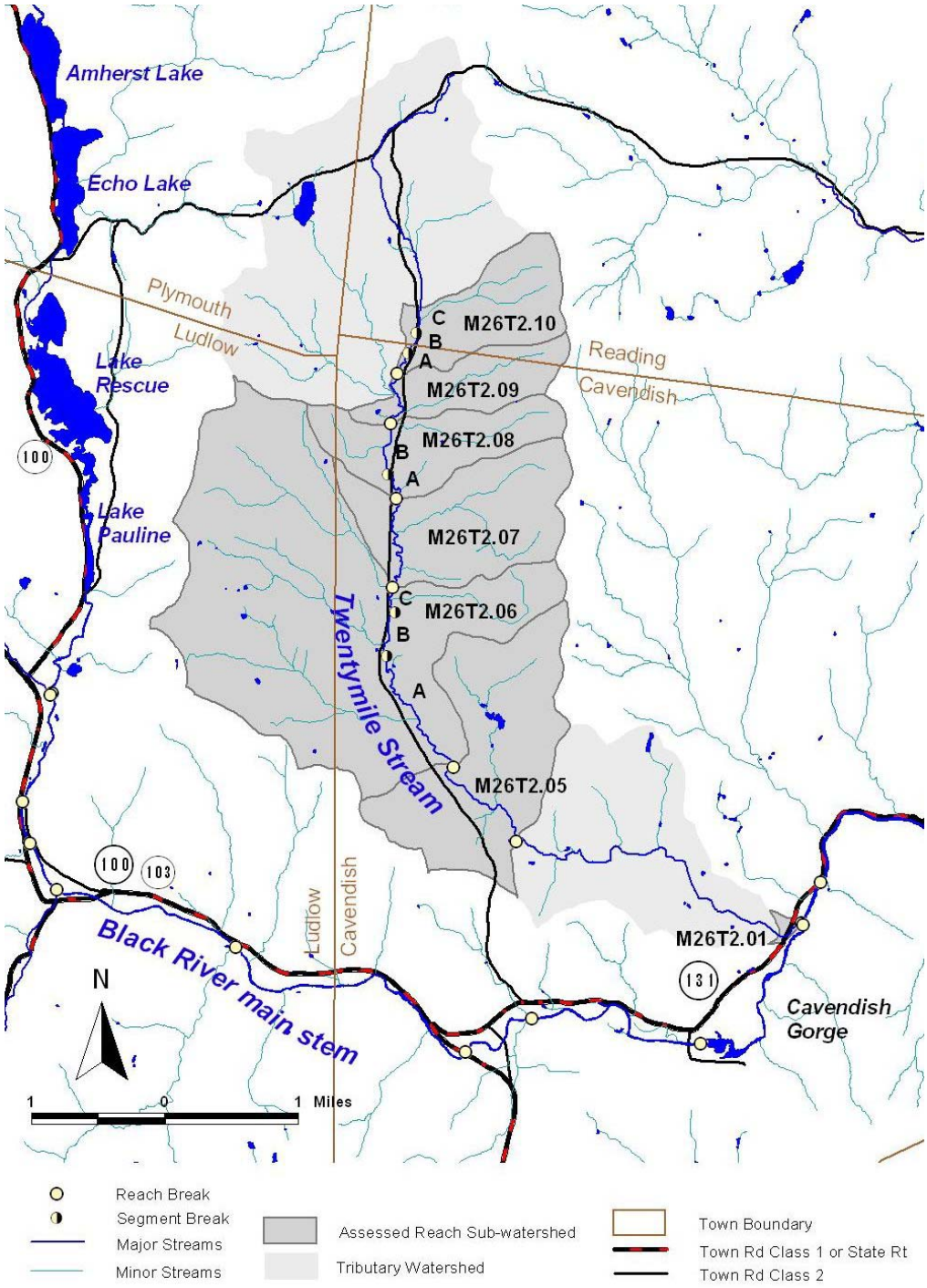



***Figure 11. Location of Twentymile Stream reaches assessed in 2007 – 2008.***

***Table 8. Results of Phase 2 Geomorphic Assessments, Twentymile Stream reaches assessed in 2008.***

| Reach | Seg-ment | Channel Length (ft) | Channel Slope (%) | Drainage Area (sq mi) | Stream Type | Incision Ratio | Width Depth Ratio | RHA Condition | RGA Condition | Active Adjustment Process | Channel Evolution Stage | Stream Type Departure? | Sensitivity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M26T2.10 | C* | 1,209 | ***1.7*** | | C4-PB | 1.67 [RAF] | 14.7 | 0.57 Fair | 0.64 Fair | Minor PF | II [F] | No | Very High |
| | B | 908 | ***3.9*** | | B3-S/P | 1.3 [RAF] | 15.1 | 0.74 Good | 0.79 Good | None | I [D] | No | Moderate |
| | A * | 1,015 | ***3.0*** | 2.4 | F4b-R/P | 2.3 [RAF] | 17.3 | 0.70 Good | 0.55 Fair | Minor PF | II [F] | Cb to Fb | Extreme |
| M26T2.09 | -- | 2,851 | 1.4 | 4.9 | C3-R/P | 1.5 [RAF] | 16.6 | 0.59 Fair | 0.59 Fair | Moderate aggr & PF | III [F] | No | High |
| M26T2.08 | B | 2,241 | ***1.1*** | | C4-R/P | 1.1 [RAF] | 20.9 | 0.70 Good | 0.69 Good | Moderate PF | I [F] | No | High |
| | A | 1,393 | ***0.7*** | 5.7 | C4-R/P | 1.95 [RAF] | 14.0 | 0.63 Fair | 0.56 Fair | Minor PF | II [F] | No | Very High |
| M26T2.07 | -- | 4,926 | 0.51 | 7.0 | C4-R/P | 1.67 [RAF] | 18.2 | 0.64 Fair | 0.56 Fair | Minor Wid, Aggr, PF | III [F] | No | Very High |
| M26T2.06 | C | 1,292 | ***0.4*** | | Not Assessed - Beaver Impounded | | | | | | | | |
| | B * | 2,050 | ***0.5*** | | C4-R/P | 1.09 [RAF] | 14.1 | 0.61 Fair | 0.84 Good | Minor Aggr | I [D] | No | High |
| | A | 6,466 | ***0.5*** | 11.4 | E4-R/P | 1.08 [RAF] | 10.4 | 0.58 Fair | 0.71 Good | Mod PF; Local Wid | IIc [D] | No | High |
| M26T2.05 | -- | 5,400 | 1.02 | 13.1 | C3-R/P | 1.15 [RAF] | 18.4 | 0.66 Good | 0.68 Good | Substantial PF | IV [F] | No | Moderate |
| M26T2.01 | -- | 1,138 | 1.32 | 15.0 | C3-PB | 1.61 [RAF] | 12.2 | 0.50 Fair | 0.63 Fair | Minor Aggr; Localized Wid | II [F] | No | High |

***Notes / Abbreviations:***

Channel Slope: Values in italic bold have been updated since the Phase 1 SGA, due to field-truthing and/or segmentation.

Stream Type: S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Br = Braided; Casc = Cascade; Ref = Reference

Incision Ratio: RAF = Recently Abandoned Floodplain; HEF = Human-elevated Floodplain (following protocols, VTANR, 2007).

Condition: RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTANR, 2007).

Adjustment: PF = Planform Adjustment; Aggr = Aggradation; Wid = Widening; Deg = Degradation; NM = Not Measured.

Channel Evolution Stage: F = F-stage model; D = D-stage model (see Appendix C of protocols, VTANR, May 2007).

* Subreach of alternate reference stream type.

## 4.4 North Branch – Reading, Cavendish, Weathersfield

The North Branch of the Black River drains a 32.0-square-mile area in the north-eastern region of the Black River watershed. This tributary joins the Black River just downstream of Perkinsville, at the upstream end of reach M15. A total of eight reaches (5.8 miles) of the North Branch were assessed in 2008 (Figure 12). The upstream drainage area of these eight reaches varied from 11.6 to 28.5 square miles. Results are summarized below in Table 9. Detailed reach narratives are presented in Appendix E.

The assessed portion of Twentymile Stream extends from Felchville in Reading downstream through the northeast corner of Cavendish, into Weathersfield ending just above Amsden Falls, and includes a one-mile section of this tributary below the falls and upstream of Stoughton Pond. Generally speaking, the gradient of this channel decreases along the length of study, from 7.3% at the bedrock falls in Felchville (M15T1.11-C) to 0.08% in reach M15T1.05 above Amsden Falls. Between these major bedrock controls at Felchville Falls and Amsden Falls, there are two sections of very broad valley comprised of alluvial sediments, separated by two more narrowly-confined, steeper-gradient reaches (M15T1.09 and M15T1.08) flowing through glaciofluvial sediments where bedrock is exposed occasionally in the channel bed and banks. Similar, bedrock-controlled, valley pinch points are evident within reach M15T1.03 below Amsden Falls and above Stoughton Pond. Stoughton Pond is a recreational and flood control reservoir constructed by the Army Corps of Engineers in 1960. Impoundment effects of the flood control dam at this reservoir extend upstream into the lower part of reach M15T1.03.

Generally, the grain size of sediments in the bed and banks decreases with distance downstream, and the cohesiveness increases, to the point where a low width/depth cross section (e.g. reference E stream type) dominates the channel in lower reaches (M15T1.06 and M15T1.05). Extensive areas of hydric soils and riparian wetlands (NWI) are mapped in these lower reaches.

Sparse residential development has encroached within the floodplain of the North Branch, generally near the periphery of the valley. Residential, commercial and municipal development is more concentrated in Felchville along reach M15T1.11. Historically, Felchville was a center of industrial activities, supported by mill dams. Above Felchville Falls, water was diverted into channels that bypassed reach M15T1.11, directed toward mills in the village, and returned to the North Branch below the village in reach M15T1.11 or M15T1.10 (Beers, 1869). Further downstream, much of the North Branch floodplain (in the lower-gradient, broadly unconfined sections) has been converted to agricultural uses including hay fields and crop fields (corn). Historic channelization is inferred along approximately 3.5 miles (or 61%) of this 5.8-mile section, given the linear planform, frequent streambank armoring (20%), and extensive berms. Local residents recall that a majority of these reaches were dredged following the 1973 flood (Willey, 2008; Miller, 2007). Where tributary channels cross the North Branch valley through agricultural fields, they generally appear to have been channelized or ditched (often through areas of hydric soils).

Berms were indexed along 13% of the assessed length of the North Branch channel, generally where adjacent agricultural uses or residential uses are at risk of flooding. In reaches M15T1.10 and M15T1.07 where the channel is transitioning from upstream, steeper-gradient, more-confined settings out into the broader, alluvial valley, berms have been constructed on one or both streambanks – along 87% and 43% of the reach length, respectively.

The upper six segments / reaches of the North Branch (2.3 miles; M15T1.11-B through M15T1.07) have undergone a vertical stream type departure (from Cb-to-Fb or C-to-F stream type) and lost connection with the surrounding floodplain as a result of historic incision, encroachments (berming), and channel management. Given their incised and entrenched condition, these segments remain highly susceptible to catastrophic erosion and channel avulsions during high flows, and have been assigned an Extreme sensitivity classification. At present, these reaches are exhibiting minor to localized aggradation. Reach M15T1.07 is dominated by major planform adjustment (meander extension, flood chutes) and overwidening, as well as moderate aggradation, due to its position along the river network at a point of transition between the steeper-gradient, more-confined setting of upstream reaches to the Very Broad,

unconfined and lower-gradient setting of downstream reaches. This condition has likely been exacerbated by the historic narrowing and removal of forested buffers along the streambanks and removal of large woody debris from the channel. The downstream four segments (M15T1.06-B, M15T1.06-A, M15T1.05 and M15T1.03) are fairly stable, have reasonable to very good floodplain access, and channel dimensions in the expected range. They are presently dominated by moderate to major planform adjustments (meander extension, translation, and neck cutoffs) as well as minor to moderate aggradation and localized widening (associated with beaver activity). Given their valley setting, low gradients, and finer substrates these segments remain susceptible to lateral adjustments and therefore have Very High to Extreme sensitivity classifications.

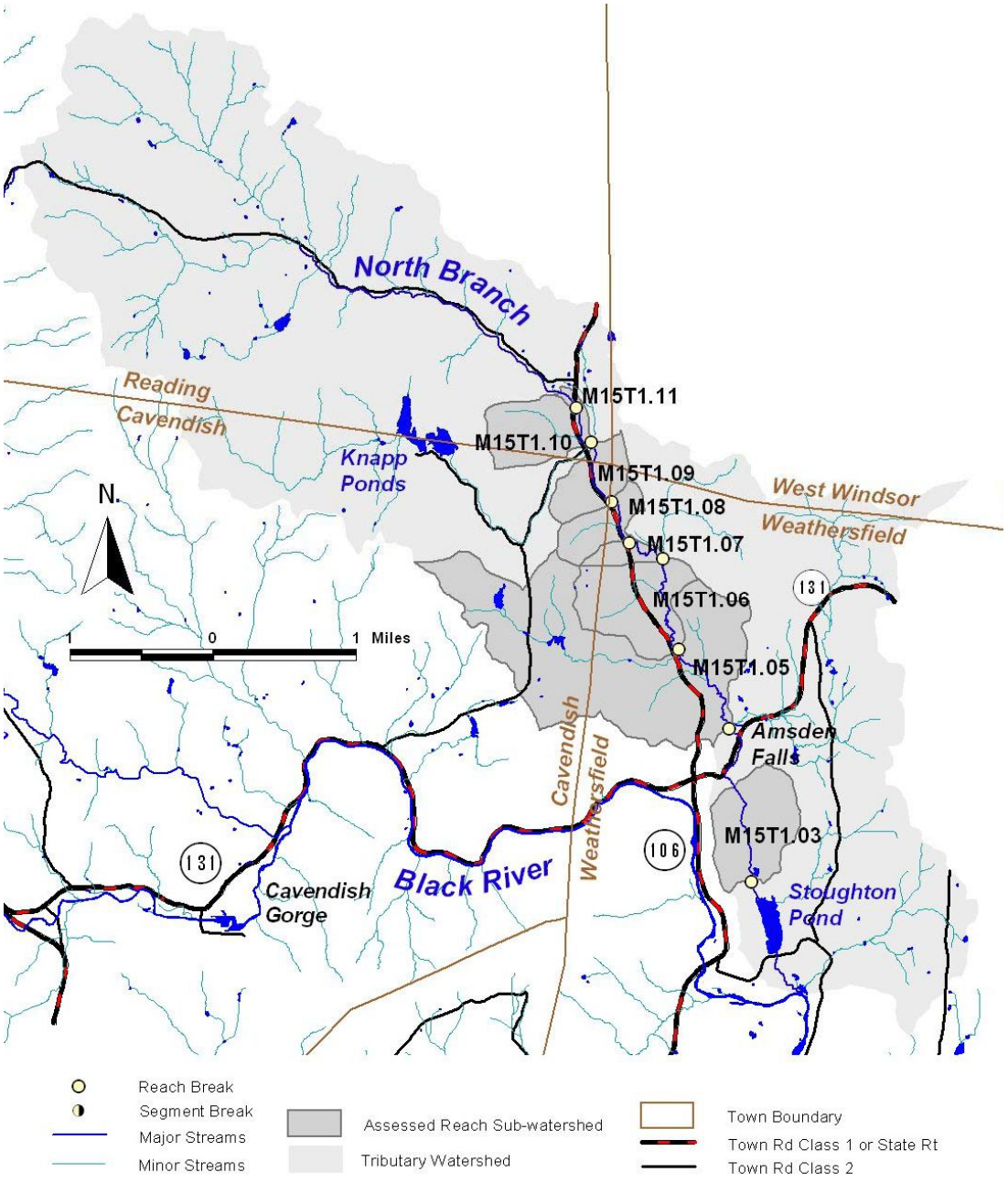



***Figure 12. Location of North Branch tributary reaches assessed in 2007 – 2008.***

***Table 9. Results of Phase 2 Geomorphic Assessments, North Branch reaches assessed in 2008.***

| Reach | Segment | Channel Length (ft) | Channel Slope (%) | Drainage Area (sq mi) | Stream Type | Incision Ratio | Width Depth Ratio | RHA Condition | RGA Condition | Active Adjustment Process | Channel Evolution Stage | Stream Type Departure? | Sensitivity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M15T1.11 | C * | 409 | ***7.3*** | | B1a-Casc | Not Assessed - Bedrock Channel | | | | | | | |
| | B * | 312 | ***3.5*** | | F3b-S/P | 3.04 [RAF] | 18.2 | 0.63 Fair | 0.63 Fair | None | II [F] | Cb to Fb | Extreme |
| | A | 417 | ***2.2*** | 11.6 | F3b-PB | 2.7 [RAF] | 22.0 | 0.39 Fair | 0.61 Fair | Minor Aggr | II [F] | Cb to Fb | Extreme |
| M15T1.10 | -- | 2,400 | 0.83 | 12.2 | F3-R/P | 2.2 [HEF] | 26.0 | 0.48 Fair | 0.50 Fair | Mod PF; Min Aggr | II [F] | C to F | Extreme |
| M15T1.09 | -- | 3,664 | 1.36 | 18.0 | F4-PB | 3.15 [RAF] | 19.3 | 0.59 Fair | 0.63 Fair | Localized Aggr | II [F] | C to F | Extreme |
| M15T1.08 | -- | 2,488 | 1.21 | 18.3 | F4-R/P | 2.2 [RAF] | 16.0 | 0.60 Fair | 0.61 Fair | Min Aggr | II [F] | C to F | Extreme |
| M15T1.07 | -- | 2,740 | 0.36 | 18.4 | F4-R/P | 2.04 [RAF] | 38.1 | 0.53 Fair | 0.33 Poor | Major PF, Wid; Mod Aggr | III [F] | C to F | Extreme |
| M15T1.06 | B | 3,718 | ***0.1*** | | E5-D/R | 1.6 [RAF] | 11.2 | 0.43 Fair | 0.50 Fair | Mod PF, Wid, Mod Aggr | III [F] | None | Extreme |
| | A | 2,829 | ***0.1*** | 20.9 | E5-D/R | 1.0 [RAF] | 13.2 | 0.48 Fair | 0.56 Fair | Major PF, Mod Wid | I [F] | None | Extreme |
| M15T1.05 | -- | 6,365 | 0.08 | 23.8 | E5-D/R | 1.0 [RAF] | 11.1 | 0.54 Fair | 0.63 Fair | Major PF, Mod Aggr | I [F] | None | Extreme |
| Amsden Falls | | | | | | | | | | | | | |
| M15T1.03 | B | 4,060 | ***0.7*** | | C4-R/P | 1.13 [RAF] | 13.7 | 0.62 Fair | 0.61 Fair | Mod PF, Aggr | IV [F] | None | Very High |
| | A | 1,428 | ***0.1*** | 28.5 | Not Assessed - Impoundment Effects of Stoughton Pond | | | | | | | | |
| Stoughton Pond & Dam (ACOE) | | | | | | | | | | | | | |

***Notes / Abbreviations:***

Channel Slope: Values in italic bold have been updated since the Phase 1 SGA, due to field-truthing and/or segmentation.

Stream Type: S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Br = Braided; Casc = Cascade; Ref = Reference

Incision Ratio: RAF = Recently Abandoned Floodplain; HEF = Human-elevated Floodplain (following protocols, VTANR, 2007).

Condition: RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTANR, 2007).

Adjustment: PF = Planform Adjustment; Aggr = Aggradation; Wid = Widening; Deg = Degradation; NM = Not Measured.

Channel Evolution Stage: F = F-stage model; D = D-stage model (see Appendix C of protocols, VTANR, May 2007).

* Subreach of alternate reference stream type.

# 5.0 DEPARTURE ANALYSIS, STRESSOR IDENTIFICATION & SENSITIVITY

Phase 1 and Phase 2 stream geomorphic assessments of the Black River main stem and tributary reaches provide for a better understanding of how human-caused disturbances at the watershed and reach level may have altered or constrained the river's ability to convey the water and sediment inputs to the watershed. Consideration of the current state of channel evolution and reach sensitivity will help to ensure that identified river management strategies and restoration or conservation projects will be successful over the long term.

Channel and watershed disturbances that exceed thresholds for change can upset the dynamic equilibrium of stream systems. Imbalance in the channel affects the sediment transport capacity of the stream system, and has significant consequences for erosion hazards, water quality and riparian habitats. Equilibrium can be disturbed locally and result in channel adjustments that are limited in magnitude and extent (for example, scour at an undersized culvert crossing). Alternately, the disturbance (or an overlapping combination of disturbances) can be of sufficient size, duration, or frequency to cause substantial channel adjustments that result in a system-wide imbalance extending far upstream and downstream through the river network.

Such imbalances, whether localized or systemic, can interfere with the river's ability to efficiently convey its water and sediment loads. These interruptions may be expressed as a sediment transport deficiency where sediment accumulates in the channel (which itself may lead to further imbalances - e.g., flow widens and splits to erode streambanks on either side, or flow may avulse or jump its banks in a flood event). Alternately, the imbalance can be expressed as an increase in sediment transport capacity. For example, a channel that has been straightened, dredged, armored and bermed has a local increase in channel slope and channel entrenchment, which creates higher flow velocities, and an increased power to erode the streambed. If the channel bed is scoured, this condition often leads to further channel adjustments including streambank collapse and widening.

Sediment transport capacity of the channel can be inferred from the geomorphic features observed during field work and from the identified reach-scale and watershed-scale stressors. Even a qualitative understanding of features and fluvial processes can help to identify and prioritize appropriate management strategies for the river that will facilitate a return toward a more balanced (dynamic equilibrium) condition.

As stated in VTANR (2007b) guidance: "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 until [quasi-]equilibrium is achieved."

The departure analysis and sensitivity analysis presented below characterize the current condition of the Black River and tributary reaches, and their degree of departure from reference, or a pre-disturbed state.

## 5.1 Departure Analysis

The departure analysis reviews watershed-level and reach-level disturbances to the channel and characterizes the potential nature and extent of these disturbances as stressors to the overall equilibrium of the river network. Changes to the hydrology and/or sediment load are important as they may significantly affect the hydraulic geometry and fluvial processes of the river and lead to an imbalance of

the river network. A channel in dis-equilibrium may undergo substantial lateral and vertical adjustments that may be "at odds" with human infrastructure or land uses in the river corridor. Watershed-scale hydrologic and sediment regime stressors are addressed in Section 5.1.1. Changes in sediment loading characteristics that influence sediment regime at both the watershed level and reach level are addressed in Section 5.1.2. Direct disturbances of the channel and/or surrounding floodplain are addressed as possible modifiers of the channel slope, channel depth, and channel and riparian boundary conditions (Sections 5.1.3 and 5.1.4). While these factors are addressed in separate sections below, in reality they are inextricably linked in the overall cause and effect cycles and fluvial processes which together govern the form and function of the river network.

As defined in VTANR guidance (VTANR, 2007b), the hydrologic regime of the river system refers to the "input and manipulation of water at the watershed scale" that may modify the timing, volume, duration and periodicity of flows in the river network. In turn, these changes to the hydrologic regime may have the potential to cause adjustments in the channel dimensions, slope, or planform – and influence the sediment transport regime. The sediment regime is defined in VTANR guidance as "the quantity, size, transport, sorting, and distribution of sediments".

### 5.1.1 Watershed Scale Hydrologic and Sediment Regime Stressors

Data are not sufficient to know with certainty whether (and to what extent and in what locations) a given change in the water or sediment inputs to a river corridor will cause the channel to incise or aggrade, widen or shift its planform. However, potential influences on the hydrology of the Black River watershed (or its tributary sub-watersheds) can be identified in a qualitative sense as a possible contributor(s) to channel dis-equilibrium. Watershed-level hydrologic and sediment regime stressors are identified through a review of existing Phase 1 and Phase 2 stream geomorphic data and include deforestation, stormwater inputs, dams, flow regulations, land use (degree of urbanization), ditching, and wetland loss. Watershed stressors are summarized in Table 10 and described further in the sections below.

#### Deforestation

Widespread deforestation of Vermont's landscape occurred by the early- to mid-1880s (Thompson & Sorensen, 2000) to support subsistence and sheep farming and the lumber industries. Deforestation is inferred to have caused increased water and sediment loads to be mobilized from the Black River watershed. Rainfall, which would previously have been intercepted by tree leaves and branches, and which would have been taken up by tree roots and evapo-transpired, instead ran off the land surface. Infiltrative capacities of the soils would have been reduced by compaction of the soils during harvesting. Increased volumes of stormwater runoff would have had increased capacity for gullying and entrainment of soils and sediments from the land surface, delivering increased sediment loads to the river network. Sediment supplies to Black River and tributary reaches would have been increased especially during flood events, leading to aggradation and planform adjustments (with the increased sediment loading), and possibly localized incision and widening (where increased hydrologic loading occurred).

Forest cover in the Vermont highlands began to regenerate in the late 1800s and early 1900s, during the industrial age and abandonment of upland farms and sawmills. During reforestation, the water and sediment balance would have again shifted (independent of global climate cycles) back to lesser volumes of runoff and reduced sediment loading. This change in the hydrologic and sediment regimes may have led to net incisional processes in parts of the Black River channel network.

***Table 10. River Stressor Identification Table (Watershed Level)***

| | **Watershed Input Stressors** | |
|---|---|---|
| **Stressor Type** | **Hydrologic Regime** | **Sediment Regime** |
| **Floods** | Events (such as the floods of 1973, 1938, 1936, and 1927) imparted event-based **increase** in hydrologic loading to the watershed (see Section 2.5). | **Increased** sediment loading from active channel adjustments in upstream reaches, would be expected as a result of major flood events, such as the 1973, 1938, 1936, and 1927 (see Section 2.5). |
| **Deforestation** | **Increased** hydrologic loading due to deforestation in mid- to late-1800s; subsequent **decreased** hydrologic loading as slopes partially reforested through the 1900s. | **Increased** sediment loading due to deforestation in mid- to late-1800s; subsequent **decreased** sediment loading as slopes partially reforested through the 1900s. |
| **Urbanization** | **Minor** increased hydrologic loading inferred due to development and increased road densities of reach subwatersheds and upstream drainage areas in recent decades. Upstream watershed development percentages (3.0 to 5.0%) are at or below the threshold of concern (5%) noted in VTANR guidance (11 July 2007). | **Minor** increased sediment loading inferred due to development and increased road densities of reach subwatersheds and upstream drainage areas in recent decades. Upstream watershed development percentages (3.0 to 5.0%) are at or below the threshold of concern (5%) noted in VTANR guidance (11 July 2007). |
| **Stormwater Inputs** | **Minor increased** hydrologic loading inferred due to road ditch, field ditch, and engineered stormwater inputs. Drainage area of most assessed reaches equals or exceeds the drainage area (0 - 15 sq mi) likely to be influenced by stormwater inputs (as noted in VTANR guidance, 11 July 2007). | **Minor increased** sediment loading inferred due to road ditch, field ditch, and engineered stormwater inputs. Drainage area of most assessed reaches equals or exceeds the drainage area (0 - 15 sq mi) likely to be influenced by stormwater inputs (as noted in VTANR guidance, 11 July 2007). |
| **Dams / Impoundments** | No dams are currently located on the 27 assessed reaches. Historic dams possibly contributed to historic incision due to "hungry water" effects downstream of the dam sites, and due to breaching effects upstream of the dam sites. | No dams are currently located on the 27 assessed reaches. At historic dam sites, sediments may be trapped in impoundments and may have been released to downstream reaches upon dam breaching. |
| **Diversions / Water Withdrawals** | **Minor** decreased hydologic loading inferred due to operation of permitted snowmaking withdrawal in reach M34, Ludlow. Unknown hydrological impacts of historic operation of flow diversions to operate mills in Ludlow, Proctorsville, Cavendish, and Felchville. | **Minor** sediment regime impacts inferred from operation of permitted snowmaking withdrawal in reach M34, Ludlow. Unknown sediment regime impacts of historic operation of flow diversions to operate mills in Ludlow, Proctorsville, Cavendish, and Felchville. |
| **Loss of Wetlands** | Increase in hydrologic loading to the assessed reaches as a result of conversion of wetlands (hydric soils) to agricultural uses through tributary channelization and ditching: **Insignificant** for Black River main stem reaches; **Very Minor** for Twentymile Stream reaches and most North Branch reaches; **Moderate** for lower North Branch reaches (M15T1.06, M15T1.05). | Increase in sediment loading to the assessed reaches as a result of conversion of wetlands (hydric soils) to agricultural uses through tributary channelization and ditching: **Insignificant** for most reaches; **Minor** for lower North Branch reaches, M15T1.06, M15T1.05. |
| **Crop Lands** | **Insignificant** increase in hydrologic loading to the assessed reaches as a result of crop land use (implying possible ditching, tile networks). Crop land use is very low (less than 2%) in the the upstream watersheds. Potential significance tempered by the size of the upstream watershed (20 to 117 square miles) in reaches with confirmed cultivated land use in the surrounding corridor (M19, M15T1.06). Possible impacts from tile / ditch drainage in M15T1.10 addressed under stormwater inputs. | Insignificant increase in sediment loading to the assessed reaches as a result of crop land use (implying possible ditching, tile networks). Crop land use is very low (less than 2%) in the the upstream watersheds. Potential significance tempered by the size of the upstream watershed (20 to 117 square miles) in reaches with confirmed cultivated land use in the surrounding corridor (M19, M15T1.06). Possible impacts from tile / ditch drainage in M15T1.10 addressed under stormwater inputs. |

**Floods**

Floods are natural events which influence the sediment and hydrologic regimes of river networks. Increased flows can lead to channel widening and incision, where the increased scour energy exceeds thresholds for erosion in the streambank and bed materials. In turn, flood-event erosion mobilizes sediments that can lead to downstream aggradation and lateral adjustments. Large-magnitude flood events occurring decades in the past may still be influencing the morphology and active adjustment processes of river channels today.

Average annual precipitation in the Northeastern United States has increased approximately 3.3 inches over the period from the year 1900 to 2000 (UNH Climate Change Research Center, 2005). The frequency and number of intense precipitation events (defined as more than two inches of rain in a 48-hour period) has also increased, particularly in the last quarter of the 19$^{th}$ century (UNH Climate Change Research Center, 2005). Available historic resources indicate that the Black River watershed has been affected by the large events of 1927, 1936, 1938 and 1973, as well as several smaller flood events (see Section 2.5). These flood events would have episodically increased flows and sediment loading in the channels of the Black River watershed.

**Urbanization**

Urbanized land uses in the watershed draining to the river can be a source of increased runoff that may serve as a stressor to the channel. Regionally, the balance of water and sediment loads conveyed within a watershed is altered by the density of settlements on the landscape and its effect on the percent of land area impervious to rainfall. Impermeable (or partially impermeable) surface types associated with development can include roof-tops, pavement, roads, and dense gravel-pack roads or driveways. Percent imperviousness refers to the proportion of the land surface converted to impermeable or reduced-permeability surfaces. In general, development results in a reduction in total land area remaining pervious to rainfall. Rainfall and snowmelt waters quickly run off the land surface to the nearest swale or stream; they are not able to infiltrate through the surface soil layers and flow diffusely through the subsurface to the river network. Instead, stormwaters are delivered in higher magnitudes to stream networks and over shorter durations, leading to a prevalence of "flashy" runoff conditions. Stormwaters diverted overland in this way have high velocities and therefore an increased capability to erode soils and debris from the land surface.

Upland development can also bring more localized stressors to the river channel including: (1) additional bridge and culvert crossings which are often undersized with respect to the bankfull widths and (2) floodplain encroachment by roads, driveways, and crossing structures which reduce the floodplain area available to the river during flood stage. Such floodplain access is a critical need of the river channel in order to dissipate energies associated with flood-stage flows – serving as a kind of pressure release valve for the river.

VTANR guidance suggests evaluating the Land Cover / Land Use data developed in the Phase 1 Stream Geomorphic Assessment (Step 4.1) to identify the potential for changes to the hydrologic regime from urbanization. Caution should be applied in using these data, due to: (1) the fact that percent development does not necessarily equate to percent imperviousness (particularly in rural watersheds); (2) the fact that developed (impervious) surfaces are hydrologically connected to the river to varying degrees; and (3) scale, minimum mapping units, age, and accuracy of the land cover / land use data sets utilized (*Landcover / Landuse for Vermont and Lake Champlain Basin [LandLandcov_LCLU, edition 2003]. Source dates of 1991 to 1993. Available at: http://www.vcgi.org/metadata/LandLandcov_LCLU.htm).* The upstream watersheds draining to each of the assessed reaches have urbanized land percentages ranging from approximately 3.0 to 5.0% (Phase 1 data, SMRC, 2007). This range of values is at or below the percentage (5%) suggested as a threshold of concern in VTANR guidance (2007b). Thus,

watershed-scale urbanization is expected to represent a relatively minor stressor to the Black River and its tributaries.

Present zoning in the towns of Ludlow, Cavendish, Weathersfield and Reading may permit development densities that result in future percent urbanized cover to rise above thresholds for concern. To the extent that stormwater runoff is not controlled or managed through treatments prescribed by State or local regulations, future development may increase to densities that present a significant impact to the Black River and its tributaries. Recent Vermont-based studies linking percent imperviousness to geomorphic and biologic condition of streams suggests that low-order streams (headwaters tributaries) may experience impacts at thresholds lower than 5% impervious cover (Fitzgerald, 2007).

**Road Networks / Ditches**

In rural watersheds, particularly on upland slopes, road and driveway ditches can be a significant contributor of stormwater and sediment to receiving tributaries and rivers. Often road ditch networks terminate at stream crossings without provision for sediment and stormwater retention, detention or treatment.

While a full inventory of these tributary road crossings was beyond the scope of Phase 2 assessments to date, the potential impact of road ditch networks on the watersheds draining to the assessed reaches can be qualitatively evaluated by summing the total length of roads in each sub-watershed and calculating road density. Table 11 summarizes road density in the upstream watershed draining to four of the major Black River tributaries and sections of the Black River main stem. Similar road densities are apparent for these portions of the Black River watershed when calculated at this large subwatershed scale.

***Table 11. Road Density in Upstream Watershed of Study Area Subwatersheds***

| Stream | Subwatershed | Subwatershed Area (sq mi) | Road Density (linear feet roads per square mile of upstream watershed) |
|---|---|---|---|
| Black River | Upstream of M19 | 116.5 | 11,799 |
| Black River | Upstream of M37 | 39.4 | 10,160 |
| North Branch | Upstream of confluence w/ Black River | 32.0 | 10,044 |
| Twentymile Stream | Upstream of confluence w/ Black River | 15.0 | 10,835 |
| Jewell Brook | Upstream of confluence w/ Black River | 9.4 | 13,002 |
| Branch Brook | Upstream of confluence w/ Black River | 15.9 | 10,405 |

Road densities were calculated at a finer resolution for the individual subwatersheds draining to each of the reaches assessed in this study. Road densities ranged from 3,700 to 61,300 linear feet of roads per square mile of upstream watershed; the average reach-based subwatershed road density for the 27 assessed reaches was 18,300 feet / square mile. Road density values were arbitrarily grouped into ranges for qualitative comparison: High road density at more than 25,000 feet / square mile; Medium road density for values between 10,000 and 25,000 feet / square mile; and Low road density for values up to and including 10,000 feet /square mile. These relative road densities are illustrated in Figure 13. As expected, the reach-based subwatersheds with High road density were those spanning village centers: Ludlow (M33, M34, M35), Proctorsville (M31), Whitesville (M26T2.01), and Felchville (M15T1.11). A VTANR literature search is underway to characterize the degree of road density which will be considered a stressor to river channels under Vermont guidance (VTANR, 2007b).

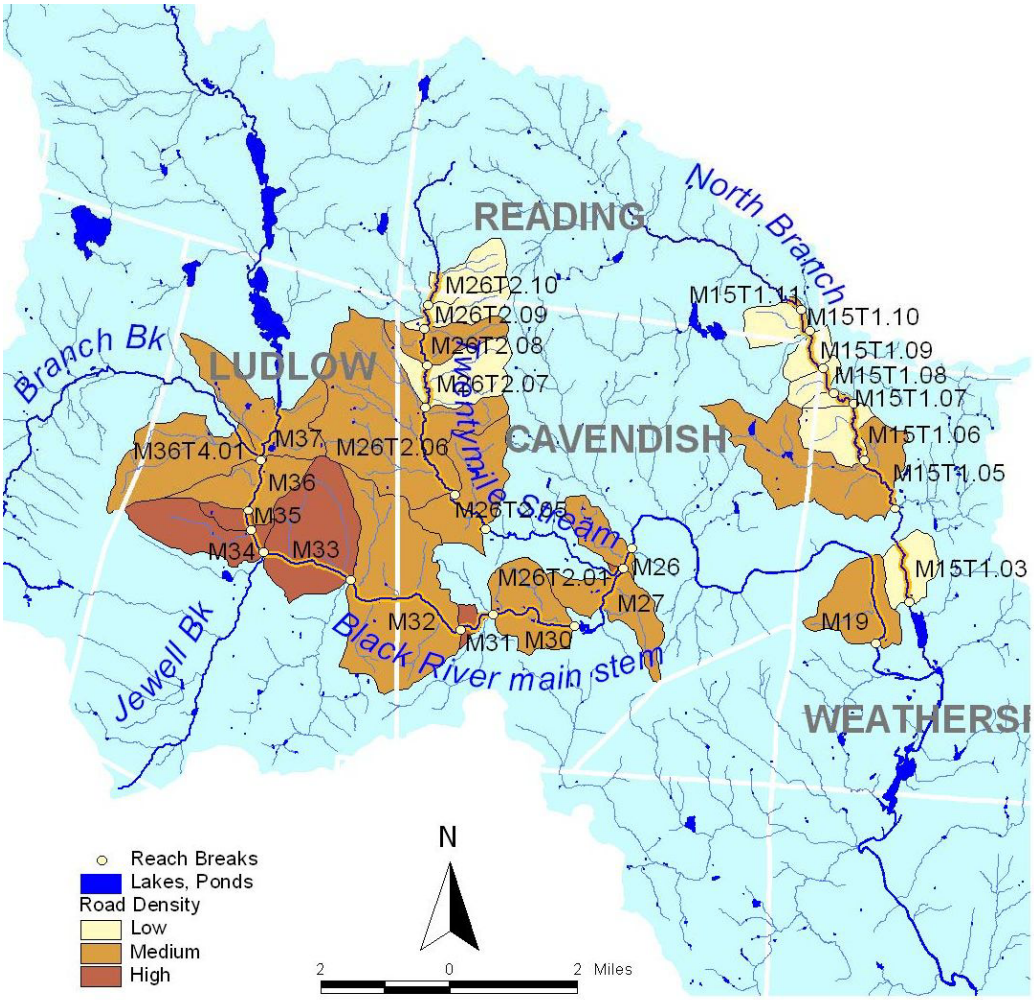



***Figure 13. Relative road density in reach-based subwatersheds for the 27 reaches of the Black River watershed assessed in 2007 – 2008.***

**Stormwater inputs**

The previous sections indirectly addressed the potential for stormwater runoff, through review of urbanized land cover and road density at the watershed scale. This section more directly evaluates stormwater inputs to the channel, including such features as road ditch outlets, road culvert outlets (connected to road ditches), agricultural ditch or tile outlets, engineered stormwater system outlets, and other outlets such as building foundation drains. While the flow of an individual stormwater outlet may be quite small, cumulatively stormwater inputs can have a measurable effect on a receiving channel, depending on the magnitude of the cumulative stormwater input compared to the flow of the receiving water. The concentration of flows from stormwater runoff can also lead to increased power to erode sediments in the stormwater channel, leading to increased gullying, sediment mobilization to the river and a potential impact on the sediment regime of the river.

VTANR guidance (2007b) suggests that stormwater inputs are potentially significant only in reaches with upstream drainage areas less than 15 square miles due to the assimilative capacity of larger channels. Most of the assessed reaches of the Black River and tributaries have upstream drainage areas greater than 15 square miles, and the potential influence of stormwater inputs on the hydrologic and sediment

regimes of the channel in these reaches is considered minor to negligible. Each of the eight assessed reaches of the Twentymile Stream and two of the uppermost assessed reaches of the North Branch had drainage areas less than 15 square miles.

In the upper North Branch reaches (M15T1.11, M15T1.10) near the village of Felchville (Reading), there is a concentration of 3 stormwater inputs within the 700 feet of reach M15T1.11 that (when flowing) may have significance as a contributor of additional storm flows to the channel. Two corrugated steel culverts are directed under Niagara Road to the LB of the channel; one small clay tile drain was noted along RB downstream of the Route 106 bridge crossing. In the half-mile reach downstream of this location (i.e., M15T1.10) agricultural land uses were associated with two stormwater inputs that may have significance as contributors of additional storm flows (and sediments) to the channel: one apparent tile drain (flowing) and one ditch (dry) extended from fields in the RB corridor.

In the Twentymile Stream, a concentration of four stormwater inputs associated with road drainage and residential land use was noted along 2,100 feet of the upstream-most assessed reach M26T2.10. An occasional field ditch associated with agricultural uses intersected the channel in downstream reach, M26T2.06. Given the linear planform and reported periodic dredging and berming of one of these ditches, fine sediments as well as increased flows would be expected at this stormwater input. Other stormwater inputs indexed occasionally along the Twentymile Stream were associated with road drainage at bridge crossing sites (Heald Rd and Davis Rd, reach M26T2.05), one culvert crossing site (Meadowbrook Farm Rd, M26T2.09) and a road culvert under Whitesville Road (M26T2.01).

**Dams**

Dams disrupt the flow dynamics (and sediment transport continuity) of rivers to varying degrees and extents, depending on their size, height, topographic setting, and operational status, and depending on the hydrologic, geomorphic and geologic characteristics of the river being impounded (Williams and Wolman, 1984; Kondolf, 1997). Depending on the size of the impoundment and operational status of the dam, sediments can be trapped in the impoundment upstream of a dam; bed load and a portion of the suspended sediment load settle out in the still water environment of the reservoir. The sediment (bed) load of water leaving the impoundment may be significantly reduced, and the water may possess enhanced energy to erode the stream bed and banks. Depending on the nature of sediments in the channel margins and underlying surficial deposits, and vegetative boundary conditions, this increased erosional potential can lead to channel incision and/or widening downstream of the dam as the river seeks to restore its sediment load – a condition often termed "hungry water" (Kondolf, 1997). If scour is significant, the channel can incise below the surrounding floodplain. On the other hand, if flows are regulated so as to significantly reduce flood peaks and magnitudes, channel aggradation and/or narrowing may result downstream of the dam. Sediments may accumulate in the downstream channel, where they are mobilized from tributaries, if flushing effects of bankfull flows and low-magnitude flood events have been eliminated or reduced as a result of flow regulation (Kondolf, 1997).

The bankfull discharge is considered the dominant discharge of rivers that reworks the channel margins to create the width, depth, slope and planform for optimal conveyance of water and sediments (Wolman & Miller, 1960). Reduced magnitude and frequency of bankfull discharge downstream of impoundments can lead to changes in the cross sectional area of channels, as well as channel slope and planform, and often results in progressive buildup of sediments in the downstream channel (Williams and Wolman, 1984).

Degraded aquatic systems may result from flow regulation by dams, due to reduced frequency and magnitude of overbank flooding which is a requirement for many riparian and floodplain ecosystems (Magilligan, *et al*, 2003).

Dams can lead to lower sinuosity and planform shifts – however, much of the Black River main stem is constrained laterally and vertically by exposed bedrock, so these potential impacts of impoundment may have been moderated.

There are presently no permanent dams on the 27 reaches assessed in 2007 - 2008. Impoundment effects of nearby dams influence base levels in M30 (above the CVPS dam at Cavendish Gorge) and in M15T1.03 on the North Branch (above the Stoughton Pond dam in Weathersfield). These impoundments probably contribute to minor aggradation local to the impoundment effects (and in downstream reservoirs). An inflatable dam / weir and Parshall Flume structure operates occasionally in the winter months to monitor flow rates during water withdrawals for snow-making from reach M34 in Ludlow. Given the transient nature of this operation, this structure is expected to have a minor effect on flows and negligible effect on sediment continuity (see Appendix E for more details).

Several historic dams were present on the Black River main stem reaches and one Twentymile Stream reach (Table 12). While these past structures no longer impound the channels, knowledge of their historic presence aids in characterizing the overall sensitivity of the river reaches and their degree of departure from reference condition, where applicable. In some cases, the present morphology and sediment regime of the river channel can still be influenced by the historic disruption of fluvial and sediment transport processes imparted by a dam(s).

Just as the presence of a dam influences the natural river balance, the subsequent removal of a dam can have an impact on future adjustment of the river channel. As the river readjusts to the lowered base level, incision and widening might be expected to migrate upstream from the former dam site. Sediments mobilized from the incising areas might contribute to aggradation, widening or planform adjustments downstream of the former dam site.

As further detailed in Appendix E and Appendix F, the historic dams along the main stem reaches may have contributed to historic incision in these reaches as a result of "hungry water" effects downstream of the dam sites while these structures were intact and subsequent to breaching effects upstream of the dam sites. While operating, these historic dams may have impounded sediments to varying degrees, depending on impoundment size and height. Upon breaching of the dams (especially during the flood of 1927 or the floods of the 1930s), sediments would have been released to downstream reaches.

**Diversions, Water Withdrawals (flow regulation)**

Changes in the flow characteristics of a river imparted by diversion structures or substantial water withdrawal sites can influence the magnitude of flows and interrupt the sediment transport functions of rivers, potentially resulting in areas of exacerbated erosion or system-wide instability in the river. No major withdrawal or diversion sites were present in the assessed reaches (the penstock diversion for the CVPS dam occurs along the Cavendish Gorge reach, M28). Several "small" withdrawals were noted, the most notable being the snowmaking water withdrawal in reach M34 in Ludlow. This water withdrawal site supports snow making at Okemo Mountain Ski Resort and has been in use since 1988. At present, the maximum permitted withdrawal rate is 11,000 gallons per minute (see Appendix E for more details). This rate represents approximately 1.8% of the total estimated flow of the river at this point during a bankfull event (1,330 cubic feet per second, or 597,000 gpm) based on VT Regional Hydraulic Geometry Curves (VTDEC, 2001).

Several historic diversion sites were noted based on review of the Beers Atlas (1869), including:

- A raceway leading from the Mill Street dam in Ludlow (M33-B);
- A raceway leading from the Smithville dam in Ludlow (M32-C);
- A canal leading from a possible dam site to mill buildings in Proctorsville (M32-A);
- A diversion channel leading from a dam site to mill buildings in Cavendish (M30); and
- A raceway(s) leading from an upstream dam site to mill buildings in Felchville (M15T1.11).

***Table 12. Summary of Available Data, Historic and Existing Dams On and Near the Assessed Reaches***

| Status | Reach/ Segment | Dam | Date Constructed | Date Breached | Associated Use / Industry | Data Source |
|---|---|---|---|---|---|---|
| **Black River main stem** | | | | | | |
| E | M38 | Lake Pauline dam | Unknown | Intact | Recreation | |
| E | M34 | Black River flow monitoring structure - inflatable bladder / weir and Parshall flume | 2005 | Intact | Monitors flow during water withdrawals from the Black River for Okemo Mountain resort snowmaking | Photographs – see Appendix E. Land Use Permit #2S0351-12F |
| H | M33-B | Ludlow Woolen Mill dam, later General Electric Co. | Prior to 1869 | 1927 ? | Water power for the mill | Beers, 1869; Sanborn, 1894; VT Landscape Change Program. |
| H | M33-B | Mill Street dam Black River Woolen Co. | c. 1870s | 1927 ? | Water power for the mill | Black River Tribune, 1/17/1990. Sanborn Fire Insurance Map, 1905 |
| H | M32-C | Smithville dam, aka Verd Mont Mills | c. 1873 | 1927 ? | Water power for the mill | Harris, 1949. Child, 1884; Beers, 1869. |
| H | M32-A | Possible dam at diversion channel inlet to Proctorsville | Unknown | >1939 ? | Water power for mills | 1939 aerial photograph; Beers, 1869. |
| H | M39 | Dam at canal inlet to Cavendish Mills | Unknown | 1927 ? | Water power for mills | 1929 USGS map; 1939 aerial photograph; Beers, 1869. |
| H | M29 | Fitton Mill dam | < 1869 | 1927 | Water power for mills | Beers, 1869; VT Landscape Change Program |
| E | M29 | CVPS Dam | c. 1907 | Intact | Hydroelectric power | Vermont Dam Inventory |
| H | M18 | Soapstone Dam | Unknown | 1927 ? | Water power to mills | Beers, 1869; 1939 aerial photo. |
| **Twentymile Stream** | | | | | | |
| H | M26T2.05 | Possible Mill Pond Dam | Unknown | Unknown | Water power to saw mill | Beers, 1869 |

Possible lasting impacts of these historic diversion channels on the present condition of these segments is difficult to predict and would be difficult to distinguish from the effects of associated operation or breaching of the historic dams.

**Loss of Wetlands / Agricultural Ditching**

Channel-contiguous wetlands offer important flood attenuation functions in the river corridor, slowing the velocity of flows and thereby reducing erosion of the stream bed and banks. Over the last 200 or more years, wetland or hydric soils along the floodplains of Vermont rivers have commonly been converted to agricultural fields. Often, field drainage is improved by channelization of small tributaries or through installation of a network of constructed ditches or underground tiles. Conversion of channel-contiguous wetlands to agricultural uses and associated ditching can increase runoff volumes and velocities in the receiving river channel. In turn, those increased flows can exceed erosion thresholds in the channel bed and banks. This factor, along with periodic ditch maintenance, can result in increased sediment mobilization to the river.

The degree of wetland loss or conversion in a watershed is difficult to estimate with accuracy. However, a qualitative evaluation can be performed by comparing the percentage (by area) of hydric soils across a watershed, to the percentage of mapped wetlands. When this review was performed for major tributaries and portions of the Black River watershed relevant to this Phase 2 study area, significant areas of possible wetland loss were apparent in the North Branch, Twentymile Stream and Branch Brook subwatersheds (Table 13).

***Table 13. Percent by Area of Hydric Soils (USDA) and National Wetland Inventory (NWI) mapped wetlands in the Upstream Drainage Area of Select Major Tributaries and Portions of the Black River watershed.***

| Stream | Subwatershed | Subwatershed Area (sq mi) | Hydric Soils (% by Area) | NWI Wetlands (% by Area) |
|---|---|---|---|---|
| Black River | Upstream of M19 | 116.5 | 4.4 | 2.0 |
| Black River | Upstream of M37 | 39.4 | 5.0 | 4.1 |
| North Branch | Upstream of confluence w/ Black River (M15T1.01) | 32.0 | 7.6 | 2.5 |
| Twentymile Stream | Upstream of confluence w/ Black River (M26T2.01) | 15.0 | 5.7 | 1.2 |
| Jewell Brook | Upstream of confluence w/ Black River (M33T3.01) | 9.4 | 2.0 | 0.4 |
| Branch Brook | Upstream of confluence w/ Black River (M36T4.01) | 15.9 | 5.1 | 1.1 |

This comparison does not directly or accurately reveal the area of wetlands drained or otherwise converted to agricultural or urbanized use, since NWI coverage does not include smaller Class III wetlands which may be present in the watershed. As with any spatial data sets, there are also issues of mapping methods, mapping resolution, scale, accuracy, and currency that would render the two data sets not directly comparable. Nevertheless, this comparison serves as a coarse measure of potential wetland loss in the portions of the Black River watershed draining to the study reaches.

A similar analysis of percent hydric soils versus percent mapped wetlands was performed for the smaller subwatersheds that drain directly to the 27 study reaches, and the aerial extent of hydric soils and wetlands was reviewed in GIS. Along portions of the North Branch and Twentymile Stream tributaries, agricultural uses are now evident in areas of hydric soils that would be expected to support wetland conditions prior to widespread colonization and cultivation of the landscape. Figure 14 displays the aerial extents of hydric soils and NWI wetlands in the corridor surrounding reaches M15T1.05 and M15T1.06

along the North Branch of the Black River in Weathersfield. Figure 15 displays the aerial extents of hydric soils and NWI wetlands in the corridor surrounding reaches M26T2.08, M26T2.07 and M26T2.06-C along the Twentymile Stream in Cavendish. Fields in these corridors have seen a mixture of cultivated uses (i.e., corn) and hay. Natural flood attenuation functions of wetlands may have been compromised to significant degrees in these reach subwatersheds as a result of tributary channelization and ditching and wetland loss. Water and sediment loading to the North Branch and Twentymile Stream may have been increased as a consequence. Prior conversion of wetlands may have been a factor contributing to a degree of historic incision in the upstream half of M15T1.06 (Segment B), and to the minor to moderate degree of localized aggradation and widening occurring in each of these reaches.

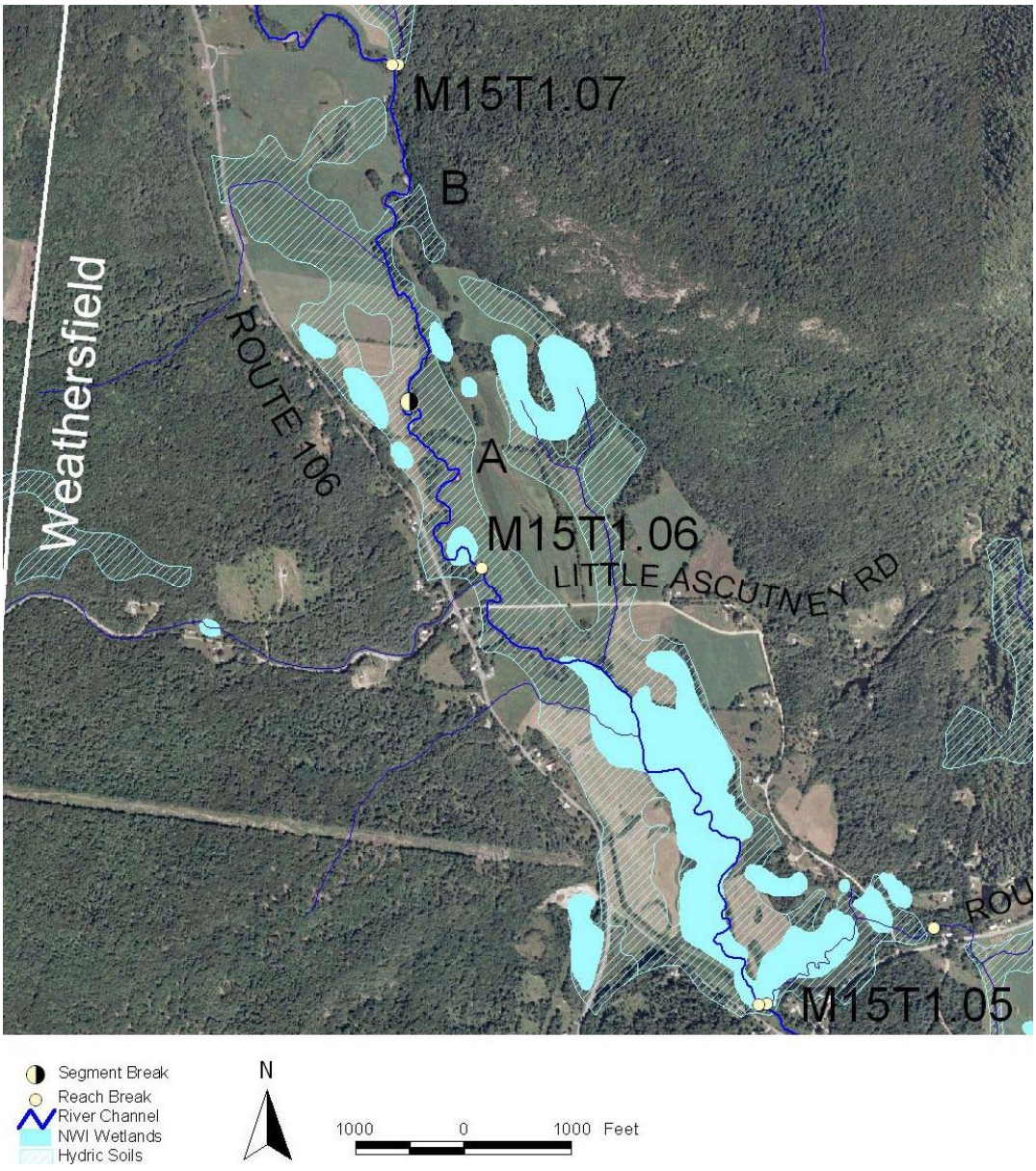



***Figure 14. Aerial extent of hydric soils (hatched teal) versus NWI wetlands (solid teal) compared in corridor lands surrounding North Branch reaches M15T1.05 and M15T1.06, Weathersfield.***

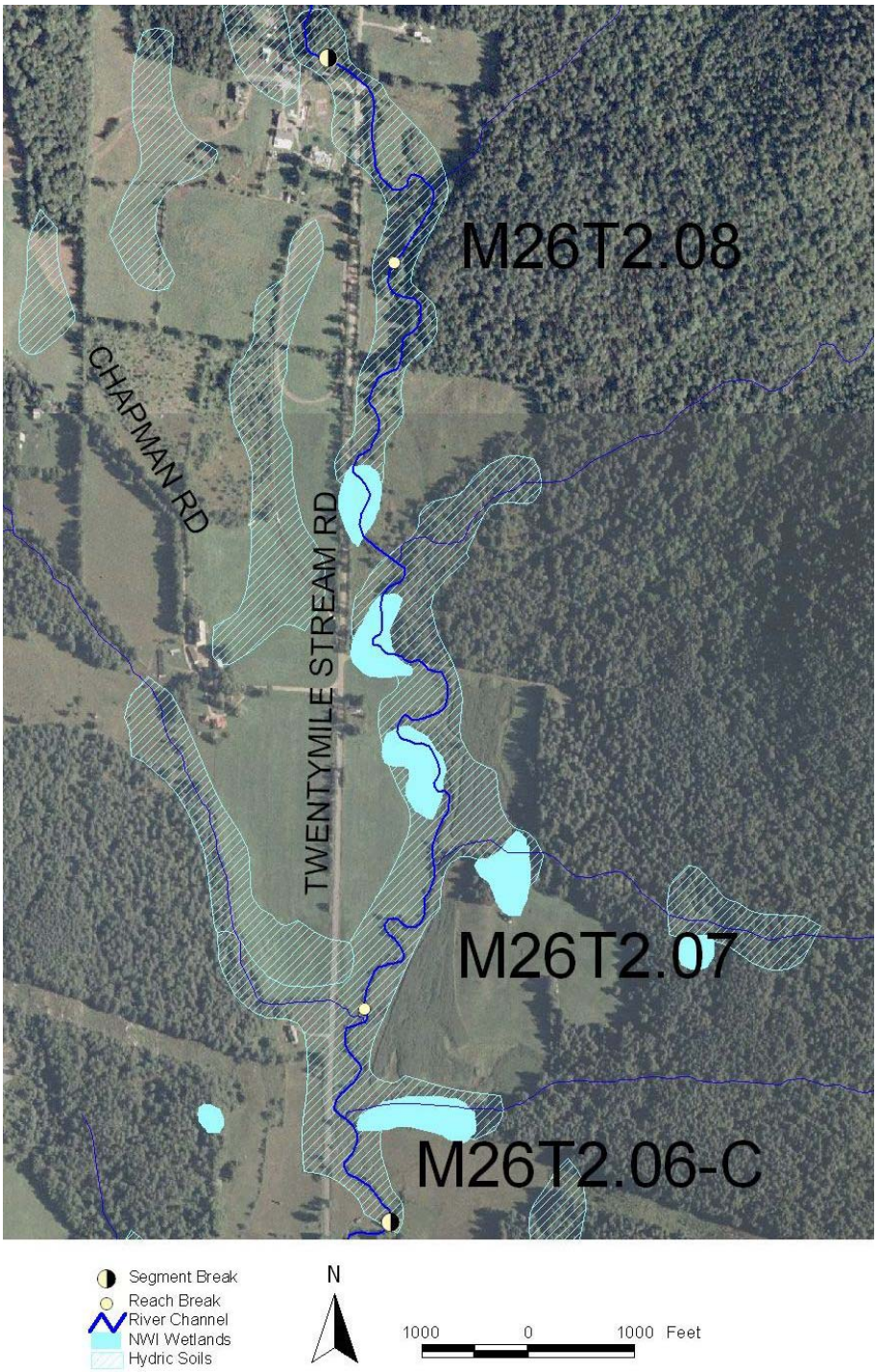



***Figure 15. Aerial extent of hydric soils (hatched teal) versus NWI wetlands (solid teal) compared in corridor lands in Twentymile Stream reaches M26T2.08, M26T2.07, and M26T2.06-C, Cavendish.***

**Crop Lands – Exposed Soils**

VTANR guidance (2007b) states that the area of cultivated lands draining to each reach can suggest the potential for land surface erosion and sediment mobilization to assessed reaches. Caution should be applied, as such an evaluation does not take into account the degree of hydrologic connection of the noted crop lands to the receiving waters. Nor does it adjust for potential erosion prevention measures or practices in place on the indicated crop lands. Further limitations of this methodology are related to the scale, accuracy, and currency of the land cover / land use data sets utilized to summarize the data: (*Landcover / Landuse for Vermont and Lake Champlain Basin (LandLandcov_LCLU, edition 2003). Source dates of 1991 to 1993. Available at: http://www.vcgi.org/metadata/LandLandcov_LCLU.htm.)*

Phase 1 stream geomorphic data (SMRC, 2007) indicate that crop land use in the upstream watersheds draining to assessed reaches of the Black River and major tributaries is quite low (2% or less) and less than the threshold (5%) considered to be of significance in VTANR guidance (2007b).

Corridor land cover / land use estimates suggest that lands within the reach-based corridor of a few of the assessed segments are more intensively cultivated than others (particularly, M15T1.10 and M15T1.06 along the North Branch; reach M19 of the Black River main stem).

- M19 - Corn fields were noted along segment M19-A during Fall 2008 assessments. Generally, a tree or scrub/shrub buffer of 50 feet to greater than 100 feet separated these corn fields from the channel, and minimal evidence of direct runoff from these fields was noted (during base flow conditions). Potential significance of crop land uses along this reach would also be tempered by the size of the upstream watershed (117 square miles).

- M15T1.10 - In the North Branch, hay fields were evident along reach M15T1.10 during Summer 2008 assessments, rather than cultivated crops; hay was also depicted on 2003 aerial photography. It is possible that the fields surrounding this reach have previously been cultivated. Two stormwater inputs were discussed in a previous section emanating from these fields along reach M15T1.10. No additional evidence of direct surface runoff from these fields was observed in September of 2008 (during base flow conditions).

- M15T1.06 - In this downstream reach, a 900-foot length of channel was closely bordered on the LB by corn fields, with minimal buffer. While, no direct surface runoff was observed during baseflow conditions during the Summer 2008 assessment, there would be a potential for land surface erosion and sediment mobilization to the North Branch during intense precipitation events, given the minimal buffer conditions. Potential significance could be mitigated by the size of the upstream watershed (20.9 square miles).

### 5.1.2 Sediment Regime Stressors (Watershed and Reach Scale)

Sediment regime stressors for the assessed reaches are summarized in Table 10 (Watershed Level Stressors) and in Tables F-1 through F4 of Appendix F (Reach Level Stressors); they are discussed briefly in the following sections. The purpose of this section is to evaluate the "cumulative impact of erosion and subsequent deposition at the watershed scale" through review of reach-based features (VTANR 2007b). Features were compiled from a review of Phase 1 and Phase 2 Stream Geomorphic Assessment data and included: (1) depositional bars / planform migration features; (2) bank erosion; (3) mass wasting sites; and (4) gully sites or rejuvenating tributaries.

### *Depositional bars and planform migration features*

Select depositional and migration features are identified in VTANR guidance as indications of potentially enhanced sediment loading or a decreased sediment transport capacity of the river channel, or both. Features include steep riffles, mid-channel bars, delta bars, flood chutes, avulsions and channel braiding. Sediment contained in the depositional bars theoretically has its source from upstream, as well as in-reach, erosion. As sediment accumulates in the channel it can cause flow in the channel to diverge and create flood chutes or avulse into a different path altogether. Thus, multiple bars and lateral adjustments in a reach may indicate a reduction in sediment transport capacity and reflect the cumulative effects of erosion at the watershed scale.

Along the Black River main stem, Segment M32-A near Winery Road in the town of Cavendish has a locally high density of depositional bars and planform migration features. These features are suggestive of increased sediment loading from upstream and instream erosion, and are associated with an absence of forested buffers and presence of highly erodible sediments in the channel boundaries.



***Figure 16. Location of active planform adjustment, aggradation and widening downstream of Winery Road crossing.*** *View downstream from high RB terrace comprised of glaciofluvial sediments. Segment M32-A, 2 October 2007.*

Along the Twentymile Stream, four segments show a relatively high density of depositional and planform migration features:

- Segment M26T2.09 where the channel transitions from upstream semi-confined sections of steeper gradient. Sediment deposition in this segment is locally enhanced by beaver dams.
- Segment M26T2.08 contains multiple flood chutes, avulsions and depositional bars which are suggestive of sediment loading from upstream and instream sources, and which may also result from a localized reduction in sediment transport capacity at the undersized instream culvert crossing of Twentymile Stream Road.
- Segments M26T2.06-A and M26T2.05 where sediment deposition and meander translation/ extension may be driven in part by narrowing of the valley walls, and in part by undersized bridge crossings of Heald and Davis Roads.

Along the North Branch, four segments show a relatively high density of depositional and planform migration features:

- Segments M15T1.07 and M15T1.06-B downstream of Ascutney Basin Road, where a reduction in sediment transport capacity is probably governed by a decrease in valley gradient and confinement. Historic removal of tree buffers to support agricultural uses has also contributed to lateral adjustments;

- Segments M15T1.06-A and M15T1.05 where a reduction in sediment transport capacity appears governed by a decrease in valley gradient just above the fixed base level of the bedrock falls at Amsden; and

- Segment M15T1.03-B where a reduction in sediment transport capacity is apparent, associated with impounding effects in the downstream Stoughton Pond.

### ***Bank Erosion***

Generally, excess stream bank erosion was not noted in most of the assessed reaches. Erosion resistance in the channel boundaries has been offered by cohesive bank sediments, occasional lateral bedrock grade controls, and forested buffers. Through the village areas, rip-rap or hard bank armoring features offer temporary stability to the banks. Erosion was of some significance along segments where planform adjustment and/or widening are the dominant adjustment processes; for example:

- Black River main stem segments M32-A below Winery Road bridge and M19-A on approach to Perkinsville;

- Twentymile Stream segments M26T2.09, M26T2.08-B, and M26T2.05; and

- North Branch reach M15T1.07 and segment M15T1.03-B.

These segments may be contributing to increased sediment loading in downstream segments.

### Mass wasting and gully sites or rejuvenating tributaries

Eight mass wasting sites were identified on six of the assessed segments, including the high mass failure of sands and gravels along LB in reach M15T1.03 (North Branch), and the high terrace of actively eroding sands and gravels along RB in segment M32-A of the Black River downstream of Winery Road. Generally, sediments generated at the point of mass failures represent a low percentage of the overall bedload in these larger channels, and are not considered to be significant reach-scale or watershed-scale sediment stressors. Mass wasting at some of these points has contributed to localized instability (e.g., M32-A).

One significant gully site was identified on the 27 assessed reaches of the Black River watershed. A RB channel directs overland flow from the paved commercial parking lot at 213 Main Street in Ludlow, and has developed into a moderately-sized gully with an associated "delta" of fine to coarse gravel sediments (see Figure 17). This gully represents a source of stormwater flows and sediment to the Black River. Potential significance of this gully site as a source of sediments may be moderated somewhat by the size of the upstream watershed of the Black River at the confluence of this stormwater channel (approximately 58 square miles).



***Figure 17. RB stormwater channel from commercial plaza near downstream end of reach M34 has developed into an erosional gully that has deposited gravels and sands in the Black River channel****. View to the northeast from corner of parking lot toward the river. Trees along the side slopes of this gully are leaning in toward the channel due to bank collapse.*
*8 November 2007.*

### 5.1.3 Reach Scale Modifiers

Valley, floodplain and channel modifications to accommodate human infrastructure and land uses can alter the channel cross section, profile and position in the landscape. Natural features of the river network, such as bedrock grade controls or tributary confluences, also influence the hydraulic geometry of the river. These modifications and features can be categorized broadly into:

- changes in channel slope and channel depth, which influence the energy gradient (stream power) of the river and the capacity to transport sediment, and
- changes in the boundary conditions (channel bed, banks, and riparian vegetation) which influence the resistance to erosion.

The impacts of reach-scale modifiers on the hydraulic geometry of the channel are complex. The influence of multiple stressors may overlap within a reach. The following sections describe reach-scale modifications in more detail. Tables F-1 through F-4 in Appendix F present a summary of the reach-scale modifiers catalogued for each of the assessed Black River main stem and tributary reaches / segments, together with the flow and sediment load modifications previously described.

#### Stream Power Modifiers

**Channel Slope**

Channel slope modifiers include stressors that lead to an ***increase*** in stream power, such as:

- channelization (straightening),
- floodplain encroachments (roads, berms, railroads),
- localized reduction of sediment supply below grade controls (bedrock, dams) or channel constrictions;

as well as stressors that can be expected to lead to a ***decrease*** in stream power, such as:

- a downstream grade control (dams, weirs),
- a downstream constriction (undersized bridge or culvert, bedrock constriction, armoring).

**Channel Depth**

Channel depth modifiers include stressors that lead to an ***increase*** in stream power, such as:

- dredging and berming,
- localized flow increases below stormwater and other outfalls;
- localized flow increases below constrictions (undersized bridge or culvert; armoring);

as well as stressors that can be expected to lead to a ***decrease*** in stream power, such as:

- gravel mining, bar scalping, where such activities result in overwidened conditions;
- localized increases of sediment supply occurring at tributary confluences and backwater areas, and impoundments behind beaver dams.

*(VTANR guidance, 2007b)*

A stressor imparting an increase in stream power may or may not lead to channel incising or widening. Effects are dependent on the magnitude of the stream power increase, the resistance to erosion offered by the unique set of boundary conditions, and whether there are other stressors acting on the reach that may decrease stream power, or lead to channel aggradation.

A stressor imparting a decrease in power may or may not lead to channel aggradation or planform adjustment. Effects are dependent on the magnitude of the stream power decrease, the degree of valley or infrastructure confinement of the channel, and whether there are other stressors acting on the reach that may increase stream power, or lead to channel incision.

**Erosion Resistance Modifiers (Boundary Conditions / Riparian Vegetation)**

The nature of sediments in the channel banks (e.g., grain sizes, cohesiveness) and the vegetative cover (e.g., type and density) or other "treatments" (e.g., rip-rap, gabion baskets, revetments, large woody debris) along the stream banks control the strength of the banks and their resistance to erosion. These boundary conditions in turn influence the degree and rate of channel widening or other lateral movement, thus influencing the ability of the river to adjust its cross-sectional dimensions to most effectively convey the water and sediment inputs to the channel. Boundary conditions also influence the nature and amounts of sediment available to be transported to downstream reaches.

**Channel Bed**

Channel bed modifications that lead to a ***decrease*** in erosion resistance include:

- snagging (removal of large woody debris),
- dredging, and
- windrowing.

Channel bed modifications that lead to an ***increase*** in erosion resistance include:

- grade controls (dams, weirs, channel-spanning bedrock), and
- bed armoring.

**Streambank and Near-bank Riparian Area**

Bank and riparian modifications that lead to a ***decrease*** in erosion resistance include:

- removal of vegetation.

Bank and riparian modifications that lead to an ***increase*** in erosion resistance include:

- bank armoring (rip-rap, gabion baskets, revetments, large woody debris).

*(VTANR guidance, 2007b)*

It is important to note that enhanced erosion resistance offered by the boundary conditions in one location along a river network may translate into increased stream power at a downstream site. For example, it is very common to observe streambank erosion beginning at the downstream end of a length of channel armoring, or bed scour downstream from a bedrock grade control or dam site.

### 5.1.4 Sediment Regime Departure, Constraints to Sediment Transport & Attenuation

Within a given reach, the watershed-level and reach-level flow and sediment load modifications, together with the reach-scale modifiers of stream power and boundary resistance, govern adjustments in the channel dimensions, profile and planform over time. These lateral and vertical adjustments, in turn, influence how the river channel transports its sediment and water inputs.

The **Departure Analysis Tables** (Tables G-1 through G-4) in Appendix G summarize the apparent status of each of the assessed reaches/segments as either transport- or attenuation-dominated. These tables also indicate the significant natural constraints (e.g., bedrock) and human constraints (e.g., roads, development) to channel adjustment that are, in part, influencing the current transport or attenuation status.

Bedrock-controlled reaches are natural transport-dominated reaches, due to the erosion resistance offered by the bedrock. It is likely that the sediment entering these channel segments is balanced by the sediment carried out of the reach (steady-state, dynamic equilibrium conditions). Only one of the assessed channel segments was classified as a bedrock channel: Segment M15T1.11-C of the North Branch of the Black River located in Felchville (Reading) is a bedrock falls characterized by cascading water and a series of steps and pools. Generally, bedrock gorges were not prioritized for assessment, but are recognized for their role as bedrock grade controls and points of fixed elevation in the overall Black River network. The Cavendish Gorge on the Black River main stem (reach M28) and Amsden Falls on the North Branch (reach M15T1.04) would be additional examples of this category of transport reaches.

Two other assessed reaches/segments were identified as natural transport-dominated reaches/segments, although bedrock exposures in the bed and banks were not prevalent:

- Close positioning of bedrock-controlled, steep valley walls along reach M35 of the Black River main stem just above Ludlow village results in a natural Semi-confined status of this reach and governs the transport-dominated condition. The natural transport-dominated function of this reach appears to have been enhanced somewhat in recent history (last 200+ years) due to encroachment by Route 106 along the RB and Dug Road along the LB.

- A 900-foot section of the Twentymile Stream in northern Cavendish (Segment M26T2.10-B) is closely confined by bedrock walls and has two exposures of channel-spanning bedrock.

Nearly all the remaining assessed reaches/ segments are located in unconfined, low- to moderate-gradient valley settings (0.2 to 0.6%: main stem; 0.9 %: Branch Brook; 0.4 to 1.7%: Twentymile Stream; 0.1 to 1.4%: North Branch), and contain few or no channel-spanning exposures of bedrock. Under dynamic equilibrium conditions these (reference C or E stream type) reaches might be expected to deposit fine sediments in their floodplains through periodic bankfull and flood-stage flows, and balance the transport of coarser sediments (bed load), such that the bedload volumes entering the reach would be similar to bedload volumes leaving the reach averaged over a one- to two-year period.

Exceptions to this generalization are three unconfined segments which have moderate to steep slopes (2.2% to 3.5%) and are transitional between upstream bedrock-controlled, confined channels and

downstream, lower-gradient, unconfined settings. All three segments have a reference Cb stream type.

- Segment M26T2.10-A (3.0%) on the Twentymile Stream is located at a point of slope reduction below a Semi-confined bedrock channel (M26T2.10-B);
- Segment M15T1.11-B (3.5%) on the North Branch is located immediately downstream of the bedrock falls in Felchville (Reading); and
- The next downstream Segment M15T1.11-A (2.2%) is located below the Route 106 bridge crossing in Felchville.

Due to the notable transition in confinement as well as gradient, these three segments are expected to represent locations of decreased sediment transport capacity and to be natural attenuation-dominated segments. The North Branch segments below the Felchville falls have been classified as "alluvial fans" by VTANR protocols (although surficial geologic mapping to confirm this classification is beyond the scope of a Phase 2 geomorphic assessment). These segments (as well as some additional lower-gradient segments) are identified as "alluvial fans" to highlight their expected function as natural depositional zones prone to enhanced lateral channel adjustments. Sediment deposition in these locations was probably much more active in earlier post-glacial environments (1,000s of years before present), under more intense hydrologic and sediment regimes, just after glaciation and prior to vegetation of the landscape. These locations may also have seen renewed sedimentation and lateral adjustments during colonial times, during widespread deforestation of upland slopes in the 1800s.

Several of the unconfined segments have been converted from depositional or equilibrium conditions to transport-dominated conditions by virtue of various channel and watershed disturbances (Tables F-1 through F-4, Appendix F). Equilibrium transport of coarse sediment fractions that might be expected in these unconfined valley settings has been compromised substantially, and these segments have been converted to a transport-dominated condition as a result of:

- channelization, removal of meanders;
- dredging, windrowing (especially following the 1927, 1936/38, and 1973 floods);
- historic incision and the resultant decrease in degree of floodplain connection;
- floodplain encroachments (berming; roads; railroad);
- corridor development (residential, commercial, municipal – particularly in the village areas of Ludlow, Proctorsville, Cavendish, Whitesville and Felchville); and
- conversion or loss of channel-contiguous wetlands (especially along portions of the North Branch and Twentymile Stream tributaries).

A few reaches/segments have experienced increased sediment attenuation in recent years, related to the upstream and in-reach production of sediments. In some locations, valley fill supporting culvert or bridge crossings is contributing to (or supporting) localized upstream attenuation (for example, in Segment M26T2.08-B of the Twentymile Stream just upstream of the culvert crossing of Twentymile Stream Road, and M26T2.05 on the same tributary upstream of Heald and Davis Road crossings). Transient, but persistent beaver activity is also contributing to aggradation in some reaches (M37-A, M32-B, M26T2.07, M26T2.06, M15T1.06, M15T1.05). Generally, reaches/segments demonstrating enhanced sediment deposition are local to natural (bedrock-controlled) constrictions of the floodplain, just upstream of valley pinch points. Sediment loading has been enhanced to a degree by erosion in the incised and entrenched

upstream segments. These segments have reasonable access to the floodplain (IR < 1.2) and (where presently unconstrained by human-constructed features) may represent key attenuation assets in the Black River network:

- M36-B, M36-A on the Black River main stem above Ludlow;
- M32-A below Winery Road bridge crossing and above Proctorsville;
- M19-A above Perkinsville;
- M26T2.09, M26T2.08-B, M26T2.06-A, and M26T2.05 on the Twentymile Stream;
- M15T1.06-A, and M15T1.05 on the North Branch above Amsden Falls; and
- M15T1.03-B and M15T1.03-A below Amsden Falls and above Stoughton Pond.

The current geomorphic condition of these reaches/segments, as modified by human factors, is summarized in the following Sediment Regime Departure Maps in Figures 18 through 21.

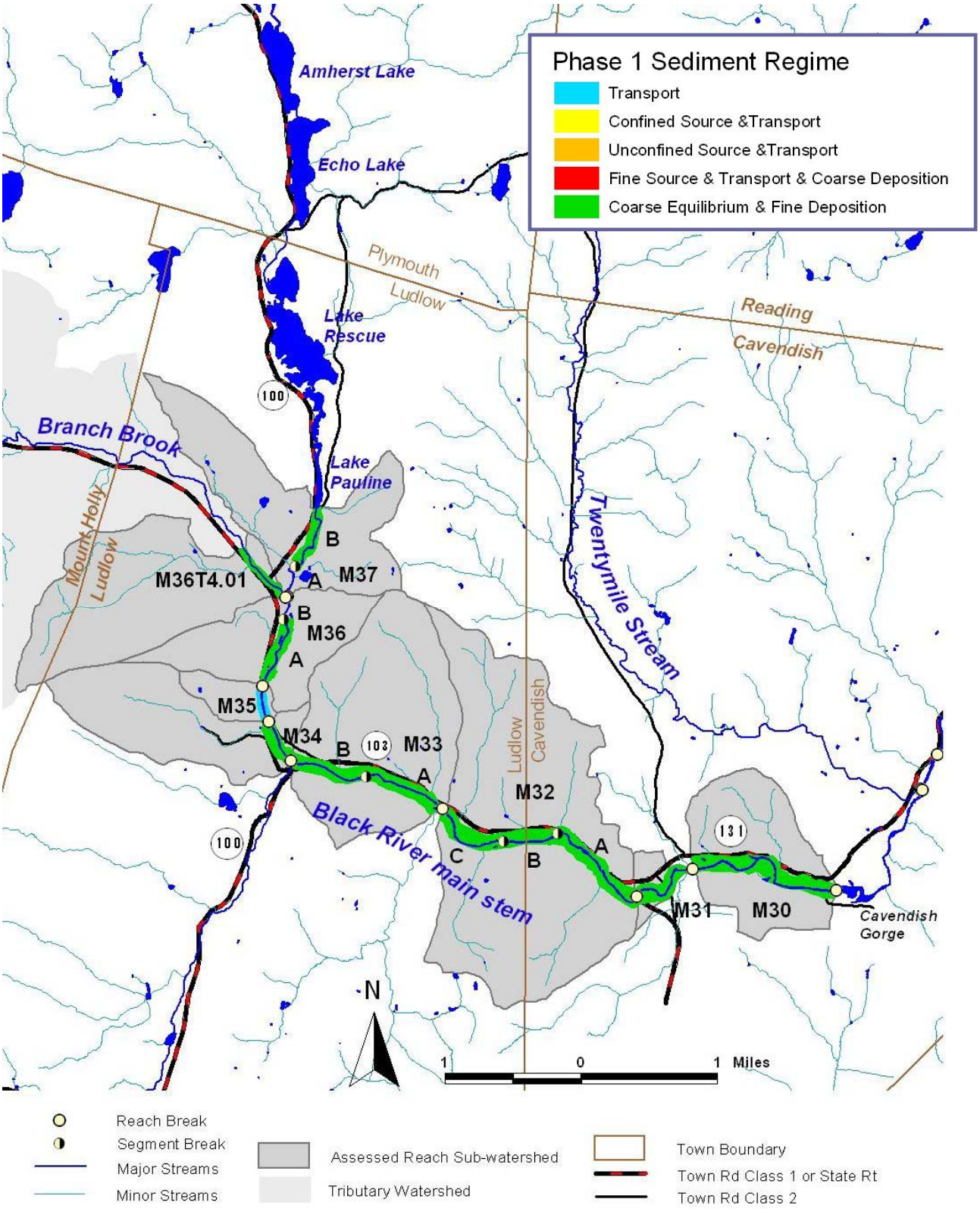



***Figure 18-a. Phase 1 (Reference) Sediment Regime Map***
***Assessed Reaches of the Black River main stem, Upstream of Cavendish Gorge.***

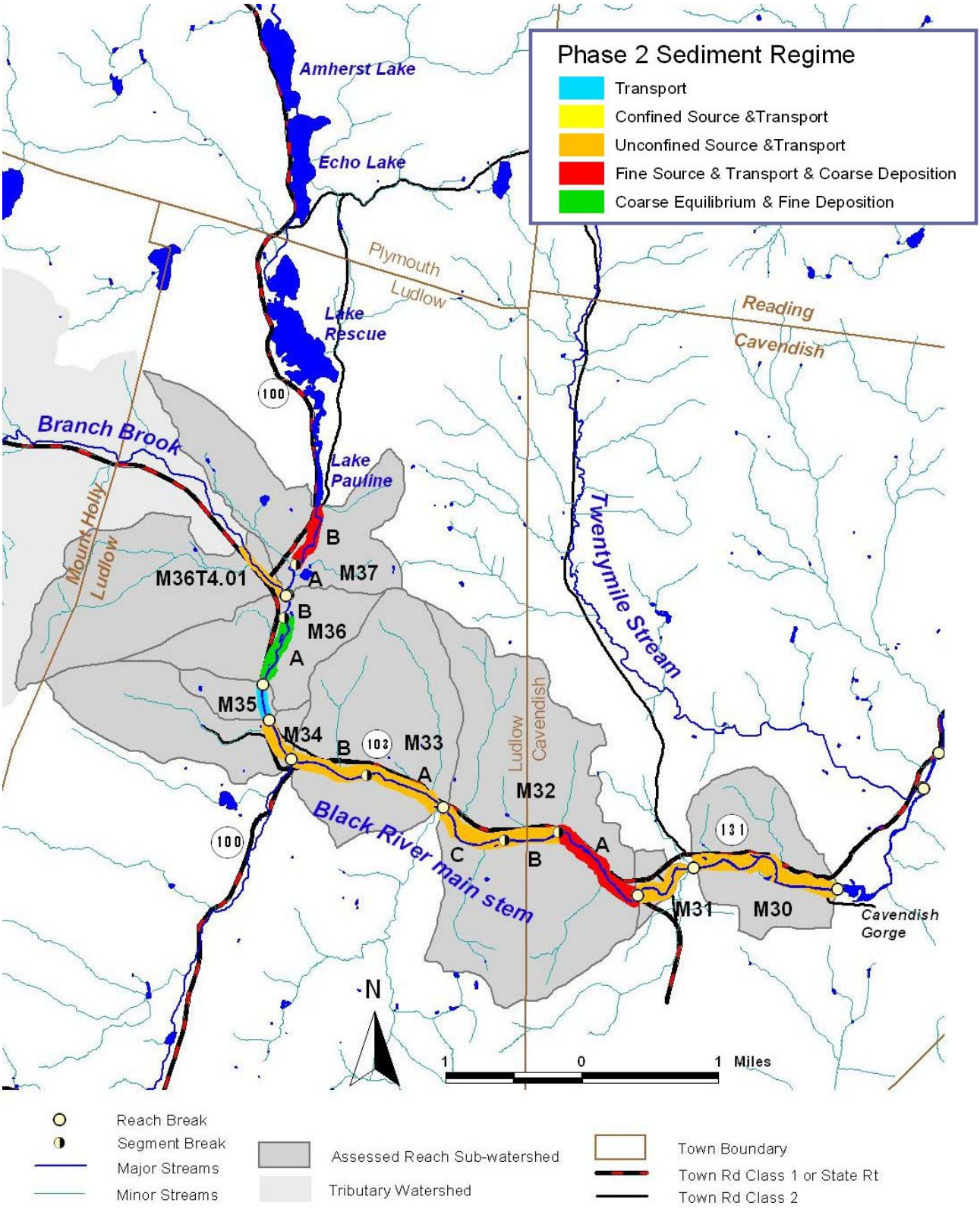



***Figure 18-b. Phase 2 (Existing) Sediment Regime Map***
***Assessed Reaches of the Black River main stem, Upstream of Cavendish Gorge.***

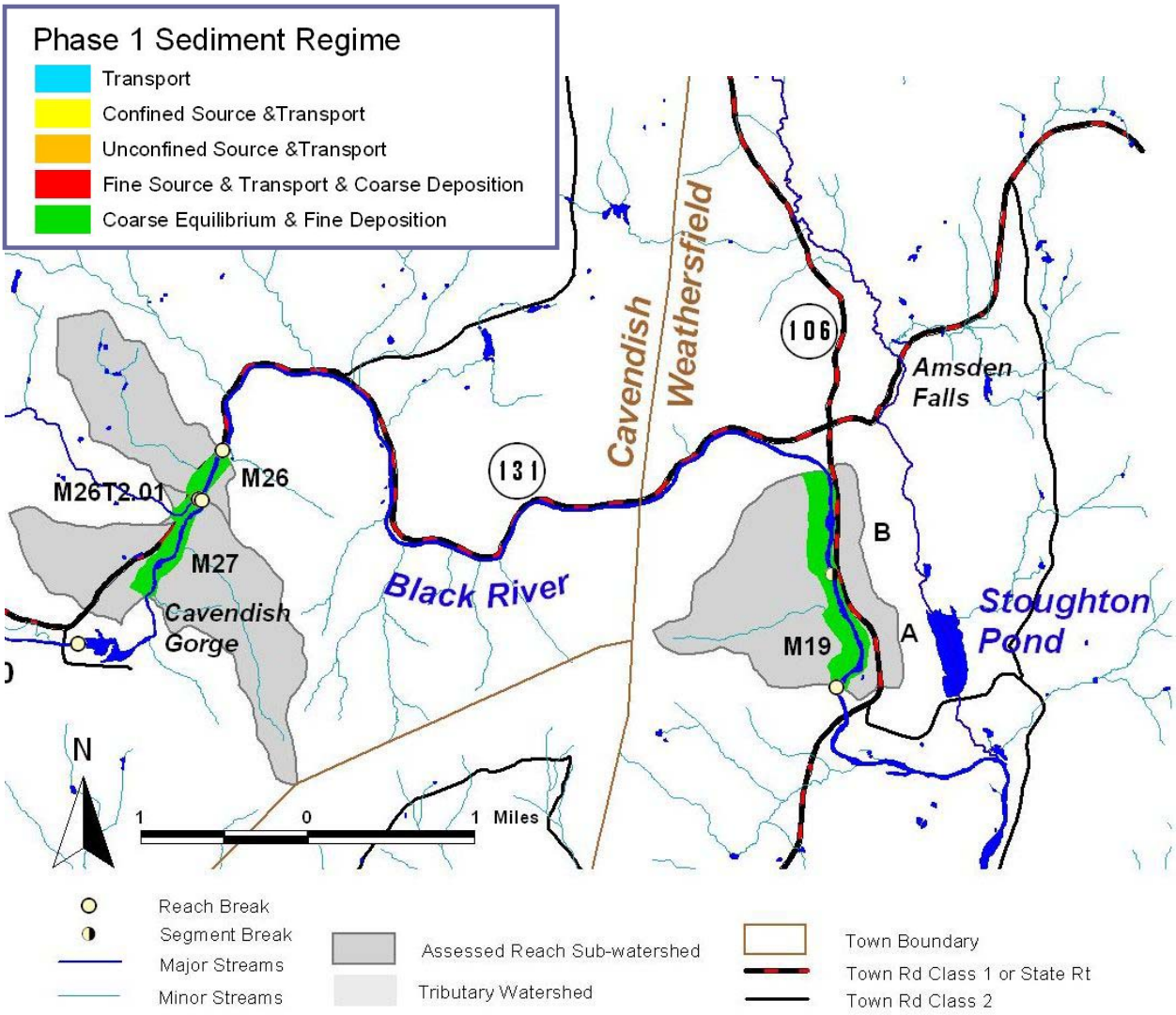



***Figure 19-a. Phase 1 (Reference) Sediment Regime Map***
***Assessed Reaches of the Black River main stem, Downstream of Cavendish Gorge***

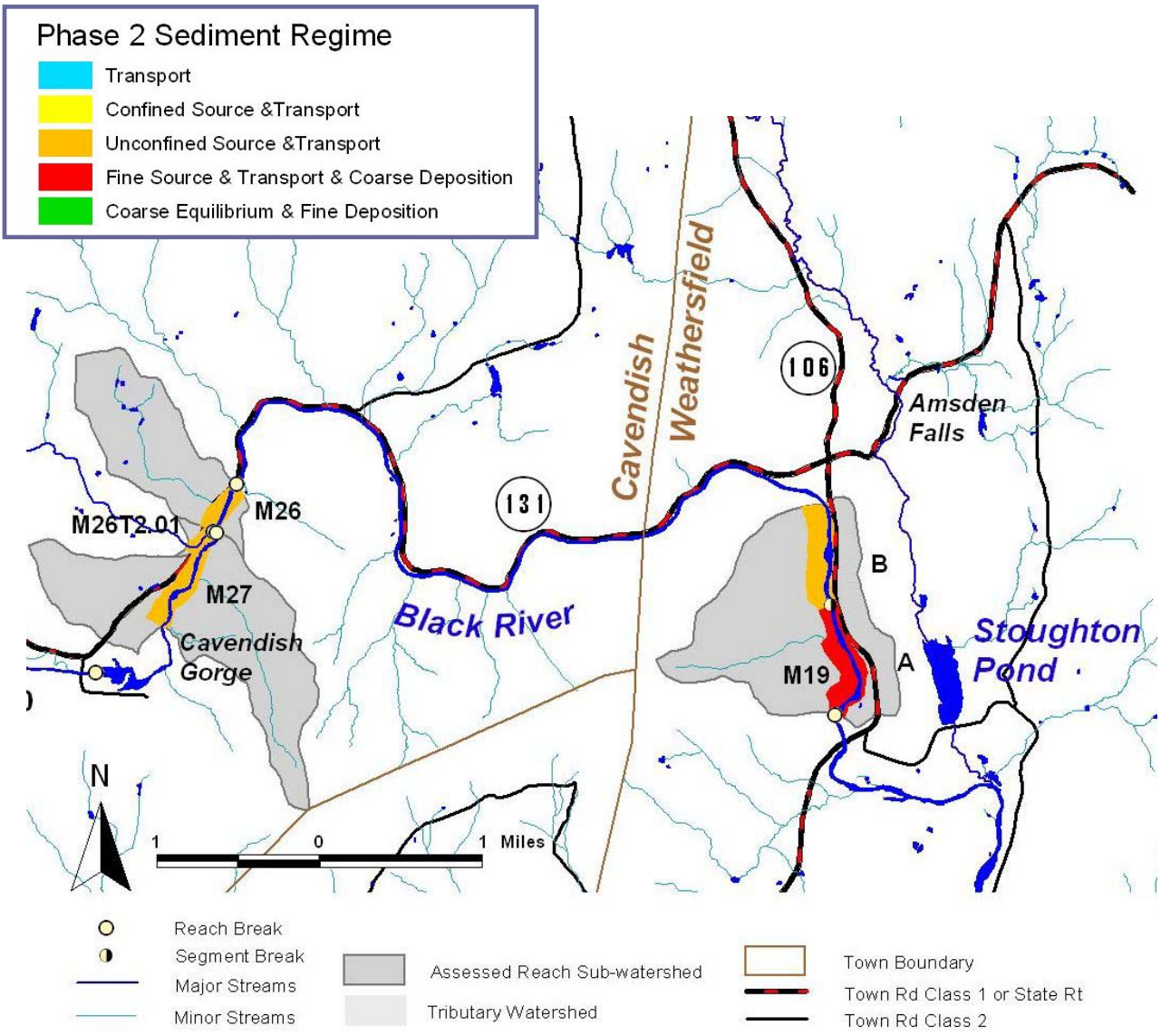



***Figure 19-b. Phase 2 (Existing) Sediment Regime Map***
***Assessed Reaches of the Black River main stem, Downstream of Cavendish Gorge***

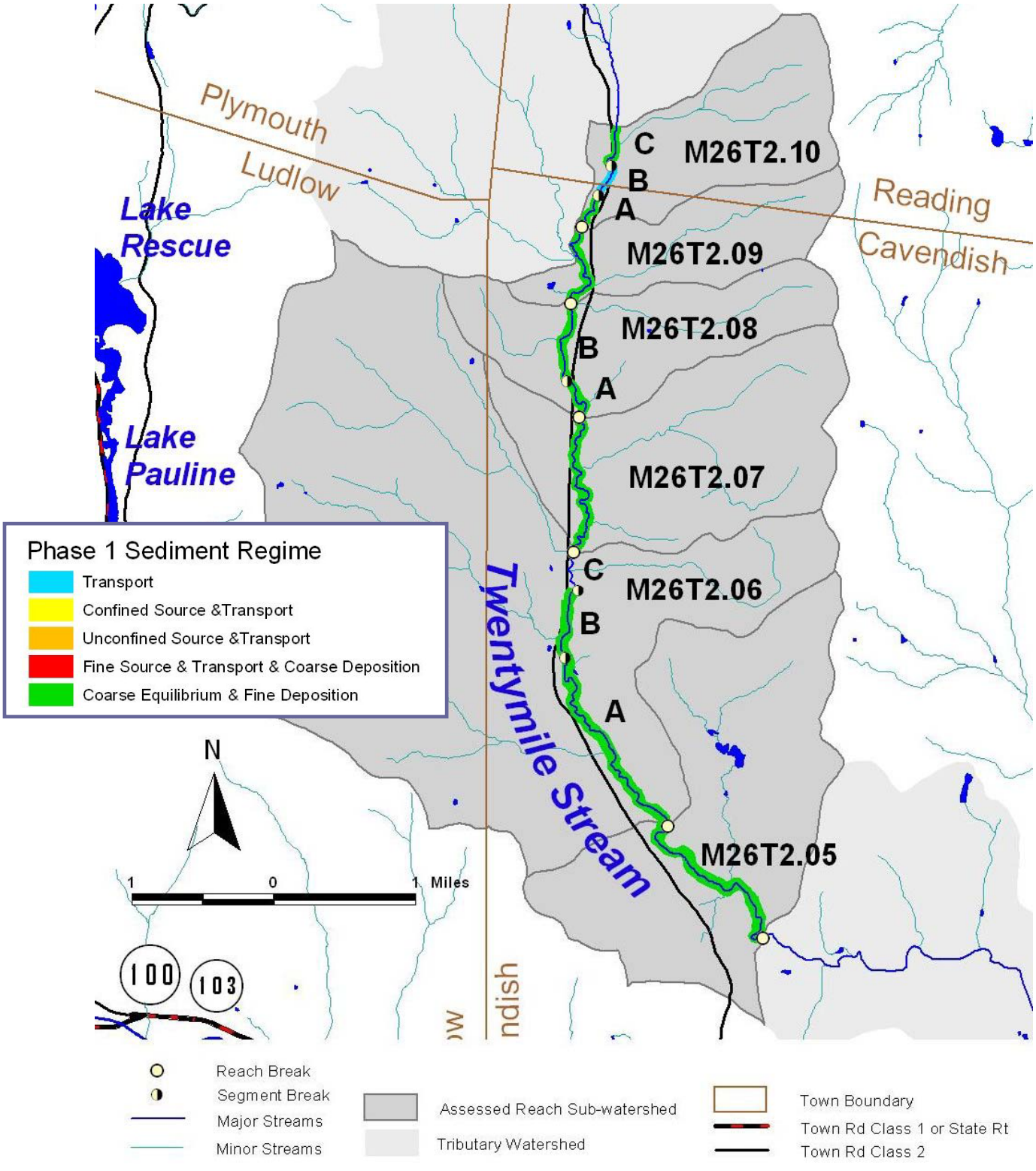



***Figure 20-a. Phase 1 (Reference) Sediment Regime Map, Assessed Reaches of Twentymile Stream tributary.***

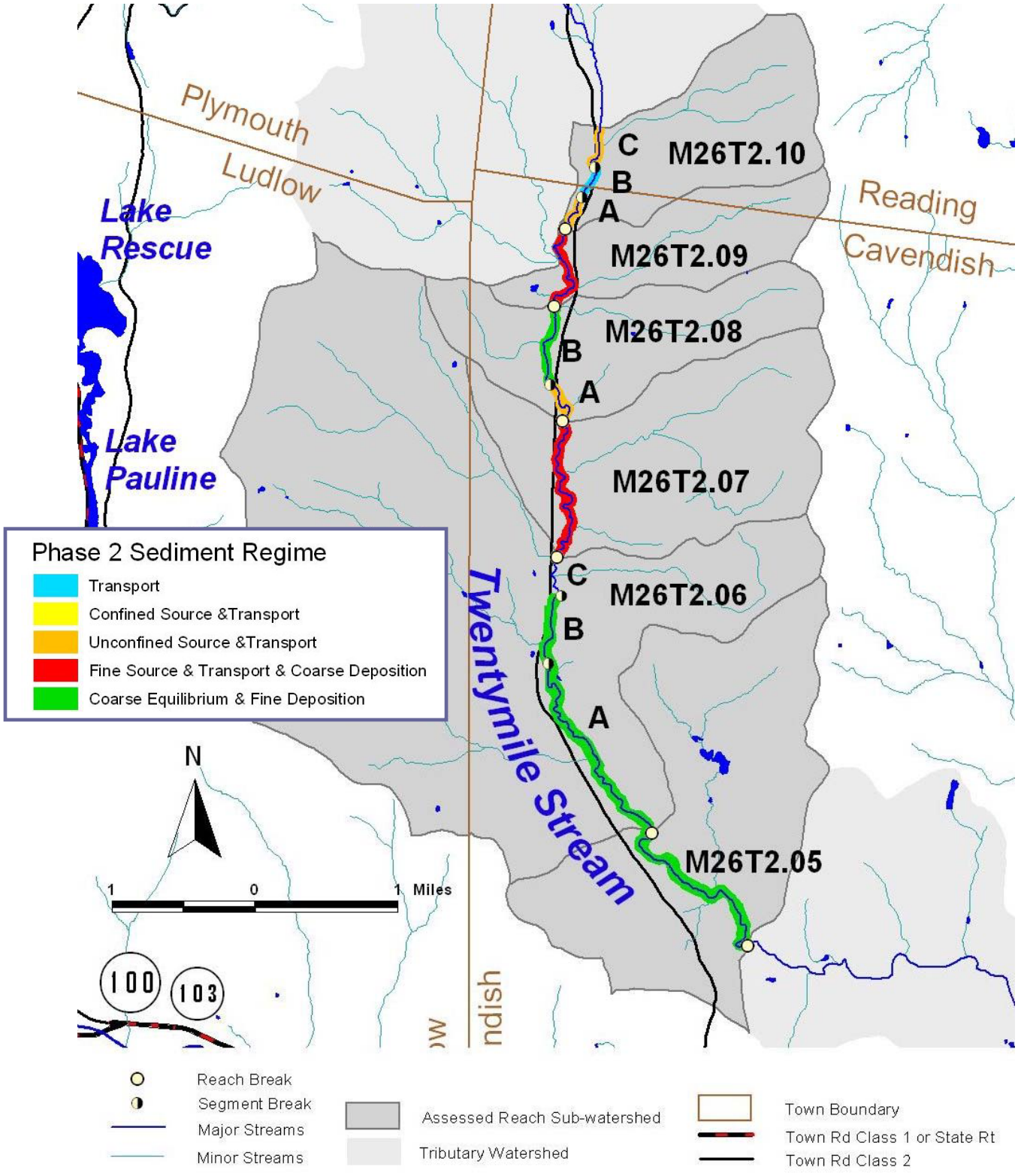



***Figure 20-b. Phase 2 (Existing) Sediment Regime Map, Assessed Reaches of Twentymile Stream tributary.***

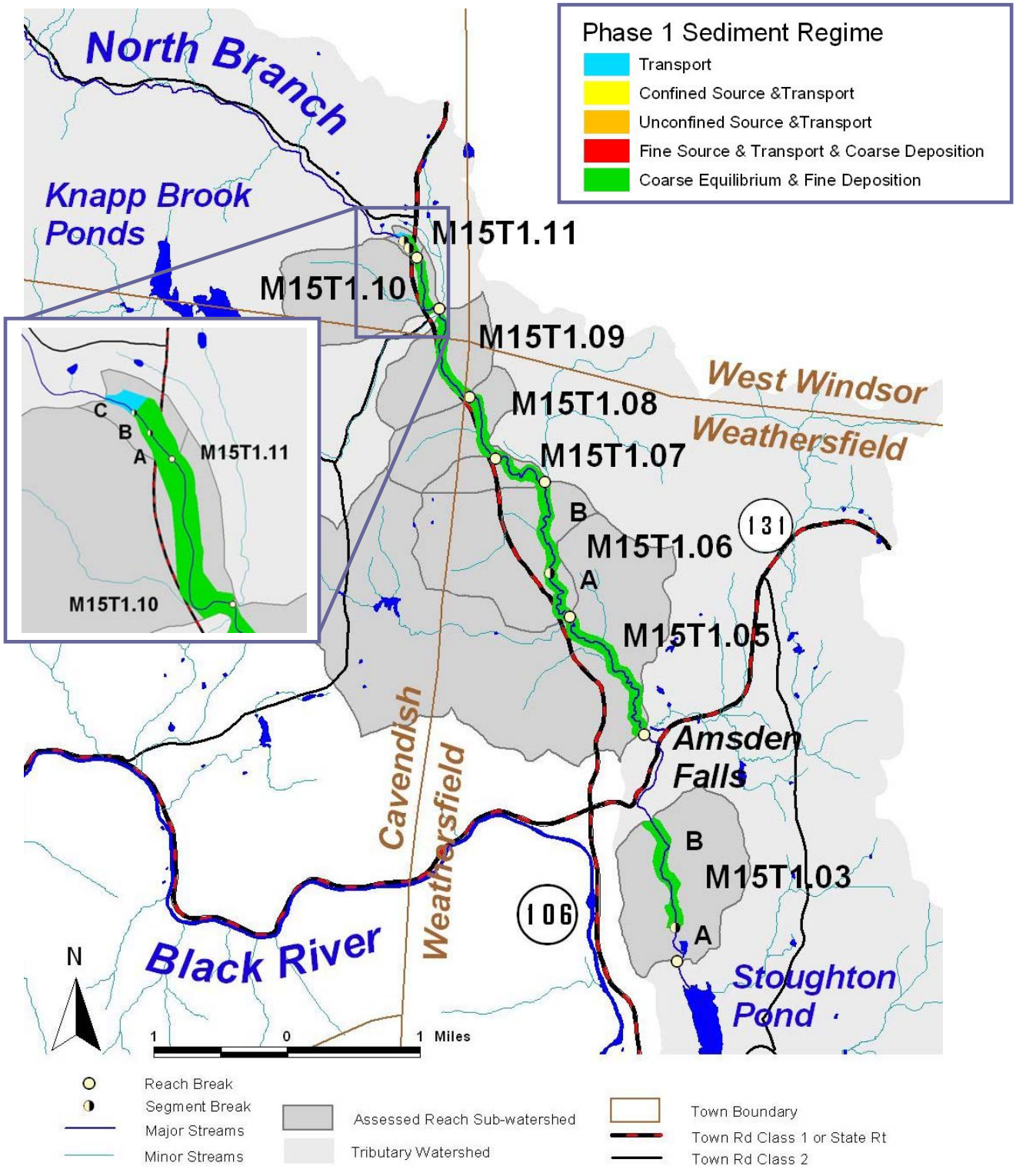



***Figure 21-a. Phase 1 (Reference) Sediment Regime Map, Assessed Reaches of the North Branch tributary***

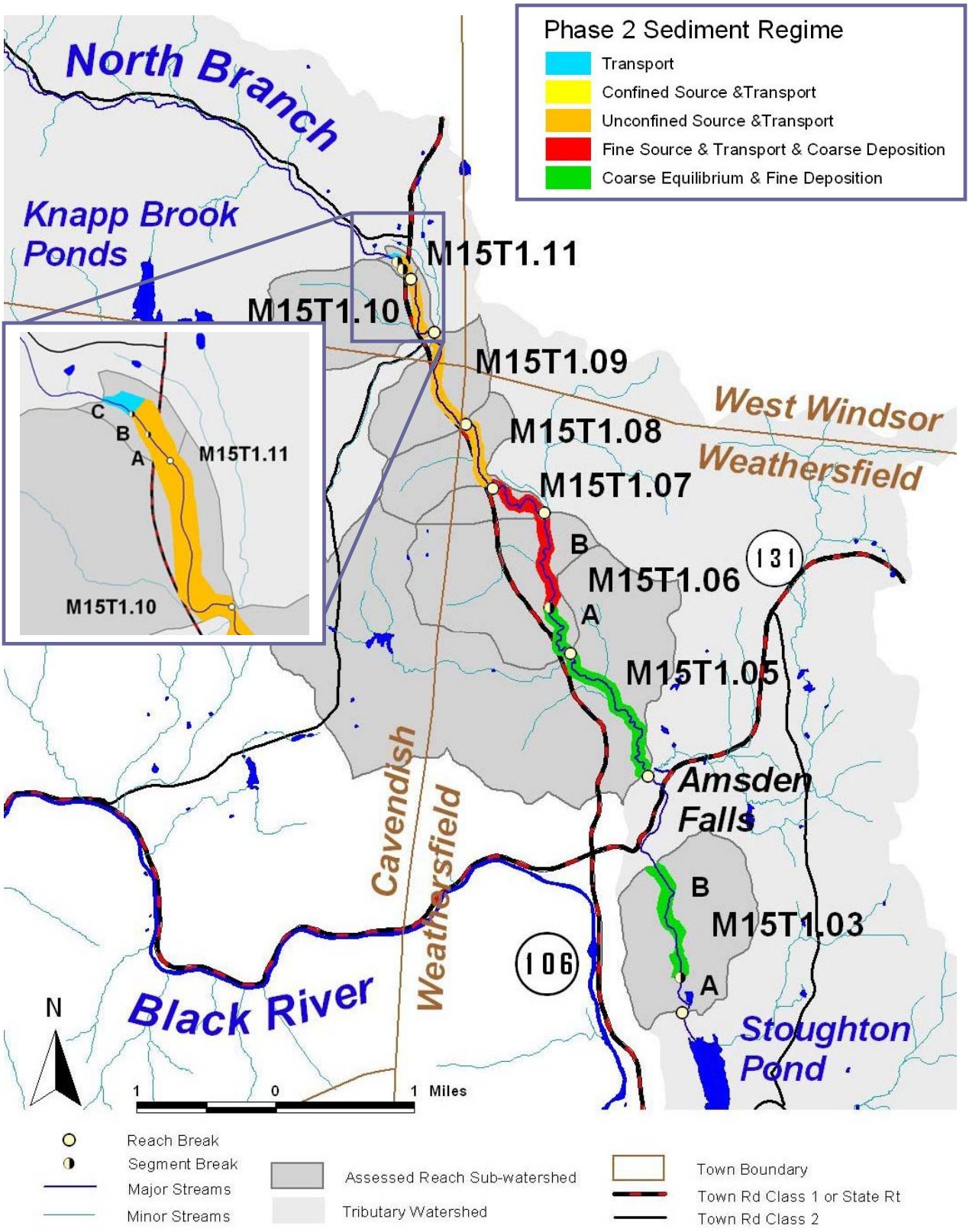



***Figure 21-b. Phase 2 (Existing) Sediment Regime Map, Assessed Reaches of the North Branch tributary***

## Phase 1 (Reference) Sediment Regime

Figures 18-a, 19-a, 20-a, and 21-a display the ***reference*** sediment regimes that are theorized to be characteristic of the assessed reaches prior to widespread human disturbance of the watershed (say, 300 years before present).

*Transport (coded blue in figures)*
Bedrock-controlled segments have been assigned a *Transport* classification for the reference (Phase 1) sediment regime.

| Tributary | Reach/Segment | Phase 1 Reference Stream Type |
|---|---|---|
| North Branch Black River | M15T1.11-C | B1a-Cascade |

Two additional reaches, while not characterized by fully-exposed bedrock in the channel bed and banks, are confined by steep, bedrock-controlled valley walls. In M35, close valley confinement creates a linear planform with limited available floodplain and no meanders for storage of sediment. In the case of M26T2.10-B, the steepness of the slope (3.9 %) prevents significant storage of sediment. Also, the erosion resistance offered by the occasional exposures of bedrock in the channel boundaries, as well as mature forested buffers, means that this channel would not be a significant source of coarse and fine sediments. Therefore, these reaches were also classified with a *Transport* reference sediment regime.

| Tributary | Reach/Segment | Phase 1 Reference Stream Type |
|---|---|---|
| Black River main stem | M35 | B4c-Riffle/Pool |
| Twentymile Stream | M26T2.10-B | B3-Step/Pool |

*Coarse Equilibrium & Fine Deposition (coded green in figures)*
Between these bedrock and transport reaches, it is theorized that the Black River and tributary channels would have had a more meandering planform (constrained locally by exposures of bedrock and variable sediment types in the stream bed and banks). If dynamic equilibrium existed, each unconfined channel would have had access to the surrounding floodplain. Fine sediments would be deposited in the floodplains through periodic bankfull and flood-stage flows, and the transport of coarser sediments (bed load) would be balanced, such that the bedload volumes entering the reach would be similar to bedload volumes leaving the reach averaged over a one- to two-year period. Deposition and erosion cycles would have been balanced, such that there would be no net change in overall channel dimensions, gradient and planform. The channel would have moved within its floodplain in its reference (pre-disturbed) condition, but there would be no net change in average, reach-wide geometry such as slope and average meander width and amplitude.

## Phase 2 (Existing) Sediment Regime

Figures 18-b, 19-b, 20-b, and 21-b display the ***existing*** sediment regimes that are hypothesized based on Phase 2 assessment results and the departure analysis previously described. The contrast in coding of the reaches between the Phase 1 (Reference) Sediment Regime figures and these Phase 2 (Existing) Sediment Regime figures illustrates the degree of departure from reference that is inferred.

*Transport (coded blue in figures)*
The semi-confined and bedrock-channel reaches/segments of the Black River and tributaries have not undergone significant lateral or vertical adjustments in response to channel and watershed disturbances, given the stability offered by the underlying bedrock and resistant boundary conditions. Thus, a *Transport* classification has been assigned for the Phase 2 (Existing) sediment regime of these segments.

| Tributary | Reach/Segment | Phase 1 Reference Stream Type | Phase 2 Reference Stream Type |
|---|---|---|---|
| Black River main stem | M35 | B4c-R/P | B4c-PB |
| Twentymile Stream | M26T2.10-B | B3-S/P | B3-S/P |
| North Branch Black River | M15T1.11-C | B1a-Cascade | B1a-Cascade |

*Coarse Equilibrium & Fine Deposition (coded green in figures)*
Based on Phase 2 assessments, a subset of the reaches/ segments appear not to have undergone a significant sediment regime departure (listed below). A minimal degree of net lateral and vertical adjustment in response to channel and watershed disturbances is apparent in these reaches/ segments. These reaches/segments have not undergone a vertical stream type departure and have maintained good floodplain access (IR < 1.2). Therefore, a *Coarse Equilibrium & Fine Deposition* classification has been assigned for the Phase 2 (Existing) sediment regime.

| Tributary | Reach/Segment | Phase 1 Reference Stream Type | Phase 2 Reference Stream Type |
|---|---|---|---|
| Black River main stem | M36-A | C4-R/P | C4-R/P |
| Twentymile Stream | M26T2.08-B | C4-R/P | C4-R/P |
| Twentymile Stream | M26T2.06-B | C4-R/P | C4-R/P |
| Twentymile Stream | M26T2.06-A | E4-R/P | E4-R/P |
| Twentymile Stream | M26T2.05 | C3-R/P | C3-R/P |
| North Branch | M15T1.06-A | E5-D/R | E5-D/R |
| North Branch | M15T1.05 | E5-D/R | E5-D/R |
| North Branch | M15T1.03-B | C4-R/P | C4-R/P |

In some cases, this inferred dynamic-equilibrium condition is associated with a relative lack of channel or watershed stressors. In other cases, the equilibrium condition exists despite the presence of channel and watershed disturbances, suggesting that boundary conditions offer sufficient resistance to stressors and/or stressors are low in magnitude or extent.

A minor (or localized) increase in sediment attenuation is sometimes evident in these segments, as a result of downstream grade controls or valley pinch points (and associated decrease in valley gradient), or as a result of downstream human-made constrictions such as bridge or culvert crossings. Most of the above-listed segments were identified as sediment attenuation assets (see page 50 and Appendix G). The presence of occasional mid-channel or diagonal bars suggests that limited storage of coarser sediment fractions is occurring within the bankfull channel (though often at the expense of pool depths and riffle/pool diversity). However, such attenuation is not substantial enough to have resulted in dis-equilibrium conditions or a sediment regime departure.

On the other hand, a degree of sediment regime departure is theorized for the remaining assessed segments of Black River and major tributaries:

*Unconfined Source & Transport (coded orange in figures)*
Twenty (20) of the assessed reaches/segments are classified in this category (listed below). Due to the vertical stream type departure (C-to-F or C-to-Bc) of twelve segments and loss of floodplain connection ($IR_{RAF}$ values ranging from 1.3 to 3.2), these segments have been converted to a

transport-dominated condition. They are inferred to have persisted in channel evolution stage II [F] or early III [F] following historic degradation often associated with channelization, dredging, armoring, and/or berming. Presence of historic dams along the Black River main stem may also have contributed to historic degradation – either through "hungry water" effects downstream of the dam sites or as a result of dam-breaching effects upstream of the dam sites, or both. Current impoundments in five miles of the river upstream of reach M37 (i.e., Lake Pauline, Lake Rescue, Echo Lake, and Lake Amherst) may also have created a sediment-limited condition in downstream reaches of the Black River through Ludlow and Cavendish, contributing to a persistence of the historically-incised condition.

Plane-bed and weak riffle/pool morphologies dominate these segments. Both fine and coarse sediment fractions are exported through the segments due to the minimal available floodplain and enhanced velocities of the incised and entrenched cross section. In various cases, extensive bank armoring, maintenance of tree buffers, cohesive sediments in the channel boundaries, and lateral exposures of bedrock provide erosion resistance which has moderated the degree of lateral and vertical adjustments. Width/depth ratios are generally low (14.0 to 33.7). The existing sediment regime for these segments has been classified as *Unconfined Source & Transport.*

| Tributary | Reach/Segment | Phase 1 Reference Stream Type | Phase 2 Reference Stream Type |
|---|---|---|---|
| Branch Brook | M36T4.01 | C3-R/P | F3-PB |
| Black River main stem | M34 | C3-R/P | F3-R/P |
| Black River main stem | M33-B | C3-R/P | F3-PB |
| Black River main stem | M33-A | C3-R/P | C3-PB |
| Black River main stem | M32-C | C4-R/P | B3c-R/P |
| Black River main stem | M32-B | C4-R/P | C4-R/P |
| Black River main stem | M31 | C4-R/P | C4-R/P |
| Black River main stem | M30 | C3-R/P | C3-R/P |
| Black River main stem | M27 | C3-R/P | C3-R/P |
| Twentymile Stream | M26T2.01 | C3-R/P | C3-PB |
| Black River main stem | M26 | C3-R/P | F4-PB |
| Black River main stem | M19-B | C3-R/P | F3-R/P |
| Twentymile Stream | M26T2.10-C | C3-R/P | C4-PB |
| Twentymile Stream | M26T2.10-A | C3-R/P | F4b-R/P |
| Twentymile Stream | M26T2.08-A | C4-R/P | C4-R/P |
| North Branch | M15T1.11-B | C3b-S/P | F3b-S/P |
| North Branch | M15T1.11-A | C3b-R/P | F3b-PB |
| North Branch | M15T1.10 | C3-R/P | F3-R/P |
| North Branch | M15T1.09 | C4-R/P | F4-PB |
| North Branch | M15T1.08 | C3-R/P | F4-R/P |

*Fine Source & Transport / Coarse Deposition (coded red in figures)*
Seven of the assessed reaches/segments of Black River and its major tributaries were classified in this category. These segments are moderately to substantially incised ($IR_{RAF}$ values ranging from 1.5 to 2.1). Three of these seven segments have undergone a vertical stream type departure (C-to-F or C-to-Bc). This sediment regime category includes segments classified in stage III [F] or late stage II [F] of channel evolution. Like the other incised and entrenched segments, these segments have experienced increased velocities of bankfull and flood-stage flows, with enhanced scour energies, and have been converted to a transport-dominated condition by virtue of the reduced frequency of overbank flooding. However, these segments are generally more prone to lateral adjustments, given: (1) the relative lack of armoring, extensive berms or encroachments, (2) the presence of more erodible sediments in the channel boundaries; and/or (3) the occasional lack of forested buffers (along one or both banks). Historic and active widening and planform adjustments (flood chutes, bifurcations, meander extension and translation) have begun to create narrow, discontinuous pockets

of floodplain at an elevation below the recently abandoned floodplain in some segments. Where tree buffers are present along the banks of these segments, they provide some measure of erosion resistance. On the other hand, historic recruitment of trees and debris jams probably contributed to the formation of flood chutes, bifurcations, and localized meander development. A low to moderate degree of coarse sediment deposition is occurring, leading to a shallow and overwidened bankfull cross section with little pool definition. A weak riffle/pool bedform has developed, characterized by diagonal riffles and a secondary, low-flow sinuosity. Generally, width/depth ratios of these segments are slightly greater than their *Unconfined Source & Transport* counterparts (ranging from 11.2 to 73). Locally, (for example, Segment M32-A below Winery Road crossing) channel widening may have contributed to a reduction in sediment transport capacity that has begun to drive deposition. In-segment and upstream erosion is contributing to coarse sediment deposition within these segments, particularly at sharp bends or upstream of constrictions (bridge and culvert crossings, undersized [armored] cross sections). Thus, these segments have been converted from a *Coarse Equilibrium* condition to *Coarse Deposition*.

| Tributary | Reach/Segment | Phase 1 Reference Stream Type | Phase 2 Reference Stream Type |
|---|---|---|---|
| Black River main stem | M37-B | C4-R/P | B4c-R/P |
| Black River main stem | M32-A | C4-R/P | B3c-R/P |
| Black River main stem | M19-A | C3-R/P | C4-R/P |
| Twentymile Stream | M26T2.09 | C3-R/P | C3-R/P |
| Twentymile Stream | M26T2.07 | C4-R/P | C4-R/P |
| North Branch | M15T1.07 | C4-R/P | F4-R/P |
| North Branch | M15T1.06-B | E5-D/R | E5-D/R |

Recovery of equilibrium conditions in many segments of the Black River and tributaries may be long term. Impoundment effects in upstream sections of the Black River network may be limiting sediment supplies to some of the assessed segments, thereby reducing the sediment volumes necessary to drive the floodplain-building processes of aggradation, widening and planform adjustment. For example:

- Recovery of main stem reaches M37 through M30 may be limited to a degree by the impoundment of sediments in the upstream 5 miles of lakes and reservoirs (Lake Pauline, Lake Rescue, Echo Lake, and Lake Amherst). Some sediment loading is occurring via the Branch Brook tributary (as evidenced by a large tributary confluence bar), but its upstream drainage area is less than half of the upstream main-stem watershed at reach M37.

- Recovery of reaches M27 and M26 may be slowed by the fact that much of the sediment from upstream Black River reaches presumably is trapped at Cavendish gorge dam (and is apparently only released in major flood events, such as 1927 Cavendish avulsion). While Twentymile Stream can be a source of sediment, this is a considerably smaller drainage area than the upstream main-stem watershed, and some sediment in the Twentymile Stream network appears to be attenuated at reach M26T2.05.

In other reaches, recovery is unlikely due to the substantial and intensive development along one or both banks. These segments are likely to see ongoing management to persist in stage II [F] and an *Unconfined Source & Transport* sediment regime:

- segments M34 and M33-B in Ludlow village;
- M31 in Proctorsville;
- M26T2.01 in Whitesville; and
- M15T1.11-B and M15T1.11-A in Felchville.

## 5.2 Sensitivity Analysis

The **Stream Sensitivity Maps** (Figures 22, 23, 24, and 25) identify the sensitivity classification for each of the assessed reaches / segments. Inherent in the stream sensitivity rating are:

- the natural sensitivity of the reach given the topographic setting (confinement, gradient) and geologic boundary conditions (sediment sizes) – as reflected in the reference stream type classification (after Rosgen, 1996 and Montgomery & Buffington, 1997); and

- the enhanced sensitivity of the reach given by the degree of departure from reference (or dynamic equilibrium) condition – as reflected in the existing stream type classification and the condition (Reference, Good, Fair to Poor ratings in the Rapid Geomorphic Assessment).

The sensitivity classification is intended to identify "the degree or likelihood that vertical and lateral adjustments (erosion) will occur, as driven by natural and/or human-induced fluvial processes" (VTANR 2007b).

These stream sensitivity data were utilized during subsequent planning steps to inform the identification and prioritization of restoration and protection projects and practices (Section 6).

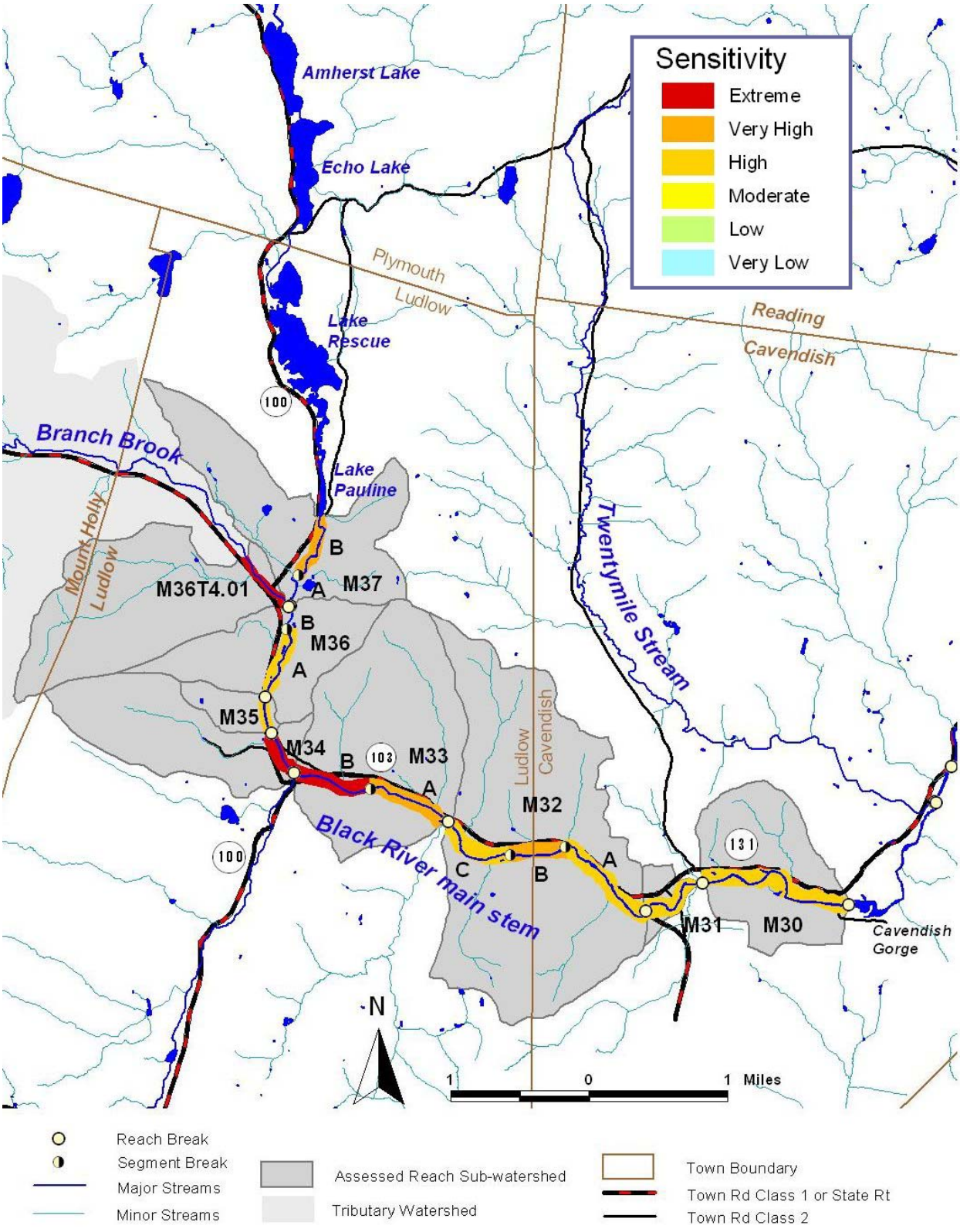



***Figure 22. Stream Sensitivity Map***
***Assessed Reaches of the Black River Main Stem, Upstream of Cavendish Gorge.***

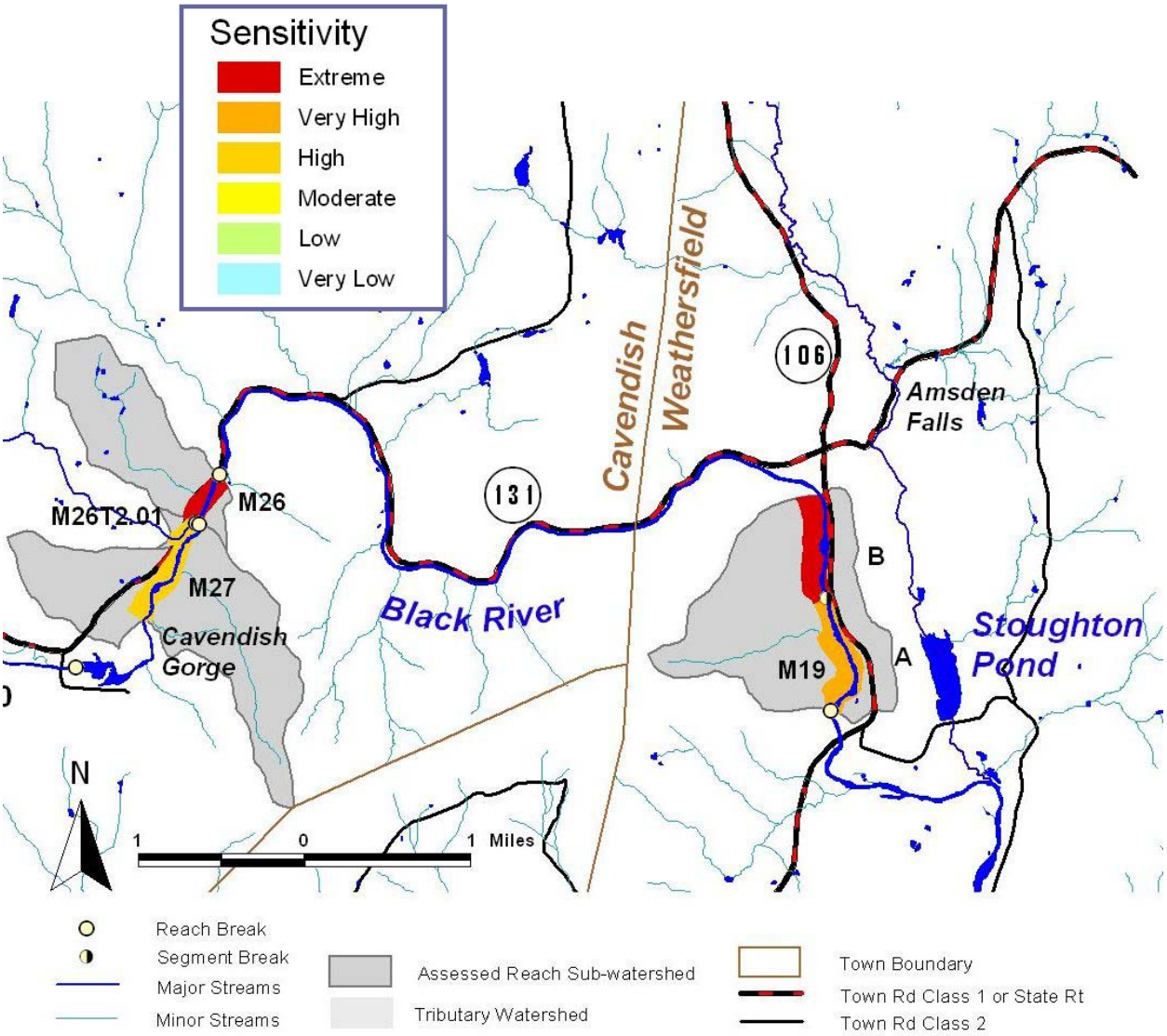



***Figure 23. Stream Sensitivity Map***
***Assessed Reaches of the Black River Main Stem, Downstream of Cavendish Gorge.***

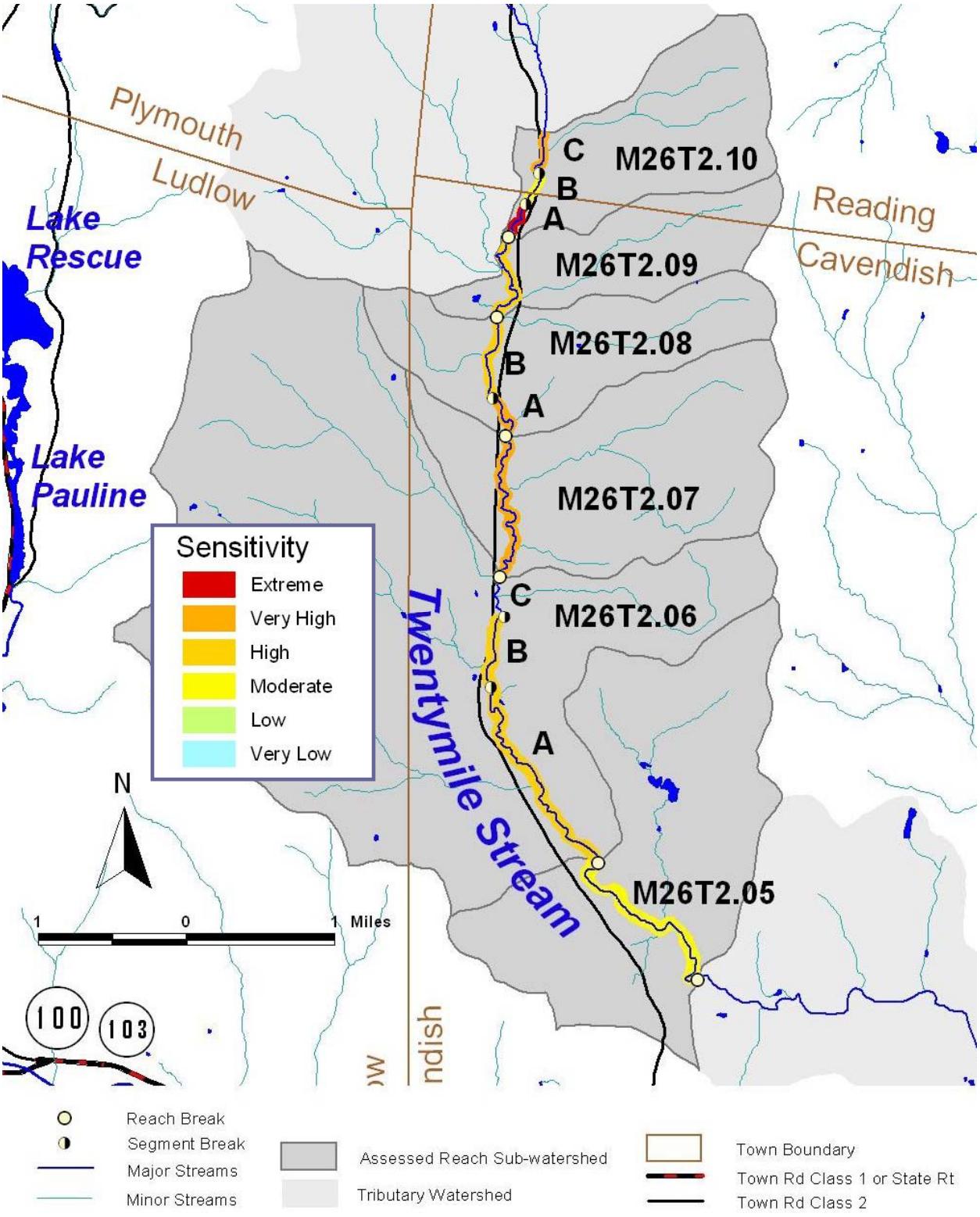



***Figure 24. Stream Sensitivity Map, Assessed Reaches of the Twentymile Stream tributary.***

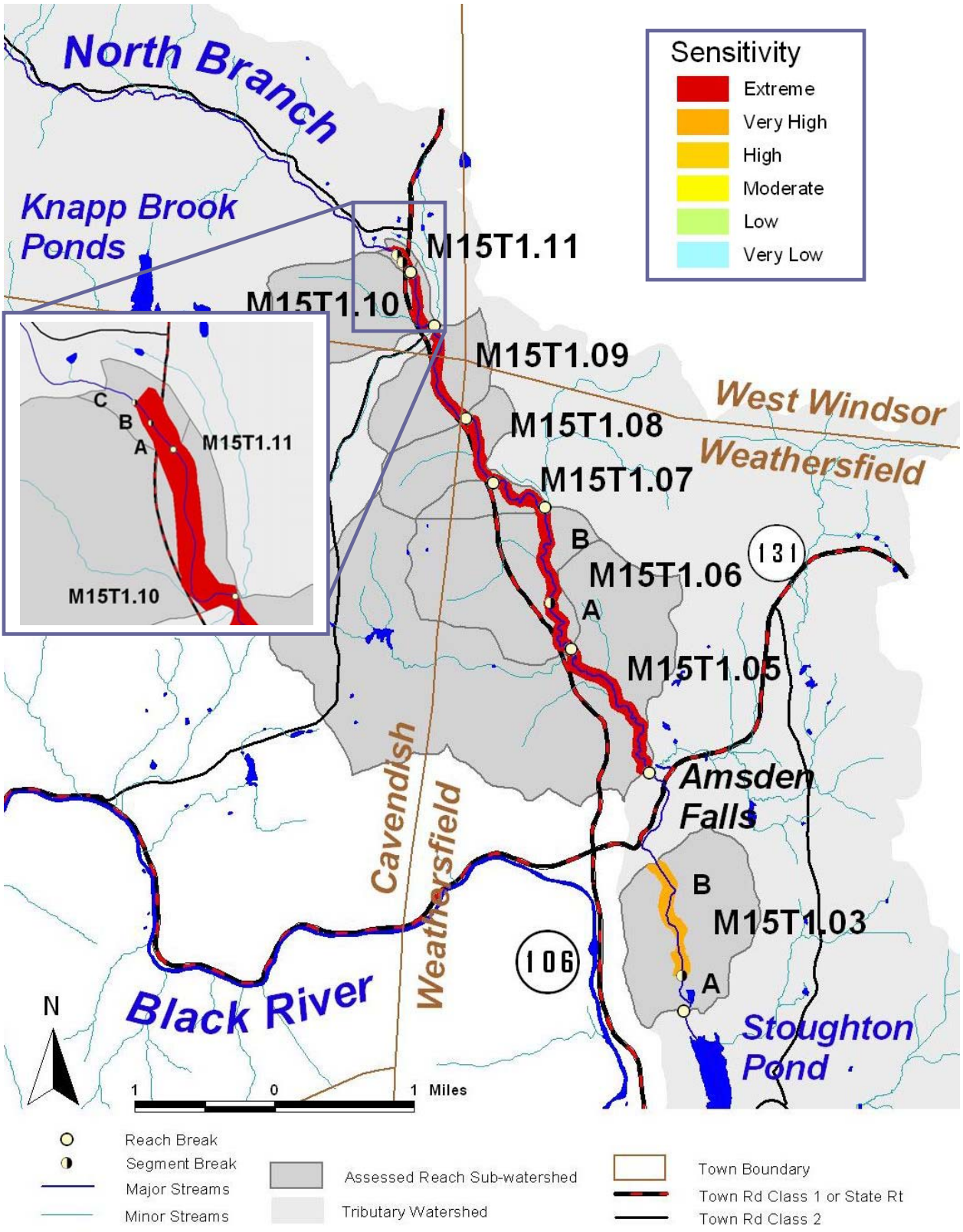



***Figure 25. Stream Sensitivity Map, Assessed Reaches of the North Branch tributary.***

# 6.0 PRELIMINARY PROJECT IDENTIFICATION (Reach & Corridor Scale)

Landowners, community members, and resource agencies, including the Southern Windsor County Regional Planning Commission, the Ottauquechee Natural Resources Conservation District, Black River Action Team, and Vermont Agency of Natural Resources, can use geomorphic data to inform future management strategies for the assessed reaches of the Black River and major tributaries. For a given reach or segment, the active adjustment processes, degree of departure from reference, and sensitivity ranking will define the short-term compatibility and long-term sustainability of various restoration or conservation options and future land use or channel management activities.

The preliminary identification and prioritization of corridor restoration and protection projects outlined below has been informed by:

- stream sensitivity data;
- qualitative observations of sediment transport and attenuation characteristics; and
- preliminary departure analysis contained in Section 5.

This provisional listing follows the outline of management actions identified in the *Step-Wise Procedure for Identifying Technically Feasible River Corridor Restoration and Protection Projects* included in VTANR guidance (2007b). The listed approaches can be classified under three broad management approaches:

> Active Geomorphic: Restore or manage rivers to a geomorphic state of dynamic equilibrium through an **active** approach that may include the removal or reduction of human-placed constraints or the construction of meanders, floodplains, and bank stabilization techniques. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.
>
> Passive Geomorphic: Allow rivers to return to a state of dynamic equilibrium through a **passive** approach that involves the removal of constraints from a river corridor thereby allowing the river, utilizing its own energy and watershed inputs to re-establish its meanders, floodplains, and self maintaining equilibrium condition over an extended time period. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.
>
> Active-Passive Combination: Use a sequenced combination of active and passive approaches to accommodate the varying constraints that typically occur along a project reach. *(VTANR, 2007b)*

Each category of restoration and conservation strategies identified in VTANR guidance (2007b) is discussed in Sections 6.1 through 6.8. An additional category (mitigating point sources of stormwater and sediment loading) is presented in Section 6.9. Section 6.10 identifies segments which are candidates for wetland restoration.

The work scope for this Phase 2 assessment has not included public outreach or analysis to determine the technical, financial and social feasibility of these listed project opportunities. Instead, this listing will form the basis for future project development and implementation efforts in the context of watershed, community, and corridor planning projects. A few of these projects (e.g., buffer plantings) can be considered for immediate implementation, independent of other watershed projects, and will require only minimal feasibility analysis and project development activities. Other identified projects may require further evaluation and efforts to perform alternatives analyses, conduct landowner outreach and negotiations, and identify potential stakeholders and funding sources.

## 6.1 Protecting River Corridors

Protection of river corridors is an essential element to all passive and active geomorphic restoration and conservation projects. River corridor protection can support multiple objectives:

- Dynamic Equilibrium - Preserve (or support a return to) reference sinuosity, slope, and channel dimensions through active or passive geomorphic approaches.
- Floodplain Access – Preserve or restore a channel's access to its surrounding floodplain in bankfull and higher flow events through active or passive geomorphic approaches.
- Sediment Attenuation – Preserve, restore, or enhance the storage of sediments (from in-reach or upstream sources) within the channel margins, floodplain, and channel-contiguous wetlands.
- Flow Attenuation – Preserve, restore, or enhance the storage and detainment of flood flows through overbank flooding, increased channel length (sinuosity), increased channel roughness (e.g., buffers), and inundation of channel-contiguous wetlands.
- Avoidance – Refrain from developments and infrastructure in the corridor to minimize future fluvial erosion losses. This can be accomplished through conservation strategies or local planning and zoning strategies, such as fluvial erosion hazard overlay districts.

Under a passive geomorphic approach, the river channel is allowed to freely meander within the area defined as the belt-width-derived river corridor. Further channelization, dredging, berming and armoring are avoided. For a reach that is already close to reference condition or exhibiting only minor adjustments, preserving a river corridor will ensure the river's ability to continue to meander through the valley unconstrained by human infrastructure. In turn, human investments in the landscape will be protected from future channel adjustments. For a reach that has seen significant channel management in the past, and has lost some degree of floodplain connection and some measure of its sinuosity and balanced planform and profile, the channel is allowed to adjust unimpeded to a more sinuous, meandering planform closer to regime conditions. During ongoing adjustments, the river will re-establish greater floodplain access (where access has been lost) and adjust channel dimensions for optimum conveyance of its water and sediment loads. Restoring channel equilibrium will reduce instream production of sediment and nutrients and enhance sediment and nutrient attenuation over the long term.

Under an active geomorphic approach, protection of the river corridor will prevent future channel management that might unravel constructed features of a recently restored reach.

Lower priority reaches for river corridor protection include "wooded corridors experiencing very little threat from encroachment and less sensitive reaches not playing a significant flow or sediment load attenuation role in the watershed" (VTANR, 2007b). Of the assessed reaches, this category would include:

- M15T1.11-C - the bedrock falls segment in Felchville which is afforded stability by the underlying bedrock; and
- M26T2.10-B – the bedrock-controlled channel along Twentymile Stream in a well-forested area west of Twentymile Stream Road; Moderate sensitivity.

Highest priority reaches for river corridor protection include "highly sensitive reaches critical for flow and sediment attenuation from upstream sources or sensitive reaches where there is a major departure from equilibrium conditions and threats from encroachment (VTANR, 2007b)". Limited-term or permanent

corridor easements are possible mechanisms for corridor protection, with the willingness of landowners. Protection of the river corridor in these reaches can serve the functions listed above. As summarized in Table 14, there are additional strategic factors that may raise the priority of corridor protection for a given reach, including:

- Locations Upstream of Constrained / Altered Reaches
  Reaches / segments which are constrained by the topographic setting (e.g., bedrock outcroppings) or by human infrastructure (e.g., berms, roads, development) are less able to adjust their dimensions, planform, and profile in response to excess sediment and water loads delivered from upstream. Corridor protection measures implemented upstream of these constrained / altered reaches will enhance sediment and flow attenuation, maintain or improve floodplain access and reduce streambank erosion over the long term. Sediment production and delivery and hydrologic stresses to the constrained / altered reach will be decreased given the flow and sediment attenuation achieved in the upstream protected corridor.

- Locations Downstream of Constrained / Altered Reaches
  Protection of segments downstream of constrained / altered reaches will help to offset the impacts of human encroachments in the disturbed reach which may have constrained the channel, reduced floodplain access, and converted a naturally deposition-dominated segment into a transport-dominated segment.

- Sediment attenuation areas
  Where increased attenuation functions are observed, and lateral adjustments can be tolerated given the adjacent land uses, such areas can be capitalized on as attenuation assets to offset the reduced floodplain access and sediment storage in upstream or downstream reaches that have been converted to a transport-dominated status. These sites are high-priority candidates for outreach and eventual conservation or protection with the willingness of landowners.

- Reaches with channel-contiguous wetlands
  Where wetlands and backwater areas are hydrologically connected to the channel, flow attenuation and suspended sediment (and nutrient) attenuation functions can be maximized.

- Reaches at alluvial fans or points of marked valley slope reduction that contribute to increased sediment aggradation and planform adjustment. Carefully manage land use changes in the upstream watershed to reduce the potential for increases in sediment or flows that may induce channel adjustments in the subject reach/segment.

- Reaches downstream of major sediment sources or tributary confluence bars that contribute to increased sediment aggradation and planform adjustment.

- Reaches where there is a major departure from equilibrium conditions – these are reaches where protection against fluvial erosion hazards (through local planning and zoning mechanisms) is especially critical as the channel is susceptible to sudden streambank erosion or avulsion in high flow events.

- Reaches Identified for Passive or Active Restoration – To support a channel where there is a moderate to major departure from equilibrium as it evolves to regain floodplain and natural meander patterns.

***Table 14. River Corridor Protection opportunities***
***Black River main stem and tributary reaches***

| Reach / Segment | Town | Priority | Protection Upstream of Constrained or Altered Reaches | Protection Downstream of Constrained or Altered Reaches | Key Sediment Attenuation Area | Channel-contiguous wetlands | Alluvial Fan or Point of Marked Valley Slope Reduction | Downstream from Major Tributary or Other Large Sediment Source | Moderate or Major Departure from Equilibrium | Accompany Passive or Active Restoration, Incised/Aggraded |
|---|---|---|---|---|---|---|---|---|---|---|
| **Black River main stem** | | | | | | | | | | |
| M37-B | Ludlow | High | √ | | | | | | √ | √ |
| M37-A | Ludlow | Very High | √ | | √ | √ | | | | |
| M36-B | Ludlow | Very High | √ | | √ | | | | | |
| M36-A | Ludlow | Very High | √ | | √ | | | √ | | |
| M35 | Ludlow | Low | | | | | | | | |
| M34 | Ludlow | Low | | | | | | | √ | √ |
| M33-B | Ludlow | Low | | | | | | | √ | √ |
| M33-A | Ludlow | Very High | | √ | | | | | | √ |
| M32-C | Ludlow | Very High | | √ | | | | | √ | √ |
| M32-B | Cavendish | Very High | | √ | | | | | | √ |
| M32-A | Cavendish | Very High | √ | √ | √ | | | | √ | √ |
| M31 | Cavendish | Moderate | | | | | | | | √ |
| M30 | Cavendish | High | | | | | | | | √ |
| M27 | Cavendish | High | | | | | √ | | √ | √ |
| M26 | Cavendish | High | | | | | | √ | √ | √ |
| M19-B | Weathersfield | High | | | | | | | √ | √ |
| M19-A | Weathersfield | Very High | | √ | √ | √ | | | √ | √ |
| **Branch Brook** | | | | | | | | | | |
| M36T4.01 | Ludlow | Very High | √ | | | | √ | | √ | √ |
| **Twentymile Stream** | | | | | | | | | | |
| M26T2.10-C | Reading | High | √ | | | | | | | √ |
| M26T2.10-B | Cavendish | Moderate | | | | | | | | |
| M26T2.10-A | Cavendish | Very High | | | | | √ | | √ | √ |
| M26T2.09 | Cavendish | High | | | √ | √ | | | | √ |
| M26T2.08-B | Cavendish | Very High | | | √ | | | | | |
| M26T2.08-A | Cavendish | High | | | | | | | √ | √ |
| M26T2.07 | Cavendish | High | | | | | | | √ | √ |
| M26T2.06-B | Cavendish | High | | | | | | | | |
| M26T2.06-A | Cavendish | Very High | | | √ | | | | | |
| M26T2.05 | Cavendish | Very High | √ | | √ | √ | | | | |
| M26T2.01 | Cavendish | Low | | | | | | | √ | √ |
| **North Branch** | | | | | | | | | | |
| M15T1.11-B | Reading | Low | | | | | √ | | √ | √ |
| M15T1.11-A | Reading | Moderate | | | | | √ | | √ | √ |
| M15T1.10 | Reading | Very High | | √ | | | | | √ | √ |
| M15T1.09 | Cavendish | High | | √ | | | | | √ | √ |
| M15T1.08 | Weathersfield | High | | | | | | | √ | √ |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| M15T1.07 | Weathersfield | Very High | | | √ | | √ | | √ | √ |
| M15T1.06-B | Weathersfield | Very High | | | | √ | | | | √ |
| M15T1.06-A | Weathersfield | Very High | | | √ | √ | | | | |
| M15T1.05 | Weathersfield | Very High | √ | | √ | √ | | | | |
| M15T1.03-B | Weathersfield | Very High | | | √ | | | | | √ |

## 6.2 Planting Stream Buffers

Forested riparian buffers improve water quality and contribute to greater flow and sediment attenuation in the floodplain. They will also help to restore and maintain dynamic equilibrium of the channel by increasing boundary resistance to shear stresses along the channel margins. Tree buffers will provide the additional benefits of organic matter, detritus, and LWD recruitment for aquatic and riparian habitats, as well as increased shading to reduce river temperatures. Connectivity of buffer areas from reach to reach along a river network also supports mammalian terrestrial habitats by providing wildlife corridors.

Tree buffers are intact along both banks of some of the assessed reaches. It is a very important to maintain buffers in these reaches, not only for streambank stability, but also for the shading and organic matter that the tree canopy provides to aquatic organisms. In other reaches through the village areas, buffers are largely absent, but buildings, roads and parking lots have encroached upon the channel, reducing the feasibility (and therefore the priority) of buffer treatments.

Low-priority segments for planting buffers are those segments which have departed from equilibrium to a moderate to severe degree, since ongoing adjustments will likely undermine the newly-planted trees / shrubs. This condition applies to a majority of the study reaches. In these cases, larger trees could be planted at the corridor limits to mark the outside area of the protected corridor.

High-priority opportunities to increase buffer widths and continuity are located along the following reaches which are closer to equilibrium condition and have good or reasonable floodplain access:

- reaches of the North Branch tributary (M15T1.06 and sections of M15T1.10);
- reaches of the Twentymile Stream (M26T2.07, M26T2.06); and
- reaches of the Black River main stem (M33-A, M30, and M19-A).

## 6.3 Stabilizing Stream Banks

Streambank stabilization can be considered in "laterally-unstable, [but vertically stable] reaches where human-placed structures are at high risk and not taking action may result in increased risk of erosion, to not only the structure, but lands that would provide the opportunity to establish a buffer" (VTANR, 2007b). Any bank stabilization project should be considered in the broader context (both in time and space) for the channel adjustment processes such management will set in motion and for the consequences to upstream and downstream reaches. No bank stabilization projects have been identified as a high priority along the assessed reaches at this time. The few study reaches with good floodplain access are located in rural settings with limited encroachments. It is important to allow lateral adjustments to proceed unconstrained in order to support passive channel restoration and a return toward dynamic equilibrium.

## 6.4 Arresting Head Cuts and Nick Points

One head-cut / nick-point site was observed on the assessed reaches / segments: a nick point located immediately upstream of the RB Coleman Brook tributary confluence in Branch Brook reach M36T4.01. As further detailed in Appendix E, the Coleman Brook passes under Route 103 through a corrugated steel, pipe-arch culvert which terminates at the confluence with Branch Brook. The downstream end of this culvert, reinforced by a concrete header, is perched above the Branch Brook channel (Figure 26a).



(a)



(b)

***Figure 26. A potential head cut (nick point) was observed immediately upstream of the Coleman Brook tributary confluence with Branch Brook reach M36T4.01.*** *This nick point does not span the bankfull channel and is associated with a scour pool beneath the Route 103 culvert crossing of the Coleman Brook which terminates at the tributary confluence with Branch Brook. (a) View upstream from Branch Brook channel into outlet of Coleman Brook instream pipe-arch culvert; assessor standing in scour pool which is coincident with Branch Brook channel; nick point immediately to picture right. (b) view upstream within Branch Brook; Coleman Brook culvert terminates at channel RB in the left center of the picture; nick point at picture center, with vegetated point bar at lower right of picture; upstream commercial driveway bridge crossing of Branch Brook visible at center right of picture.*

The nick point in the Branch Brook channel is present immediately upstream of this culvert associated with a significant scour pool at the base of the culvert. The origin of this nick point is uncertain. It is possible that this nick point has resulted from recent incisional processes in the Branch Brook. More detailed survey work and hydraulic analyses would be required to understand if recent changes in the position of the confluence with Black River (for example) have contributed to incisional processes in Branch Brook. However, it seems likely that a mid-reach bedrock vertical grade control (located 125 feet downstream of this tributary junction) would have constrained headward migration of an incisional process from the vicinity of the Branch Brook confluence with Black River. Therefore the nick point may instead have formed due to the scour pool associated with increased flows through the perched culvert on the Coleman Brook.

Further evaluation of the Coleman Brook watershed, and monitoring of this nick-point condition, are recommended prior to undertaking a restoration activity to stabilize the nick point. Geomorphic assessment in the Coleman Brook watershed would help to evaluate the potential for increased flows from this tributary watershed associated with recent and substantial land use changes (see Appendix E). A hydraulic analysis could model flows through the culvert and evaluate the degree of likely downstream

scour – to confirm if the depth and width of the noted downstream scour pool is consistent with expected conditions given constriction of flows through this undersized structure. Evaluation and continued monitoring of this culvert would indicate whether rehabilitation or replacement is warranted. Continued monitoring of the condition and location of this nick point would reveal if incisional processes are active within the Branch Brook channel itself, warranting stabilization of the nick point. Based on limited windshield surveys, the nearest upstream channel-spanning exposure of bedrock (that could serve to limit headward migration of this nick point if it became active) is more than 3,800 feet upstream at the vicinity of the Rod & Gun Club Road bridge crossing – a distance greater than 85 times the regime channel width of 44 ft. A RB commercial property, a driveway crossing, and a length of the Buttermilk Falls Road located along this channel section would potentially be at risk of destabilization, should a wave of incision work headward in this reach.

## 6.5 Removing Berms / Other Constraints to Flood & Sediment Load Attenuation

Removing berms or other constraints to the full meander expression and floodplain connection of a river channel may accelerate a return to dynamic equilibrium in the channel, and reduce impacts to downstream segments, by creating more opportunities for sediment and flow attenuation along the corridor. Further study is necessary to evaluate the feasibility of various active geomorphic and engineering techniques to remove constraints. The benefits of such projects need to be evaluated in light of the costs and potential short-term consequences in terms of sediment and nutrient mobilization, and risk to infrastructure and public safety.

While berms were noted along portions of one or both banks of several study reaches, berm removal was considered a low priority in each case (following VTANR guidance) due to the fact that:

- the channel was already incised below the floodplain ($IR_{RAF}$ nearly equal or exceeding 2.0) such that berm removal alone would not result in greater floodplain access – (e.g., M36T4.01, M34, M33-B, M26, M15T1.11-B, M15T1.11-A, M15T1.10, M15T1.09, M15T1.08, M15T1.07);

- the noted berm(s) was coincident with a high bank or terrace, and removal of the berm would not appreciably increase the meander belt width area available to the channel (e.g., M37-B, M34, M33-B, M26T2.11, M15T1.07);

- residential, commercial, or municipal infrastructure was present close to the channel and would be placed at greater risk of flooding if the berm were removed (e.g., M34, M33-B, M33-A, M32-B, M15T1.11-B, M15T1.11-A);

- the noted berm(s) was very short in length and/or was associated with nearby valley fill for a bridge crossing that was likely to be maintained (e.g., M30, M26T2.01, M26T2.11, M26T2.08, M15T1.08); and/or

- the noted berm(s) had well-established mature tree or shrub buffers which – if removed – would degrade habitats or result in significant disruption of the corridor lands (e.g., M19-B, M15T1.10, M15T1.08).

## 6.6 Removing / Replacing Structures

Human-placed structures which span and "constrain the vertical and lateral movement of the channel and/or result in a significant constriction of the floodplain" can be considered for removal or replacement to support dynamic equilibrium of the channel (VTANR, 2007b)". In the study reaches, constraining structures include bridges and culverts (section 6.6.1), and old abutments (section 6.6.2).

### 6.6.1 Bridge and Culvert Crossings

A total of 34 bridge and culvert crossings were encountered on the assessed reaches: 31 bridges and 3 instream culverts. Twenty-six structures (including 3 culverts) supported road or driveway crossings. Six structures (all bridges) supported farm road or trail (e.g., snowmobile) crossings. Two bridges supported railroad crossings. The status of each bridge and culvert as either a bankfull or flood-prone-width constrictor is summarized in Step 4.8 of the Phase 2 reach reports (Appendix A) and in the Bridge & Culvert Assessment reports (Appendix B). Nineteen of the 34 structures were bankfull-constricting structures. Eight out of the ten bridge and culvert structures encountered on Twentymile Stream had spans less than the bankfull width; the three instream culverts encountered during the study were located on this tributary.

Table 15 below presents a listing of eight bridges and culverts that are of highest priority for replacement. Priority is suggested without regard to technical feasibility, social feasibility, or cost; rather the priority is based on the geomorphic and habitat condition of the given reach or segment, and its relationship to (and potential impact on) the crossing structure. These structures are located on assessed reaches of the Twentymile Stream and North Branch tributaries. They are listed as priorities for replacement: (1) since the span of these structures is less than 50% of the reference (or measured) bankfull channel width; and/or (2) due to conditions that suggest localized channel instability that has the potential to impact the stability of the crossing structure itself (e.g., sharp approach angle, scour undermining the abutments, sediment obstructing the inlet, scour pool developing at the outlet); and/or (3) due to conditions (e.g., perched culvert) impacting fish passage and continuity of aquatic habitats.

Additional details for three notable structures are provided below:

(a) An instream culvert crossing of the Twentymile Stream (M26T2.10-A) has been constructed for a private driveway off Twentymile Stream Rd in the town of Cavendish. This culvert is a significant constrictor of the bankfull flow. The culvert width (7 ft) is only 36% of the regime bankfull width of 19.3 ft (VTDEC, 2006). A steep riffle of gravel and cobble sediments is evident at the culvert inlet (Figure 27a). A wide and deep (3.2 feet) scour pool has developed on the downstream end of the culvert. The slope of the culvert is less than the slope of the surrounding channel, and a cascade flow has developed at the outlet (i.e., the culvert is perched; (Figure 27b). This undersized crossing is a likely debris jam site and potential channel avulsion site. Replacement of this crossing with a wider-span bridge would mitigate this source of localized channel instability, and reduce the risk for debris jams and associated avulsion.

Replacement of this driveway culvert is also advisable from a habitat perspective. Flow is quite shallow inside the culvert, and continuity of natural substrates and flow depths is not maintained through the structure. These conditions can inhibit the movement of benthic organisms and fish as well as other species (e.g., salamander, crayfish, muskrat, etc). An open-bottom structure (i.e., arch or bridge) or an embedded pipe-arch culvert (with natural substrates comprising the bottom 20% of the structure) would provide more optimal conditions for fish and wildlife passage.

***Table 15. Highest Priority Bridge & Culvert Structure Replacements***
***Black River main stem and tributary reaches***

| Channel | Reach / Segment | Town | Road | Structure Type | Constriction Status | Other Issues | Priority |
|---|---|---|---|---|---|---|---|
| Twentymile Stream | M26T2.10-C | Reading | Twentymile Stream Rd | Bridge | 62% | Stepped footers (LB); sharp approach angle. | High |
| | M26T2.10-A **(see note a)** | Cavendish | Twentymile Stream Rd | Culvert | 36% | Sediment (steep riffle) obstructing inlet. Culvert is perched with 0.8 ft cascading flow at outlet (potential fish passage issue). Downstream scour pool. Partially failing stream bank armoring – LB, downstream. | Very High |
| | M26T2.08-A | Cavendish | Twentymile Stream Rd | Culvert | 48% | (No significant downstream scour or upstream sedimentation.) | Moderate |
| | M26T2.07 | Cavendish | Farm road / trail | Bridge | 36% | Sharp approach angle; Downstream scour pool. | High |
| | M26T2.05 | Cavendish | Heald Road | Bridge | 45% | Stepped footers (RB); Downstream scour pool. | High |
| North Branch | M15T1.11-A **(see note b)** | Reading | Route 106 | Bridge | 102% | Sharp approach angle; Located at significant reduction in valley slope; sediment (steep riffle) partially obscuring structure inlet. Site of previous ice jam flooding. | Very High |
| | M15T1.09 | Cavendish | Private driveway | Bridge | 92% | Streambed scour causing undermining at RB abutment (upstream and downstream) and LB abutment (downstream). Timber "piers" reinforcing bridge decking near LB and RB abutments. | High |
| | M15T1.05 **(see note c)** | Weathersfield | Little Ascutney Rd | Bridge | 41% | Sharp approach angle; RB abutments cracked and displaced. Stepped footer (RB). Streambed scour undermining RB and LB abutments. Downstream scour pool. Above conditions persist following Fall 2008 replacement of bridge decking. | High |

*Note: Constriction status is calculated as structure span divided by bankfull width, expressed as a percent.*



(a) (b)

***Figure 27. Instream culvert supporting driveway crossing of Twentymile Stream (M26T2.10-A) in Cavendish.*** *(a) View downstream to culvert inlet; steep aggradational riffle partially obscuring flows. (b) View upstream to culvert outlet; 0.8-foot cascade of flow to downstream scour pool.*

(b) VT Route 106 crosses the North Branch tributary at a point mid-way along a reach (M15T1.11) which marks a significant reduction in valley gradient and a transition from confined to unconfined conditions. Armored streambank berms have been constructed upstream and downstream of the bridge to constrain channel flows. The channel is incised and entrenched below the floodplain in this reach upstream and downstream of the bridge. The channel is undersized (less than the regime bankfull width) upstream of the bridge. The span of this bridge crossing is 102% of the regime bankfull width. Sediment has accumulated in a steep aggradational riffle upstream of the bridge. Recent ice jams and debris jams are reported in the vicinity of this bridge crossing (NCDC, 2007). Replacement of this crossing with a wider-span bridge with higher clearance would reduce the likelihood of debris and ice jams and reduce the potential for channel avulsion.



***Figure 28. VT Route 106 bridge crossing of North Branch tributary (M15T1.11-A).*** *View downstream to bridge inlet.*

(c) The Little Ascutney Road bridge crossing of the North Branch (M15T1.05) in Weathersfield was recently improved with replacement of the bridge decking (at a slightly higher elevation) in the Fall of 2008. Abutments appeared unchanged, and conditions suggest that this bridge crossing is the site of localized channel instability. The span is a bankfull-constrictor, at only 41% of the measured bankfull width. The RB has a stepped footer, suggesting past repairs to address scour of the channel bed. Streambed scour was evident beneath both the LB and RB abutments. The channel has a sharp approach angle to the bridge. On the outside of the sharp approach meander, the position of the upstream portion of the RB abutment appears to have shifted on the footer.



(a) (b)

***Figure 29. Little Ascutney Road bridge crossing of North Branch tributary (M15T1.05) in Weathersfield.*** *(a) View upstream to bridge outlet, 20 June 2008; sharp approach angle, displaced RB upstream end of abutment at photo center. (b) View upstream to bridge outlet, 7 November 2008; bridge decking recently replaced; clearance from underside of deck to channel bed slightly improved from 8.2 to 8.7 feet; abutments unchanged in recent rehabilitation.*

### 6.6.2 Other constrictions

Table 16 provides a listing of the old bridge or dam abutments encountered on the study reaches and summarizes their priority for removal. Each of the abutment pairs was a constrictor of the bankfull width to varying degrees. Two abutment sites are ranked as a high priority for removal due to their constriction status less than 50% and observed local impacts to the channel. While other abutments may have had similar constriction status, there were other mitigating factors that reduced the priority for recommended removal – such as, presence of bedrock coincident with the former crossing location that provided stability to the channel; or habitat considerations.

***Table 16. Old abutment candidates for removal in the assessed reaches of Black River and major tributaries***

| Stream | Reach / Segment | Location | Constriction Status | Issues / Considerations | Priority |
|---|---|---|---|---|---|
| Black River main stem | M37-B | Old abutments on bedrock (RB). Downstream half of segment | 56% | Deposition above, in part due to bedrock constriction. | Low |
| | **M32-A** | RB abutment; LB rip-rap; upstream of railroad crossing at Jct Routes 131 & 103. | 44% | Scour below. Removal may lessen constraints on lateral adjustments to southwest (RB). | **High** *(pending hydraulic analysis)* |
| | M32-A | Downstream third; former dam? / diversion inlet | 86% | None apparent. Historic structure. | Low |
| | M30 | Downstream third; former dam abutments | 70% | None apparent. Historic structure. | Low |
| Twentymile Stream | M26T2.06-B | Mid-segment | 47% | Sharp approach angle. Segment stable and in only minor (localized) adjustment. Structure contributing to habitat (pool formation). | Low |
| North Branch | M15T1.09 | Upstream end (#1) | 70% | Sedimentation above; sharp approach angle; somewhat mitigated by downstream bedrock lateral controls (LB) | Moderate |
| | M15T1.09 | Mid-reach (#2) | 72% | None. Mitigated by bedrock vertical and lateral controls. | Low |
| | **M15T1.08** | Upstream of Ascutney Basin Rd bridge | 53% | Sedimentation above; scour pool below; may serve to lessen sedimentation above Ascutney Basin Rd bridge (constriction status = 70%). | **High** *(pending hydraulic analysis)* |

*Note: Constriction status is calculated as structure span divided by bankfull width, expressed as a percent.*

## 6.7 Restoring Incised Reaches

Further study can evaluate the feasibility of various active geomorphic and engineering techniques to restore historically-incised reaches, accelerate a return to dynamic equilibrium of the channel, and reduce impacts to downstream segments, by creating more opportunities for sediment and flow attenuation along the corridor.

A majority of the study reaches are historically incised and many have undergone a vertical stream type departure, losing access to the surrounding floodplain. Generally, historic incision is inferred to have been caused by a long history of channelization/ dredging/ berming/ armoring in response to past flood events, as well as historical operation of dams and diversion channels (particularly on the Black River main stem). In the village areas, development and encroachments have contributed to the incised and entrenched status of river reaches. None of the study reaches/segments was noted as having undergone active or recently-occurring incision.

Generally, active restoration of incised reaches in the study area is considered a very low priority for the following reasons:

- High density of commercial, municipal, residential development and related encroachments that will likely require ongoing management of the entrenched and transport-dominated condition of the channel through village areas (e.g., M35, M34, M33-B in Ludlow; M31 through Proctorsville; M26T2.01 at Whitesville; and M15T1.11 at Felchville);
- Intractable constraints of infrastructure (roads, railroads, engineered levees or bridge / culvert crossings) (e.g., portions of M32-A; M19-B; M26T2.08-A, M15T1.09) or bedrock (e.g., M27, M26) that limit the full expression of meanders and floodplain access and would reduce the technical feasibility or effectiveness of active restoration;
- Generally limited sediment supply in the upper Black River study reaches of the Ludlow area (due to 5+ miles of natural and human impoundments) that would result in a prolonged recovery time (e.g., M37-B) and limited effectiveness (high cost/benefit ratio) of active restoration measures;
- Low overall valley and channel gradients which limit the feasibility of in-channel structure placement designed to induce aggradation (most of Black River main stem);
- Detrimental impacts to in-stream and riparian habitats, since lowering of the river-bank elevation adjacent to the channel to increase the degree of floodplain connection and flow and sediment attenuation would involve removal of mature or regenerating vegetated buffers (e.g., M27, M15T1.10, M15T1.03); and
- Limited area of floodplain access gained by reconnecting the channel to the floodplain (e.g., M26T2.10-C, M15T1.09, M15T1.08).

Instead, passive restoration through corridor protection is recommended as a High to Very High priority for incised reaches in relatively undeveloped sections of the study area (see Section 6.1, Table 14) to support meander redevelopment and floodplain building. Naturally-enhanced attenuation at transition points of reduced valley gradient and/or confinement (perhaps enhanced by natural LWD recruitment and/or beaver activity) will accomplish channel restoration within reasonable timeframes at much lower cost and higher success rates, if the corridor is protected and society refrains from further channel management (e.g., M26T2.10-A, M26T2.09, M26T2.07, M15T1.07, M15T1.06-B). A Very High priority is also assigned to reaches located downstream or immediately upstream of constrained / channelized reaches.

One possibility for active restoration does exist along appropriate sections of the Black River main stem segments M32-C and M32-B between Ludlow and Proctorsville and reach M30 between Proctorsville and Cavendish. At present, development is relatively minor along these segments. It would be technically feasible to lower the elevation of the LB along these sections in order to reconnect the incised channel ($IR_{RAF}$ 1.4 to 1.7) with a floodplain and provide increased flow and sediment attenuation. Tree buffers along the LB are largely absent, and often dominated by invasive species (e.g., Japanese Knotweed). Therefore, impacts to instream habitat (through reduced shading, organic inputs) would be relatively negligible, and habitats could be improved through the establishment of native buffer plantings. Habitats may be further improved through increased meander development (and pool/riffle diversity) that would be expected to follow from improved floodplain connection. Improved flow and sediment attenuation in these segments could be strategic both downstream and upstream of established village areas (Ludlow, Proctorsville, Cavendish) where the channel is much more constrained. Further study (including hydrologic and hydraulic analyses) would be warranted to evaluate the feasibility and potential benefits and impacts of such an active restoration approach. At a minimum, corridor protection in these segments should be pursued to limit the likelihood for further development on the channel that would then be at risk of fluvial erosion hazards. In reach M30, in particular, it is important to protect the river's access to abandoned meanders and flood chutes in the river valley that could provide important flow and sediment attenuation during high-magnitude flood events.

## 6.8 Restoring Aggraded Reaches

Further study is sometimes warranted to evaluate the feasibility of various active geomorphic and engineering techniques to restore aggraded reaches which could accelerate a return to dynamic equilibrium of the channel, by restoring equilibrium of sediment transport processes. Aggrading reaches can also be restored through passive measures including corridor protection.

Three of the study segments were identified with locally aggrading conditions. The channel in each of these segments is relatively unconstrained by encroachments, and is reasonably free to adjust its planform, dimensions and profile in response to changes in sediment and water loading. These segments are partially or fully incised below their floodplains, and active aggradation and lateral adjustments are serving to build sections of new floodplain at a lower elevation. Active restoration of the moderately-aggraded condition might be feasible (e.g., placement of structures to restore equilibrium W/D ratio and support further development of the incipient floodplain). However, such an approach is not recommended at this time (for reasons discussed below). Instead of active restoration measures in these three segments, a return toward equilibrium conditions can be supported through passive restoration techniques in the context of river corridor protection (Section 6.1 above).

(1) ***M32-A of the Black River*** (at the upstream end near Winery Road) is an aggraded section that exhibits localized channel braiding and steeply-faced depositional bars. Where the channel impinges on a high bank (RB) of erodible, glaciofluvial sediments, streambank erosion has also contributed a local source of sediments (Figure 30). Upstream (watershed-scale) hydrologic loading (associated with channelization, encroachment, and historic incision) is thought to be a contributing stressor governing adjustment processes in this reach. Roads, railroads, and an old abutment artificially constrain the planform upstream and downstream of the adjusting section. These factors reduce the feasibility of active restoration measures. This reach is an important sediment attenuation area, and is a Very High priority for river corridor protection to support passive restoration (Section 6.1, Table 14).



***Figure 30. High terrace of glaciofluvial sediments contributes to sedimentation in segment M32-A.*** *View upstream, 2 October 2007.*

(2) ***M15T1.07 of the North Branch*** (downstream of the Ascutney Basin Road bridge) contains an aggrading, overwidened section that exhibits localized channel braiding and steeply-faced depositional bars. Substantial meander extension, translation and flood chutes have occurred in recent years as evident from a comparison of 1994 channel position to the current planform (Figure 31). Removal of vegetated buffers to support agricultural uses in the corridor has also lead to streambank erosion that contributes locally to sedimentation. This reach's position at a point of reduced valley gradient and confinement make it particularly sensitive to lateral adjustments (and would reduce the longterm feasibility of active restoration methods). This reach is a key sediment attenuation area, and is a Very High priority for passive restoration through river corridor protection (Section 6.1, Table 14).

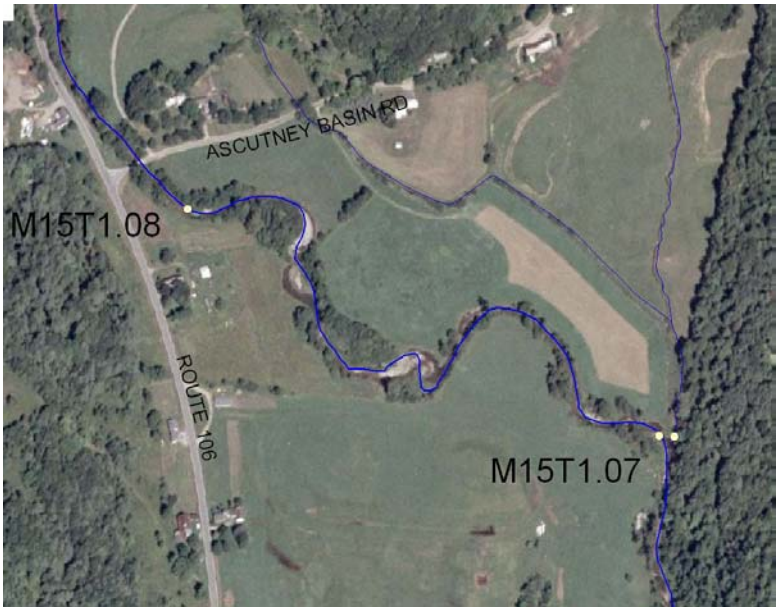



***Figure 31. Aggradational reach M15T1.07 of North Branch tributary.*** *Base image dated 2003. Blue line represents 1994 channel position.*

(3) ***M15T1.03-B of the North Branch*** (downstream of Amsden Falls, upstream of Stoughton Pond) is an aggrading, laterally adjusting reach with occasional steeply-faced depositional bars and steep aggradational riffles. Aggradation is expected given this reach's position at a point of reduced valley gradient and confinement, but has likely been enhanced since 1960 by impoundment of the downstream reach to create Stoughton Pond. This segment is a key sediment attenuation area, and is a Very High priority for river corridor protection (Section 6.1, Table 14).

## 6.9 Mitigating Point Sources of Increased Stormwater and Sediment Loading

There are opportunities to improve management of stormwater runoff and reduce erosion along road ditches and at culvert outlets. Road maintenance practices to mitigate for stormwater and sediment runoff may include: stabilization of road surfaces (different gravel materials), improvement of roadside ditches (excavation, stone lining and/or seeding and mulching), alternative grading practices (turnouts, check-basins); re-orientation of culvert crossings; protection of culvert headers; and gully stabilization. Technical and financial resources are available to the towns through the Better Back Roads program (Northern Vermont Resource Conservation and Development Council) as well as the VT Department of Transportation.

Specifically, the following projects are recommended:

- Evaluate the geomorphic condition of the Coleman Brook watershed (draining to Branch Brook M36T4.01) with a focus on possible impacts of stormwater runoff (see Section 6.4 and Appendix E).

- Evaluate and mitigate potential sources of sediment to M35 via a RB culvert under Route 103.

- Evaluate and mitigate stormwater runoff from the commercial parking lot in Ludlow that appears to be associated with development of gully erosion and sedimentation to reach M34 of the Black River main stem (see Section 5.1.2 and Appendix E).

- Conduct a geomorphic assessment of the Jewell Brook (M33T3) which joins the Black River at the upstream end of reach M33; a large depositional bar of cobbles and gravels is evident at the confluence suggesting Jewell Brook is an ongoing source of sediment to the Black River.

- Evaluate and mitigate stormwater runoff and sources of sediment to the unnamed, ephemeral tributary that drains steep slopes along Commonwealth Avenue to the north of Ludlow village and joins the Black River main stem in segment M33-B between the Main Street and Mill Street bridge crossings (see Appendix E).

- Evaluate the geomorphic condition of the RB tributary (M32S1) that joins the Black River main stem in segment M32-C just downstream of the Ludlow wastewater treatment facility. A tributary confluence bar was noted, and a 500-ft section of this tributary just upstream of the confluence appeared overwidened, with large, steep-faced depositional bars.

- Evaluate the geomorphic condition of the Knapp Brook (M15T109S1) that joins the North Branch Black River in reach M15T1.09 near the junction of Felchville Gulf Road and Route 106. A tributary confluence bar was noted. The Knapp Brook is bermed along both banks just above the confluence, and there are many occurrences of stormwater runoff from the Felchville Gulf Road along more than a mile of this tributary.

## 6.10 Restoration of Channel-Contiguous Wetlands

Three potential wetland restoration projects have been identified along the study reaches:

- Restoration of prior-converted wetlands along North Branch reaches M15T1.06 and M15T1.05 in Weathersfield (see Section 5.1.1, Figure 14) (High Priority);
- Restoration of prior-converted wetlands along Twentymile Stream reaches M26T2.08, M26T2.07, and M26T2.06-C in Cavendish (see Section 5.1.1, Figure 15) (High Priority); and
- Restoration of channel-contiguous wetlands that have been partially converted to hay production along the downstream half of Twentymile Stream reach M26T2.09 in Cavendish (Figure 32). Given the relatively small size, this wetland restoration project is identified as a Moderate priority.

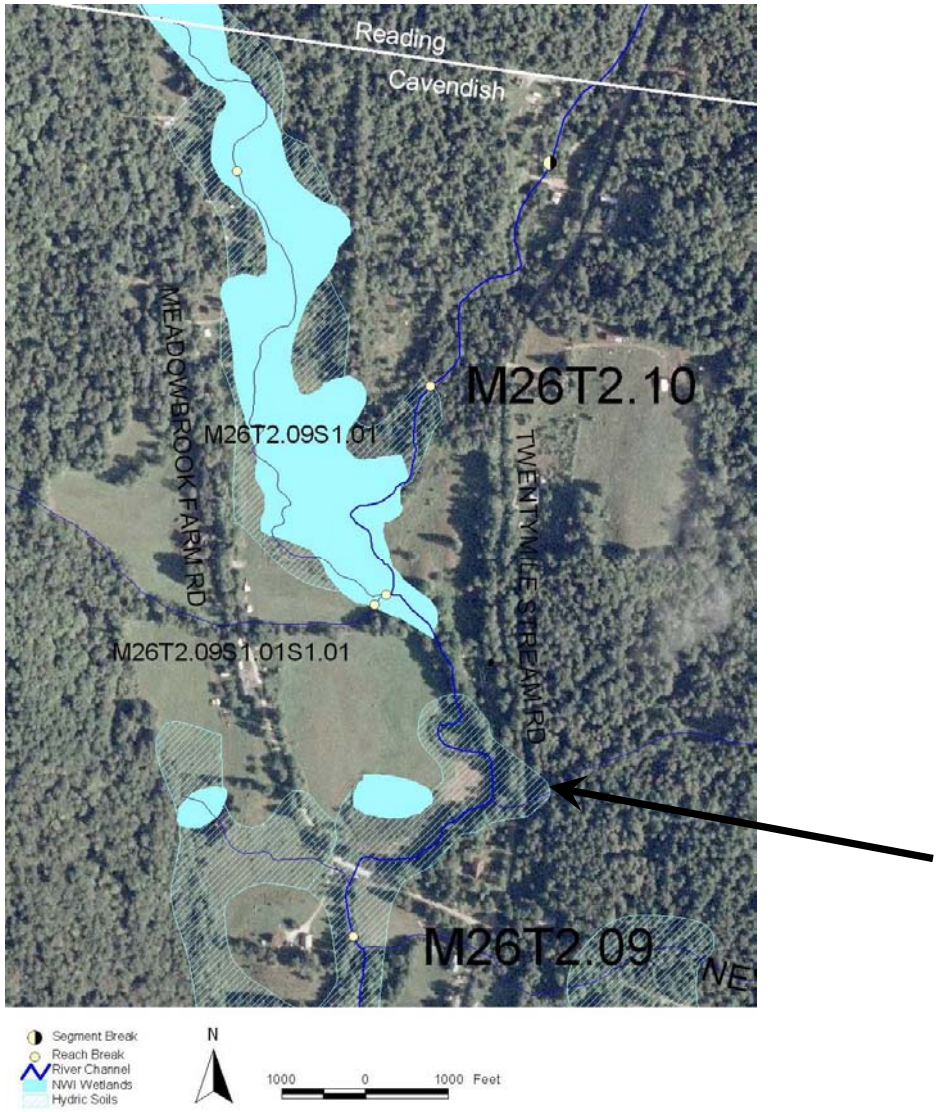



***Figure 32. Potential channel-contiguous wetland restoration site along Twentymile Stream reach M26T2.09 in Cavendish.*** *(Moderate Priority) (See arrow).*

# 7.0 WATERSHED-LEVEL MANAGEMENT STRATEGIES

The following sections identify watershed-level management strategies that should be undertaken to reduce potential for future fluvial erosion hazards, achieve nutrient / sediment reductions, and restore and conserve riparian habitats. Watershed-level management strategies are a combination of regulatory and nonregulatory approaches. Since the study reaches cross town boundaries, and many issues of river corridor management are shared by the watershed towns, efficiency can be gained by inter-town cooperation for certain education and outreach tasks. To facilitate the watershed-level strategies discussed below, as well as the relevant site-specific projects recommended in Section 6, towns should include the appropriate enabling language in next updates to the their respective Town Plans.

## 7.1 Town Planning incorporating river corridors

A river in dynamic equilibrium, connected to its floodplain, with a naturally-vegetated corridor can serve many important services for a community, namely:

- Flow attenuation to reduce the peak and intensity of downstream floods;
- Sediment storage, in river meanders, the floodplain, and in riparian wetlands and flood chutes;
- Attenuation, transformation, and uptake of nutrients such as phosphorus and nitrates in riparian wetlands and the floodplain;
- Diversity of channel bedforms and riparian landforms (pools, riffles, eddies, connected wetlands) which help to regulate water temperatures and provide habitat and refuge areas for riparian and aquatic species;
- Improved filtering and treatment of particulates and contaminants in storm flows; and
- Increased recharge to groundwater (which in turn supports the community with drinking and process water, and which increases base flows of the river during drought conditions).

When the river and floodplain are supported through corridor protection and management, the community can achieve the goals of: (1) reduced fluvial erosion hazards; (2) improved water quality; and (3) improved aquatic and riparian habitats.

A river corridor management area that acknowledges the dynamic nature of rivers and which is based on the geomorphic condition of the channel has advantages over a simple, no-build setback from the river. River channels vary in width along their length, depending on the size and nature of the upstream watershed draining to a given location, and the valley setting of the channel. Rivers are also continuously adjusting their position in the landscape, both vertically and laterally, in an attempt to optimize their slope and channel dimensions to efficiently carry the water and sediment loads supplied from the upstream watershed. A default setback is often inadequate and can be difficult to administer where a river is adjusting laterally at a rate of several feet per year.

A river corridor is a footprint in the landscape, which encompasses the dynamically-adjusting river channel. The corridor varies in width along its length, accounting for the actual width of the river channel at various locations, the size and nature of the watershed draining to that particular reach, the sensitivity of the reach (Section 5.2), knowledge of historic migration patterns of the river, and the position of the valley walls adjacent to the channel.

A river corridor overlay district with the objective of supporting dynamic equilibrium can be developed along the Black River and major tributaries for the towns of Ludlow, Cavendish, Reading and Weathersfield. Generally speaking, this corridor delineation method relies on the meander belt-width concept as outlined in various guidance documents from VTANR (for example, see VTANR, 2008a; VTANR, 2008b).

**Definitions**

**Setback** – a specified distance perpendicular to a channel or waterbody, in which specific standards are established concerning structures, land use activities, and/or vegetative conditions. For example, setbacks could be established to prevent new structures adjacent to waterways. While new structures would not be allowed, the area of land within the setback could be considered to count toward density requirements under zoning.

**Buffer** – zone of undisturbed natural vegetation alongside a channel or waterbody, in which no new structures are permitted, and disturbance of the natural land surface is minimized. The vegetated buffer represents a transition zone which functions to protect the waterway from disturbances and adjacent land uses. Buffers can be established at a default distance perpendicular to the channel or waterbody. Ideally, for rivers and streams, buffer distances should be informed by geomorphic assessments, and will be wider for adjusting reaches, narrower for stable reaches (e.g., following VTANR Riparian Buffer Guidance).

**Overlay District** – an area of variable size and width surrounding a channel or waterbody, in which specific standards are established concerning structures, land use activities, and/or vegetative conditions. Overlay Districts are informed by geomorphic assessments and developed to meet specific functions, such as reducing streambank erosion losses and reducing sediment and nutrient loading to receiving waters by managing toward the equilibrium channel.

A meander belt is defined by connecting the outside point of meander bends along the left and right banks of a channel. In a river system in dynamic equilibrium that has not been subjected to intensive floodplain encroachment and channel management, the meanders will theoretically have full expression, and connecting the outside points of each meander will approximate a minimum area through which the river channel can be expected to migrate laterally and longitudinally.

Since many of Vermont's streams have been channelized and straightened with the meanders removed or significantly reduced in amplitude, connecting the points at the outside edge of these straightened meanders would result in a narrow "meander belt" that was insufficient in width to represent a minimum area of likely future adjustments. Therefore, Vermont guidance calls for a meander belt width to be buffered at a specified distance off a meander center line (or stream center line). The meander center line, is a line connecting each successive meander cross-over point, proceeding down-valley (see VTANR guidance documents for more detailed explanation).

The distance buffered off the meander center line is determined (1) by the approximate channel width in the reach, and (2) by the present geomorphic condition and sensitivity of that reach to further adjustments. Channel widths and sensitivity ratings are determined during Phase 1 and Phase 2 Stream Geomorphic Assessments. The Sensitivity ranking (from Very Low to Extreme) is dependent on the stream type (e.g., steep, narrow channels in mountainous settings versus shallow, meandering channels in broader valley settings) and the geomorphic condition of the reach (Reference, Minor Adjustment, Major Adjustment, Stream Type Departure). Further details are provided in the Phase 1 and 2 Stream Geomorphic Assessment protocols (VTANR, 2007a).

Depending on the Sensitivity rating, a channel is buffered to varying widths, which increase with increasing sensitivity (Table 17).

***Table 17. Meander Belt Width Dimensions based on Geomorphic Sensitivity***

| Sensitivity | Meander Belt Width, based on reference channel width |
|---|---|
| Very Low | Equal to the reference channel width |
| Low | Two (2) channel widths |
| Moderate | Four (4) channel widths |
| High | Six (6) channel widths<br>Eight (8) channel widths for E stream types |
| Very High | Six (6) channel widths<br>Eight (8) channel widths for E stream types |
| Extreme | Six (6) channel widths<br>Eight (8) channel widths for D & E stream types |

*Reference: River Corridor Protection Guide*
VT Agency of Natural Resources, 2008 November

The process of corridor delineation in GIS, as prescribed in VTANR protocols, will identify where the above meander belt width impinges on a valley wall. In those cases, the meander belt width is clipped to the valley wall and the clipped area is re-distributed to the opposite side of the channel (where available). In some cases, the valley walls are so narrowly-confining, that the full dimension of the meander belt width is not expressed, and the corridor width may become defined by the left and right valley walls.

This meander-belt-width-based river corridor, is designed as a minimum set-aside area within which the river can freely meander and adjust both laterally and vertically to maintain and/or re-establish connection with its floodplain and maintain and/or move toward a condition of dynamic equilibrium – with the expectation that setting aside this area will reduce fluvial erosion hazards (and also improve water quality and improve riparian and instream habitats) over the long term.

If a community(ies) adopts a regulatory approach to corridor protection, this meander-belt-width-based river corridor can serve as

- a minimum set-aside area within which the community has decided it will no longer invest public resources to manage the channel (for example, through stream bank armoring, channelization, dredging, etc.) except where existing public (and possibly private) development warrants protection; and consequently:
- a minimum set-aside area within which the community will discourage new development so as to avoid future conflicts with an adjusting river, avoid future personal and property losses, and reduce future costs to the town associated with repeated, unsustainable channel management that would undoubtedly be required to protect new development if it were to be allowed in this set-aside area.

Black River watershed communities may opt to develop Fluvial Erosion Hazard corridors following VTANR guidance (2008), and based in part on the geomorphic data summarized in this report. The following specific recommendations are offered with regard to fluvial erosion hazard corridor development based on the Phase 2 assessment results for the Black River main stem and tributary reaches. (This is not necessarily a complete listing, and does not constitute a comprehensive review of fluvial erosion hazards in the study area).

1) In four segments classified as an E stream type, the bankfull width measured in Phase 2 was substituted for the reference channel width in the Phase 1 database, at the request of the River Management Section during the QA review process (see Appendix C). This substitution was

conducted since the VT Regional Hydraulic Geometry Data (VTDEC, 2006) are based largely on C stream types (and some Bc and B stream types) and tend to overestimate channel widths for E stream types which are typically narrower and deeper. Thus, although E stream types (with High to Extreme Sensitivity) are buffered at eight channel widths (see Table 17 above), the overall corridor dimension ends up being similar to that of a C stream type buffered at six times the channel width – since the bankfull width of C streams tends to be larger than E streams.

| | Use of Curve-predicted Width (a) | | Use of Phase 2 Measured Width (c) | |
|---|---|---|---|---|
| Reach/ Segment | Channel Width (ft) | Corridor Dimension (ft) of E stream at 8 times channel width (b) | Channel Width (ft) | Corridor Dimension (ft) of E stream at 8 times channel width (b) |
| M26T2.06-A High sensitivity | 38 | 304 | 28.8 | 230 |
| M15T1.06-B Extreme | 49.9 | 399 | 41.4 | 331 |
| M15T1.06-A Extreme | 49.9 | 399 | 41.3 | 330 |
| M15T1.05 Extreme | 52.9 | 423 | 41.0 | 328 |

(a) VTDEC, 2006 Regional Hydraulic Geometry Curve data based on C and some B stream types.
(b) River Corridor Protection Guide, 12 Nov. 2008 draft
(c) Measured during Phase 2 assessments, summer 2008 (this study)

2) **M37-B** – The valley walls for purposes of defining the Phase 2 stream type and degree of departure from reference stream type are delineated along the approximate position of a high glacial-fluvial terrace on either side of the channel – generally at heights above 3 times the bankfull depth and generally within 1.8 to 3 times the channel width. Sediments comprising these terraces are mapped as containing sands, gravels, and cobbles. It is expected that they would be relatively non-cohesive, unconsolidated, and therefore susceptible to channel widening and planform adjustment. The degree to which these terraces will serve as a constraint to lateral channel migration is uncertain based on currently available data. This segment ranked in "Fair" condition, with a "Very High" sensitivity. As such, a meander-belt-width-based corridor would be buffered at six times the channel width according to VTANR guidance. However, if the Phase 2 valley walls were incorporated as is, this buffer would be clipped to the valley wall and would therefore range from 2 to 6 times the channel width. It may be important to delineate and utilize a "FEH valley wall" further away from the channel at the contact between the glaciofluvial sediments and till. This would allow for a greater degree of protection for this segment from fluvial erosion hazards. An alternate approach would be to consider some magnitude of setback from the Phase 2 valley wall to protect against landslide hazards along these terrace faces (further discussion of the valley walls is provided in Appendix H).

3) **M26T2.05** – The mapping of valley walls in this reach – particularly in vicinity of the Heald Road crossing – is uncertain. See notes in Appendix E (page 50) and in Appendix C (page 23-24) for further clarification.

4) **M15T1.11** - At the segment break between Segment C and B, the channel takes a sharp turn to the southeast. The elevation of the upstream bedrock channel at this point relative to the LB, as well as the somewhat undersized width of the downstream channel, suggest that an avulsion is possible during times of high flood stage that would direct flows across Niagara St and into the

village area of Felchville. National Climatic Data Center records and anecdotal evidence indicate this location and the Route 106 crossing are sites of past ice jam flooding. A river corridor delineated following VTANR protocols might not necessarily capture this risk of break-out flooding or associated erosion hazards

5) **M15T1.08** – is located in a setting where the Phase 2 valley wall – if used to delineate an FEH corridor – would clip the sensitivity-buffered corridor to something less than what the sensitivity rating would define in absence of the valley-wall clipping. These terraces appear to be comprised of materials that may offer greater boundary resistance and incorporate more exposed bedrock than in the M37-B case. However, parties involved in FEH delineation should be aware of the nature of this setting. Landslide protection may be warranted.

6) **M19** - It should be noted that the prescribed width of the meander-belt-width-based corridor does not fully encompass the area of the floodplain which experienced significant fluvial erosion (and inundation) in the 1973 flood. Adjustments to the FEH corridor would be advised to capture these active river areas.

## 7.2 Buffers for waterways not covered by Phase 2 Assessments

Beyond the 23.5 miles of channel assessed as part of this study, several additional miles of tributaries exist in the watershed towns. Often, these tributaries are small enough in size that geomorphic assessment is either not practical or affordable in the near term. Yet, protection of these smaller tributaries from encroachment, channelization, dredging, berming and other impacts is critical to the overall watershed goals of mitigating for increased flows and sediment loading. While impacts to any one small tributary may be small in degree, impacts to several small-order tributaries can accumulate in the watershed to result in significant impacts to the Black River and major tributaries.

For maximum protection of surface waters, towns can implement a combined approach of corridor protection for larger waterways, and a default buffer for smaller channels. A minimal 50-foot setback maintained with natural vegetation (i.e., a buffer) is recommended by the VT Agency of Natural Resources for channels with upstream drainage areas equal to or less than 2 square miles (VTANR, 2008a).

## 7.3 Additional Planning / Zoning Strategies to Mitigate Stormwater / Sediment Impacts

Towns can consider a variety of additional planning and zoning strategies to reduce stormwater and sediment runoff to the Black River and its tributaries, such as:

- Implement Low Impact Development techniques:
    - Establish or Increase Minimum Lot Sizes
    - Establish or Reduce Maximum Lot Coverages / Minimize Percent Impervious
    - Minimize land disturbance / compaction during construction
    - Prevent stormwater outfalls from crossing vegetated buffers and entering rivers and streams without treatment or energy dissipation.
    - Specify maximum road and driveway widths.
    - Review parking space ratios for minimum impacts.

- Incorporate practices for area-based zoning, transfer-of-development rights and clustering into zoning and subdivision regulations to encourage protection of river corridors.

- Add relevant language to zoning and subdivision regulations for protection against fluvial erosion hazards – Special Flood Hazard Area regulations established for floodways defined on FEMA-FIRM maps are designed to protect against inundation (rising water) flooding. These practices do not necessarily adequately protect against erosion hazards (or sudden streambank erosion, avulsion) during flooding events.

- Consider forested (vegetative) buffers and erosion control along tributaries and unnamed streams that are not covered by corridor plans and/or Fluvial Erosion Hazard overlay districts.

- Consider local-level stormwater ordinances for development projects that fall under the thresholds for triggering Act 250 review or the States Stormwater Management rule.

- Consider local road & driveway and bridge & culvert ordinances or review standards.

- Continue improved road maintenance practices to mitigate for stormwater and sediment runoff, including: stabilization of road surfaces (different gravel materials), improvement of roadside ditches (excavation, stone lining and/or seeding and mulching), alternative grading practices (turnouts, check-basins); re-orientation of culvert crossings; and culvert header protection.

## 7.4 Maintenance and Replacement of Crossing Structures

Undersized bridge crossing structures were identified as contributors to localized channel instabilities in the assessed reaches (Section 6.6.1). Similar conditions likely exist at crossings sites dispersed throughout the watershed on smaller tributaries that ultimately drain to these reaches.

Additional watershed-wide and town-scale strategies for installation and maintenance of bridge and culvert structures should be considered. The watershed towns could establish ordinances or identify zoning requirements which would ensure adherence to proper siting and design practices for bridge and culvert crossings. The geomorphic context should be considered when designing new and rehabilitated structures within the watershed:

- New or replacement bridges and culverts should ideally have openings which pass the bankfull width without constriction.

- Bridges and culverts should be designed to cross the river without creating channel approaches at an angle to structures. Such sharp angles can lead to undermining of fill materials and structural components.

- The historic channel migration pattern of the river should be considered when installing new or replacement crossing structures (and when constructing new roads, driveways, and buildings). Corridor protection strategies that prevent or limit placement of infrastructure within the corridor will protect structures from future erosion and flood losses.

- Planned build-out for watershed communities and resultant channel enlargement (from increased percent imperviousness) should be considered when designing new or replacement bridges and crossing structures.

- Road ditch runoff should be diverted to side-slopes where energy can be dissipated, stormwaters can infiltrate, and sediment / detritus loads can be deposited on the land and not directly to streams.

# 8.0 REFERENCES

Army Corps of Engineers, 2007, *North Springfield Lake, General Information*. Available at http://www.nae.usace.army.mil/recreati/nsl/nslgen.htm; downloaded 1 June 2007.

Beers, F. W., 1869, Atlas of Windsor Co., Vermont. New York, NY: F. W. Beers, A. D. Ellis & C.G. Soule.

Bierman, Paul, Andrea Lini, Paul Zehfuss, Amy Church, 1997, *Postglacial Ponds and Alluvial Fans: Recorders of Holocene Landscape History*. GSA Today, vol. 7, no. 10.

Black River Tribune, 1991 (Jan 30), and 1990 (Jan 17), Ludlow Past and Present articles reviewed at Black River Academy Museum and Historical Society, Ludlow, Vermont.

Bodin, Madeline, 2005, "Vermont Be Dammed" appearing 14 August in the *Hartford Courant*, obtained online at http://www.courant.com/

Brakenride, G. Robert, Peter A. Thomas, Laura E. Conkey, Jane C. Schiferle, 1988. *Fluvial Sedimentation in Response to Postglacial Uplift and Environmental Change, Missisquoi River, Vermont*. Quaternary Research, vol. 30, p.190-203.

Chace, J., Jr., 1854, Map of Rutland County, Vermont. Philadelphia, PA: James D. Scott, Publishers.

Child, 1884, *Gazetteer and Business Directory of Windsor County, Vermont: Town of Ludlow*. Syracuse, NY.

Cold Regions Research and Engineering Laboratory, 2007, Ice Jam Database, maintained by the Ice Engineering Research Group, Hanover, NH. Accessed online at: www.crrel.usace.army.mil/ierd/ijdb/

Fitzgerald, Evan P., 2007, Linking Urbanization to Stream Geomorphology and Biotic Integrity in the Lake Champlain Basin, Vermont. Masters Thesis, University of Vermont, M. Sc. Natural Resources.

Gay, Leon S., 1927, The Vermonter: Black River Valley and Cavendish Flood, Special Edition. Vol. 32, No. 12, White River Junction, VT: Chas. R. Cummings, publisher.

Harris, Joseph Nelson, 1949, History of Ludlow, Vermont. Charlestown, NH: Harding & Harding.

Jenkins, J. and P. Zika, 1985. *The Waterfalls, Cascades and Gorges of Vermont*. VTANR Department of Environmental Conservation and VTANR Department of Forests, Parks, and Recreation.

Karabinos, Paul and James B. Thompson, Jr., 1997, *Basement-cover Relationships in Southern Vermont* , in New England Intercollegiate Geological Conference: Guidebook to Field Trips in Vermont and Adjacent New Hampshire and New York.

Kondolf, G. M., 1997, Hungry Water: Effects of Dams and Gravel Mining on Rivers. Environmental Management, 21 (4) pp 533-551.

Koteff C. and F. D. Larsen, 1989, Postglacial Uplift in Western New England: Geologic Evidence for Delayted Rebound. *In*: Earthquakes at North-Atlantic Passive Margins: Neotectonics and Postglacial Rebound, S. Gregersen and P.W. Basham (Ed.). Kluwer Academic Publishers, pp. 105-123.

Lyndes, E. J. and Theo. Menard, 1927. The Black River's Rampage, 1927: Springfield, Vermont. Springfield, VT: Springfield Post No. 18, American Legion.

Magilligan, Francis J., Keith H. Nislow, and Brian E. Graber, 2003, Scale-independent assessment of discharge reduction and riparian disconnectivity following flow regulation by dams. *Geology*, v. 31, no. 7, pp 569-572.

Magilligan, Francis J. and Keith H. Nislow, 2001, Long-term Changes in Regional Hydrologic Regime Following Impoundment in a Humid-Climate Watershed. Journal of the American Water Resources Association, 37 (6): 1551-1569

Miller, Katherine, 2007, personal communication, riparian landowner along North Branch tributary, Weathersfield, VT.

Minsinger, W. E., 2002, *The 1927 Flood in Vermont and New England: November 3-7, 1927; An Historical and Pictorial Summary*. East Milton, MA: The Blue Hill Meteorological Observatory and Science Center.

Montgomery, D. R. and J. M. Buffington, 1997, Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin, v.109, no. 5, p. 596-611.

National Agricultural Imagery Program (NAIP), 2003, TIFF ortho images obtained from Vermont Center for Geographic Information. http://www.vcgi.org/dataware/products/metadata/naip2003.htm#Technical%20Doc

National Climatic Data Center Storm Event Database, 1996 – 2006, published by the National Oceanic and Atmospheric Administration, Viewed at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, queried on 16 June 2007.

National Weather Service, Burlington Vermont office, 2008, *The Flood of 1927*, available online at: http://www.erh.noaa.gov/btv/events/27flood.shtml

Nicholson, Fred, 10 July 2007, personal interview with Brendan O'Shea. Stream Alteration Engineer, VTDEC Water Quality Division Rutland Regional office.

Okemo Mountain Resort, 2007, "History of Okemo". Website accessed in June 2007 via the internet at: http://www.okemo.com/okemowinter/pressroom/presskit/history.asp

Olson, Scott A., 2002, Flow-Frequency Characteristics of Vermont Streams. USGS Water-Resources Investigations Report 02-4238.

Perkins Landscape Change Program website (http://www.uvm.edu/perkins/landscape)

Ratcliffe, N.M, T. R. Armstrong, and J. N. Aleinikoff, 1997, *Stratigraphy, Geochronology, and Tectonic Evolution of the Basement and Cover Rocks of the Chester and Athens Domes*, in New England Intercollegiate Geological Conference: Guidebook to Field Trips in Vermont and Adjacent New Hampshire and New York.

Ratcliffe, N.M., 1996, Digital bedrock geologic map of the Andover quadrangle, Vermont: USGS Open-File Report 96-31-A, http://maps.anr.state.vt.us/vgisdata/layers_anr/PrePackaged_Shapefiles/GeologicBedrock_BDRK24K/GeologicBedrock_BDRK24K0706.zip

Ratcliffe, N.M., 1995a, Digital bedrock geologic map of the Cavendish quadrangle, Vermont: USGS Open-File Report 95-203, http://maps.anr.state.vt.us/vgisdata/layers_anr/PrePackaged_Shapefiles/GeologicBedrock_BDRK24K/GeologicBedrock_BDRK24K0807.zip

Ratcliffe, N.M., 1995b, Digital bedrock geologic map of the Chester quadrangle, Vermont: USGS Open-File Report 95-576, http://maps.anr.state.vt.us/vgisdata/layers_anr/PrePackaged_Shapefiles/GeologicBedrock_BDRK24K/GeologicBedrock_BDRK24K0806.zip

Ridge, John C., 2003, *The Last Deglaciation of the Northeastern United States: A Combined Varve, Paleomagnetic, and Calibrated $^{14}C$ Chronology*, in Geoarchaeology of Landscapes in the Glaciated Northeast. Cremeens, David L. and Hart, John P, Ed. Albany, NY: New York State Museum Bulletin 497.

Ridge, J. C. 2001, Surficial Geologic Map of Part of the Springfield Quadrangle, Sullivan County, N.H. and Windsor County, VT. New Hampshire Geological Survey Open-File Report, 3 sheets.

Rittenour, T. M., 2007. Glacial Lake Hitchcock. Accessed via the internet at: http://www.bio.umass.edu/biology/conn.river/hitchcock.html

Rosgen, D., 1996, Applied Fluvial Morphology. Wildland Hydrology Books, Pagosa Springs, Co.

Salant, N. L., C. E. Renshaw, and F. J. Magilligan, 2006, Short and long-term changes to bed mobility and bed composition under altered sediment regimes. *Geomorphology*. Vol. 76, pp. 43 – 53.

Sanborn Fire Insurance Maps, 1894, 1905, 1921, 1928 for Ludlow, Vermont.

Schumm, Stanley A., 2005. River Variability and Complexity. New York, NY: Cambridge University Press.

Severson, J. P., 1991, Patterns and causes of 19th and 20th century shoreline changes of the Winooski Delta. University of Vermont, Field Naturalist Program, M.S. Thesis.

South Mountain Research & Consulting, 2007, Phase 1 Stream Geomorphic Assessment: Black River Watershed, Windsor & Rutland Counties, Vermont. Prepared for Southern Windsor County Regional Planning Commission. Available at: http://www.anr.state.vt.us/dec/waterq/rivers/docs/FinalReports/118_P1A.pdf

Stewart, David P., 1975. Geology for environmental planning in the Brattleboro-Windsor region, Vermont. Vermont Geological Survey Environmental Publication #2. Waterbury, Vermont.

Stewart, David P., 1972. Geology for environmental planning in the Rutland-Brandon region, Vermont. Vermont Geological Survey Environmental Publication #7. Waterbury, Vermont.

Stewart, David P. and Paul MacClintock, 1969, *The Surficial Geology and Pleistocene History of Vermont*. Vermont Geological Survey Bulletin No. 31.

Thomas, P. A., 1985, Archeological and geomorphological evaluation; M5000 (3) northern connector material supply/disposal area, Howe Farm flood plain: Burlington, VT: University of Vermont, Department of Anthropology, no. 54, 41 pp.

Thompson, E. H. and E. R. Sorensen, 2000. Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont. The Nature Conservancy and Vermont Department of Fish and Wildlife. University Press of New England.

UNH Climate Change Research Center and Clean Air – Cool Planet, 2005, Indicators of Climate Change in the Northeast, available at: http://www.cleanair-coolplanet.org/information/pdf/indicators.pdf

USDA Natural Resource Conservation Service, 2005, State Data Table Top 20, published by the United States Department of Agriculture, NRCS; available at: ftp://ftp-fc.sc.egov.usda.gov/VT/Soils/top20/

USDA Natural Resource Conservation Service, 1998, Soil Survey Geographic (SSURGO) database for Windsor County, Vermont, available at: http://www.vcgi.org/dataware/default.cfm?layer=GeologicSoils_SO

USGS, 2008, on-line surface water data, <http://waterdata.usgs.gov/vt/nwis>.

USGS, 1990, National Water Summary 1988-89 – Floods and Droughts: State Summaries: Vermont,

USGS, 1929, Ludlow, VT, 15-min. Topographic Quadrangles (obtained from UNH Dimond Library Documents Department & Data Center online at http://docs.unh.edu/nhtopos/Pawlet.htm.

VT Agency of Natural Resources, 2008a, River Corridor Protection Guide: Fluvial Geomorphic-Based Methodology to Reduce Flood Hazards and Protect Water Quality. Available at: http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_RiverCorridorProtectionGuide.pdf

VT Agency of Natural Resources, 2008b, Municipal Guide to Fluvial Erosion Hazard Mitigation. Available at: http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_municipalguide.pdf

VT Agency of Natural Resources, 2007a, Stream Geomorphic Assessment Protocol Handbooks, Remote Sensing and Field Surveys Techniques for Conducting Watershed and Reach Level Assessments. Available at: http://www.vtwaterquality.org/rivers/htm/rv_geoassesspro.htm

VT Agency of Natural Resources, 2007b (11 July draft). *River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects*. Available at: http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rivercorridorguide.pdf

VT Center for Geographic Information, 2005, Vermont Dam Inventory (EmergencyOther_DAMS) viewed 2007 online at: http://www.vcgi.org/metadata/EmergencyOther_DAMS.htm

VT Center for Geographic Information, 2003, Landcover / Landuse for Vermont and Lake Champlain Basin (LandLandcov_LCLU, edition 2003). Source dates of 1991 to 1993. Further details of this land cover / land use data set are available at: http://www.vcgi.org/metadata/LandLandcov_LCLU.htm

VT DEC Water Quality Division, 2006, *Vermont Regional Hydraulic Geometry Curves.*

VT DEC Water Quality Division, 2001, *Vermont Regional Hydraulic Geometry Curves: 2001 Provisional*.

VT DEC Water Quality Division, February 1999, Options for State Flood Control Policies and a Flood Control Program, prepared for the Vermont General Assembly pursuant to Act 137 Section 2 (1998).

VT DEC Water Quality Division, 1976, *Black and Ottauquechee River Water Quality Management Plan*.

VT Environmental Board, 1992, Record of Decision re: Okemo Mountain, Inc. Application #2S0351-12A-EB: Findings of Fact, Conclusions of Law, and Order. Accessed via the internet at: http://www.nrb.state.vt.us/lup/decisions/1992/2s0351-12a-eb-fco.pdf

Wagner, Heindel, & Noyes, 1995, Source Protection Plan: Okemo Gravel Well: Ludlow, VT.

Walsh, G.J., Armstrong, T.R. and Ratcliffe, N.M., 1996, Digital bedrock geologic map of the Vermont part of the 7.5 x 15 minute Mount Ascutney and Springfield quadrangles, Vermont: USGS Open-File Report 96-733, http://maps.anr.state.vt.us/vgisdata/layers_anr/PrePackaged_Shapefiles/GeologicBedrock_BDRK24K/GeologicBedrock_BDRK24K0907.zip

Walsh, G.J., and Ratcliffe, N.M., 1994, Digital bedrock geologic map of the Plymouth quadrangle, Vermont: USGS Open-File Report 94-654, http://maps.anr.state.vt.us/vgisdata/layers_anr/PrePackaged_Shapefiles/GeologicBedrock_BDRK24K/GeologicBedrock_BDRK24K0708.zip

Walsh, G.J., Ratcliffe, N.M., Dudley, J.B., and Merrifield, T., 1994, Digital bedrock geologic map of the Mount Holly and Ludlow quadrangles, Vermont: USGS Open-File Report 94-229, http://maps.anr.state.vt.us/vgisdata/layers_anr/PrePackaged_Shapefiles/GeologicBedrock_BDRK24K/GeologicBedrock_BDRK24K0607.zip

Wheeler, Lois, 1952. History of Cavendish, Vermont. published Proctorsville, VT.

Willey, Dan, 2008, personal communication, riparian landowner along North Branch tributary, Weathersfield, VT.

Williams, G. P. and M. G. Wolman, 1984, *Downstream effects of dams on alluvial rivers*. United States Geological Survey Professional Paper 1286, 83 pp.

# APPENDIX A

## Phase 1 (Updated) and Phase 2 Stream Geomorphic Assessment Reach Summary Reports

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **North Branch Black River** Reach **M15T1.03**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **East side Branch Brook Rd d/s of Route 131 junction**
1.2 Towns: **Weathersfield**
1.3 Downstream Latitude: **43.39**
1.3 Downstream Longitude: **-72.50**

### Step 2. Stream Type

2.1 Elevation Upstream: **530**
2.1 Elevation Downstream: **502**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **5053** feet. **0.96** Miles.
2.3 Valley Slope: **0.55** %
2.4.Channel Length: **5488** feet. **1.04** Miles.
2.5 Channel Slope: **0.51** %
2.6 Sinuosity: **1.09**
2.7 Watershed Area: **29** Square Miles
2.8 Channel Width: **57** feet.
2.9 Valley Width: **555** feet.
2.10 Confinement Ratio: **10**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Ice-Contact 51.0** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Extremely Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **71.0** % |
| Flooding: | **None/Rare** | **52.0** % |
| Water Table Deep: | **3.0** | **43.0** % |
| Water Table Shallow: | **1.5** | **71.0** % |
| Erodibility: | **Moderate** | **40.0** % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from Sept 2008, SMRC

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest 83.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest 61.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **>100** | **26-50** |
| Sub-dominant: | **51-100** | **0-25** |
| Length w/ less than 25 ft.: | **0** | **1014** |

4.4 Ground Water Inputs: **Minimal**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **0** **0** %
5.3 Bank Armoring: **0 %**
Left **25** Right **0.0**
5.4 Channel Straightening: **4222** **76 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **2134** ft. **38 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **2134** ft. | **0.0** | ft. |
| Railroad: | **0.0** ft. | **0.0** | ft. |
| Berm: | **0.0** ft. | **0.0** | ft. |
| Improved Path: | **0.0** ft. | **0.0** | ft. |
| 6.2 Development: | **0.0** ft. | **0.0** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **57.2** Ratio: **1.0**
6.6 Wavelength: **57.2** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **1,200.78 ft.**
7.2 Bank Height: **3.80 ft.**
7.3 Ice/Debris Jam Potential: **Debris**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 1 Low | 0 N.S. | 0 N.S. | 0 N.S. | 2 High | 0 N.S. | 2 High | 0 N.S. | 1 Low | 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 15 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **North Branch Black River** Reach **M15T1.05**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Wetland reach from Little Ascutney Rd crossing d/s to Amsden Falls**
1.2 Towns: **Weathersfield**
1.3 Downstream Latitude: **43.41**
1.3 Downstream Longitude: **-72.51**

### Step 2. Stream Type

2.1 Elevation Upstream: **595**
2.1 Elevation Downstream: **590**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **4953** feet. **0.94** Miles.
2.3 Valley Slope: **0.10** %
2.4.Channel Length: **6365** feet. **1.21** Miles.
2.5 Channel Slope: **0.08** %
2.6 Sinuosity: **1.29**
2.7 Watershed Area: **24** Square Miles
2.8 Channel Width: **41** feet.
2.9 Valley Width: **1,830** feet.
2.10 Confinement Ratio: **45**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **E**
Bedform: **Dune-Ripple**
Sub-class Slope: **None**
Bed Material: **Sand**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **99.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Hilly**
3.4 Right Valley Side **Very Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **C** | **96.0** % |
| Flooding: | **Frequent** | **97.0** % |
| Water Table Deep: | **1.5** | **96.0** % |
| Water Table Shallow: | **0.0** | **97.0** % |
| Erodibility: | | **0.0** % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from June 2008, SMRC. Measured channel width from Phase 2 assessment of this E stream type substituted in Step 2.8 for the channel

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **85.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **59.0** %
Current Sub-Dominant Land Cover: **Wetland**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **>100** | **>100** |
| Length w/ less than 25 ft.: | **4065** | **3226** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **2** **3** %
5.3 Bank Armoring: **6 %**
Left **135** Right **256**
5.4 Channel Straightening: **2729** **42 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **425** ft. **6 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **425** ft. | **0.0** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **0.0** ft. | **0.0** ft. |
| Improved Path: | **0.0** ft. | **0.0** ft. |
| 6.2 Development: | **182.2** ft. | **110** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Migration**
6.5 Meander Width: **123.0** Ratio: **3.0**
6.6 Wavelength: **283.0** Ratio: **6.9**

### Step 7. Windshield Survey

7.1 Bank Erosion: **3,792.97 ft.**
7.2 Bank Height: **7.44 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 1 Low | 2 High | 2 High | 1 Low | 0 N.S. | 2 High | 1 Low | 1 Low | 1 Low | 0 N.S. | 1 Low | 17 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **North Branch Black River** Reach **M15T1.06**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Along east side Route 106 u/s of LIttle Ascutney Rd**
1.2 Towns: **Weathersfield**
1.3 Downstream Latitude: **43.42**
1.3 Downstream Longitude: **-72.52**

### Step 2. Stream Type

2.1 Elevation Upstream: **600**
2.1 Elevation Downstream: **595**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **5289** feet. **1.00** Miles.
2.3 Valley Slope: **0.09** %
2.4.Channel Length: **6547** feet. **1.24** Miles.
2.5 Channel Slope: **0.08** %
2.6 Sinuosity: **1.24**
2.7 Watershed Area: **21** Square Miles
2.8 Channel Width: **41** feet.
2.9 Valley Width: **1,299** feet.
2.10 Confinement Ratio: **31**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **E**
Bedform: **Dune-Ripple**
Sub-class Slope: **None**
Bed Material: **Sand**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **92.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Very Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **C** | **73.0** % |
| Flooding: | **Frequent** | **72.0** % |
| Water Table Deep: | **1.5** | **72.0** % |
| Water Table Shallow: | **0.0** | **72.0** % |
| Erodibility: | **slight** | **6.0** % |

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **85.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **30.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **>100** | **26-50** |
| Length w/ less than 25 ft.: | **4075** | **5063** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **0** **0** %
5.3 Bank Armoring: **7 %**
Left **199** Right **304**
5.4 Channel Straightening: **4155** **63 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **531** ft. **8 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **531** ft. | **0.0** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **0.0** ft. | **0.0** ft. |
| Improved Path: | **0.0** ft. | **0.0** ft. |
| 6.2 Development: | **54** ft. | **0.0** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **138.0** Ratio: **3.3**
6.6 Wavelength: **293.0** Ratio: **7.1**

### Step 7. Windshield Survey

7.1 Bank Erosion: **5,592.80 ft.**
7.2 Bank Height: **7.12 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from June & Nov 2008, SMRC. Measured channel width from Phase 2 assessment of this E stream type substituted in

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 1 Low | 2 High | 2 High | 1 Low | 0 N.S. | 2 High | 2 High | 1 Low | 1 Low | 0 N.S. | 1 Low | 18 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **North Branch Black River** Reach **M15T1.07**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From Ascutney Basin Rd to east valley wall**
1.2 Towns: **Weathersfield**
1.3 Downstream Latitude: **43.43**
1.3 Downstream Longitude: **-72.52**

### Step 2. Stream Type

2.1 Elevation Upstream: **610**
2.1 Elevation Downstream: **600**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1880** feet. **0.36** Miles.
2.3 Valley Slope: **0.53** %
2.4.Channel Length: **2740** feet. **0.52** Miles.
2.5 Channel Slope: **0.36** %
2.6 Sinuosity: **1.46**
2.7 Watershed Area: **18** Square Miles
2.8 Channel Width: **47** feet.
2.9 Valley Width: **2,190** feet.
2.10 Confinement Ratio: **46**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **96.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Extremely Steep**
*3.5 Soils*

| | | | |
|---|---|---|---|
| Hydrologic Group: | **B** | **96.0** | % |
| Flooding: | **Occasional** | **96.0** | % |
| Water Table Deep: | **3.0** | **96.0** | % |
| Water Table Shallow: | **1.5** | **96.0** | % |
| Erodibility: | **slight** | **3.0** | % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from June 2008, SMRC

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **85.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Field** **39.0** %
Current Sub-Dominant Land Cover: **Forest**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **None** | **None** |
| Length w/ less than 25 ft.: | **2384** | **2348** |

4.4 Ground Water Inputs: **None**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **0** **0** %
5.3 Bank Armoring: **32 %**
Left **556** Right **324**
5.4 Channel Straightening: **1414** **51 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **1169** ft. **42 %**

| | One Side | | Both Sides | |
|---|---|---|---|---|
| Road: | **0.0** | ft. | **0.0** | ft. |
| Railroad: | **0.0** | ft. | **0.0** | ft. |
| Berm: | **945** | ft. | **224** | ft. |
| Improved Path: | **0.0** | ft. | **0.0** | ft. |
| 6.2 Development: | **0.0** | ft. | **0.0** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **184.0** Ratio: **3.9**
6.6 Wavelength: **557.0** Ratio: **11.8**

### Step 7. Windshield Survey

7.1 Bank Erosion: **1,935.40 ft.**
7.2 Bank Height: **2.92 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 2 High | 2 High | 2 High | 2 High | 0 N.S. | 2 High | 2 High | 1 Low | 0 N.S. | 1 Low | 2 High | 21 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **North Branch Black River** Reach **M15T1.08**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **East side Route 106 u/s of Ascutney Basin Rd**
1.2 Towns: **Weathersfield**
1.3 Downstream Latitude: **43.43**
1.3 Downstream Longitude: **-72.53**

### Step 2. Stream Type

2.1 Elevation Upstream: **640**
2.1 Elevation Downstream: **610**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2480** feet. **0.47** Miles.
2.3 Valley Slope: **1.21** %
2.4.Channel Length: **2488** feet. **0.47** Miles.
2.5 Channel Slope: **1.21** %
2.6 Sinuosity: **1.00**
2.7 Watershed Area: **18** Square Miles
2.8 Channel Width: **47** feet.
2.9 Valley Width: **375** feet.
2.10 Confinement Ratio: **8**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Ledge**
3.3 Dominant Geologic Mat.: **Ice-Contact 66.0** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Hilly**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **A** | **62.0** % |
| Flooding: | **None/Rare** | **72.0** % |
| Water Table Deep: | **6.0** | **68.0** % |
| Water Table Shallow: | **6.0** | **68.0** % |
| Erodibility: | **Severe** | **67.0** % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from June 2008, SMRC

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **85.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **29.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **>100** | **None** |
| Length w/ less than 25 ft.: | **1546** | **2183** |

4.4 Ground Water Inputs: **Minimal**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **2** **6** %
5.3 Bank Armoring: **32 %**
Left **361** Right **450**
5.4 Channel Straightening: **2141** **86 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **2042** ft. **82 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **712.5** ft. | **417.9** | ft. |
| Railroad: | **0.0** ft. | **0.0** | ft. |
| Berm: | **0.0** ft. | **189** | ft. |
| Improved Path: | **722** ft. | **0.0** | ft. |
| 6.2 Development: | **436** ft. | **97** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **47.1** Ratio: **1.0**
6.6 Wavelength: **47.1** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **280.52 ft.**
7.2 Bank Height: **2.68 ft.**
7.3 Ice/Debris Jam Potential: **Bridge**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 2 High | 2 High | 2 High | 2 High | 2 High | 0 N.S. | 1 Low | 2 High | 2 High | 0 N.S. | 2 High | 23 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **North Branch Black River** Reach **M15T1.09**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Downstream from Knapp Brook confluence**
1.2 Towns: **Cavendish, Reading, Weathersfield**
1.3 Downstream Latitude: **43.44**
1.3 Downstream Longitude: **-72.53**

### Step 2. Stream Type

2.1 Elevation Upstream: **690**
2.1 Elevation Downstream: **640**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3502** feet. **0.66** Miles.
2.3 Valley Slope: **1.43** %
2.4.Channel Length: **3664** feet. **0.69** Miles.
2.5 Channel Slope: **1.36** %
2.6 Sinuosity: **1.05**
2.7 Watershed Area: **18** Square Miles
2.8 Channel Width: **47** feet.
2.9 Valley Width: **370** feet.
2.10 Confinement Ratio: **8**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Waterfall**
3.3 Dominant Geologic Mat.: **Ice-Contact 85.0** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Very Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **93.0** % |
| Flooding: | **None/Rare** | **91.0** % |
| Water Table Deep: | **2.5** | **82.0** % |
| Water Table Shallow: | **1.5** | **90.0** % |
| Erodibility: | **slight** | **7.0** % |

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest 86.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest 44.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **>100** | **0-25** |
| Sub-dominant: | **0-25** | **26-50** |
| Length w/ less than 25 ft.: | **1096** | **3325** |

4.4 Ground Water Inputs: **Minimal**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **55 %**
Left **832** Right **1186**
5.4 Channel Straightening: **951** **25 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **2701** ft. **73 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **2101** ft. | **0.0** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **56.5** ft. | **0.0** ft. |
| Improved Path: | **543** ft. | **0.0** ft. |
| 6.2 Development: | **1067** ft. | **0.0** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration:
6.5 Meander Width: **46.7** Ratio: **1.0**
6.6 Wavelength: **46.7** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **423.59 ft.**
7.2 Bank Height: **3.87 ft.**
7.3 Ice/Debris Jam Potential: **Bridge**

7.4 Comments:

Possible Ice jam evidence within the reach (see Appendix O of Phase 1 report).
Updated Dec 2008 with Phase 2 field-based observations from Sept 2008, SMRC

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 2 High | 2 High | 0 N.S. | 2 High | 2 High | 1 Low | 0 N.S. | 2 High | 2 High | 0 N.S. | 1 Low | 19 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **North Branch Black River** Reach **M15T1.10**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From vicinity Route 106 crossing at Felchville, d/s to Knapp Brook**
1.2 Towns: **Reading**
1.3 Downstream Latitude: **43.45**
1.3 Downstream Longitude: **-72.53**

### Step 2. Stream Type

2.1 Elevation Upstream: **710**
2.1 Elevation Downstream: **690**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2020** feet. **0.38** Miles.
2.3 Valley Slope: **0.99** %
2.4.Channel Length: **2400** feet. **0.45** Miles.
2.5 Channel Slope: **0.83** %
2.6 Sinuosity: **1.19**
2.7 Watershed Area: **12** Square Miles
2.8 Channel Width: **39** feet.
2.9 Valley Width: **757** feet.
2.10 Confinement Ratio: **19**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **89.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Extremely Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **99.0** % |
| Flooding: | **Occasional** | **89.0** % |
| Water Table Deep: | **3.0** | **89.0** % |
| Water Table Shallow: | **1.5** | **99.0** % |
| Erodibility: | | **0.0** % |

7.4 Comments:

Likely Ice jam evidence within the reach (see Appendix O, Phase 1 report).
Updated Dec 2008 with Phase 2 field-based observations from August 2008, SMRC.

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **85.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **25.0** %
Current Sub-Dominant Land Cover: **Field**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **None** | **None** |
| Length w/ less than 25 ft.: | **2334** | **2337** |

4.4 Ground Water Inputs: **Minimal**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **4** %
5.3 Bank Armoring: **17 %**
Left **0.0** Right **408**
5.4 Channel Straightening: **2269** **94 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **2316** ft. **96 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **219** ft. | **0.0** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **116** ft. | **1980** ft. |
| Improved Path: | **0.0** ft. | **0.0** ft. |
| 6.2 Development: | **0.0** ft. | **30.0** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **39.3** Ratio: **1.0**
6.6 Wavelength: **39.3** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **877.55 ft.**
7.2 Bank Height: **4.03 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 1 Low | 2 High | 2 High | 2 High | 0 N.S. | 1 Low | 1 Low | 2 High | 2 High | 1 Low | 2 High | 21 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **North Branch Black River** Reach **M15T1.11**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Short, steep reach w/ bedrock falls southwest of Felchville village**
1.2 Towns: **Reading**
1.3 Downstream Latitude: **43.45**
1.3 Downstream Longitude: **-72.54**

### Step 2. Stream Type

2.1 Elevation Upstream: **760**
2.1 Elevation Downstream: **710**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1130** feet. **0.21** Miles.
2.3 Valley Slope: **4.42** %
2.4.Channel Length: **1138** feet. **0.22** Miles.
2.5 Channel Slope: **4.39** %
2.6 Sinuosity: **1.01**
2.7 Watershed Area: **12** Square Miles
2.8 Channel Width: **39** feet.
2.9 Valley Width: **370** feet.
2.10 Confinement Ratio: **10**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **b**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **Waterfall**
3.3 Dominant Geologic Mat.: **Alluvial** **44.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Hilly**
3.4 Right Valley Side **Very Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **58.0** % |
| Flooding: | **None/Rare** | **55.0** % |
| Water Table Deep: | **3.0** | **44.0** % |
| Water Table Shallow: | **1.5** | **45.0** % |
| Erodibility: | **slight** | **21.0** % |

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **86.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Urban** **75.0** %
Current Sub-Dominant Land Cover: **Field**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **None** | **26-50** |
| Length w/ less than 25 ft.: | **1087** | **846** |

4.4 Ground Water Inputs: **None**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **9** %
5.3 Bank Armoring: **90 %**
Left **544** Right **480**
5.4 Channel Straightening: **670** **58 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **1466** ft. **128 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **819** ft. | **0.0** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **246** ft. | **176** ft. |
| Improved Path: | **224** ft. | **0.0** ft. |
| 6.2 Development: | **334** ft. | **518** ft. |

6.3 Channel Bars: **Side**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **290.41 ft.**
7.2 Bank Height: **3.27 ft.**
7.3 Ice/Debris Jam Potential: **Bridge**

7.4 Comments:

Bedrock grade controls (3.2) include waterfall at Felchville. Vicinity of historic flow diversion to manufacturing interests at Felchville, and vicinity of sawmill and pond (Beers, 1869). Exempted

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 19 |
| Low | High | High | N.S. | Low | High | High | High | High | High | N.S. | N.S. | N/A | N/A | Low | High | |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M19**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Along east valley wall east of Upper Falls Road, from Downers**
1.2 Towns: **Weathersfield**
1.3 Downstream Latitude: **43.38**
1.3 Downstream Longitude: **-72.51**

### Step 2. Stream Type

2.1 Elevation Upstream: **560**
2.1 Elevation Downstream: **532**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **7376** feet. **1.40** Miles.
2.3 Valley Slope: **0.38** %
2.4.Channel Length: **7697** feet. **1.46** Miles.
2.5 Channel Slope: **0.36** %
2.6 Sinuosity: **1.04**
2.7 Watershed Area: **117** Square Miles
2.8 Channel Width: **106** feet.
2.9 Valley Width: **1,075** feet.
2.10 Confinement Ratio: **10**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **71.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Very Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **59.0** % |
| Flooding: | **Occasional** | **47.0** % |
| Water Table Deep: | **3.0** | **35.0** % |
| Water Table Shallow: | **1.5** | **44.0** % |
| Erodibility: | **slight** | **25.0** % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from Sept 2008, SMRC

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **83.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **47.0** %
Current Sub-Dominant Land Cover: **Crop**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **26-50** | **0-25** |
| Sub-dominant: | **0-25** | **>100** |
| Length w/ less than 25 ft.: | **2177** | **2418** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **0** **0** %
5.3 Bank Armoring: **4 %**
Left **315** Right **0.0**
5.4 Channel Straightening: **7593** **98 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **2466** ft. **32 %**

| | One Side | | Both Sides | |
|---|---|---|---|---|
| Road: | **1205** | ft. | **0.0** | ft. |
| Railroad: | **0.0** | ft. | **0.0** | ft. |
| Berm: | **1261** | ft. | **0.0** | ft. |
| Improved Path: | **0.0** | ft. | **0.0** | ft. |
| 6.2 Development: | **367.0** | ft. | **0.0** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **106.3** Ratio: **1.0**
6.6 Wavelength: **106.3** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **2,074.72 ft.**
7.2 Bank Height: **5.86 ft.**
7.3 Ice/Debris Jam Potential: **Shallow**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 0 N.S. | 2 High | 2 High | 2 High | 0 N.S. | 2 High | 2 High | 2 High | 2 High | 0 N.S. | 1 Low | 20 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M26**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From Twenty Mile Stream confluence at Whitesvillle d/s to valley**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.40**
1.3 Downstream Longitude: **-72.59**

### Step 2. Stream Type

2.1 Elevation Upstream: **750**
2.1 Elevation Downstream: **740**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1810** feet. **0.34** Miles.
2.3 Valley Slope: **0.55** %
2.4.Channel Length: **1815** feet. **0.34** Miles.
2.5 Channel Slope: **0.55** %
2.6 Sinuosity: **1.00**
2.7 Watershed Area: **100** Square Miles
2.8 Channel Width: **100** feet.
2.9 Valley Width: **650** feet.
2.10 Confinement Ratio: **7**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **73.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Extremely Steep**
*3.5 Soils*

| | | | |
|---|---|---|---|
| Hydrologic Group: | **B** | **74.0** | % |
| Flooding: | **Occasional** | **73.0** | % |
| Water Table Deep: | **3.0** | **55.0** | % |
| Water Table Shallow: | **1.5** | **56.0** | % |
| Erodibility: | **slight** | **25.0** | % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from Sept 2008, SMRC.

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **83.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **43.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **>100** |
| Sub-dominant: | **26-50** | **None** |
| Length w/ less than 25 ft.: | **1730** | **0** |

4.4 Ground Water Inputs: **Minimal**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **0** **0** %
5.3 Bank Armoring: **9 %**
Left **181** Right **0.0**
5.4 Channel Straightening: **1698** **93 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **2332.0** ft. **128 %**

| | One Side | | Both Sides | |
|---|---|---|---|---|
| Road: | **1733** | ft. | **0.0** | ft. |
| Railroad: | **0.0** | ft. | **0.0** | ft. |
| Berm: | **598** | ft. | **0.0** | ft. |
| Improved Path: | **0.0** | ft. | **0.0** | ft. |
| 6.2 Development: | **125.8** | ft. | **0.0** | ft. |

6.3 Channel Bars: **None**
6.4 Meander Migration:
6.5 Meander Width: **99.5** Ratio: **1.0**
6.6 Wavelength: **99.5** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **None**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 1 Low | 2 High | 2 High | 2 High | 1 Low | 0 N.S. | 0 N.S. | 2 High | 2 High | 0 N.S. | 0 N.S. | 17 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Twentymile Stream** Reach **M26T2.01**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From northwest valley wall to east valley wall of Black River, at**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.39**
1.3 Downstream Longitude: **-72.59**

### Step 2. Stream Type

2.1 Elevation Upstream: **765**
2.1 Elevation Downstream: **750**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1030** feet. **0.20** Miles.
2.3 Valley Slope: **1.46** %
2.4.Channel Length: **1138** feet. **0.22** Miles.
2.5 Channel Slope: **1.32** %
2.6 Sinuosity: **1.10**
2.7 Watershed Area: **15** Square Miles
2.8 Channel Width: **43** feet.
2.9 Valley Width: **200** feet.
2.10 Confinement Ratio: **5**
2.10 Confinement Type: **Narrow**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Ice-Contact 76.0** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Hilly**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **96.0** % |
| Flooding: | **None/Rare** | **76.0** % |
| Water Table Deep: | **2.5** | **72.0** % |
| Water Table Shallow: | **1.5** | **91.0** % |
| Erodibility: | **slight** | **20.0** % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from Sept 2008, SMRC

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **82.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Urban** **63.0** %
Current Sub-Dominant Land Cover: **Forest**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **None** | **>100** |
| Length w/ less than 25 ft.: | **1096** | **757** |

4.4 Ground Water Inputs: **None**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **7** %
5.3 Bank Armoring: **55 %**
Left **329** Right **304.3**
5.4 Channel Straightening: **1100** **96 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **974** ft. **85 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **914** ft. | **0.0** | ft. |
| Railroad: | **0.0** ft. | **0.0** | ft. |
| Berm: | **60** ft. | **0.0** | ft. |
| Improved Path: | **0.0** ft. | **0.0** | ft. |
| 6.2 Development: | **490** ft. | **89.5** | ft. |

6.3 Channel Bars: **Side**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **43.1** Ratio: **1.0**
6.6 Wavelength: **43.1** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **78.50 ft.**
7.2 Bank Height: **5.00 ft.**
7.3 Ice/Debris Jam Potential: **Bridge**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 2 High | 2 High | 0 N.S. | 2 High | 2 High | 0 N.S. | 1 Low | 2 High | 2 High | 1 Low | 1 Low | 21 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Twentymile Stream** Reach **M26T2.05**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Through wetlands crossing under Heald Road and Davis Rd**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.40**
1.3 Downstream Longitude: **-72.63**

### Step 2. Stream Type

2.1 Elevation Upstream: **1100**
2.1 Elevation Downstream: **1045**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **4813** feet. **0.91** Miles.
2.3 Valley Slope: **1.14** %
2.4.Channel Length: **5400** feet. **1.02** Miles.
2.5 Channel Slope: **1.02** %
2.6 Sinuosity: **1.12**
2.7 Watershed Area: **13** Square Miles
2.8 Channel Width: **41** feet.
2.9 Valley Width: **315** feet.
2.10 Confinement Ratio: **8**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **69.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Very Steep**
*3.5 Soils*

| | | | |
|---|---|---|---|
| Hydrologic Group: | **B** | **78.0** | % |
| Flooding: | **Occasional** | **52.0** | % |
| Water Table Deep: | **3.0** | **52.0** | % |
| Water Table Shallow: | **1.5** | **71.0** | % |
| Erodibility: | **slight** | **16.0** | % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from June 2008, SMRC.

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **82.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **61.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **>100** | **>100** |
| Sub-dominant: | **0-25** | **0-25** |
| Length w/ less than 25 ft.: | **380** | **1160** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **2** **4** %
5.3 Bank Armoring: **12 %**
Left **389** Right **293**
5.4 Channel Straightening: **1701** **31 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **356** ft. **6 %**

| | One Side | | Both Sides | |
|---|---|---|---|---|
| Road: | **356** | ft. | **0.0** | ft. |
| Railroad: | **0.0** | ft. | **0.0** | ft. |
| Berm: | **0.0** | ft. | **0.0** | ft. |
| Improved Path: | **0.0** | ft. | **0.0** | ft. |
| 6.2 Development: | **566.7** | ft. | **114** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **40.6** Ratio: **1.0**
6.6 Wavelength: **40.6** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **853.92 ft.**
7.2 Bank Height: **2.74 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 1 Low | 2 High | 0 N.S. | 0 N.S. | 1 Low | 2 High | 0 N.S. | 1 Low | 1 Low | 1 Low | 2 High | 2 High | 2 High | 0 N.S. | 1 Low | 17 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Twentymile Stream** Reach **M26T2.06**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Through fields east of Twentymile Stream Rd**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.41**
1.3 Downstream Longitude: **-72.64**

### Step 2. Stream Type

2.1 Elevation Upstream: **1150**
2.1 Elevation Downstream: **1100**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **8145** feet. **1.54** Miles.
2.3 Valley Slope: **0.61** %
2.4.Channel Length: **9808** feet. **1.86** Miles.
2.5 Channel Slope: **0.51** %
2.6 Sinuosity: **1.20**
2.7 Watershed Area: **11** Square Miles
2.8 Channel Width: **29** feet.
2.9 Valley Width: **370** feet.
2.10 Confinement Ratio: **13**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **E**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Ledge**
3.3 Dominant Geologic Mat.: **Alluvial** **72.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **C** | **52.0** % |
| Flooding: | **Frequent** | **49.0** % |
| Water Table Deep: | **1.5** | **49.0** % |
| Water Table Shallow: | **0.0** | **49.0** % |
| Erodibility: | **slight** | **10.0** % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from June 2008, SMRC

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **83.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **34.0** %
Current Sub-Dominant Land Cover: **Crop**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **>100** | **>100** |
| Length w/ less than 25 ft.: | **8040** | **8728** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **2** **1** %
5.3 Bank Armoring: **28 %**
Left **1222** Right **1559**
5.4 Channel Straightening: **3425** **34 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **2561** ft. **26 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **2561** ft. | **0.0** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **0.0** ft. | **0.0** ft. |
| Improved Path: | **0.0** ft. | **0.0** ft. |
| 6.2 Development: | **259** ft. | **93** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **90.0** Ratio: **3.1**
6.6 Wavelength: **302.0** Ratio: **10.5**

### Step 7. Windshield Survey

7.1 Bank Erosion: **1,144.43 ft.**
7.2 Bank Height: **4.09 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 15 |
| Low | High | High | N.S. | N.S. | High | High | N.S. | High | N.S. | Low | Low | Low | N.S. | N.S. | Low | |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Twentymile Stream** Reach **M26T2.07**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Through fields east of Twenty Mile Stream Rd, west of Mt Gilead**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.43**
1.3 Downstream Longitude: **-72.65**

### Step 2. Stream Type

2.1 Elevation Upstream: **1175**
2.1 Elevation Downstream: **1150**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3615** feet. **0.68** Miles.
2.3 Valley Slope: **0.69** %
2.4.Channel Length: **4926** feet. **0.93** Miles.
2.5 Channel Slope: **0.51** %
2.6 Sinuosity: **1.36**
2.7 Watershed Area: **7** Square Miles
2.8 Channel Width: **31** feet.
2.9 Valley Width: **957** feet.
2.10 Confinement Ratio: **31**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **88.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Very Steep**
*3.5 Soils*

| | | | |
|---|---|---|---|
| Hydrologic Group: | **C** | **80.0** | % |
| Flooding: | **Frequent** | **80.0** | % |
| Water Table Deep: | **1.5** | **80.0** | % |
| Water Table Shallow: | **0.0** | **80.0** | % |
| Erodibility: | **slight** | **2.0** | % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from June 2008, SMRC

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **85.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **37.0** %
Current Sub-Dominant Land Cover: **Crop**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **>100** | **None** |
| Length w/ less than 25 ft.: | **2956** | **4772** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **10 %**
Left **172** Right **361**
5.4 Channel Straightening: **627** **12 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **1490** ft. **30 %**

| | One Side | | Both Sides | |
|---|---|---|---|---|
| Road: | **877** | ft. | **0.0** | ft. |
| Railroad: | **0.0** | ft. | **0.0** | ft. |
| Berm: | **184** | ft. | **0.0** | ft. |
| Improved Path: | **428** | ft. | **0.0** | ft. |
| 6.2 Development: | **0.0** | ft. | **36.4** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **85.0** Ratio: **2.8**
6.6 Wavelength: **266.0** Ratio: **8.6**

### Step 7. Windshield Survey

7.1 Bank Erosion: **1,460.53 ft.**
7.2 Bank Height: **3.47 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 1 Low | 2 High | 0 N.S. | 0 N.S. | 1 Low | 1 Low | 0 N.S. | 2 High | 0 N.S. | 1 Low | 1 Low | 2 High | 0 N.S. | 0 N.S. | 1 Low | 13 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Twentymile Stream** Reach **M26T2.08**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **West side Twenty Mile Stream Rd, d/s of Meadowbrook Farm Rd**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.44**
1.3 Downstream Longitude: **-72.65**

### Step 2. Stream Type

2.1 Elevation Upstream: **1210**
2.1 Elevation Downstream: **1175**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3128** feet. **0.59** Miles.
2.3 Valley Slope: **1.12** %
2.4.Channel Length: **3634** feet. **0.69** Miles.
2.5 Channel Slope: **0.96** %
2.6 Sinuosity: **1.16**
2.7 Watershed Area: **6** Square Miles
2.8 Channel Width: **28** feet.
2.9 Valley Width: **290** feet.
2.10 Confinement Ratio: **10**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **52.0** %
3.3 Sub-dominant Geological Mat.: **Till**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **C** | **89.0** % |
| Flooding: | **Frequent** | **52.0** % |
| Water Table Deep: | **1.5** | **52.0** % |
| Water Table Shallow: | **0.0** | **52.0** % |
| Erodibility: | **Moderate** | **40.0** % |

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **84.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **45.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **>100** | **>100** |
| Sub-dominant: | **0-25** | **0-25** |
| Length w/ less than 25 ft.: | **981** | **1656** |

4.4 Ground Water Inputs: **Minimal**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **10 %**
Left **194** Right **195**
5.4 Channel Straightening: **1379** **37 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **594** ft. **16 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **476** ft. | **117** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **0.0** ft. | **0.0** ft. |
| Improved Path: | **0.0** ft. | **0.0** ft. |
| 6.2 Development: | **64.8** ft. | **120** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **554.02 ft.**
7.2 Bank Height: **2.24 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

7.4 Comments:

Exempted from meander geometry evaluation (6.5, 6.6) due to inferred bedrock controls; no meander sets available for measurement. Updated Dec 2008 with Phase 2 field-based

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 0 | 0 | 1 | 2 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 12 |
| Low | Low | High | N.S. | N.S. | Low | High | N.S. | Low | Low | Low | Low | N/A | N/A | N.S. | Low | |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Twentymile Stream** Reach **M26T2.09**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Through wetland between Twenty Mile Stream Rd and Meadowbrook**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.45**
1.3 Downstream Longitude: **-72.65**

### Step 2. Stream Type

2.1 Elevation Upstream: **1250**
2.1 Elevation Downstream: **1210**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2177** feet. **0.41** Miles.
2.3 Valley Slope: **1.84** %
2.4.Channel Length: **2851** feet. **0.54** Miles.
2.5 Channel Slope: **1.40** %
2.6 Sinuosity: **1.31**
2.7 Watershed Area: **5** Square Miles
2.8 Channel Width: **26** feet.
2.9 Valley Width: **879** feet.
2.10 Confinement Ratio: **33**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **59.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Hilly**
3.4 Right Valley Side **Hilly**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **C** | **66.0** % |
| Flooding: | **Frequent** | **59.0** % |
| Water Table Deep: | **1.5** | **59.0** % |
| Water Table Shallow: | **0.0** | **59.0** % |
| Erodibility: | **slight** | **16.0** % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from Sept 2008, SMRC. Meander geometry (6.5, 6.6) previously evaluated on the basis of only 2 meander sets - upon Phase 2

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **86.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **42.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **26-50** | **>100** |
| Length w/ less than 25 ft.: | **1347** | **1536** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **4 %**
Left **66** Right **65**
5.4 Channel Straightening: **2158** **75 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **568** ft. **19 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **466** ft. | **101** | ft. |
| Railroad: | **0.0** ft. | **0.0** | ft. |
| Berm: | **0.0** ft. | **0.0** | ft. |
| Improved Path: | **0.0** ft. | **0.0** | ft. |
| 6.2 Development: | **284** ft. | **65** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **26.0** Ratio: **1.0**
6.6 Wavelength: **26.0** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **1,266.51 ft.**
7.2 Bank Height: **3.77 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 0 | 1 | 17 |
| Low | High | High | N.S. | N.S. | N.S. | High | N.S. | Low | Low | Low | High | High | High | N.S. | Low | |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Twentymile Stream** Reach **M26T2.10**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Along Twenty Mile Stream Rd, crosses Reading / Cavendish town line**
1.2 Towns: **Cavendish, Reading**
1.3 Downstream Latitude: **43.45**
1.3 Downstream Longitude: **-72.65**

### Step 2. Stream Type

2.1 Elevation Upstream: **1335**
2.1 Elevation Downstream: **1250**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2800** feet. **0.53** Miles.
2.3 Valley Slope: **3.04** %
2.4.Channel Length: **3132** feet. **0.59** Miles.
2.5 Channel Slope: **2.71** %
2.6 Sinuosity: **1.12**
2.7 Watershed Area: **2** Square Miles
2.8 Channel Width: **19** feet.
2.9 Valley Width: **48** feet.
2.10 Confinement Ratio: **2**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **B**
Bedform: **Step-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Multiple**
3.3 Dominant Geologic Mat.: **Till** **84.0** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Very Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **C** | **100.** % |
| Flooding: | **None/Rare** | **85.0** % |
| Water Table Deep: | **3.5** | **74.0** % |
| Water Table Shallow: | **2.0** | **74.0** % |
| Erodibility: | **Very Severe** | **85.0** % |

7.4 Comments:

Updated Dec 2008 with Phase 2 field-based observations from Sept 2008, SMRC

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **89.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **31.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **51-100** | **>100** |
| Sub-dominant: | **0-25** | **0-25** |
| Length w/ less than 25 ft.: | **1206** | **1080** |

4.4 Ground Water Inputs: **Minimal**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **2** **3** %
5.3 Bank Armoring: **17 %**
Left **391** Right **161**
5.4 Channel Straightening: **842** **26 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **1391** ft. **44 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **855** ft. | **0.0** | ft. |
| Railroad: | **0.0** ft. | **0.0** | ft. |
| Berm: | **105** ft. | **0.0** | ft. |
| Improved Path: | **430** ft. | **0.0** | ft. |
| 6.2 Development: | **207** ft. | **100** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **771.63 ft.**
7.2 Bank Height: **5.27 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 0 | 0 | 1 | 2 | 0 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 14 |
| Low | High | High | N.S. | N.S. | Low | High | N.S. | High | Low | Low | Low | N/A | N/A | N.S. | Low | |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M27**
Topo Maps: **CAVENDISH**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From below CVPS power plant d/s to Twenty Mile Stream confluence**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.39**
1.3 Downstream Longitude: **-72.59**

### Step 2. Stream Type

2.1 Elevation Upstream: **770**
2.1 Elevation Downstream: **750**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3804** feet. **0.72** Miles.
2.3 Valley Slope: **0.53** %
2.4.Channel Length: **3999** feet. **0.76** Miles.
2.5 Channel Slope: **0.50** %
2.6 Sinuosity: **1.05**
2.7 Watershed Area: **85** Square Miles
2.8 Channel Width: **92** feet.
2.9 Valley Width: **573** feet.
2.10 Confinement Ratio: **6**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Multiple**
3.3 Dominant Geologic Mat.: **Alluvial** **46.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Very Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **54.0** % |
| Flooding: | **None/Rare** | **53.0** % |
| Water Table Deep: | **3.0** | **30.0** % |
| Water Table Shallow: | **1.5** | **53.0** % |
| Erodibility: | **slight** | **10.0** % |

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **84.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **54.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **>100** | **>100** |
| Sub-dominant: | **0-25** | **0-25** |
| Length w/ less than 25 ft.: | **982** | **1457** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **2689** **67 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **0.0** ft. **0.0**

| | One Side | Both Sides |
|---|---|---|
| Road: | **0.0** ft. | **0.0** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **0.0** ft. | **0.0** ft. |
| Improved Path: | **0.0** ft. | **0.0** ft. |
| 6.2 Development: | **438** ft. | **40** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **92.4** Ratio: **1.0**
6.6 Wavelength: **92.4** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **55.06 ft.**
7.2 Bank Height: **4.00 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

7.4 Comments:

Historic grist mill, saw mill (and potential for dam) noted on Beers, 1869 near downstream end of reach. Downstream end of historic and very substantial avulsion in 1927 flood in which Black

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 1 Low | 2 High | 0 N.S. | 0 N.S. | 0 N.S. | 2 High | 2 High | 0 Unk. | 1 Low | 1 Low | 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 16 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M30**
Topo Maps: **CAVENDISH, LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From Proctorsville d/s to Mill Street crossing**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.38**
1.3 Downstream Longitude: **-72.61**

### Step 2. Stream Type

2.1 Elevation Upstream: **916**
2.1 Elevation Downstream: **885**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **7335** feet. **1.39** Miles.
2.3 Valley Slope: **0.42** %
2.4.Channel Length: **8101** feet. **1.53** Miles.
2.5 Channel Slope: **0.38** %
2.6 Sinuosity: **1.10**
2.7 Watershed Area: **83** Square Miles
2.8 Channel Width: **91** feet.
2.9 Valley Width: **725** feet.
2.10 Confinement Ratio: **8**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **74.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Extremely Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **65.0** % |
| Flooding: | **Occasional** | **64.0** % |
| Water Table Deep: | **6.0** | **40.0** % |
| Water Table Shallow: | **6.0** | **40.0** % |
| Erodibility: | **slight** | **15.0** % |

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **84.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Urban** **26.0** %
Current Sub-Dominant Land Cover: **Forest**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **None** | **51-100** |
| Length w/ less than 25 ft.: | **5573** | **3873** |

4.4 Ground Water Inputs: **Minimal**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **Small Withdrawal**
Use: **Other**
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **21 %**
Left **1241** Right **507.7**
5.4 Channel Straightening: **6159** **76 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **7677** ft. **94 %**

| | One Side | | Both Sides | |
|---|---|---|---|---|
| Road: | **4368** | ft. | **0.0** | ft. |
| Railroad: | **2725.8** | ft. | **0.0** | ft. |
| Berm: | **123** | ft. | **0.0** | ft. |
| Improved Path: | **459** | ft. | **0.0** | ft. |
| 6.2 Development: | **2327** | ft. | **310** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **91.5** Ratio: **1.0**
6.6 Wavelength: **91.5** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **2,219.81 ft.**
7.2 Bank Height: **5.05 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

7.4 Comments:

Historic diversion channel associated with manufacturing interests at Cavendish near downstream end of reach (Beers, 1869). Historic dam noted just upstream of Cavendish on Beers

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 1 | 0 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 0 | 2 | 24 |
| Low | High | High | Low | N.S. | High | High | High | High | High | Low | Low | High | High | N.S. | High | |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M31**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Reach through Proctorsville**
1.2 Towns: **Cavendish**
1.3 Downstream Latitude: **43.38**
1.3 Downstream Longitude: **-72.63**

### Step 2. Stream Type

2.1 Elevation Upstream: **928**
2.1 Elevation Downstream: **916**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3041** feet. **0.58** Miles.
2.3 Valley Slope: **0.39** %
2.4.Channel Length: **3741** feet. **0.71** Miles.
2.5 Channel Slope: **0.32** %
2.6 Sinuosity: **1.23**
2.7 Watershed Area: **79** Square Miles
2.8 Channel Width: **90** feet.
2.9 Valley Width: **710** feet.
2.10 Confinement Ratio: **8**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **52.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **49.0** % |
| Flooding: | **Occasional** | **49.0** % |
| Water Table Deep: | **3.0** | **49.0** % |
| Water Table Shallow: | **1.5** | **49.0** % |
| Erodibility: | | **0.0** % |

7.4 Comments:

Historic flow diversion to woolen mill and marble shop at Proctorsville (Beers, 1869). Ice jam evidence within the reach (see Appendix O).

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **84.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Urban** **37.0** %
Current Sub-Dominant Land Cover: **Forest**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **26-50** | **0-25** |
| Sub-dominant: | **0-25** | **26-50** |
| Length w/ less than 25 ft.: | **1183** | **1660** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **2** **4** %
5.3 Bank Armoring: **29 %**
Left **610** Right **497**
5.4 Channel Straightening: **2879** **76 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **4555** ft. **121 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **1391** ft. | **172** ft. |
| Railroad: | **2990** ft. | **0.0** ft. |
| Berm: | **0.0** ft. | **0.0** ft. |
| Improved Path: | **0.0** ft. | **0.0** ft. |
| 6.2 Development: | **1643** ft. | **1071** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **89.6** Ratio: **1.0**
6.6 Wavelength: **89.6** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **779.74 ft.**
7.2 Bank Height: **6.38 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 2 High | 2 High | 0 N.S. | 2 High | 2 High | 1 Low | 1 Low | 2 High | 2 High | 1 Low | 2 High | 22 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M32**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Reach from Smithville to Proctorsville**
1.2 Towns: **Cavendish, Ludlow**
1.3 Downstream Latitude: **43.38**
1.3 Downstream Longitude: **-72.64**

### Step 2. Stream Type

2.1 Elevation Upstream: **960**
2.1 Elevation Downstream: **928**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **10839** feet. **2.05** Miles.
2.3 Valley Slope: **0.30** %
2.4.Channel Length: **12000** feet. **2.27** Miles.
2.5 Channel Slope: **0.27** %
2.6 Sinuosity: **1.11**
2.7 Watershed Area: **79** Square Miles
2.8 Channel Width: **90** feet.
2.9 Valley Width: **730** feet.
2.10 Confinement Ratio: **8**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Dam**
3.3 Dominant Geologic Mat.: **Alluvial** **52.0** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Extremely Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **41.0** % |
| Flooding: | **None/Rare** | **47.0** % |
| Water Table Deep: | **3.0** | **38.0** % |
| Water Table Shallow: | **1.5** | **38.0** % |
| Erodibility: | **slight** | **25.0** % |

7.4 Comments:

Historic raceway from the Black River to mills at Smithville (1905 Sanborn). Former dam at Smithville (now breached) noted on 1869 Beers (saw mill); 1929 topo, and 1905 Sanborn.

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **84.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **29.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **None** | **26-50** |
| Length w/ less than 25 ft.: | **10767** | **6168** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **4** **3** %
5.3 Bank Armoring: **25 %**
Left **1476** Right **1627**
5.4 Channel Straightening: **11838.8** **98 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **14912** ft. **124 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **4560.1** ft. | **3116** | ft. |
| Railroad: | **6935** ft. | **0.0** | ft. |
| Berm: | **300** ft. | **0.0** | ft. |
| Improved Path: | **0.0** ft. | **0.0** | ft. |
| 6.2 Development: | **2001** ft. | **3010** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **89.5** Ratio: **1.0**
6.6 Wavelength: **89.5** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **2,185.58 ft.**
7.2 Bank Height: **6.04 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 2 High | 2 High | 2 High | 2 High | 2 High | 1 Low | 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 22 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M33**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From Ludlow to Smithville**
1.2 Towns: **Ludlow**
1.3 Downstream Latitude: **43.39**
1.3 Downstream Longitude: **-72.68**

### Step 2. Stream Type

2.1 Elevation Upstream: **986**
2.1 Elevation Downstream: **960**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **7840** feet. **1.48** Miles.
2.3 Valley Slope: **0.33** %
2.4.Channel Length: **7849** feet. **1.49** Miles.
2.5 Channel Slope: **0.33** %
2.6 Sinuosity: **1.00**
2.7 Watershed Area: **70** Square Miles
2.8 Channel Width: **85** feet.
2.9 Valley Width: **990** feet.
2.10 Confinement Ratio: **12**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Dam**
3.3 Dominant Geologic Mat.: **Ice-Contact 67.0** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Extremely Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **Not Rated** | **64.0** % |
| Flooding: | **None/Rare** | **72.0** % |
| Water Table Deep: | **3.0** | **25.0** % |
| Water Table Shallow: | **1.5** | **25.0** % |
| Erodibility: | **slight** | **7.0** % |

7.4 Comments:

Historic diversions / raceways to mills through Ludlow (Beers, 1869; 1885 Sanborn). Gravel extraction in vicinity of upstream end of reach (Jewell Brook confluence) in 1992 (Stream Alt

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **85.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Urban** **70.0** %
Current Sub-Dominant Land Cover: **Forest**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **26-50** | **None** |
| Length w/ less than 25 ft.: | **6357** | **7461** |

4.4 Ground Water Inputs: **Minimal**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **4** **5** %
5.3 Bank Armoring: **1.0**
Left **5904** Right **5261**
5.4 Channel Straightening: **7708** **98 %**
5.5 Dredging History: **Multiple**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **8669** ft. **110 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **2173** ft. | **5426** | ft. |
| Railroad: | **0.0** ft. | **0.0** | ft. |
| Berm: | **1069** ft. | **0.0** | ft. |
| Improved Path: | **0.0** ft. | **0.0** | ft. |
| 6.2 Development: | **2587** ft. | **4945** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **84.9** Ratio: **1.0**
6.6 Wavelength: **84.9** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **228.55 ft.**
7.2 Bank Height: **5.00 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 2 High | 2 High | 2 High | 2 High | 2 High | 1 Low | 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 23 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M34**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From valley pinch point d/s along Route 103 past shopping plazas in**
1.2 Towns: **Ludlow**
1.3 Downstream Latitude: **43.40**
1.3 Downstream Longitude: **-72.70**

### Step 2. Stream Type

2.1 Elevation Upstream: **991**
2.1 Elevation Downstream: **986**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2155** feet. **0.41** Miles.
2.3 Valley Slope: **0.23** %
2.4.Channel Length: **2161** feet. **0.41** Miles.
2.5 Channel Slope: **0.23** %
2.6 Sinuosity: **1.00**
2.7 Watershed Area: **58** Square Miles
2.8 Channel Width: **78** feet.
2.9 Valley Width: **720** feet.
2.10 Confinement Ratio: **9**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Dam**
3.3 Dominant Geologic Mat.: **Ice-Contact 100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **Not Rated** | **92.0** % |
| Flooding: | **None/Rare** | **100.** % |
| Water Table Deep: | **6.0** | **7.0** % |
| Water Table Shallow: | **6.0** | **7.0** % |
| Erodibility: | **slight** | **7.0** % |

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **86.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Urban** **60.0** %
Current Sub-Dominant Land Cover: **Wetland**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **26-50** | **>100** |
| Sub-dominant: | **0-25** | **51-100** |
| Length w/ less than 25 ft.: | **835** | **778** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **Small Withdrawal**
Use: **Recreation**
5.2 Bridges and Culverts: **0** **0** %
5.3 Bank Armoring: **27 %**
Left **0.0** Right **595**
5.4 Channel Straightening: **2114** **97 %**
5.5 Dredging History: **Gravel Mining**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **3311.8**ft. **153 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **715** ft. | **1366** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **1229** ft. | **0.0** ft. |
| Improved Path: | **0.0** ft. | **0.0** ft. |
| 6.2 Development: | **1931** ft. | **0.0** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **78.2** Ratio: **1.0**
6.6 Wavelength: **78.2** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **970.25 ft.**
7.2 Bank Height: **3.96 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

7.4 Comments:

Water withdrawal site behind shopping plaza supports snow making at Okemo Mountain Ski Resort - in use since 1988. See Phase 1 report for more details. Gravel extraction in vicinity of

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 1 Low | 0 N.S. | 2 High | 2 High | 1 Low | 2 High | 2 High | 1 Low | 1 Low | 2 High | 2 High | 1 Low | 1 Low | 23 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M35**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **Short, semi-confined reach upstream of Ludlow, d/s of Dug Road**
1.2 Towns: **Ludlow**
1.3 Downstream Latitude: **43.40**
1.3 Downstream Longitude: **-72.71**

### Step 2. Stream Type

2.1 Elevation Upstream: **995**
2.1 Elevation Downstream: **991**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1700** feet. **0.32** Miles.
2.3 Valley Slope: **0.24** %
2.4.Channel Length: **1713** feet. **0.32** Miles.
2.5 Channel Slope: **0.23** %
2.6 Sinuosity: **1.01**
2.7 Watershed Area: **57** Square Miles
2.8 Channel Width: **77** feet.
2.9 Valley Width: **180** feet.
2.10 Confinement Ratio: **2**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **B**
Bedform: **Riffle-Pool**
Sub-class Slope: **c**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Ice-Contact 94.0** %
3.3 Sub-dominant Geological Mat.: **Till**
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Extremely Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **56.0** % |
| Flooding: | **None/Rare** | **100.** % |
| Water Table Deep: | **2.5** | **50.0** % |
| Water Table Shallow: | **1.5** | **50.0** % |
| Erodibility: | **slight** | **25.0** % |

7.4 Comments:

Apparent utility crossing (possibly water line from Okemo Snow Pond to Okemo Mtn) - Stream Alt Permit SA-1-0182.

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **86.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Urban** **51.0** %
Current Sub-Dominant Land Cover: **Forest**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **0-25** |
| Sub-dominant: | **26-50** | **None** |
| Length w/ less than 25 ft.: | **1112** | **1639** |

4.4 Ground Water Inputs: **None**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **6** %
5.3 Bank Armoring: **67 %**
Left **145** Right **1009**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **1656** ft. **96 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **0.0** ft. | **1656** | ft. |
| Railroad: | **0.0** ft. | **0.0** | ft. |
| Berm: | **0.0** ft. | **0.0** | ft. |
| Improved Path: | **0.0** ft. | **0.0** | ft. |
| 6.2 Development: | **1009** ft. | **81** | ft. |

6.3 Channel Bars: **Delta**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **115.76 ft.**
7.2 Bank Height: **2.00 ft.**
7.3 Ice/Debris Jam Potential: **Bridge**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 0 | 1 | 2 | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 1 | 15 |
| Low | High | High | N.S. | Low | High | N.S. | N.S. | High | High | N.S. | Low | N/A | N/A | Low | Low | |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M36**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From Branch Brook confluence, d/s under Fox Lane to Dug Rd**
1.2 Towns: **Ludlow**
1.3 Downstream Latitude: **43.41**
1.3 Downstream Longitude: **-72.71**

### Step 2. Stream Type

2.1 Elevation Upstream: **1010**
2.1 Elevation Downstream: **995**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **4535** feet. **0.86** Miles.
2.3 Valley Slope: **0.33** %
2.4.Channel Length: **4713** feet. **0.89** Miles.
2.5 Channel Slope: **0.32** %
2.6 Sinuosity: **1.04**
2.7 Watershed Area: **57** Square Miles
2.8 Channel Width: **77** feet.
2.9 Valley Width: **815** feet.
2.10 Confinement Ratio: **11**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Ice-Contact 62.0** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Extremely Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **C** | **37.0** % |
| Flooding: | **None/Rare** | **62.0** % |
| Water Table Deep: | **1.5** | **37.0** % |
| Water Table Shallow: | **0.0** | **37.0** % |
| Erodibility: | **Moderate** | **34.0** % |

7.4 Comments:

Reach crosses Black River Overlook water system Source Protection Area - shallow gravel source well located along the west side of Black River.

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest 86.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest 56.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **0-25** | **>100** |
| Sub-dominant: | **None** | **51-100** |
| Length w/ less than 25 ft.: | **2717** | **172** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **Small Withdrawal**
Use: **Other**
5.2 Bridges and Culverts: **1** **2** %
5.3 Bank Armoring: **20 %**
Left **674** Right **282**
5.4 Channel Straightening: **4619** **98 %**
5.5 Dredging History: **None**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **3357** ft. **71 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **1429** ft. | **644** | ft. |
| Railroad: | **0.0** ft. | **0.0** | ft. |
| Berm: | **0.0** ft. | **0.0** | ft. |
| Improved Path: | **1284** ft. | **0.0** | ft. |
| 6.2 Development: | **1122.4** ft. | **43** | ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **77.3** Ratio: **1.0**
6.6 Wavelength: **77.3** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **857.01 ft.**
7.2 Bank Height: **2.62 ft.**
7.3 Ice/Debris Jam Potential: **Bridge**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 1 Low | 0 N.S. | 2 High | 2 High | 0 N.S. | 2 High | 2 High | 1 Low | 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 21 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Branch Brook** Reach **M36T4.01**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From Buttermilk Falls Rd junction with Route 103 d/s to confluence**
1.2 Towns: **Ludlow**
1.3 Downstream Latitude: **43.42**
1.3 Downstream Longitude: **-72.70**

### Step 2. Stream Type

2.1 Elevation Upstream: **1040**
2.1 Elevation Downstream: **1010**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3149** feet. **0.60** Miles.
2.3 Valley Slope: **0.95** %
2.4.Channel Length: **3228** feet. **0.61** Miles.
2.5 Channel Slope: **0.93** %
2.6 Sinuosity: **1.03**
2.7 Watershed Area: **16** Square Miles
2.8 Channel Width: **44** feet.
2.9 Valley Width: **495** feet.
2.10 Confinement Ratio: **11**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **Waterfall**
3.3 Dominant Geologic Mat.: **Ice-Contact 71.0** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **37.0** % |
| Flooding: | **None/Rare** | **71.0** % |
| Water Table Deep: | **2.5** | **37.0** % |
| Water Table Shallow: | **1.5** | **37.0** % |
| Erodibility: | **Moderate** | **29.0** % |

7.4 Comments:

"Stream cleaning" following the 1973 flood (Ludlow 1973 ann. rpt.). Updated Dec 2008 with Phase 2 field-based observations from August 2008, SMRC.

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **85.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **30.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **>100** | **0-25** |
| Sub-dominant: | **0-25** | **>100** |
| Length w/ less than 25 ft.: | **1195** | **2277** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **2** **4** %
5.3 Bank Armoring: **43 %**
Left **402** Right **986.9**
5.4 Channel Straightening: **2572** **79 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **4189** ft. **129 %**

| | One Side | Both Sides |
|---|---|---|
| Road: | **1858** ft. | **278** ft. |
| Railroad: | **0.0** ft. | **0.0** ft. |
| Berm: | **1008** ft. | **1043** ft. |
| Improved Path: | **0.0** ft. | **0.0** ft. |
| 6.2 Development: | **505** ft. | **129** ft. |

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **44.3** Ratio: **1.0**
6.6 Wavelength: **44.3** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **412.26 ft.**
7.2 Bank Height: **3.54 ft.**
7.3 Ice/Debris Jam Potential: **Bridge**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 2 High | 2 High | 2 High | 2 High | 1 Low | 1 Low | 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 21 |

# Black River

## Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Black River** Reach **M37**
Topo Maps: **LUDLOW**
Date Last Edited: **Tue, April 07, 2009**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

### Step 1. Reach Location

1.1 Reach Description: **From Reservoir Pond dam (Lake Pauline) d/s to Branch Brook**
1.2 Towns: **Ludlow**
1.3 Downstream Latitude: **43.42**
1.3 Downstream Longitude: **-72.70**

### Step 2. Stream Type

2.1 Elevation Upstream: **1030**
2.1 Elevation Downstream: **1010**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **4621** feet. **0.88** Miles.
2.3 Valley Slope: **0.43** %
2.4.Channel Length: **5311** feet. **1.01** Miles.
2.5 Channel Slope: **0.38** %
2.6 Sinuosity: **1.15**
2.7 Watershed Area: **39** Square Miles
2.8 Channel Width: **66** feet.
2.9 Valley Width: **280** feet.
2.10 Confinement Ratio: **4**
2.10 Confinement Type: **Narrow**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

### Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Ice-Contact 71.0** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Hilly**
*3.5 Soils*

| | | |
|---|---|---|
| Hydrologic Group: | **B** | **43.0** % |
| Flooding: | **None/Rare** | **75.0** % |
| Water Table Deep: | **2.5** | **39.0** % |
| Water Table Shallow: | **1.5** | **39.0** % |
| Erodibility: | **Moderate** | **34.0** % |

7.4 Comments:

Historic sawmill & woolen mill at downstream end of reach (1869 Beers).
Updated Dec 2008 with Phase 2 field-based observations from Sept 2008, SMRC.

### Step 4. Land Cover - Reach Hydrology

*4.1 Watershed*
Historic Land Cover:
Current Dominant land Cover: **Forest** **87.0** %
Current Sub-Dominant Land Cover: **Urban**
*4.2 Corridor*
Historic Land Cover:
Current Dominant land Cover: **Forest** **54.0** %
Current Sub-Dominant Land Cover: **Urban**

| 4.3 Riparian Buffer | Left Bank | Right Bank |
|---|---|---|
| Dominant: | **26-50** | **>100** |
| Sub-dominant: | **>100** | **0-25** |
| Length w/ less than 25 ft.: | **862** | **1976** |

4.4 Ground Water Inputs: **Abundant**

### Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **2** %
5.3 Bank Armoring: **3 %**
Left **36** Right **171**
5.4 Channel Straightening: **2792** **52 %**
5.5 Dredging History: **Dredging**

### Step 6. Floodplain Modifications

6.1 Berms and Roads old **2252** ft. **42 %**

| | One Side | Both Sides | |
|---|---|---|---|
| Road: | **664** ft. | **150.5** | ft. |
| Railroad: | **0.0** ft. | **0.0** | ft. |
| Berm: | **1436** ft. | **0.0** | ft. |
| Improved Path: | **0.0** ft. | **0.0** | ft. |
| 6.2 Development: | **1149** ft. | **810** | ft. |

6.3 Channel Bars: **Point**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **66.0** Ratio: **1.0**
6.6 Wavelength: **66.0** Ratio: **1.0**

### Step 7. Windshield Survey

7.1 Bank Erosion: **466.61 ft.**
7.2 Bank Height: **2.69 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

| 4.1 | 4.2 | 4.3 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 6.1 | 6.2 | 6.3 | 6.4 | 6.5 | 6.6 | 7.1 | 7.2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Low | 2 High | 2 High | 0 N.S. | 0 N.S. | 0 N.S. | 2 High | 2 High | 2 High | 2 High | 0 N.S. | 1 Low | 2 High | 2 High | 0 N.S. | 1 Low | 19 |

Stream: **North Branch Black River** Reach # **M15T1.03** Segment: **A** Completion Date: **September 5, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: **impounded** Rain: **No**

Segment Length (ft): **1,428** Segment Location: **Downstream 1/3 of reach at upstream end of Stoughton Pond.**

**QC Status - Staff: Provisional Cons**

## Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **0** |
| height | **0** | **0** |
| Roads | **1,384** | **0** |
| height | **7** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **0** | **0** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Very Steep** | **Extremely** |
| Continuous w/ | **Never** | **Never** |
| W/in 1 Bankfill | **Never** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **500**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **0**

2.2 Max Depth (ft) **0.00**

2.3 Mean Depth (ft) **0.00**

2.4 Floodprone Width (ft) **0**

Notes:

Downstream end of reach, impounded by dam at Stoughton Pond in downstream reach. Branch Brook Rd follows along the right valley wall, occasionally coincident with RB. A sediment delta has prograded out into the Stoughton Pond reservoir in the years

**Passed** *Step 2. (Contued)*

2.5 Aband. Floodpln **0.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **0.00**

2.7 Entrenchment Ratio **0.00**

2.8 Incision Ratio **0.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity

2.10 Riffles Type

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Silt/Clay Present?

Detritus **0** %

# Large Woody **0**

2.13 Average Largest Particle on

Bed **0.0**

Bar **0.0**

2.14 Stream Type

Stream Type:

Bed Material:

Subclass Slope:

Bed Form:

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Moderate**

| 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) | **0** | **0** |
| Erosion Height (ft) | **0.00** | **0.00** |
| Revetmt. Type | **None** | **None** |
| Revetmt. Length (ft) | **0** | **0** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Herbaceous** | **Herbaceous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **1-25** | **1-25** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **>100** | **>100** |
| Sub-dominant | **None** | **0-25** |
| W less than 25 | **0** | **306** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Mixed Trees** | **Mixed Trees** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Forest** | **Forest** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Abundant**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **Store-release**

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **0** | **0** |

| Diagonal | Delta | Island |
|---|---|---|
| **0** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **0** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **588**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **North Branch Black River** Reach # **M15T1.03** Segment: **B** Completion Date: **September 5, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **4,060** Segment Location: **East side Branch Brook Rd d/s of Route 131 junction**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 750 | 0 |
| height | 9 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 0 | 0 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Very Steep | Extremely |
| Continuous w/ | Sometimes | Sometimes |
| W/in 1 Bankfill | Sometimes | Sometimes |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **540**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **39**

2.2 Max Depth (ft) **4.00**

2.3 Mean Depth (ft) **2.81**

2.4 Floodprone Width (ft) **300**

Notes:

Slight human-caused change in valley width, by Branch Brook Rd along RB corridor. Not sufficient to cause change in valley type (Broad) or confinement status (Unconfined). Downstream impoundment of Stoughton Pond behind ACOE dam circa 1960 (reach

*Step 2. (Contued)*

2.5 Aband. Floodpln **4.50** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **13.70**

2.7 Entrenchment Ratio **7.79**

2.8 Incision Ratio **1.13**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Sedimented**

2.11 Riffle/Step Spacing (ft) **250**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 0% |
| Cobble | 37% |
| Coarse Gravel | 22% |
| Fine Gravel | 5% |
| Sand | 35% |
| Silt and smaller | 1% |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **55**

2.13 Average Largest Particle on

Bed **149.0** mm

Bar **150.0** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | One | 80.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Gravel | Gravel |
| Consistency | Non-cohesive | Non-cohesive |
| Lower | | |
| Material Type | Gravel | Gravel |
| Consistency | Non-cohesive | Non-cohesive |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | 468 | 733 |
| Erosion Height (ft) | 3.69 | 3.87 |
| Revetmt. Type | Rip-Rap | None |
| Revetmt. Length (ft) | 26 | 0 |
| Near Bank Veg. Type | Left | Right |
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Deciduous | Deciduous |
| Bank Canopy | Left | Right |
| Canopy % | 76-100 | 76-100 |
| Mid-Channel Canopy | Open | |

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | >100 | 26-50 |
| Sub-dominant | 51-100 | 0-25 |
| W less than 25 | 0 | 708 |
| Buffer Veg. Type | Left | Right |
| Dominant | Mixed Trees | Mixed Trees |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Forest |
| Sub-dominant | None | Hay |
| Mass Failures | 59 | 0 |
| Height | 80 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 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 **3**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **Store-release**

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 0 | 6 | 8 |
| Diagonal | Delta | Island |
| 9 | 0 | 1 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 5 | 0 | 1 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 2 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **3,635**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **North Branch Black River** Reach # **M15T1.05** Segment: **0** Completion Date: **June 20, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **6,365** Segment Location: **Reach from Little Ascutney Basin Rd crossing downstream to Amsden Falls.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 425 | 0 |
| height | 9 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 182 | 110 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Hilly | Very Steep |
| Continuous w/ | Never | Never |
| W/in 1 Bankfill | Never | Never |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **1,510**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **41**

2.2 Max Depth (ft) **5.90**

2.3 Mean Depth (ft) **3.69**

2.4 Floodprone Width (ft) **300**

Notes:

Very broad valley setting gradually narrowing to the bedrock-controlled valley pinch point at Amsden Falls (downstream reach M15T1.04). Slight human-caused change in valley width due to Rt 106 (RB) and Lottery Lane (LB), but not sufficient to cause change in valley type

*Step 2. (Contued)*

2.5 Aband. Floodpln **5.90** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **11.11**

2.7 Entrenchment Ratio **7.32**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Not Applicable**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 0% |
| Cobble | 0% |
| Coarse Gravel | 1% |
| Fine Gravel | 29% |
| Sand | 52% |
| Silt and smaller | 18% |

Silt/Clay Present? **Yes**

Detritus **5** %

# Large Woody **110**

2.13 Average Largest Particle on

Bed **N/A**

Bar **N/A**

2.14 Stream Type

Stream Type: **E**

Bed Material: **Sand**

Subclass Slope: **None**

Bed Form: **Dune-Ripple**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Sand | Sand |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Silt | Silt |
| Consistency | Cohesive | Cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 1,741 | 2,052 |
| Erosion Height (ft) | 7.37 | 7.50 |
| Revetmt. Type | Multiple | Multiple |
| Revetmt. Length (ft) | 135 | 256 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |

| Bank Canopy | Left | Right |
|---|---|---|
| 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 | 4,065 | 3,226 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Herbaceous | Deciduous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Hay | Shrubs/Saplin |
| Sub-dominant | Shrubs/Saplin | Hay |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Abundant**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **3**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 1 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 5 | 30 | 3 |

| Diagonal | Delta | Island |
|---|---|---|
| 1 | 2 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 0 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **2,730**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **North Branch Black River** Reach # **M15T1.06** Segment: **A** Completion Date: **June 11, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **2,829** Segment Location: **Downstream 1/3 of reach.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 531 | 0 |
| height | 7 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 55 | 0 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Extremely | Very Steep |
| Continuous w/ | Never | Never |
| W/in 1 Bankfill | Never | Never |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **2,000**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **41**

2.2 Max Depth (ft) **4.60**

2.3 Mean Depth (ft) **3.12**

2.4 Floodprone Width (ft) **300**

Notes:

Slight reduction in valley width due to Route 106 encroachment along west valley wall (RB corr). Valley type (V. Broad) and confinement status (Unconfined) remain unchanged. Extensive hydric soils are mapped in the floodplain; limited wetlands are mapped,

*Step 2. (Contued)*

2.5 Aband. Floodpln **4.60** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **13.22**

2.7 Entrenchment Ratio **7.27**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Not Applicable**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 0% |
| Cobble | 0% |
| Coarse Gravel | 14% |
| Fine Gravel | 23% |
| Sand | 53% |
| Silt and smaller | 11% |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **15**

2.13 Average Largest Particle on

Bed **N/A**

Bar **N/A**

2.14 Stream Type

Stream Type: **E**

Bed Material: **Sand**

Subclass Slope: **None**

Bed Form: **Dune-Ripple**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Sand | Sand |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Silt | Silt |
| Consistency | Cohesive | Cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 1,204 | 1,350 |
| Erosion Height (ft) | 7.26 | 7.20 |
| Revetmt. Type | None | Rip-Rap |
| Revetmt. Length (ft) | 0 | 115 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Bare | Bare |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 0 | 0 |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | 0-25 | 0-25 |
| Sub-dominant | None | 26-50 |
| W less than 25 | 2,685 | 1,371 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Hay | Hay |
| Sub-dominant | Crop | Shrubs/Saplin |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## 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 **1**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 1 | 10 | 0 |

| Diagonal | Delta | Island |
|---|---|---|
| 0 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 1 | 3 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,244**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **North Branch Black River** Reach # **M15T1.06** Segment: **B** Completion Date: **June 11, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **3,718** Segment Location: **Upstream 2/3 of the reach.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 0 | 0 |
| height | 0 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 0 | 0 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Extremely | Very Steep |
| Continuous w/ | Sometimes | Never |
| W/in 1 Bankfill | Sometimes | Never |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **1,500**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **41**

2.2 Max Depth (ft) **5.70**

2.3 Mean Depth (ft) **3.68**

2.4 Floodprone Width (ft) **200**

Notes:

Channel follows the left valley wall at the upstream end. Hay and crop fields in left and right corridors. RB tributary has been regularly dredging/bermed according to landowner to facilitate drainage in hay field. Hydric soils are prevalent across the valley

*Step 2. (Contued)*

2.5 Aband. Floodpln **9.20** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **11.25**

2.7 Entrenchment Ratio **4.83**

2.8 Incision Ratio **1.61**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Not Applicable**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 0% |
| Cobble | 15% |
| Coarse Gravel | 30% |
| Fine Gravel | 5% |
| Sand | 39% |
| Silt and smaller | 11% |

Silt/Clay Present? **No**

Detritus **5** %

# Large Woody **20**

2.13 Average Largest Particle on

Bed **N/A**

Bar **N/A**

2.14 Stream Type

Stream Type: **E**

Bed Material: **Sand**

Subclass Slope: **None**

Bed Form: **Dune-Ripple**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Sand | Sand |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Sand | Sand |
| Consistency | Cohesive | Cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 1,530 | 1,508 |
| Erosion Height (ft) | 7.01 | 7.05 |
| Revetmt. Type | Rip-Rap | Rip-Rap |
| Revetmt. Length (ft) | 200 | 190 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Bare | Bare |

| Bank Canopy | Left | Right |
|---|---|---|
| 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 | 26-50 |
| W less than 25 | 1,389 | 3,692 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Deciduous | Deciduous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Hay | Hay |
| Sub-dominant | Crop | None |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## 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 **3**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 1 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **1**

Affected Length (ft) **800**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 1 | 9 | 2 |

| Diagonal | Delta | Island |
|---|---|---|
| 0 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 1 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **Yes**

5.5 Straightening **Straightening**

Straightening Length: **2,911**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **North Branch Black River** Reach # **M15T1.07** Segment: **0** Completion Date: **June 11, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **2,740** Segment Location: **Crosses valley from Ascutney Basin Rd bridge to east valley wall.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **946** | **224** |
| height | **7** | **6** |
| Roads | **0** | **0** |
| height | **0** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **0** | **0** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Extremely** | **Extremely** |
| Continuous w/ | **Never** | **Never** |
| W/in 1 Bankfill | **Never** | **Never** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **2,190**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **61**

2.2 Max Depth (ft) **2.70**

2.3 Mean Depth (ft) **1.61**

2.4 Floodprone Width (ft) **79**

Notes:

Active agriculture in LB / RB corridors (hay). Sparse residential development along Ascutney Basin Rd to north and Route 106 to west. A large oval impression is visible in the RB corridor (south side of the channel) on a 1994 orthophoto; a track is depicted on the

*Step 2. (Contued)*

2.5 Aband. Floodpln **5.50** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **38.14**

2.7 Entrenchment Ratio **1.29**

2.8 Incision Ratio **2.04**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Sedimented**

2.11 Riffle/Step Spacing (ft) **215**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **5** % |
| Cobble | **34** % |
| Coarse Gravel | **27** % |
| Fine Gravel | **2** % |
| Sand | **32** % |
| Silt and smaller | **0** % |

Silt/Clay Present? **No**

Detritus **3** %

# Large Woody **19**

2.13 Average Largest Particle on

Bed **260.0** mm

Bar **147.0** mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Sand** | **Sand** |
| Consistency | **Cohesive** | **Cohesive** |
| Lower | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | **970** | **966** |
| Erosion Height (ft) | **2.79** | **3.04** |
| Revetmt. Type | **Multiple** | **Rip-Rap** |
| Revetmt. Length (ft) | **556** | **324** |
| Near Bank Veg. Type | Left | Right |
| Dominant | **Herbaceous** | **Herbaceous** |
| Sub-dominant | **Bare** | **Bare** |
| Bank Canopy | Left | Right |
| 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** | **None** |
| W less than 25 | **2,384** | **2,348** |
| Buffer Veg. Type | Left | Right |
| Dominant | **Herbaceous** | **Herbaceous** |
| Sub-dominant | **Deciduous** | **Deciduous** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Hay** | **Hay** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **None**

4.2 Adjacent Wetlands **None**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **2**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **4** | **6** | **5** |

| Diagonal | Delta | Island |
|---|---|---|
| **2** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **4** | **0** | **0** | **1** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,415**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **North Branch Black River** Reach # **M15T1.08** Segment: **0** Completion Date: **June 11, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **2,488** Segment Location: **East side Route 106 upstream of Ascutney Basin Rd bridge crossing.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **190** |
| height | **0** | **6** |
| Roads | **713** | **418** |
| height | **16** | **7** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **722** | **0** |
| height | **11** | **0** |
| Development | **437** | **97** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Very Steep** | **Hilly** |
| Continuous w/ | **Sometimes** | **Never** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Mixed** | **Gravel** |

1.5 Valley Features

Valley Width (ft) **346**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **42**

2.2 Max Depth (ft) **3.10**

2.3 Mean Depth (ft) **2.65**

2.4 Floodprone Width (ft) **58**

Notes:

Very minor human-caused change in valley width due to slight encroachment along RB by Route 106; no change in valley type (Broad, on average) or confinement status (Unconfined). Bedrock is exposed along the left valley wall near the upstream end of the

*Step 2. (Contued)*

2.5 Aband. Floodpln **6.90** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **16.00**

2.7 Entrenchment Ratio **1.37**

2.8 Incision Ratio **2.23**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **325**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **6** % |
| Cobble | **43** % |
| Coarse Gravel | **43** % |
| Fine Gravel | **1** % |
| Sand | **5** % |
| Silt and smaller | **2** % |

Silt/Clay Present? **Yes**

Detritus **2** %

# Large Woody **11**

2.13 Average Largest Particle on

Bed **284.0** mm

Bar **245.0** mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Cohesive** | **Cohesive** |
| Lower | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Cohesive** | **Cohesive** |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | **226** | **55** |
| Erosion Height (ft) | **2.60** | **3.00** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **361** | **450** |
| Near Bank Veg. Type | Left | Right |
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Deciduous** | **Deciduous** |
| Bank Canopy | Left | Right |
| Canopy % | **51-75** | **76-100** |
| Mid-Channel Canopy | | **Open** |

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **>100** | **None** |
| W less than 25 | **1,546** | **2,183** |
| Buffer Veg. Type | Left | Right |
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Coniferous** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Hay** | **Hay** |
| Sub-dominant | **Forest** | **Forest** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **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 Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **1** | **3** |
| **Diagonal** | **Delta** | **Island** |
| **2** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **1** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **1** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **2,142**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **North Branch Black River** Reach # **M15T1.09** Segment: **0** Completion Date: **September 4, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **3,664** Segment Location: **Downstream from Knapp Brook confluence**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **57** | **0** |
| height | **9** | **0** |
| Roads | **2,102** | **0** |
| height | **20** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **543** | **0** |
| height | **10** | **0** |
| Development | **1,067** | **0** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Steep** | **Very Steep** |
| Continuous w/ | **Sometimes** | **Never** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **290**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **41**

2.2 Max Depth (ft) **3.30**

2.3 Mean Depth (ft) **2.13**

2.4 Floodprone Width (ft) **50**

Notes:

Minor human-caused change in valley width due to encroachment of Route 106 along western valley wall. Not sufficient to change valley type (Broad) or confinement status (Unconfined). Berm along RB for short section. Improved path is forest trail

*Step 2. (Contued)*

2.5 Aband. Floodpln **10.40** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **19.34**

2.7 Entrenchment Ratio **1.21**

2.8 Incision Ratio **3.15**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **19** % |
| Cobble | **27** % |
| Coarse Gravel | **31** % |
| Fine Gravel | **12** % |
| Sand | **11** % |
| Silt and smaller | **0** % |

Silt/Clay Present? **No**

Detritus **1** %

# Large Woody **12**

2.13 Average Largest Particle on

Bed **467.0** mm

Bar **N/A** mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Boulder/Cobbl** | **Boulder/Cobbl** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **253** | **171** |
| Erosion Height (ft) | **3.78** | **4.00** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **832** | **1,187** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Coniferous** | **Shrubs/Saplin** |
| Sub-dominant | **Deciduous** | **Deciduous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **76-100** | **51-75** |

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 | **1,096** | **3,325** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Coniferous** | **Deciduous** |
| Sub-dominant | **Deciduous** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Forest** | **Residential** |
| Sub-dominant | **Residential** | **Forest** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **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 Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **5** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **2** | **1** |

| Diagonal | Delta | Island |
|---|---|---|
| **1** | **1** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **0** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **1** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **952**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **North Branch Black River** Reach # **M15T1.10** Segment: **0** Completion Date: **August 29, 2008**

Organization: **South Windsor County Regional** Observers: **KLU - SMRC; GA, SP - VTDEC** Why Not assessed: Rain: **No**

Segment Length (ft): **2,400** Segment Location: **From vicinity Route 106 crossing at Felchville, d/s to Knapp Brook confluence**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **117** | **1,980** |
| height | **8** | **6** |
| Roads | **219** | **0** |
| height | **7** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **0** | **30** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Extremely** | **Extremely** |
| Continuous w/ | **Never** | **Never** |
| W/in 1 Bankfill | **Never** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **610**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **38**

2.2 Max Depth (ft) **2.00**

2.3 Mean Depth (ft) **1.48**

2.4 Floodprone Width (ft) **42**

Notes:

Route 106 along the far western edge of valley causes slight decrease in valley width, but not enough to change the valley type (V. Broad) or confinement status (Unconfined). Historic topo maps (1929, 1932, Ludlow USGS) show Route 106 positioned farther

*Step 2. (Contued)*

2.5 Aband. Floodpln **3.60** ft.

Human Elev Floodpln **4.40** ft.

2.6 Width/Depth Ratio **25.95**

2.7 Entrenchment Ratio **1.09**

2.8 Incision Ratio **1.80**

Human Elevated Inc Rat **2.20**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **172**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **1** % |
| Cobble | **50** % |
| Coarse Gravel | **39** % |
| Fine Gravel | **3** % |
| Sand | **7** % |
| Silt and smaller | **0** % |

Silt/Clay Present? **No**

Detritus **4** %

# Large Woody **6**

2.13 Average Largest Particle on

Bed **198.0** mm

Bar **210.0** mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Boulder/Cobbl** | **Boulder/Cobbl** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **495** | **383** |
| Erosion Height (ft) | **4.00** | **4.07** |
| Revetmt. Type | **None** | **Multiple** |
| Revetmt. Length (ft) | **0** | **408** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Herbaceous** | **Herbaceous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **76-100** | **76-100** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **None** | **None** |
| W less than 25 | **2,334** | **2,337** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Hay** | **Hay** |
| Sub-dominant | **Forest** | **Forest** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **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 **1**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **1** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **1** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **1** | **7** | **2** |
| **Diagonal** | **Delta** | **Island** |
| **3** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **1** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **With Windrowing**

Straightening Length: **2,270**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **North Branch Black River** Reach # **M15T1.11** Segment: **A** Completion Date: **August 29, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **417** Segment Location: **From just upstream of Route 106 bridge to downstream reach break approximately 400 ft**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **Yes**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **48** | **177** |
| height | **8** | **7** |
| Roads | **356** | **0** |
| height | **8** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **224** | **0** |
| height | **0** | **0** |
| Development | **0** | **380** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Flat** | **Very Steep** |
| Continuous w/ | **Never** | **Never** |
| W/in 1 Bankfill | **Never** | **Never** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **310**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **41**

2.2 Max Depth (ft) **2.30**

2.3 Mean Depth (ft) **1.84**

2.4 Floodprone Width (ft) **51**

Notes:

Human-caused change in valley width due to Route 106 (RB) and improved path (agricultural road, LB). Change in valley type (V. Broad to Broad), but confinement status remains unchanged (Unconfined). Segment is located at transition from Semi-confined

*Step 2. (Contued)*

2.5 Aband. Floodpln **6.20** ft.

Human Elev Floodpln **7.10** ft.

2.6 Width/Depth Ratio **22.01**

2.7 Entrenchment Ratio **1.26**

2.8 Incision Ratio **2.70**

Human Elevated Inc Rat **3.09**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **10** % |
| Cobble | **55** % |
| Coarse Gravel | **26** % |
| Fine Gravel | **4** % |
| Sand | **3** % |
| Silt and smaller | **2** % |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **0**

2.13 Average Largest Particle on

Bed **360.0** mm

Bar **N/A** mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Cobble**

Subclass Slope: **b**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Boulder/Cobbl** | **Boulder/Cobbl** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **79** | **211** |
| Erosion Height (ft) | **3.00** | **3.36** |
| Revetmt. Type | **Rip-Rap** | **Multiple** |
| Revetmt. Length (ft) | **171** | **170** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Herbaceous** | **Bare** |
| Sub-dominant | **Deciduous** | **Deciduous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **76-100** | **76-100** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **None** | **None** |
| W less than 25 | **387** | **383** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **None** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Hay** | **Hay** |
| Sub-dominant | **Residential** | **Residential** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **None**

4.2 Adjacent Wetlands **None**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **1** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **1** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **0** | **1** |

| Diagonal | Delta | Island |
|---|---|---|
| **0** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **0** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **375**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **North Branch Black River** Reach # **M15T1.11** Segment: **B** Completion Date: **August 29, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **312** Segment Location: **From base of bedrock falls downstream near to Route 106 bridge.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **Yes**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **199** | **0** |
| height | **9** | **0** |
| Roads | **312** | **0** |
| height | **8** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **59** | **138** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Hilly** | **Very Steep** |
| Continuous w/ | **Never** | **Never** |
| W/in 1 Bankfill | **Never** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **140**

Width Determination **Measured**

Confinement Type **Semi-confined**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **33**

2.2 Max Depth (ft) **2.70**

2.3 Mean Depth (ft) **1.84**

2.4 Floodprone Width (ft) **37**

Notes:

Beers map (1869) indicates a historic diversion (upstream of Segment C) that would have directed a portion of flows out of this reach to supply mills and other industrial applications in the Felchville village area to the northeast. And historically, a large

*Step 2. (Contued)*

2.5 Aband. Floodpln **8.20** ft.

Human Elev Floodpln **8.50** ft.

2.6 Width/Depth Ratio **18.15**

2.7 Entrenchment Ratio **1.11**

2.8 Incision Ratio **3.04**

Human Elevated Inc Rat **3.15**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **47**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **15** % |
| Cobble | **51** % |
| Coarse Gravel | **23** % |
| Fine Gravel | **7** % |
| Sand | **4** % |
| Silt and smaller | **0** % |

Silt/Clay Present? **No**

Detritus **1** %

# Large Woody **0**

2.13 Average Largest Particle on

Bed **610.0** mm

Bar **N/A** mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Cobble**

Subclass Slope: **b**

Bed Form: **Step-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

**C 3 b Step-Pool**

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Boulder/Cobbl** | **Boulder/Cobbl** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Boulder/Cobbl** | **Boulder/Cobbl** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **0** | **1** |
| Erosion Height (ft) | **0.00** | **4.00** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **312** | **311** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Herbaceous** | **Herbaceous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **26-50** | **51-75** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **None** | **None** |
| W less than 25 | **311** | **247** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Residential** | **Hay** |
| Sub-dominant | **Commercial** | **Residential** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **None**

4.2 Adjacent Wetlands **None**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **1** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **0** | **1** |

| Diagonal | Delta | Island |
|---|---|---|
| **0** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **0** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **295**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **North Branch Black River** Reach # **M15T1.11** Segment: **C** Completion Date: **August 29, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: **bedrock gorge** Rain: **No**

Segment Length (ft): **409** Segment Location: **From upstream end of reach near ball park to downstream end of waterfall at Niagara Street**

**QC Status - Staff: Provisional Cons**

## Step 1. Valley and Floodplain

1.1 Segmentation **Grade Controls**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **0** |
| height | **0** | **0** |
| Roads | **151** | **0** |
| height | **8** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **275** | **0** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Steep** | **Very Steep** |
| Continuous w/ | **Sometimes** | **Always** |
| W/in 1 Bankfill | **Sometimes** | **Always** |
| Texture | **Bedrock** | **Bedrock** |

1.5 Valley Features

Valley Width (ft) **90**

Width Determination **Measured**

Confinement Type **Semi-confined**

Rock Gorge? **Yes**

Human-caused Change? **No**

## Step 2. Stream Channel

2.1 Bankfull Width **0**

2.2 Max Depth (ft) **0.00**

2.3 Mean Depth (ft) **0.00**

2.4 Floodprone Width (ft) **0**

Notes:

Segment is a bedrock waterfall. In accordance with protocols, cross section not measured and RGA / RHA not completed.

**Passed** *Step 2. (Contued)*

2.5 Aband. Floodpln **0.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **0.00**

2.7 Entrenchment Ratio **0.00**

2.8 Incision Ratio **0.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity

2.10 Riffles Type

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Silt/Clay Present?

Detritus **0** %

# Large Woody **1**

2.13 Average Largest Particle on

Bed **0.0**

Bar **0.0**

2.14 Stream Type

Stream Type:

Bed Material:

Subclass Slope:

Bed Form:

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

**B 1 a Cascade**

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Moderate**

| 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** |
| Erosion Height (ft) | **0.00** | **0.00** |
| Revetmt. Type | **Rip-Rap** | **None** |
| Revetmt. Length (ft) | **62** | **0** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **51-75** | **76-100** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **26-50** |
| Sub-dominant | **26-50** | **None** |
| W less than 25 | **388** | **215** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **None** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Residential** | **Hay** |
| Sub-dominant | **Forest** | **Forest** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **None**

4.2 Adjacent Wetlands **None**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **0** | **0** |

| Diagonal | Delta | Island |
|---|---|---|
| **0** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **0** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **None**

Straightening Length: **0**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **Black River** Reach # **M19** Segment: **A** Completion Date: **September 16, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **4,243** Segment Location: **Downstream half of reach that extends from Downers Corners to Perkinsville, east of Upper**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 1,206 | 0 |
| height | 9 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 260 | 0 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Extremely | Very Steep |
| Continuous w/ | Sometimes | Never |
| W/in 1 Bankfill | Sometimes | Never |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **970**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **129**

2.2 Max Depth (ft) **4.20**

2.3 Mean Depth (ft) **3.06**

2.4 Floodprone Width (ft) **400**

Notes:

Slight human-caused change in valley width due to encroachment of Upper Falls Rd (RB) and driveway/former road (LB). No change in average valley type (Broad) or confinment status (Unconfined). Bedrock exposed along LB providing lateral grade control. Riffle/pool

*Step 2. (Contued)*

2.5 Aband. Floodpln **7.10** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **42.09**

2.7 Entrenchment Ratio **3.11**

2.8 Incision Ratio **1.69**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **590**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 0% |
| Cobble | 32% |
| Coarse Gravel | 39% |
| Fine Gravel | 0% |
| Sand | 21% |
| Silt and smaller | 8% |

Silt/Clay Present? **No**

Detritus **1** %

# Large Woody **15**

2.13 Average Largest Particle on

Bed **125.0** **mm**

Bar **104.0** **mm**

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | One | 13.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Gravel | Sand |
| Consistency | Non-cohesive | Cohesive |
| Lower | | |
| Material Type | Boulder/Cobbl | Gravel |
| Consistency | Non-cohesive | Non-cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 938 | 291 |
| Erosion Height (ft) | 6.90 | 5.00 |
| Revetmt. Type | Rip-Rap | None |
| Revetmt. Length (ft) | 316 | 0 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 76-100 | 26-50 |
| Mid-Channel Canopy | Open | |

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | 26-50 | 0-25 |
| Sub-dominant | 0-25 | >100 |
| W less than 25 | 2,056 | 2,198 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Deciduous | Shrubs/Saplin |
| Sub-dominant | Coniferous | Deciduous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Crop |
| Sub-dominant | Residential | Shrubs/Saplin |
| Mass Failures | 149 | 0 |
| Height | 13 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 1 | 0 | 0 |
| **Diagonal** | **Delta** | **Island** |
| 2 | 0 | 2 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 4 | 0 | 0 | 2 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **4,185**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **Black River** Reach # **M19** Segment: **B** Completion Date: **September 16, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **3,454** Segment Location: **Upstream half of the reach that flows from Downers Corners to Perkinsville east of Upper**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **1,261** | **0** |
| height | **16** | **0** |
| Roads | **0** | **0** |
| height | **0** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **107** | **0** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Extremely** | **Very Steep** |
| Continuous w/ | **Sometimes** | **Never** |
| W/in 1 Bankfill | **Sometimes** | **Never** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **950**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **120**

2.2 Max Depth (ft) **3.40**

2.3 Mean Depth (ft) **2.50**

2.4 Floodprone Width (ft) **135**

Notes:

Upper Falls Road encroaches slightly along RB corridor, reducing valley width slightly, and changing valley confinment from reference Very Broad to modified Broad. Agricultural activities (hay) and light density residential in LB corridor. Floodwaters of

*Step 2. (Contued)*

2.5 Aband. Floodpln **7.30** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **48.12**

2.7 Entrenchment Ratio **1.12**

2.8 Incision Ratio **2.15**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **590**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **4** % |
| Cobble | **49** % |
| Coarse Gravel | **29** % |
| Fine Gravel | **0** % |
| Sand | **13** % |
| Silt and smaller | **5** % |

Silt/Clay Present? **No**

Detritus **1** %

# Large Woody **2**

2.13 Average Largest Particle on

Bed **215.0** mm

Bar **104.0** mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Boulder/Cobbl** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **319** | **527** |
| Erosion Height (ft) | **5.00** | **5.00** |
| Revetmt. Type | **None** | **None** |
| Revetmt. Length (ft) | **0** | **0** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Herbaceous** | **Herbaceous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **76-100** | **26-50** |
| Mid-Channel Canopy | | **Open** |

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **26-50** | **0-25** |
| Sub-dominant | **0-25** | **>100** |
| W less than 25 | **120** | **220** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Shrubs/Saplin** |
| Sub-dominant | **Coniferous** | **Deciduous** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Forest** | **Shrubs/Saplin** |
| Sub-dominant | **Shrubs/Saplin** | **Hay** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **2** | **0** |

| Diagonal | Delta | Island |
|---|---|---|
| **0** | **0** | **1** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **0** | **0** | **0** | **1** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **3,408**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River** | **Phase 2 Segment Summary** | May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M26** Segment: **0** Completion Date: **September 17, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **1,815** Segment Location: **From Twenty Mile Stream confluence at Whitesvillle d/s to valley pinch point**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **598** | **0** |
| height | **8** | **0** |
| Roads | **1,734** | **0** |
| height | **13** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **126** | **0** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Very Steep** | **Extremely** |
| Continuous w/ | **Never** | **Sometimes** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **570**

Width Determination **Estimated**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **122**

2.2 Max Depth (ft) **3.20**

2.3 Mean Depth (ft) **2.86**

2.4 Floodprone Width (ft) **155**

Notes:

Valley width narrower slightly by Route 131 in LB corridor; enough to change valley type (from Broad to Narrow) but still unconfined. Subtle berm along LB. At thalweg height of 8 ft (or 2.5 times nearest measured bankfull depth), this feature enhances channel

## Step 2. (Contued)

2.5 Aband. Floodpln **7.50** ft.

Human Elev Floodpln **8.00** ft.

2.6 Width/Depth Ratio **42.66**

2.7 Entrenchment Ratio **1.27**

2.8 Incision Ratio **2.34**

Human Elevated Inc Rat **2.50**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **6** % |
| Cobble | **42** % |
| Coarse Gravel | **33** % |
| Fine Gravel | **0** % |
| Sand | **16** % |
| Silt and smaller | **3** % |

Silt/Clay Present? **No**

Detritus **1** %

# Large Woody **5**

2.13 Average Largest Particle on

| | | |
|---|---|---|
| Bed | **279.0** | **mm** |
| Bar | **N/A** | **mm** |

2.14 Stream Type

Stream Type: **F**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Cohesive** | **Cohesive** |
| Lower | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Cohesive** | **Cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **0** | **0** |
| Erosion Height (ft) | **0.00** | **0.00** |
| Revetmt. Type | **Rip-Rap** | **None** |
| Revetmt. Length (ft) | **181** | **0** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Herbaceous** |
| Sub-dominant | **Herbaceous** | **Shrubs/Saplin** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **1-25** | **76-100** |

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 | **1,730** | **0** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Coniferous** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Hay** | **Forest** |
| Sub-dominant | **Shrubs/Saplin** | **None** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **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 Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **0** | **0** |

| Diagonal | Delta | Island |
|---|---|---|
| **0** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **0** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,699**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Twentymile Stream** Reach # **M26T2.01** Segment: **0** Completion Date: **September 5, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **1,138** Segment Location: **From northwest valley wall to east valley wall of Black River, at Whitesville, crossing under**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **Yes**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **60** | **0** |
| height | **8** | **0** |
| Roads | **914** | **0** |
| height | **11** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **490** | **90** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Steep** | **Hilly** |
| Continuous w/ | **Never** | **Sometimes** |
| W/in 1 Bankfill | **Never** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **180**

Width Determination **Estimated**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **33**

2.2 Max Depth (ft) **3.60**

2.3 Mean Depth (ft) **2.70**

2.4 Floodprone Width (ft) **140**

Notes:

Route 131 and Whitesville Rd cause reduction in valley width, changing valley type from average Broad to average Narrow confinement. Still Unconfined. Whitesville Rd and adjacent commercial parking lot are at approx thalweg height of 9.8 (or 2.7 times

*Step 2. (Contued)*

2.5 Aband. Floodpln **5.80** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **12.19**

2.7 Entrenchment Ratio **4.26**

2.8 Incision Ratio **1.61**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **16** % |
| Cobble | **42** % |
| Coarse Gravel | **18** % |
| Fine Gravel | **6** % |
| Sand | **13** % |
| Silt and smaller | **5** % |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **3**

2.13 Average Largest Particle on

Bed **336.0** mm

Bar **N/A** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Boulder/Cobbl** | **Boulder/Cobbl** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **79** | **0** |
| Erosion Height (ft) | **5.00** | **0.00** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **330** | **304** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Herbaceous** | **Herbaceous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **0** | **1-25** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **None** | **>100** |
| W less than 25 | **1,096** | **757** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Deciduous** |
| Sub-dominant | **Deciduous** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Residential** | **Residential** |
| Sub-dominant | **None** | **Forest** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **None**

4.2 Adjacent Wetlands **None**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **1** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **0** | **3** |

| Diagonal | Delta | Island |
|---|---|---|
| **0** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **1** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **2** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,101**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **Twentymile Stream** Reach # **M26T2.05** Segment: **0** Completion Date: **June 19, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **5,400** Segment Location: **Through wetlands crossing under Heald Rd and Davis Rd**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **0** |
| height | **0** | **0** |
| Roads | **356** | **0** |
| height | **6** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **567** | **114** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Very Steep** | **Very Steep** |
| Continuous w/ | **Never** | **Sometimes** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **315**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **No**

## Step 2. Stream Channel

2.1 Bankfull Width **39**

2.2 Max Depth (ft) **3.30**

2.3 Mean Depth (ft) **2.13**

2.4 Floodprone Width (ft) **140**

Notes:

Near the upstream end of the reach, the Beers (1869) map depicts an “ancient road” crossing from Twentymile Stream Rd to Heald Road (west to east ). Traces of this road are visible on the 1994 black and white orthophotograph and on the 1939 aerial

*Step 2. (Contued)*

2.5 Aband. Floodpln **3.80** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **18.43**

2.7 Entrenchment Ratio **3.57**

2.8 Incision Ratio **1.15**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **450**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **39** % |
| Cobble | **17** % |
| Coarse Gravel | **18** % |
| Fine Gravel | **5** % |
| Sand | **18** % |
| Silt and smaller | **3** % |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **45**

2.13 Average Largest Particle on

| | | |
|---|---|---|
| Bed | **426.0** | **mm** |
| Bar | **180.0** | **mm** |

2.14 Stream Type

Stream Type: **C**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **Multiple** | **13.50** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Undercut**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Boulder/Cobbl** | **Boulder/Cobbl** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **548** | **306** |
| Erosion Height (ft) | **2.47** | **3.23** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **390** | **293** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Herbaceous** | **Herbaceous** |
| Sub-dominant | **Deciduous** | **Deciduous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **76-100** | **76-100** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **>100** | **>100** |
| Sub-dominant | **0-25** | **0-25** |
| W less than 25 | **380** | **1,160** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Mixed Trees** | **Mixed Trees** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Forest** | **Forest** |
| Sub-dominant | **Residential** | **Residential** |
| Mass Failures | **114** | **75** |
| Height | **4** | **20** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Abundant**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **2** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **3** | **7** | **3** |

| Diagonal | Delta | Island |
|---|---|---|
| **2** | **0** | **2** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **6** | **0** | **0** | **4** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,702**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Twentymile Stream** Reach # **M26T2.06** Segment: **A** Completion Date: **June 19, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **6,466** Segment Location: **Downstream 2/3 of reach.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 0 | 0 |
| height | 0 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 0 | 38 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Steep | Steep |
| Continuous w/ | Sometimes | Sometimes |
| W/in 1 Bankfill | Sometimes | Sometimes |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **330**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **No**

## Step 2. Stream Channel

2.1 Bankfull Width **29**

2.2 Max Depth (ft) **4.00**

2.3 Mean Depth (ft) **2.78**

2.4 Floodprone Width (ft) **300**

Notes:

RMS instructed to utilize measured bankfull width (Step 2.1) to calculate valley confinement (Step 1.5). Hay fields and fallow lands along the LB / RB corridors. Riffle/pool bedform is weakly formed. "Riffles" are short and generally run-like. Occasional armoring

*Step 2. (Contued)*

2.5 Aband. Floodpln **4.30** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **10.35**

2.7 Entrenchment Ratio **10.43**

2.8 Incision Ratio **1.08**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **190**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 2% |
| Cobble | 29% |
| Coarse Gravel | 34% |
| Fine Gravel | 3% |
| Sand | 32% |
| Silt and smaller | 0% |

Silt/Clay Present? **No**

Detritus **1** %

# Large Woody **40**

2.13 Average Largest Particle on

Bed **151.0** mm

Bar **92.0** mm

2.14 Stream Type

Stream Type: **E**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Silt | Silt |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Gravel | Gravel |
| Consistency | Non-cohesive | Non-cohesive |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | 568 | 419 |
| Erosion Height (ft) | 4.62 | 3.91 |
| Revetmt. Type | Rip-Rap | Rip-Rap |
| Revetmt. Length (ft) | 1,194 | 1,449 |
| Near Bank Veg. Type | Left | Right |
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |
| Bank Canopy | Left | Right |
| Canopy % | 0 | 0 |

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 | 5,354 | 5,409 |
| Buffer Veg. Type | Left | Right |
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Mixed Trees | Mixed Trees |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Hay | Hay |
| Sub-dominant | Forest | Forest |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **3**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 1 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **4**

Affected Length (ft) **1,304**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 3 | 20 | 2 |
| Diagonal | Delta | Island |
| 3 | 0 | 1 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 5 | 0 | 0 | 3 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **Yes**

5.5 Straightening **Straightening**

Straightening Length: **2,319**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River** | **Phase 2 Segment Summary** | May 19, 2009 | SGAT Version: 4.56

Stream: **Twentymile Stream** | Reach # **M26T2.06** | Segment: **B** | Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** | Observers: **KLU, BOS - SMRC** | Why Not assessed: | Rain: **Yes**

Segment Length (ft): **2,051** | Segment Location: **Narrow section of channel from farmstead downstream past Nelson Rd intersection with**

**QC Status - Staff: Provisional Cons** **Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Subreach**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 1,591 | 0 |
| height | 10 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 260 | 55 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Hilly | Steep |
| Continuous w/ | Sometimes | Sometimes |
| W/in 1 Bankfill | Sometimes | Sometimes |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **150**

Width Determination **Measured**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **32**

2.2 Max Depth (ft) **3.50**

2.3 Mean Depth (ft) **2.26**

2.4 Floodprone Width (ft) **275**

Notes:

RMS instructed to utilize measured bankfull width (Step 2.1) to calculate valley confinement (Step 1.5). Segment is a subreach of alternate stream type (reference C4-R/P) and valley confinment (Narrow). Some reduction in valley width caused by

*Step 2. (Contued)*

2.5 Aband. Floodpln **3.80** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **14.07**

2.7 Entrenchment Ratio **8.65**

2.8 Incision Ratio **1.09**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **125**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 19% |
| Cobble | 14% |
| Coarse Gravel | 11% |
| Fine Gravel | 16% |
| Sand | 40% |
| Silt and smaller | 0% |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **5**

2.13 Average Largest Particle on

Bed **402.0** **mm**

Bar **N/A** **mm**

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

**C** **4** **Non Riffle-Pool**

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Moderate**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | 53 | 105 |
| Erosion Height (ft) | 2.00 | 3.03 |
| Revetmt. Type | Hard Bank | Hard Bank |
| Revetmt. Length (ft) | 29 | 28 |
| Near Bank Veg. Type | Left | Right |
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Herbaceous | Herbaceous |
| Bank Canopy | Left | Right |
| Canopy % | 51-75 | 51-75 |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | 0-25 | 0-25 |
| Sub-dominant | >100 | 26-50 |
| W less than 25 | 1,412 | 2,050 |
| Buffer Veg. Type | Left | Right |
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Deciduous | Deciduous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Hay |
| Sub-dominant | Hay | Forest |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 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 Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 1 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **1**

Affected Length (ft) **120**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 0 | 1 | 1 |
| **Diagonal** | **Delta** | **Island** |
| 0 | 1 | 1 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 0 | 0 | 0 | 1 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **Yes**

5.5 Straightening **Straightening**

Straightening Length: **1,106**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **Twentymile Stream** Reach # **M26T2.06** Segment: **C** Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: **beaver dam** Rain: **Yes**

Segment Length (ft): **1,292** Segment Location: **Upstream end of reach, impounded by multiple beaver dams.**

**QC Status - Staff: Provisional Cons** **Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 971 | 0 |
| height | 8 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 0 | 0 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Hilly | Steep |
| Continuous w/ | Never | Sometimes |
| W/in 1 Bankfill | Sometimes | Sometimes |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **820**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **0**

2.2 Max Depth (ft) **0.00**

2.3 Mean Depth (ft) **0.00**

2.4 Floodprone Width (ft) **0**

Notes:

Segment is a subreach of alternate stream type (reference C4-R/P) and valley confinement (Very Broad). Has been impounded by three beaver dams. One is near the upstream reach break and impounds a channel length of approximately 700 ft

*Step 2. (Contued)*

2.5 Aband. Floodpln **0.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **0.00**

2.7 Entrenchment Ratio **0.00**

2.8 Incision Ratio **0.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity

2.10 Riffles Type

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Silt/Clay Present?

Detritus **0** %

# Large Woody **0**

2.13 Average Largest Particle on

Bed **0.0**

Bar **0.0**

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Silt | Silt |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Sand | Sand |
| Consistency | Cohesive | Cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 0 | 0 |
| Erosion Height (ft) | 0.00 | 0.00 |
| Revetmt. Type | None | Rip-Rap |
| Revetmt. Length (ft) | 0 | 83 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 0 | 0 |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | 0-25 | 0-25 |
| Sub-dominant | None | None |
| W less than 25 | 1,273 | 1,268 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Herbaceous | Herbaceous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Hay | Hay |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 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 Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **3**

Affected Length (ft) **925**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 0 | 0 | 0 |

| Diagonal | Delta | Island |
|---|---|---|
| 0 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 0 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **None**

Straightening Length: **0**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Twentymile Stream** Reach # **M26T2.07** Segment: **0** Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **4,926** Segment Location: **Through fields east of Twenty Mile Stream Rd, west of Mt Gilead**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **184** | **0** |
| height | **6** | **0** |
| Roads | **877** | **0** |
| height | **4** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **429** | **0** |
| height | **8** | **0** |
| Development | **0** | **36** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Steep** | **Very Steep** |
| Continuous w/ | **Sometimes** | **Never** |
| W/in 1 Bankfill | **Sometimes** | **Never** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **510**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **29**

2.2 Max Depth (ft) **2.40**

2.3 Mean Depth (ft) **1.60**

2.4 Floodprone Width (ft) **700**

Notes:

Valley width reduced somewhat by Twentymile Stream Rd which passes through RB corridor close to the right valley wall. Not sufficient to cause change in valley type (V. Broad) or confinement status (Unconfined). RB berm is present just downstream of VAST

*Step 2. (Contued)*

2.5 Aband. Floodpln **4.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **18.19**

2.7 Entrenchment Ratio **24.05**

2.8 Incision Ratio **1.67**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **210**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **0** % |
| Cobble | **0** % |
| Coarse Gravel | **27** % |
| Fine Gravel | **48** % |
| Sand | **18** % |
| Silt and smaller | **7** % |

Silt/Clay Present? **No**

Detritus **10** %

# Large Woody **40**

2.13 Average Largest Particle on

Bed **29.6** mm

Bar **28.5** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Silt** | **Silt** |
| Consistency | **Cohesive** | **Cohesive** |
| Lower | | |
| Material Type | **Sand** | **Sand** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **794** | **666** |
| Erosion Height (ft) | **3.02** | **4.00** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **173** | **361** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Herbaceous** |
| Sub-dominant | **Herbaceous** | **Shrubs/Saplin** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **0** | **0** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **>100** | **None** |
| W less than 25 | **2,956** | **4,772** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Herbaceous** | **Herbaceous** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Crop** | **Hay** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Abundant**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **3**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **2**

Affected Length (ft) **300**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **2** | **17** | **3** |

| Diagonal | Delta | Island |
|---|---|---|
| **2** | **0** | **1** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **2** | **0** | **0** | **1** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **Yes**

5.5 Straightening **Straightening**

Straightening Length: **627**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Twentymile Stream** Reach # **M26T2.08** Segment: **A** Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **1,393** Segment Location: **From vicinity of Twentymile Stream Rd culvert crossing to downstream end of reach.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 477 | 118 |
| height | 7 | 11 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 0 | 120 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Steep | Steep |
| Continuous w/ | Sometimes | Sometimes |
| W/in 1 Bankfill | Sometimes | Sometimes |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **225**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **22**

2.2 Max Depth (ft) **2.20**

2.3 Mean Depth (ft) **1.57**

2.4 Floodprone Width (ft) **75**

Notes:

Fallow fields and hay fields surround the channel in this segment; forest along LB at downstream end. Narrow shrub buffer along both banks. A similar land use was depicted on historic aerial photographs from 1939, 1977 and 1994. Slight human-caused

*Step 2. (Contued)*

2.5 Aband. Floodpln **4.30** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **14.01**

2.7 Entrenchment Ratio **3.41**

2.8 Incision Ratio **1.95**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **140**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 3% |
| Cobble | 38% |
| Coarse Gravel | 39% |
| Fine Gravel | 2% |
| Sand | 6% |
| Silt and smaller | 13% |

Silt/Clay Present? **No**

Detritus **1** %

# Large Woody **2**

2.13 Average Largest Particle on

Bed **220.0** mm

Bar **131.0** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Boulder/Cobbl | Boulder/Cobbl |
| Consistency | Non-cohesive | Non-cohesive |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | 0 | 134 |
| Erosion Height (ft) | 0.00 | 3.01 |
| Revetmt. Type | Rip-Rap | Rip-Rap |
| Revetmt. Length (ft) | 167 | 195 |
| Near Bank Veg. Type | Left | Right |
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Herbaceous | Herbaceous |
| Bank Canopy | Left | Right |
| Canopy % | 76-100 | 76-100 |
| Mid-Channel Canopy | Closed | |

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | 0-25 | 0-25 |
| Sub-dominant | >100 | 26-50 |
| W less than 25 | 925 | 1,366 |
| Buffer Veg. Type | Left | Right |
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Mixed Trees | Deciduous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Hay | Hay |
| Sub-dominant | Forest | Shrubs/Saplin |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 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 Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 1 | 5 | 1 |
| **Diagonal** | **Delta** | **Island** |
| 0 | 1 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 3 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **Yes**

5.5 Straightening **Straightening**

Straightening Length: **1,022**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Twentymile Stream** Reach # **M26T2.08** Segment: **B** Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **2,241** Segment Location: **West side of Twentymile Stream Rd, downstream of Meadowbrook Farm Rd nearly to the**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 0 | 0 |
| height | 0 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 65 | 0 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Steep | Steep |
| Continuous w/ | Sometimes | Sometimes |
| W/in 1 Bankfill | Sometimes | Sometimes |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **245**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **No**

## Step 2. Stream Channel

2.1 Bankfull Width **27**

2.2 Max Depth (ft) **2.40**

2.3 Mean Depth (ft) **1.30**

2.4 Floodprone Width (ft) **55**

Notes:

Forested cover surrounds all but the upstream extreme of the segment. A similar land use was depicted on historic aerial photographs from 1939, 1977 and 1994. Sparse residential / agricultural development on the valley walls surrounding the floodplain.

*Step 2. (Contued)*

2.5 Aband. Floodpln **2.60** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **20.92**

2.7 Entrenchment Ratio **2.02**

2.8 Incision Ratio **1.08**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **140**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 14% |
| Cobble | 14% |
| Coarse Gravel | 27% |
| Fine Gravel | 9% |
| Sand | 36% |
| Silt and smaller | 0% |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **34**

2.13 Average Largest Particle on

Bed **410.0** **mm**

Bar **131.0** **mm**

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | One | 8.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Gravel | Gravel |
| Consistency | Non-cohesive | Non-cohesive |
| Lower | | |
| Material Type | Gravel | Gravel |
| Consistency | Non-cohesive | Non-cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 224 | 196 |
| Erosion Height (ft) | 2.00 | 2.00 |
| Revetmt. Type | Rip-Rap | None |
| Revetmt. Length (ft) | 27 | 0 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Deciduous | Deciduous |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 76-100 | 76-100 |

Mid-Channel Canopy **Closed**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | >100 | >100 |
| Sub-dominant | None | 0-25 |
| W less than 25 | 55 | 289 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Mixed Trees | Mixed Trees |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Forest |
| Sub-dominant | None | None |
| Mass Failures | 26 | 0 |
| Height | 8 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Abundant**

4.2 Adjacent Wetlands **None**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **1**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 1 | 2 | 9 |

| Diagonal | Delta | Island |
|---|---|---|
| 1 | 1 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 0 | 0 | 1 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **Yes**

5.5 Straightening **Straightening**

Straightening Length: **357**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Twentymile Stream** Reach # **M26T2.09** Segment: **0** Completion Date: **September 22, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **2,851** Segment Location: **Through wetland between Twenty Mile Stream Rd and Meadowbrook Farm Rd**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **0** |
| height | **0** | **0** |
| Roads | **467** | **101** |
| height | **12** | **9** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **284** | **65** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Hilly** | **Hilly** |
| Continuous w/ | **Sometimes** | **Never** |
| W/in 1 Bankfill | **Sometimes** | **Never** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **630**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **27**

2.2 Max Depth (ft) **2.00**

2.3 Mean Depth (ft) **1.64**

2.4 Floodprone Width (ft) **300**

Notes:

Twentymile Stream Road along LB corridor causes slight reduction in valley width; not sufficient to cause change in valley type (V. Broad) or confinement status (Unconfined). Sparse residential development along LB (and fallow pasture). Old stone foundation

*Step 2. (Contued)*

2.5 Aband. Floodpln **3.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **16.59**

2.7 Entrenchment Ratio **11.03**

2.8 Incision Ratio **1.50**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Sedimented**

2.11 Riffle/Step Spacing (ft) **120**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **1** % |
| Cobble | **55** % |
| Coarse Gravel | **31** % |
| Fine Gravel | **1** % |
| Sand | **11** % |
| Silt and smaller | **1** % |

Silt/Clay Present? **No**

Detritus **3** %

# Large Woody **31**

2.13 Average Largest Particle on

Bed **179.0** mm

Bar **136.0** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

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

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **734** | **532** |
| Erosion Height (ft) | **4.06** | **3.38** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **66** | **66** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Deciduous** | **Herbaceous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **51-75** | **26-50** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **26-50** | **>100** |
| W less than 25 | **1,347** | **1,536** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Deciduous** | **Deciduous** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Forest** | **Hay** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Abundant**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **1** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **1**

Affected Length (ft) **150**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **2** | **7** | **5** |
| **Diagonal** | **Delta** | **Island** |
| **3** | **1** | **1** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **3** | **0** | **1** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **2** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **2,158**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Twentymile Stream** Reach # **M26T2.10** Segment: **A** Completion Date: **September 22, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **1,015** Segment Location: **Downstream 1/3 of reach, from private driveway culvert crossing downstream to next reach.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Subreach**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 0 | 0 |
| height | 0 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 430 | 0 |
| height | 7 | 0 |
| Development | 60 | 48 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Very Steep | Very Steep |
| Continuous w/ | Sometimes | Sometimes |
| W/in 1 Bankfill | Sometimes | Sometimes |
| Texture | Mixed | Mixed |

1.5 Valley Features

Valley Width (ft) **140**

Width Determination **Measured**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **No**

## Step 2. Stream Channel

2.1 Bankfull Width **20**

2.2 Max Depth (ft) **2.00**

2.3 Mean Depth (ft) **1.16**

2.4 Floodprone Width (ft) **29**

Notes:

Segment in coniferous forest. Culvert crossing (bankfull constrictor) for private driveway at top of segment. Old foundation along the LB corridor approx 300 ft downstream of the residence near the culvert crossing. The foundation remnants are

*Step 2. (Contued)*

2.5 Aband. Floodpln **4.60** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **17.28**

2.7 Entrenchment Ratio **1.45**

2.8 Incision Ratio **2.30**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **144**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 10% |
| Cobble | 34% |
| Coarse Gravel | 26% |
| Fine Gravel | 11% |
| Sand | 13% |
| Silt and smaller | 6% |

Silt/Clay Present? **No**

Detritus **3** %

# Large Woody **15**

2.13 Average Largest Particle on

Bed **404.0** **mm**

Bar **135.0** **mm**

2.14 Stream Type

Stream Type: **F**

Bed Material: **Gravel**

Subclass Slope: **b**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

**C** **4** **b** **Riffle-Pool**

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Undercut**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 186 | 92 |
| Erosion Height (ft) | 2.00 | 4.20 |
| Revetmt. Type | Rip-Rap | Rip-Rap |
| Revetmt. Length (ft) | 208 | 95 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Coniferous | Coniferous |
| Sub-dominant | Deciduous | Deciduous |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 76-100 | 76-100 |

Mid-Channel Canopy **Closed**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | >100 | >100 |
| Sub-dominant | 0-25 | 0-25 |
| W less than 25 | 140 | 105 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Coniferous | Coniferous |
| Sub-dominant | Deciduous | Deciduous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Forest |
| Sub-dominant | Residential | None |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 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 **1**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 1 | 4 | 2 |

| Diagonal | Delta | Island |
|---|---|---|
| 1 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 3 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **Yes**

5.5 Straightening **None**

Straightening Length: **0**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Twentymile Stream** Reach # **M26T2.10** Segment: **B** Completion Date: **September 22, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **908** Segment Location: **Middle segment of reach - from just below the Twentymile Stream Rd bridge crossing to just**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 0 | 0 |
| height | 0 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 0 | 0 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Very Steep | Very Steep |
| Continuous w/ | Sometimes | Sometimes |
| W/in 1 Bankfill | Always | Always |
| Texture | Mixed | Mixed |

1.5 Valley Features

Valley Width (ft) **39**

Width Determination **Measured**

Confinement Type **Semi-confined**

Rock Gorge? **No**

Human-caused Change? **No**

## Step 2. Stream Channel

2.1 Bankfull Width **21**

2.2 Max Depth (ft) **2.00**

2.3 Mean Depth (ft) **1.40**

2.4 Floodprone Width (ft) **41**

Notes:

Twentymile Stream Rd follows along LB but elevated well above channel on valley side slope. Toe of valley side slope is stream-ward of the road, so road not indexed as an encroachment. Two occurrences of channel-spanning bedrock ("ledge"). Old foundation

*Step 2. (Contued)*

2.5 Aband. Floodpln **2.60** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **15.07**

2.7 Entrenchment Ratio **1.94**

2.8 Incision Ratio **1.30**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **75**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 17% |
| Cobble | 33% |
| Coarse Gravel | 33% |
| Fine Gravel | 8% |
| Sand | 9% |
| Silt and smaller | 0% |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **20**

2.13 Average Largest Particle on

| | | |
|---|---|---|
| Bed | 409.0 | mm |
| Bar | N/A | mm |

2.14 Stream Type

Stream Type: **B**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Step-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 290 | 0 |
| Erosion Height (ft) | 9.48 | 0.00 |
| Revetmt. Type | Rip-Rap | None |
| Revetmt. Length (ft) | 22 | 0 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Deciduous | Deciduous |
| Sub-dominant | Coniferous | Coniferous |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 76-100 | 76-100 |

Mid-Channel Canopy **Closed**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | 51-100 | >100 |
| Sub-dominant | 26-50 | 26-50 |
| W less than 25 | 709 | 242 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Deciduous | Deciduous |
| Sub-dominant | Coniferous | Coniferous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Forest |
| Sub-dominant | None | None |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 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 **2**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 1 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 0 | 0 | 2 |

| Diagonal | Delta | Island |
|---|---|---|
| 0 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 1 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **None**

Straightening Length: **0**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Twentymile Stream** Reach # **M26T2.10** Segment: **C** Completion Date: **September 22, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **1,209** Segment Location: **Upstream 1/3 of reach to a point just downstream of the Twentymile Stream Rd bridge**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Subreach**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **106** | **0** |
| height | **5** | **0** |
| Roads | **856** | **0** |
| height | **15** | **0** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **148** | **53** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Steep** | **Very Steep** |
| Continuous w/ | **Sometimes** | **Sometimes** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **100**

Width Determination **Estimated**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **19**

2.2 Max Depth (ft) **1.80**

2.3 Mean Depth (ft) **1.30**

2.4 Floodprone Width (ft) **100**

Notes:

Subreach of lesser gradient, unconfined channel (C-R/P) in otherwise B-S/P channel. Short length of berm apparent along LB upstream of the Twentymile Stream Rd bridge crossing and across from RB residence. Another short length of berm

*Step 2. (Contued)*

2.5 Aband. Floodpln **3.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **14.69**

2.7 Entrenchment Ratio **5.24**

2.8 Incision Ratio **1.67**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **6** % |
| Cobble | **36** % |
| Coarse Gravel | **24** % |
| Fine Gravel | **7** % |
| Sand | **14** % |
| Silt and smaller | **13** % |

Silt/Clay Present? **No**

Detritus **5** %

# Large Woody **3**

2.13 Average Largest Particle on

Bed **274.0** mm

Bar **N/A** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

**C 4 Non Riffle-Pool**

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Undercut**

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

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **169** | **35** |
| Erosion Height (ft) | **2.90** | **2.00** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **162** | **67** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Herbaceous** | **Herbaceous** |
| Sub-dominant | **Deciduous** | **Deciduous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **76-100** | **51-75** |

Mid-Channel Canopy **Closed**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **>100** | **26-50** |
| Sub-dominant | **0-25** | **0-25** |
| W less than 25 | **357** | **731** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Forest** | **Forest** |
| Sub-dominant | **Residential** | **Residential** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **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 Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **1** |
| Other | **1** | Tile Drain | **1** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **2** | **3** |

| Diagonal | Delta | Island |
|---|---|---|
| **0** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **1** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **842**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River** | **Phase 2 Segment Summary** | May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M27** Segment: **0** Completion Date: **September 17, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **3,999** Segment Location: **From below CVPS power plant d/s to Twenty Mile Stream confluence at Whitesville**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 0 | 0 |
| height | 0 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 439 | 41 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Very Steep | Very Steep |
| Continuous w/ | Never | Sometimes |
| W/in 1 Bankfill | Never | Sometimes |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **573**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **No**

## Step 2. Stream Channel

2.1 Bankfull Width **85**

2.2 Max Depth (ft) **4.80**

2.3 Mean Depth (ft) **3.55**

2.4 Floodprone Width (ft) **300**

Notes:

Bedrock ledge near upstream end of reach (at base of Cavendish Gorge). Substantial bedrock exposure (falls) at downstream end of reach, at and just downstream of Carlton Rd bridge crossing at Whitesville. Historic grist mill, saw mill (and potential for dam)

*Step 2. (Contued)*

2.5 Aband. Floodpln **8.60** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **23.92**

2.7 Entrenchment Ratio **3.53**

2.8 Incision Ratio **1.79**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Sedimented**

2.11 Riffle/Step Spacing (ft) **510**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 4% |
| Cobble | 55% |
| Coarse Gravel | 26% |
| Fine Gravel | 3% |
| Sand | 12% |
| Silt and smaller | 0% |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **5**

2.13 Average Largest Particle on

Bed **234.0** mm

Bar **N/A** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Moderate**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 55 | 0 |
| Erosion Height (ft) | 4.00 | 0.00 |
| Revetmt. Type | None | None |
| Revetmt. Length (ft) | 0 | 0 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Herbaceous | Herbaceous |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 1-25 | 1-25 |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | >100 | >100 |
| Sub-dominant | 0-25 | 0-25 |
| W less than 25 | 982 | 1,457 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Shrubs/Saplin | Deciduous |
| Sub-dominant | Deciduous | Coniferous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Forest |
| Sub-dominant | Residential | Residential |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **Run-of-river**

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 2 | 0 | 0 |

| Diagonal | Delta | Island |
|---|---|---|
| 1 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 3 | 0 | 1 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **2,690**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **Black River** Reach # **M30** Segment: **0** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; SP - BRAT** Why Not assessed: Rain: **No**

Segment Length (ft): **8,101** Segment Location: **From Proctorsville d/s to Mill Street crossing in Cavendish**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **124** | **0** |
| height | **11** | **0** |
| Roads | **4,369** | **0** |
| height | **17** | **0** |
| Railroads | **2,726** | **0** |
| height | **20** | **0** |
| Improved Paths | **459** | **0** |
| height | **8** | **0** |
| Development | **2,327** | **310** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Very Steep** | **Extremely** |
| Continuous w/ | **Sometimes** | **Sometimes** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **715**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **85**

2.2 Max Depth (ft) **4.60**

2.3 Mean Depth (ft) **3.98**

2.4 Floodprone Width (ft) **550**

Notes:

Glacio-fluvial high terrace along LB (and occasionally along RB) considered valley wall for purposes of defining reference stream type and reference valley confinement. Slight (negligible) human-caused change in valley width by RB railroad at upstream end of

*Step 2. (Contued)*

2.5 Aband. Floodpln **6.40** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **21.36**

2.7 Entrenchment Ratio **6.47**

2.8 Incision Ratio **1.39**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **980**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **0** % |
| Cobble | **60** % |
| Coarse Gravel | **29** % |
| Fine Gravel | **3** % |
| Sand | **6** % |
| Silt and smaller | **2** % |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **19**

2.13 Average Largest Particle on

Bed **170.0** mm

Bar **150.0** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **Multiple** | **15.33** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Silt** | **Silt** |
| Consistency | **Cohesive** | **Cohesive** |
| Lower | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **1,396** | **824** |
| Erosion Height (ft) | **5.55** | **4.19** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **1,242** | **508** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Deciduous** |
| Sub-dominant | **Deciduous** | **Shrubs/Saplin** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **1-25** | **51-75** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **None** | **51-100** |
| W less than 25 | **5,573** | **3,873** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Coniferous** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Hay** | **Forest** |
| Sub-dominant | **Industrial** | **Hay** |
| Mass Failures | **171** | **96** |
| Height | **16** | **15** |
| Gullies | **0** | **0** |
| Height | **0** | **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 **1**

4.5 Flow Regulation Type **Small**

Flow Regulation Use **Other**

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **Down Stream**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **1** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **3** | **3** |

| Diagonal | Delta | Island |
|---|---|---|
| **2** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **2** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **1** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **6,159**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River** | **Phase 2 Segment Summary** | May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M31** Segment: **0** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; SP - BRAT** Why Not assessed: Rain: **No**

Segment Length (ft): **3,741** Segment Location: **Reach through Proctorsville.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **0** |
| height | **0** | **0** |
| Roads | **1,392** | **173** |
| height | **15** | **15** |
| Railroads | **2,990** | **0** |
| height | **10** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **1,644** | **1,072** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Very Steep** | **Steep** |
| Continuous w/ | **Never** | **Sometimes** |
| W/in 1 Bankfill | **Never** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **460**

Width Determination **Estimated**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **78**

2.2 Max Depth (ft) **4.50**

2.3 Mean Depth (ft) **3.50**

2.4 Floodprone Width (ft) **550**

Notes:

High glaciofluvial terrace on both LB and RB considered valley walls for purpose of defining reference stream type and valley confinement. Human-caused change in valley width due to road and railroad encroachment - also commercial and

*Step 2. (Contued)*

2.5 Aband. Floodpln **6.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **22.40**

2.7 Entrenchment Ratio **7.02**

2.8 Incision Ratio **1.33**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **770**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **1** % |
| Cobble | **48** % |
| Coarse Gravel | **40** % |
| Fine Gravel | **5** % |
| Sand | **6** % |
| Silt and smaller | **0** % |

Silt/Clay Present? **No**

Detritus **4** %

# Large Woody **3**

2.13 Average Largest Particle on

Bed **165.0** mm

Bar **156.0** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | **159** | **620** |
| Erosion Height (ft) | **4.00** | **6.99** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **611** | **498** |
| Near Bank Veg. Type | Left | Right |
| Dominant | **Shrubs/Saplin** | **Deciduous** |
| Sub-dominant | **Deciduous** | **Shrubs/Saplin** |
| Bank Canopy | Left | Right |
| Canopy % | **76-100** | **51-75** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **26-50** | **0-25** |
| Sub-dominant | **0-25** | **26-50** |
| W less than 25 | **1,183** | **1,660** |
| Buffer Veg. Type | Left | Right |
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Forest** | **Residential** |
| Sub-dominant | **Residential** | **Forest** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **2** |
| Other | **1** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **2** | **3** | **1** |
| **Diagonal** | **Delta** | **Island** |
| **0** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **2** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **2,879**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **Black River** Reach # **M32** Segment: **A** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; SP - BRAT** Why Not assessed: Rain: **No**

Segment Length (ft): **5,429** Segment Location: **From Winery Road crossing to the downstream end of the reach at Proctorsville below the**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **0** |
| height | **0** | **0** |
| Roads | **2,203** | **3,116** |
| height | **9** | **10** |
| Railroads | **4,237** | **0** |
| height | **15** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **1,116** | **2,318** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Extremely** | **Very Steep** |
| Continuous w/ | **Never** | **Sometimes** |
| W/in 1 Bankfill | **Never** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **270**

Width Determination **Estimated**

Confinement Type **Semi-confined**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **135**

2.2 Max Depth (ft) **4.00**

2.3 Mean Depth (ft) **1.84**

2.4 Floodprone Width (ft) **250**

Notes:

Rt 103 encroaches substantially along the LB - including channel relocation near Winery Road between 1980 and 1994. Greven Rd Extension encroaches along RB. Green Mtn Railroad encroaches along RB in the upstream end of the segment, crosses the

*Step 2. (Contued)*

2.5 Aband. Floodpln **8.50** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **73.21**

2.7 Entrenchment Ratio **1.86**

2.8 Incision Ratio **2.13**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **786**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **0** % |
| Cobble | **61** % |
| Coarse Gravel | **27** % |
| Fine Gravel | **1** % |
| Sand | **11** % |
| Silt and smaller | **0** % |

Silt/Clay Present? **No**

Detritus **1** %

# Large Woody **21**

2.13 Average Largest Particle on

Bed **155.0** mm

Bar **110.0** mm

2.14 Stream Type

Stream Type: **B**

Bed Material: **Cobble**

Subclass Slope: **c**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Silt** | **Silt** |
| Consistency | **Cohesive** | **Cohesive** |
| Lower | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **229** | **1,100** |
| Erosion Height (ft) | **5.00** | **7.71** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **1,029** | **1,414** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Deciduous** | **Deciduous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **1-25** | **26-50** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **26-50** | **51-100** |
| Sub-dominant | **0-25** | **26-50** |
| W less than 25 | **5,043** | **3,974** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Deciduous** |
| Sub-dominant | **Deciduous** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Commercial** | **Residential** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **Up Stream**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **2** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **4** | **4** | **0** |

| Diagonal | Delta | Island |
|---|---|---|
| **1** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **5** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **1** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **5,385**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River** | **Phase 2 Segment Summary** | May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M32** Segment: **B** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; SP - BRAT** Why Not assessed: Rain: **No**

Segment Length (ft): **2,626** Segment Location: **From East Hill Rd bridge crossing downstream nearly to Winery Rd crossing.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 300 | 0 |
| height | 7 | 0 |
| Roads | 1,791 | 0 |
| height | 11 | 0 |
| Railroads | 1,839 | 0 |
| height | 20 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 433 | 0 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Steep | Extremely |
| Continuous w/ | Never | Sometimes |
| W/in 1 Bankfill | Never | Sometimes |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **480**

Width Determination **Estimated**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **80**

2.2 Max Depth (ft) **4.30**

2.3 Mean Depth (ft) **2.38**

2.4 Floodprone Width (ft) **440**

Notes:

Slight reduction in valley width caused by Route 103 along LB; no change in valley type (Narrow) or confinement status (Unconfined). Subtle, low-profile berm along LB opposite Fletcher Fields, results in Human-Elevated-Floodplain as defined by protocols

*Step 2. (Contued)*

2.5 Aband. Floodpln **5.80** ft.

Human Elev Floodpln **7.10** ft.

2.6 Width/Depth Ratio **33.70**

2.7 Entrenchment Ratio **5.49**

2.8 Incision Ratio **1.35**

Human Elevated Inc Rat **1.65**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **915**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 0% |
| Cobble | 30% |
| Coarse Gravel | 57% |
| Fine Gravel | 9% |
| Sand | 4% |
| Silt and smaller | 0% |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **3**

2.13 Average Largest Particle on

Bed **140.0** mm

Bar **110.0** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Silt | Silt |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Gravel | Gravel |
| Consistency | Non-cohesive | Non-cohesive |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | 99 | 465 |
| Erosion Height (ft) | 3.00 | 3.27 |
| Revetmt. Type | Other | Rip-Rap |
| Revetmt. Length (ft) | 25 | 31 |
| Near Bank Veg. Type | Left | Right |
| Dominant | Invasives | Deciduous |
| Sub-dominant | Deciduous | Shrubs/Saplin |
| Bank Canopy | Left | Right |
| Canopy % | 1-25 | 76-100 |
| Mid-Channel Canopy | Open | |

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | 0-25 | 26-50 |
| Sub-dominant | 51-100 | >100 |
| W less than 25 | 2,134 | 1,287 |
| Buffer Veg. Type | Left | Right |
| Dominant | Invasives | Deciduous |
| Sub-dominant | Deciduous | Coniferous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Hay | Forest |
| Sub-dominant | Residential | Commercial |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 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 **1**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **1**

Affected Length (ft) **550**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 1 | 0 | 3 |
| **Diagonal** | **Delta** | **Island** |
| 0 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 2 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **2,626**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M32** Segment: **C** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; SP - BRAT** Why Not assessed: Rain: **No**

Segment Length (ft): **3,945** Segment Location: **From Ludlow WWTF to just downstream of East Hill Road bridge crossing.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **0** |
| height | **0** | **0** |
| Roads | **567** | **0** |
| height | **20** | **0** |
| Railroads | **859** | **0** |
| height | **25** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **452** | **693** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Extremely** | **Extremely** |
| Continuous w/ | **Never** | **Sometimes** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **765**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **75**

2.2 Max Depth (ft) **3.80**

2.3 Mean Depth (ft) **2.76**

2.4 Floodprone Width (ft) **140**

Notes:

Rt 103 encroaches within LB corridor to a minor degree; no significant change in valley type (Broad) or confinement status (Unconfined). Remnants of the Smithville dam were indexed as a grade control; negligible impoundment effects (dam is

*Step 2. (Contued)*

2.5 Aband. Floodpln **6.40** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **26.99**

2.7 Entrenchment Ratio **1.88**

2.8 Incision Ratio **1.68**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **740**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **12** % |
| Cobble | **42** % |
| Coarse Gravel | **29** % |
| Fine Gravel | **1** % |
| Sand | **16** % |
| Silt and smaller | **0** % |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **20**

2.13 Average Largest Particle on

Bed **340.0** mm

Bar **110.0** mm

2.14 Stream Type

Stream Type: **B**

Bed Material: **Cobble**

Subclass Slope: **c**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Silt** | **Silt** |
| Consistency | **Cohesive** | **Cohesive** |
| Lower | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **292** | **0** |
| Erosion Height (ft) | **6.00** | **0.00** |
| Revetmt. Type | **Multiple** | **Rip-Rap** |
| Revetmt. Length (ft) | **423** | **182** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Deciduous** |
| Sub-dominant | **Deciduous** | **Coniferous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **1-25** | **76-100** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **>100** |
| Sub-dominant | **None** | **51-100** |
| W less than 25 | **3,589** | **907** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Coniferous** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Hay** | **Forest** |
| Sub-dominant | **Commercial** | **Commercial** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## 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 **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **1** | **1** | **5** |

| Diagonal | Delta | Island |
|---|---|---|
| **2** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **1** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **3,827**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River** | **Phase 2 Segment Summary** | May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M33** Segment: **A** Completion Date: **October 1, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: Rain: **No**

Segment Length (ft): **4,053** Segment Location: **From just d/s of Mill Street bridge crossing to confluence w/ M32S1 below the Wastewater**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **765** | **0** |
| height | **7** | **0** |
| Roads | **1,630** | **2,333** |
| height | **9** | **8** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **1,640** | **2,135** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Extremely** | **Extremely** |
| Continuous w/ | **Never** | **Sometimes** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **630**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **68**

2.2 Max Depth (ft) **5.00**

2.3 Mean Depth (ft) **3.47**

2.4 Floodprone Width (ft) **800**

Notes:

Human-caused change in valley width by Main St (LB), has changed the valley confinement from a reference Very Broad to modified average Broad (ranging from Narrow to Very Broad). RB valley wall (for purposes of defining reference stream type)

*Step 2. (Contued)*

2.5 Aband. Floodpln **6.70** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **19.57**

2.7 Entrenchment Ratio **11.78**

2.8 Incision Ratio **1.34**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **1,290**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0**% |
| Boulder | **4**% |
| Cobble | **87**% |
| Coarse Gravel | **8**% |
| Fine Gravel | **1**% |
| Sand | **0**% |
| Silt and smaller | **0**% |

Silt/Clay Present? **No**

Detritus **3** %

# Large Woody **2**

2.13 Average Largest Particle on

| | | |
|---|---|---|
| Bed | **250.0** | **mm** |
| Bar | **N/A** | **mm** |

2.14 Stream Type

Stream Type: **C**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Moderate**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **0** | **0** |
| Erosion Height (ft) | **0.00** | **0.00** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **3,248** | **2,566** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Deciduous** | **Deciduous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **76-100** | **51-75** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **None** | **None** |
| W less than 25 | **3,508** | **3,685** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Commercial** | **Commercial** |
| Sub-dominant | **Residential** | **Residential** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **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 Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **Up Stream**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| 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**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **1** | **1** |

| Diagonal | Delta | Island |
|---|---|---|
| **1** | **1** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **1** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **3** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **4,002**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M33** Segment: **B** Completion Date: **October 1, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS** Why Not assessed: Rain: **No**

Segment Length (ft): **3,796** Segment Location: **From Jewell Brook confluence to just d/s of Mill Street bridge crossing.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **304** | **0** |
| height | **11** | **0** |
| Roads | **543** | **3,093** |
| height | **15** | **10** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **948** | **2,810** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Extremely** | **Extremely** |
| Continuous w/ | **Sometimes** | **Sometimes** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **400**

Width Determination **Estimated**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **59**

2.2 Max Depth (ft) **4.20**

2.3 Mean Depth (ft) **3.10**

2.4 Floodprone Width (ft) **66**

Notes:

LB valley wall (for purposes of defining reference stream type) is a high glacio-fluvial terrace. Human-caused change in valley width due to various roads and commercial/residential encroachment. Valley confinement reduced from Very Broad to an

*Step 2. (Contued)*

2.5 Aband. Floodpln **8.40** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **18.87**

2.7 Entrenchment Ratio **1.13**

2.8 Incision Ratio **2.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0**% |
| Boulder | **14**% |
| Cobble | **70**% |
| Coarse Gravel | **13**% |
| Fine Gravel | **2**% |
| Sand | **1**% |
| Silt and smaller | **0**% |

Silt/Clay Present? **No**

Detritus **3** %

# Large Woody **0**

2.13 Average Largest Particle on

Bed **250.0** mm

Bar **N/A** mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | **229** | **0** |
| Erosion Height (ft) | **5.00** | **0.00** |
| Revetmt. Type | **Multiple** | **Multiple** |
| Revetmt. Length (ft) | **2,657** | **2,696** |
| Near Bank Veg. Type | Left | Right |
| Dominant | **Deciduous** | **Shrubs/Saplin** |
| Sub-dominant | **Shrubs/Saplin** | **Deciduous** |
| Bank Canopy | Left | Right |
| Canopy % | **76-100** | **51-75** |
| Mid-Channel Canopy | **Open** | |

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **26-50** | **None** |
| W less than 25 | **2,848** | **3,775** |
| Buffer Veg. Type | Left | Right |
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Residential** | **Residential** |
| Sub-dominant | **Forest** | **Commercial** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **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 Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **Up Stream**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **3** |
| Other | **3** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **4** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **1** | **0** | **2** |
| **Diagonal** | **Delta** | **Island** |
| **0** | **2** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **0** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **1** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **3,707**

5.5 Dredging **Dredging, Gravel Mining**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **Black River** Reach # **M34** Segment: **0** Completion Date: **October 1, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; MLC - DEC;** Why Not assessed: Rain: **No**

Segment Length (ft): **2,161** Segment Location: **From valley pinch-point d/s along Route 103 past RB shopping plazas to Jewell Brook**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **1,230** | **0** |
| height | **10** | **0** |
| Roads | **715** | **1,367** |
| height | **38** | **20** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **1,932** | **0** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Extremely** | **Steep** |
| Continuous w/ | **Always** | **Never** |
| W/in 1 Bankfill | **Always** | **Never** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **260**

Width Determination **Estimated**

Confinement Type **Semi-confined**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **84**

2.2 Max Depth (ft) **4.00**

2.3 Mean Depth (ft) **3.14**

2.4 Floodprone Width (ft) **95**

Notes:

Human-caused change in valley width due to Route 103 encroachment (RB), floodplain fill for two shopping plazas, and RB berms. Reference valley confinement (Broad) reduced to Semi-confined. Recently-abandoned floodplain elevation along RB

*Step 2. (Contued)*

2.5 Aband. Floodpln **9.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **26.82**

2.7 Entrenchment Ratio **1.13**

2.8 Incision Ratio **2.25**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **675**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **6** % |
| Cobble | **52** % |
| Coarse Gravel | **31** % |
| Fine Gravel | **5** % |
| Sand | **6** % |
| Silt and smaller | **0** % |

Silt/Clay Present? **No**

Detritus **5** %

# Large Woody **13**

2.13 Average Largest Particle on

Bed **280.0** **mm**

Bar **220.0** **mm**

2.14 Stream Type

Stream Type: **F**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **Multiple** | **4.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Gravel** | **Gravel** |
| Consistency | **Non-cohesive** | **Non-cohesive** |
| Lower | | |
| Material Type | **Boulder/Cobbl** | **Boulder/Cobbl** |
| Consistency | **Non-cohesive** | **Non-cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **478** | **492** |
| Erosion Height (ft) | **3.00** | **4.90** |
| Revetmt. Type | **None** | **Multiple** |
| Revetmt. Length (ft) | **0** | **595** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **None** | **None** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **76-100** | **76-100** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **26-50** | **>100** |
| Sub-dominant | **0-25** | **51-100** |
| W less than 25 | **835** | **778** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Deciduous** |
| Sub-dominant | **Coniferous** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Forest** | **Forest** |
| Sub-dominant | **Residential** | **Commercial** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **1**

4.5 Flow Regulation Type **Small**

Flow Regulation Use **Recreation**

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **1** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **1** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **1**

Affected Length (ft) **150**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **2** | **2** |

| Diagonal | Delta | Island |
|---|---|---|
| **1** | **1** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **2** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **With Windrowing**

Straightening Length: **2,114**

5.5 Dredging **Gravel Mining**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **Black River** Reach # **M35** Segment: **0** Completion Date: **October 1, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; MLC - DEC;** Why Not assessed: Rain: **No**

Segment Length (ft): **1,713** Segment Location: **Short semi-confined reach upstream of Ludlow, downstream of Dug Road bridge crossing.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **0** |
| height | **0** | **0** |
| Roads | **0** | **1,657** |
| height | **0** | **9** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **0** | **0** |
| height | **0** | **0** |
| Development | **1,009** | **81** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Extremely** | **Extremely** |
| Continuous w/ | **Never** | **Never** |
| W/in 1 Bankfill | **Sometimes** | **Sometimes** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **160**

Width Determination **Measured**

Confinement Type **Semi-confined**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **92**

2.2 Max Depth (ft) **3.30**

2.3 Mean Depth (ft) **2.52**

2.4 Floodprone Width (ft) **160**

Notes:

Slight human-caused change in valley width: RB, Route 103; LB, Dug Road. Enough to change valley confinement from Semi-Confined to Narrowly-Confined. No significant change in confinement status (naturally confined by bedrock-controlled

*Step 2. (Contued)*

2.5 Aband. Floodpln **3.30** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **36.43**

2.7 Entrenchment Ratio **1.74**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Sedimented**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **2** % |
| Cobble | **1** % |
| Coarse Gravel | **31** % |
| Fine Gravel | **19** % |
| Sand | **35** % |
| Silt and smaller | **12** % |

Silt/Clay Present? **No**

Detritus **5** %

# Large Woody **0**

2.13 Average Largest Particle on

Bed **35.0** mm

Bar **N/A** mm

2.14 Stream Type

Stream Type: **B**

Bed Material: **Gravel**

Subclass Slope: **c**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Cohesive** | **Cohesive** |
| Lower | | |
| Material Type | **Mix** | **Mix** |
| Consistency | **Cohesive** | **Cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **116** | **0** |
| Erosion Height (ft) | **2.00** | **0.00** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **145** | **1,010** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Deciduous** | **Deciduous** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **51-75** | **1-25** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **0-25** | **0-25** |
| Sub-dominant | **26-50** | **None** |
| W less than 25 | **1,112** | **1,639** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Deciduous** | **Shrubs/Saplin** |
| Sub-dominant | **Shrubs/Saplin** | **Deciduous** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Shrubs/Saplin** |
| Sub-dominant | **Forest** | **Commercial** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **None**

4.2 Adjacent Wetlands **None**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **3** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **1**

Affected Length (ft) **1**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **0** | **0** |

| Diagonal | Delta | Island |
|---|---|---|
| **0** | **1** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **1** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **None**

Straightening Length: **0**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River** | **Phase 2 Segment Summary** | May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M36** Segment: **A** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; MLC - DEC;** Why Not assessed: Rain: **No**

Segment Length (ft): **3,496** Segment Location: **From Fox Lane bridge d/s to Dug Road bridge crossing.**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | **0** | **0** |
| height | **0** | **0** |
| Roads | **1,184** | **644** |
| height | **12** | **7** |
| Railroads | **0** | **0** |
| height | **0** | **0** |
| Improved Paths | **96** | **0** |
| height | **8** | **0** |
| Development | **0** | **0** |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | **Steep** | **Extremely** |
| Continuous w/ | **Sometimes** | **Never** |
| W/in 1 Bankfill | **Sometimes** | **Never** |
| Texture | **Not Evalua** | **Not Evalua** |

1.5 Valley Features

Valley Width (ft) **575**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **80**

2.2 Max Depth (ft) **3.70**

2.3 Mean Depth (ft) **2.30**

2.4 Floodprone Width (ft) **400**

Notes:

Slight human-caused change in valley width due to RB encroachment of Route 103; no change in valley confinement. LB glacio-fluvial terrace = LVW for purposes of defining reference stream type. Some plane-bed form downstream end of reach. Commercial land

*Step 2. (Contued)*

2.5 Aband. Floodpln **3.70** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **34.91**

2.7 Entrenchment Ratio **4.98**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Sedimented**

2.11 Riffle/Step Spacing (ft) **360**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | **0** % |
| Boulder | **6** % |
| Cobble | **17** % |
| Coarse Gravel | **43** % |
| Fine Gravel | **13** % |
| Sand | **6** % |
| Silt and smaller | **15** % |

Silt/Clay Present? **No**

Detritus **4** %

# Large Woody **20**

2.13 Average Largest Particle on

Bed **355.0** mm

Bar **105.0** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | **None** | **0.00** |
| Gullies | **None** | **0.00** |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | **Mix** | **Silt** |
| Consistency | **Cohesive** | **Cohesive** |
| Lower | | |
| Material Type | **Mix** | **Silt** |
| Consistency | **Cohesive** | **Cohesive** |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | **418** | **196** |
| Erosion Height (ft) | **2.93** | **2.74** |
| Revetmt. Type | **Rip-Rap** | **Rip-Rap** |
| Revetmt. Length (ft) | **675** | **283** |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Shrubs/Saplin** | **Herbaceous** |
| Sub-dominant | **Coniferous** | **Shrubs/Saplin** |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | **76-100** | **26-50** |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | **26-50** | **>100** |
| Sub-dominant | **51-100** | **None** |
| W less than 25 | **1,588** | **150** |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | **Coniferous** | **Herbaceous** |
| Sub-dominant | **Deciduous** | **Shrubs/Saplin** |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | **Commercial** | **Shrubs/Saplin** |
| Sub-dominant | **Forest** | **None** |
| Mass Failures | **0** | **0** |
| Height | **0** | **0** |
| Gullies | **0** | **0** |
| Height | **0** | **0** |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | **0** | Road Ditch | **0** |
| Other | **0** | Tile Drain | **0** |
| Overland Flow | **0** | Urb Strm Wtr Pipe | **0** |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| **0** | **1** | **7** |

| Diagonal | Delta | Island |
|---|---|---|
| **2** | **0** | **0** |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| **5** | **0** | **0** | **0** |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| **0** | **0** | **No** |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **3,457**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River** **Phase 2 Segment Summary** May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M36** Segment: **B** Completion Date: **November 8, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: **Other (to be explained in** Rain: **Yes**

Segment Length (ft): **1,217** Segment Location: **From upper Branch Brook confluence d/s to Fox Lane bridge crossing.**

**QC Status - Staff: Provisional Cons** **Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 246 | 0 |
| height | 12 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 1,188 | 0 |
| height | 8 | 0 |
| Development | 1,122 | 44 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Steep | Extremely |
| Continuous w/ | Sometimes | Never |
| W/in 1 Bankfill | Sometimes | Never |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **630**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **64**

2.2 Max Depth (ft) **5.20**

2.3 Mean Depth (ft) **3.85**

2.4 Floodprone Width (ft) **500**

Notes:

Approximately 1/3 flow "pirated" by Branch Brook. Confluence location depicted on VHD is "pirating" location. Actual full confluence is now approximately 600 feet downstream. Cross section data was measured in a channel that carries approximately 2/3 of the

*Step 2. (Contued)*

2.5 Aband. Floodpln **5.20** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **16.68**

2.7 Entrenchment Ratio **7.79**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 0% |
| Cobble | 12% |
| Coarse Gravel | 50% |
| Fine Gravel | 25% |
| Sand | 10% |
| Silt and smaller | 3% |

Silt/Clay Present? **No**

Detritus **5** %

# Large Woody **3**

2.13 Average Largest Particle on

Bed **0.0**

Bar **0.0**

**Not Evaluated**

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **c**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 118 | 125 |
| Erosion Height (ft) | 2.00 | 2.00 |
| Revetmt. Type | None | None |
| Revetmt. Length (ft) | 0 | 0 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Coniferous | Deciduous |
| Sub-dominant | Deciduous | Shrubs/Saplin |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 76-100 | 76-100 |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | 0-25 | >100 |
| Sub-dominant | None | None |
| W less than 25 | 1,128 | 21 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Coniferous | Deciduous |
| Sub-dominant | Deciduous | Shrubs/Saplin |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Commercial | Forest |
| Sub-dominant | Forest | None |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Abundant**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **Small**

Flow Regulation Use **Other**

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 0 | 0 | 0 |

| Diagonal | Delta | Island |
|---|---|---|
| 0 | 0 | 1 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 1 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,162**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River**

# Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Stream: **Branch Brook** Reach # **M36T4.01** Segment: **0** Completion Date: **August 27, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS** Why Not assessed: Rain: **No**

Segment Length (ft): **3,228** Segment Location: **From Buttermilk Falls Rd junction with Route 103, downstream to confluence with Black**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **Yes**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 1,009 | 1,044 |
| height | 7 | 7 |
| Roads | 1,858 | 279 |
| height | 14 | 10 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 506 | 130 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Steep | Steep |
| Continuous w/ | Sometimes | Never |
| W/in 1 Bankfill | Sometimes | Never |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **340**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **46**

2.2 Max Depth (ft) **2.60**

2.3 Mean Depth (ft) **1.60**

2.4 Floodprone Width (ft) **65**

Notes:

Encroachment of Route 103 reduces valley width somewhat, enough to change valley type from V. Broad to Broad, but still unconfined. Extensive berms along both banks further constrain available floodplain, and increase degree of entrenchment.

*Step 2. (Contued)*

2.5 Aband. Floodpln **8.30** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **28.56**

2.7 Entrenchment Ratio **1.42**

2.8 Incision Ratio **3.19**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 9% |
| Cobble | 47% |
| Coarse Gravel | 19% |
| Fine Gravel | 9% |
| Sand | 14% |
| Silt and smaller | 2% |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **39**

2.13 Average Largest Particle on

Bed **307.0** mm

Bar **N/A** mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Cobble**

Subclass Slope: **None**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | One | 12.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Boulder/Cobbl | Boulder/Cobbl |
| Consistency | Non-cohesive | Non-cohesive |
| Lower | | |
| Material Type | Boulder/Cobbl | Boulder/Cobbl |
| Consistency | Non-cohesive | Non-cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 63 | 350 |
| Erosion Height (ft) | 4.00 | 3.46 |
| Revetmt. Type | Rip-Rap | Rip-Rap |
| Revetmt. Length (ft) | 403 | 987 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Herbaceous | Herbaceous |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 26-50 | 26-50 |

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 | 1,195 | 2,277 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Deciduous | Shrubs/Saplin |
| Sub-dominant | Shrubs/Saplin | Deciduous |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Shrubs/Saplin |
| Sub-dominant | Commercial | Forest |
| Mass Failures | 87 | 0 |
| Height | 12 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 1 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 1 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 0 | 2 | 4 |

| Diagonal | Delta | Island |
|---|---|---|
| 2 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 5 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 1 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **2,572**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Stream: **Black River** Reach # **M37** Segment: **A** Completion Date: **September 23, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Why Not assessed: **wetland** Rain: **No**

Segment Length (ft): **1,842** Segment Location: **Segment has wetland characteristics rather than fluvial form.**

**QC Status - Staff: Provisional Cons**

## Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 0 | 0 |
| height | 0 | 0 |
| Roads | 0 | 0 |
| height | 0 | 0 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 383 | 729 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Very Steep | Hilly |
| Continuous w/ | Never | Never |
| W/in 1 Bankfill | Sometimes | Never |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **940**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **0**

2.2 Max Depth (ft) **0.00**

2.3 Mean Depth (ft) **0.00**

2.4 Floodprone Width (ft) **0**

Notes:

Segment has wetland characteristics - very wide, deep, low-gradient "channel". Some beaver activity along the banks.

**Passed** *Step 2. (Contued)*

2.5 Aband. Floodpln **0.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **0.00**

2.7 Entrenchment Ratio **0.00**

2.8 Incision Ratio **0.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity

2.10 Riffles Type

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Silt/Clay Present?

Detritus **0** %

# Large Woody **0**

2.13 Average Largest Particle on

Bed **0.0**

Bar **0.0**

2.14 Stream Type

Stream Type:

Bed Material:

Subclass Slope:

Bed Form:

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |
| Lower | | |
| Material Type | Mix | Mix |
| Consistency | Cohesive | Cohesive |

| Bank Erosion | Left | Right |
|---|---|---|
| Erosion Length (ft) | 0 | 0 |
| Erosion Height (ft) | 0.00 | 0.00 |
| Revetmt. Type | None | Rip-Rap |
| Revetmt. Length (ft) | 0 | 89 |

| Near Bank Veg. Type | Left | Right |
|---|---|---|
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Herbaceous | Herbaceous |

| Bank Canopy | Left | Right |
|---|---|---|
| Canopy % | 1-25 | 1-25 |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | >100 | >100 |
| Sub-dominant | 51-100 | 0-25 |
| W less than 25 | 91 | 594 |

| Buffer Veg. Type | Left | Right |
|---|---|---|
| Dominant | Deciduous | Deciduous |
| Sub-dominant | Coniferous | Shrubs/Saplin |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Forest |
| Sub-dominant | Commercial | Residential |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **Run-of-river**

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 0 | 0 | 0 |

| Diagonal | Delta | Island |
|---|---|---|
| 0 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 0 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 0 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,079**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Black River** | **Phase 2 Segment Summary** |  | May 19, 2009 SGAT Version: 4.56

Stream: **Black River** Reach # **M37** Segment: **B** Completion Date: **September 23, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS** Why Not assessed: Rain: **No**

Segment Length (ft): **3,469** Segment Location: **From Reservoir Pond dam (Lake Pauline) downstream to wetlands (Segment A)**

**QC Status - Staff: Provisional Cons Passed**

## Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

| Length (ft) | One | Both |
|---|---|---|
| Berms | 1,437 | 0 |
| height | 7 | 0 |
| Roads | 665 | 151 |
| height | 9 | 11 |
| Railroads | 0 | 0 |
| height | 0 | 0 |
| Improved Paths | 0 | 0 |
| height | 0 | 0 |
| Development | 766 | 82 |

| 1.4 Adjacent Side | Left | Right |
|---|---|---|
| Hillside Slope | Very Steep | Hilly |
| Continuous w/ | Sometimes | Never |
| W/in 1 Bankfill | Sometimes | Never |
| Texture | Not Evalua | Not Evalua |

1.5 Valley Features

Valley Width (ft) **280**

Width Determination **Estimated**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **Yes**

## Step 2. Stream Channel

2.1 Bankfull Width **63**

2.2 Max Depth (ft) **3.00**

2.3 Mean Depth (ft) **2.08**

2.4 Floodprone Width (ft) **115**

Notes:

Slight reduction in valley width caused by Route 100 (RB corridor, upstream end); however, no change in valley type (Narrow) or confinement status (Unconfined). Historic "woolen mill" and saw mill noted on island between split channel, mid-reach. Old

*Step 2. (Contued)*

2.5 Aband. Floodpln **4.40** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **30.35**

2.7 Entrenchment Ratio **1.82**

2.8 Incision Ratio **1.47**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **600**

2.12 Substrate Composition

| | |
|---|---|
| Bedrock | 0% |
| Boulder | 5% |
| Cobble | 43% |
| Coarse Gravel | 31% |
| Fine Gravel | 8% |
| Sand | 12% |
| Silt and smaller | 1% |

Silt/Clay Present? **No**

Detritus **2** %

# Large Woody **17**

2.13 Average Largest Particle on

Bed **239.0** mm

Bar **150.0** mm

2.14 Stream Type

Stream Type: **B**

Bed Material: **Gravel**

Subclass Slope: **c**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

| 3.3 old | Amount | Mean Height |
|---|---|---|
| Failures | None | 0.00 |
| Gullies | None | 0.00 |

## Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

| Bank Texture | Left | Right |
|---|---|---|
| Upper | | |
| Material Type | Gravel | Gravel |
| Consistency | Non-cohesive | Non-cohesive |
| Lower | | |
| Material Type | Boulder/Cobbl | Boulder/Cobbl |
| Consistency | Non-cohesive | Non-cohesive |
| Bank Erosion | Left | Right |
| Erosion Length (ft) | 351 | 115 |
| Erosion Height (ft) | 2.58 | 3.00 |
| Revetmt. Type | Rip-Rap | Rip-Rap |
| Revetmt. Length (ft) | 37 | 82 |
| Near Bank Veg. Type | Left | Right |
| Dominant | Shrubs/Saplin | Shrubs/Saplin |
| Sub-dominant | Deciduous | Deciduous |
| Bank Canopy | Left | Right |
| Canopy % | 51-75 | 51-75 |

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

| Buffer Width | Left | Right |
|---|---|---|
| Dominant | 26-50 | >100 |
| Sub-dominant | >100 | 0-25 |
| W less than 25 | 770 | 1,382 |
| Buffer Veg. Type | Left | Right |
| Dominant | Mixed Trees | Deciduous |
| Sub-dominant | Shrubs/Saplin | Shrubs/Saplin |

3.3 Riparian Corridor

| Corridor Land | Left | Right |
|---|---|---|
| Dominant | Forest | Forest |
| Sub-dominant | Commercial | Hay |
| Mass Failures | 0 | 0 |
| Height | 0 | 0 |
| Gullies | 0 | 0 |
| Height | 0 | 0 |

## Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **Run-of-river**

4.7 StormwaterInputs

| | | | |
|---|---|---|---|
| Field Ditch | 0 | Road Ditch | 0 |
| Other | 0 | Tile Drain | 0 |
| Overland Flow | 0 | Urb Strm Wtr Pipe | 0 |

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

## Step 5. Channel Bed and Planform Changes

5.1 Bar Types

| Mid | Point | Side |
|---|---|---|
| 0 | 2 | 0 |

| Diagonal | Delta | Island |
|---|---|---|
| 0 | 0 | 0 |

5.2 Other Features

| Flood | Neck Cutoff | Avulsion | Braiding |
|---|---|---|---|
| 7 | 0 | 0 | 0 |

5.3 Steep Riffles and Head Cuts

| Steep Riffles | Head Cuts | Trib Rejuv. |
|---|---|---|
| 2 | 0 | No |

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,714**

5.5 Dredging **Dredging**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Narrative:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model
Channel Evolution Stage
Geomorphic Condition
Stream Sensitivity

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Stream: **North Branch Black River** Reach # **M15T1.03** Segment: **B** Completion Date: **September 5,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **4,060** Segment Location: **East side Branch Brook Rd d/s of Route 131 junction**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **15** | **None** | **Yes** |
| 7.2 Channel Aggradation | **10** | **None** | **No** |
| 7.3 Widening Channel | **16** | | **No** |
| 7.4 Change in Planform | **8** | | **No** |

| | |
|---|---|
| Total Score | **49** |
| Geomorphic Rating | **0.6125** |
| Channel Evolution Model | **F** |
| Channel Evolution Stage | **IV** |
| Geomorphic Condition | **Fair** |
| Stream Sensitivity | **Very High** |

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **15** |
| 6.4 Sediment Deposition | **11** |
| 6.5 Channel Flow Status | **15** |
| 6.6 Channel Alteration | **3** |
| 6.7 Frequency of Riffles/Steps | **17** |
| 6.8 Bank Stability | **Left: 7 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 7 Right: 7** |
| 6.10 Riparian Vegetation Zone Width | **Left: 9 Right: 3** |
| Total Score | **124** |
| Habitat Rating | **0.62** |
| Habitat Stream Condition | **Fair** |

Narrative:

Moderate planform adjustment (flood chutes) and aggrad (diag bars, point bars); historic incision; good access to floodplain.

Stream: **North Branch Black River** Reach # **M15T1.05** Segment: **0** Completion Date: **June 20, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **6,365** Segment Location: **Reach from Little Ascutney Basin Rd crossing downstream to Amsden Falls.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **17.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above,Scour Below,Alignment** | | | | |
| **Bridge** | **50.0** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **Deposition Above,Deposition Below** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **16** | **None** | **No** |
| 7.2 Channel Aggradation | **11** | **None** | **No** |
| 7.3 Widening Channel | **13** | | **No** |
| 7.4 Change in Planform | **10** | | **No** |
| Total Score | **50** | | |
| Geomorphic Rating | **0.625** | | |

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **16** |
| 6.2 Pool Substrate | **13** |
| 6.3 Pool Variability | **13** |
| 6.4 Sediment Deposition | **10** |
| 6.5 Channel Flow Status | **13** |
| 6.6 Channel Alteration | **8** |
| 6.7 Channel Sinuosity | **8** |
| 6.8 Bank Stability | **Left: 6 Right: 5** |
| 6.9 Bank Vegetation Protection | **Left: 6 Right: 5** |
| 6.10 Riparian Vegetation Zone Width | **Left: 3 Right: 3** |
| Total Score | **109** |
| Habitat Rating | **0.545** |

Habitat Stream Condition **Fair**

Narrative:

Substantial planform adjustment (enhanced by reach position immed u/s of bedrock-controlled valley narrowing at Amsden Falls). Localized moderate (historic) incision, otherwise good floodplain access.

Stream: **North Branch Black River** Reach # **M15T1.06** Segment: **A** Completion Date: **June 11, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **2,829** Segment Location: **Downstream 1/3 of reach.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **18** | **None** | **No** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **8** | | **No** |
| 7.4 Change in Planform | **6** | | **No** |
| Total Score | **45** | | |
| Geomorphic Rating | **0.5625** | | |

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **11** |
| 6.2 Pool Substrate | **8** |
| 6.3 Pool Variability | **15** |
| 6.4 Sediment Deposition | **11** |
| 6.5 Channel Flow Status | **15** |
| 6.6 Channel Alteration | **8** |
| 6.7 Channel Sinuosity | **10** |
| 6.8 Bank Stability | **Left: 4 Right: 4** |
| 6.9 Bank Vegetation Protection | **Left: 4 Right: 4** |
| 6.10 Riparian Vegetation Zone Width | **Left: 1 Right: 2** |
| Total Score | **97** |
| Habitat Rating | **0.485** |

Habitat Stream Condition **Fair**

Narrative:

Substantial planform adjustment (meander extension, migration, translation) and moderate widening (in part, due to lack of tree buffers). Extensive historic channelization.

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **8** | **None** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **11** | | **No** |
| 7.4 Change in Planform | **8** | | **No** |
| Total Score | **40** | | |
| Geomorphic Rating | **0.5** | | |

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

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **10** |
| 6.3 Velocity/Depth Patterns | **13** |
| 6.4 Sediment Deposition | **11** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **3** |
| 6.7 Frequency of Riffles/Steps | **6** |
| 6.8 Bank Stability | **Left: 4 Right: 4** |
| 6.9 Bank Vegetation Protection | **Left: 3 Right: 3** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 1** |
| Total Score | **86** |
| Habitat Rating | **0.43** |

Habitat Stream Condition **Fair**

Narrative:
Moderate planform adjustment (meander extension, translation, migration); localized widening; minor to moderate aggradation. Historic incision.

Stream: **North Branch Black River** Reach # **M15T1.07** Segment: **0** Completion Date: **June 11, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **2,740** Segment Location: **Crosses valley from Ascutney Basin Rd bridge to east valley wall.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **5** | **C to F** | **Yes** |
| 7.2 Channel Aggradation | **10** | **None** | **No** |
| 7.3 Widening Channel | **8** | | **No** |
| 7.4 Change in Planform | **3** | | **No** |
| Total Score | **26** | | |
| Geomorphic Rating | **0.325** | | |

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Poor**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **8** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **15** |
| 6.4 Sediment Deposition | **10** |
| 6.5 Channel Flow Status | **15** |
| 6.6 Channel Alteration | **8** |
| 6.7 Frequency of Riffles/Steps | **16** |
| 6.8 Bank Stability | **Left: 5 Right: 5** |
| 6.9 Bank Vegetation Protection | **Left: 2 Right: 3** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 2** |
| Total Score | **106** |
| Habitat Rating | **0.53** |

Habitat Stream Condition **Fair**

Narrative:

Active planform adjustment (meander extension, flood chutes) and widening with moderate aggradation. Historic incision (channelization/dredging).

Stream: **North Branch Black River** Reach # **M15T1.08** Segment: **0** Completion Date: **June 11, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **2,488** Segment Location: **East side Route 106 upstream of Ascutney Basin Rd bridge crossing.**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Ledge** | **Mid-segment** | **1.00** | **1.00** | **Yes** | |

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **40.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **None** | | | | |
| **Old** | **25.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above,Scour Below** | | | | |
| **Bridge** | **33.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **5** | **C to F** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **16** | | **Yes** |
| Total Score | **49** | | |
| Geomorphic Rating | **0.6125** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **13** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **18** |
| 6.6 Channel Alteration | **4** |
| 6.7 Frequency of Riffles/Steps | **15** |
| 6.8 Bank Stability | **Left: 8 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 7 Right: 7** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 1** |
| Total Score | **120** |
| Habitat Rating | **0.6** |

Habitat Stream Condition **Fair**

Narrative:

Minor aggradation. Historic incision and planform adjustment (managment). Stream type departure from C to F.

Stream: **North Branch Black River** Reach # **M15T1.09** Segment: **0** Completion Date: **September 4,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **3,664** Segment Location: **Downstream from Knapp Brook confluence**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Waterfall** | **Mid-segment** | **3.00** | **2.00** | **Yes** | |

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Old** | **33.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above,Alignment** | | | | |
| **Old** | **34.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **None** | | | | |
| **Bridge** | **43.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **None** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **5** | **C to F** | **Yes** |
| 7.2 Channel Aggradation | **15** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **15** | | **Yes** |
| Total Score | **50** | | |
| Geomorphic Rating | **0.625** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **13** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **15** |
| 6.6 Channel Alteration | **9** |
| 6.7 Frequency of Riffles/Steps | **5** |
| 6.8 Bank Stability | **Left: 8 Right: 8** |
| 6.9 Bank Vegetation Protection | **Left: 6 Right: 5** |
| 6.10 Riparian Vegetation Zone Width | **Left: 9 Right: 2** |
| Total Score | **118** |
| Habitat Rating | **0.59** |

Habitat Stream Condition **Fair**

Narrative:

Minor (localized) aggradation at upstream end reach. Historic incision. Stream type departure: C to F.

Stream: **North Branch Black River** Reach # **M15T1.10** Segment: **0** Completion Date: **August 29, 2008**

Organization: **South Windsor County Regional** Observers: **KLU - SMRC; GA, SP - VTDEC** Rain: **No**

Segment Length (ft): **2,400** Segment Location: **From vicinity Route 106 crossing at Felchville, d/s to Knapp Brook confluence**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **45.0** | **Yes** | **Yes** | **No** | **Yes** |

Problem **None**

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 | **13** | **None** | **No** |
| 7.3 Widening Channel | **13** | | **No** |
| 7.4 Change in Planform | **11** | | **No** |
| Total Score | **40** | | |
| Geomorphic Rating | **0.5** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **6** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **8** |
| 6.6 Channel Alteration | **2** |
| 6.7 Frequency of Riffles/Steps | **13** |
| 6.8 Bank Stability | **Left: 7 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 6 Right: 5** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 2** |
| Total Score | **97** |
| Habitat Rating | **0.485** |

Habitat Stream Condition **Fair**

Narrative:

Minor to moderate planform change (at downstream end); minor aggradation. Localized widening. Historic incision due to channelization/dredging; entrenchment enhanced by high berms both banks.

Stream: **North Branch Black River** Reach # **M15T1.11** Segment: **A** Completion Date: **August 29, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **417** Segment Location: **From just upstream of Route 106 bridge to downstream reach break approximately**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Other** | **51.0** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **None** | | | | |
| **Bridge** | **39.2** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Alignment** | | | | |

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 | **13** | **None** | **Yes** |
| 7.3 Widening Channel | **15** | | **Yes** |
| 7.4 Change in Planform | **18** | | **Yes** |
| Total Score | **49** | | |
| Geomorphic Rating | **0.6125** | | |
| Channel Evolution Model | **F** | | |
| Channel Evolution Stage | **II** | | |
| Geomorphic Condition | **Fair** | | |
| Stream Sensitivity | **Extreme** | | |

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **8** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **8** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **8** |
| 6.6 Channel Alteration | **3** |
| 6.7 Frequency of Riffles/Steps | **3** |
| 6.8 Bank Stability | **Left: 7 Right: 4** |
| 6.9 Bank Vegetation Protection | **Left: 3 Right: 2** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 2** |
| Total Score | **78** |
| Habitat Rating | **0.39** |
| Habitat Stream Condition | **Fair** |

Narrative:

Minor aggradation. Historic incision, widening, planform change. Stream type departure from reference C3b to F3b.

Stream: **North Branch Black River** Reach # **M15T1.11** Segment: **B** Completion Date: **August 29, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **312** Segment Location: **From base of bedrock falls downstream near to Route 106 bridge.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Other** | **37.0** | **Yes** | **Yes** | **Yes** | **Yes** |

Problem **None**

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 | **16** | **None** | **No** |
| 7.3 Widening Channel | **16** | | **No** |
| 7.4 Change in Planform | **15** | | **Yes** |
| Total Score | **50** | | |
| Geomorphic Rating | **0.625** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **15** |
| 6.2 Embeddedness | **16** |
| 6.3 Velocity/Depth Patterns | **15** |
| 6.4 Sediment Deposition | **16** |
| 6.5 Channel Flow Status | **13** |
| 6.6 Channel Alteration | **1** |
| 6.7 Frequency of Riffles/Steps | **18** |
| 6.8 Bank Stability | **Left: 9 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 5 Right: 5** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 2** |
| Total Score | **126** |
| Habitat Rating | **0.63** |

Habitat Stream Condition **Fair**

Narrative:

None (very minor planform adjustment at downstream end). Historic incision and PF modification (straightening, dredging, encroachment). Vertical stream type departure is Cb to F.

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Waterfall** | **Mid-segment** | **30.00** | **28.00** | **Yes** | |

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Narrative:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model
Channel Evolution Stage
Geomorphic Condition
Stream Sensitivity

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Stream: **Black River** Reach # **M19** Segment: **A** Completion Date: **September 16,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **4,243** Segment Location: **Downstream half of reach that extends from Downers Corners to Perkinsville, east of**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **8** | **None** | **Yes** |
| 7.2 Channel Aggradation | **11** | **None** | **No** |
| 7.3 Widening Channel | **10** | | **No** |
| 7.4 Change in Planform | **8** | | **No** |
| Total Score | **37** | | |
| Geomorphic Rating | **0.4625** | | |

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **11** |
| 6.2 Embeddedness | **10** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **13** |
| 6.6 Channel Alteration | **5** |
| 6.7 Frequency of Riffles/Steps | **16** |
| 6.8 Bank Stability | **Left: 7 Right: 8** |
| 6.9 Bank Vegetation Protection | **Left: 6 Right: 8** |
| 6.10 Riparian Vegetation Zone Width | **Left: 3 Right: 2** |
| Total Score | **113** |
| Habitat Rating | **0.565** |

Habitat Stream Condition **Fair**

Narrative:

Moderate planform adjustment and widening; minor aggradation. Historic degradation associated with channelization.

Stream: **Black River** Reach # **M19** Segment: **B** Completion Date: **September 16,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **3,454** Segment Location: **Upstream half of the reach that flows from Downers Corners to Perkinsville east of**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **5** | **C to F** | **Yes** |
| 7.2 Channel Aggradation | **15** | **None** | **No** |
| 7.3 Widening Channel | **11** | | **Yes** |
| 7.4 Change in Planform | **13** | | **No** |
| Total Score | **44** | | |
| Geomorphic Rating | **0.55** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **15** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **16** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **1** |
| 6.7 Frequency of Riffles/Steps | **16** |
| 6.8 Bank Stability | **Left: 8 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 8 Right: 7** |
| 6.10 Riparian Vegetation Zone Width | **Left: 3 Right: 3** |
| Total Score | **124** |
| Habitat Rating | **0.62** |

Habitat Stream Condition **Fair**

Narrative:

Minor planform adjustment (FCs, bifurcations); minor aggradation.; historic degradation, widening. Stream type departure from C to F.

Stream: **Black River** Reach # **M26** Segment: **0** Completion Date: **September 17,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **1,815** Segment Location: **From Twenty Mile Stream confluence at Whitesvillle d/s to valley pinch point**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

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 | **10** | **None** | **Yes** |
| 7.3 Widening Channel | **10** | | **Yes** |
| 7.4 Change in Planform | **16** | | **Yes** |
| Total Score | **39** | | |
| Geomorphic Rating | **0.4875** | | |
| Channel Evolution Model | **F** | | |
| Channel Evolution Stage | **II** | | |
| Geomorphic Condition | **Fair** | | |
| Stream Sensitivity | **Extreme** | | |

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **2** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **8** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **2** |
| 6.7 Frequency of Riffles/Steps | **5** |
| 6.8 Bank Stability | **Left: 9 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 6 Right: 6** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 10** |
| Total Score | **103** |
| Habitat Rating | **0.515** |
| Habitat Stream Condition | **Fair** |

Narrative:

None. Historic incision, widening associated with dredging/ channelization and major aggradation post 1927 flood.

Stream: **Twentymile Stream** Reach # **M26T2.01** Segment: **0** Completion Date: **September 5,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **1,138** Segment Location: **From northwest valley wall to east valley wall of Black River, at Whitesville, crossing**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **45.0** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **Deposition Above** | | | | |
| **Other** | **35.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **8** | **None** | **Yes** |
| 7.2 Channel Aggradation | **11** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **16** | | **Yes** |
| Total Score | **50** | | |
| Geomorphic Rating | **0.625** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **13** |
| 6.6 Channel Alteration | **1** |
| 6.7 Frequency of Riffles/Steps | **5** |
| 6.8 Bank Stability | **Left: 8 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 5 Right: 6** |
| 6.10 Riparian Vegetation Zone Width | **Left: 1 Right: 2** |
| Total Score | **99** |
| Habitat Rating | **0.495** |

Habitat Stream Condition **Fair**

Narrative:

Minor aggradation; localized widening. Historic incision and planform modification. Some lateral bedrock grade controls. Wid moderated by rip-rap, tree buffers (RB).

Stream: **Twentymile Stream** Reach # **M26T2.05** Segment: **0** Completion Date: **June 19, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **5,400** Segment Location: **Through wetlands crossing under Heald Rd and Davis Rd**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **18.4** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Scour Below** | | | | |
| **Bridge** | **21.5** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above,Scour Below** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **18** | **None** | **No** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **8** | | **No** |
| Total Score | **54** | | |
| Geomorphic Rating | **0.675** | | |

Channel Evolution Model **F**

Channel Evolution Stage **IV**

Geomorphic Condition **Good**

Stream Sensitivity **Moderate**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **13** |
| 6.2 Embeddedness | **11** |
| 6.3 Velocity/Depth Patterns | **15** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **10** |
| 6.6 Channel Alteration | **9** |
| 6.7 Frequency of Riffles/Steps | **13** |
| 6.8 Bank Stability | **Left: 8 Right: 8** |
| 6.9 Bank Vegetation Protection | **Left: 7 Right: 8** |
| 6.10 Riparian Vegetation Zone Width | **Left: 9 Right: 9** |
| Total Score | **133** |
| Habitat Rating | **0.665** |

Habitat Stream Condition **Good**

Narrative:

Substantial planform adjustment (meander extension, mass failures, flood chutes, bifurcation, avulsion). Limited vertical adjustment in response to inferred Straightening possibly due to bedrock controls, well developed buffers.

Stream: **Twentymile Stream** Reach # **M26T2.06** Segment: **A** Completion Date: **June 19, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **6,466** Segment Location: **Downstream 2/3 of reach.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **29.0** | **Yes** | **Yes** | **Yes** | **Yes** |

Problem **Scour Below**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **18** | **None** | **No** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **11** | | **No** |
| Total Score | **57** | | |
| Geomorphic Rating | **0.7125** | | |

Channel Evolution Model **D**

Channel Evolution Stage **IIc**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **13** |
| 6.2 Embeddedness | **11** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **11** |
| 6.5 Channel Flow Status | **13** |
| 6.6 Channel Alteration | **9** |
| 6.7 Frequency of Riffles/Steps | **16** |
| 6.8 Bank Stability | **Left: 8 Right: 8** |
| 6.9 Bank Vegetation Protection | **Left: 7 Right: 6** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 2** |
| Total Score | **117** |
| Habitat Rating | **0.585** |

Habitat Stream Condition **Fair**

Narrative:

Moderate planform adjustment (meander extension, flood chutes, bifurcations). Widening localized to beaver dams (intact and breached). Lateral adjustments somewhat moderated by cohesive soils and streambank armoring. Good floodplain connection.

Stream: **Twentymile Stream** Reach # **M26T2.06** Segment: **B** Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **2,051** Segment Location: **Narrow section of channel from farmstead downstream past Nelson Rd intersection**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Ledge** | **Mid-segment** | **1.00** | **0.00** | **No** | |

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **25.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Scour Below** | | | | |
| **Old** | **18.0** | **Yes** | **No** | **Yes** | **Yes** |
| Problem | **Alignment** | | | | |

Narrative:
Minor aggradation.

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **18** | **None** | **No** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **18** | | **No** |
| 7.4 Change in Planform | **18** | | **Yes** |
| Total Score | **67** | | |
| Geomorphic Rating | **0.8375** | | |

Channel Evolution Model **D**
Channel Evolution Stage **I**
Geomorphic Condition **Good**
Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **8** |
| 6.2 Embeddedness | **10** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **8** |
| 6.7 Frequency of Riffles/Steps | **18** |
| 6.8 Bank Stability | **Left: 9 Right: 8** |
| 6.9 Bank Vegetation Protection | **Left: 9 Right: 8** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 2** |
| Total Score | **122** |
| Habitat Rating | **0.61** |

Habitat Stream Condition **Fair**

Stream: **Twentymile Stream** Reach # **M26T2.06** Segment: **C** Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **1,292** Segment Location: **Upstream end of reach, impounded by multiple beaver dams.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Narrative:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition **Good**

Stream Sensitivity

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Stream: **Twentymile Stream** Reach # **M26T2.07** Segment: **0** Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **4,926** Segment Location: **Through fields east of Twenty Mile Stream Rd, west of Mt Gilead**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **11.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above,Scour Below,Alignment** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **8** | **None** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **11** | | **No** |
| 7.4 Change in Planform | **13** | | **No** |
| Total Score | **45** | | |
| Geomorphic Rating | **0.5625** | | |

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **13** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **13** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **13** |
| 6.6 Channel Alteration | **14** |
| 6.7 Frequency of Riffles/Steps | **15** |
| 6.8 Bank Stability | **Left: 7 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 7 Right: 7** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 1** |
| Total Score | **127** |
| Habitat Rating | **0.635** |

Habitat Stream Condition **Fair**

Narrative:

Minor widening, aggrad, planform adjustment; historic incision. Lateral adjustment moderated somewhat by cohesiveness of soils.

Stream: **Twentymile Stream** Reach # **M26T2.08** Segment: **A** Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **1,393** Segment Location: **From vicinity of Twentymile Stream Rd culvert crossing to downstream end of reach.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Culvert** | **13.5** | **Yes** | **Yes** | **Yes** | **Yes** |

Problem **None**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **6** | **None** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **11** | | **No** |
| Total Score | **45** | | |
| Geomorphic Rating | **0.5625** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **13** |
| 6.6 Channel Alteration | **9** |
| 6.7 Frequency of Riffles/Steps | **18** |
| 6.8 Bank Stability | **Left: 9 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 8 Right: 8** |
| 6.10 Riparian Vegetation Zone Width | **Left: 3 Right: 2** |
| Total Score | **126** |
| Habitat Rating | **0.63** |

Habitat Stream Condition **Fair**

Narrative:

Minor planform adjustment (flood chutes, meander extension).

Stream: **Twentymile Stream** Reach # **M26T2.08** Segment: **B** Completion Date: **June 12, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **2,241** Segment Location: **West side of Twentymile Stream Rd, downstream of Meadowbrook Farm Rd nearly to**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **16** | **None** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **11** | | **No** |
| Total Score | **55** | | |
| Geomorphic Rating | **0.6875** | | |

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **10** |
| 6.4 Sediment Deposition | **11** |
| 6.5 Channel Flow Status | **11** |
| 6.6 Channel Alteration | **13** |
| 6.7 Frequency of Riffles/Steps | **18** |
| 6.8 Bank Stability | **Left: 8 Right: 8** |
| 6.9 Bank Vegetation Protection | **Left: 9 Right: 10** |
| 6.10 Riparian Vegetation Zone Width | **Left: 9 Right: 9** |
| Total Score | **139** |
| Habitat Rating | **0.695** |

Habitat Stream Condition **Good**

Narrative:

Moderate planform adjustment - flood chutes, small avulsion (bifurcation). Minor degree historic incision.

Stream: **Twentymile Stream** Reach # **M26T2.09** Segment: **0** Completion Date: **September 22,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **2,851** Segment Location: **Through wetland between Twenty Mile Stream Rd and Meadowbrook Farm Rd**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Culvert** | **13.8** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Below** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **8** | **None** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **16** | | **No** |
| 7.4 Change in Planform | **10** | | **No** |
| Total Score | **47** | | |
| Geomorphic Rating | **0.5875** | | |
| Channel Evolution Model | **F** | | |
| Channel Evolution Stage | **III** | | |
| Geomorphic Condition | **Fair** | | |
| Stream Sensitivity | **High** | | |

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **11** |
| 6.2 Embeddedness | **16** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **11** |
| 6.5 Channel Flow Status | **15** |
| 6.6 Channel Alteration | **6** |
| 6.7 Frequency of Riffles/Steps | **18** |
| 6.8 Bank Stability | **Left: 6 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 6 Right: 7** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 2** |
| Total Score | **118** |
| Habitat Rating | **0.59** |
| Habitat Stream Condition | **Fair** |

Narrative:

Moderate aggrad (depositional bars) and planform adjustment (meander extension, avulsion, flood chutes). Historic incision.

Stream: **Twentymile Stream** Reach # **M26T2.10** Segment: **A** Completion Date: **September 22,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **1,015** Segment Location: **Downstream 1/3 of reach, from private driveway culvert crossing downstream to next**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Culvert** | **7.00** | **Yes** | **No** | **Yes** | **Yes** |
| Problem | **Deposition Above,Scour Below** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **5** | **C to F** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **11** | | **No** |
| Total Score | **44** | | |
| Geomorphic Rating | **0.55** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **13** |
| 6.6 Channel Alteration | **16** |
| 6.7 Frequency of Riffles/Steps | **16** |
| 6.8 Bank Stability | **Left: 7 Right: 8** |
| 6.9 Bank Vegetation Protection | **Left: 5 Right: 7** |
| 6.10 Riparian Vegetation Zone Width | **Left: 9 Right: 9** |
| Total Score | **139** |
| Habitat Rating | **0.695** |

Habitat Stream Condition **Good**

Narrative:

Minor planform adjustment (flood chutes, meander extension). Aggrad / wid apparently moderated by cohesive bed/banks. Historic incision - possible u/s migration of head cuts from d/s straightened reaches.

Stream: **Twentymile Stream** Reach # **M26T2.10** Segment: **B** Completion Date: **September 22,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **908** Segment Location: **Middle segment of reach - from just below the Twentymile Stream Rd bridge crossing**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Ledge** | **Mid-segment** | **1.00** | **1.00** | **Yes** | |
| **Ledge** | **Mid-segment** | **1.00** | **1.00** | **No** | |

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **13** | **None** | **Yes** |
| 7.2 Channel Aggradation | **16** | **None** | **No** |
| 7.3 Widening Channel | **16** | | **No** |
| 7.4 Change in Planform | **18** | | **No** |
| Total Score | **63** | | |
| Geomorphic Rating | **0.7875** | | |

Channel Evolution Model **D**

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **Moderate**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **13** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **13** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **15** |
| 6.6 Channel Alteration | **16** |
| 6.7 Frequency of Riffles/Steps | **18** |
| 6.8 Bank Stability | **Left: 5 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 5 Right: 9** |
| 6.10 Riparian Vegetation Zone Width | **Left: 6 Right: 9** |
| Total Score | **148** |
| Habitat Rating | **0.74** |

Habitat Stream Condition **Good**

Narrative:

None (historic slight incision possible). Cohesive banks, confinement, and bedrock grade controls probably moderated potential for lateral and vertical adjustments.

Stream: **Twentymile Stream** Reach # **M26T2.10** Segment: **C** Completion Date: **September 22,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **1,209** Segment Location: **Upstream 1/3 of reach to a point just downstream of the Twentymile Stream Rd bridge**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Waterfall** | **Mid-segment** | **3.00** | **2.00** | **Yes** | |

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **12.0** | **Yes** | **Yes** | **Yes** | **Yes** |

Problem **Deposition Below,Alignment**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **8** | **None** | **Yes** |
| 7.2 Channel Aggradation | **15** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **13** | | **No** |
| Total Score | **51** | | |
| Geomorphic Rating | **0.6375** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **6** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **8** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **15** |
| 6.6 Channel Alteration | **6** |
| 6.7 Frequency of Riffles/Steps | **5** |
| 6.8 Bank Stability | **Left: 7 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 6 Right: 8** |
| 6.10 Riparian Vegetation Zone Width | **Left: 9 Right: 5** |
| Total Score | **114** |
| Habitat Rating | **0.57** |

Habitat Stream Condition **Fair**

Narrative:

Minor planform adjustment (slight meander extension). Historic incision. Till slopes, cohesive banks, tree buffers may have moderated potential for widening.

Stream: **Black River** Reach # **M27** Segment: **0** Completion Date: **September 17,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **3,999** Segment Location: **From below CVPS power plant d/s to Twenty Mile Stream confluence at Whitesville**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Ledge** | **Mid-segment** | **2.00** | **0.00** | **Yes** | |
| **Waterfall** | **Mid-segment** | **12.00** | **12.00** | **Yes** | |

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **85.0** | **Yes** | **Yes** | **No** | **Yes** |

Problem **None**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **8** | **None** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **Yes** |
| 7.3 Widening Channel | **13** | | **No** |
| 7.4 Change in Planform | **13** | | **No** |
| Total Score | **47** | | |
| Geomorphic Rating | **0.5875** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **13** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **16** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **7** |
| 6.7 Frequency of Riffles/Steps | **18** |
| 6.8 Bank Stability | **Left: 9 Right: 10** |
| 6.9 Bank Vegetation Protection | **Left: 9 Right: 10** |
| 6.10 Riparian Vegetation Zone Width | **Left: 9 Right: 9** |
| Total Score | **154** |
| Habitat Rating | **0.77** |

Habitat Stream Condition **Good**

Narrative:

Minor widening, planform adjustment. Historic incision and aggradation.

Stream: **Black River** Reach # **M30** Segment: **0** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; SP - BRAT** Rain: **No**

Segment Length (ft): **8,101** Segment Location: **From Proctorsville d/s to Mill Street crossing in Cavendish**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Old** | **64.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **None** | | | | |
| **Bridge** | **96.0** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **None** | | | | |

Narrative:

Minor, localized aggradation and planform adjustment.

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **10** | **None** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **13** | | **Yes** |
| Total Score | **51** | | |
| Geomorphic Rating | **0.6375** | | |
| Channel Evolution Model | **F** | | |
| Channel Evolution Stage | **II** | | |
| Geomorphic Condition | **Fair** | | |
| Stream Sensitivity | **High** | | |

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **11** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **10** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **7** |
| 6.7 Frequency of Riffles/Steps | **13** |
| 6.8 Bank Stability | **Left: 7 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 5 Right: 7** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 3** |
| Total Score | **116** |
| Habitat Rating | **0.58** |
| Habitat Stream Condition | **Fair** |

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **82.0** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **Deposition Below,Scour Below** | | | | |
| **Bridge** | **137.** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **Deposition Above,Scour Below** | | | | |

Narrative:
Minor aggradation, widening, planform adjustment. Historic incision.

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **13** | **None** | **Yes** |
| 7.2 Channel Aggradation | **15** | **None** | **No** |
| 7.3 Widening Channel | **15** | | **No** |
| 7.4 Change in Planform | **15** | | **Yes** |
| Total Score | **58** | | |
| Geomorphic Rating | **0.725** | | |

| | |
|---|---|
| Channel Evolution Model | **F** |
| Channel Evolution Stage | **II** |
| Geomorphic Condition | **Good** |
| Stream Sensitivity | **High** |

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **11** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **15** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **7** |
| 6.7 Frequency of Riffles/Steps | **13** |
| 6.8 Bank Stability | **Left: 9 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 7 Right: 5** |
| 6.10 Riparian Vegetation Zone Width | **Left: 3 Right: 2** |
| Total Score | **121** |
| Habitat Rating | **0.605** |

Habitat Stream Condition **Fair**

Stream: **Black River** Reach # **M32** Segment: **A** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; SP - BRAT** Rain: **No**

Segment Length (ft): **5,429** Segment Location: **From Winery Road crossing to the downstream end of the reach at Proctorsville below**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Other** | **42.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above,Scour Below** | | | | |
| **Bridge** | **76.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Scour Below** | | | | |
| **Old** | **40.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Scour Below** | | | | |
| **Bridge** | **180.** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **Deposition Above,Deposition Below** | | | | |
| **Old** | **77.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **None** | | | | |
| **Bridge** | **152.** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **Deposition Above,Deposition Below** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **5** | **C to B** | **Yes** |
| 7.2 Channel Aggradation | **8** | **None** | **No** |
| 7.3 Widening Channel | **10** | | **No** |
| 7.4 Change in Planform | **8** | | **No** |
| Total Score | **31** | | |
| Geomorphic Rating | **0.3875** | | |
| Channel Evolution Model | **F** | | |
| Channel Evolution Stage | **III** | | |
| Geomorphic Condition | **Fair** | | |
| Stream Sensitivity | **High** | | |

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **11** |
| 6.2 Embeddedness | **11** |
| 6.3 Velocity/Depth Patterns | **13** |
| 6.4 Sediment Deposition | **11** |
| 6.5 Channel Flow Status | **10** |
| 6.6 Channel Alteration | **3** |
| 6.7 Frequency of Riffles/Steps | **14** |
| 6.8 Bank Stability | **Left: 9 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 8 Right: 4** |
| 6.10 Riparian Vegetation Zone Width | **Left: 3 Right: 6** |
| Total Score | **110** |
| Habitat Rating | **0.55** |
| Habitat Stream Condition | **Fair** |

Narrative:

Moderate aggradation, planform adjustment, and widening. Historic incision. C to Bc stream type departure.

Stream: **Black River** Reach # **M32** Segment: **B** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; SP - BRAT** Rain: **No**

Segment Length (ft): **2,626** Segment Location: **From East Hill Rd bridge crossing downstream nearly to Winery Rd crossing.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Narrative:
Minor to moderate widening (localized).

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **8** | **None** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **11** | | **No** |
| 7.4 Change in Planform | **13** | | **No** |
| Total Score | **45** | | |
| Geomorphic Rating | **0.5625** | | |

Channel Evolution Model **F**
Channel Evolution Stage **II**
Geomorphic Condition **Fair**
Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **13** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **15** |
| 6.6 Channel Alteration | **3** |
| 6.7 Frequency of Riffles/Steps | **12** |
| 6.8 Bank Stability | **Left: 9 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 9 Right: 7** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 6** |
| Total Score | **123** |
| Habitat Rating | **0.615** |

Habitat Stream Condition **Fair**

Stream: **Black River** Reach # **M32** Segment: **C** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; SP - BRAT** Rain: **No**

Segment Length (ft): **3,945** Segment Location: **From Ludlow WWTF to just downstream of East Hill Road bridge crossing.**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Dam** | **Mid-segment** | **0.00** | **0.00** | **No** | |

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **68.0** | **Yes** | **Yes** | **Yes** | **Yes** |

Problem **None**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **7** | **C to B** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **11** | | **No** |
| 7.4 Change in Planform | **13** | | **Yes** |
| Total Score | **44** | | |
| Geomorphic Rating | **0.55** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **10** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **15** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **15** |
| 6.6 Channel Alteration | **3** |
| 6.7 Frequency of Riffles/Steps | **13** |
| 6.8 Bank Stability | **Left: 8 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 7 Right: 9** |
| 6.10 Riparian Vegetation Zone Width | **Left: 1 Right: 8** |
| Total Score | **128** |
| Habitat Rating | **0.64** |

Habitat Stream Condition **Fair**

Narrative:

Minor to moderate widening (localized). Historic incision. C to Bc stream type departure.

Stream: **Black River** Reach # **M33** Segment: **A** Completion Date: **October 1, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **4,053** Segment Location: **From just d/s of Mill Street bridge crossing to confluence w/ M32S1 below the**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **130.** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **Deposition Above** | | | | |
| **Other** | **42.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above,Deposition Below** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **11** | **None** | **Yes** |
| 7.2 Channel Aggradation | **8** | **None** | **No** |
| 7.3 Widening Channel | **16** | | **No** |
| 7.4 Change in Planform | **16** | | **Yes** |
| Total Score | **51** | | |
| Geomorphic Rating | **0.6375** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **8** |
| 6.2 Embeddedness | **15** |
| 6.3 Velocity/Depth Patterns | **13** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **1** |
| 6.7 Frequency of Riffles/Steps | **8** |
| 6.8 Bank Stability | **Left: 9 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 1 Right: 2** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 2** |
| Total Score | **101** |
| Habitat Rating | **0.505** |

Habitat Stream Condition **Fair**

Narrative:

Minor to moderate localized aggradation upstream of constrictions and bends. Historic incision, moderate floodplain access.

Stream: **Black River** Reach # **M33** Segment: **B** Completion Date: **October 1, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS** Rain: **No**

Segment Length (ft): **3,796** Segment Location: **From Jewell Brook confluence to just d/s of Mill Street bridge crossing.**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Dam** | **Mid-segment** | **2.00** | **1.00** | **Yes** | |

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **91.0** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **None** | | | | |
| **Bridge** | **83.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above** | | | | |
| **Bridge** | **77.0** | **No** | **No** | **Yes** | **Yes** |
| Problem | **None** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **5** | **C to F** | **Yes** |
| 7.2 Channel Aggradation | **15** | **None** | **No** |
| 7.3 Widening Channel | **16** | | **No** |
| 7.4 Change in Planform | **16** | | **Yes** |
| Total Score | **52** | | |
| Geomorphic Rating | **0.65** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Good**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **8** |
| 6.2 Embeddedness | **16** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **1** |
| 6.7 Frequency of Riffles/Steps | **5** |
| 6.8 Bank Stability | **Left: 8 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 5 Right: 5** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 1** |
| Total Score | **102** |
| Habitat Rating | **0.51** |

Habitat Stream Condition **Fair**

Narrative:

None (minor to negligible adjustment). Extreme sensitivity due to Stream Type Departure (C to F).

Stream: **Black River** Reach # **M34** Segment: **0** Completion Date: **October 1, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; MLC - DEC; SP -** Rain: **No**

Segment Length (ft): **2,161** Segment Location: **From valley pinch-point d/s along Route 103 past RB shopping plazas to Jewell Brook**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Dam** | **Mid-segment** | **2.00** | **1.00** | **Yes** | |

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

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 | **13** | **None** | **No** |
| 7.3 Widening Channel | **13** | | **No** |
| 7.4 Change in Planform | **15** | | **Yes** |
| Total Score | **44** | | |
| Geomorphic Rating | **0.55** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **8** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **8** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **3** |
| 6.7 Frequency of Riffles/Steps | **14** |
| 6.8 Bank Stability | **Left: 7 Right: 7** |
| 6.9 Bank Vegetation Protection | **Left: 7 Right: 3** |
| 6.10 Riparian Vegetation Zone Width | **Left: 4 Right: 8** |
| Total Score | **111** |
| Habitat Rating | **0.555** |

Habitat Stream Condition **Fair**

Narrative:

Minor widening, aggradation. Historic incision. Entrenchment increased by floodplain encroachments. Extreme senstivity due to stream type departure (C to F).

Stream: **Black River** Reach # **M35** Segment: **0** Completion Date: **October 1, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; MLC - DEC; SP -** Rain: **No**

Segment Length (ft): **1,713** Segment Location: **Short semi-confined reach upstream of Ludlow, downstream of Dug Road bridge**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **52.4** | **Yes** | **Yes** | **Yes** | **Yes** |

Problem **None**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **16** | **None** | **No** |
| 7.2 Channel Aggradation | **8** | **None** | **No** |
| 7.3 Widening Channel | **13** | | **No** |
| 7.4 Change in Planform | **15** | | **No** |
| Total Score | **52** | | |
| Geomorphic Rating | **0.65** | | |

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **3** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **8** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **18** |
| 6.6 Channel Alteration | **8** |
| 6.7 Frequency of Riffles/Steps | **5** |
| 6.8 Bank Stability | **Left: 8 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 7 Right: 3** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 1** |
| Total Score | **98** |
| Habitat Rating | **0.49** |

Habitat Stream Condition **Fair**

Narrative:

Moderate aggradation, minor widening.

Stream: **Black River** Reach # **M36** Segment: **A** Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC; MLC - DEC; SP -** Rain: **No**

Segment Length (ft): **3,496** Segment Location: **From Fox Lane bridge d/s to Dug Road bridge crossing.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **79.0** | **Yes** | **Yes** | **Yes** | **Yes** |

Problem **None**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **18** | **None** | **No** |
| 7.2 Channel Aggradation | **13** | **None** | **No** |
| 7.3 Widening Channel | **13** | | **No** |
| 7.4 Change in Planform | **11** | | **No** |
| Total Score | **55** | | |
| Geomorphic Rating | **0.6875** | | |

Channel Evolution Model **D**

Channel Evolution Stage **IIc**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **8** |
| 6.2 Embeddedness | **13** |
| 6.3 Velocity/Depth Patterns | **13** |
| 6.4 Sediment Deposition | **13** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **3** |
| 6.7 Frequency of Riffles/Steps | **18** |
| 6.8 Bank Stability | **Left: 7 Right: 8** |
| 6.9 Bank Vegetation Protection | **Left: 6 Right: 7** |
| 6.10 Riparian Vegetation Zone Width | **Left: 5 Right: 9** |
| Total Score | **126** |
| Habitat Rating | **0.63** |

Habitat Stream Condition **Fair**

Narrative:

Moderate planform adjustment (meander extension, flood chutes). Despite inferred channelization, good flood plain access. Incision may have been moderated by cohesive bed/banks, woody buffers (LB), relatively low gradient..

Stream: **Black River** Reach # **M36** Segment: **B** Completion Date: **November 8,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **Yes**

Segment Length (ft): **1,217** Segment Location: **From upper Branch Brook confluence d/s to Fox Lane bridge crossing.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Narrative:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition

Stream Sensitivity

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Stream: **Branch Brook** Reach # **M36T4.01** Segment: **0** Completion Date: **August 27, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS** Rain: **No**

Segment Length (ft): **3,228** Segment Location: **From Buttermilk Falls Rd junction with Route 103, downstream to confluence with**

1.6 Grade Controls

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|
| **Waterfall** | **Mid-segment** | **2.00** | **1.00** | **Yes** | |

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **67.0** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **None** | | | | |
| **Bridge** | **80.0** | **Yes** | **Yes** | **No** | **Yes** |
| Problem | **None** | | | | |

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 | **10** | **None** | **No** |
| 7.3 Widening Channel | **13** | | **Yes** |
| 7.4 Change in Planform | **13** | | **No** |
| Total Score | **39** | | |
| Geomorphic Rating | **0.4875** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **8** |
| 6.2 Embeddedness | **11** |
| 6.3 Velocity/Depth Patterns | **10** |
| 6.4 Sediment Deposition | **15** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **6** |
| 6.7 Frequency of Riffles/Steps | **5** |
| 6.8 Bank Stability | **Left: 9 Right: 8** |
| 6.9 Bank Vegetation Protection | **Left: 8 Right: 4** |
| 6.10 Riparian Vegetation Zone Width | **Left: 9 Right: 2** |
| Total Score | **111** |
| Habitat Rating | **0.555** |

Habitat Stream Condition **Fair**

Narrative:

Mod aggrad, PF. Historic incis, wid. Current PF change / wid moderated by bank armoring, berms, tree buffers. Extreme sens due to STD from C to F. Headcut noted mid reach may be assoc w/ flows through perched culv (see Ph2 rpt).

Stream: **Black River** Reach # **M37** Segment: **A** Completion Date: **September 23,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **1,842** Segment Location: **Segment has wetland characteristics rather than fluvial form.**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions **None**

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|

Narrative:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition

Stream Sensitivity

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Stream: **Black River** Reach # **M37** Segment: **B** Completion Date: **September 23,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS** Rain: **No**

Segment Length (ft): **3,469** Segment Location: **From Reservoir Pond dam (Lake Pauline) downstream to wetlands (Segment A)**

1.6 Grade Controls **None**

| Type | Location | Total | Total Height Above Water | Photo Taken | GPSTaken |
|---|---|---|---|---|---|

4.8 Channel Constrictions

| Type | Width | Photo Taken? | GPS Taken? | Channel Constriction? | Floodprone Constriction? |
|---|---|---|---|---|---|
| **Bridge** | **51.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Scour Below** | | | | |
| **Old** | **37.0** | **Yes** | **Yes** | **Yes** | **Yes** |
| Problem | **Deposition Above** | | | | |

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

| | Score | STD | Historic |
|---|---|---|---|
| 7.1 Channel Degradation | **5** | **C to B** | **Yes** |
| 7.2 Channel Aggradation | **13** | **None** | **Yes** |
| 7.3 Widening Channel | **10** | | **Yes** |
| 7.4 Change in Planform | **10** | | **No** |
| Total Score | **38** | | |
| Geomorphic Rating | **0.475** | | |

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

| | Score |
|---|---|
| 6.1 Epifaunal Substrate - Available Cover | **8** |
| 6.2 Embeddedness | **18** |
| 6.3 Velocity/Depth Patterns | **11** |
| 6.4 Sediment Deposition | **16** |
| 6.5 Channel Flow Status | **16** |
| 6.6 Channel Alteration | **7** |
| 6.7 Frequency of Riffles/Steps | **13** |
| 6.8 Bank Stability | **Left: 8 Right: 9** |
| 6.9 Bank Vegetation Protection | **Left: 8 Right: 9** |
| 6.10 Riparian Vegetation Zone Width | **Left: 2 Right: 9** |
| Total Score | **134** |
| Habitat Rating | **0.67** |

Habitat Stream Condition **Good**

Narrative:

Moderate planform adjustment; historic incision, widening, aggradation. Stream type departure from C4 to B4c.

# APPENDIX B

## Bridge and Culvert Assessment Summary Reports

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Culvert Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 700000000014063 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 09/22/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | Driveway crossing 185 ft W of Twentymile Stream Rd, 1000 ft S of Jct Twentymile Stream Rd & Crown Point Drive | **Reach VTID** | M26T2.10 |
| **Latitude** | 43.46 | **Longitude** | -72.65 |
| **Road Name** | --- | **Road Type** | Gravel |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 19 ft. ( Curve) |

## Culvert Information

| | | | |
|---|---|---|---|
| | | **Material** | Steel Corrugated |
| **Culvert Length** | 17 ft. | **Number of culverts** | 1 |
| **Culvert Height** | 7 ft. | **Culvert Overflow Pipe** | No |
| **Culvert Width** | 7 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Culvert slope as compared with channel slope is significantly** | Lower |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | Sediment |
| **Steep riffle present immediately upstream of structure** | Yes |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Naturally Straight |

### Downstream

| | |
|---|---|
| **Water depth in culvert (at outlet)** | 0.3 ft. |
| **Culvert outlet invert** | Cascade |
| **Backwater Length (measured from outlet)** | 0.0 ft. |
| **Outlet drop (invert to water surface)** | 0.8 ft. |
| **Pool present immediately downstream of structure** | Yes |
| **Pool Depth at point of streamflow entry** | 1.0 ft. |
| **Maximum pool depth** | 3.2 ft. |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Cobble | None |
| **Bedrock Present** | No | No | |
| **Material Present throughout** | | | No |
| **Type of Sediment Deposits** | Mid-channel | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | Low | High | |
| **Hard Bank Armoring** | Intact | Failing | |
| **Stream bed scour causing undermining around or under structure** | None | Culvert | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|

| | | |
|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Mixed Forest |
| **Dominant Vegetation Type - Right** | Mixed Forest | Mixed Forest |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | |
| **Vegetation Band - Left** | No | No |
| **Vegetation Band - Right** | Yes | No |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | No | **Photos taken?** | Yes |
| **Comments** | Values for LAT/LON are from a GPS waypoint approx 120 ft upstream of the culvert site. Hard bank armoring is intact on RB downstream, but failing on LB downstream. | | |



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 700000000114063 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 06/11/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | Trail / farm road crossing 420 ft NE of Chapman Rd intersection w/ Twentymile Stream Road | **Reach VTID** | M26T2.07 |
| **Latitude** | 43.43 | **Longitude** | -72.65 |
| **Road Name** | --- | **Road Type** | Trail |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 31 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 15 ft. | **Material** | Concrete |
| **Bridge Clearance** | 4 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 11 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Sharp Bend |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Gravel |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | Point | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Herbaceous/Grass | |
| **Dominant Vegetation Type - Right** | Herbaceous/Grass | Herbaceous/Grass | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | Yes | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Signage indicates VAST trail use. Beaver dams downstream of structure (greater than 100ft). | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 700000000214063 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 06/12/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | Trail / farm road access to E side of Twentymile Stream Rd approx 1000 ft N of Jct w/ Nelson Rd | **Reach VTID** | M26T2.06 |
| **Latitude** | 43.43 | **Longitude** | -72.65 |
| **Road Name** | --- | **Road Type** | Trail |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 38 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 13 ft. | **Material** | Timber |
| **Bridge Clearance** | 9 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 25 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Naturally Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Shrub/Sapling | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Road Embankment | Road Embankment | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | Yes | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Beaver dams upstream of structures (greater than 100 ft). | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 700000000314063 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 06/19/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | trail / farm road crossing 300 ft E of Twentymile Stream Rd at a point 580 ft S of Nelson Rd intersection. | **Reach VTID** | M26T2.06 |
| **Latitude** | 43.42 | **Longitude** | -72.65 |
| **Road Name** | --- | **Road Type** | Trail |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 29 ft. ( Measured) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 18 ft. | **Material** | Timber |
| **Bridge Clearance** | 7 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 29 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Mild Bend |
| **Downstream** | |
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | Side |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | Low | Low | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Herbaceous/Grass | Herbaceous/Grass | |
| **Dominant Vegetation Type - Right** | Herbaceous/Grass | Herbaceous/Grass | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Beaver dams downstream of structures (greater than 100 ft). Used measured bankfull width, since VTRHGC data overpredict widths for E stream types. Wood turtle observed downstream of the structure (greater than 100 ft). | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 700000000414063 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 09/04/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | driveway 110 ft E of Route 106 at point 1570 ft S of Jct w/ Felchville Gulf Rd | **Reach VTID** | M15T1.09 |
| **Latitude** | 43.44 | **Longitude** | -72.53 |
| **Road Name** | --- | **Road Type** | Gravel |
| **Stream Name** | North Branch Black River | **High flow stage** | No |
| | | **Channel width** | 47 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 12 ft. | **Material** | Timber |
| **Bridge Clearance** | 11 ft. | **Number of bridge piers/arches** | 2 |
| **Bridge/Arch Span** | 43 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Mild Bend |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Bedrock | Bedrock | Boulder |
| **Bedrock Present** | Yes | Yes | Yes |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | Abutments | Abutments | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Piers are constructed of timber placed at the edge of the channel close to the concrete and earthen abutments. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 990000000014063 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/02/2007 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | Railroad bridge 230 ft NW of Main St and Route 103 intersection | **Reach VTID** | M32 |
| **Latitude** | 43.38 | **Longitude** | -72.65 |
| **Road Name** | --- | **Road Type** | Railroad |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 90 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 16 ft. | **Material** | Steel |
| **Bridge Clearance** | 11 ft. | **Number of bridge piers/arches** | 1 |
| **Bridge/Arch Span** | 180 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | Wood debris |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Sharp Bend |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Gravel |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | Mid-channel | Mid-channel |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | Yes | Yes |
| **Bank Erosion** | Low | Low | |
| **Hard Bank Armoring** | Intact | None | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Road Embankment | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Shrub/Sapling | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 990000000114063 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/02/2007 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | Railroad bridge 350 ft downstream of Depot St bridge crossing, Proctorsville | **Reach VTID** | M31 |
| **Latitude** | 43.38 | **Longitude** | -72.64 |
| **Road Name** | --- | **Road Type** | Railroad |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 90 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 18 ft. | **Material** | Steel |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 137 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Sharp Bend |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Gravel |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | Point | None | Point |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | High | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | No | **Photos taken?** | Yes |
| **Comments** | Bridge truss: "1897" | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100030000014061 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 09/17/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 280 ft SE of Jct w/ Route 131, Whitesville | **Reach VTID** | M27 |
| **Latitude** | 43.39 | **Longitude** | -72.59 |
| **Road Name** | CARLTON RD | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 92 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 16 ft. | **Material** | Concrete |
| **Bridge Clearance** | --- ft. | **Number of bridge piers/arches** | 1 |
| **Bridge/Arch Span** | 110 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Mild Bend |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Bedrock | Bedrock |
| **Bedrock Present** | Yes | Yes | Yes |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | None | None | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Shrub/Sapling | Shrub/Sapling | |
| **Dominant Vegetation Type - Right** | Shrub/Sapling | Shrub/Sapling | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100021000014061 | **Local SgaID** | --- |
| **VOBCIT struct_num** | 101406003714061 | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 06/18/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 580 ft E of Jct w/ Heald Rd | **Reach VTID** | M26T2.05 |
| **Latitude** | 43.40 | **Longitude** | -72.63 |
| **Road Name** | DAVIS RD | **Road Type** | Gravel |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 41 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 8 ft. | **Material** | Timber |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 22 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Follow Road |
| **Estimated distance avulsion would follow road** | 300 ft. |
| **Angle of stream flow approaching structure** | Mild Bend |
| **Downstream** | |
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | Side | Side | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | Low | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Herbaceous/Grass | Herbaceous/Grass | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | Yes | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Sediment wash off from bridge decking. Stone-lined ditch along Davis Road appears to deliver stormwater runoff directly to area of upstream LB abutment. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100001000014061 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/02/2007 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 860 ft SE of Jct w/ Route 131, Proctorsville | **Reach VTID** | M31 |
| **Latitude** | 43.38 | **Longitude** | -72.64 |
| **Road Name** | DEPOT ST | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 90 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 39 ft. | **Material** | Concrete |
| **Bridge Clearance** | 13 ft. | **Number of bridge piers/arches** | 1 |
| **Bridge/Arch Span** | 82 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | Wood debris |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Gravel |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | Mid-channel | Mid-channel |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | Abutments | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Shrub/Sapling | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | Yes | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Wood debris at upstream end pier. Concrete spalling and scour at downstream end concrete pier. New concrete surface / point on upstream end of pier. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 400011000014061 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 06/18/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 1000 ft N of Jct w/ Davis Road | **Reach VTID** | M26T2.05 |
| **Latitude** | 43.41 | **Longitude** | -72.64 |
| **Road Name** | HEALD RD | **Road Type** | Paved |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 41 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 37 ft. | **Material** | Concrete |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 18 ft. | **Skewed to roadway?** | Yes |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | Unsure |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Follow Road |
| **Estimated distance avulsion would follow road** | 150 ft. |
| **Angle of stream flow approaching structure** | Mild Bend |
| **Downstream** | |
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | Yes |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | Yes | No | Yes |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Road Embankment | |
| **Dominant Vegetation Type - Right** | Coniferous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | Yes | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Culvert Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 400007000014061 | **Local SgaID** | --- |
| **VOBCIT struct_num** | 990007002614061 | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 09/22/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 475 ft W of Jct w/ Twentymile Stream Road | **Reach VTID** | M26T2.09 |
| **Latitude** | 44.45 | **Longitude** | -72.65 |
| **Road Name** | MEADOWBROOK FARM RD | **Road Type** | Gravel |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 27 ft. ( Curve) |

## Culvert Information

| | | | |
|---|---|---|---|
| | | **Material** | Steel Corrugated |
| **Culvert Length** | 60 ft. | **Number of culverts** | 1 |
| **Culvert Height** | 8 ft. | **Culvert Overflow Pipe** | No |
| **Culvert Width** | 14 ft. | **Skewed to roadway?** | Yes |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Culvert slope as compared with channel slope is significantly** | Same |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Mild Bend |

### Downstream

| | |
|---|---|
| **Water depth in culvert (at outlet)** | 0.7 ft. |
| **Culvert outlet invert** | Partially Backwatered |
| **Backwater Length (measured from outlet)** | 100.0 ft. |
| **Outlet drop (invert to water surface)** | 0.0 ft. |
| **Pool present immediately downstream of structure** | No |
| **Pool Depth at point of streamflow entry** | 0.7 ft. |
| **Maximum pool depth** | 0.7 ft. |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Gravel |
| **Bedrock Present** | No | No | |
| **Material Present throughout** | | | Yes |
| **Type of Sediment Deposits** | None | Mid-channel | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | None | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Shrub/Sapling | Shrub/Sapling | |
| **Dominant Vegetation Type - Right** | Shrub/Sapling | Shrub/Sapling | |

| Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream? | | |
|---|---|---|
| **Vegetation Band - Left** | No | No |
| **Vegetation Band - Right** | Yes | No |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | No | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100004000014061 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/03/2007 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 540 ft S of Jct w/ Route 131, near Mack Molding | **Reach VTID** | M30 |
| **Latitude** | 43.38 | **Longitude** | -72.61 |
| **Road Name** | MILL ST | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 92 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 21 ft. | **Material** | Timber |
| **Bridge Clearance** | 12 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 96 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Follow Road |
| **Estimated distance avulsion would follow road** | 250 ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Gravel |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Road Embankment | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | Yes | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Downstream impoundment above CVPS dam and Cavendish Gorge. Timber pedestrian bridge on upstream side of bridge. "1905" plaque on bridge truss. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 200103000014062 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/02/2007 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 1735 ft SE of Jct w/ Route 131 | **Reach VTID** | M32 |
| **Latitude** | 43.38 | **Longitude** | -72.64 |
| **Road Name** | ROUTE 103 | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 90 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 30 ft. | **Material** | Concrete |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 1 |
| **Bridge/Arch Span** | 152 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | Sediment |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Gravel |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | Mid-channel | Mid-channel | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | Yes | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | Yes | |
| **Vegetation Band - Right** | No | Yes | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 200131000014062 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 09/05/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 70 ft NE of Jct w/ Whitesville Rd | **Reach VTID** | M26T2.01 |
| **Latitude** | 43.39 | **Longitude** | -72.59 |
| **Road Name** | ROUTE 131 | **Road Type** | Paved |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 43 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 45 ft. | **Material** | Concrete |
| **Bridge Clearance** | 9 ft. | **Number of bridge piers/arches** | 1 |
| **Bridge/Arch Span** | 93 ft. | **Skewed to roadway?** | Yes |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | Yes |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | Yes |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | Side |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Shrub/Sapling | Shrub/Sapling | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Shrub/Sapling | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Bridge has overflow area to LB of pier. RB channel occupied at low to moderate flow (45 ft span RB abut to pier, perpendicular to channel). Both channels occupied at bankfull and higher flows. Channel makes sharp turn to north under bridge. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Culvert Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 400003000014061 | **Local SgaID** | --- |
| **VOBCIT struct_num** | 990003001914061 | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 06/12/2008 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 0.42 mile S of Jct w/ Meadowbrook Farm Rd | **Reach VTID** | M26T2.08 |
| **Latitude** | 43.44 | **Longitude** | -72.65 |
| **Road Name** | TWENTY MILE STREAM RD | **Road Type** | Gravel |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 28 ft. ( Curve) |

## Culvert Information

| | | | |
|---|---|---|---|
| | | **Material** | Steel Corrugated |
| **Culvert Length** | 100 ft. | **Number of culverts** | 1 |
| **Culvert Height** | 8 ft. | **Culvert Overflow Pipe** | No |
| **Culvert Width** | 14 ft. | **Skewed to roadway?** | Yes |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Culvert slope as compared with channel slope is significantly** | Same |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Mild Bend |

### Downstream

| | |
|---|---|
| **Water depth in culvert (at outlet)** | 0.5 ft. |
| **Culvert outlet invert** | Partially Backwatered |
| **Backwater Length (measured from outlet)** | 30.0 ft. |
| **Outlet drop (invert to water surface)** | 0.0 ft. |
| **Pool present immediately downstream of structure** | No |
| **Pool Depth at point of streamflow entry** | 0.5 ft. |
| **Maximum pool depth** | 1.0 ft. |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Gravel |
| **Bedrock Present** | No | No | |
| **Material Present throughout** | | | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Shrub/Sapling | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Shrub/Sapling | |

| Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream? | | |
|---|---|---|
| **Vegetation Band - Left** | Yes | No |
| **Vegetation Band - Right** | No | No |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100045000014061 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/02/2007 |
| **Town** | Cavendish | **Project Name:** | Black River |
| **Location** | 160 ft SW of Jct w/ Route 103 | **Reach VTID** | M32 |
| **Latitude** | 43.39 | **Longitude** | -72.65 |
| **Road Name** | WINERY RD | **Road Type** | Gravel |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 90 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 17 ft. | **Material** | Concrete |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 76 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Boulder | Cobble | Boulder |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Road Embankment | Herbaceous/Grass | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Herbaceous/Grass | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Appear to be some rip-rap boulders in middle of channel upstream of bridge that have collapsed from LB (along road) . | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 700000000014103 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC; G Alexander, S. Pealer - VTDEC | **Assessment Date** | 08/27/2008 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | driveway, commercial property access off Route 103 approx 1160 ft NW of Jct Route 100. | **Reach VTID** | M36T4.01 |
| **Latitude** | 43.42 | **Longitude** | -72.71 |
| **Road Name** | --- | **Road Type** | Gravel |
| **Stream Name** | Branch Brook (Black River) | **High flow stage** | No |
| | | **Channel width** | 44 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 20 ft. | **Material** | Timber |
| **Bridge Clearance** | 11 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 67 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | Point |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | High | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Shrub/Sapling | |
| **Dominant Vegetation Type - Right** | Road Embankment | Road Embankment | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | Yes | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | LB downstream stormwater input. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100308000014101 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/01/2007 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | 200 ft N of Jct w/ Main St | **Reach VTID** | M33 |
| **Latitude** | 43.40 | **Longitude** | -72.70 |
| **Road Name** | DEPOT ST | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 85 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 31 ft. | **Material** | Concrete |
| **Bridge Clearance** | 20 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 91 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Bare | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | "1953" stamped on bridge. Two large-diameter insulated pipes running under bridge. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100003000014101 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/01/2007 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | Just E of Jct w/ Route 103. | **Reach VTID** | M35 |
| **Latitude** | 43.41 | **Longitude** | -72.71 |
| **Road Name** | DUG RD | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 78 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 29 ft. | **Material** | Concrete |
| **Bridge Clearance** | 8 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 52 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Follow Road |
| **Estimated distance avulsion would follow road** | 500 ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Shrub/Sapling | Road Embankment | |
| **Dominant Vegetation Type - Right** | Road Embankment | Road Embankment | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100004000014101 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 09/23/2008 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | 95 ft E of Jct w/ Rt 100 | **Reach VTID** | M37 |
| **Latitude** | 43.43 | **Longitude** | -72.70 |
| **Road Name** | E LAKE RD | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 66 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 25 ft. | **Material** | Concrete |
| **Bridge Clearance** | 9 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 51 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Naturally Straight |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Road Embankment | Road Embankment | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Trib entering on LB downstream. Dam for Reservoir Pond (Lake Pauline) w/in 130 ft upstream of bridge. Bridge Plaque: "1974" "SSAB 84 21". Struct_num = 101410000614101 | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100029000014101 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/02/2007 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | 585 ft S of Jct w/ Route 103 | **Reach VTID** | M32 |
| **Latitude** | 43.39 | **Longitude** | -72.67 |
| **Road Name** | EAST HILL RD | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 90 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 26 ft. | **Material** | Concrete |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 68 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | Point | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | None | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | No | **Photos taken?** | Yes |
| **Comments** | Bridge plaque: "1976" | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100017000014101 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/01/2007 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | 500 ft NE of Jct w/ Route 100/103 | **Reach VTID** | M36 |
| **Latitude** | 43.41 | **Longitude** | -72.70 |
| **Road Name** | FOX LN | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 77 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 24 ft. | **Material** | Concrete |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 79 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | Side | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | Low | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | Yes | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100001000014101 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/01/2007 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | 1190 ft E of Depot St Jct | **Reach VTID** | M33 |
| **Latitude** | 43.40 | **Longitude** | -72.70 |
| **Road Name** | MAIN ST | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 85 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 40 ft. | **Material** | Concrete |
| **Bridge Clearance** | 16 ft. | **Number of bridge piers/arches** | 1 |
| **Bridge/Arch Span** | 83 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | Side |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | Abutments | Abutments | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | slight abutment scour | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100324000014101 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/03/2007 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | 50 ft N of Jct w/ Pleasant Street Extension | **Reach VTID** | M33 |
| **Latitude** | 43.39 | **Longitude** | -72.69 |
| **Road Name** | MILL ST | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 85 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 26 ft. | **Material** | Concrete |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 77 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Follow Road |
| **Estimated distance avulsion would follow road** | 150 ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Road Embankment | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | No | **Photos taken?** | Yes |
| **Comments** | Low-head dam remnants (concrete, channel-spanning) 5 ft downstream of bridge | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100026000014101 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 10/02/2007 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | 150 ft SW of Jct w/ Main Street (Rt 103) | **Reach VTID** | M33 |
| **Latitude** | 43.39 | **Longitude** | -72.68 |
| **Road Name** | PLEASANT ST EXT | **Road Type** | Paved |
| **Stream Name** | Black River | **High flow stage** | No |
| | | **Channel width** | 85 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 26 ft. | **Material** | Concrete |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 1 |
| **Bridge/Arch Span** | 130 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | Yes |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Failing | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Road Embankment | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | --- | --- | --- |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Full span (including pier) is 130 ft. Typical flow occurs between pier and RB abutment (span of 65.5 ft), w/ overflow to left of pier. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 200100000014102 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC; G Alexander, S. Pealer - VTDEC | **Assessment Date** | 08/27/2008 |
| **Town** | Ludlow | **Project Name:** | Black River |
| **Location** | 150 ft NE of Jct w/ VT Route 103 | **Reach VTID** | M36T4.01 |
| **Latitude** | 43.42 | **Longitude** | -72.71 |
| **Road Name** | ROUTE 100 | **Road Type** | Paved |
| **Stream Name** | Branch Brook (Black River) | **High flow stage** | No |
| | | **Channel width** | 44 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 30 ft. | **Material** | Concrete |
| **Bridge Clearance** | 10 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 80 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Herbaceous/Grass | Herbaceous/Grass | |
| **Dominant Vegetation Type - Right** | Road Embankment | Herbaceous/Grass | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Bridge plaque: "1966" | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 700000000014143 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU - SMRC; GA, SP - VTDEC | **Assessment Date** | 08/29/2008 |
| **Town** | Reading | **Project Name:** | Black River |
| **Location** | Farm road / VAST trail bridge 350 ft E of Route 106 at a point 775 ft S of Jct w/ Niagara St. | **Reach VTID** | M15T1.10 |
| **Latitude** | 43.45 | **Longitude** | -72.54 |
| **Road Name** | --- | **Road Type** | Trail |
| **Stream Name** | North Branch Black River | **High flow stage** | No |
| | | **Channel width** | 39 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 12 ft. | **Material** | Timber |
| **Bridge Clearance** | 9 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 45 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | Yes |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | Side | Side |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Signage indicates snowmobile use. Also farm access to hay fields. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 200106000014142 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 08/29/2008 |
| **Town** | Reading | **Project Name:** | Black River |
| **Location** | Just S of Jct w/ Niagara Falls Rd, Felchville | **Reach VTID** | M15T1.11 |
| **Latitude** | 43.45 | **Longitude** | -72.54 |
| **Road Name** | ROUTE 106 | **Road Type** | Paved |
| **Stream Name** | North Branch Black River | **High flow stage** | No |
| | | **Channel width** | 39 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 35 ft. | **Material** | Concrete |
| **Bridge Clearance** | 8 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 39 ft. | **Skewed to roadway?** | Yes |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | Yes |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | Sediment |
| **Steep riffle present immediately upstream of structure** | Yes |
| **If channel avulses, stream will** | Follow Road |
| **Estimated distance avulsion would follow road** | 1000 ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | Side |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | Low | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Road Embankment | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 400003000014141 | **Local SgaID** | --- |
| **VOBCIT struct_num** | 990003001514141 | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 09/22/2008 |
| **Town** | Reading | **Project Name:** | Black River |
| **Location** | 165 ft N of Jct w/ Crown Point Drive | **Reach VTID** | M26T2.10 |
| **Latitude** | 43.46 | **Longitude** | -72.65 |
| **Road Name** | TWENTY MILE STREAM RD | **Road Type** | Gravel |
| **Stream Name** | Twentymile Stream (Black River) | **High flow stage** | No |
| | | **Channel width** | 19 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 21 ft. | **Material** | Timber |
| **Bridge Clearance** | 7 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 12 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Sharp Bend |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | Yes |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Gravel | Gravel |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | Side | Side |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | Low | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Mixed Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | Yes | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

| Other Information | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | --- | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 700000000014203 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 06/11/2008 |
| **Town** | Weathersfield | **Project Name:** | Black River |
| **Location** | trail for apparent logging or recreational access located 350 ft E of Route 106 at a point 1650 ft NW of Ascutney Basin Rd Jct w/ Route 106. | **Reach VTID** | M15T1.08 |
| **Latitude** | 43.44 | **Longitude** | -72.53 |
| **Road Name** | --- | **Road Type** | Trail |
| **Stream Name** | North Branch Black River | **High flow stage** | No |
| | | **Channel width** | 47 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 7 ft. | **Material** | Timber |
| **Bridge Clearance** | 9 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 40 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Not Significant |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Channelized Straight |
| **Downstream** | |
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Cobble | Cobble | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Deciduous Forest | |
| **Dominant Vegetation Type - Right** | Deciduous Forest | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Trail (recreational?) reduces buffer width. Floodplain not significantly filled by roadway approaches, since channel already entrenched - to some degree natural entrenchment. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671


A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 700000000114203 | **Local SgaID** | --- |
| **VOBCIT struct_num** | | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 06/20/2008 |
| **Town** | Weathersfield | **Project Name:** | Black River |
| **Location** | trail / farm road crossing located 1000 ft ENE of Route 106 Jct w/ Amsden School Rd | **Reach VTID** | M15T1.05 |
| **Latitude** | 43.41 | **Longitude** | -72.51 |
| **Road Name** | --- | **Road Type** | Trail |
| **Stream Name** | North Branch Black River | **High flow stage** | No |
| | | **Channel width** | 41 ft. ( Measured) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 12 ft. | **Material** | Timber |
| **Bridge Clearance** | 9 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 50 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Partially |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Mild Bend |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Sand | Sand | Sand |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | Point | Side | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | High | High | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Herbaceous/Grass | Shrub/Sapling | |
| **Dominant Vegetation Type - Right** | Shrub/Sapling | Shrub/Sapling | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | Yes | Yes | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Species** | None | Deer - Sighting | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Used measured bankfull width, since VRHGC data overpredict width for E stream types. Signage indicates snowmobile use of trail at crossing and along LB upstream of the crossing. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 100006000014201 | **Local SgaID** | --- |
| **VOBCIT struct_num** | 101420006314201 | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 11/08/2007 |
| **Town** | Weathersfield | **Project Name:** | Black River |
| **Location** | 125 ft E of Jct w/ Route 106 | **Reach VTID** | M15T1.08 |
| **Latitude** | 43.43 | **Longitude** | -72.53 |
| **Road Name** | ASCUTNEY BASIN RD | **Road Type** | Paved |
| **Stream Name** | North Branch Black River | **High flow stage** | No |
| | | **Channel width** | 47 ft. ( Curve) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 18 ft. | **Material** | Timber |
| **Bridge Clearance** | 7 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 33 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

### General

| | |
|---|---|
| **Floodplain filled by roadway approaches** | Entirely |
| **Structure is located at significant break in valley slope** | No |

### Upstream

| | |
|---|---|
| **Obstructions at the opening of the structure** | None |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Cross Road |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Mild Bend |

### Downstream

| | |
|---|---|
| **Pool present immediately downstream of structure** | No |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | No |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Gravel |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | Side | None | None |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | None | None | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | None | None | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Shrub/Sapling | |
| **Dominant Vegetation Type - Right** | Shrub/Sapling | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Road is paved over the bridge, but turns to gravel just beyond the bridge. Plaque: "TF-14-1962". Pair of old bridge abutments short distance upstream. | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resources

VT DEC

Vermont.gov



# Bridge Summary Report

## General Information

| | | | |
|---|---|---|---|
| **SgaID** | 400005000014201 | **Local SgaID** | --- |
| **VOBCIT struct_num** | 990005001614201 | | |
| **Observers** | KLU, BOS - SMRC | **Assessment Date** | 11/07/2008 |
| **Town** | Weathersfield | **Project Name:** | Black River |
| **Location** | 290 ft E of Jct w/ Route 106 | **Reach VTID** | M15T1.05 |
| **Latitude** | 43.42 | **Longitude** | -72.52 |
| **Road Name** | LITTLE ASCUTNEY RD | **Road Type** | Paved |
| **Stream Name** | North Branch Black River | **High flow stage** | No |
| | | **Channel width** | 41 ft. ( Measured) |

## Bridge/Arch Information

| | | | |
|---|---|---|---|
| **Bridge Width** | 20 ft. | **Material** | Concrete |
| **Bridge Clearance** | 8 ft. | **Number of bridge piers/arches** | 0 |
| **Bridge/Arch Span** | 17 ft. | **Skewed to roadway?** | No |

## Geomorphic Information

| | |
|---|---|
| **General** | |
| **Floodplain filled by roadway approaches** | Partially |
| **Structure is located at significant break in valley slope** | No |
| **Upstream** | |
| **Obstructions at the opening of the structure** | Sediment |
| **Steep riffle present immediately upstream of structure** | No |
| **If channel avulses, stream will** | Unsure |
| **Estimated distance avulsion would follow road** | --- ft. |
| **Angle of stream flow approaching structure** | Sharp Bend |
| **Downstream** | |
| **Pool present immediately downstream of structure** | Yes |
| **Downstream bank heights are substantially higher than upstream bank heights** | No |
| **Stepped footers** | Yes |

## More Geomorphic Information

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Bed Material** | Gravel | Gravel | Cobble |
| **Bedrock Present** | No | No | No |
| **Type of Sediment Deposits** | None | Side | Side |
| **Elevation of sediment deposits greater than 1/2 bankfull** | No | No | No |
| **Bank Erosion** | High | High | |
| **Hard Bank Armoring** | Intact | Intact | |
| **Stream bed scour causing undermining around or under structure** | Abutments | Abutments | |
| **Beaver Dam near Structure** | No | No | |
| **Beaver Dam distance (ft.)** | --- | --- | |

## Vegetation

| | Upstream | Downstream | In Structure |
|---|---|---|---|
| **Dominant Vegetation Type - Left** | Deciduous Forest | Herbaceous/Grass | |
| **Dominant Vegetation Type - Right** | Herbaceous/Grass | Deciduous Forest | |
| **Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?** | | | |
| **Vegetation Band - Left** | No | No | |
| **Vegetation Band - Right** | No | No | |

## Wildlife

| | Roadkill | Outside Structure | Inside Structure |
|---|---|---|---|
| **Species** | None | None | None |

## Other Information

| | | | |
|---|---|---|---|
| **Spatial location data collected with GPS?** | Yes | **Photos taken?** | Yes |
| **Comments** | Timber deck replaced w/concrete btwn 6/20/08 &11/7/08 - newly paved, gravel beyond. Used measured BFLwidth since VTRHGC data overestimate width for E stream types. RB upstream abutment is cracked, appears shifted on its base (not replaced). | | |

VT DEC • 103 South Main Street • Waterbury, VT 05671



A Vermont Government Website Copyright 2008 State of Vermont

# APPENDIX C

# QA Documentation

To: Kristen Underwood, South Mountain Research & Consulting
From: Sacha Pealer, VT DEC River Management
Date: 12/30/08

# Black River Phase 2 QA

*Note:* The questions raised in this Quality Assurance are meant to address potential discrepancies within the data, uncover data entry errors, or otherwise clarify and confirm those observations that might not have been expected. It is important to take into consideration how data might be viewed or interpreted by the myriad of users who are familiar with the science and protocols but may be unfamiliar with the assessed reaches. While providing notes and comments, try to anticipate the types of questions that may arise due to outliers and exceptions observed within the reach or segment.

After reviewing the comments below, please update this document (preferably in a second color) with what steps were (or were not) taken to address the comments/questions.

South Mountain Research & Consulting Services (SMRC) appreciates the opportunity to enhance data accuracy, clarify data limitations, and maximize the utility of the Black River Phase 2 (2007-2008) data set. This response to VT River Management Section QA Review Comments has been completed by Kristen L. Underwood, PG, on 4/7/2009. SMRC responses are in blue text following each comment below. Applicable updates have been made to the Phase 1 and Phase 2 data in the VTDEC Data Management System (DMS) and to the summary report which accompanies this data.

S.Pealer, RMP, 4/15/2009. My latest comments are highlighted in gray. Items needing further input from SMRC contain bold text.

KU, SMRC, 4/22/2009. Responses in blue text highlighted in gray.

S. Pealer, RMP, 5/15/2009. My latest comments are highlighted in blue. These comments follow a meeting with Kristen and other RMP staff (G. Alexander, K. Dolan, M. Kline) in Waterbury, discussing phase 2 and FEH valley wall considerations. The only segments I commented on are M35-0, M26T2.01-0, M26T2.06-B, and M26T2.07-0.

KU, SMRC, 5/19/2009. I have addressed your remaining comments on segments M26T2.06-B and M26T2.07-0 in the pages below. Thank you.

**General Feedback:**

- The excel x-sections frequently show right and left pins, often at very different elevations. Is this because someone is holding up one end of the tape? Please confirm your tape was level☺!
  Consistent with protocols, SMRC utilizes a leveled fiberglass tape or cam line stretched between two pins to capture cross sections. Placement of the pins is facilitated by the use of a hand level; an additional check of the level is performed by measuring the vertical distance from the tape to the LEW and REW. Occasionally, the top end of either pin may have been a few inches above the ground surface. Where bank sediments consisted of large rounded cobbles and boulders, or highly erodible gravels, that did not provide secure footing for the pins, often one end (or both ends) of the tape was secured to a tree. The elevations entered in the cross section spreadsheet reflect the ground surface along the line of section (i.e., calculated as the "depth" of various ground features measured below the arbitrary elevation of the tape).

- Step 2.5 and 2.8. HEF evaluation is meant to help flag segments where floodplain restoration projects may be possible, e.g. removing berms or rerouting improved paths to reduce incision and possibly reconnect the channel to its floodplain. In cases where the encroachment has become the new valley wall, or there is RAF at a lower elevation on the bank opposite the encroachment, an HEF & HEF incision ratio are N/A. For illustration, see "Incision Ratio Addendum" (July 2007). Below, I've identified several reaches where HEF is N/A. Be sure to

update the DMS and excel, and adjust step 7.1 RGA if needed. See reaches M31, M15T1.08 (xs 1), M26T2.01 (xs 2), M36T4.01 (xs 1). I am familiar with the Incision Ratio Addendum (July 2007) and believe that I correctly applied its guidance in each case. In other words, when Situation C of the addendum applied (M31 and M26T2.01 xs2), I ignored the IRhef value when completing RGA Steps 7.1.2 and 7.3.3. In the case of the other two segments (M15T1.08 xs1 and M36T4.01 xs1) none of the A, B, or C scenarios in the July 2007 addendum applied. Instead these channels are incised below the RAF (IRraf > 2.0) as well as having an encroachment along one side. Therefore, if either value (IRraf or IRhef) was used to classify RGA Step 7.1.2 and 7.3.3, it would be ranked in the "Poor" quadrant – and a vertical STD has occurred, by virtue of the ER value less than 2.2. (So, no adjustment to RGA Step 7.1 is required).

After email communications in recent weeks, I now understand that when the IRhef value is defined as "not applicable" under guidance of the July 2007 Addendum, we are to leave the HEF box blank in the DMS under Step 2.5 (even if we do have a human structure such as a berm in our representative cross section). Where applicable, I have removed the N/A HEF values from the DMS. In none of these cases did I identify "HEF" in the cross section spreadsheets – rather the feature itself was described (e.g., railroad or berm) – so the cross sections did not need to be edited for this.

- In general, when there is an HEF, please enter the HEF elevation in the "Elevation RAF" field of the xsection spreadsheet, rather than the RAF (yes, this field needs to be better named). Doing so will enable the spreadsheet to calculate and display the HEF incision ratio. You can then enter a comment in the spreadsheet that documents the RAF incision ratio. The idea is for the xsection to reflect the existing physical incision. Also, please label the HEF and RAF features in the plot diagram. See M15T1.10 (xs 2 & 3), M15T1.11A, M15T1.11B, & M26. (Encroachment features represented in these cross sections include berms and the minor paved road Niagara Rd).

  Four of the five listed cross sections (all but M15T1.10 xs2) are cases where the channel is incised below the floodplain at an IRraf value greater than 2.0. While this situation is not explicitly discussed in the July 2007 Incision Ratio Addendum, I understand from our recent email conversations, that the HEF is Not Applicable in these cases. Therefore, I have not substituted the elevation of the encroachment features in the "Elevation RAF" field of these cross section spreadsheets. Please confirm that this is the correct procedure.

  For **M15T1.10 xs2**, see specific comments under that reach.
  **M15T1.07 xs2** is also in this category; see comments under that reach.
  Actually, there is not a "rule" per se that if the IRraf>2.0, then the HEF is NA. Looking back at your email, I see where you mentioned such a scenario, but don't think any RMP staff addressed that particular point fully (realized what you were asking), nor did we mean to imply that such a rule exists. It is true that if the HEF feature were removed, the stream would still be incised and have a poor degradation rating. However, it is okay to enter an HEF in that situation, as long as it meets the other criteria for an HEF (is not the new valley wall, is blocking access to a floodplain/RAF, and there is not lower elevation floodplain on the bank opposite the encroachment). In the four cross sections discussed above (M15T1.10 xs3, M15T1.11A, M15T1.11B, & M26), the IR raf >2, but all should be listed in the DMS as having an HEF. All do now, except for M26. **Please keep the HEF in the DMS for M26 (HEF=8' above TW).** I also suggested that the cross section spreadsheets themselves should contain the HEF under the "Elevation RAF" field. It seems you did not make this change because you thought the HEF was NA; we should not let this detail bog us down, so for now the spreadsheets are okay, since the encroachments are shown in the plot diagram. Just be aware that in the future, xs spreadsheets with an HEF should calculate the IRhef in the incision ratio field.

  Okay, this is helpful clarification. I have added the value of 8 in the HEF cell of the DMS for the LB berm that qualifies as an HEF in M26.

- Please be sure all excel xsections have labels in the Notes column for bankfull features & RAF. It is important to show which feature plotted in the xsection is the basis for the Elevation Bankfull. If there is no feature plotted at that elevation, then please explain how you determined the Elevation Bankfull. See reaches M30, M31, M32, M15T1.06A, M15T1.06B, M15T1.07, M15T1.08, M15T1.10, M26T2.05, M26T2.06A, M27, & M37-B. Revised cross sections have been uploaded to the DMS.

- Step 3.1. Did you mean to say sand is cohesive for bank texture? Seems like sand would erode easily. See reaches M15T1.05, M15T1.06A & B, M15T1.07, M19, & M26T2.06C. While sand is the dominant bank sediment size in these segments, there is a significant percentage of silt and/or clay in the matrix of these bank sediments; causing a degree of cohesiveness.

- Phase 1 channel widths. Reference channel width should be updated when field-measured ph. 2 channel widths are believed to be more accurate than the regional hydraulic geometry curve widths. In particular, reaches with an E reference stream type often need updated widths, because the curve generally underestimates reference channel width for Es. In such cases, use the most representative channel width measured in ph. 2. See reaches M15T1.05, M15T1.06, & M26T2.06. Also, please update the metadata and include comments (in Ph. 1 step 7 of DMS) alerting others that the ph.1 channel width has been modified. I agree that regional hydraulic geometry curve data sets (VTDEC, 2006) are developed based on largely C stream types and some B stream types, and therefore tend to *over*-estimate the reference channel width for E stream types. I have substituted the measured bankfull width in these E streams for the width predicted by the curves, after reviewing the data to be certain that the degree of active channel adjustment post-disturbance is minor and does not appear to have lead to substantial channel widening. A note indicating this update has been added to Phase 1 Step 7, and the metadata for Phase 1 Step 2.8 has been updated accordingly, for the above three reaches.
  You are correct; I meant to write "overestimates." Thank you for this analysis.

As a consequence of this substitution, the FEH corridor dimension developed at 8 times the Phase-2-updated-Phase 1 channel width will equal approximately 6 times the Curve-predicted width – In other words, these E streams will be buffered at roughly the same total dimension as a C stream type of similar upstream drainage area.

| | Use of Curve-predicted Width (a) | | Use of Phase 2 Measured Width (c) | |
|---|---|---|---|---|
| Reach/ Segment | Channel Width (ft) | Corridor Dimension (ft) of E stream at 8 times channel width (b) | Channel Width (ft) | Corridor Dimension (ft) of E stream at 8 times channel width (b) |
| M26T2.06-A High sensitivity | 38 | 304 | 28.8 | 230 |
| M15T1.06-B Extreme | 49.9 | 399 | 41.4 | 331 |
| M15T1.06-A Extreme | 49.9 | 399 | 41.3 | 330 |
| M15T1.05 Extreme | 52.9 | 423 | 41.0 | 328 |

(a) VTDEC, 2006 Regional Hydraulic Geometery Curve data based on C and some B stream types.
(b) River Corridor Protection Guide, 12 Nov. 2008 draft
(c) Measured during Phase 2 assessments, summer 2008 (this study)

Valley Walls

A few of the comments below ask for revisions to valley walls. It would be helpful if the River Corridor Protection Guide (Nov, 2008, pp. 16-17), Technical Appendix to the Vermont River Corridor Protection Guide (Nov. 12, 2008, pp. 8-9), and the Phase 2 protocols provided more specific instructions and clearly spelled out VTANR expectations with respect to field-truthing valley walls. Definitions would also be helpful to reduce confusion – for example, Phase 1 valley wall, Phase 2 valley wall, FEH valley wall, physical valley wall, modified valley wall, new valley wall, what constitutes a major road, what defines a minor road, when a determination of major versus minor road is to be applied (e.g., in a determination of Phase 2 modified valley width/confinement?; only at the FEH development stage?) what constitutes a human-caused-change in valley width under Step 1.5 (major roads and railroads only?), etc. If a terrace is to be delineated as a valley wall, should the valley wall line be delineated at the base of the terrace, or at the top of the terrace? See specific responses under M26T2.01-0, M26T2.05, M26T2.06-B, M26T2.06-C, and M26T2.07.

Forgive me for adding to the confusion; you are correct that administration modifications of the valley for FEH purposes (with respect to roads) can be made during the FEH process and not as part of the phase 2 valley wall shape file. You are also correct that in ph. 2 valley wall verification, the important thing is to map the encroachments that act as barriers to lateral channel movement, such as roads that modify a valley because of substantial road bed fill. Currently, the distinction between major and minor roads is that a major road has a route number assigned to it, whereas a minor road does not. However, in phase 2, this distinction is not important when it comes to determining if the road constitutes a new valley wall.

I believe the confusion we are experiencing on this topic of valley walls is due to the fact that VTANR protocols (2007) and guidance documents (2008) are not clear on this subject. What are the specific criteria that VTANR is saying should be considered when determining if the road constitutes a "new valley wall"? This becomes critical as I understand from your comments and the November 2008 *River Corridor Protection Guide* (p 16) that this new valley wall (delineated along "significant human-constructed features, such as engineered levees and major road and railroad embankments placed on fill") is to be utilized as a delimiter of the Fluvial Erosion Hazard corridor. I have offered more specific comments under reaches M26T2.01, M26T2.06-B, and M26T2.07, as well as M35, M15T1.08.

Channel Evolution Model / Channel Evolution Stage

Several of the comments below ask for further clarification of Channel Evolution Model and stage. In the time crunch last fall, regretfully, I did not thoroughly QA my selections for CEM/CES before I sent the data sets to you for review. I would agree with you that the stated CEM/CES was not appropriate on many of the reaches/segments below. I should have reviewed these assignments more carefully before forwarding the data for your review. It probably would have saved you some time and aggravation.

Also, data for the 2007 reaches were submitted to the DMS in March 2008, and channel evolution classifications had been made following the May 2007 version of Appendix C to the VTANR protocols (which presents the Channel Evolution Model descriptions). In a meeting with Shannon Pytlik and Mike Kline on April 14, 2008, revisions to Appendix C were discussed that would expand the definition of a Channel Evolution Stage II [F] channel to include C or E stream types (with incision ratios greater than 1.2 but less than 2.0). Also, greater clarification was provided on the D-stage evolution model. To my knowledge, a revised version of Appendix C has not yet been issued, but I am generally operating under the feedback provided at that April 2008 meeting.

Speaking generally, I would like to note the high uncertainty and subjectivity inherent in assigning both CEM and CES to segments based on the results of Phase 2 assessments from one date. Inferring a possible evolution of channel adjustments based on one discrete and limited set of observations and measurements from one snapshot in time, with limited knowledge of the historic channel and watershed stressors, is at best theoretical. A trend cannot be definitively assigned on the basis of one set of data.

Generally, historic data are insufficient at this time to know with certainty how and with what intensity and frequency a given reach was modified after each of the major floods over the last couple of centuries. Available data are not sufficient to state with certainty the nature of overlapping waves of incision and aggradation that may have worked through a reach over recent centuries. The current channel form and degree of

disconnection with the floodplain are often the net result of multiple cycles of erosion/ deposition/ channel management.

Fortunately, to some extent, the QA and comments/documentation process allows assessors to qualify the CEM/CES choice, as well as to acknowledge clues and unknowns about more complex cycles of channel adjustment.

**Comments by Reach (2007):**

M30-0

- Steps 4.5 and 4.6. You note a flow regulation in step 4.5, although your step 5 comments indicate the CVPS hydro dam (flow regulation) is actually downstream in M29. Use step 4.6 for flow regulations that are affecting M30-0, but are not actually in the reach. Step 4.5 would be if the regulation (or source of it) is located within the reach/segment in question. I selected a "small withdrawal" under Step 4.5 (characterized as "Other") to capture a small pump with attached hose at LB, located within 1000 feet of the upstream end of reach M30. Therefore no revision of Step 4.5 is necessary. I have, however, revised Step 4.6 to refer to the downstream CVPS dam which apparently has an impoundment effect that extends into the downstream end of reach M30.
  Okay, but apparently your changes to 4.6 did not save in the DMS; it still says "none." **Please try again.**

  I couldn't say for sure (it's possible that this was an oversight on my part), but the fact that it occurred on all these reaches requiring a Step 4.6 update has me concerned that it might have been a DMS bug. Here's the order of my FIT / DMS corrections in case that might help with de-bugging. I made manual DMS corrections and created segment records for the newly segmented reaches ***before*** re-uploading the revised FIT records for all the reaches/segments. Perhaps (under Step 4.6 only), the FIT upload had the effect of reversing (or overwriting somehow) the contents of Step 4.6 such that the manual DMS changes I had made to this step did not persist in the database? In any case, I should have checked more thoroughly to make sure that all my changes had saved properly in the DMS before submitting the corrected data. I have now made this correction of "Downstream" under Step 4.6 and it appears to have saved properly.
- Riffle type. In step 2.10, you indicate that riffles are complete, but in step 7.1, your answer to question 3 suggests otherwise. If riffles are incomplete, due to degradation or aggradation, then choose "eroded" or "sedimented" for riffle type, or explain this apparent inconsistency. The riffle/pool bedform is weak in this slowly recovering reach. The riffles are complete but short in length; pools are shallow in depth and often more run-like than pool-like. The predominance of runs (i.e., shallow pools) is what prompted me to select the "Fair" quadrant under RGA 7.1.3. I speculate that there were multiple overlapping waves of incision and aggradation in this reach in response to decades of channel management and disturbance. The net result at this point in time is a weak riffle/pool bedform. Given the scarcity of deep pools, I did not choose the "Good" quadrant response under RGA 7.1.3, as there is not a "Full complement of expected bed features". Since the description under the "Good" quadrant for RGA 7.1.3 states that riffles…may appear incomplete", I don't see that this response is necessarily inconsistent with the selection of "Complete" riffles under Step 2.10.
- The two x-sections (one considered not representative) both support an existing stream type of C. I see that in Step 5, I discussed XS-1 as being Not Representative; I have revised this Comments field, as my notes record (and the FIT files show) that I classified both cross sections as "Representative". However, one cross section has an incision ratio of 1.39 and one an incision ratio of 1.78. This difference may be substantial enough to indicate different channel adjustment stages. How much of the reach had the more incised condition? (I generally track the low-bank thalweg height on my sketch maps as we proceed downstream; I have a few measurements along this reach that seem to indicate a gradual, slight, increase in incision ratio with distance downstream). What were your reasons for not segmenting? There can be variability in the degree of incision along the length of a reach due to: (1) potential for regrading of terraces immediately adjacent to the channel associated with reported channelization / dredging, etc following 1973 and 1938 /1936 (and 1927?) floods; (2) possible modification of terrace (RAF) features by ice erosion (see

records of ice jams on reach – Appendix O of Phase 1 report); (3) possible slight under- or over-estimation of bankfull elevation (and therefore IRraf) in Phase 2 assessments based on limited or weak bankfull features. The important finding is that this reach neither has full access to its floodplain (IR = 1.0 and Step 7.1 in "reference" condition) nor is the channel (in whole or in part) entrenched to the degree that results in a vertical stream type departure (IR >= 2.0 and Step 7.1 ranked in "Poor" condition). The reach is somewhere along the continuum between these two extremes by virtue of historic channelization, dredging, and inferred incision. No indications of active incision were observed. If the XS2 IR value of 1.39 is rounded to the nearest tenth, it equals 1.4, which is in the same Condition quadrant of "Fair" under RGA Step 7.1.2 as the IR value from the second cross section (XS1) of 1.78. These two values were collectively considered when ranking RGA Step 7.1.2 – weighting the overall Degradation score (Step 7.1) to a value of "10".

In this case, I did not notice a variation in other metrics or features that would suggest the need to segment based on different channel adjustment stage along the reach. The overall reach showed a rather consistent width/ depth ratio (in the "Good" quadrant of Step 7.3.1) and a weak riffle/pool bedform.

- Please explain why you chose Channel Evolution Stage V. Although you note that degradation is historic, neither cross section shows new floodplain that is fully accessible at bankfull flow events. In stage V, the reach should have evolved back to an equilibrium condition with new floodplain built at a lower elevation. In xsection 2, there is a left terrace, but the RAF is still 1.8' above bankfull. The CES of F[V] was chosen for this reach and entered in the DMS in March of 2008. The wording of the then current May 2007 Appendix C appeared to exclude C streams with a moderate degree of incision from being classified in stage II. Following feedback received from RMS in April 2008, I understand the Appendix C will be revised to include C stream types under Stage II [F]. The CES has been revised to II [F].
  Okay, these changes seem reasonable. As you know, the CEM is a tool meant to provide some qualitative understanding of the adjustment processes at a given location. Perhaps in this case you observed a reach where the stage II process (ie, degradation) did not quite progress to the point where entrenchment changes to that more characteristic of a B stream type (ER=1.4-2.2). As the incision ratio on M30 increases going downstream, the entrenchment ratio decreases (approaching but not reaching B channel dimensions). I don't believe the Appendix C is meant to be exclusive—so that a C is "not permitted" in stage II. Rather, the text is meant to describe (and perhaps a revision would be helpful for some readers) the common/classic progression of stream type/channel dimensions with respect to the more qualitative processes described in each stage. The important thing is to look at the best choice for adjustment *process*, with stream type/channel dimension providing one clue toward possible processes.

M31-0

- As noted above in General Comments, HEF incision is N/A for this reach, because the RAF on the right side is not blocked by the berm. I agree; this would be analogous to "Situation C" in the July 2007 Incision Ratio Addendum. That is why I used the IRraf value of 1.33 in the RGA (Steps 7.1.2 and 7.3.3) and I did not identify a vertical stream type departure (from C to F). Based on recent email correspondence from the RMS, I now understand that the HEF box in the DMS is to be left blank when Situation C applies, so as not to improperly prioritize the segment as one where human-placed structures in the floodplain warrant removal. I have removed data from the HEF cell.
- Again, I am not sure why this reach is called stage V. While the incision ratio is only moderate (1.33), it is still incised, and I don't see new floodplain at a lower elevation than RAF. In stage V, the channel should be able to access new floodplain at bankfull events. Please explain.
  The CES of F[V] was originally chosen for this reach and entered in the DMS in March of 2008, due to the wording of the then current May 2007 Appendix C which appeared to exclude C streams with a moderate degree of incision from being classified in stage II. Following feedback received from RMS in

April 2008, I understand that Appendix C will be revised to include C stream types under Stage II [F]. CES has been revised accordingly.

M32-0

- This reach is long (~ 2.3 miles!), and there are 3 cross sections with varying degrees of incision. Two cross sections indicate stream type Bc, and one indicates type C. In your comments, you describe the channel as having "locally" gained floodplain access and "locally" incised to ~1.7. How long (approximate channel length) are these deviations from incision ratio ~1.4? It is good that you captured them in cross-section, but these differences seem notable enough to segment, especially since there are areas of stream type departure. Please explain why you decided not to segment.
  I have reviewed the cross sections and data for this reach and decided to segment the reach. I have also reconsidered the incision ratio of XS-1, as you suggest below. Please see DMS and Phase 2 summary report.

- In xsection 2, where does the RAF elevation of 7' come from? Please label RAF. Is the "subtle" berming mentioned in your step 5 comments visible on the LB in this xsection? Please label any berms. The berm noted is coincident with LTOB; I have added a notation of "berm?" to this cell in the spreadsheet. There is some uncertainty re: RAF at this cross section, as it appears that the soccer field installed here sometime after 1994 may have involved some excavation / regrading of the RAF. So, I had estimated an elevation of 7 feet for RAF based on observations at the edge of the soccer field. I have labeled the RAF in the spreadsheet and used the actual point elevation of "6.8" – which was taken in a subtle swale just beyond the southern edge of the soccer field. I expect that the RAF (before soccer field construction) was probably a little higher than this swale, but will work with the actual cross section point data. The possible berm along LB qualifies as an HEF, so an elevation value of 8.1 ft was entered in the XS2 spreadsheet, and a thalweg height value of 7.1 ft was entered in the DMS.
- Please explain why you selected stage V for this reach. Given the shifts in incision and stream type throughout 12,000' of channel, it seems likely there is more than one Channel Evolution Stage present (in different segments). Either way, I do not see evidence in your cross sections of a new floodplain formed at a lower elevation, allowing access at bankfull events. The exception would be on xs #2, if the LTER is treated as the RAF and the soccer field is accessible at bankfull events (current elevation of 5.8'is within 0.5' of your BF elevation). Is this what you meant by stage V? If so, the incision ratio (historic) would be around 2. The CES of F[V] was chosen for this reach and entered in the DMS in March of 2008, due to the wording of the then current May 2007 Appendix C which appeared to exclude C streams with a moderate degree of incision from being classified in stage II. Following feedback received from RMS in April 2008, I understand the Appendix C will be revised to include C stream types under Stage II [F]. Given the segmentation discussed above, CES has been revised accordingly.
- In xsection #1, the incision ratio is currently recorded as 1.00. I'm wondering about the LTER/road. If this were considered the RAF, and the area between the LTER and the left bank were accessible flood plain, then the xsection would support stage IV or V with historic incision (IR=8.5÷4=2.13). In other words, the channel has incised a lot in the past (perhaps because of extensive straightening & dredging) but formed/is forming a new floodplain at the lower elevation (~5'). Have you considered this scenario/interpretation? While there is uncertainty as to the true elevation of the RAF versus what amount of fill material has been placed on a previously-existing LTER to construct / reconstruct Route 103, I can accept your classification of the LTER as a RAF, with an associated IR of 2.13. I have revised the cross section spreadsheet accordingly. The reach has also been segmented as discussed above.

Okay, thanks. Note that you entered the RAF elevation as 7.5' rather than 8.5' above thalweg in the DMS, which appears to be an error. As a result, the incision ratio is now calculated by the DMS as 1.88, although the xs spreadsheet correctly shows IR=2.13. **Please fix DMS.**
Thanks for catching that. It was an entry error. I have corrected the RAF value to 8.5, and the IR is now calculated in the DMS as 2.1.

M33A

- Step 5 comments mention possible effects on this segment's flow from inflatable dam on M34. Please record this information manually in step 4.6. In recent months, I have acquired more detailed information about the nature and operational status of this inflatable bladder/weir and flume structure in reach M34 (see Phase 2 report, and responses under M35 below). Based on the available information, I do not believe this inflatable dam has a significant impact on flow / sediment continuity in segment M33A or in reach M34. I have revised the Step 5 comments, accordingly. There is, however, the snowmaking water withdrawal intake approximately 125 feet upstream of this inflatable bladder, and I have changed the DMS Step 4.6 for segment M33A to record the presence of a water withdrawal in the upstream reach M34. As presently written, Step 4.6 of the protocols (v. 2007) does not permit one to distinguish the simple presence/absence of the upstream (or downstream) flow regulation from the degree of effect that this flow regulation is inferred to have on the reach/segment in question. More detailed hydrologic and hydraulic analyses would be required to know with certainty if the snowmaking withdrawal in M34 has a significant effect on the flow and/or sediment continuity in segment M33A. Restrictions have been placed on the timing and rate of water withdrawals from the Black River in the context of Land Use Permits granted to Okemo. The maximum permitted withdrawal rate (11,000 gpm) equates to approximately 1.8% of the bankfull discharge at the approximate location of the withdrawal (see ph2 report). Based on this factor alone, it seems that the effects on downstream reaches would be minimal.
  Currently, "None" is saved for out-of-reach withdrawals on step 4.6 of DMS. Perhaps there was a problem with data saving? Although you note the withdrawal likely has a minimal effect on the downstream segments, the comments in step 5 suggest that you meant to enter something in step 4.6. **Please try again, and let us know if this is a DMS bug. The same scenario exists on M33B.**
  I have now made this correction of "Upstream" under Step 4.6 and it appears to have saved properly.
- Are you sure this segment is best described by stage IV, and if so, what are your reasons? Both cross sections appear incised with little if any juvenile floodplain/benches forming. Hard to tell but the data make it sound more like stage II or early III(?). Please reconsider and/or comment.
  I agree with you that a Stage II [F] is more appropriate. When I originally assigned this CES for this segment in March 2008, the May 2007 version of Appendix C did not include a C stream type in the definition of Model F, Stage II. I did not feel comfortable assigning Stage II[F] to this segment, since the IR was only 1.34 and the segment had not undergone a vertical stream type departure. At an April 2008 meeting with Shannon Pytlik and Mike Kline, I learned that Appendix C was going to be revised to include C (and E) stream types.
- I'm concerned this segment RGA condition is coming out "good" when there is almost 99% straightening, extensive riprap is present on both banks, most of the buffer is <25', at least part of the segment has an incision ratio of 1.91, and the bed form has been changed to plane bed from riffle-pool. Please reconsider step 7 scores or explain. I believe I have correctly applied the protocols in this case. As I understand it, the overall geomorphic rating score describes the degree of active adjustment (which in this case is minor) and the degree of departure from regime. A rating in the "Good" quadrant of the adjustment condition does not mean that the reach is not susceptible to catastrophic adjustment in future high flows. This susceptibility is captured in the sensitivity rating. The degradation adjustment process (probably enhanced by periodic post-flood dredging/windrowing/ channelization) which has resulted in the degree of incision (1.34) is inferred to be historic in nature. The degree of channel incision (as well as the valley setting, straightened planform, and nature of bank and bed sediment sizes) does make the channel susceptible to catastrophic adjustments in future flows. Accordingly, the sensitivity would be noted as "High", following protocols. The segment has been converted from a reference meandering C-riffle pool status to a straightened, armored, partly bermed,

undersized-width, transport-dominated, C-plane bed status with moderate incision. Despite being narrow in width, the nearly continuous tree buffer along both banks (along with streambank armoring) has likely moderated the potential for widening and planform adjustment.

That said, upon reviewing the Step 7 scores more closely, I did downgrade the scoring for Step 7.2.1 and Step 7.2.2, resulting in a Step 7.2 score change from 15 to 8, which itself caused the overall Step 7.5 score to change to 0.64. This segment is now classified in the Fair quadrant, with a corresponding sensitivity of "Very High".

- You have two cross sections—one of C type with incision ratio of 1.34 and one of E type with incision ratio 1.91. A stream type departure from C to E is noteworthy, as it is likely due to channelization, and the high incision of xs#1 is also cause for concern. Please indicate how much of the segment has this more incised condition, and why you chose not to segment. XS-2 is representative of the segment – the C3 stream type with incision ration (RAF) of 1.34. XS-1 was measured in a discrete armored section of the segment downstream of the Pleasant Street Extension bridge crossing across from the Wastewater Treatment Plant. This is a location of historic channelization and encroachment (see summary report). Armoring along LB and fill/armoring along RB have constricted the channel at this location for an approximate channel length of 200 feet. Due to the extensive channel management, bankfull indicators were weak to non-existent. I therefore estimated bankfull width in the cross section spreadsheet based in part upon weak features observed in the field, and based on a corresponding cross sectional area that was similar to that estimated for upstream XS-2 (which did have reasonably strong bankfull indicators). The bankfull width, bankfull depth, and incision ratio values for XS-1 should be considered approximate only. The main purpose for recording this quick cross section was to capture the sudden, localized decrease in width/depth ratio and channel width apparently resulting from historic channel management. Since the length of channel affected by this encroachment / channelization was relatively small compared to the overall reach length (approximately 3%) I chose not to segment such a short section. However, I had logged this location as a constriction under Step 4.8 since the measured approximate channel width (42 ft) is only 49% of the reference channel width for the reach (85 ft) and 62% of the measured channel width (67.9 ft) at XS-2.

M33B

- Again, in step 4.6, please record effects on this segment's flow from inflatable dam on M34 See comments under M33A. "Upstream" was selected under Step 4.6 for the snowmaking withdrawal in M34. DMS now says "None" for 4.6. See my latest comments above for M33A; **please try fixing DMS again.** I have now made this correction of "Upstream" under Step 4.6 and it appears to have saved properly.
- If there is a change from a riffle-pool system to plane bed, then step 2.10 should be evaluated. Depending on the channel evolution that has occurred/is occurring, the riffles can be said to be "eroded" or "sedimented." Please fix. Based on limited observations from one snap shot in time, I believe that (historic) incisional processes (and extensive channel management) were largely responsible for the current plane bed form. Therefore, I chose "eroded" under Step 2.10. Repeat cross sections through time would be required to confirm a net aggradation, net incision, or stable elevation of the channel in recent years. Aggradation seems minor in degree, based on the presence of only one mid-channel bar and two side bars in the segment. The segment has been converted to a transport-dominated channel by virtue of historic channel management and encroachments as well as degradation.
- With a stream type departure from C to F, and an incision ratio of 2.00, it is hard to believe this segment is in "good" geomorphic condition. Please reconsider RGA scores. I believe I have correctly applied the protocols in this case, in a manner that is consistent with approaches taken and approved in other regions of Vermont. The fact of the C to F departure is captured by the assignment of a STD itself (and the resulting "Poor" quadrant score under Channel Degradation, RGA Step 7.1). The overall geomorphic rating score describes the overall degree of active adjustment (which in this case is minor). The adjustment process (degradation) which resulted in the STD is inferred to be historic in nature. The vertical stream type departure (as well as the valley setting, straightened

planform, and degree of encroachment) does make the channel very susceptible to catastrophic adjustments in future flows. Accordingly, the sensitivity is noted as "Extreme" due to the STD (which overrides the "High" sensitivity classification that ordinarily would be assigned to a channel in "Good" condition with score of 0.65 – in absence of the STD).

I understand your point, although I would point out that an RGA of 0.65 is right on the line (1 raw point difference) with Fair. **I suggest adding a comment to the DMS step 5 highlighting that the score is nearly Fair.**

I have added this comment to the DMS under Step 5.

- Where is the HEF coming from? I see the berms in the xsection but the HEF elevation does not correspond. The berms I do see are not completely blocking access to the floodplain (lower than 2x max depth), and there is not really floodplain made available if they are removed, so HEF may be N/A for this segment. Following our email conversations of recent weeks, I now understand that the HEF box in the DMS is to remain blank in this situation. I have removed data from the HEF data cell in Step 2.8.
- Should there be roads in the cross section? You indicate in step 1.5 that there is a human caused change in valley width, and the ph. 2 valley wall verification follows two roads. I have revised the cross section to depict the roads. The ph2 LVW is Meadow Street. In the RB corridor, Pleasant Street (ph2 RVW) is essentially flush with the gradually-inclined surface (occupied by residential buildings) that leads from the RTOB to the steep, bedrock-controlled ph1 RVW.

M34-0

- Please label HEF/berm in cross section. I can only guess that it is RTER 1. Yes, the feature selected as HEF was the berm/ RTER 1. However, if I understand correctly our email conversations over recent weeks, in this situation the HEF would be ignored, since the channel is already incised and entrenched below the RAF, with an $IR_{RAF}$ of 2.25. For that reason, I have removed the HEF value from the DMS and not placed an HEF label in the cross section spreadsheet. Please advise if this is correct.

Actually, there is not a "rule" per se that if the IRraf>2.0, then the HEF is NA. I don't think any RMP staff meant to imply that such a rule exists. It is true that if there were no HEF feature, the stream would still be incised and have a poor degradation rating. It appears the berm is actually fill pushed up against a terrace, without any RAF available on the right side of the berm. If this is the case, then it does not make sense to identify an IR hef for floodplain restoration projects.

M35-0

- Step 4.6. Does the dam in M34 affect flow on M35? If so, please indicate this in 4.6. The "dam" located in M34 is actually a flow monitoring structure installed by Okemo in 2005. It is comprised of an inflatable rubber bladder constructed on a concrete foundation (weir) adjacent to a ten-foot-wide Parshall flume. When the bladder is fully inflated, its top elevation is approximately two feet above the concrete foundation, which itself is more or less flush with the upstream channel bed. To monitor flow rates during the snowmaking season (November 1 through March 31), the bladder is inflated deflecting flows (and sediment) through the Parshall flume. "In times of exceptionally high flow conditions during the snowmaking season, as well as during the non-snowmaking season, the bladder [is] deflated" (LUP 2S0351-12F, p. 5). When the bladder is deflated, flow (and sediment) moves through the reach largely un-impeded. For purposes of this Phase 2 stream geomorphic assessment (and Phase 1 updates), the inflatable bladder / weir structure was indexed as a "dam" – a small, run-of-river structure, with Low impact. However, given the relatively limited duration of inflation (in a given year), and the fact that the bladder is automatically deflated during bankfull or higher flows during the snowmaking season (see report), it is likely that this dam does not significantly affect upstream reach M35. Based on hydraulic / hydrologic evaluations performed in support of the Land Use Permit issued for this weir/flume structure, impounding effects of this structure during a 100-year peak flow were limited to an approximate channel length of 50 ft at the structure location (Redondo, 2004).
- Why did you choose channel evolution model D? There is no incision (which fits model D), and yet you indicate historical degradation and "eroded" riffles. Generally, if there has been

some historical degradation, then we say the reach is best described by CEM F. I meant to enter "sedimented" riffles as I believe aggradation and associated widening to be the dominant current process contributing to plane bed morphology. I have revised the CEM to F [I] as the relatively fine bed materials could be subject to erosion and channel down-cutting. I have removed the selection of historic from Step 7.1.

- Please explain your thinking. Perhaps you meant to say "sedimented" for riffle type, because the dominant processes are aggradation and widening, which created the plane bed system? I meant to enter "sedimented" riffles as I believe aggradation and associated widening to be the dominant current process contributing to plane bed morphology.
- I notice there is a change in bedform (from riffle-pool to plane bed) and the d50 is barely fine gravel. What adjustment process do you think has caused the bedform to be plane bed? aggradation and associated widening. Is aggradation more significant than what the 7.2 score would suggest? Perhaps the Fair quadrant score for Step 7.2.1 could be weighted more than I originally considered, to result in an overall score of 8 rather than 13 for Step 7.2 Aggradation. The overall condition rating has been revised from 0.713 (Good) to 0.65 (Good). Also, I revised the Historic value for Degradation, Widening, and Planform to "No" from "Yes".

- Also, based on the General Comments above, and the recent email discussions, it is still unclear to me whether the value of the LB Dug Road (elevated above the floodplain at a thalweg height of 9.3, or 2.8 times the bankfull depth at XS-1) should be entered in the DMS as a HEF. Your assistance on this point would be appreciated.

  It appears from the valley wall shapefiles that Dug Road hugs the natural valley wall (left). Assuming the left side of the valley does gradually slope upward from the LPIN to the edge of Dug Road (as xsection suggests), it would appear that Dug Road is not on fill, blocking access to a naturally broader floodplain. You have effectively called the road the new valley wall. In these cases, we do not need to document the road as an HEF. Looks okay as is.

I need to be clear that I do not intend for the phase 2 valley wall shape file that I have delineated as a part of this project (on the river side of both Dug Road and Route 103 in this case) to be utilized as a building block for any FEH corridor developed by others. (This was not an explicit requirement of the contracted work plan, and the Nov 12, 2008 *River Corridor Protection Guide* that provides some improved clarity with regard to updating valley wall delineations in Phase 2 was issued by VTANR after the field work had already been completed and most of the data was entered for this project). The phase 2 valley wall shape file that I provided as a deliverable simply represents a documentation of those features that appear to have reduced the valley width by cutting off a portion of the floodplain (through elevation and/or extensive fill) and supports the determination in Phase 2 Step 1.5 that a human-caused change in valley width has occurred. It also serves as documentation for the answer in RGA Step 7.1.4.

Without subsurface geotechnical borings or review of engineered drawings, it is not possible for me to classify whether Dug Road is on fill (I suspect that it is because most roads have some degree of base fill material). Without benefit of detailed hydrologic / hydraulic analyses that are developed for a specified flow magnitude, it is not possible for me to characterize whether either Dug Road or the armored Route 103 will laterally constrain the channel at the specified flow or flood stage, or whether either road will be damaged or washed out due to fluvial erosion hazards (I suspect that they will be impacted by fluvial erosion when flood velocities are high enough to exceed thresholds for erosion governed by channel sediment sizes and properties, as well as vegetation and armoring conditions). Such analyses are beyond the scope of a Phase 2 geomorphic assessment. Nevertheless, it appears that VTANR guidance (page 16 of the Nov 12, 2008 *River Corridor Protection Guide*) is instructing us to delineate "major" roads as an artificial valley wall – in other words adjust the reference (natural) valley wall to a position on the river side of the "significant human-constructed features". This modified valley wall effectively becomes a management boundary - which results in a management adjustment to the FEH corridor delimited by this valley wall. (Page 16 of the Nov 2008 *River Corridor Protection Guide* states that "[t]his approach recognizes that the administrative entity overseeing the maintenance of the major infrastructure will have the need and capacity to do so for the foreseeable future".) This management adjustment does not rely on any detailed geotechnical or hydrologic / hydraulic analyses to

indicate this road will function as a laterally-constraining feature to the river. This management adjustment is made without regard for whether this infrastructure (or any lands/properties beyond it) is truly at risk of fluvial erosion hazards.

In this case (on M35), if VTANR is defining a "major" road as one with a state- or federal route number, then Route 103 would be classified as a "major" road (i.e., new valley wall), and Dug Road would be classified as a "minor" road (i.e., not a new valley wall) as it only has a town route number (Town Highway 4). If the VTANR is defining a "major" road as one which is at an elevation at least two times the bankfull depth, then both Dug Road and Route 103 would be defined as "major" roads (i.e., new valley wall) since their approximate thalweg heights are greater than two times the bankfull depth. Whether or not these roads are interpreted or classified as "major" under VTANR guidance will have implications for whether they are considered as a management boundary (i.e., new valley wall) for delimiting the FEH corridor. This classification will also apparently affect whether the features are identified as an HEF under the 2007 Incision Ratio Addendum.

Following our Waterbury meeting on 5/15, it appears that you've delineated the phase 2 valley wall (in the shapefile submitted 4/30/09) based on the phase 2 constraints to confinement and channel hydraulics, calling Dug Road the valley wall. For the current scope of work, this is appropriate. When the FEH valley wall is created, the Dug Road boundary may need to be reevaluated in light of the uncertainties for lateral constraint during flooding, as you've noted above.

M36-A

I made a change to the nature of planform adjustment in this segment. Originally, I had selected "Yes" for historic, because evidence suggests a substantial straightening of the channel planform, which has remained essentially the same in past aerial photographs (1980, 1977, 1939). However, since there is also evidence of moderate ***active*** planform adjustment (FCs, meander extension), I revised this check box to "No", to indicate that the assigned score reflects active planform adjustment. Okay, thank you.

**Comments by Reach (2008):**

M15T1.03B

- In step 7 narrative, you say incision is historic, but step 7.1 contradicts this comment because "No" has been entered for Historic. Please fix. Value has been changed to "Yes".
  Looks like your change to "yes" did not save, as the DMS still says "no." **Please try again.**
  This appears to have been an oversight on my part, not a DMS bug. I have fixed it now.
- Step 7.2. Should aggradation score lower than "good", considering there multiple bars, 1 island, 5 flood chutes, 1 avulsion, 2 steep riffles, "sedimented" riffles, an 80' mass failure, moderate bank erosion, and adjacent gravel pits? I have changed the Aggradation score of 7.2.2 to the "Fair" quadrant (due to the 9 diagonal bars, one island, two steep riffles and depositional bars sometimes higher than ½ bankfull elevation). The overall aggradation score (7.2) changed from 13 to 10 (to the "Fair" quadrant). I have also weighted the 7.4.2 score more heavily and changed the overall Planform score (7.4) from 11 to 8 (into the "Fair" quadrant). The total RGA score changed from 55 to 49, resulting in a Condition Rating of 0.613, or "Fair". Adjacent gravel pits are excavated at 40 to 220 feet above the channel. Forested buffers are present between the channel and the active working face of these pits (generally greater than 200 feet in width, as measured on the 2003 aerial photo) – except for the one point location along LB of a 80-foot mass failure, impacting approximately 50 feet of channel length. No mapped tributaries drain to the North Branch through these pits. Surely the downstream impoundment has helped accentuate the aggradation on this segment as well. Yes, through the increase in base level elevation, and decrease in slope since construction of the impoundment c. 1960. (Periodic dredging of the channel inlet to Stoughton Pond may also have locally induced incisional processes following dredging events, until slopes were re-stabilized and/or offset by sedimentation from upstream sources).
  The changes to scores noted above did not persist/store in the DMS**. Please try to change and save again.**
  These scores have been changed in the DMS, and appear to have stored.

- Why do you think this segment is in stage V? I agree the incision is minor and floodplain access is available, at least based on cross section 1. Often, in stage V there is evidence of historical incision, reflected in the incision ratio; do you think the right terrace in xsection 1 (elevation 9.5') represents the former floodplain (when the stream was last in stage I?). In xs #2, there is a right terrace at a comparable elevation (9.8'). Have you considered using this terrace elevation to calculate the incision ratio for the segment? Also, the shape of xsection 2 reminds me of stage IV, where some floodplain is building. Given the substantial planform adjustment on this segment, do you think it would be better to say this segment is in stage IV? While some floodplain access is occurring, as noted for xs #1, it seems the segment is not completely through the adjustment processes yet, which would be worth documenting. What do you think? I can agree with a CES of IV [F] and have made this change in the DMS. Particularly in the upstream half of Segment B, the channel has less access (vertically) to a much narrower incipient floodplain – where the North Branch is transitioning out of the steep, semi-confined, bedrock channel of Amsden Falls. More detailed surficial geologic mapping would be required to know the origin and age of the terraces surrounding the channel. The RB terraces you note are at 2.1 and 2.3 times the bankfull depth. According to protocols (2007, page 27), this would be within the range of incision ratios (i.e., less than 3.0) that can be considered historic in nature (last 200+ years) and may not be post-glacial. However, it's possible that an inferred reduction in sediment transport capacity caused by the downstream impoundment (since 1960) has resulted in sediment in-filling of this valley, such that the "incision" ratios are reduced in magnitude as the channel bed aggrades. NRCS soil mapping would seem to suggest a glacio-fluvial origin of these higher terraces, rather than alluvial origin.
  The change to CEM stage noted above did not persist/store in the DMS. **Please try to change and save again.**
  The CEM stage has been changed in the DMS, and appears to have stored.

M15T1.05-0

- RGA question 7.1.2. Please enter an answer for this question in the DMS (blank now). Value has been entered. Not sure why the DMS QC check X.2 did not catch this as a blank value.
  Thanks. Unfortunately, I do not think X.2 catches blanks in the individual RGA questions. This would be a helpful feature.
- Following your General Comment #6, I substituted the measured bankfull width at XS-1 (41.0 ft) for the reference channel width (52.9 ft) predicted from VT Regional Hydraulic Geometry Curves (2006) - in Phase 1 Step 2.8. Metadata also changed, and comment stored in Step 7 Comments field of Phase 1 database.
- For reasons similar to those discussed under M15T1.06A (below), I changed the CES to I [ F].
  Okay, but **would you mind adding a comment to the DMS explaining why the segment is NOT considered to be in CEM D?** Seeing the combination of stage I (in F) and Fair may otherwise seem incongruous to data users.
  Comments have been added to the DMS, Step 5.

M15T1.06A

- Step 7. Have you considered channel evolution model D for this reach? Model F is characterized by some incision (active or historical). Model D may be appropriate in a location with fine substrates, E channel dimensions, lots of planform adjustment, and incision ratio=1.00. If you go with D, please also update the stage. Conservatively, I would like to keep the F-model classification for M15T1.06A (at the same time recognizing the limitations of such models discussed under General Comments on page 3). I understand from April 2008 discussions with Mike Kline and Shannon Pytlik that Appendix C of the protocols will be revised to allow reaches/segments with an IR < 1.2 to be classified in the D stage model. While Segment A has a measured IR raf = 1.0, the immediately upstream segment B (with very similar fine substrates and E channel dimensions) has an historic incision ratio of IRraf = 1.6, suggesting that there is a similar potential for incision/degradation in Segment A. I originally chose a CES of IV [F] to highlight the active planform adjustment that is ongoing in Segment A (evidenced by the moderate W/D ratio for this E stream type

(13.2); and the meander migration, extension and translation; as well as three neck cutoffs in recent decades). I have reconsidered this assignment, and changed the CES to I [F]. It seems that the moderate to low RGA scores for widening (Step 7.3) and planform adjustment (Step 7.4) will be sufficient to highlight the importance of ongoing lateral adjustments. And I wouldn't want assignment of a IV [F] CES to imply that the channel had undergone some recent degradation to abandon an RAF and create a floodplain at a lower elevation. Based on very limited surficial geologic information and Phase 2 observations from one snapshot in time, I would theorize that the adjacent floodplain in Segment A (to which the channel is reasonably well connected) represents more or less the same floodplain surface that existed prior to intensive colonization of the watershed 200+ years ago (i.e., the reference channel floodplain). Although – anecdotal evidence suggests overbank flooding (and inferred deposition of fine sediments) occurred during the 1973 flood (and probably occurred during the 1936/1938 and 1927 floods as well).

Okay, your explanation is helpful. **Would you mind adding a comment to the DMS explaining why the segment is NOT considered to be in CEM D?** Seeing the combination of stage I (in F) and Fair may otherwise seem incongruous to data users.

Comments have been added to the DMS, Step 5.

- Following your General Comment #6, I substituted the measured bankfull width at Segment A XS-1 (41.3 ft) for the reference channel width (49.9 ft) of the full reach predicted from VT Regional Hydraulic Geometry Curves (2006) - in Phase 1 Step 2.8. Metadata also changed, and comment stored in Step 7 Comments field of Phase 1 database.

M15T1.06B

- Step 1.5. Are you sure there is no human caused change in valley width from Rte 106? I have changed this response to Yes; (this was an apparent oversight on my part). The reduction in valley width is very minor. No change in valley type (Very Broad) or confinement status (Unconfined).

M15T1.07-0

- Step 1.5. Are you sure there is no human caused change in valley width from Rte 106? I have changed this response to Yes. The reduction in valley width is very minor. No change in valley type (Very Broad) or confinement status (Unconfined).
- In step 2, is the HEF from the non-representative xsection (#2)? If so, please include a note in the DMS explaining that step two channel dimensions are based on one cross section and HEF is based on another. Or, are you basing it on a berm in xsection #1? If so, please label the berm in xs 1 (I can't see one there). Is it really ~flat between top of berm and valley wall toe?

The HEF originally entered was from the RB of XS1. A berm that is more prominent for a length of about 850 ft upstream of this point is fading out at this cross section location, becoming more or less coincident with the RTOB and RB field elevation. The cross section should be representative of the reach; so, when there are berms on a reach, the cross section would include the berm—*if* the berm has a predominant influence on the reach as a whole. Where the reach does have berms, but they are shorter and do not characterize the reach, then the cross section does not need to include the berm. If the cross section location does not include a measurable berm, then there would not be an HEF recorded. In any case, since the IRraf value is > 2.0, I understand that an HEF for this cross section is Not Applicable. There is not a "rule" that if the IRraf>2.0, then the HEF is NA. It is true that if the HEF feature were removed, the stream would still be incised and have a poor degradation rating. However, it is okay to enter an HEF in that situation, as long as it meets the other criteria for an HEF (is not the new valley wall, is blocking access to a floodplain even if an RAF, and there is not lower elevation floodplain on the bank opposite the encroachment).

The RVW in XS1 is at the base of the forested steep slope on the far side (east side) of the North Branch channel. The line of cross section intersects the river again at cross section Distance (900+ ft) - just downstream of the LB confluence of the M15T1.06S1 trib. (I did not include the second crossing of the channel, because this would have affected the calculation of bankfull width, etc.) A note explaining this has been added to the Comments field of the cross section spreadsheet.

There is a brief section of channel at XS2 where the river has slight access to the floodplain (IRraf =

1.74) along RB. There are two berms at this location – one on LB at a thalweg height of 6.9 ft, or 2.2 times the bankfull depth; a second one along RB at a thalweg height of 5.6 feet, or 1.8 times the bankfull depth. This is a short section, not characteristic of the reach, and not warranting segmentation. But it does offer an opportunity for berm removal to perhaps speed recovery of this actively widening reach. A notation of HEF has been added to the RB berm (as the lower of the two berms), and this elevation was substituted in the "Elevation RAF" cell of the XS2 spreadsheet. Okay, good. In this case, the HEF is not entered in the DMS under step 2.5 (because it is not considered representative) but it is noted in the spreadsheet, and could be identified in your report as a possible project area.

M15T1.08-0

- In xsection 1, where does the RAF elevation of 6.9 come from? Did you mean to enter 7.9 for the "field" on stream left? Please fix. Yes, the RAF is the field on LB; I mistakenly entered the thalweg height of the field, when I should have entered the elevation.
- Following your General Comment #2, I have removed the value from the HEF cell of Steps 2.5 / 2.8 in the DMS, since the IRhef calculation is Not Applicable in this cross section where IRraf > 2.0. Good to remove HEF here, since road is considered new valley wall. However, the NA is not because the IRraf being greater than 2 (no such 'rule').
  Please see my comments elsewhere in the document concerning identification of a new valley wall (e.g., under M35, M26T2.01, etc.). It seems that in this case, Route 106 would be considered a "major" road warranting delineation as a new valley wall, because it has a state route number and its thalweg height is greater than 2 times the bankfull depth (if these are in fact the criteria used by VTANR to classify a "major" road). Delineation of this road as a "new valley wall" does not necessarily mean that it would not be affected by fluvial erosion, and does not necessarily mean that it would laterally constrain the channel particularly in a large flood. As I understand it, the new valley wall is simply a management boundary (that would be used to delimit the FEH corridor) recognizing that this road would be maintained / restored in its present planform well into the foreseeable future if damaged by fluvial erosion.
- If this reach is in stage II, then I would expect the predominant adjustment process to be degradation, and yet you chose "sedimented" for step 2.10 riffle type. There are other signs of aggradation: a few bars, 1 steep riffle, and change from cobble to gravel. Do you think this reach could be in stage III? Or could riffles be primarily "eroded" and the stage is II, with a little aggradation beginning at the downstream end of the reach? I have changed step 2.10 to "eroded", to be more consistent with a CES of II [F]. The departure from an inferred reference bedform of riffle/pool to dominantly plane-bed morphology is likely the net result of a long history of alternating cycles of degradation / aggradation and channel management.
  Degradation is the adjustment process that scored the lowest. Based on absence of features such as head cuts, actively undercutting banks, or freshly-exposed tree roots, net channel incision was characterized as "historic" in the RGA (i.e., not actively occurring). In part (especially in the upstream half of the reach), the degree of vertical separation of the channel from the immediately-adjacent terrace, may be related to post-glacial stream dissection of glaciofluvial sediments (i.e., thousands of year ago). It is also likely that some degree of net historic incision may have resulted from floodplain encroachments and reported extensive channelization/ dredging that occurred during flood recovery efforts following the 1927, 1938 and 1973 (and other?) floods.
  The dominant **active** adjustment process is minor, localized aggradation, as evidenced by two diagonal bars mid-reach, and one steep riffle upstream of an old-abutment constriction. I don't believe there is a substantial shift of the D50 from cobble to gravel as a result of aggradation stressors. Rather there appears to be a gradual fining-downstream sequence from small cobbles to coarse gravels, probably induced by the slight, gradual decrease in channel gradient with distance downstream, and maybe as a result of a fining down-valley of source sediments in the channel boundaries.
  I believe that a CES of II [F] is more appropriate than III [F], given the minimal lengths of erosion overall, only localized aggradation/widening, minimal flood chutes (1). Armoring and intact tree buffers along the banks, combined with the apparent cohesiveness of streambank sediments (large cobble and

boulders in relatively-cohesive silty-sand matrix) and occasional bedrock exposures have probably moderated the potential for active channel widening.

M15T1.09-0

- Step 2.10 & QC check X.4. This step gets evaluated for plane bed systems, if the bed form is not plane bed by *reference*. If you forgot to evaluate 2.10, please select Not Evaluated in DMS. I chose "eroded" to be more consistent with a selection of II [F] for CES. A long history of repeated cycles of degradation, aggradation, and channel management, are collectively responsible for a departure from inferred reference R/P to PB morphology.
- Did you mean to enter cobble as the d50? Please check; it looks like it should be gravel. I agree; I have changed the d50 to gravel. I have also changed the Phase 1 reference D50 to gravel.
- Shouldn't 7.1.3 and 7.2.1 be answered as "poor" because of plane bed? Shouldn't 7.1.6 and 7.3.5 score lower due to development/ 5 road ditch inputs? It is my understanding that if incision is believed to be more responsible for a riffle/pool-to-plane bed departure, then 7.1.3 is rated more poorly than 7.2.1. If aggradation is more responsible, then 7.2.1 is rated more poorly than 7.1.3. Either choice requires serious speculation. Since, the current plane bed form is probably the result of a long history of repeated cycles of degradation, aggradation, and channel management, it is impossible to ascribe one or the other vertical adjustment process as being more dominant over that long history. So, I scored them equally. And I scored them in the Fair quadrant rather than the Poor quadrant, because there is evidence of a weak riffle/pool form developing with a low-flow secondary sinuosity – although plane bed still dominates. A choice of Fair or Poor quadrant for 7.1.3 or 7.2.1 would not significantly affect the score under either adjustment process (degradation = 5, "Poor"; aggradation = 15, "Good").

  The 5 road ditch inputs indexed within the reach are reflected in the choice of the "Good" quadrant for both Step 7.1.6 and Step 7.3.5 – under which flow alterations or flow increases are described as **minor**. The 2007 (11 July draft) *River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects* (page 17) suggests that stormwater inputs are reduced in significance for drainage areas greater than 15 square miles. The upstream drainage area of the North Branch at reach M15T1.09 is 17.97 square miles. Therefore, I characterized potential flow increases as minor. In this case, I believe the marginally increased flows possible from stormwater culverts under Route 106 pale in comparison to other factors that have lead to the current degree of historic incision (e.g., channelization, encroachments, armoring, flooding, flood recovery).

  Development (Urbanization) can also be considered under the general category of flow alterations or increases (and sediment inputs) addressed in Steps 7.1.6 and 7.3.5 - as a possible contributor to stormwater runoff due to increased percent imperviousness. The cumulative upstream percentage of urban land use in the watershed draining to reach M15T1.09 is 4% (see Phase 1 database), below the percentage (5%) suggested as a threshold of concern in VTANR guidance (2007, 11 July draft, page 19). Therefore, I believe flow alterations and increases (under Degradation) and increases in flow/sediments (under Widening) are properly characterized as "minor" (i.e., "Good" quadrant) under Steps 7.1.6 and 7.3.5.

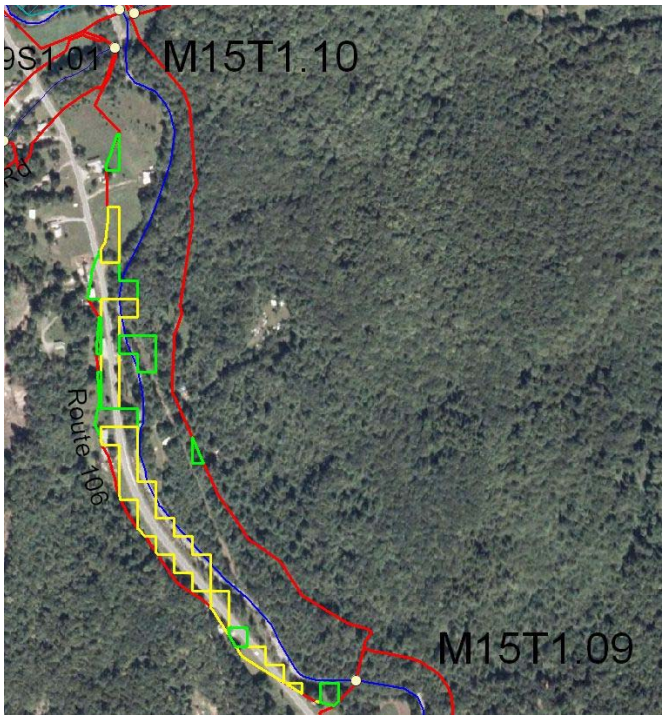
  You may be noting the Corridor-Area percent urbanization of 22% for M15T1.09 (calculated in Phase 1) and suggesting that this amount of Urbanization exceeds thresholds outlined in the River Corridor guidance (page 19). However, I would offer that a Corridor-Area percent urbanization is not a valid predictor of channel adjustment for the following reasons:

  - The River Corridor guidance appears to be equating urbanized land cover / land use to total percent imperviousness, relying on Vermont-based studies and national guides (e.g., Center for Watershed Protection) to equate impervious cover to geomorphic and biological impacts to streams. However, % Urbanized does not equal % Impervious.

- Urbanization calculated from 1993 land cover land use data sets includes residential (lclu code 11), industrial (code 13), commercial (12), and transportation (14) categories. This coverage is raster-based (pixilated with a 25-meter pixel size), and therefore the aerial extent of roads, residential use, etc. tends to be overestimated. Also, this method does not account for the variability in actual percent impervious of features overlapped by a lclu pixel that is coded "urbanized" – e.g., rooftops or roads (100% impervious) versus road shoulders and lawns (less than 100%) versus forested tracks (far less than 100% impervious). In the case of the M15T1.09 corridor, the calculated 22% urbanized land cover land use consists of 7% Residential (code 11, outlined in green on the map below) and 15.0% Transportation (code 14, outlined in yellow on the map below). The figure below shows how this pixilated coverage overlaps areas of other, far less impermeable land cover.

- Because the minimum mapping unit of the lclu data sets is so coarse (25 meters square), the methods of using urbanized categories of lclu data as a proxy for impervious surface (and impervious surface as an indicator of impacts to streams) lose their validity as the size of the watershed drops below 1 square mile. Center for Watershed Protection methods preclude use of watershed sizes less than 1 square mile. The corridor area for M15T1.09 (0.0435 square mile) is too small to use the 1993 lclu data sets to estimate percent urbanized as a predictor of channel instability.

- Actual impervious cover does not necessarily equate to impervious cover that is hydrologically connected to the river channel.




M15T1.10-0
With regard to General Comment #3, I have entered the HEF value (for the LB berm) in the "Elevation RAF" field of the XS2 spreadsheet, rather than the RAF value. And I have placed a note in the comments field of the XS spreadsheet recording the IRraf. The revised cross section spreadsheet has been uploaded to the DMS. Since XS2 was chosen as representative of the reach for completion of Phase 2 Step 2, the HEF feature was also entered in the DMS under Step 2.8. The IRhef at this cross section site reflects a channel encroachment (e.g., berm) that is elevated above the channel floodplain and has resulted in increased channel entrenchment,

and is combined with a degree of actual historic incision (channel downcutting). Good, thank you.

Berms are also present at XS3 along both the LB and RB. At thalweg heights that are 3.7 and 4.0 times the measured bankfull depth, these berms enhance the degree of channel entrenchment beyond that which has resulted from historic incision (IRraf = 3.17). However, since the channel is already entrenched (i.e., IRraf > 2.0) at that cross section, I understand from our recent email conversations that identification of a berm as an HEF in the XS3 spreadsheet would be Not Applicable. Actually, there is no specific protocol "rule" that when the IR raf>2, the HEF is automatically NA. We would've had you note this HEF in the xs3 spreadsheet. If you wish, you may modify the excel spreadsheet, but the necessary features are there, so no need to worry about it now.

M15T1.11A

- Step 2.10. This step gets evaluated for plane bed systems, if the bed form is not plane bed by reference. If you forgot to evaluate 2.10, please select Not Evaluated in the DMS. I chose "eroded" to be more consistent with a selection of II [F] for CES. In reality, a long history of aggradation, degradation, channel management, and lateral channel adjustments are collectively responsible for a departure from inferred reference R/P to PB morphology. Your changes did not persist to the DMS. It still says "Not Applicable". **Please try changing to "eroded" and saving again.** Correction has been made in the DMS, and appears to have stored.
- Step 7. Please enter the RGA scores and fill out the RGA questions. Currently, they're blank in the DMS. Sorry for this oversight; scores have been added. I'm not sure why the DMS internal QC Check Step X.2 did not catch this.

M15T1.11B

- Step 2.14/2.15. Why did you enter a subreach reference stream type? It is the same as the phase 1 type for the reach. From step 5 comments, it seems you mean for the phase 1 type to be C3b Riffle-Pool, but the data currently indicate step-pool. You may need to fix phase 1. If protocols allow for a subreach designation to be made on the basis of bedform only - yes, I have changed the Phase 1 reference stream type for the reach to C3b-R/P (rather than S/P). Then, Segment B is classified as a subreach due to the predominance of step/pool bedform – which happens to have undergone a stream type departure from Cb-S/P to Fb-PB.

M19-0

- Looking at your two cross sections, along with step 5 features (flood chutes, braiding, islands, mid/diagonal) and bank erosion, I wonder if this reach could be adjusting beyond stage II. In (non-representative) xsection 1, a bench may be forming, as the river attempts to build new floodplain (?). In xs 2, the channel looks to be widening/widened, and you have said degradation is historic. Have you considered stage III for the reach?
  I have reviewed the data and decided to segment the reach. The upstream third is likely in stage II [F] (or early III [F]), with a Phase 2 sediment regime of Unconfined S & T. The downstream third is likely in late stage III [F] (or early stage IV [F]) with a Phase 2 sediment regime of Fine S & T / Coarse Deposition.

M26-0

- If this reach is still in stage II, characterized by degradation, then why do you say riffles are "sedimented" in step 2.10? Should they be "eroded"? I have changed Step 2.10 to "eroded" so that it is more consistent with a CES of II[F]. The net degree of historic incision in this reach (and the C to F STD, and the inferred CES of II[F]) are likely due to a combination of repeated cycles of flooding (deposition) and channel management (dredging/channelization causing a lowering of the channel), possibly leading to additional incision, probably undergoing subsequent aggradation from upstream sediment sources). This reach's position in the river network, just upstream from a valley pinch point, would tend to induce aggradation. The Cavendish avulsion of 1927 reportedly deposited tons of sediment in this M27 and M26 valley. Post-1927 dredging/ channelization are inferred. Probably, similar "stream cleaning" occurred following the floods of the 1930s and 1973. This long and complex channel adjustment history is responsible for the theorized departure from a reference riffle/pool

bedform to plane bed conditions. To simply classify riffles as "eroded" or "sedimented" does not adequately capture such a complex channel adjustment history.

- With regard to the General Comment #3, since the IRraf value was > 2, I understand from our recent email conversations that calculating an IRhef value is Not Applicable. I have removed the HEF value from the DMS.

  There is no such rule, and I recommend keeping the HEF value in the DMS, since it meets the other requirements of the protocol. However, it is understandable why you thought this was an appropriate approach. In the future, it is preferrable to keep these HEF values. See my general comment #3 above.

M26T2.01-0

- In upper portion of reach, Whitesville Road does not look major enough or elevated enough to provide a new (physical or FEH) valley wall. I agree Rte. 131 would be the new valley wall lower down, but I suggest editing the ph. 2 valley wall to include Whitesville Road. I think that it is very likely that the RB floodplain has been modified extensively here, such that fill material for the paved Whitesville Road has been placed at more-or-less the same elevation as the paved parking area for the general store and the foundation of the general store. In other words, this whole area probably has a couple of feet of fill over the original floodplain surface in order to meet the elevated Route 131 at a similar grade. For purposes of defining the Phase 2 existing stream type, therefore, the valley width has been modified (reduced) in a semi-permanent way, and the aerial extent of the floodplain has essentially been eliminated to the southwest of Whitesville Road (except for very high stage floods).

  It was my understanding that the Phase 2 valley wall shape file was intended to mark those features that reduce the valley width by cutting off a portion of the floodplain (through elevation and/or extensive fill) – regardless of whether we consider this road a minor or major one for purposes of FEH corridor development. Marking the Phase 2 valley wall at the river side of Whitesville Road serves as documentation to support the determination in Step 1.5 that a human-caused change in valley width has occurred – in this case enough to cause a change in valley type from Broad to Narrow confinement. And it provides documentation for the answer in RGA Step 7.1.4. If these encroachments had narrowed the floodplain to the degree that the channel became Confined (and were elevated more than 2 times the bankfull depth), delineation of this Phase 2 valley wall would have provided documentation of a possible stream type departure (e.g., from C to B or C to F).

  Then, an FEH corridor is delineated using the field-verified Phase 1 valley wall, which may be modified for reason of the Encroachment of a "major" road (as discussed on page 13 of the Nov 2008 Technical Appendix of the VT River Corridor Protection Guide). It seems that the discussion of minor vs. major road comes during the FEH corridor development, and should not influence the characterization of whether encroachments and a human-caused-change in VW have occurred, or the characterization of the modified valley confinement under Ph2 Step 1.5.
  Please advise if my understanding is inconsistent with protocols or VTANR guidance.

  You are largely correct, and I apologize for creating confusion. The minor/major road question can be ignored for the purposes of drawing a phase 2 valley wall. However, this shapefile is the one that will be used to create the FEH corridor, with some modifications for major roads (roads with a number), not the phase 1/ natural valley wall as you suggest above. Encroachments that act as physical barriers to lateral channel movement should be high enough to be called the phase 2 valley wall, and these features are used to create the phase 2 valley wall shapefile (and are field-verified). In this particular case, I looked at xs2 and questioned whether Whitesville Road was high enough to be considered the "new" valley wall. The cross section indicates the road elevation is 10.8' (9.8' above thalweg); this is 2.72 times max depth, which is a dubious valley wall. Generally, we look for features that are more substantial; 20' has been a loose rule of thumb. **Please reconsider valley wall at this location.**

  I believe the confusion we are experiencing on this topic of valley walls is due to a lack of clarity in VTANR protocols (2007) and guidance documents (2008). I think that it is important to document our discussion so that future users of this Phase 2 data and the valley wall shape files that I have delineated can be fully aware of the purpose and limitations of these shape files. I also wish to document the strong concerns I have about which valley wall is being utilized to develop the "Fluvial

Erosion Hazard" areas, and how that valley wall shape file is being developed.

I understand the correction you have pointed out above – that (according to VTANR guidance) future delineators of the FEH corridor should be utilizing some version of a phase 2 informed valley wall (not the field-truthed phase 1 reference valley wall that I suggest they should) as a starting point for the final FEH valley wall that ultimately is utilized to delimit the meander-belt-width-based area and create the FEH corridor. I find this implied in the discussions of Phase 2 valley walls on pages 15, 16, and 17 of the *River Corridor Protection Guide* (Nov 2008). My concern, however, is that if a phase 2 valley wall is delineated in the way that VTANR guidance instructs (i.e., is clipped to "significant human-constructed features, such as engineered levees and major road and railroad embankments placed on fill", page 16 of the same Guide), then the FEH corridor that results will not truly represent a delineation of the area at risk of fluvial erosion hazards (as much as a meander-belt-width-based corridor relying on regionalized data can represent fluvial erosion hazard risk). It will instead be a hybrid, science-based and policy-based area. If protected in some way by the community, this area will be more supportive of ongoing lateral and vertical adjustments of the channel to maintain / or regain dynamic equilibrium, thereby ***reducing*** fluvial erosion hazards (and improving water quality and habitats) over the long term.

I want to comply with VTANR protocols / guidance (while acknowledging the above concerns), but I am also confused since VTANR protocols or guidance documents are not explicit about which roads are to be defined as "major" to create a "new valley wall" or a "Phase 2 valley wall" that is intended (by VTANR) to serve as a delimiter of the FEH corridor. I think I understand that VTANR intends this "new valley wall" to be adjusted to fall along the river side of "major" roads (and railroads and engineered levees) that are expected to serve as confining features to lateral channel adjustment (as per page 16 of the Guide). But to accurately determine which human-constructed features will truly function as a confining feature to lateral channel migration requires analysis beyond the scope of a Phase 2 geomorphic assessment and should be defined within a specified range of flow conditions (e.g., less than the 500-year flood?) and a specified time period (100-year time scale?). In absence of that kind of detailed geotechnical and hydrologic/hydraulic analyses, VTANR phase 2 protocols (2007; page 19) seem to suggest that we are to define "major" roads as "highways [with] permanent high embankments… designed and maintained to elevate the road above the flood prone elevation". In your comments above, you are suggesting that we consider roads with a route number as "major". Does this include roads with a town route number (such as Whitesville Road which is Town Highway 6), or just state- or federally-numbered routes? (I couldn't find this in the protocols or guidance). Also, your comments seem to suggest a minimum height requirement for roads to be considered "major" – is it a thalweg height of on the order of 20 feet like the "rule of thumb" you suggest above, or is it a thalweg height at least two times the bankfull depth of the channel as seems to be suggested by the wording on page 19 of the phase 2 protocols (2007).

I agree with you that the Whitesville Road will be susceptible to fluvial erosion because it is comprised of unconsolidated sands and gravels and cobbles and it is "dubious" that it will serve as a lateral constraint to the Twentymile Stream channel – particularly in a very large flood. The same could be said about Route 131 which I think your comments suggest should be labeled as a "major" road (since it has a state route number, and since it is at a thalweg height of approximately 4.2 times the bankfull depth of the channel – although it is less than 20 feet high). Indeed all encroaching roads are susceptible to fluvial erosion and it is doubtful that they will serve as a lateral constraint to the river channel where the flood is big enough that flow velocities exceed thresholds for erosion governed by sediment sizes and properties, as well as vegetation and armoring conditions. Nevertheless, protocols and guidance documents are instructing us to delineate "major" roads as an artificial valley wall – in other words adjust the reference (natural) valley wall to a position on the river side of the "significant human-constructed features". This modified valley wall effectively becomes a management boundary - which results in a management adjustment to the FEH corridor delimited by this valley wall. (Page 16 of the Nov 2008 *River Corridor Protection Guide* states that "[t]his approach recognizes that the administrative entity overseeing the maintenance of the major infrastructure will have the need and

capacity to do so for the foreseeable future".) This management adjustment does not rely on any detailed geotechnical or hydrologic / hydraulic analyses to indicate this road will function as a laterally-constraining feature to the river. This management adjustment is made without regard for whether this infrastructure (or any lands/properties beyond it) is truly at risk of fluvial erosion hazards. The important limitations of such a management adjustment need to be clearly communicated to the communities that will be receiving this FEH corridor delineation for consideration (as suggested under the heading of Encroachment on page 13 of the Nov 2008 *Technical Appendix of the VT River Corridor Protection Guide*).

I believe the process of delineating FEH corridors would be much more transparent to communities if the field-truthed Phase 1 (reference or natural) valley wall were utilized as the delimiter of the initial "science-based" FEH corridor that is presented to the community. Then the community, working with VTANR and other partners, can decide whether or not to accept the risk of a management adjustment of the FEH corridor for reasons of encroachment of various human-constructed features (whether or not they are ultimately defined as either "major" or "minor") - because they recognize this infrastructure will be maintained (and restored to its present alignment after flood damages) well into the future and they have provided a theoretical meander-belt-width area on the river side of this human infrastructure.

In fact, isn't it likely that a community would restore "minor" as well as "major" roads to their current planform following damages by a flood – in other words, I would think that maintenance/restoration would not be limited only to roads with a state or federal route number.

I need to be more clear that I did not intend for the phase 2 valley wall shape file that I have delineated as a part of this project to be utilized as a building block for any FEH corridor developed by others. (This was not an explicit requirement of the contracted work plan, and the Nov 12, 2008 *River Corridor Protection Guide* that provides some improved clarity with regard to updating valley wall delineations in Phase 2 was issued by VTANR after the field work had already been completed and most of the data was entered for this project). The phase 2 valley wall shape file that I provided as a deliverable simply represents a documentation of those features that have reduced the valley width by cutting off a portion of the floodplain (through elevation and/or extensive fill) and supports the determination in Phase 2 Step 1.5 that a human-caused change in valley width has occurred. It also serves as documentation for the answer in RGA Step 7.1.4.

If I need to more closely comply with requirements of the VTANR protocols and 2008 guidance, to generate a phase 2 informed valley wall that will be utilized by others to delimit the FEH corridor, I am willing to do so, if VT River Management Section could please provide clarification of what constitutes a "major" road. I would start with the field-truthed Phase 1 valley wall and adjust it to fall along the river side of roads (and/or railroads and/or engineered levees) that fall within that valley and are defined as "major". If VTANR defines a "major" road as one which has a state- or federally-assigned route number, then the valley wall would be adjusted only along: Route 100 and 103 in Ludlow; Route 131 through Cavendish; and along Route 106 through Reading, Cavendish, and Weathersfield. In that case, in this particular reach M26T2.01, the FEH valley wall would be delineated out at the phase 1 valley wall position along RB (southwest of Whitesville Road) upstream of the Route 131 bridge crossing, and delineated along the river side of Route 131 along the LB downstream of the Route 131 crossing.

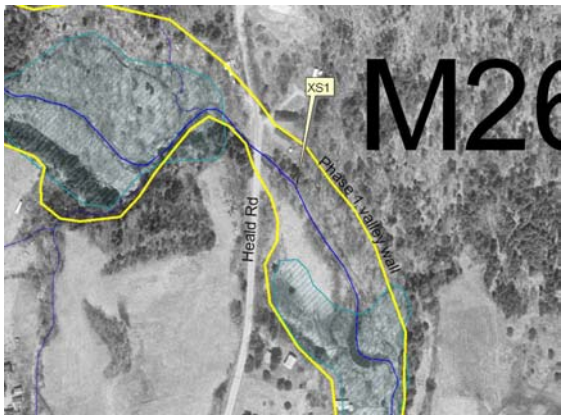
Thank you for your comments. Again, you've delineated the phase 2 valley wall (in the shapefile submitted 4/30/09) based on the phase 2 constraints to confinement and channel hydraulics (i.e., the valley is restricted to the area below floodprone elevation or 2X max depth), calling Whitesville Road the valley wall. As you've noted above, this is appropriate to document the changes in confinement for step 1.5. Doing so is agreeable, following our discussion in Waterbury on 5/15. When the FEH valley wall is created, the Whitesville Road boundary may need to be reevaluated in light of the uncertainties for lateral constraint during flooding.

- Is there a second xsection location? Only one is mapped in the FIT shapefile. Thanks for catching that oversight. I have added XS-1 to the FIT records.

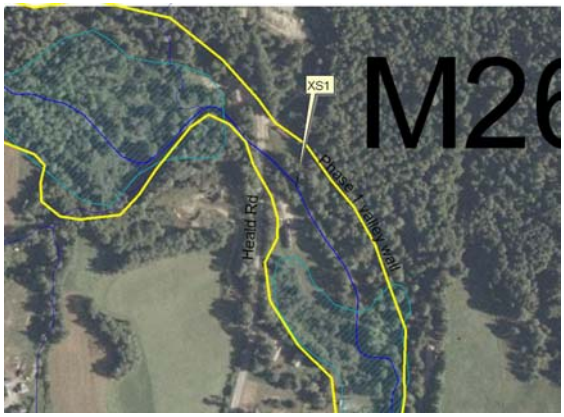
- If this reach is in stage II, then why do you say riffles are "sedimented" in step 2.10? Should they be "eroded"? Incision is historic, and the current active adjustment processes appear to be minor aggradation and widening. I probably chose sedimented to capture the two steep riffles noted in the segment local to a bedrock constriction and the Route 131 bridge. I have changed this to "eroded" to reflect that the dominant process responsible for the current plane bed form and removal of riffles is the historic incision (and associated channel management).
- As noted above in General Comments, HEF is N/A on this reach because there is lower abandoned floodplain on LB (xs#2). Please leave the HEF field in DMS step 2.5 blank. Data in the HEF cell of the DMS has been deleted.

M26T2.05-0

- In xs #1 (non-representative), should there be an HEF (just in this xs)? It looks like the road is creating an incision ratio of 2.24. If you agree, please enter the HEF elevation in the "Elevation RAF" field of the spreadsheet, and make a note about what the incision ratio would be without this fill feature, as it looks like the road does not constitute a new valley wall. A RB terrace is present at the XS1 cross section site at a thalweg height of 7.4 ft (or 2.3 times the bankfull depth). Coincident with the terrace is a driveway leading to a house that was constructed between 1994 and 2003, according to review of aerial photographs. A cleared (mowed) area is visible in this location in the 1994 photograph that predates construction; a terrace is depicted at this location on 1983 USGS topographic map. Data available at this time are insufficient to state with certainty whether the driveway along RB was installed at grade on a pre-existing terrace, or whether fill material was brought in to elevate the driveway / house above grade – and either create this terrace, or add to the elevation of and/or widen an existing terrace. This house and XS1 are located at a valley pinch point between sediments of till parent material to the northeast and sediments of lacustrine origin to the southwest (as mapped by NRCS). Bedrock exposures were also noted in this location (along LB upstream of the Heald Rd bridge crossing, and under the RB bridge abutment).




*1994 base photo*




*2003 base photo*

Conversations with the landowner would be required to understand if fill material was placed here to elevate the driveway and/or buildings. Auguring or excavation of the RB terrace would be required to know if the sediments comprising the terrace were alluvial, lacustrine, or glacial till (or of some other origin). If they are lacustrine or till (or bedrock), it would be appropriate to revise the Phase 1 valley wall to the terrace face. Similarly, the high terrace coincident with LB (at an approximate thalweg height of 14 feet, or 4.3 times the measured bankfull depth) appears comprised of a mix of grain sizes with the appearance of glacial till. If this LTER face and the RTER face comprise the Phase 1 valley wall for purposes of defining stream type, at a distance of 60 feet apart they would define a Narrowly-

Confined valley confinement or reference stream type of Bc along a very short section of the reach. The measured cross section is classified as a Bc3 stream type, which would be consistent with this reference stream type (with some historic incision, IRraf = 1.15), and would therefore not constitute a stream type departure. Technically, this very short section of channel would constitute a subreach of alternate reference stream type.

Erring on the side of caution, however, (and not knowing the origin and age of the RB terrace), I kept the Phase 1 valley wall further to the southwest at the approximate position of the contact between alluvial and lacustrine sediments (as defined coarsely by NRCS mapping). In a similar conservative approach, I chose not to establish the LB Phase 1 valley wall at the base or top of the terrace face which is coincident with LB. Instead, since the LTER face shows signs of active mass wasting, I chose to delineate the Phase 1 valley wall at the base of the next rise in topography approximately 80 ft to the northeast of the top of this LTER – also at the approximate contact between alluvial sediments and till / glaciofluvial sediments. At this distance apart, the Phase 1 LVW and RVW would define a reference C confinement (i.e., 210 ft / 32.6 ft = 6.4 confinement ratio, or "Broad"), in which case conditions measured at the specific cross section location technically would constitute a C to Bc stream type departure.

If the RB terrace is comprised (in whole or in part) of fill material, then it is possible that this encroachment lead to a human-caused reduction in the valley width at this location, from Broad confinement to Narrowly-confined. An associated ***lateral*** stream type departure from C to Bc would be evident as a result of this hypothetical filling of the floodplain.

This valley pinch point exists for a stream length of approximately 425 ft, or only 7.8% of the total reach length. Given this very short length, and the uncertainty regarding origin of the RB terrace, the reach was not segmented to capture this very short subreach. If an FEH corridor is developed for this reach in the future, the four-channel-widths dimension of the corridor (for a Moderate-sensitivity C3-riffle/pool stream type characteristic of the overall reach) will be clipped to the Phase 1 valley wall in this location, resulting in a slight narrowing of the FEH corridor. Given the conservative placement of the Phase 1 valley walls described above, the FEH corridor dimension might be somewhat overly conservative in this point location, if the RB terrace is in fact a natural feature of cohesive (or erosion-resistant) sediments (or bedrock) that would laterally constrain the channel.
Okay, thank you. This rationale is helpful to have documented.

- There are two xsections; one is a C stream type (representative) and one is a B type. The B type (not rep.) would be a stream type departure from C to B. The entrenchment ratio is lowered by the driveway at this location. Please include comments in the DMS step 5 explaining why the B type cross section is not representative, and why it was not worth segmenting. See above comments. Okay, understood.
- Step 7. CEM D does not have a stage IV. Please choose a stage in Appendix C. Data entry error. I meant to enter IV [F]. Based on April 2008 feedback from RMS, if the IRraf > 1.2 (as it was in at least one local area at XS1), the F model should be selected. Still, lateral adjustments seem more prominent in the reach than vertical adjustments. Degradation has perhaps been moderated by the presence of bedrock in some locations, as well as the generally coarser bed materials. Similarly, widening may have been moderated by coarse bed and bank materials and the maintenance of wide, forested buffers along much of the reach. The channel has lengthened and has opportunities to dissipate scour energies by accessing several flood chutes, and through localized bifurcations and braiding. Given the dominance of planform adjustments, I classified the reach in stage IV [F]. Okay, this is reasonable.

M26T2.06A

- Step 1.5. Given that this segment is in good geomorphic condition, and it is E by reference (and E channel widths tend to be underestimated by the regional curve), please calculate phase 2 confinement with the phase 2 channel width. Doing so results in a Very Broad confinement. At your suggestion, I used the measured channel width (28.8 ft at XS1) rather than the predicted

channel width (38 ft) to calculate a Very Broad reference and existing valley confinement (330/28.8 = 11.5). Phase 2 Step 1.5 was revised. Phase 1 Steps 2.8 and 2.10 were also revised using this measured channel width (consistent with your general comment on page 2), since this Segment A is representative of a majority of the reach. Yes, again I meant "overestimated."

M26T2.06B

- Twenty Mile Str. Road does not look elevated enough or major enough to be considered the new valley wall. Suggest including it within the ph. 2 valley (shapefile). Same for M26T2.06C. See also General Comments. Twentymile Stream Road is paved (in this section; gravel in sections to the north) and considerably elevated above the road. The fill material for this road has encroached within the Twentymile Stream floodplain in this segment, reducing the width of the available floodplain to a moderate degree. The Phase 2 valley wall shape file that I submitted records this encroachment and supports the estimate of modified Valley Width (and confinement classification) entered in Step 1.5. It is possible that some would consider this to be a "minor" road – depending on one's definition of "minor". It is very possible that the river could erode this road in a flood event – just as many "major" roads (e.g., Route 106, Route 131) have been eroded by the river in a flood event (elsewhere in the watershed). If the parties involved in future FEH corridor development for this reach agreed that this would be classified as a "minor" road, then the FEH corridor in this reach would be clipped to the Phase 1 valley wall (which is to the west beyond this road). If it is not defined as a "Major" road, then no adjustment of the FEH corridor (i.e., FEH valley wall) would be warranted for reasons of Encroachment of a "major" road (as discussed on page 13 of the Nov 2008 Technical Appendix of the VT River Corridor Protection Guide).

  You are correct: the evaluation of major vs. minor road can occur during the FEH delineation process (although the reason I called Twentymile Stream Road "minor" is that it is not assigned a route number). The important question for the phase 2 data is whether it represents a confining feature for the channel such that the road/ road embankment acts as a new valley wall. From the cross section, the road is at an elevation of 5.8', whereas the bankfull elevation is 4.5'. While the road at this location may prevent access to a portion of the floodplain during bankfull event, the road is not high enough to be considered a new valley wall. It is not even as high as the feature labeled as LTOB (6.3'), and it is within the floodprone area. **Is there an error in the cross section elevations? Am I missing something?**

  The cross section is correct. The new comments I have made under M26T2.01 might be helpful to the discussion here. To accurately determine which human-constructed features will truly function as a confining feature to lateral channel migration requires analysis beyond the scope of a Phase 2 geomorphic assessment and should be defined within a specified range of flow conditions (e.g., less than the 500-year flood?) and a specified time period (100-year time scale?). In absence of that kind of detailed geotechnical and hydrologic/hydraulic analyses, VTANR protocols and guidance documents need to clearly define what constitutes a "major" road, warranting delineation of the management boundary that is being referred to as a "new valley wall" or "artificial valley wall" or "phase 2 valley wall".

  If VTANR is defining a "major" road as one with a state- or federal route number, then yes, this would be a "minor" road as it only has a town route number (Town Highway 3). If the VTANR is defining a "major" road as one which is at an elevation at least two times the bankfull depth, then yes, this would be a "minor" road, as the cross section correctly indicates that this road is at a thalweg height of 4.8 feet, or (4.8/3.5 =) 1.4 times the bankfull depth. If Twentymile Road is a minor road, then an FEH valley wall utilized to delimit a FEH corridor for this reach would be positioned beyond Twentymile Stream Road coincident with the phase 1 reference valley wall. Thus, Twentymile Road would *not* be defined as a management boundary for delimiting the FEH corridor under VTANR guidance.

  I did not intend for the phase 2 valley wall shape file that I have delineated as a part of this project to be utilized as a building block for any FEH corridor developed by others. (This was not an explicit requirement of the contracted work plan, and the Nov 12, 2008 *River Corridor Protection Guide* that provides some improved clarity with regard to updating valley wall delineations in Phase 2 was issued by VTANR after the field work had already been completed and most of the data was entered for this project). The phase 2 valley wall shape file that I provided as a deliverable simply represents a

documentation of those features that have reduced the valley width by cutting off a portion of the floodplain (through elevation and/or extensive fill) and supports the determination in Phase 2 Step 1.5 that a human-caused change in valley width has occurred. It also serves as documentation for the answer in RGA Step 7.1.4.

**I am still confused by this segment.** The Twenty Mile Stream road (whether major, minor, or otherwise) does not appear high enough in elevation to create a change in confinement as addressed in step 1.5, because it is within the floodprone area. Remember, in the phase 2 Handbook, May 2007, p.19, "If the structures (railroads and highways) are not built up off the floodplain, and can be flooded, they should not be counted as the 'valley walls.' The influence of these structures for lateral constraint can be captured in Step 1.3."

The cross section for segment B clearly shows that the road is lower than the floodprone elevation. We have said that the phase 2 field-verified valley wall should reflect step 1.5, showing where there are changes in confinement and channel hydraulics. The phase 2 valley wall shapefile (submitted 4/30/09) contradicts the cross section, suggesting that the Twenty Mile Stream Road *is* higher than the floodprone elevation. You have said that the cross section is correct. Therefore, I would assume the phase 2 valley wall should coincide with the phase 1 field-verified valley wall on the west side of the road. Note that the FEH valley wall may be later moved to the eastern edge of the road, depending on whether it is ultimately considered "major" or "minor" in the political sense.

For a short section (too short to segment) just downstream of the farm bridge crossing at the mid-point of this segment, the road is elevated greater than 2 times the bankfull depth. I suspect there is some degree of road base fill that was placed on a natural terrace to result in this configuration, but how much is unknown. Otherwise, though, you are correct – the Twentymile Stream Road is not elevated greater than 2 x Dmx. So, I have moved the Phase 2 valley wall line back to the approximate position of the Phase 1 valley wall.

- Step 1.5. Because this segment is in good geomorphic condition, please calculate phase 2 confinement with the phase 2 channel width. Doing so results in the confinement remaining Narrow, rather than being changed to Semi-confined. I have utilized the measured bankfull width (31.8 feet) to estimate the valley confinement (150/31.8 = 4.7) of Narrow. Since the confinement is now > 4, I re-calculated the geomorphic condition using an Unconfined RGA. Same score and same sensitivity rating resulted.

M26T2.07-0

- Twenty Mile Str. Road does not look elevated enough or major enough to be considered the new valley wall. Suggest including it within the ph. 2 valley (shapefile).
  See also General Comments. Twentymile Stream Road is often elevated above the floodplain (though occasionally close to grade). The fill material for this road has encroached within the Twentymile Stream floodplain in this segment (and upstream segments/reaches), reducing the width of the available floodplain to a moderate degree. In a few locations (in this segment and upstream segments/reaches), rip-rap armoring reinforces the road where it conflicts directly with a meander of the channel. The Phase 2 valley wall shape file that I submitted records this encroachment and supports the estimate of modified Valley Width (and confinement classification) entered in Step 1.5. It is possible that some would consider this to be a "minor" road – depending on one's definition of "minor". It is very possible that the river could erode this road in a flood event – just as many "major" roads (e.g., Route 106, Route 131) have been eroded by the river in a flood event (elsewhere in the watershed). If the parties involved in future FEH corridor development for this reach agreed that this would be classified as a "minor" road, then the FEH corridor in this reach would be clipped to the Phase 1 valley wall (which is to the west beyond this road). If it is not defined as a "Major" road, then no adjustment of the FEH corridor (i.e., FEH valley wall) would be warranted for reasons of Encroachment of a "major" road (as discussed on page 13 of the Nov 2008 Technical Appendix of the VT River Corridor Protection Guide).

  As in M26T2.06B, you are correct the evaluation of major vs. minor road can occur during the FEH delineation process; however, the road does not appear to be high enough in the cross section to constitute a new valley wall. In xs1, the road elevation is at 5.5', which is below the floodprone height. In xs2, the road is just 0.6' above the flood prone height, not what would be considered a phase 2 valley wall. Better to leave it at the right phase 1 valley wall. **Please explain or adjust.**

My comments here would be the same as the new comments provided above under M26T2.06-B. The new comments I have made under M26T2.01 might also be helpful.
Similar to M26T2.06B, Twenty Mile Stream Road may not actually be elevated above the floodprone height in all areas; in fact, cross section 1 for T2.07 is showing that the road elevation is not greater than 2X max depth, while cross section 2 is. I think ideally the phase 2 verified valley wall shapefile would show where the road falls within the floodplain (as defined by floodprone elevation) and where it does not. Currently, the shapefile (submitted 4/30/09) simply follows the road. **Is it possible from your field notes/recollections for the shapefile to be refined?** This may mean the floodprone width and entrenchment ratio on cross section 1 should be reevaluated, although the difference in entrenchment would not trigger a different phase 2 stream type.

From my notes and sketch map, I have identified a point just upstream of XS-1 as the approximate location where the thalweg height of the road becomes less than 2 times the bankfull depth. I have revised the phase 2 vw to fall approximately at the phase 1 vw position from this point moving downstream.

Regarding your suggestion that the FPW of XS-1 be revised…. It was my understanding that Flood Prone Width (and therefore entrenchment ratio) is not intended to be a highly-precise measurement in broad-valley, unconfined settings (at ER > 2.2). Rather our goal is to determine whether the channel is entrenched or not (entrenchment ratio greater or less than 2.2) – for purposes of defining Phase 2 stream type. At ER values less than 2.2, we can be more precise with our FPW, ER measurements. Actual inundation width during a Q10 to Q50 flood in an unconfined, not-significantly-entrenched channel may be far less than the width defined at an elevation two times the max depth of the channel (as protocols define the FPW). So there is high uncertainty in the estimate of FPW / ER at values greater than perhaps, 3, in a C or E channel.

Acknowledging this point, I entered a somewhat arbitrary value of 300 ft for FPW for XS-1, knowing that the reach is unconfined, moderately incisied and only slightly entrenched. However, I see that this is contrary to protocols which ask us to enter the FPW as the width of the area defined at an elevation two times the max depth of the channel. So, I have changed the "300" value to "700". Since Phase 2 assessments do not make use of highly-accurate survey techniques, this value of 700 ft should be considered very approximate and will not necessarily reflect the full width of inundation during a Q10 to Q50 storm. I have re-uploaded the cross section spreadsheet for M26T2.07.

- In xs#1, where is the bankfull elevation? RBF is labeled at RPIN at 4.1', but then 3.4' is entered in the "Elevation Bankfull" field. Which is correct? Incision ratio will be affected. I mistakenly left "RBF" associated with RPIN. There are two prominent benches along RB at this cross section site. Originally, we anticipated that BF was at the upper bench where RPIN was secured (elev 4.1 ft). But noted the lower bench also as a possible BFL. When the completed cross section calculated a substantially higher than regime (and higher than surrounding measured) bankfull width and depth (and cross sectional area) at that higher bench, I revised the bankfull to be at the lower bench (i.e., elevation 3.4 ft), which yielded channel dimensions more consistent with nearby cross sections in similar settings. But I forgot to change the "RBF" label in the cross section to point 32, 3.4 (that represents the lower bench). The cross section has been revised and uploaded to the DMS. Granted, there is some uncertainty in the choice of bankfull elevation, as features are weak in this C4-R/P channel comprised of cohesive silty sands in the channel margins. If the chosen bankfull elevation (3.4 ft) happens to be lower than actual, then we may have somewhat overstated the degree of historic incision (Fair quadrant, rather than Good quadrant). In both cases (IR = 1.67 vs IR = 1.29), there is partial access to the surrounding floodplain; in neither case is the channel incised to a degree that would result in a C to F stream type departure. In either case, the overall reach score would vary by no more than 3 points, would score in the Fair quadrant and be assigned the same sensitivity score.
- I opted to change the channel evolution stage from II [F] to early stage III [F] due to the localized aggradation/widening/planform change induced by occasional DJs (2), LWD (40),

and beaver dam activity. Localized widening is also reflected in the high W/D ratio of XS2.

M26T2.08-0

Following review of your comments below, and reconsideration of the data, I agree with you that the reach does warrant segmentation.

- Please explain why you did not segment this reach due to buffers and/or channel dimensions. The unbuffered portion is >1200' long. The incision ratios are pretty different (1.08 vs. 1.95), and the existing stream types may be different (C and Bc). The reach has been segmented to capture the difference in incision ratios, as well as inferred sediment regime. As it happens the change in buffers coincides with the difference in incision ratios.
- Why did you choose xs # 2 to be representative? The entrenchment ratio and shape of channel suggest stream type Bc (rather than C as you have noted), possibly because the xsection looks to be at a pronounced pinch point in the valley. Is this really representative? In hindsight, the cross section at this location (because it is near a valley pinch point) is not entirely representative of (now) Segment B. It does still, however, represent the entrenchment of a C channel when the +0.2 value is added to the measured ER = 2.02, as permitted under protocols (Table 2.3, page 35, Phase 2 protocols, May 2007). Based on visual observations and field notes, the remainder of this segment (upstream of the Twentymile Stream culvert crossing) had similar access (IR <1.2) to a floodplain which ranges between 140 and 400 feet wide, or 5 to 15 times the measured (and reference) bankfull width.
- If there is historical incision, then the channel evolution model should be F. Although xs#2 indicates only minor incision, F should be used if there is a chance the reach can incise. Xs#1 does have high incision, if only (?) below the culvert (~1100' of stream). Please reconsider and explain your choice of evolution model and stage. According to feedback received at a April 2008 meeting with Mike Kline and Shannon Hill Pytlik, it was my understanding that reaches with an incision ratio less than 1.2 can be classified in a D stage evolution model, where dominant active adjustment processes are lateral (widening, planform adjustment) and/or aggradational, rather than incisional. The channel bed in Segment B is theorized to be more resistant to erosional scour than the stream banks (under current conditions) due to the presence of flood chutes and a debris-jam-influenced channel avulsion. However, since this determination is subjective (speculative) in the absence of more detailed sediment transport modeling or hydraulic analyses, I have changed the channel evolution stage to I [F]. Downstream of the culvert crossing, in Segment A, where the incision ratio is greater than 1.2, I would agree with you that the channel has demonstrated a propensity for incision, and should be classified in the F-stage channel evolution model – inferred stage II [ F].

M26T2.09-0

- Step 7. Please enter the RGA scores and fill out the RGA questions. Currently, they're blank in the DMS. Sorry for that oversight. They have been entered.

  Also, I decided to change the CES slightly to late stage III [F] rather than stage IV [F], since an incipient floodplain has formed only in select locations and not along a majority of the reach. While the cross section site does not capture a location of incipient floodplain, and the width/depth ratio is lower than would be expected for a stage III channel, this reach overall has begun to actively widen through planform adjustments (meander extension, flood chutes) and moderate aggradation. Notes to this effect have been added to Step 5 Comments in the DMS.

M26T2.10-C

- Why did you choose channel evolution stage II? Your step 5 comments suggest ongoing sedimentation is possible and degradation is historical. Have you considered early stage III? It might make more sense with "sedimented" riffles. Please explain. I chose "sedimented" since current active adjustment processes are aggradation and widening – though they are very minor in degree – probably moderated by till slopes, cohesive banks, and tree buffers. But historic degradation

associated with channel management and encroachments is probably the dominant process responsible for the theorized departure from riffle/pool to plane bed form. I have revised Step 2.10 to "eroded", which is more consistent with II [F] CES. I don't believe that III [F] CES is more appropriate, given the very low W/D ratio (14.7); minimal aggradation & widening; absence of mid-channel bars, steep riffles, or diagonal riffles; and relatively limited degree of erosion.

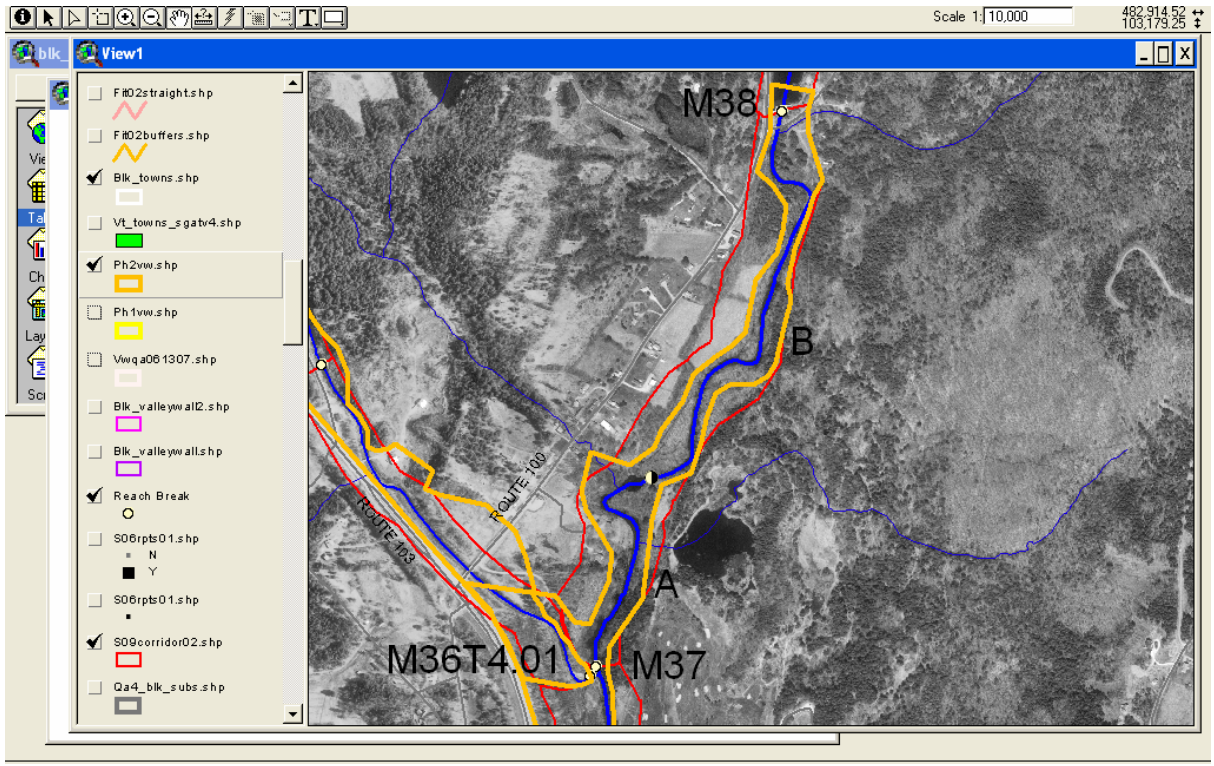
M36T4.01

- In xs #1, I suggest calling Route 103 the new valley wall, rather than point (222, 16). Although the elevation of the road is marginally high enough to be valley wall, for our purposes, Route 103 is encroaching on the stream, and the road will not likely be moved. The road fill is not the HEF because it is not likely to be moved, and there are lower encroachments (berms). I agree with you that Route 103 is considered the Phase 2 modified valley wall – the valley wall shape files that I previously submitted portray this. The "RVW" that I had entered for point (222, 16) is the Phase 1 reference valley wall. I have clarified this by adding "ph1 VW" and "ph2 VW" to the xs#1 spreadsheet.
- Looks like HEF is N/A on this reach. In xs#1, berms are at the same elevation as or lower than the RAF. In xs#2, the berm is located on one side of the stream, and there is barely elevated encroachment on the right side where the RAF is located. Buttermilk Falls Road is only 0.1' above the floodplain, so isn't much of an HEF, and it is too minor to be considered the new valley wall. You could calculate an HEF IR (3.35), but it would be very close to the RAF IR (3.32). Feel free to comment on the elevated encroachments, but HEF is unnecessary in step 2. I see your logic, and following our general discussions about HEF, I understand that I am to leave this cell in the DMS blank. I would also note, that it is very possible that the RTOB in xs#2 (what we are calling RAF), has been modified either during construction of the Buttermilk Falls Road, or during flood recovery efforts, or both. Similarly, the RAF along the LB in xs#1 has likely been modified by fill materials during post-flood dredging, channelizing, berming. So that the current state of channel entrenchment and degree of vertical separation of the thalweg from what we are calling the RAF, likely resulted from some combination of both incision and encroachment (fill).

M37-B

- In xs#1, a berm is on the right side. Is there a drop in elevation (not shown) beyond the berm (between top of berm and RVW)? If there is, it could affect RAF. No there is not a drop in elevation beyond the berm; the cross section correctly depicts the "lay of the land". The berm was apparently pushed up against the RTER at this location.
- Step 2.5. In DMS, did you mean to enter 5.4' for elevation of abandoned floodplain? In the cross section, the elevation is 5.4, but with the thalweg at 1. Please revisit, as this affects the incision ratio. Thank you for catching this. I should have entered the thalweg height of 4.4, not the elevation. This has been corrected in the DMS. The IRraf = 1.47.
- Step 2.14. Did you mean to choose stream type C? The entrenchment ratio is 1.82, which indicates stream type Bc, even with Rosgen's variation of +/- 0.2 units. Please take another look at stream type and possible STD in step 7.1. RGA and sensitivity may be affected. Thank you for catching this inconsistency. After reviewing the data more carefully for reach M37, it seems that a revision of the reference and existing stream type is warranted – as well as the delineation of the Phase 1 and 2 valley walls. I have made the judgment (based on limited available surficial geologic data and limited available channel management history) that the high glaciofluvial terraces close to the channel on either bank represent terraces formed by glacial deposition (kame terrace) and were abandoned by post-glacial incision. And that a lower, very narrow and discontinuous bench (evident along LB in XS-1, for example) represents a more recently-abandoned incipient floodplain perhaps associated with dredging/channelization and/or incision following the 1973, 1936/1938 and/or 1927 floods. The thalweg elevations of the higher glaciofluvial terraces are greater than three times the channel depth; therefore, consistent with protocols (p. 27, 2007) they have been ignored in the calculation of incision ratio. These high glaciofluvial terraces, therefore, represent the reference (Phase

1) valley wall for purposes of defining the reference stream type and the degree of stream type departure. The distance between these high terraces ranges from approximately 130 feet (locally) to generally between 270 and 400 feet, or 4 to 6 times the reference channel width, which defines a valley of Narrow confinement for the Black River channel – i.e., a C reference stream type. Since the present channel is inferred to have historically incised to some degree (IRraf = 1.47) within this Narrow valley as a result of reported channel management (1973, 1936/1938, and probably 1927), the floodplain available to the incised channel is somewhat narrower, yielding an ER = 1.82 – which you correctly note is in the range of a B stream type. Therefore, a C to Bc STD is evident. In the RGA, Step 7.1 score changed to 5, and the overall score changed to 0.475. This score is still classified in the "Fair" quadrant.
Okay, but the STD for 7.1 still says "None". **Please update DMS**.
Sorry about that. I have made the correction and it appears to have stored properly to the DMS.
A B4c channel with C to Bc STD is classified with a sensitivity of "Very High" – thus, Sensitivity remained unchanged. Revised valley wall shape files have been transmitted along with this QA review. Here is a visual of the revised valley wall:




- Step 7. You note all four adjustment processes of step 7 as being historic. Why do you think this segment may be "stuck" in stage IV? I have revised the CES to II [F] (see general comments on pages 3-4]. And I believe the segment to be "stuck" in stage II. This reach is downstream of essentially 5 miles of impounded channel (Lake Pauline, Lake Rescue, Echo Lake, and Lake Amherst). Except during large flood events, it is likely that the sediment supply to this reach is minimized. Thus, aggradation was classified as historic – and observed features suggest aggradation is minor in degree. I hypothesize that the moderate width/depth ratio (ranging from 30 to 31 in the two cross sections) may have more to do with historic manipulations of the channel during "stream cleaning" following major events than with active ongoing widening processes. Signs of active, segment-wide widening - excessive streambank erosion, undercut banks with leaning trees from both banks in riffle or straight sections - are not evident. Incision was classified as historic, based on the absence of features that would suggest an active incision process – active head-cutting, rejuvenating tributaries, recently exposed tree roots. I did, however, revise the classification of planform adjustment. Originally, I had

selected "Yes" for historic, since some degree of historic channelization is inferred. However, I have since revised this to "No", because several flood chutes indexed within the segment suggest a degree of current planform adjustment.

# APPENDIX D

# Reach Segmentation

## Table D-1
## Segmentation of Select Black River and Tributary Reaches, 2007 – 2008 Assessments

| Reach | Segment | Feature | Point | Total Reach Length (ft) | Segment Lengths (ft) | Elevation (ft) | Segment Slopes | Reach Slope |
|---|---|---|---|---|---|---|---|---|
| M37 | | d/s end reach | | | | 1010 | | |
| | A | segment break | A/B | | 1,842 | 1018 | 0.4% | |
| | B | u/s end reach | | 5,311 | 3,469 | 1030 | 0.3% | 0.4% |
| M36 | | d/s end reach | | | | 995 | | |
| | A | segment break | A/B | | 3,496 | 1005 | 0.3% | |
| | B | u/s end reach | | 4,713 | 1,217 | 1010 | 0.4% | 0.3% |
| M33 | | d/s end reach | | | | 960 | | |
| | A | segment break | A/B | | 4,053 | 978 | 0.4% | |
| | B | u/s end reach | | 7,849 | 3,796 | 986 | 0.2% | 0.3% |
| M32 | | d/s end reach | | | | 928 | | |
| | A | segment break | A/B | | 5429 | 942 | 0.3% | |
| | B | segment break | B/C | | 2626 | 950 | 0.3% | |
| | C | u/s end reach | | 12,000 | 3945 | 960 | 0.3% | 0.3% |
| M19 | | d/s end reach | | | | 532 | | |
| | A | segment break | A/B | | 4,243 | 540 | 0.2% | |
| | B | u/s end reach | | 7,697 | 3,454 | 560 | 0.6% | 0.4% |
| M26T2.10 | | d/s end reach | | | | 1250 | | |
| | A | segment break | A/B | | 1,015 | 1280 | 3.0% | |
| | B | segment break | B/C | | 908 | 1315 | 3.9% | |
| | C | u/s end reach | | 3,132 | 1,209 | 1335 | 1.7% | 2.7% |
| M26T2.08 | | d/s end reach | | | | 1175 | | |
| | A | segment break | A/B | | 1393 | 1185 | 0.7% | |
| | B | u/s end reach | | 3,634 | 2241 | 1210 | 1.1% | 1.0% |
| M26T2.06 | | d/s end reach | | | | 1100 | | |
| | A | segment break | A/B | | 6,466 | 1135 | 0.5% | |
| | B | segment break | B/C | | 2,050 | 1145 | 0.5% | |
| | C | u/s end reach | | 9,808 | 1,292 | 1150 | 0.4% | 0.5% |
| M15T1.11 | | d/s end reach | | | | 710 | | |
| | A | segment break | A/B | | 417 | 719 | 2.2% | |
| | B | segment break | B/C | | 312 | 730 | 3.5% | |
| | C | u/s end reach | | 1,138 | 409 | 760 | 7.3% | 4.4% |
| M15T1.06 | | d/s end reach | | | | 595 | | |
| | A | segment break | A/B | | 2,829 | 597 | 0.1% | |
| | B | u/s end reach | | 6,547 | 3,718 | 600 | 0.1% | 0.1% |
| M15T1.03 | | d/s end reach | | | | 502 | | |
| | A | segment break | A/B | | 1,428 | 503 | 0.1% | |
| | B | u/s end reach | | 5,488 | 4,060 | 530 | 0.7% | 0.5% |

# APPENDIX E

## Reach Summaries

**TABLE OF CONTENTS**

E.1 Black River main stem from Ludlow to Cavendish ..... 1
M37 ..... 1
M36T4.01 (Branch Bk at confluence with Black River) ..... 5
M36 ..... 9
M35 ..... 13
M34 ..... 15
M33 ..... 20
M32 ..... 27
M31 ..... 32
M30 ..... 33
M27 ..... 38
M26T2.01 (Twentymile Stream at confluence with Black River) ..... 39
M26 ..... 40
M19 ..... 42
E.2 Twentymile Stream ..... 45
M26T2.10 ..... 45
M26T2.09 ..... 46
M26T2.08 ..... 47
M26T2.07 ..... 47
M26T2.06 ..... 48
M26T2.05 ..... 49
E.3 North Branch of Black River ..... 51
M15 T1.11 ..... 51
M15T1.10 ..... 53
M15T1.09 ..... 53
M15T1.08 ..... 55
M15T1.07 ..... 56
M15T1.06 ..... 57
M15T1.05 ..... 60
M15T1.04 ..... 62
M15T1.03 ..... 62

.

## E.1 Black River main stem from Ludlow to Cavendish

This section includes assessment summaries for Black River main stem reaches from M37 (below Lake Pauline, town of Ludlow) downstream to reach M30 at Mack Molding in Cavendish just above the Cavendish Gorge – as well as reaches M27 and M26 below the gorge and M19 above Perkinsville (town of Weathersfield).

Also included in this section are: (1) the downstream-most reach of Branch Brook (M36T4.01) which joins the Black River main stem at the upstream end of reach M36 in the town of Ludlow and (2) the downstream-most reach of Twentymile Stream (M26T2.01) which joins the Black River main stem in Whitesville (town of Cavendish) at the upstream end of reach M26.

**M37**

Reach M37 extends from just below the dam at the downstream end of Lake Pauline (identified on the USGS topographic map as Reservoir Pond) to the confluence with Branch Brook (M36T4). The channel flows to the southwest parallel to Route 100. Regionally, reach M37 is in a broad valley setting of glaciofluvial sediments bound on the near east and far west by steep, forested slopes of glacial till overlying bedrock. Sediments of more recent alluvial origin are mapped closer to the actual channel in the downstream half of the reach (as mapped by USDA). Soils of glacial till parent material are mapped continuous with the LB in the upstream third of the reach (USDA). Hydric soils (USDA) and wetlands (NWI, VSWI) are mapped contiguous to the channel in the downstream half of the reach. Several water-filled depressions are located in the Black River valley in this area of the Branch Brook confluence (e.g., Cook Pond, a pond in the LB corridor [now incorporated within the golf course lands], and several wetland depressions). These are suggestive of a glacial kettle lake, or kettle depression origin. Bedrock is exposed along the RB near the mid-point of reach M37.

The Black River channel in reach M37 is confined by high terraces along both banks. Thalweg heights of these terraces are generally greater than three times the maximum bankfull depth. The distance between the terraces ranges from approximately 130 feet (locally) to generally between 270 and 400 feet, or 4 to 6 times the reference channel width. Detailed surficial geologic mapping would be required to know with certainty whether these terraces were abandoned as a result of post-glacial incision (several thousands of years before present) or whether they represent more recently-abandoned floodplain surfaces. It is possible that the elevation of terraces have been reworked, leveled and even elevated during flood recovery efforts. Gravel was reportedly removed from the Black River channel during "stream cleaning" recovery efforts from the 1973, 1938/1936, and possibly the 1927 floods, and may have initiated incision. VTANR protocols (p. 27, 2007) instruct the user to ignore higher-elevation terraces (especially, those higher than 3 times the bankfull depth) as likely representing older terraces formed during incisional processes that pre-date colonial times. It would not be unusual to see post-glacial terraces in this valley setting that resulted from base level changes either locally or further downstream in the Black River main stem during the draining of high-level glacial lakes several thousands of years before present.

Based on the limited data available, a judgment was made that these terraces formed as a result of post-glacial incision, and that a lower, very narrow and discontinuous bench (evident along LB in XS-1, for example) represented a more recently-abandoned incipient floodplain perhaps associated with dredging/channelization and/or incision following the 1973, 1936/1938 and/or 1927 floods.

The Phase 1 valley wall along both banks (and especially along the RB) was updated to reflect the approximate top of these high glaciofluvial terraces (and the base of a valley wall comprised of till (USDA) along LB in the upstream third of the reach). These valley positions define a valley confinement that ranges between "Semi-Confined" and "Broad". Reach-wide, the average confinement is "Narrow", suggesting a C reference stream type.

The upstream two-thirds of reach M37 is characterized by a gravel-dominated riffle/pool bedform; the downstream third of the reach is characteristic of a wetland, with beaver activity noted along the banks. Several very wide and deep pools are incorporated along the channel within this downstream end of the reach. Reach M37 was segmented to capture this change in flow characteristics (Figure 1).

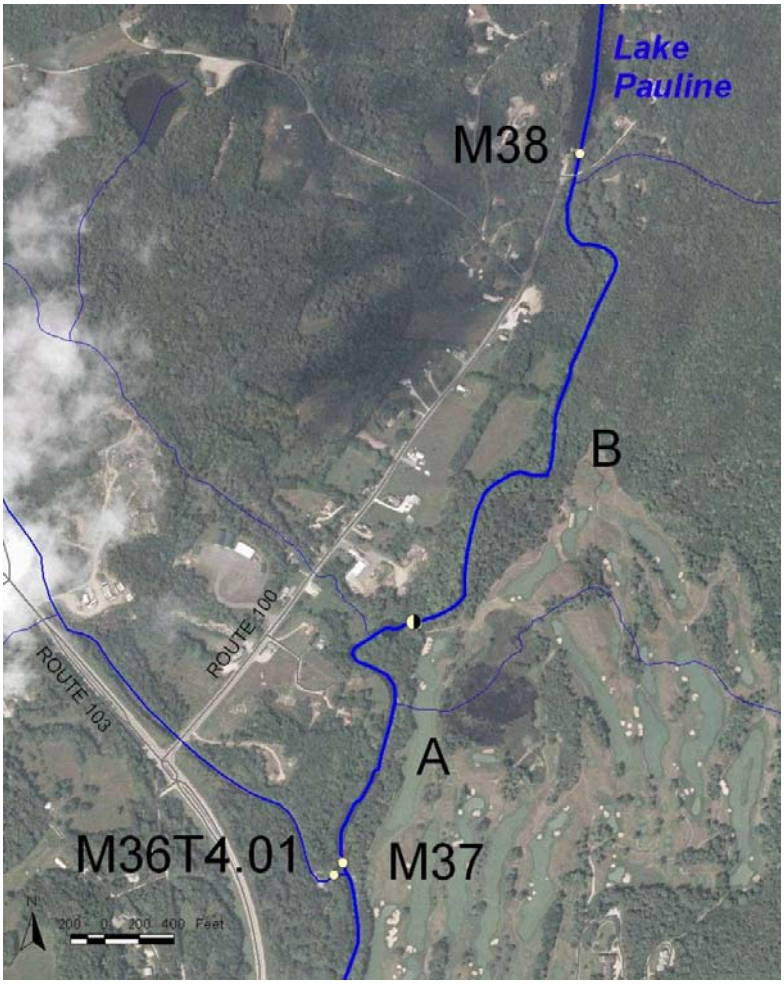



*Figure 1. Segmentation of reach M37, Black River main stem, Ludlow.*

**Segment B**

Segment M37-B is 3,469 feet in length and extends from just below the Lake Pauline dam (Figure 2) to the vicinity of the Okemo Valley Golf Club course approximately 1,800 feet upstream of the confluence of Branch Brook. Based on the discussion above, a C-riffle/pool reference stream type is inferred from the valley setting.



*Figure 2.*
*View upstream from East Lake Rd to low-head dam impounding Lake Pauline.*

Segment M37-B is largely undeveloped along its length. There is a slight reduction in valley width caused by the elevation of Route 100 above the floodplain in the RB corridor near the upstream end of the reach. However, this encroachment is not significant enough to cause a change in valley type (Very Broad) or confinement status (Unconfined). A bridge crossing for the East Lake Road is located immediately downstream of the Lake Pauline dam at the upstream end of the segment. This crossing structure is a bankfull constrictor; a moderate degree of downstream scour was noted under and just downstream of this structure. The golf course in the LB corridor has expanded northward in recent years, reducing the forested buffer available along the LB in the downstream half of Segment B (and Segment A).

The low-head dam at Lake Pauline was reportedly installed in 1920 (Vermont Dam Inventory). This impoundment is absent on the 1869 Beers Atlas of Windsor County, but is present on the 1929 historic USGS topographic map, and a 1939 aerial photograph. Originally the dam was constructed for purposes of hydroelectric power generation, and once supplied electricity to street lights in the village of Ludlow. Today, the impoundment is used for recreational purposes, and the dam is owned by the Town of Ludlow (Vermont Dam Inventory). The Beers Atlas (1869) depicts a large bifurcation in the channel mid-reach, with a woolen mill on the island between the split channels and a saw mill near the confluence of a RB tributary. Old abutments are built on bedrock at this location and appear to represent an old bridge crossing. This abutment pair is located at the approximate position of a road crossing leading to the woolen mill depicted on the Beers Atlas (1869). While the span of this old abutment pair (37 ft) is only 59% of the bankfull width measured in the segment (63 ft), the nature of the constriction at this point is largely a function of the underlying bedrock. Sediment has built up above the constriction, resulting in a steep riffle.

The channel in reach M37 has a similar planform as that represented on historic aerial photographs (1980, 1977, and 1939). An active flood chute is depicted along the LB corridor (see Figure 3) on the 1977 photograph, and may represent the path of flood flows during the 1973 flood. A long, high, and wide cobble/boulder/earthen berm is present along the RB corridor within 5 to 200 feet distant from the channel for the mid-section of this segment (Figure 3). Historic channelization and dredging are inferred from the linear planform of the channel and presence of this berm. The Ludlow annual report (year ending 1973) also indicates "stream cleaning" following the 1973 flood in vicinity of the Branch Brook. The size (inferred age) of trees incorporated within this berm suggests an older date for the berm (perhaps following the

1936/1938 or 1927 floods); tree ring analyses to confirm the age of the trees was beyond the scope of this study.

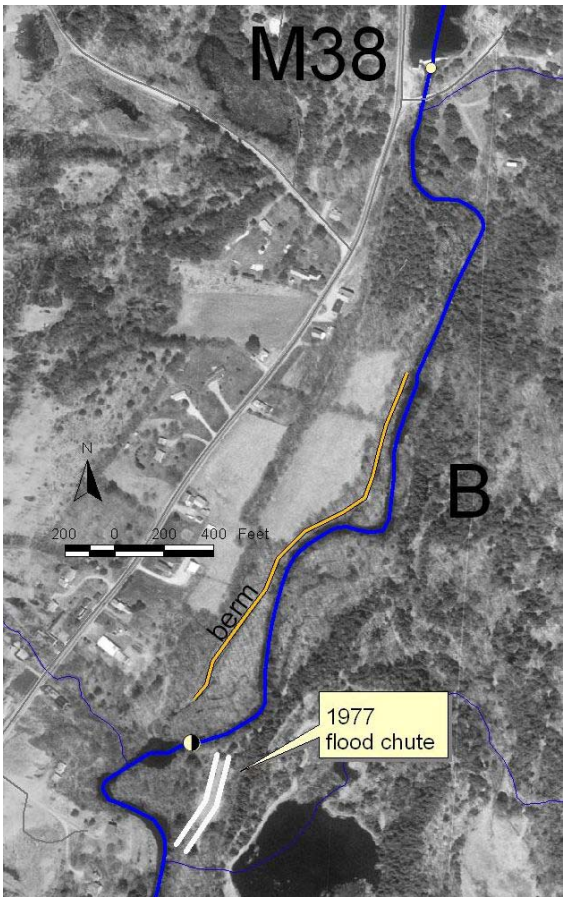



*Figure 3.*
*Approximate position of cobble/ boulder/ earthen berm within RB corridor of Black River (M37-B), possibly created during the flood recovery efforts following the 1936/1938 or 1973 floods, or both. A 1977 aerial photograph shows a major flood chute at the downstream end of the segment which may represent the path of the river during the 1973 floods. Base map is 1994 orthophotograph (VT Mapping Program).*

Dominant bed materials appeared to decrease somewhat with distance downstream; coarse gravel was dominant overall, but cobbles were more dominant in the upstream end of the segment. It is possible that fines have been winnowed from the stream bed a short distance downstream of the Lake Pauline dam, where "hungry water" conditions may characterize the flow for a short distance. Impoundments characterize the nature of flow in the Black River for a distance of five miles upstream of reach M37 (i.e., Lake Pauline, Lake Rescue, Echo Lake, and Lake Amherst).

Two cross sections were completed in Segment B. One measured near the upstream end of the reach indicated a C-riffle/pool stream type with an Entrenchment Ratio of 2.97. The second cross section completed mid-segment was more characteristic of the reach as a whole and indicated a Bc stream type departure with an Entrenchment Ratio of 1.8. The narrow floodplain available to the channel has been reduced somewhat by a degree of historic incision ($IR_{RAF}$= 1.5) and encroachment (berms). Both the upstream impoundment and a reported history of channelization and dredging may have contributed to this historic incision, as well as past flooding – particularly the 1927 event. A geomorphic condition rating of Fair was assigned indicating a minor to moderate degree of adjustment overall. Moderate planform adjustment was indicated by the presence of flood chutes; minor to moderate (and historic) widening is indicated by the measured width/depth ratios (30 to 31). Following protocols, a sensitivity of "Very High" was assigned for this B4c channel which has undergone a vertical stream type departure (C to Bc). Lateral and vertical channel adjustments may have been moderated by the

presence of reasonably intact shrub/sapling and forested buffers along both banks and the relatively low channel gradient (0.3%). Also, sediment supply from upstream reaches has likely been reduced by the impoundment of waters at Lake Pauline (and in upstream impoundments). A channel evolution stage of II [F-stage] is inferred.

***Segment A***

Consistent with protocols, Segment M37-A was not assessed due to the predominance of wetland characteristics (Figure 4). At the very downstream end of this segment near the approximate confluence of Branch Brook, substantial sediment has accumulated in the channel and may be contributing to the impoundment of Segment M37-A. Branch Brook appears to have contributed to channel aggradation local to this confluence. Also, according to a local resident (Barton, 2008) this is the approximate location of a former beaver dam, which was breached by ice flows. Based on review of aerial photographs, a pre-1994 avulsion of the Branch Brook occurred along with a partial "pirating" of flow from the Black River (see more discussion under M36 and M36T4.01).



*Figure 4. Segment A of reach M37 exhibits wetland characteristics.*

**M36T4.01 (Branch Bk at confluence with Black River)**

Reach M36T4.01 is the downstream-most reach of Branch Brook, a tributary draining 15.9 square miles which enters the Black River main stem just below the downstream end of reach M37. This reach is approximately 3,228 feet in length and begins at a point just upstream of the intersection between Buttermilk Falls Rd and Route 103. The reach flows through sediments of glaciofluvial origin, predominantly, with a greater prevalence of hydric, alluvial sediments near the confluence with Black River (USDA). Wetlands (NWI, VSWI) are mapped near the confluence. Channel-spanning bedrock was observed at the mid-point of the reach.

The channel in reach M36T4.01 appears naturally confined by high glacio-fluvial terraces in the left and right corridors; the valley width ranges from 6 to greater than 10 times the channel width, with an average valley confinement classified as Very Broad. A reference stream type of gravel C-riffle/pool is inferred.

Encroachment of Rt 103 reduces the valley width somewhat, enough to change the valley type from Very Broad to Broad; however, the confinement status remains unchanged (Unconfined). Based on review of aerial photographs, the current Route 103 highway was constructed sometime between 1939 and 1977. Sand and gravel excavation also expanded within this time period at a location to the immediate northeast of the channel in the upstream third of the reach. Some regeneration of forest cover appears to have occurred in recent decades along the LB corridor and in the downstream third of the reach in vicinity of the confluence with Black River. A limited degree of commercial development (both banks, upstream third) and residential development (LB, downstream end) is evident along the reach. Rip-rap armoring has been installed to protect these investments and the roads and bridge crossings.

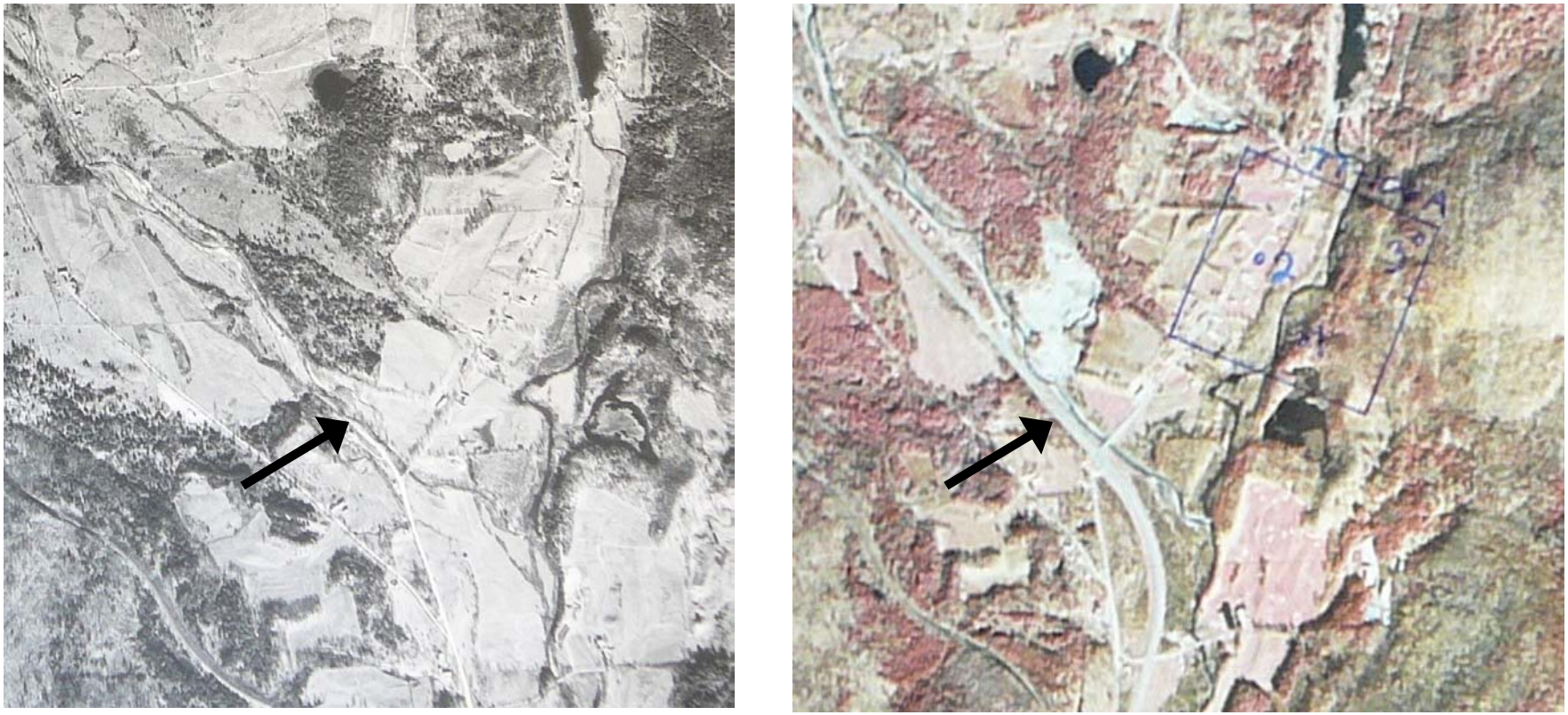
Two bridge crossings constrict the flood prone width of the Branch Brook channel at points along the reach:

- A commercial driveway crosses the channel in the upstream third of the reach. The measured span (67 ft) of this bridge is approximately 147% of the measured bankfull width (45.7 ft). Stormwater inputs to the channel (one culvert, one overland flow) are associated with this bridge.
- State Route 100 crosses the channel near the mid-point of the reach. The measured span (80 ft) is approximately 175% of the bankfull width.

Extensive berms are present along one or both banks for more than 2,000 feet (62%) of the reach length. These berms constrain the availability of floodplain along the channel and increase the degree of entrenchment. Berms appear to be associated with extensive channelization (and inferred dredging) that occurred in response to the 1973 flood. Branch Brook "stream cleaning" was noted in the Ludlow annual report following the 1973 flood. Channelization following the 1927 and/or 1938 floods is also possible. Figure 5 compares the channel planform observed on aerial photographs from 1939 and 1977.

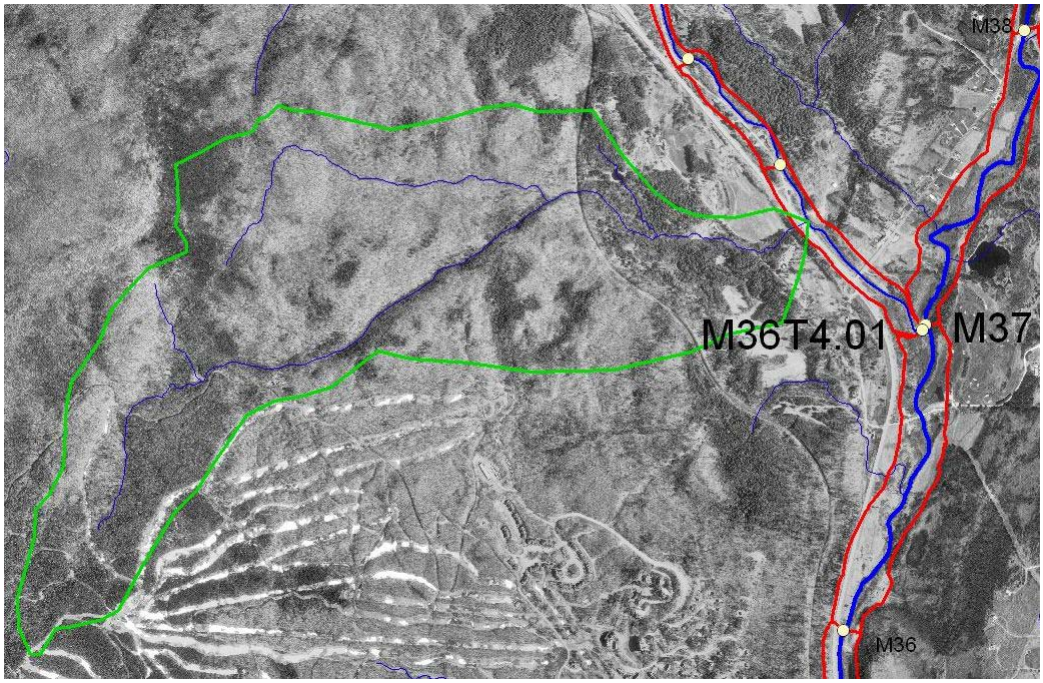
Field reconnaissance on 8 November 2007 (and during the August 2008 assessment of this reach) revealed that approximately one third of the flow from the Black River main stem has been "captured" by the Branch Brook, and the confluence has shifted to a point approximately 600 feet downstream of the position indicated on the VHD and the 1983 topographic map. Sediment from Branch Brook appears to have contributed to channel aggradation local to this confluence. Also, according to a local resident (Barton, 2008) this is the approximate location of a former beaver dam, which was breached by ice flows. Based on review of aerial photographs, this avulsion and partial "pirating" of flow from the Black River occurred prior to 1994 (see more discussion under M36).

Coleman Brook drains the northeastern slopes of Ludlow Mountain and joins the Branch Brook in this reach along the RB, after passing through a corrugated steel, pipe-arch culvert that crosses under Route 103. This 1.2-square mile watershed represents approximately 8% of the Branch Brook watershed at the point where it joins the Branch Brook. The downstream end of this culvert, reinforced by a concrete header, is perched above the Branch Brook channel. A nick point is located in the Branch Brook channel immediately upstream of this culvert due to the significant scour pool at the base of the culvert. It is possible that this nick point has resulted from recent incisional processes in the Branch Brook. More detailed survey work and hydraulic analyses would be required to understand if recent changes in the position of the confluence with Black River (for example) have contributed to incisional processes in Branch Brook. However, it seems likely that the mid-reach bedrock vertical grade control (located 125 feet downstream of this tributary junction) would have constrained headward migration of an incisional process from the vicinity of the Branch Brook confluence with Black River. Therefore the nick point may instead have formed due to the scour pool associated with increased flows through the perched culvert on the Coleman Brook.

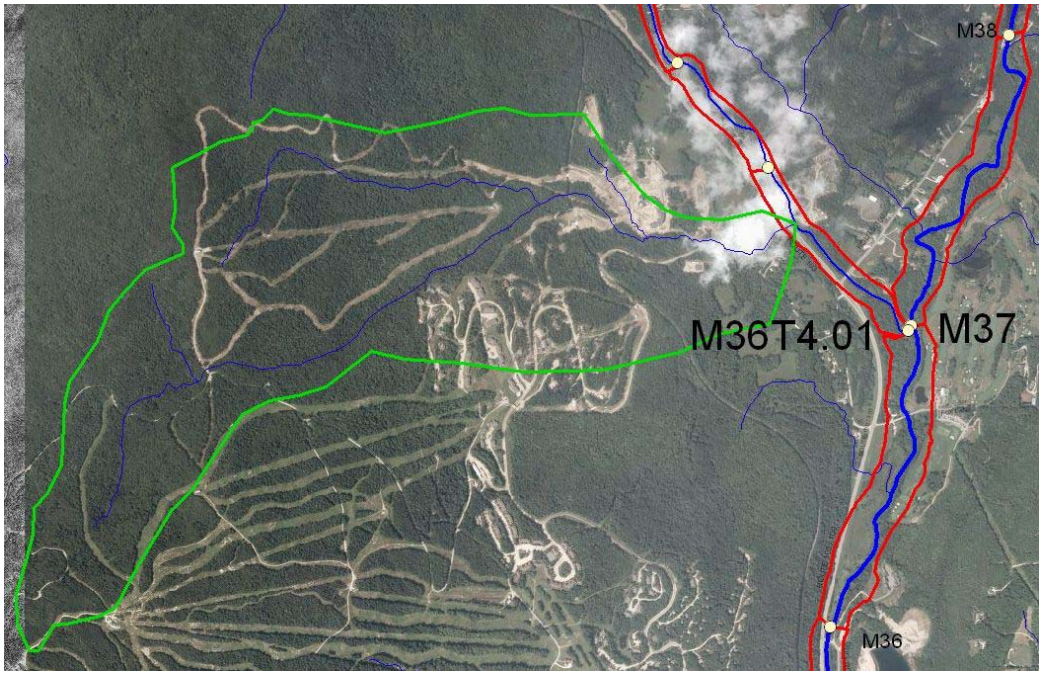


(a) (b)

*Figure 5. Aerial view of the confluence between Branch Brook and Black River from (a) 1939 and (b) 1977. Branch Brook shows significant braiding upstream of the Route 100 crossing in the 1939 photograph (see arrow), whereas, this same area appears as a single-thread, straightened channel in the 1977 photograph. Substantial berms were noted along both banks in this vicinity and downstream of the Route 100 crossing during field assessments in August 2008. The Route 103 highway was constructed in the RB corridor of the Branch Brook and Black River main stem sometime between 1939 and 1977.*




(a)




(b)

*Figure 6. Coleman Brook watershed depicted in green, draining to Branch Brook reach M36T4.01 on (a) 1994 orthophotograph and (b) 2003 aerial photography. Expansion of the Okemo Mountain ski resort and development of residential housing have occurred in the indicated time frame.*

Figure 6 displays the approximate watershed of the Coleman Brook in 1994 and 2003. From this comparison, it is evident that substantial expansion of the Okemo Mountain ski resort began within this timeframe and extended into the Coleman Brook watershed. In addition, development of residential units has occurred in the downstream end of the watershed. Depending upon the nature and adequacy of stormwater management practices and structures implemented within the Coleman Brook watershed in recent years, it is possible that stormwater flows to the Branch Brook from this tributary have increased in volume, intensity and frequency.

Two cross sections performed in Branch Brook reach M36T4.01 indicate a substantial degree of channel degradation ($IR_{RAF}$ ranging from 3.19 to 3.3). In both cross section locations, it is likely that the "recently abandoned floodplain" (RAF) surface has been modified during post-flood dredging, channelizing, and berming. In the upstream third of the reach, it is likely that the RAF has also been altered by fill material for the Buttermilk Falls Road and a commercial parking lot near the intersection of this road with Route 103. Therefore, the current degree of vertical separation of the thalweg from the RAF, likely resulted from some combination of both incision and encroachment (fill). A stream type departure (from C3-riffle/pool to F3-plane bed) is evident from the degree of channel degradation and the measured entrenchment ratios (1.1 and 1.4). Channel degradation was noted as historic (although it is possible that avulsion at the Black River confluence and (or) increased stormwater runoff via Coleman Brook have contributed to a degree of more recent incision).

The reach was classified in Fair condition reflecting the minor to moderate degree of active lateral and vertical adjustments. Moderate aggradation in the reach is suggested by the presence of side bars, and a few point and diagonal bars. Moderate planform adjustment is indicated by the presence of several flood chutes. Channel adjustments appear to have been moderated by bank armoring, berms, and regenerating tree buffers. A sensitivity of "Extreme" was assigned due to the vertical stream type departure. A channel evolution stage of II [F] is inferred. If stormwater flows are contributing to localized incision at the confluence of the Coleman Brook, and stormwater flows proceed unchecked, this localized instability could lead to more widespread incision and/or widening upstream of this tributary confluence.

**M36**

Reach M36 extends from the Branch Brook confluence downstream under the Fox Lane bridge nearly to the Dug Road bridge. Sediments of glaciofluvial origin (kame terrace and outwash deposits) dominate the Black River valley in this reach (Stewart & MacClintock, 1969). Sediments of a more recent alluvial origin and a hydric nature are mapped within close proximity to the channel in the upstream half of the reach (USDA). The area of these alluvial soils extending southward from the Branch Brook confluence is mapped as a wetland complex (NWI, VSWI, USGS topographic map). Bedrock was not observed within the reach.

The natural valley ranges from Very Broad to Broad, confined by till-blanketed steep bedrock slopes along the right valley wall and a 10- to 15-foot terrace of glaciofluvial sediments along the LB (upon which is developed the Okemo Valley Golf Club course). A reference C-riffle/pool stream type is inferred.

Based on review of 1994 and 2003 orthophotographs, the location of the Branch Brook confluence has shifted over time. Field reconnaissance on 8 November 2007 revealed that approximately one third of the flow from the Black River main stem has been "pirated" by the Branch Brook, and the confluence has shifted to a point approximately 600 feet downstream of the position indicated on the 1994 topographic map (see Figure 7). As a consequence, approximately 600 feet of the Black River main stem from the pirating location downstream to

the new confluence contains approximately two-thirds of the full flow of the river. A 1,217-foot section of M36 upstream of the Fox Lane crossing was segmented because of the highly variable flow status.

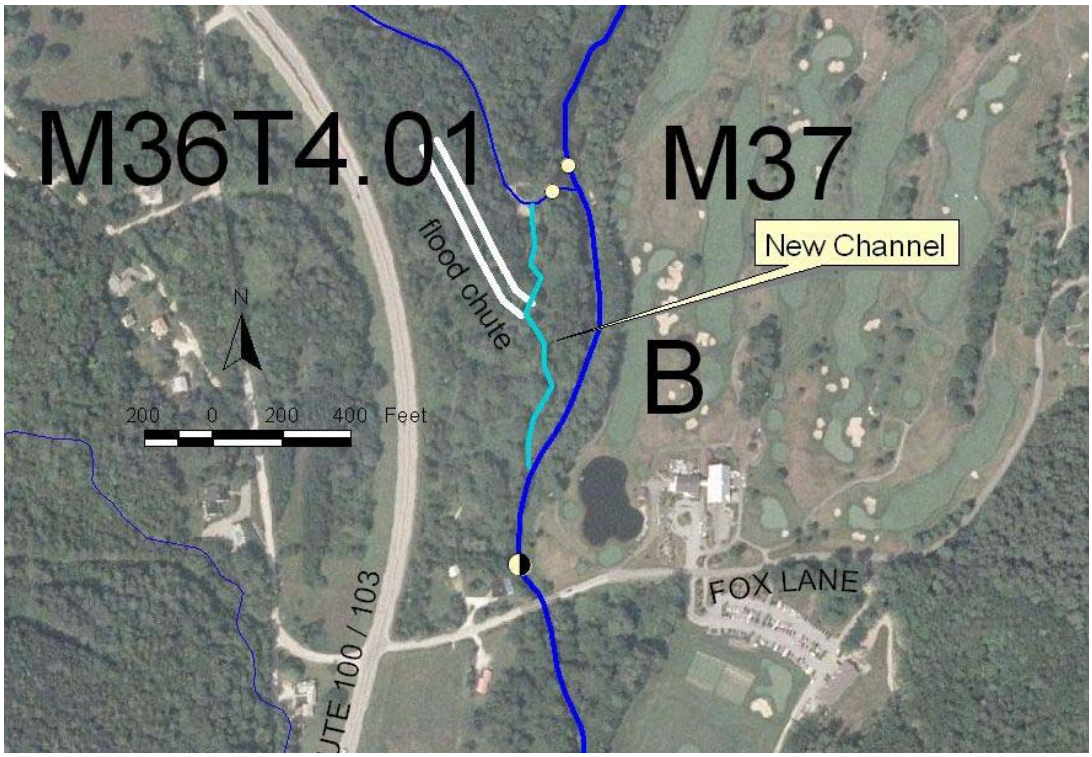



*Figure 7. (Segment M36-B). A pre-1994 avulsion has resulted in a shift of the Branch Brook confluence to a position approximately 600 ft downstream of the confluence noted on the VHD. Approximately one-third of the Black River main stem flow has been "pirated" from the former confluence position to flow in the extended Branch Brook segment. Base map is 2003 aerial photograph (National Agricultural Imagery Program).*

**Segment B**

Segment M36-B extends from the Branch Brook confluence (location as depicted on the VHD) downstream nearly to the Fox Lane bridge crossing. Encroachments along the valley include Route 103 which is elevated above the valley floor on fill materials. This major State route was constructed sometime prior to 1977, based on review of historic aerial photographs. This encroachment reduces the valley width somewhat; in Segment B the valley confinement is reduced from Very Broad to Broad.

A mostly linear planform suggests historic channelization of the Black River through this segment. The Ludlow annual report (year ending 1973) indicates "stream cleaning" following the 1973 flood in vicinity of the Branch Brook. Based on review of aerial photographs, the Okemo Valley Golf Club was developed on previously agricultural lands sometime between 1939 and 1977 within the LB corridor. Comparison of 1994 to 2003 aerial photographs shows that the golf course more than doubled in size between 1994 and 2003 – extending further to the north and east of the Branch Brook confluence and south of Fox Lane. Buffer widths along the LB of the Black River were substantially reduced as a result of this expansion. (A narrow, paved golf

course path was indexed as an improved path, while the paved club house access road was indexed as a road using the Feature Indexing Tool).

Water is withdrawn from the Black River and directed to an irrigation pond just north of Fox Lane (Figure 8). The size of this pond increased between 1994 and 2003. This withdrawal - indexed as small under Step 4 of the Phase 2 protocols - is expected to be seasonal, as irrigation piping was observed to be dismantled during a November 2007 survey of the reach.



*(a)* *(b)*

*Figure 8. Irrigation withdrawals from Black River reach M36 (Segment B) direct water to an irrigation pond at the Okemo Valley Golf Club. (a) upstream withdrawal point; (b) supplemental (?) withdrawal approximately 200 feet downstream. 27 August 2008. Given the proximity of these two withdrawal points and the fact that they appear to both be directed to the same irrigation pond, they were indexed as one single withdrawal.*

A cross section was completed mid-segment, indicating a gravel-dominated C-riffle/pool stream type, with good floodplain access ($IR_{RAF}$ = 1.0). However, caution should be applied when interpreting these cross section measurements, as the channel appears to be carrying approximately two-thirds of the Black River main stem flow, since a portion of the flow has been "pirated" from this segment by the Branch Brook tributary. Given the unusual flow status in this Segment M36-B, a Rapid Geomorphic Assessment and Rapid Habitat Assessment were not completed.

**Segment A**

Segment A of reach M36 extends from the Fox Lane bridge crossing downstream to the Dug Lane crossing. The unconfined valley setting indicates a reference C-riffle/pool stream type. Encroachments along the valley include Route 103 which is elevated above the valley floor on fill materials. This encroachment reduces the valley width somewhat, but in Segment A the reduction in valley width is not significant enough to change the confinement (Broad). Fox Lane Road crosses the channel at the upstream end of Segment B, providing access to the Okemo Valley Golf Club. The span of the Fox Lane bridge crossing (79 ft) is approximately 98% of the measured bankfull width (80.3 ft), suggesting that it is a slight constrictor of the bankfull flow.

As noted under Segment B above, the Okemo Valley Golf Club was expanded in aerial extent between 1994 and 2003 – along a 1500-foot length of the Black River channel south of the Fox Lane bridge crossing. Buffer widths along the LB of the Black River were substantially reduced as

a result of this expansion. Occasionally, where the channel impinges upon the high glaciofluvial terrace that supports the golf course, channel armoring was noted – consisting apparently of rounded cobbles and coarse gravel that appear to have been tossed over the bank (possibly during construction of the golf course (Figure 9). Several dozen golf balls were retrieved from the Black River channel and side bars in an informal "clean up" effort as the assessors proceeded downstream.

According to records maintained at the VT Water Supply Division, the Black River channel flows through the Source Protection Area (SPA) for the Black River Overlook water system (WSID #20618). A shallow gravel well is located along the west side of the Black River and the SPA for this well includes an area of 200-foot buffer along the river for the full length of reach M36 (SMRC, 2007).



*Figure 9. Armoring View upstream 1 October 2007.*

A mostly linear planform, and proximity of agricultural fields (now fallow) along the RB, suggest historic channelization of the Black River through this segment. The Ludlow annual report (year ending 1973) indicates "stream cleaning" following the 1973 flood along the Black River main stem. The channel is often "pinned" against the LB high terrace.

A cross section completed mid-segment confirmed a gravel C-riffle/pool channel. For a short section near the downstream end of the segment, a plane-bed form separated by a couple of very deep pools was evident as the channel transitioned into the next reach. Despite extensive historic channelization, the channel appears to have good access to the floodplain along RB ($IR_{RAF}$ = 1.0). Historic incision may have been moderated by cohesive materials in the bed and banks, as well as maintenance of forested buffers (LB). It is also possible that historic incision was offset by aggradation occurring during flood events. There is a substantial natural constriction of the Black River valley where the channel transitions from this Broad valley setting into a Semi-Confined (bedrock-controlled) valley in downstream reach M35, where channel confinement has been enhanced by close encroachment of roads along both banks.

A moderate degree of planform adjustment was evident in segment M36-A, including slight meander extension and multiple active flood chutes. A low-flow secondary sinuosity was noted. The cross section was captured local to a flood chute, which contributed to the somewhat elevated W/D ratio (34) recorded at this site. Otherwise, signs of active widening were not prevalent. Occurrence of side bars (less than one-half bankfull height) and an occasional diagonal bar indicated that minor to moderate aggradation is occurring. Upstream erosion on the

Branch Brook including the pre-1994 avulsion, may be a source of sediment to this segment. Segment M36-A still has a relatively low overall sinuosity with a planform that has appeared generally the same on recent aerial photographs (1980, 1977, 1939).

Segment M36-A was ranked in the "Good" quadrant of the RGA, reflecting the minor to moderate degree of adjustment. A CES of IIc[D] was inferred, as the apparent boundary conditions of the channel have resisted channel degradation, and dominant adjustments are instead occurring laterally. Nevertheless, the segment has been converted to a more transport-dominated condition by the historic channelization. The channel may persist for quite a long time in stage IIc[D] due to the cohesive banks, and somewhat limited sediment supply (due to upstream impoundments on the Black River main stem).

**M35**

Reach M35 is a short section of the Black River channel closely confined on either side by a bedrock-controlled narrowing of the valley. Glacial till along RB and high glaciofluvial terraces along LB (USDA) comprise the natural valley walls surrounding the channel. A reference stream type of gravel-dominated Bc riffle/pool channel is inferred from the valley setting.

Close encroachment by roads along 97% of the channel length (Route 103 along RB and Dug Road along LB) has reduced the valley confinement from Semi-confined to Narrowly-confined. The Dug Road bridge crossing near the upstream end of the reach is an estimated bankfull constriction; the measured span (52.4 ft) is 57% of the measured bankfull width (91.8 ft). Limited residential development is present along RB near the downstream end of the reach (on the far side of Route 103). Three stormwater inputs were indexed along the RB in reach M35; significant deposition of fine to medium gravels and sands was noted at the confluence of one of these stormwater channels (Figure 10).



*Figure 10. Deposition of fine to medium gravel sediments at RB confluence of stormwater channel directed through a culvert under Route 103. 1 October 2007.*

In 1994, a snowmaking pond was constructed high on the glaciofluvial terrace outside the LB corridor; this pond was expanded in aerial extent in 2004. The capacity of this pond is approximately 154.5 million gallons (VTANR Land Use Permit Project Summary). Water stored in this pond supports snowmaking operations at Okemo Mountain ski resort, and is withdrawn from the Black River (reach M34). Records of the VT Water Quality Division Stream Alteration Engineer note an Okemo Mountain utility crossing within reach M35 - presumably associated with the Okemo snow-making pond (SA-1-0182, 4/28/1994; Nicholson, 2007).

A cross section performed mid-reach indicated a gravel-dominated Bc-plane bed stream type. A narrow floodplain is present along LB for much of the reach, and the channel appears to have access to this floodplain (estimated $IR_{RAF}$ = 1.0). Route 103 is elevated above the channel in the RB corridor at an approximate height of 3.3 times the bankfull depth; rip-rap armoring is extensive along this RB. Dug Road is elevated above the LB floodplain at an approximate height of 2.8 times the bankfull depth. The available floodplain in the LB corridor is generally less than one channel width, and has been encroached upon to some degree by fill material for Dug Road.

Pebble count results suggest that the bed surface sediments are at or below the bankfull threshold for mobility. Also a slight bi-modal pattern of sediment distribution is apparent, with an increase in coarse sand sediments (approximately 1 mm). This may be related to stormwater inputs within the reach and/or to transient beaver dam activity (a partially-channel-spanning beaver dam was observed on 1 October 2007).



*(a)* *(b)*

*Figure 11. View downstream of Dug Road bridge (a) at moderate stage – 1 October 2007; (b) near bankfull stage – 27 November 2007.*

Reach M35 appears dominated by a moderate degree of aggradation and associated widening that have resulted in a plane bed morphology and a somewhat high W/D ratio (36.4). Moderate aggradation is suggested by the filling of pools, and prevalence of runs over riffles. No significant depositional bars (other than a "delta" of fine sediments from a stormwater input) were noted in the reach, which may be a function of the linear planform largely controlled by closely-confining, bedrock valley walls. Valley confinement has also been increased by encroaching roads on either bank. Lateral and vertical adjustments of the channel may have been moderated by extensive bank armoring (especially RB) and the cohesiveness of bank sediments. Also, the river network at this location may be somewhat sediment-supply-limited due to the natural and human impoundments in upstream reaches. Reach M35 was ranked in the "Good" quadrant of the RGA, reflecting the overall minor to moderate degree of active lateral and vertical channel adjustments. A B4c channel in the "Good" quadrant is assigned a "High" sensitivity by protocols. A CES of I [F] was inferred.

**M34**

Reach M34 of the Black River extends from the fire house just north of the Okemo Marketplace to the Jewell Brook (M33T3) confluence. From the valley pinch point in upstream reach M35, the natural floodplain opens to a Broad confinement, filled by alluvial and glaciofluvial sediments. A reference C-riffle/pool stream type is inferred.

Route 103 passes parallel to the channel along the right corridor, and commercial development has grown in the RB corridor over recent decades. As recently as the 1980s, this RB corridor was generally undeveloped, with the occasional residential or commercial building close to Route 103. Wetlands (mapped by NWI and VSWI) were apparently filled and two shopping plazas were constructed in the RB flood plain of the river at the upstream and downstream ends of the reach. A smaller pocket of wetlands remains between the two plazas, contiguous to the channel. The reference valley width, estimated to range from 550 to 1100 feet (average Broad confinement), has been reduced to an estimated 150 to 470 feet (average Semi-confined status) as a result of the floodplain encroachments in the RB corridor.

Channelization is inferred from the straightened planform. The channel had some degree of sinuosity (see Figure 12) as observed on 1939 aerial photographs. However, the prominent meander observed in Figure 12 was cut off some time between 1939 and 1977, as the channel was straightened. A boulder/cobble berm is present along the RB spanning this meander cut-off site. This RB berm is at an approximate thalweg height of 12 feet and secures the channel in a straightened planform against the LB valley wall which is a high (20 ft) glaciofluvial terrace. A double row of berms is also present along RB further upstream east of the Okemo Marketplace at an approximate thalweg height of 12 and 14.5 feet, respectively.

Stream Alteration Permit records indicate that gravel was extracted from the Black River "across from Jewell Brook" (at the downstream end of reach M34) in 1992 (Project ID GR-1-0027; Nicholson, 2007). In addition, the Ludlow annual report (year ending 1973) indicates "stream cleaning" following the 1973 flood in the Black River main stem from Ludlow to Cavendish. Channel windrowing is inferred from this note and from the RB berms.

(a)

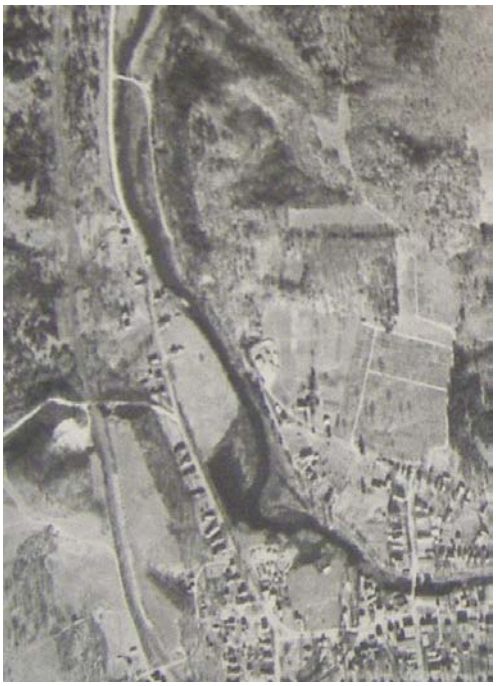
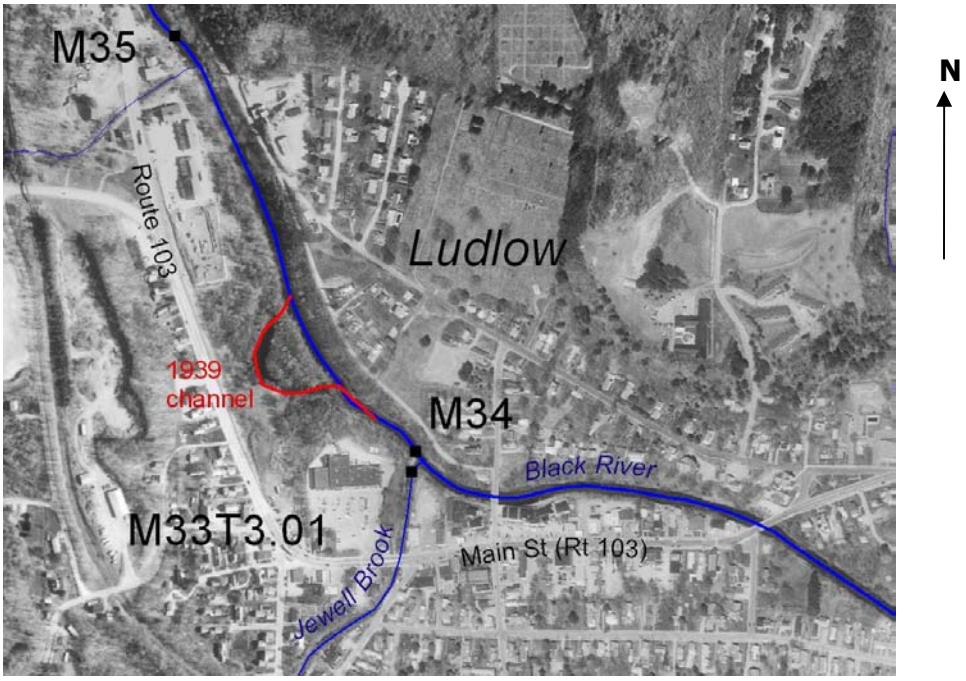


*Figure 12. (a) (left) Black River planform through Ludlow, reach M34, 1939.*

*Comparison to Figure 12b (below), shows that the right-bank corridor along reach M34 was less intensively developed than now. Also, residential development northeast of High Street on the LB terrace was less dense.*

*(b) (below) Post-1939 channelization of the Black River (Reach M34) along Route 103 just upstream of the present Shaws supermarket, Ludlow. Base map image is dated 1994.*

(b)



A water withdrawal site is located in reach M34 behind the shopping plaza off Route 103 in Ludlow. This water withdrawal site supports snow making at Okemo Mountain Ski Resort and has been in use since 1988 (LUP 2S0351-12F Project Summary; Nicholson, 2007: Stream Alteration Permit, SA-2-0161, 1986). In early years, water was pumped to the West Hill Reservoir for storage. Land Use Permits in effect at the time (#2S03351-12 and #2S0351-12A-EB) permitted a maximum withdrawal rate of 3,000 gallons per minute (gpm), and required that a minimum flow was maintained in the Black River downstream of the intake – specified as 0.78 cubic feet per second for each square mile of upstream drainage area (csm). In 1994, a 73-million-gallon capacity storage reservoir – the Okemo Snow Pond - was built on the hillside east of the Black River just north of Ludlow village (reach M35), and a portion of the water withdrawn from Black River was directed to this pond. Land Use Permit #2S351-24 (issued in June 1994) allowed an increase in the withdrawal of water from the Black River at a maximum rate of 11,000 gpm, and required an adjustment in the conservation flow (February Median Flow) to 0.8 csm. During expansion of the Okemo Mountain ski resort to Jackson Gore, permit amendments allowed water withdrawal direct to the mountain (still at a maximum withdrawal rate of 11,000 gpm) with the conservation flow set at 0.8 csm. In 2004, Okemo expanded the snowmaking pond to a capacity of 154.5 million gallons (14.5 acres).

The total seasonal water demand for snowmaking at Okemo Mountain ski resort is 520 million gallons (LUP 2S0351-24B Permit Summary, issued January 2004). The maximum withdrawal rate (11,000 gpm) represents approximately 1.8% of the total estimated flow of the river at this point during a bankfull event (1,330 cubic feet per second, or 597,000 gpm) based on VT Regional Hydraulic Geometry Curves (VTDEC, 2001).



*Figure 13. Water withdrawal intake structure for Okemo Mountain snow making located on the Black River (reach M34). An inflatable dam/ weir and flume apparatus for monitoring flow rates on the Black River during snowmaking withdrawals is located approximately 150 feet downstream of this intake structure (see Figure 14). Dam not inflated on date of observation, 1 October 2007.*

In June 2004, a Land Use Permit (2S0351-12F) was issued to Okemo, LLC to permit installation of an instream flow monitoring structure on the Black River behind the Okemo Marketplace off Pond Street (Route 103) in Ludlow. Constructed in 2005, this structure is comprised of an inflatable rubber bladder constructed on a concrete foundation (weir) adjacent to a ten-foot-wide Parshall flume. When the bladder is fully inflated, its top elevation is approximately two feet above the concrete foundation, which itself is more or less flush with the upstream channel bed. Permanent sheet piling was installed along both banks to ensure that all water in the Black River channel (below normal high water mark) is diverted through this weir/flume structure. To monitor flow rates during the snowmaking season (November 1 through March 31), the bladder

is inflated, deflecting flows (and sediment) through the Parshall flume. "In times of exceptionally high flow conditions during the snowmaking season, as well as during the non-snowmaking season, the bladder [is] deflated" (LUP 2S0351-12F, p. 5). According to documents attached as exhibits to the Act 250 application "the structure would be designed so that the rubber dam is automatically deflated during episodes of elevated discharge greater than the 2-year peak discharge event" (Redondo, 2004). When the bladder is deflated, flow (and sediment) moves through the reach largely un-impeded. For purposes of this Phase 2 stream geomorphic assessment (and Phase 1 updates), the inflatable bladder / weir structure was indexed as a "dam" – small, run-of-river structure, with Low impact.



*Figure 14a. Inflatable bladder /weir and flume for measurement of Black River flows associated with Okemo Mountain snow making project. Located on the Black River (reach M34) in Ludlow. Dam not inflated at time of observation, 29 May 2006. View to northeast from RB.*

*Figure 14b. Inflatable bladder /weir and flume; bladder (dam) inflated at time of observation, some spillage over the dam/weir evident.*
*View upstream from RB.*
*8 November 2007.*



Stormwater inputs indexed along reach M34 included:

- a road culvert along LB which directs stormwater under High Road and has formed a shallow gully with associated minor sediment inputs to the Black River just downstream of the weir / flume structure; and
- a RB channel which directs overland flow from the Shaws parking lot, and has developed into a moderately-sized gully with an associated "delta" of fine to coarse gravel sediments (see Figure 15).



*Figure 15. RB stormwater channel from commercial plaza near downstream end of reach M34 has developed into an erosional gully that has deposited gravels and sands in the Black River channel, 8 November 2007.*

One beaver dam was observed near the downstream end of the reach on 1 October 2007, and was impounding flows for approximately 150 feet of the upstream channel. This dam is likely to be washed out in a moderate flow.

A cross section was completed near the upstream end of the reach. The designated "recently-abandoned floodplain" (RAF) elevation corresponds to a narrow strip of floodplain between the channel and the RB berm. This RAF may have been modified (reworked) over time during post-flood recovery work (windrowing, "stream cleaning"). At the cross section site, this RAF corresponds to a calculated $IR_{RAF}$ of 2.25. Thus, the channel has undergone a vertical stream type departure from C3 to F3. A weak riffle/pool bedform dominates, although pools are mostly dominated by runs.

Incision is estimated as historic in nature due to the absence of features which might suggest active incision. Tree roots exposed along the undercut banks are old and decaying. It is possible that incision occurred in this reach in the 1970s during flooding and following reported channelization and stream cleaning in this and downstream reaches after the 1973 flood (and as a result of channel management following the 1927 and 1936/1938 floods). It is also possible that historic breaching of the dam at the Ludlow Woolen Mill in reach M33 contributed to incision in reach M34. A weak cobble and coarse gravel riffle/pool bedform dominates, although there are sections of the channel where plane bed form is present. Minor widening is indicated by a modest width/depth ratio (27), and a bankfull width only marginally larger than regime. Widening in response to past channelization and incision may have been moderated by the maintenance of forested buffers (especially along LB) and presence of RB streambank armoring and berms. Minor aggradation is suggested by the presence of a few transverse bars and side bars. Overall, the reach was rated in the "Fair" quadrant of the RGA given the historic incision that resulted in a vertical stream type departure and the minor to moderate degree of active lateral and vertical adjustments. An Extreme sensitivity was assigned

due to the STD. The channel in reach M34 persists in an entrenched condition – an inferred channel evolution stage of II [F]. As such, it is highly susceptible to catastrophic erosion in future high flow events.

**M33**

Reach M33 flows through a wide alluvial valley of Broad to Very Broad confinement marked by a steep bedrock-controlled left valley wall and a glacio-fluvial terrace along the right corridor. Beyond this RB terrace to the south is a matching bedrock-controlled steep valley wall marking the southern extent of the Black River valley.

Over time, Route 103 and several smaller residential streets through the village of Ludlow have encroached within the floodplain of the Black River. Residential and commercial properties are densely developed within the LB and RB corridors. There is a long history of industrial and mill development utilizing dams on the Black River (and Jewell Brook) and canals of water diverted from both channels (Sanborn Fire Insurance Maps, 1885). Channelization is inferred from the linear planform and extensive streambank armoring. Fill material is inferred along the reach (especially in the upstream half) and the original floodplain elevation has likely been disturbed by decades of construction, sediment reworking and urban fill.

Encroachments and development within the floodplain are more dense in the upstream half of reach M33, and have contributed to a greater degree of channel entrenchment in the upstream half. Therefore, the reach was segmented to capture this difference in entrenchment status:

- Segment B: 3,796 ft, 0.2% gradient, $IR_{RAF}$ = 2.0
- Segment A: 4,053 ft, 0.4% gradient, $IR_{RAF}$ ranging from 1.3 to 1.9.

**Segment B**

Segment M33-B extends from the Jewell Brook confluence downstream through Ludlow village to a point just below the Mill Street bridge crossing (Figure 16). The LB valley wall (for purposes of defining the reference stream type) is a high glacio-fluvial terrace that is coincident with the LB upstream of the Main Street bridge and pulls away from the channel to follow Main Street in the downstream half of the segment. To the south, in the RB corridor, the channel is confined by a steep, forested, bedrock-controlled valley wall. The Black River channel impinges on this RVW near the downstream end of the segment. A reference stream type of C-riffle/pool is suggested by this Very Broad confinement.

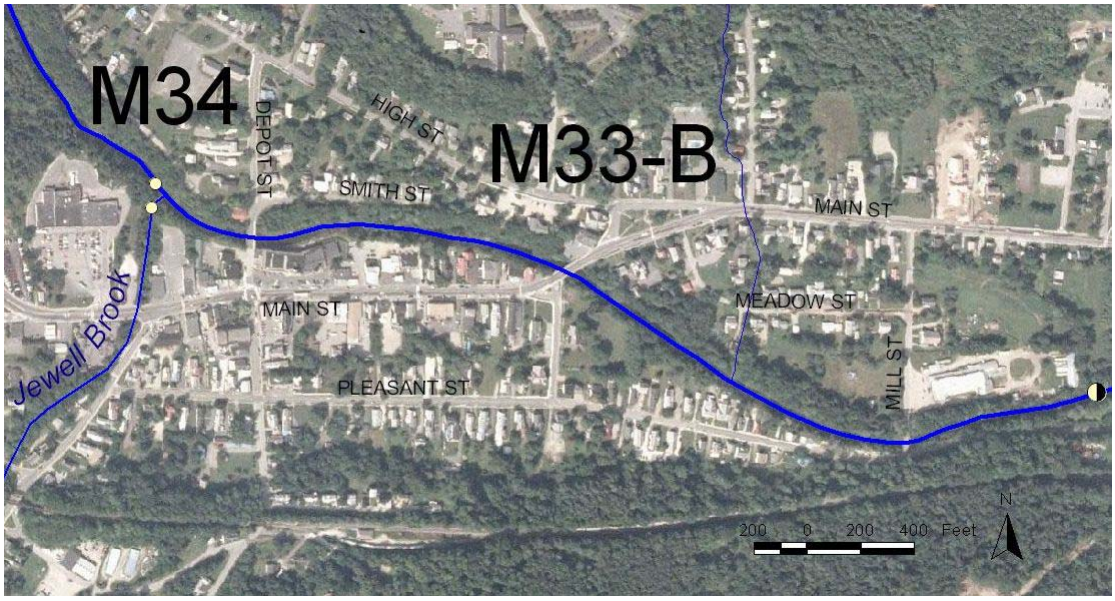



*Figure 16. Segment M33-B of the Black River main stem through Ludlow village.*

Over recent centuries, residential, commercial, municipal and industrial developments have encroached along the channel. Main Street (Route 103) crosses the segment at the mid-point; the span of this bridge is a bankfull constriction. A network of secondary roads fills the floodplain elsewhere in the segment, and includes the Depot Street bridge crossing at the upstream end (flood-prone-constrictor), and the Mill Street bridge crossing at the downstream end (bankfull- constrictor). Channelization is inferred from the linear planform and close encroachments. "Stream cleaning" following the 1973 flood was noted in Ludlow annual reports; similar channel management is suspected following previous large floods including the 1927 and 1936/1938 floods. Armoring (including rip-rap, vertical concrete retaining walls, and concrete crib walls) lines both banks of the channel upstream of the Main Street crossing. A quick cross-section measurement in this area indicated a 67 ft span between reinforced banks – approximately 79% of the reference channel width (85 ft). Rip-rap armoring is also extensive along both banks downstream of the Main Street bridge. Gravel berms, sometimes in double rows, are present along the LB downstream of the Main Street crossing. Often the thalweg height of these berms is lower than the adjacent floodplain. Possibly these "berms" represent dredging spoils from flood recovery efforts following the 1973 flood (or later flood events). It is also possible that these features are associated with a former raceway that directed flows above a historic dam near the Mill Street crossing to mills along the LB (Sanborn Fire Insurance Map, 1921).

Two historic dams were present in Segment B in the 1800s and early 1900s and would have impounded Black River flows and sediments during their operation:

- The Ludlow Woolen Mill dam just below the Depot Street bridge provided water power to the mill operations from some time prior to 1869 (Figure 17). This mill was later occupied by General Electric Co from c. 1928 through the 1970s. This dam is no longer present on the Black River channel. As of this reporting, the exact date of the dam breaching is not known.

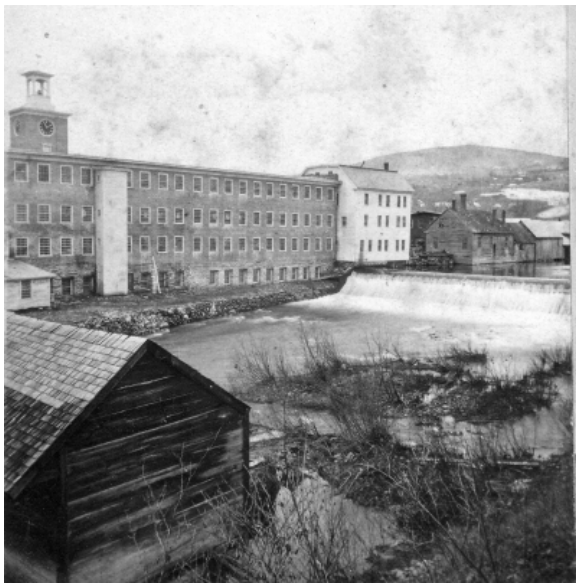


*Figure 17. Historic dam at Ludlow Mill just downstream of Depot Street bridge crossing.*

*Source: Perkins Landscape Change web page.*

- Old dam remnants are visible just below the Mill Street bridge (Figure 18). A dam was present in this general location on 1905 and 1921 Sanborn Fire Insurance Maps, but absent on the 1928 update of these maps, suggesting that this dam may have been breached in the 1927 flood. Manufacturing interests associated with this dam and the mill buildings in the LB corridor included the Black River Woolen Company (1905 & 1921 Sanborn), Woolart Mills Inc. (silk carding & spinning; 1928 Sanborn); Ludlow Manufacturing Co. (late 1880s; Black River Tribune, 1990); and toy manufacturing companies (1870s; Black River Tribune, 1990).



*Figure 18. Remnants of historic dam below Mill Street bridge crossing, 1 October 2007. This dam remnant was indexed as a grade control, but is not expected to have significant impoundment effects or disrupt sediment continuity to a significant degree.*

A large "delta" of coarse gravel and cobble sediments was observed at the Jewell Brook confluence along LB near the upper end of Segment M33-B. As noted under reach M34, sediment has periodically been extracted from the channel at this location. Several dams were once operational on the Jewell Brook (1905, 1921 Sanborns) and were washed out in previous large floods, including the 1850 freshet and the 1927 flood (Harris, 1949). The Jewell Brook was not assessed as part of this study, but continuing adjustments along this tributary appear to be an ongoing source of sediment to the Black River main stem.

A second "delta" was observed at the confluence of a LB ephemeral tributary which joined the channel downstream of the Main Street crossing. This unnamed tributary drains steep slopes along Commonwealth Avenue to the north of the village and passes through residential and agricultural properties, receiving

stormwater runoff from this road and several intersecting driveways. Several direct stormwater inputs were indexed in segment M33-B, including drain pipes that extended through retaining walls and streambank armoring along the RB upstream and downstream of the Main Street crossing.

A cross section was completed between the Main Street bridge and the Mill Street bridge. The intensively managed channel has a bankfull width (58.5 ft) that is substantially narrower than regime. This factor, combined with a somewhat deeper-than-regime bankfull depth yields a low W/D ratio (18.9). The designated "recently-abandoned floodplain" elevation along LB has likely been modified over time during post-flood recovery work (windrowing, "stream cleaning") and construction of a raceway leading toward the former Black River Woolen Company mill buildings. An incision ratio ($IR_{RAF}$ ) of 2.0 was calculated, indicating a vertical stream type departure from C3 to F3 stream type. A plane bed form dominates.

Incision is estimated as historic in nature due to the absence of features which might suggest active incision. It is possible that incision occurred in this reach in the 1970s during flooding and following reported channelization and stream cleaning in this and downstream reaches after the 1973 flood (and as a result of channel management following the 1927 and 1936/1938 floods). It is also possible that historic breaching of the dam at the Black River Woolen Company Mill near the Mill Street crossing contributed to incision in segment M33-B. Minor widening is indicated by a very low width/depth ratio (18), and a bankfull width (58.5 ft) significantly narrower than regime. Widening in response to past channelization and incision may have been moderated by the presence of streambank armoring and maintenance of forested buffers (especially along LB). Minor aggradation is suggested by the presence of two side bars and one mid-channel bar. Overall, the reach was rated in the "Good" quadrant of the RGA given the minor to moderate degree of active lateral and vertical adjustments despite historic incision that resulted in a vertical stream type departure. An Extreme sensitivity was assigned due to the stream type departure. Like upstream reach M34, the channel in segment M33-B persists in an entrenched condition – an inferred channel evolution stage of II [F]. As such, it is highly susceptible to catastrophic erosion in future high flow events.

**Segment A**

Segment M33-A extends from the Mill Street bridge crossing downstream to just below the Ludlow wastewater treatment facility (Figure 18). The valley is defined along the LB by steep, forested, till-mantled bedrock slopes and along the RB by a high glaciofluvial terrace. Further to the south of this high terrace, beyond Pleasant Street Extension, is a steep, forested slope of shallow till over bedrock. The natural valley confinement ranges from Broad to Very Broad, indicating a C-riffle/pool reference stream type.

Main Street has encroached upon the valley to a degree along the LB corridor, reducing the average valley confinement from Very Broad to Broad. Near the downstream end of the segment, Main Street is coincident with LB for a short section. Pleasant Street Extension crosses the channel in the downstream half of the segment; the measured span of this bridge (130 ft) includes an overflow area to the north (LB) of a mid-span pier. A small delta of gravels was noted at the confluence of an unnamed LB tributary that joins the Black River main stem in vicinity of this bridge span.

Residential and commercial development has filled the floodplain along the LB corridor, and commercial and municipal development has occurred within the RB corridor near the downstream end of the segment. Modifications of the channel planform occurred after 1939 and prior to 1983, cutting off a former meander bend, and channelizing the river to accommodate the Ludlow wastewater treatment facility (WWTF) (see Figure 19). Records of the Stream Alteration Engineer (Nicholson, 2007) note a 90-ft sewer line crossing within this segment (SA-1-0504, 4/24/2004) and a sewage syphone / utility crossing (SA-2-0238, 8/3/1990). A concrete vault is located mid-channel next to the WWTF; this is the point of discharge for treated sewage to the Black River. According to Discharge Permit #93-1208 and Land Use Permit #2S0839-2, the capacity of this WWTF was upgraded from 700,000 gallons per day (annual average) to 1,050,000 gallons per day in 2003. This new permitted discharge amounts to less than one tenth of one percent of the estimated

bankfull discharge of the Black River at this location (1,660 cfs, or 1,072 million gallons per day, based on VT Regional Hydraulic Geometry Curve data, VTDEC, 2001).

"Stream cleaning" following the 1973 flood is noted in the Ludlow annual report. Similar channelization/ windrowing/ berming likely followed the 1927 and 1936/1938 floods. A very linear planform is evident in the 1939 photograph in Figure 19a. Berms are evident along discrete sections of the LB, protecting residential and commercial properties, and along RB on approach to the Pleasant Street Extension bridge crossing. Streambank armoring was indexed along approximately 80% of the LB and 63% of the RB.

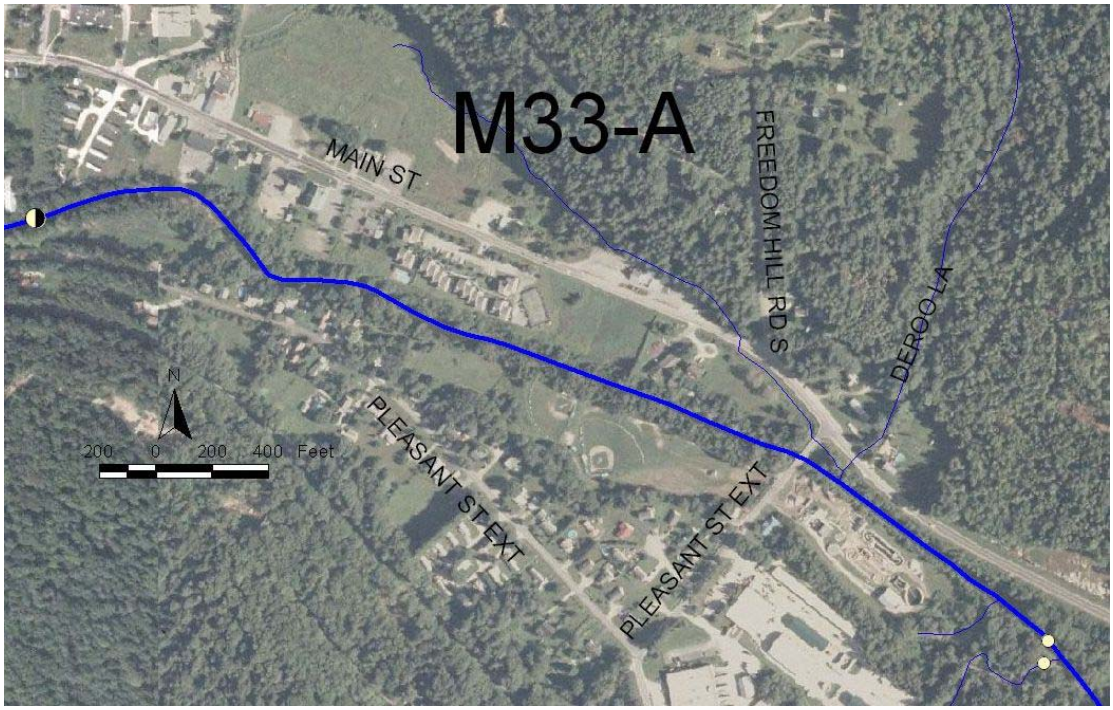



*Figure 18. Segment M33-A of the Black River main stem downstream of Ludlow village.*

For a short section of Segment M33-A (approximately 200 ft) adjacent to the Ludlow WWTF, the channel is constricted between armoring along the LB at the base of Main Street and fill/armoring along RB. The measured approximate channel width (42 ft) is only 49% of the reference channel width for the reach (85 ft). Therefore, this location was indexed as a channel constriction. This constriction of the channel at the WWTF, the somewhat undersized Pleasant Street Extension bridge, and the source of tributary sediment ("delta") from the LB at this crossing have combined to create a localized area of aggradation (steep riffle) immediately upstream of this bridge crossing. Given the markedly reduced channel capacity in this short section alongside the Ludlow WWTF, this is a likely site of avulsion and/or debris jam in a future flood.

A cross section measured across from the recreational fields at the mid-point of Segment M33-A was representative of the segment and indicated a moderate degree of historic incision ($IR_{RAF}$ = 1.34). Incision is estimated as historic in nature due to the absence of features which might suggest active incision. It is possible that incision occurred in this reach in the 1970s during flooding and following reported channelization and stream cleaning in this and downstream reaches after the 1973 flood (and as a result of channel management following the 1927 and 1936/1938 floods). It is also possible that historic breaching of the dam at Smithville (approximately 1,500 feet downstream in reach M32) contributed to historic incision in Segment M33-A.

A narrower-than-regime bankfull width (67.9 ft) and somewhat deeper-than-regime bankfull depth contribute to the low W/D ratio (19.6). The cross section of the channel has been modified by a long history of channelization, dredging, berming and armoring. Widening and planform adjustments appear to have been moderated by the presence of extensive streambank armoring, occasional berms, and maintenance of narrow but continuous tree buffers. A plane-bed form dominates the overall segment, and the reference riffle/pool bedform is inferred to have been historically altered due to repeated, post-flood "stream cleaning". Three steep riffles were noted in the segment, as well as one diagonal riffle, one side bar and one point bar. This moderate degree of aggradation is especially evident upstream of constrictions and moderate bends in the channel planform.

Overall, the reach was rated in the "Fair" quadrant of the RGA given the minor to moderate degree of active lateral and vertical adjustments. A Very High sensitivity was assigned, following protocols. Like upstream reach M34 and segment M33-B, the channel in segment M33-A persists in a partially incised and entrenched condition – an inferred channel evolution stage of II [F]. M33-A would appear to have more ready access to the floodplain in higher-stage flows than the entrenched upstream segments.

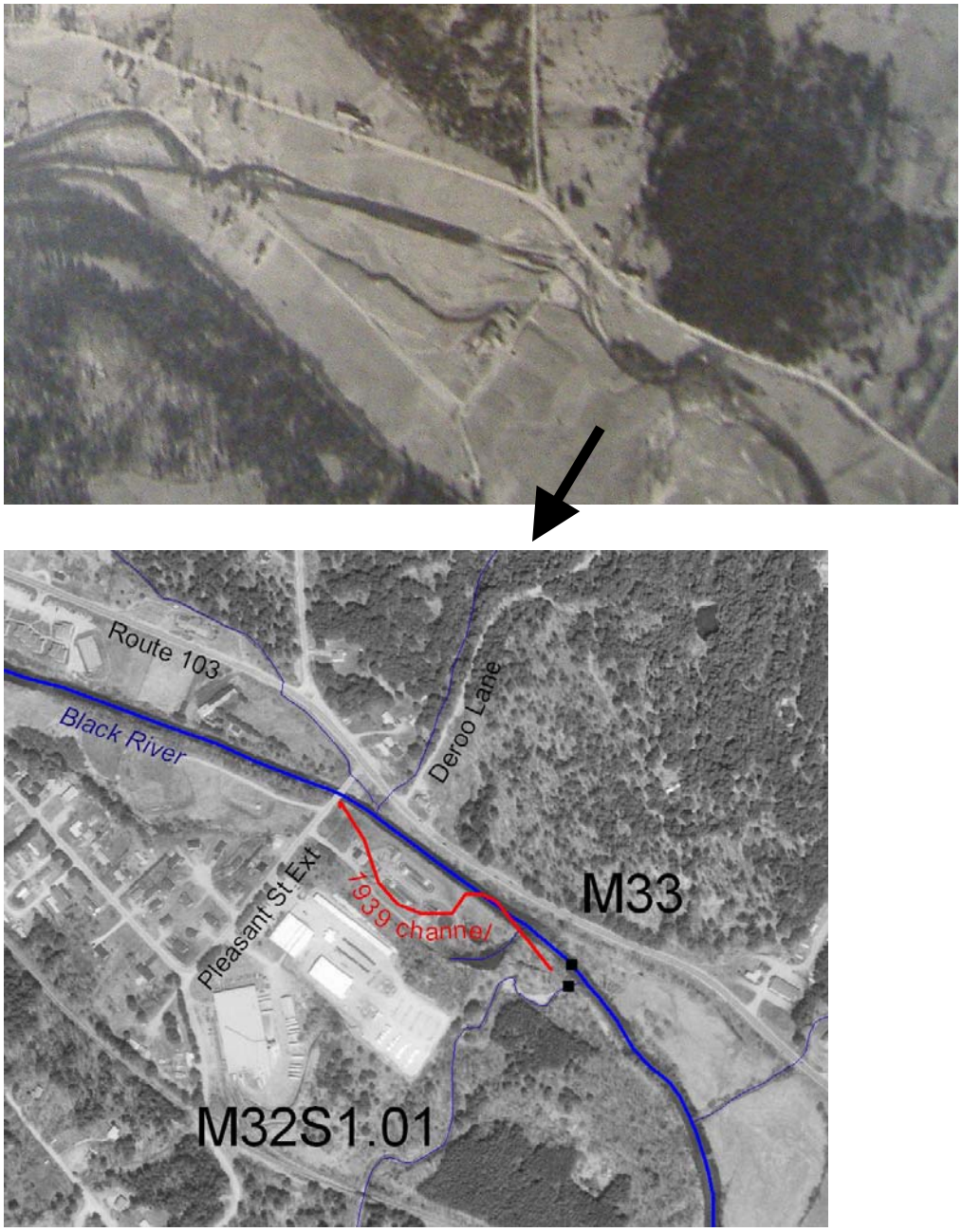



*Figure 19. Post-1939 channelization of the Black River (Segment M33-A) along Route 103 in the area of the present-day wastewater treatment plant, Ludlow, Vermont. (a) (top) is Segment M33-A in 1939; (b) (bottom) is same location in 1994. Review of the 1939 aerial photograph also highlights the considerable degree of floodplain development that has occurred over the last 70 years.*

**M32**

M32 is a 2.3-mile reach which begins near the Ludlow WWTF, crosses into the town of Cavendish near Fletcher Fields, and ends just downstream of the Route 103 bridge crossing in Proctorsville. The Black River valley is broadly defined by steep, forested, bedrock-controlled slopes to the north and south of the channel. Within the valley are high glaciofluvial terraces and lower terraces comprised of alluvial sediments. For purposes of defining the reference stream type, a Phase 1 valley wall was delineated along the high glaciofluvial terraces and occasionally along the base of the till-veneered valley side walls. This reference valley wall defines a valley confinement ranging from Narrow (4 to 6 times the channel width) to Very Broad (greater than 10 times channel width). A reference C-riffle/pool stream type is inferred from this valley setting. Hydric soils are mapped adjacent to the channel at the very upstream end of the reach and in the downstream half of the reach. Limited wetlands (NWI, VSWI) are also mapped in these areas. Bedrock is exposed along the RB at the mid-point of the reach.

In recent centuries, the Black River floodplain has been encroached upon by roads, and the Green Mountain Railroad. Route 103 follows along the LB corridor and reduces the floodplain width especially in the downstream half of the reach. Three bridge crossings are located in the reach, including East Hill Road near historic Smithville (bankfull-constriction), Winery Road (bankfull-constriction), and Route 103 in Proctorsville (flood-prone-width-constriction). In addition, a pair of bankfull-constricting abutments for an apparent former bridge were indexed in the reach, approximately 625 feet upstream of the railroad crossing. Railroad construction in the Ludlow area began in 1848 and was finished by 1850 (Harris, 1949). Generally, the railroad is elevated above the flood prone width of the Black River channel high on the RB valley wall, except for the vicinity of the railroad bridge crossing in Proctorsville. The railroad bridge crosses the channel at an oblique angle with a mid-span masonry pier; this crossing is a flood-prone-width constrictor. Sediment deposition was noted upstream and downstream of this railroad crossing. Road and railroad encroachments within the reach have reduced the valley confinement from Broad to an average of Narrow (ranging from Semi-confined [locally] to Broad).

Residential and commercial development has also filled the floodplain to a degree along reach M32. Sand and gravel quarrying is occurring in the RB corridor downstream of the Winery Road crossing. Occasional short sections of rip-rap armoring were observed along either streambank. A short section of possible berm was noted along LB opposite Fletcher Fields. Channelization is inferred due to the linear planform. "Stream cleaning" following the 1973 flood was noted in the Ludlow annual report for that year – from Ludlow to Cavendish. The channel has a very similar planform as depicted in a 1939 aerial photograph, with the exception of the vicinity of the Winery Road intersection.

Sometime between 1980 and 1994, the Black River channel was modified to accommodate the straightening of Route 103 at the Winery Road intersection (Figure 20). The channel was shifted approximately 250 feet to the southwest and the Winery Road bridge crossing and intersection with Route 103 were shifted to the southeast. A channel section approximately 650 feet in length was shortened to approximately 475 feet. On approach to the Winery Road crossing, rip-rap has been installed along both banks and results in a constriction of the channel (a span of
42 ft, or 47% of the reference channel width). A steep riffle was observed upstream of this constriction and coincident with the sharp bend in the channel forced by the encroachment of Route 103 along the LB.

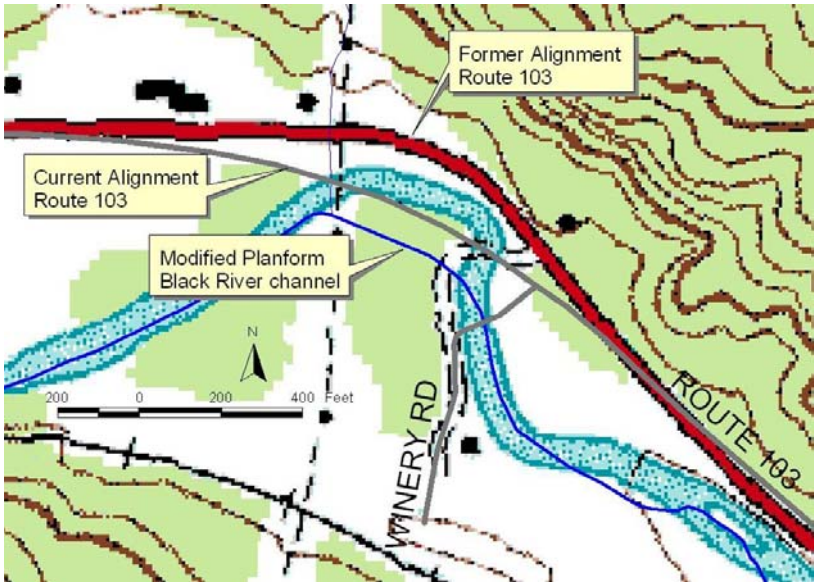



*Figure 20. Pre-1994, post-1980 modification of Black River channel to accommodate realignment of Rt 103. Flow is from picture left to picture right.*

*Base map: 1983 Ludlow, VT 7.5-Minute USGS topographic map.*

Historically, two impoundments were present on reach M32:

- A dam was present in the upstream third of the reach at Smithville. Remnants of the Smithville dam are visible in the stream bed and banks (Figure 21). A dam was present in this location from c. 1835 (Harris 1949) initially operating in support of a sawmill. Later restorations of this dam supported the Freeman Stone Company (1870s), and the Verd Mont Woolen Company which was in operation into the mid 1900s (Harris, 1949). A raceway was depicted leading from the dam toward manufacturing buildings at Smithville on the 1905 Sanborn map. Remnants of this diversion channel can be observed today behind the self-storage facility.



*Figure 21. Historic dam at Ludlow Mill just downstream of Depot Street bridge crossing. This dam remnant was indexed as a grade control, but is not expected to have significant impoundment effects or disrupt sediment continuity to a significant degree.*

- A dam or impoundment of some kind was formerly located near the downstream end of reach M32, downstream of the railroad crossing near Proctorsville. Presence of a historic impoundment here is suggested by the appearance of a substantial diversion channel leading eastward from this location toward mill buildings in Proctorsville – depicted on the Beers Atlas (1869) and visible on a 1939 aerial photograph (Figure 22). Laid-up stone abutments are present on either bank of the channel in this location; a span of 77 feet was measured. The LB abutment appears to have two holes (intakes?) at the

approximate bankfull elevation. If a dam was historically present at this location, it was probably a low-head construction, given the low elevation of these apparent intakes and the relatively limited impoundment width of the channel depicted on the 1939 photograph.




*Figure 22. Historic diversion channel from Black River main stem to Proctorsville. Apparent impoundment of the Black River channel is visible extending approximately 1400 ft upstream of this diversion channel inlet (picture left). 1939 aerial photograph.*

The history of channel disturbances in reach M32 appears to have resulted in slightly varying degrees of historic incision and vertical stream type departure revealed from three cross sections completed in the reach. The reach was segmented to capture these variations in condition.

- Seg C – 3945 ft, estimated gradient of 0.3%, reference C-riffle/pool departed to a Bc;
- Seg B – 2626 ft, estimated grad. of 0.3%, reference & existing C-riffle/pool, $IR_{HEF}$ = 1.7;
- Seg A – 5429 ft, estimated gradient of 0.3%, reference C-riffle/pool departed to a Bc.

It is possible that a higher density of cross sections in the reach would support delineation of additional segments. The towns of Ludlow and Cavendish may wish to perform additional Phase 2 or Phase 3 assessment of this reach to capture subtle differences in incision ratio, and active adjustment processes along the reach, at a site-level or property-level scale.

**Segment C**

Segment M32-C extends from the Ludlow WWTF downstream just past the East Hill Road bridge crossing. A cross section performed mid-segment indicated a cobble-dominated Bc-riffle/pool stream type, with an incision ratio of $IR_{RAF}$ = 1.7. This partly-incised channel has likely undergone repeated episodes of channel dredging and/or windrowing during post-flood recovery efforts (c. 1973, 1938, 1927?). Historic incision may also have been (in part) associated with operation of the dam at Smithville in the upper third of the reach. The cross section was located downstream of the dam, where historic incision may have been initiated by "hungry water" effects below the dam and its associated diversion channel. Upstream of the dam, historic incision may have occurred following breaching of the dam and local base-level changes.

It is possible that streambank and terrace (RAF) features have been modified by ice erosion (Black River main stem has been the location of historic ice jams – see Phase 1 report Appendix O). It is possible that channel boundaries and adjacent terraces have been regraded during reported channelization / windrowing following 1973 and 1938/1936 (and 1927?) floods. Local widening through bank slumping and erosion (or some combination of the above) has also occurred. The current channel form and degree of disconnection with the floodplain are the net result of multiple cycles of erosion, deposition, and channel management. The measured entrenchment ratio (1.88) is within the range (1.4 to 2.2) characteristic of a B stream type, indicating a C to Bc stream type departure.

The measured bankfull width (74.5 ft) is somewhat narrower than the regime bankfull width (90 ft) estimated for a channel of this watershed size. Widening and planform adjustments appear to have been moderated by the presence of somewhat cohesive streambank sediments, occasional streambank armoring, and maintenance of tree buffers along the RB. The reference riffle/pool bedform is inferred to have been historically altered due to repeated, post-flood "stream cleaning", but has recovered to a degree. Short, but regularly-spaced riffles are evident, but pools are infrequent and generally very shallow in depth. Five side bars, and one point bar, observed in the reach reflect a low-flow secondary sinuosity. One mid-channel bar and two diagonal riffles indicate a minor degree of aggradation.

Overall, the reach was rated in the "Fair" quadrant of the RGA given the minor to moderate degree of active lateral and vertical adjustments. A High sensitivity was assigned, following protocols. The segment has been converted from a reference meandering C-riffle pool status to a straightened, armored, undersized-width, transport-dominated, Bc riffle/pool channel with moderate incision. Like upstream segments, the channel in segment M32-C persists in a partially incised and entrenched condition – an inferred channel evolution stage of II [F].

**Segment B**

Segment M32-B spans Fletcher Fields and ends just upstream of the Winery Road bridge crossing. A cross section was completed mid-segment and indicated a C-riffle/pool stream type, consistent with reference, and a degree of historic incision ($IR_{RAF}$ = 1.35) which appears to have been locally enhanced by a low-relief berm along LB ($IR_{HEF}$ = 1.65). The cross section pebble count indicated coarse gravel in contrast to the other two cross sections in this reach which each had a dominant sediment size of small cobble. This Segment B cross section was located just downstream of a beaver dam that was breached between the original date of observation (2 October 2007) and the date of the pebble count (28 June 2008). It is likely that aggradation upstream of this beaver dam contributed to the dominance of coarse gravels, locally.

A history of channelization and dredging during flood recovery efforts appears to have converted this segment from a reference meandering C-riffle pool status to a straightened, transport-dominated, C-riffle/pool channel with moderate historic incision. Historic aggradation may have offset the degree of incision. Widening and planform adjustments appear to have been moderated by the presence of somewhat cohesive streambank sediments and maintenance of tree buffers along the RB. The reference riffle/pool bedform is inferred to have been historically altered due to repeated, post-flood "stream cleaning", but has recovered to a degree. Short riffles are evident, but pools are infrequent and generally very shallow in depth. Three side bars and one mid-channel bar observed in the segment reflect a low-flow secondary sinuosity and minor degree of aggradation. The measured width/depth ratio (33.8) is somewhat high and appears related to a local phenomenon of divergent flow just downstream of the breached beaver dam – and is not characteristic of the segment as a whole.

Overall, the reach was rated in the "Fair" quadrant of the RGA given the minor to moderate degree of active lateral and vertical adjustments. A Very High sensitivity was assigned, following protocols, due to the dominance of gravel-sized sediments. The channel in segment M32-B persists in a partially incised condition. A late-stage II [F] channel evolution stage is inferred.

**Segment A**

Segment M32-A extends from the Winery Road bridge crossing downstream to the end of the reach just below the Route 103 bridge crossing. Encroachments by Route 103 and the railroad along the LB and the railroad and Greven Road Extension along the RB have significantly reduced the floodplain width, increasing the valley confinement from a reference Broad condition to a modified Semi-confined condition. A cross section was completed near the upstream end of the segment, and indicated a cobble-dominated Bc-riffle/pool stream type, constituting a stream type departure (from C to Bc). An incision ratio of $IR_{RAF}$ = 2.1 is calculated if the LB terrace supporting Route 103 is considered to be a recently-abandoned floodplain, defined by protocols. There is some uncertainty as to the degree of fill and regrading of that left terrace during construction of Route 103; the degree of vertical separation of this terrace from the channel thalweg was likely enhanced by human activities. Recent planform adjustments (meander extension, meander translation, active flood chutes) and sediment deposition (point bars and mid-channel bars) in this vicinity have created a short section of incipient floodplain to which the current channel is connected. The measured bankfull width (135 ft) is wider than regime, and contributes (along with a shallow mean depth) to a locally high width /depth ratio (73). By virtue of this overwidened cross section, the Entrenchment Ratio (1.86) is in the range classified with a B stream type. A channel evolution stage of III [F] is inferred.



*Figure 23. Location of active planform adjustment, aggradation and widening downstream of Winery Road crossing. View downstream from high RB terrace comprised of glaciofluvial sediments. Segment M32-A, 2 October 2007.*

In a strict sense, the Segment A cross section (XS-1) is not entirely representative of conditions elsewhere in the segment. In vicinity of this cross section, the Black River channel is flowing alongside less cohesive and more erodible sands and gravels of glaciofluvial origin, where the channel impinges on a high terrace along RB. These erodible sediments are contributing to local aggradation, widening and lateral shifts of the channel – which are somewhat more active in this upper end than elsewhere in the segment. The incision ratio (2.1) is likely enhanced by floodplain elevation for the construction of Route 103, resulting (locally) in a stream type departure (from C3 to B3c). Whereas, elsewhere in the segment there are short sections of the low bank that are at an elevation between 1.5 and 2 times the bankfull depth. Therefore, a lesser degree of historic incision is evident downstream of XS-1, and these areas might instead be classified as a C3 channel consistent with reference. They would not have undergone a vertical stream type departure, and would likely have a marginally better RGA score as a result. However, both a C3 channel in Fair condition and a B3c channel in Fair condition (and with a vertical stream type departure) are classified with a Sensitivity of "High", according to protocols. Both sensitivity classifications would be buffered at the same dimension for preparation of a river corridor, for example (see main report, Section 7.1). It is believed that aggradation, planform adjustments and widening will continue to progress in these downstream sections, consistent with early stage III of the F-stage channel evolution model.

**M31**

Reach M31 is a 3,741-foot reach which passes through Proctorsville from the Route 103 bridge crossing to the LB confluence of an unnamed tributary which flows along Twentymile Stream Road. High terraces along LB and RB define a natural floodplain that ranges between 5 and 10 times the channel width (average Broad valley confinement). A C-riffle/pool reference stream type is inferred. Wetlands (NWI, VSWI) are mapped contiguous to the channel in the LB corridor; a limited area of hydric soils is mapped in the LB corridor near the downstream end of the reach.

In recent centuries, the village of Proctorsville was developed on the high terraces to the north and south of the river. Route 131 appears to be constructed on the terrace surface along the LB and does not significantly encroach upon the channel. Similarly Route 103 and a network of secondary roads in the southern portion of the village are constructed on the terrace surfaces along the RB corridor. Depot Street crosses the channel mid-reach via a concrete bridge crossing and pier structure; the measured span suggests this is a flood-prone-width constrictor. Green Mountain railroad – constructed c. 1849 (Harris, 1949) encroaches on the floodplain and constrains the channel along LB in the upstream half of the reach. Within a short distance after crossing the channel approximately 300 feet downstream of the Depot Street bridge, the railroad crosses to the high RB terraces and valley wall downstream and does not significantly constrain the channel in the downstream half of the reach. Human modifications in the floodplain have reduced the available valley width, resulting in a modified Narrow valley confinement between 4 and 6 times the channel width.

Historically (Beers Atlas, 1869), a diversion channel lead from upstream Segment M32-A eastward to mill and factory buildings in Proctorsville as visible on a 1939 photograph of the area (see Figure 32). Water was returned to the Black River at the approximate location of the downstream reach break for M31.

A representative cross section measured across from the Greven recreational fields at the mid-point of the reach indicated a moderate degree of historic incision ($IR_{RAF}$ = 1.33). The reach was classified with a gravel-dominated C-riffle/pool stream type, consistent with reference. Incision is estimated as historic in nature due to the absence of features which might suggest active incision. It is possible that incision occurred in this reach as a result of localized channelization to accommodate the railroad, and/or associated with "stream cleaning" during flood recovery efforts.

A narrower-than-regime bankfull width (78.4 ft) and somewhat deeper-than-regime bankfull depth (4.5 ft) contribute to the modest W/D ratio (22.2) measured at the M31 cross section. Widening and planform adjustments may have been moderated by the presence of streambank armoring and maintenance of narrow but long sections of tree buffers along both banks. A weak riffle/pool bedform dominates the reach; riffles are short in length and pools are shallow. Minor aggradation, widening and planform adjustment are indicated by the presence of two mid-channel bars (one local to the pier of the Depot Street bridge crossing), three small point bars, one side bar, and two shallow active flood chutes.

Overall, the reach was rated in the "Good" quadrant of the RGA given the minor degree of active lateral and vertical adjustments. A High sensitivity was assigned, following protocols. Reach M31 persists in a partly-incised condition – an inferred channel evolution stage of II [F] – although M31 would appear to have more ready access to the floodplain in higher-stage flows than upstream segments which are generally incised and entrenched to a greater degree. Anecdotal data indicates that Greven Field floods occasionally (i.e., every few years).

**M30**

Reach M30 is approximately 1.5 miles long, begins at the eastern edge of Proctorsville and ends just below the Mill Street bridge crossing in Cavendish. Steep forested slopes of the Proctor-Piper State Forest define the southern wall of the Black River valley in this reach. A combination of steep, till-covered bedrock slopes and high glaciofluvial terraces define the valley wall along the LB (to the north) of the Black River. The valley width ranges between 4 and more than 10 times the channel width; average valley confinement is considered Broad. A reference C-riffle/pool stream type is inferred.

The Green Mountain Railroad follows the Black River near the base of the right valley wall, usually elevated above the floodplain on the valley side slope. Occasionally, the railroad encroaches slightly on the Black River floodplain. The villages of Proctorsville and Cavendish are developed on the terrace surfaces along the left valley wall. Route 131 follows the river, usually on the LB terrace surface, but occasionally encroaching slightly within the Black River floodplain. These minor encroachments of Route 131 and the railroad have reduced the valley width to a negligible degree.

The Black River channel impinges on the RB and LB valley walls in a few locations in reach M30. Records of the Stream Alteration Engineer (HD-1-0819, 5/8/1996; Nicholson, 2007) note streambank armoring installed to stabilize a slump along LB near the mid-point of the reach where a mass failure threatened the stability of Route 131. A mass failure has developed just downstream of this armored section where the channel impinges upon a 12-foot high terrace of gravels and sands. Rip-rap was observed in discrete sections on either bank elsewhere in the reach, and on both banks at the Mill Street bridge crossing.

Land uses within the corridor include forest, agricultural fields (apparent hay), commercial/industrial development in Cavendish, and residential / commercial development near Proctorsville. In the last few years, agricultural lands in the LB corridor along Route 131 just east of Proctorsville have been converted to residential use. New homes are being constructed within the meander belt width of the Black River.

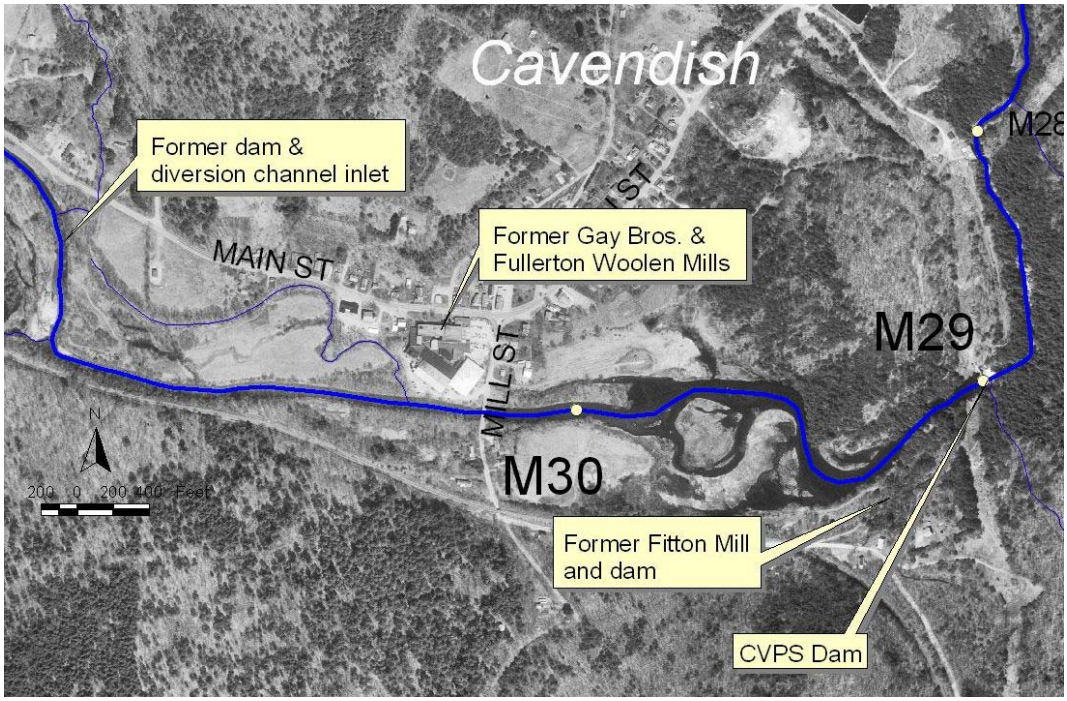
Historically, a dam was present approximately one-half mile upstream of the Fullerton Woolen Mills at Cavendish. (This facility later operated as the Gay Brothers Woolen Mill until the late 1930s, when ownership transferred to Mack Molding). Waters impounded at this dam were diverted through a constructed channel to the former Fullerton Mills and other local industries including a tannery, blacksmith shop, and wagon shop (Beers, 1969). Water was then returned to the Black River in vicinity of the Mill Street crossing. This dam and diversion channel are also visible on the 1929 Ludlow, Vermont, USGS topographic map and a 1939 aerial photograph (Figure 24). Remnants of this dam (abutments) were visible in the channel on the assessment date (2 October 2007). The span between these abutments was measured at 64 feet. Breaching of this dam may have contributed to historic incision upstream of the dam site, along with reported post-flood "stream cleaning".

A downstream dam at the CVPS hydroelectric power generating station (in reach M29) impounds water for an approximate length of 3,000 feet, extending partially into reach M30 near the Mill Street bridge crossing. A historic avulsion occurred in downstream reach M29 during the 1927 flood, when Black River flows bypassed the Cavendish Gorge (see discussion under reaches M29/M28). This avulsion event temporarily dropped local base levels until flood waters receded and flows were restored to the gorge. This avulsion event combined with reported channelization and dredging during post-flood recovery efforts likely induced a degree of historic incision in reach M30.

Two representative cross sections measured within reach M30 indicated a moderate degree of historic incision ($IR_{RAF}$ = 1.39 to 1.78). The reach was classified with a cobble-dominated C-riffle/pool stream type, consistent with reference. Incision is estimated as historic in nature due to the absence of features which might suggest active incision. Low to moderate width/depth ratios (21.4 and

24.6) indicate minimal widening. Scarcity of depositional bars and flood chutes in this 1.5-mile reach suggests minimal aggradation and planform adjustment. Lateral adjustments may have been moderated by the presence of somewhat cohesive sediments in the upper streambanks (outside of short sections where the channel impinges on erodible glaciofluvial sediments). Maintenance of tree buffers along sections of both banks also appears to offer boundary resistance. A weak riffle/pool bedform dominates the reach; riffles are short in length and pools are shallow.

Overall, the reach was rated in the "Fair" quadrant of the RGA given the minor degree of active lateral and vertical adjustments. A High sensitivity was assigned, following protocols. Reach M30 persists in a partly-incised condition – an inferred channel evolution stage of II [F].




*(a)*



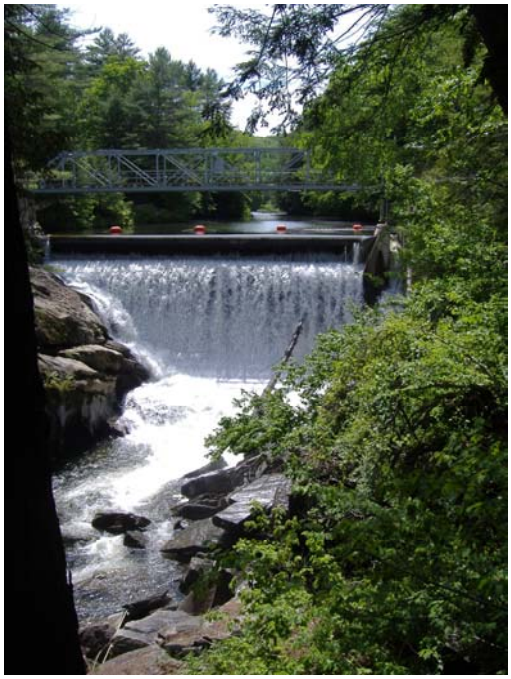
*(b)*

*Figure 24. Historic flow diversion and impoundments in reaches M30 through M28 of the Black River main stem, Cavendish, Vermont. (a) 1994 orthophotograph base; (b) 1939 aerial photograph of same area.*

**M29 / M28**

Reaches M29 and M28 were excluded from Phase 2 assessment: M29 is the impoundment above the CVPS hydroelectric facility dam. Reach M28 is the Cavendish Gorge - a steep (6.9%) bedrock gorge with sheer bedrock walls, consisting of " a series of small falls or chutes linking pools of various sizes" (Jenkins and Zika, 1985).

The CVPS dam is constructed of concrete and is approximately 230 feet long and 46 feet high (VT Dam Inventory, VCGI, 2005). Water is diverted from the impoundment through a penstock to the CVPS power generation facility at the base of Cavendish Gorge.



(a)



(b)

*Figure 25. CVPS hydroelectric project at Cavendish Gorge: (a) dam at top of gorge; (b) power generation station at bottom of gorge where water diverted via the penstock is returned to the Black River channel.*

Prior to construction of the CVPS dam in the early 1900s, a separate dam was apparently present at the former Fitton Woolen Mill approximately 600 feet upstream of this location (Figure 26). The Fitton Mill operated in the mid- to late- 1800s and is visible on the 1869 Beers Atlas.



*Figure 26. Historic Fitton mill. View to the east (downstream)*

*Source: Perkins Landscape Change web page.*

A notable avulsion occurred on the Black River in the town of Cavendish during the flood of 1927. Waters of the Black River were impounded behind the dam at the top of Cavendish gorge. A secondary dike, or levee structure, was present along the north side of the impoundment along the southern margins of the Cavendish village. This earthen dike was outflanked by flood waters of the 1927 flood. A quarter-mile long channel avulsion bypassed the Cavendish Gorge and eroded approximately 2 million tons of sediment down to bedrock leaving a channel 150 feet deep and 600 feet wide. Several buildings and a long section of Main Street (Route 131) were washed away (Gay, 1927; Minsinger, 2002).

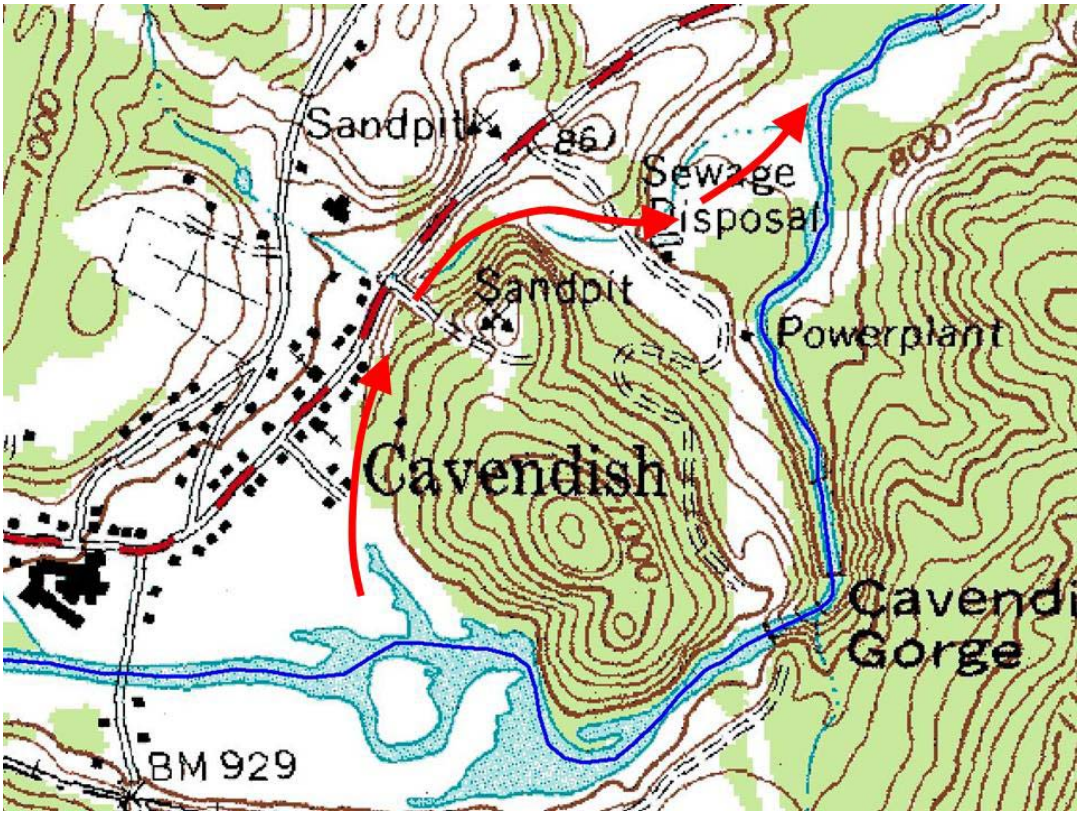



*Figure 27. Approximate path of channel avulsion on the Black River main stem during the 1927 flood (from Reach M29 to M27), Cavendish, VT.*

**M27**

Reach M27 flows to the northeast from the base of the Cavendish Gorge to the village of Whitesville at the LB confluence of Twentymile Stream. A Broad valley confinement is defined by till-covered bedrock slopes to the southeast (RB) and glaciofluvial terraces to the northwest (LB). Channel-spanning bedrock (ledge) is present at the upstream end of the reach where the channel transitions out of the gorge. Bedrock is also exposed in the bed and banks downstream of the Carlton Road bridge crossing at Whitesville near the downstream end of the reach (Figure 28). Hydric soils and wetlands (NWI, VSWI) are mapped contiguous to the channel.



*Figure 28. Bedrock falls below Carlton Road bridge, reach M27, Cavendish (Whitesville), 17 September 2008.*

Carlton Road crosses the channel near the downstream end of reach M27 and provides access from Route 131 to residential buildings along the LB and RB of the river. Otherwise, current developments within the corridor are minimal. At the upstream end of the reach, the Cavendish wastewater treatment facility was originally located on the LB floodplain at a lower elevation and closer to the channel. This facility was destroyed during the 1973 flood and was later rebuilt at its current location which is farther to the north and on a higher terrace (VTWQD, 1976).

The community of Whitesville near the confluence of Twentymile Stream historically included a grist mill and saw mill in vicinity of the Carlton Road bridge crossing, as noted on the Beers Atlas (1869).

Historical accounts describe tons of sediment eroded by the Cavendish avulsion during the 1927 flood accumulating in the Black River channel down to Whitesville (Minsinger, 2002). Extensive "stream cleaning" was reportedly undertaken. The mostly linear planform of the reach is indicative of channelization and inferred dredging in response to the 1927 flood (and possibly the floods of 1936, 1938 and/or 1973).

A cross section completed mid-reach reveals a cobble-dominated C-riffle/pool stream type, consistent with reference. A moderate to high degree of incision (historic) is evident from the degree of vertical separation of the low bank from the thalweg. An incision ratio of $IR_{RAF}$ = 1.79 was measured at the cross section site. This net degree of historic incision is probably related to post-flood channel management in the 1920s, 1930s and 1970s. It is possible that incision had a contribution from "hungry water" effects downstream of historic and current impoundments at Cavendish gorge, where sediments transported in the Black River are trapped. Further study would be required to understand the degree to which human impoundments at the

top of the gorge increase the amount of sediment impoundment beyond that which would be expected naturally at this bedrock gorge.

A moderate width/depth ratio (23.9) and presence of two mid-channel bars and one diagonal bar, suggest a minor degree of widening and aggradation. Three flood chutes were indexed in the reach, suggesting minor to moderate planform adjustment. This reach has a similar planform on 1939, 1977, and 1994 aerial photographs. Lateral adjustments may have been moderated by the presence of cohesive sediments in the streambanks. Also, forests have begun to regenerate along the banks and within the corridor since 1939, when the corridor appeared largely unforested. Maintenance of tree buffers has apparently offered boundary resistance. A riffle/pool bedform dominates the reach. Outside of the bedrock-controlled channel sections at the upstream and downstream ends of the reach, pools are shallow and run-like.

Overall, the reach was rated in the "Fair" quadrant of the RGA given the minor degree of active lateral and vertical adjustments. A High sensitivity was assigned, following protocols. Reach M27 persists in a partly-incised condition – an inferred channel evolution stage of II [F].

**M26T2.01 (Twentymile Stream at confluence with Black River)**

M26T2.01 is a very short reach (1,138 ft) of the Twentymile Stream that joins the Black River in Whitesville at the upstream end of reach M26. Within this reach, the Twentymile Stream transitions from upstream steeper-gradient, narrow to semi-confined step/pool channel sections out into the Broad valley setting of the Black River main stem. Mid-reach bedrock exposures in the channel banks constrain the planform of this reach along the RB. This exposure appears connected to the bedrock falls in the Black River channel (reach M27) below the Carlton Road crossing just 200 feet to the south east. A C3-riffle/pool reference stream type is inferred for reach M26T2.01.

Fill materials for the paved Whitesville Road and paved parking area associated with the general store at the junction of Whitesville Road and Route 131 have encroached upon the RB corridor upstream of the Route 131 bridge crossing, resulting in a human-caused reduction in the valley width. The Whitesville Road is at an approximate thalweg height of 9.8 feet, or approximately 2.7 times the nearest measured bankfull depth. The road is coincident with the RB which is extensively armored by rip-rap. Downstream of the bridge, Route 131 encroaches on the LB floodplain, reducing the valley width. Route 131 is at an approximate thalweg height of 11 feet, or 4 times the nearest measured bankfull depth. A Narrow to Broad reference valley confinement has been modified to an average Narrow confinement. Channelization is inferred along much of the reach, although the linear planform downstream of the bridge crossing is at least in part due to the lateral constraints of bedrock.

A short section of berm is present at a thalweg height of 8 feet along the LB immediately upstream of the Route 131 crossing. At the bridge crossing the Twentymile Stream turns sharply to the northeast, where the planform is constrained by bedrock exposures along RB. The Route 131 bridge has two spans separated by a concrete pier. Water flows through the RB channel at low flow (this channel has a deeper thalweg than the LB channel). Based on the absence of established vegetation and the imbrication of cobbles/gravels in the LB span, it is likely that this LB channel is occupied at bankfull and higher flow stages. The total span of the bridge (including the LB overflow channel) is approximately 93 ft measured perpendicular to the channel – an expected flood-prone-width constriction. The span of the RB channel is 45 ft measured perpendicular to the channel – nearly equivalent to the reference channel width of 43 ft.

Upstream of the bridge, a commercial property is present in the RB corridor of the reach and a residential property is developed in the far LB corridor. Downstream of the bridge, several residences are present within one bankfull width of the channel along LB. Rip-rap armoring reinforces the LB adjacent to these homes. A forested bedrock knoll is present along RB.



*(a)* *(b)*

*Figure 29. Twentymile Stream reach M26T2.01 near the confluence with Black River (M26). (a) View upstream of Route 131 bridge (b) View downstream of Route 131 bridge – 5 September 2008.*

Two cross sections were completed in the reach: one upstream of the Route 131 crossing and one downstream of the crossing. Dimensions at both cross section sites indicated a C3-plane bed stream type, with a moderate degree of incision ($IR_{RAF}$ = 1.6 upstream, $IR_{RAF}$ = 1.5 downstream). The upstream cross section reveals a channel somewhat narrower and deeper than regime with a low W/D ratio (12.1) due to the encroachment of Whitesville Road along RB and channel armoring. The downstream cross section has a greater W/D ratio (30.0) and somewhat wider than expected bankfull width. These are local phenomena given the lesser degree of channel armoring and encroachment (locally), and due to localized aggradation/ widening above a channel constriction caused by LB armoring and RB bedrock exposures. Both cross sections are considered representative of the reach in terms of characterizing the Phase 2 stream type. The lower W/D ratio of the upstream cross section is characteristic of sections of the reach where armoring, encroachments and bedrock laterally constrain the channel. The higher W/D characteristics of the downstream cross section are descriptive of sections of the channel where these constraints are absent (e.g., just below the bridge and in the downstream 200 feet of the reach).

Incision is classified as historic, possibly resulting from channel management in the Black River and/or reach M26T2.01 following past flood events. Upstream migration of incision in the Twentymile Stream would have been constrained at channel-spanning bedrock exposures in upstream reaches (M26T2.02, M26T2.03). Given the valley setting of this reach, at a point of reduced valley gradient, it is likely that historic aggradation also occurred to offset incision. At present, a minor to moderate degree of aggradation appears to be the dominant adjustment process, based on the presence of two steep riffles (local to constrictions) and three low side bars. Potential planform adjustments and widening have been constrained by channel armoring, as well as maintenance of tree buffers and exposed bedrock along the RB in the downstream half of the reach. Reach M26T2.01 was ranked in the "Fair" quadrant of the RGA and assigned a High sensitivity. A channel evolution stage of II [F] is inferred.

**M26**

M26 is a short reach extending from the LB confluence of Twentymile Stream (M26T2) to a point 1,815 feet downstream where the Black River valley transitions from a Broad confinement to a Semi-confined and bedrock-controlled channel. The upstream drainage area of Twentymile Stream (15 sq. mi.) represents 15% of the total upstream drainage area of the Black River at reach M26 (100 sq. mi.).

The Broad valley confinement of reach M26 is defined by till-covered bedrock slopes (RB) and high glaciofluvial terraces (LB). Wetlands are mapped near the downstream end of the reach. While bedrock was not observed in the bed or banks of the channel in M26, channel-spanning bedrock is exposed immediately upstream in reach M27, in the Twentymile Stream upstream of its confluence with reach M26, and in downstream reach M25.

Route 131 encroaches along the left valley wall, reducing the valley width somewhat and resulting in a human-modified Narrow valley confinement. Historic channelization and dredging are inferred from the very linear planform. It is likely that sediments accumulated in reach M26 (i.e., beyond Whitesville) during the Cavendish avulsion of the 1927 flood. A low-elevation berm is apparent along the LB in this channel; hay fields are present beyond this berm extending to the Route 103 fill. The RB is coincident with the forested valley wall. A swale / flood chute along Route 131 in the LB corridor may represent a former path of the Black River that is re-occupied during large flood events (e.g., 1927, 1936/1938, 1973). Similarly, a large flood chute coincident with channel-contiguous wetlands in the RB corridor near the downstream end of the reach may represent a former path of the river. Reach M26 has a very similar (linear) planform on available historic photographs (1939, 1977, 1980, 1994).

A representative cross section completed mid-reach indicates that a vertical stream type departure has occurred resulting in a gravel-dominated F-plane bed stream type. An incision ratio of $IR_{RAF}$ = 2.34 was measured. The LB berm is present at a thalweg height of approximately 8 feet (or 2.5 times the bankfull depth of the channel) – and modestly increases the degree of channel entrenchment. Incision was classified as historic in nature, based on the absence of features which would suggest active incision. Historic degradation is likely the result of reported channelization and dredging in response to the 1927 flood (and possibly 1930s floods and the 1973 flood). Incision along the main stem in response to channel modifications would be limited by the upstream and downstream exposures of channel-spanning bedrock. Similarly, incision in the Twentymile Stream would be limited at the channel-spanning exposures of bedrock in upstream reaches. Reach M26 is longitudinally pinned between upstream bedrock falls at Carlton Road crossing and the downstream bedrock-controlled, semi-confined reaches (M25 – M21). There is a very limited length for adjustments of the vertical elevation (i.e., channel profile) to occur.

At present, active lateral and vertical adjustments in the reach are negligible, and widening, aggradation and planform adjustments were characterized as historic. Indirectly, historic aggradation (of flood-related sediments) is theorized as the dominant process responsible for a "departure" from cobble-riffle/pool to gravel plane bed channel. A high width/depth ratio was measured at the cross section site (42.8); this overwidened condition is characteristic of the reach as a whole. The overwidened channel may be related to the nature of dredging activities performed after the 1927 flood (and other floods) to "clean" the channel of sediment and debris generated during the Cavendish avulsion. If a wide and shallow channel (vertically disconnected from its floodplain) was created through dredging, this may have limited sediment transport capacity of the channel locally, contributing to the plane bed form, aggradation and filling of pools, and high W/D ratio. If dredging activities did not leave an overwidened channel, historic widening (following dredging) probably created the present overwidened form. Aggradation in this reach would also be naturally enhanced by transition from the Broad alluvial valley to the Semi-confined, bedrock-controlled, channel in downstream reaches.

Overall, reach M26 was rated in the "Fair" quadrant of the RGA given the minor degree of active lateral and vertical adjustments. An Extreme sensitivity was assigned, due to the stream type departure (C to F). Reach M26 persists in an incised and entrenched condition – an inferred channel evolution stage of II [F].

**M19**

Reach M19 is located between Downersville and Perkinsville in the town of Weathersfield, approximately 5.4 miles downstream of reach M26. The intervening reaches (M25 – M20) were not assessed as part of this study. Reaches M25 through M21 flow through a semi-confined, bedrock-controlled valley (along Route 131) with an overall gradient less than 1%, where sinuosity is controlled by structural elements of the underlying bedrock. M20 is a very short reach downstream of the Upper Falls Road covered bridge where the valley transitions from a Semi-Confined to a Very Broad confinement.

M19 is a 1.5-mile reach of Broad to Very Broad confinement that extends from just downstream of the Upper Falls Road crossing downstream nearly to the Route 106 crossing at Perkinsville. The valley is bounded on the LB (east side) by a steep valley wall, comprised of a high terrace of glaciofluvial sediments (USDA) followed by a till-covered bedrock knob (Pine Hill). Route 106 from Downers Corners to Perkinsville follows the river high on the terrace at a thalweg height ranging from approximately 20 to 75 feet above the channel. Bedrock was observed at the base of this valley wall coincident with the LB of the channel: (1) mid-reach and (2) near the downstream end of the reach. Along the RB (west side), the channel is confined by a somewhat wider terrace of sediment with glacio-fluvial origin (USDA), followed by a prominent till-covered bedrock knob (Hawks Mountain). Wetlands are mapped contiguous to the channel in the upstream third of the reach and at the downstream end of the reach. Hydric soils are also mapped in vicinity of historic channel migration zones. A C3-riffle/pool reference stream type is inferred.

The Upper Falls Road encroaches within the RB corridor to a minor degree, resulting in an increase in the average valley confinement from a reference Very Broad to a modified Broad. Near the downstream end of the reach, the historic alignment for Route 106 used to encroach within the LB corridor. Sometime prior to 1977 this road segment was moved to the east, higher on the RB valley wall. The abandoned segment of Route 106 is present on the 1977 and 1994 aerial photographs, still connecting to the modern Route 106 at both ends. By 2003, a residential building was present in the small section of floodplain pinned between the channel and the steep valley wall; the abandoned road segment appears to serve as a driveway that no longer connects to Rt 106 at the north end. Sections of streambank armoring (rip-rap) were noted along the LB in vicinity of this residence (former road bed).

Overall, sparse residential development is present in the reach corridor. Except for the one recent house described above, development has typically occurred along the far western margins of the valley along Upper Falls Road. The floodplain itself has seen intensive agricultural use (hay and crop fields). Active sand and gravel quarrying is visible at the downstream end of the reach in photographs from the 1970s through present.

The Black River had a more sinuous planform in past decades (Figure 30). Prior to 1977, the channel was straightened. Dredging is also inferred due to the presence of a wide, high berm along the RB of the straightened channel (Figure 30b) that ranges in thalweg height from 14 to 16 feet. In late June of 1973, flood waters inundated the Upper Falls Road at the upstream end of the reach (Weathersfield Weekly, 5 July 1973, p.1). According to a local riparian landowner, the channel was straightened, dredged and bermed following the 1973 flood, resulting in the more linear planform of today. In years prior to this flood, ice jams were prevalent along this section of the river; following channelization, water no longer overtops the banks during spring runoff (Hastings, 2008).

Historically, a dam ("Soapstone") was present at Perkinsville approximately 1,150 ft downstream of M19 (Beers, 1869). This dam is visible on the 1939 aerial photograph (Figure 30a) but not on the 1977 or more current photographs. Today, only remnants of the dam are visible amidst exposures of channel-spanning bedrock. In the 1939 photograph (Figure 30a), the channel upstream of the dam site is not appreciably wider than the current channel viewed on the 1994 or 2003 aerial photographs. Channel-spanning bedrock

at the same approximate location as the dam may be contributing to a slightly overwidened channel that extends approximately 600 feet upstream of the dam / bedrock falls. The extent of upstream impoundment effects of the Soapstone Dam (when it was intact) is unknown. It is possible that this low-head dam created only a small impoundment when intact. It is also possible that the Soapstone dam had been breached in the 1927 flood (or floods of the 1930s), such that a negligible impoundment is visible on the 1939 photograph.

Two cross sections were completed in the reach, which indicated varying degrees of channel degradation. The reach was segmented to capture this difference which has lead to a vertical stream type departure for the upstream third of the reach:

- Segment B – 3454 ft, 0.6% gradient, C to F stream type departure, $IR_{RAF}$ = 2.2;
- Segment A – 4243 ft, 0.2% gradient, C4 stream type, $IR_{RAF}$ = 1.7.

**Segment B**

Segment M19-B comprises the upstream 3454 feet of the reach, which was channelized, dredged and bermed following the 1973 flood. This segment has a moderately steeper gradient than the remainder of the reach. At the cross section site near the downstream end of this segment, an incision ratio of $IR_{RAF}$ = 2.2 was measured, indicating a stream type departure from C3 to F3. The RB berm (located just upstream of the cross section site) enhances the degree of channel entrenchment along a majority of the segment, at a thalweg height ranging from 4.1 to 4.7 times the bankfull depth. Incision was classified as historic in nature, based on the absence of features which would suggest active incision. Historic degradation is likely the result of reported channel management.

At present, active lateral and vertical adjustments in the reach are relatively minor in degree. Minor planform adjustment and aggradation are suggested by the presence of one flow bifurcation around a vegetated island and two low-elevation point bars. A high width/depth ratio was measured at the cross section site (48.8); this overwidened condition is characteristic of much of the segment. The overwidened channel may be related to the nature of dredging activities performed after the 1973 flood to "clean" the channel of sediment and debris and move the river to a position in the valley that would be less directly in conflict with the road and nearby human land uses. If a wide and shallow channel (vertically disconnected from its floodplain) was created through dredging, this may have limited sediment transport capacity of the channel locally, contributing to aggradation (historic), and the high W/D ratio. The high and wide berm along much of the RB, and the steep valley wall (including occasional exposures of bedrock) along the LB laterally constrain the channel planform. Reach M19 is also longitudinally pinned between channel-spanning bedrock in upstream reaches (e.g., M21) and bedrock falls at Perkinsville in reach M18; thus, there is a very limited length for adjustments of the vertical elevation (i.e., channel profile) to occur. Through channel management activities Segment M19-B has been converted to a transport-dominated, incised and entrenched, linear channel with very limited floodplain access.

Segment M19-B was rated in the "Fair" quadrant of the RGA given the minor degree of active lateral and vertical adjustments. An Extreme sensitivity was assigned, due to the stream type departure (C to F) with an inferred channel evolution stage of II [F].

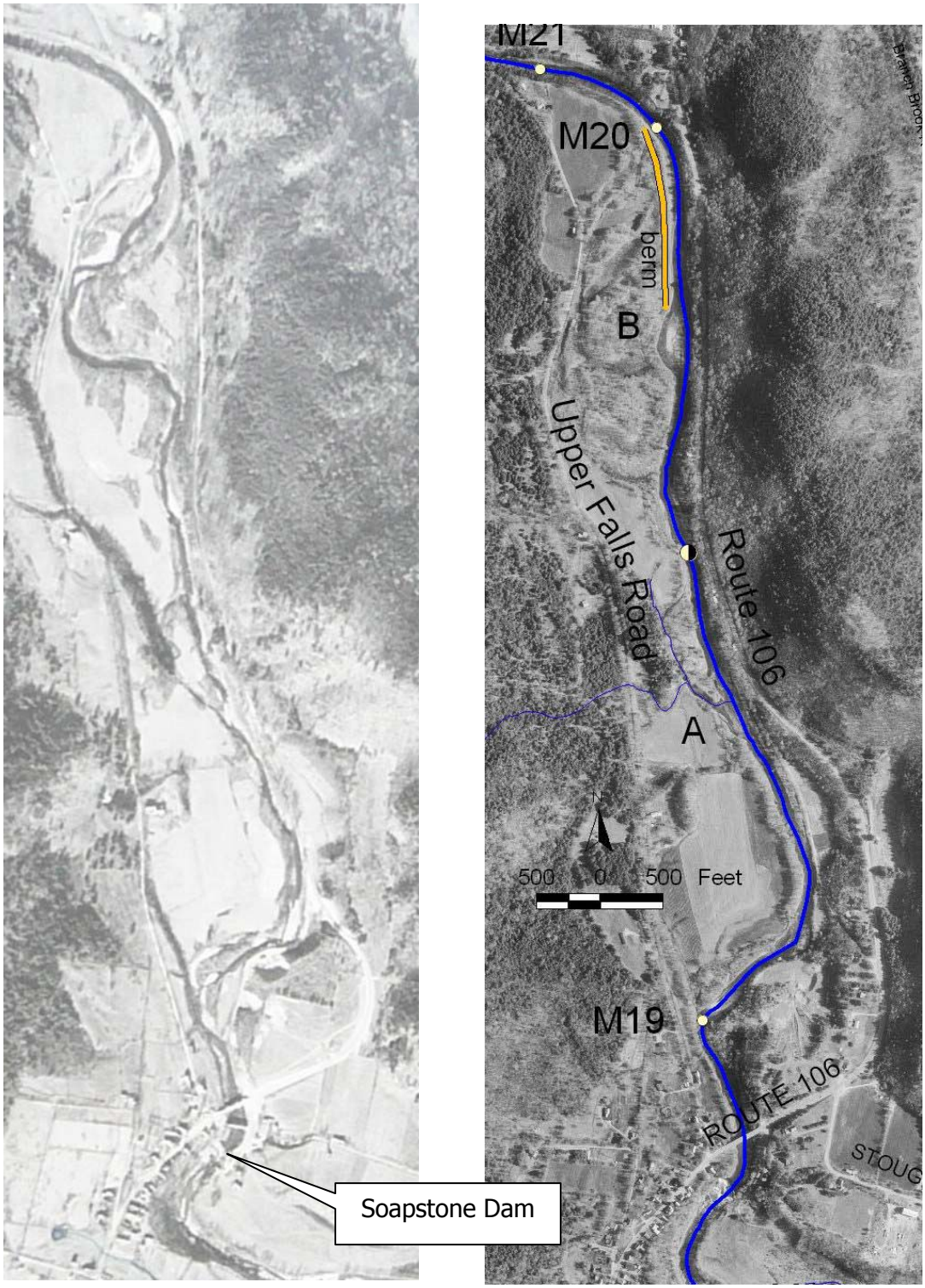



*Figure 30. Comparison of M19 planform in (a) 1939 versus (b) 1994. Upper third of reach was channelized, dredged and bermed following the 1973 flood (Weathersfield Weekly, 5 July 1973).*

**Segment A**

Segment M19-A comprises the downstream 4243 feet of the reach. It is likely that historic channelization and possibly dredging occurred in this segment in response to past floods such as the 1927 flood or floods of the 1930s. Stream cleaning may also have occurred following the 1973 flood, although this segment was not apparently bermed in a manner similar to Segment B.

Incision was classified as historic in nature, based on the absence of features which would suggest active incision. Through moderate planform adjustments (meander extension, flood chutes, bifurcations) and associated widening, Segment M19-A is developing sections of incipient floodplain at a lower elevation. Localized aggradation (one mid-channel bar, two diagonal riffles) is also contributing to development of sinuosity. A high width/depth ratio was measured at the cross section site (42.1); this overwidened condition is characteristic of the segment as a whole. The overwidened status of the channel appears more related to ongoing lateral adjustments, but may also be related to historic channel management. Aggradation and planform adjustments in this segment are also naturally enhanced local to the transition from the Broad alluvial valley to the Semi-confined, bedrock-controlled, channel in downstream Perkinsville – which is coincident with a sharp turn in the channel at the downstream segment break.

Corn fields were noted along segment M19-A during Fall 2008 assessments. Generally, a tree or scrub/shrub buffer of 50 feet to greater than 100 feet separated these corn fields from the channel, and minimal evidence of direct runoff from these fields was noted (during base flow conditions).

Segment M19-A was rated in the "Fair" quadrant of the RGA given the moderate degree of active lateral and vertical adjustments. A Very High sensitivity was assigned, following protocols. This segment is theorized to be in late stage III [F] (or early stage IV [F]) of channel evolution.

## E.2 Twentymile Stream

### M26T2.10

Reach was segmented to capture upstream and downstream ends which have a different reference stream type (subreaches).

**Segment C**

Subreach of lesser gradient, unconfined channel (C-R/P) in otherwise B-S/P channel. Short length of berm apparent along LB upstream of the Twentymile Stream Rd bridge crossing and across from RB residence. Another short length of berm (grading to stone wall) along LB next to LB residence immediately downstream of Twentymile Stream Rd crossing. Channel-spanning bedrock next to this LB residence near the downstream end of the segment. Twentymile Stream Rd follows the channel in the RB corridor and reduces valley width, such that valley type is modified from Broad to Narrow, though still Unconfined. Expected riffle/pool bedform is replaced by plane bed form, possibly related to historic incision and/or ongoing aggradation. Channel has sharp approach angle to Twentymile Stream Rd bridge; streambanks protected by armoring. Bridge span is a bankfull constrictor. Straightening is inferred from linear planform and short berm length. Three stormwater inputs in the segment: 1 LB roof drain at garage of LB house below bridge crossing; 1 RB culvert from under driveway just below bridge crossing; 1 LB pipe (gray water?) from vicinity of LB house just downstream of bedrock grade control.

**Segment B**

Reference and existing B-S/P channel. Two occurrences of channel-spanning bedrock ("ledge"). Twentymile Stream Rd follows along LB but elevated well above channel on valley side slope. Toe of valley side slope is stream-ward of the road, so road not indexed as an encroachment. Significant overland runoff of road sediment from Twentymils Stream Rd at upstream end of segment (LB). Old foundation along the LB corridor near the mid-section of the segment in vicinity of the channel-spanning bedrock exposures – suggestive of a possible historic mill dam. (No such historic structure is depicted on the Beers Atlas).

**Segment A**

Subreach of unconfined channel (Cb-R/P) in otherwise B-S/P channel, that has departed to a F4b-R/P channel due to historic incision. Segment generally surrounded by coniferous forest. Culvert crossing for private driveway. At 7 feet wide, this structure is only 34% of the average measured bankfull width of the segments upstream and downstream of the crossing. Sedimentation upstream (MCB) and scour pool downstream. Also minimal depth of flow in the culvert itself.

Old foundation along the LB corridor approx 300 ft downstream of the residence near the culvert crossing. The foundation remnants are positioned spanning a flood chute channel that connects with the Twentymile Stream – suggestive of a possible historic mill dam diversion. (No such historic structure is depicted on the Beers Atlas).

Improved path (forest road) along RB (within 1 bankfull width at the base of a high RB terrace - valley wall) and elevated approximately 4.5 times the thalweg height. This road later drops in elevation to cross the channel mid-segment. Remnants of a washed out wooden bridge are now incorporated in a debris jam a few feet downstream of this crossing.

## M26T2.09

Wetlands are mapped in the RB corridor (USGS, NWI, VSWI) at the upstream end of the reach, where several RB tributaries cross the broad valley to join the channel mid-reach. A beaver dam was present just downstream of these converging channels and impounded the reach for a short distance (approximately 150 ft). Hay fields are present within the RB corridor in the downstream half of the reach and extend beyond a distant RB valley wall which parallels the Meadowbrook Farm Rd.

Planform appears historically straightened along a LB terrace which ranges in thalweg height from 8 to 16 feet (or 4 to 8 times the bankfull depth) along the reach length. Similar planform is depicted on the 1939 aerial photograph (and 1977 color imagery). Has been widening through lateral shifts of the channel (meander extension, flood chutes, one bifurcation. Widening moderated by ??

Fallow pasture lands are present at the top of the LB at the mid-point of the reach. A long old stone foundation (possibly a former barn) is located along LB just downstream of this pasture area. Two homes are present on the LB terrace in the downstream half of the reach.

Small avulsion pre 2003 post 1994.

Culvert – bankfull-constricting

Moderate aggradation (diagonal riffles and depositional bars), working to widen its floodplain (and has good floodplain access – IR = 1.0 – in small pockets). The cross section site, itself does not completely capture an

incipient floodplain that is more evident in pockets elsewhere along the reach. Lateral adjustments have been enhanced by beaver dams active in the reach. Late stage III [F] (or Early stage IV) – Attenuation asset. Possible wetland restoration site.

**M26T2.08**

Forested cover surrounds all but the upstream and downstream extremes of the reach. A similar land use was depicted on historic aerial photographs from 1939, 1977 and 1994. Downstream cross section measured downstream of the culvert crossing depicted a more pronounced degree of historic incision ($IR_{RAF}$ = 1.95). The reach was segmented to capture this difference in incision status.

**Segment B**

This segment extends 2241 feet from the upstream reach break to a location just upstream of the instream culvert crossing for Twentymile Stream Road. Forested cover surrounds all but the upstream extreme of the segment. A similar land use was depicted on historic aerial photographs from 1939, 1977 and 1994. Sparse residential / agricultural development on the valley walls surrounding the floodplain. One ford mid-segment. Historic channelization inferred near upstream crossing of Meadow Brook Farm road (next upstream reach). Delta of gravels at LB trib confluence near upstream end of segment. Reasonable floodplain connection; flow and sediment attenuation asset.

The cross section for Segment B was measured just upstream of a localized valley pinch point. In hindsight, the cross section at this location (because it is near a valley pinch point) is not entirely representative of Segment B. It does still, however, represent the entrenchment of a C channel when the +0.2 value is added to the measured ER = 2.02, as permitted under protocols (Table 2.3, page 35, Phase 2 protocols, May 2007). Based on visual observations and field notes, the remainder of Segment B had similar access (IR <1.2) to a floodplain which ranges between 140 and 400 feet wide, or 5 to 15 times the measured (and reference) bankfull width.

**Segment A**

1393 feet long, spanning Twentymile Stream instream culvert. Fallow fields and hay fields surround the channel in this segment below the culvert; forest along LB at downstream end. Narrow shrub buffer along both banks. A similar land use was depicted on historic aerial photographs from 1939, 1977 and 1994. Slight human-caused change in valley width due to encroachment / crossing of Twentymile Stream Rd and LB farm road. No change in average valley type (Broad) or confinement status (Unconfined). Instream culvert for Twentymile Stream Rd is bankfull constrictor. No significant upstream/downstream aggradation or scour. One ford (seldom used) mid-segment. Historic channelization inferred near culvert crossing due to linear planform. Incision ratio of $IR_{RAF}$ = 1.95. This is thought to be a localized phenomenon, possibly related to historic management of the channel (channelization, dredging?) near this culvert crossing.

**M26T2.07**

Reach is 4926 feet long, extending through fields east of Twentymile Stream Road, west of Mt Gilead. Channel impinges on LVW at one location mid-reach. Generally, alluvial (hydric) and glaciofluvial soils mapped in floodplain. Lots hydric soils, limited wetland mapping – prior converted.

Valley width reduced somewhat by Twentymile Stream Rd which passes through RB corridor close to the right valley wall. Not sufficient to cause change in valley type (V. Broad) or confinement status (Unconfined). RB berm is present just downstream of VAST / farm bridge which crosses the reach near the

mid-point and provides access to LB-corridor hay and crop fields. Two equipment fords. Occasional sections of armoring where road encroaches upon channel. Minimal buffers. Some straightening inferred from linear planform – however, review of 1939, 1977 and 1994 aerial photographs indicates that such straightening occurred prior to 1939, since the channel has a very similar planform on these historic photographs. Active beavers mid-reach (downstream of VAST trail bridge) are causing multi-thread channels and localized widening and deposition of sands and gravels. Also, a beaver dam at the very downstream end of the reach (actually located in downstream reach M26T2.06) was causing impounded effects for the downstream 700 ft of the reach). Bed material fining with distance downstream. Bank sediments also becoming finer in grain size and more cohesive. Almost an E-dune-ripple bedform in lower half of the reach with characteristic lower W/D ratio. Early Stage III [F].

**M26T2.06**

This reach was segmented to capture a short subreach of alternate reference stream type at the upstream end (which was not assessed due to extensive beaver impoundments) and subreach of alternate reference stream type in the upstream third of the reach.

**Segment C**

Segment C (1292 feet) is a subreach of alternate stream type (reference C4-R/P) and valley confinement (Very Broad) - distinct from the lower two-thirds of reach M26T2.06 which has a reference E-riffle/pool stream type with low W/D ratio. Floodplain somewhat limited along RB by encroachment of Twentymile Stream Road, but not substantially enough to change valley type or confinement status (Unconfined). If flows and sediment transport regimes were not influenced by impounding effects of multiple beaver dams, it is suspected the reach would demonstrate a gravel-C-riffle/pool stream type, similar to the upstream reach.

Segment C has been impounded by three beaver dams. One is near the upstream reach break and impounds a channel length of approximately 700 ft (upstream into reach M26T2.07). A second dam impounds a length of approximately 730 ft, and a third impounds 125 ft of channel. Control heights of the dams above the stream thalweg ranged from 5.5 ft at the upstream dam to 2.0 ft at the downstream dam. The uppermost dam is trapping substantial volumes of fine gravels and sand, and appears connected to a wide area of wetlands in the LB corridor. Segment C was not assessed due to the extent of these beaver impoundments.

**Segment B**

Segment B is a subreach of alternate stream type (reference C4-R/P) and valley confinement (Narrow) - distinct from the lower two-thirds of reach M26T2.06 which has a reference E-riffle/pool stream type with low W/D ratio. For a length of approximately 2050 feet, this segment of the Twentymile Stream flows through a Semi-confined to Broad valley setting. This narrowing of the valley walls appears related to a prominence of sediments which are mapped as glaciofluvial and glacial till (USDA). Bed materials in Segment B are somewhat coarser than the remainder of the reach, revealing a greater percentage of cobbles and boulders than upstream and downstream cross sections. An exposure of channel-spanning bedrock ("ledge") is present near the downstream end of Segment B. The segment has valley width ranging from 110 (Semi-confined) to 275 (Broad). Cross section happens to be at locally wider spot in the valley. The measured bankfull width (31.8 feet) was used to estimate the valley confinement (150/31.8 = 4.7) of Narrow. Overall, a reference C4-riffle/pool stream type is inferred from the valley setting.

The beavers have capitalized on this narrowing of the valley, building the multiple dams mentioned in Segment C at the transition from Very Broad to Semi-Confined confinement. An additional beaver dam (control height of 2.5 ft) is present within Segment B, approximately 240 ft downstream of the segment break. This dam impounds an approximately channel length of 120 ft (low control height).

Some reduction in valley width has been caused by encroachment of the Twentymile Stream Road along the RB corridor near the mid-section of Segment B (for a very short length). No change in valley type (average Narrow).

Some channelization of the segment is inferred from the linear planform. The low sinuosity may also be the result of bedrock-controlled confinement of the valley.

Beers Atlas (1869) notes a saw mill and small impoundment mid-segment. One equipment ford was observed mid-segment. A timber farm bridge crossing near the upstream end of the segment is a bankfull constrictor - scour pool below. Pair of old abutments near downstream end of segment (bankfull constrictor) - channel approaches at oblique angle. Small delta of sediment at confluence of RB tributary. Some accumulation of fine gravels and sands in pools.

**Segment A**

Segment A is approximately 6466 feet in length and comprises the lower two-thirds of reach M26T2.06. A reference E-riffle/pool stream type was assigned given the low W/D ratio, sinuosity and fine-grained, cohesive nature of streambed and banks. Narrow to Very Broad confinement; average Very Broad if the Phase 2 measured bankfull width is substituted for the reference bankfull width.

Property owners near upstream end of segment (Winston and Judith) note that spring ice-out contributes to erosion of stream banks. Water rises to bankfull every 2 to 3 years. The floods of 1973 and 1976 filled the valley with water.

Wood turtle observed within segment (see pictures on Project CD).

Hay fields and fallow lands along the LB / RB corridors. Historic straightening in some sections inferred from linear planform and encroachment of agricultural fields - probably pre-1939 since channel appears to have very similar planform on 1939, 1977 and 1980 aerial photographs. Occasional armoring along streambanks. One equipment ford (mowed path) near mid-point of segment. Farm bridge crossing near the upstream end of the segment (bankfull-constrictor).

Riffle/pool bedform is weakly formed. "Riffles" are short and generally run-like. Four beaver dams noted in the segment, listed in order from upstream to downstream: #4 = 500 ft impoundment; #3 = 800 ft impoundment; #2 = 2 ft (recently breached); #1 = 2 ft (recently breached).

**M26T2.05**

Mostly forested reach passing through valley of average Broad confinement, with occasional valley pinch points. Near the upstream end of the reach, the Beers (1869) map depicts an "ancient road" crossing from Twentymile Stream Rd to Heald Road (west to east). Traces of this road are visible on the 1994 black and white orthophotograph and on the 1939 aerial photograph. A saw mill with mill pond on the Twentymile Stream was present on the north side of this former road; a grist mill is shown on the south side of this former road crossing (Beers, 1869). Stone foundation remnants were noted along the LB at the downstream end of the prominent meander bend near the top of the reach - in what would have been the vicinity of the former saw mill. Lateral bedrock controls were observed near the Heald Road bridge crossing: LB exposures upstream of the bridge, and RB exposures under the RB abutment. Riffle/pool bedform is not well defined, but several pools are present ranging in depth from 2 to 5.5 ft deep. Occasional lengths of rip-rap both banks, especially near crossings. Stormwater inputs are road runoff near bridge crossings. Both bridge

crossings (Heald Rd, Davis Rd) in downstream half of reach are bankfull-constricting. Inferred historic straightening in parts of the reach.

Downstream cross section XS1 is considered "Not Representative" of the reach as discussed below (and in Appendix C). A RB terrace is present at the XS1 cross section site at a thalweg height of 7.4 ft (or 2.3 times the bankfull depth). Coincident with the terrace is a driveway leading to a house that was constructed between 1994 and 2003, according to review of aerial photographs. A cleared (mowed) area is visible in this location in the 1994 photograph that predates construction; a terrace is depicted at this location on 1983 USGS topographic map. Data available at this time are insufficient to state with certainty whether the driveway along RB was installed at grade on a pre-existing terrace, or whether fill material was brought in to elevate the driveway / house above grade – and either create this terrace, or add to the elevation of and/or widen an existing terrace. This house and XS1 are located at a valley pinch point between sediments of till parent material to the northeast and sediments of lacustrine origin to the southwest (as mapped by NRCS). Bedrock exposures were also noted in this location (along LB upstream of the Heald Rd bridge crossing, and under the RB bridge abutment). Further investigation would be required to understand if fill material was placed here to elevate the driveway and/or buildings. Auguring or excavation of the RB terrace would be required to know if the sediments comprising the terrace were alluvial, lacustrine, or glacial till (or of some other origin). If they are lacustrine or till (or bedrock), it would be appropriate to revise the Phase 1 valley wall to the terrace face. Similarly, the high terrace coincident with LB (at an approximate thalweg height of 14 feet, or 4.3 times the measured bankfull depth) appears comprised of a mix of grain sizes with the appearance of glacial till. If this LTER face and the RTER face comprise the Phase 1 valley wall for purposes of defining stream type, at a distance of 60 feet apart they would define a Narrowly-Confined valley confinement or reference stream type of Bc along a very short section of the reach. The measured cross section is classified as a Bc3 stream type, which would be consistent with this reference stream type (with some historic incision, IRraf = 1.15), and would therefore not constitute a stream type departure. Technically, this very short section of channel would constitute a subreach of alternate reference stream type.

Erring on the side of caution, however, (and not knowing the origin and age of the RB terrace), the Phase 1 valley wall was delineated further to the southwest at the approximate position of the contact between alluvial and lacustrine sediments (as defined coarsely by NRCS mapping). In a similar conservative approach, the LB Phase 1 valley wall was not delineated at the base or top of the terrace face which is coincident with LB. Instead, since the LTER face shows signs of active mass wasting, the Phase 1 valley wall was delineated at the base of the next rise in topography approximately 80 ft to the northeast of the top of this LTER – also at the approximate contact between alluvial sediments and till / glaciofluvial sediments. At this distance apart, the Phase 1 LVW and RVW would define a reference C confinement (i.e., 210 ft / 32.6 ft = 6.4 confinement ratio, or "Broad"), in which case conditions measured at the specific cross section location technically would constitute a C to Bc stream type departure.

If the RB terrace is comprised (in whole or in part) of fill material, then it is possible that this encroachment lead to a human-caused reduction in the valley width at this location, from Broad confinement to Narrowly-confined. An associated ***lateral*** stream type departure from C to Bc would be evident as a result of this hypothetical filling of the floodplain.

This valley pinch point exists for a stream length of approximately 425 ft, or only 7.8% of the total reach length. Given this very short length, and the uncertainty regarding origin of the RB terrace, the reach was not segmented to capture this very short subreach. If an FEH corridor is developed for this reach in the future, the four-channel-widths dimension of the corridor (for a Moderate-sensitivity C3-riffle/pool stream type characteristic of the overall reach) will be clipped to the Phase 1 valley wall in this location, resulting in a slight narrowing of the FEH corridor. Given the conservative placement of the Phase 1 valley walls described above, the FEH corridor dimension might be somewhat overly conservative in this point location, if the RB terrace is in fact a natural feature of cohesive (or erosion-resistant) sediments (or bedrock) that would laterally constrain the channel.

## E.3 North Branch of Black River

### M15 T1.11

Within reach M15T1.11, the North Branch is transitioning from upstream higher-gradient, semi-confined to narrowly-confined reaches out into a very broad alluvial valley section downstream of Felchville. The reach was classified as an "alluvial fan" to capture the substantial gradient change. This relatively short reach is highly variable in its bedform and gradient, as well as the degree of residential/ commercial and road encroachments along its length. The reach was segmented to capture a subreach of alternate stream type at the upstream end and to demarcate a middle segment with a greater degree of encroachment (and steeper gradient and alternate reference bed form).

- C – 409 ft, 7.3 % gradient, bedrock cascade channel;
- B – 312 ft, 3.5 % gradient, cobble step/pool channel with close encroachment along the LB by Niagara St and residential and commercial development (as well as berm along LB);
- A – 417 ft, 2.1 % gradient, reference cobble riffle/pool channel that has departed to a plane-bed dominated channel.

**Segment C**

Segment C is the bedrock-falls at the upstream end of reach M15T1.11. Consistent with protocols, this "bedrock gorge" was not assessed. It should be noted that at the segment break between Segment C and B, the channel takes a sharp turn to the southeast. The elevation of the upstream bedrock channel at this point relative to the LB, as well as the somewhat undersized width of the downstream channel, suggest that an avulsion is possible during times of flood stage that would direct flows across Niagara St and into the village area of Felchville. National Climatic Data Center records indicate past flooding in this area (28 March 2005 ; "Ice jam on the north branch of the Black River in Reading… resulting in minor flooding and chunks of ice on Route 106"; NCDC, 2007). Anecdotal evidence (Reading elementary school students and teacher) also indicates that the Route 106 bridge is a location of past ice jams and local flooding.

At one time, water in the North Branch channel used to be diverted (in whole or in part) from impoundments above these bedrock falls, to a channel that passed directly through the Felchville village via the Mill Pond. Water was then returned to the channel either: via the tributary (M15T1.09S2) that follows the far valley wall east of the village and rejoins the channel near the downstream end of reach M15T1.10 (1932 Ludlow USGS topographic maps); or just downstream of the village near the upstream reach break of M15T1.10 (Beers, 1869). Today the upper reaches of this diversion channel are generally dry and the remants of a dam or sluiceway are visible. Groundwater apparently feeds the Mill Pond (which is used for fire protection in the village).

**Segment B**

Segment B is short section of the reach which extends from the base of the bedrock falls to just above the Route 106 bridge crossing. Valley confinement and gradient are transitional in this segment, leading to a classification of "alluvial fan". An expected reference C3b-step/pool stream type has been modified through encroachments and channel management, resulting in a stream type departure to F3b-S/P channel.

Historic channelization and dredging are suspected due to the linear planform, berms along RB, and close encroachment of Niagara Street and residential and commercial properties along the LB. Beers map (1869) indicates a historic diversion that would have directed a portion of flows out of this reach to supply mills and other industrial applications in the Felchville village area to the northeast (see discussion above). And

historically, a large impoundment was located in upstream reach M15T1.12 that would have trapped sediments and may have contributed to downstream incision in M15T1.11 Segment B.

The measured bankfull width in Segment B (33.4 ft) is somewhat undersized when compared to predicted widths of a channel with this size upstream drainage area (39 ft; VTRHGC 2006). This narrower-than-expected width may be due to historic encroachments and armoring of Niagara St. along the LB and maintenance of berms along RB; this narrow armoring-to-berm span was recorded as a constriction under Step 4.8 of the protocols. It may also be related to the fact that the channel has a steep gradient and step/pool bedform and such channels tend to be narrower and deeper than the channels (mostly gravel-dominated riffle/pool stream types) upon which the VT Regional Hydraulic Geometry Curves were developed.

Historic channelization, inferred dredging, berming, armoring, and encroachments have likely contributed to the current incised and entrenched status of the channel. Sediment deposition within the segment is essentially absent, and the segment functions as a transport-dominated channel. At present, bank armoring and a single row of deciduous trees along portions of both banks provides sufficient erosion resistance to mean that the segment is largely stable. However, the channel remains susceptible to catastrophic failure and erosion during larger flood events. Ice jams (reported in the reach) can also destabilize elements of bank protection.

Stream bank armoring on both banks for entire segment. One stormwater input (LB) upstream of bridge: culvert under Niagara St. The road fill / armoring along LB and berm /armoring along RB are noted as a channel constriction under Step 4.8. The span between these features is undersized with respect to the predicted bankfull width (and measured bankfull width in downstream segment / reaches).

**Segment A**

Segment A is a short section of channel (417 feet) extending downstream from the Route 106 crossing. It is characterized by a Cb-riffle/pool reference stream type, that has departed (through past channel management and historic incision) to a F3b-PB stream type. Encroachments along the segment include Route 106 (RB) and an improved path (agricultural road, LB). A human-caused change in valley type is inferred (from V. Broad to Broad), but confinement status remains unchanged (Unconfined). Segment is located at transition from Semi-confined valley (upstream reaches) to downstream Very Broad valley, and at gradient transition from >2% (upstream reaches) to less than 2% - i.e., "alluvial fan" according to protocols.

Berms along both banks increase the degree of channel incision (entrenchment). Armoring (rip-rap and vertical stone wall) is present along sections of both banks. The Route 106 bridge crossing is a bankfull constrictor and the channel has a sharp approach angle to the bridge. The berms along both banks were logged as a constriction under Step 4.8. Historic channelization (and associated dredging) is inferred due to the linear planform, presence of berms on both banks, and residential and agricultural encroachments.

Historic channelization, inferred dredging, berming, armoring, and encroachments have likely contributed to the current incised and entrenched status of the channel. Sediment deposition is negligible within the segment given the absence of floodplain access, although a very subtle secondary sinuosity seems to be developing a very low flow with somewhat increased erosion on alternating stream banks. Overall, the segment functions as a transport-dominated channel at bankfull flow. The channel remains susceptible to catastrophic failure and erosion during larger flood events. Ice jams (reported in the reach) can also destabilize elements of bank protection.

Sediments comprising the berms and the bank materials (including apparent occasional armoring) are rounded cobbles of a size that is comparable or smaller than the largest fractions of bed materials. Pebble count data from the one cross section in the segment suggest that all but perhaps the largest 10% of the bed sediments would be mobile in a bankfull event. More rigorous tests and measurements would be required to determine with certainty (and were beyond the scope of this assessment), but the above

qualitative observations suggest that the banks and berms along Segment A would be highly susceptible to erosion and undermining in a moderate to high-magnitude flood event. The roots of the single row of trees already appear partially exposed and susceptible to sudden undermining in a flood event.

One LB road culvert at the Rt 106 bridge was indexed as a stormwater input. One small clay tile drain was noted along RB downstream of the Route 106 bridge crossing.

**M15T1.10**

This reach is located in a Very Broad valley setting, of alluvial sediments overlying glaciofluvial outwash (NRCS), bounded on either side by steep valley walls of glacial till and dense till. Rt 106 encroaches within the RB corridor, though not enough to cause change in valley type (Very Broad) or confinement status (unconfined). Historic topo maps (1929, 1932, Ludlow USGS) show Route 106 positioned farther from the channel – apparent road realignment occurred post-1932 (and pre-?) that caused the road to encroach more closely to the channel near the intersection of Felchville Gulf Road. Floodplain is actively farmed (hay fields) and some light residential development is present along RB corridor on the far side of Rt 106.

Historic straightening /dredging are inferred from linear planform and presence of high cobble/ gravel/ earthen berms along both banks for nearly the entire reach. Rip-rap armoring is present near the downstream end of the reach where the channel impinges on Rt 106. Channel gradient decreases at the downstream end where channel approaches valley pinch point. Also confluence of two tributaries, one of which (Knapp Brook) has generated a large tributary confluence bar.

Historic incision has lead to a stream type departure (C to F). The degree of entrenchment has been enhanced along a majority of the reach by the berms which range in thalweg height from 4.7 to 8.6 along LB and 6 to 9.3 along RB. A weak riffle/pool stream type has developed through the reach, particularly in the downstream two-thirds of the reach; the upstream third is dominated by a plane bed form. Pools are quite shallow and run-like throughout. Dominant bed materials seem to show a fining downstream sequence from medium cobble in XS-3 to small cobble at XS-2 to coarse gravel at XS-1. A minor degree of secondary sinuosity is evident in the low-flow channel, with a few minor point bars and side bars developing, and a few diagonal riffles.

Active meander migration and deposition of gravels is evident near the downstream end of the reach, where berms are absent. The channel has greater access to the floodplain at this downstream end of the reach, and the XS-1 shows a C4-R/P stream type. While not representative of the reach as a whole, this short section of C4-R/P stream type was not long enough to warrant segmentation.

Agricultural land uses were associated with two stormwater inputs that may have significance as contributors of additional storm flows (and sediments) to the channel: one apparent tile drain (flowing) and one ditch (dry) extended from fields in the RB corridor. No additional evidence of direct surface runoff from these fields was observed in September of 2008 (during base flow conditions). There is a record of ice jams within this segment (see Appendix O of Phase 1 report - SMRC, 2007)

**M15T1.09**

This reach is in a Narrow to Broad valley setting of glaciofluvial sediments bound on the east and west by steep, forested slopes of glacial till overlying bedrock. Inside these valley walls are glacialfluvial terraces along both banks of the channel. The LB terraces ranges in thalweg height from 9 to 12 feet above the channel thalweg. The RB terrace ranges in height from 5 to 15 feet above the thalweg. Where Route 106 encroaches along the RB terrace, thalweg heights of 17 to 22 were recorded. Bedrock is exposed along the LB, providing lateral grade control, near the upstream end of the reach. A channel-spanning of exposure was also noted near the mid-point of the reach. A moderately-steeper gradient and coarser bed material

was evident for a 1000-ft length of channel downstream of this bedrock exposure. Overall, the reach has a gradient of approximately 1.4 %.

Reach M15T1.09 has had a similar planform for several decades based on review of aerial photographs from 1939, 1973 and 1980, as well as historic topographic maps from 1929. Route 106 encroaches along RB at the top of a terrace and base of the right valley wall. Some residences are positioned along the RVW and closer to the channel at the top of this terrace. Sparse residential development in the forested LB corridor is evident from review of aerial photographs. Forest trail (logging? recreation?) was indexed as "improved path" along LB corridor. One active bridge crossing for a private driveway was encountered at the mid-point of the reach, in vicinity of the channel-spanning bedrock. The bridge is constructed of steel I-beams and wooden decking supported on concrete abutments and wooden posts. The span of the bridge is (43 ft) is somewhat less than bankfull width (measured 46 ft; predicted 47 ft), with a reasonable clearance (12.4 ft to the thalweg). Two old abutments were also noted as bankfull constrictions: (1) a pair of laid-up stone abutments on bedrock with a 34-ft span located just upstream from the present bridge, and (2) a pair of laid-up stone abutments with a 33-ft span near the upstream end of the reach.

Based on results from two cross sections, the channel is historically incised and entrenched below adjacent terraces. Based on the absence of head cuts, and actively collapsing banks, incision is inferred to be historic in nature and may even be attributed (at least in part) to post-glacial incision occurring several thousands of years before present. It is possible that extensive channel management along the North Branch during flood recovery efforts following the 1938 and 1973 (and possibly other floods) may have contributed to headcutting that increased the degree of incision. The channel-spanning exposure of bedrock mid-reach would tend to limit the upstream migration of head cuts.

Localized deposition (2 point bars, 1 side bar, 1 transverse riffle) and meander migration are occurring at the upstream end of the reach where the North Branch receives the Knapp Brook. A large delta and braided flow at the confluence indicates that this RB tributary is a significant source of sediment. Windshield surveys along the Knapp Brook revealed extensive berming along both banks approximately 750 feet upstream from the confluence. Also, the Felchville Gulf Rd (gravel) shares a very narrow, steep valley with the Knapp Brook for nearly one mile upstream of Route 106 and several direct sources of sediment runoff from this road were observed.

The majority of reach M15T1.09, however, shows negligible signs of planform adjustment, aggradation or widening. The channel has had much the same planform for several decades. A very subtle secondary sinuosity appears to be developing in the low-flow channel (upstream of the bedrock grade control and bridge site). Somewhat enhanced streambank erosion was noted along the outside edge of these incipient meanders. A weak riffle/pool form is developing in the channel that is otherwise dominated by a plane-bed morphology.

Given the incised and entrenched status of the channel and minimal floodplain, very little sediment deposition is occurring (with the exception of at the very upstream extent where meander migration has created a narrow floodplain and deposition of point bars is evident). Overall, the segment functions as a transport-dominated channel at bankfull flow. The channel remains susceptible to catastrophic failure and erosion during larger flood events; rip-rap armoring adjacent to residential buildings and along Route 106 suggests a history of erosion hazards in the reach.

Record of ice jams within this segment (see Appendix O of Phase 1 report - SMRC, 2007). Five road ditch inputs indexed within the reach were characterized as a minor flow alterations or flow increases. The upstream drainage area of the North Branch at reach M15T1.09 is moderately large (17.97 square miles) and would be expected to assimilate additional incremental stormwater flows from these road ditches. The marginally increased flows possible from stormwater culverts under Route 106 are considered less important than other factors potentially associated with the current degree of historic incision (e.g., channelization, encroachments, armoring, flooding, flood recovery).

**M15T1.08**

Reach M15 T1.08 flows through a valley setting of glaciofluvial sediments bound on the east and west by till-covered, bedrock-controlled steep valley walls. Bedrock is exposed along the left valley wall near the upstream end of the reach and is also channel-spanning at the apex of the prominent meander bend, providing a vertical grade control within the reach. Within this reach, the channel is transitioning out of a local valley pinch point toward the very broad alluvial-valley setting of downstream reaches M15T1.07 – T1.05.

Multiple terraces are evident in the glaciofluvial sediments that fill this valley. The lowest terraces (TER1) comprise the immediate left and right banks of the channel in the downstream half of the reach. Along the LB, this lowest terrace is more continuous and ranges in height above the thalweg from 5.8 ft to 6.9 ft along the LB – or 1.9 to 2.2 times the measured thalweg depth. Along the RB, TER1 is more discontinuous and ranges in height from 5 to 6.5 ft to above the thalweg (1.6 to 2.1 times the thalweg depth). A second set of terraces (TER2) is evident at an approximate thalweg height ranging from 9.5 to 12.5 feet. In the upstream half of the reach, TER2 is mostly coincident with the LB and RB (i.e., the channel is entrenched within these high terraces). In the downstream half of the reach, TER2 is absent along the RB and is more than 5 channel widths away from the channel along the LB. A third prominent terrace at an approximate thalweg height of 18 to 25 ft is present along the RB at a distance of 2 to 10+ channel widths away from the channel. (A short, narrow terrace of comparable height ($H_{TW}$ = 17.5) is present along the LB near the prominent meander bend at the upstream end of the reach).

Presence of these terraces complicated the task of delineating a valley wall in the reach for purposes of defining a reference stream type. In the absence of detailed surficial geologic mapping, the Phase 1 valley wall along the LB was updated to reflect the contact between USDA-mapped soils of glacial till parent material and soils of glaciofluvial origin (i.e., where TER2 intersects the steeper, till-veneered bedrock valley wall). The Phase 1 valley wall along the RB was modified to fall at the base of TER3. These positions define a valley confinement that ranges between "Semi-Confined" and "Very Broad". Reach-wide, the average confinement is "Broad", suggesting a C reference stream type.

At present, the North Branch channel occupies a very narrow, flat-bottomed floodplain entrenched and incised between terraces (of varying heights). Incision ratios ranged from 5.2 (at upstream XS-2) to 2.2 (at downstream XS-1). Based on absence of features such as head cuts, actively undercutting banks, or freshly-exposed tree roots, incision was characterized as "historic" in the RGA (i.e., not actively occurring). In part (especially in the upstream half of the reach), the degree of vertical separation of the channel from immediately-adjacent terrace, may be related to post-glacial stream dissection of glaciofluvial sediments (i.e., occurring thousands of year ago). The North Branch channel could have down-cut through valley fill sediments due to a drop of local base levels as well as isostatic rebound following recession of the glaciers. (Topography and regional surficial geologic mapping suggest a possible high-level pro-glacial lake in the immediately downstream reaches, M15T1.07 – M15T1.05). It is also likely that some degree of historic incision may have resulted from reported extensive channelization, dredging and floodplain encroachments that occurred during flood recovery efforts following the 1927, 1938 and 1973 (and other?) floods. Several features observed in the reach suggest incision occurring more recently than post-glacial times. These include: (1) narrow but distinct benches at elevations lower than the adjacent terrace surfaces and moderately higher than estimated bankfull stage (e.g., just upstream of XS-1); (2) double sets of rip-rap armoring along some sections of the reach – one at a higher elevation farther from the channel, and a second set at a lower elevation closer to the current channel bottom; and (3) well-vegetated (i.e, abandoned) depositional side bars within the narrow floodplain between adjacent terraces.

Channel straightening is inferred due to the linear planform and rip-rap armoring. Likely historic - since the planform appears the same on 1939 aerial photograph. Anecdotal evidence suggests that this section of the channel was bulldozed and windrowed after the 1973 flood (Willey, 2008). Route 106 follows the valley in

the RB corridor (on TER3) and encroaches on the channel along RB near the downstream end of the reach, at a thalweg height of 18 to 20 feet within one bankfull width of the channel. This road is reinforced with rip-rap armoring at the base of the slope. Two bridges cross the channel within the reach: (1) a timber VAST trail (?) or logging road in the upper half of the reach provides access to a forest road that follows the channel for a short distance at the top of the LB terrace; and (2) the Ascutney Basin Rd bridge crosses the channel near the downstream end of the reach. Both structures are bankfull constrictors. Slight deposition (side bar) was noted above the Ascutney Basin Rd bridge; reportedly this bridge was the site of a debris jam during the 1973 flood (Willey, 2008). An old abutment of laid-up stone (LB) and concrete (RB) is present approximately 100 feet upstream of this bridge. The span of these abutments is 53% of the reference bankfull width, and this constriction appears to have generated a downstream scour pool and a steep upstream riffle of sediment that might otherwise be trapped at the Ascutney Basin Rd bridge abutments.

The upper half of the reach is dominated by a cobble plane-bed form. Following a subtle decrease in gradient, the bed material becomes finer with distance downstream (fining to coarse gravel at XS-1), and a weak riffle/pool form develops, although pools are quite shallow and run-like. Anecdotal accounts of riparian landowners suggest that pools were much deeper and more frequent in past decades before channel was "flat-bottomed" (dredged) following the 1973 flood (Willey, 2008; Duffy, 2008).

The downstream cross section (XS-1) of F4-R/P was chosen to represent the reach. This represents a conservative approach with respect to defining the sensitivity rating for the reach. While both an F3 channel and an F4 channel represent a stream type departure and are assigned a sensitivity of "Extreme" under VTANR protocols, the F4 channel is assigned a slightly higher hazard index (stream type grouping of 9 rather than 8 in Table 1, page 14 of the November 2008 VTANR *River Corridor Protection Guide*) due to the presumed higher likelihood that these finer bed sediments would be subject to erosion.

Transport functions of this reach may have been enhanced by entrenchment of the channel through historic incision, especially in the downstream half of the reach. (Upstream half may naturally have been more of a transport-dominated reach – as this, arguably, could be a Bc reference stream type confined by high terraces of glaciofluvial sediments). It is possible that incision in response to anthropogenic factors (channelization, encroachments) has increased the degree to which this upstream half of the reach is disconnected from its floodplain. Very little coarse sediment storage in the reach due to narrow floodplain, as signaled by near absence of active depositional bars. Fine, overbank sedimentation has been nearly eliminated by the entrenched status of the channel. Armoring and tree buffer along the banks (combined with the apparent cohesiveness of streambank sediments (few exposures revealed relatively unsorted sediments - large cobble and boulders in relatively, cohesive silty sand matrix) mean that the reach is not presently a significant source of fine and coarse sediment fractions. Remains susceptible to catastrophic erosion in higher flow stage.

Cross section chosen for Step 2 to characterize the reach (XS1) happens to have a D50 (63.1 mm) on the cusp between a coarse gravel and small cobble classification. Step 2.14 bed material of gravel represents conditions at this downstream cross section and does not constitute a substantial, stressor-induced departure from cobble to gravel. Rather, this reflects a slight, gradual fining-downstream trend of D50 with slightly decreasing gradient and perhaps a down-valley fining sequence of source material in the channel boundaries. A second cross section located in the upstream half of the reach indicated a D50 = 95mm (small cobble).

**M15T1.07**

Reach M15 T1.07 (2740 feet) enters the northern end of a very broad alluvial valley which extends more than two miles to the south to the bedrock gorge at Amsden. Alluvial and glaciofluvial sediments (USDA) are bound on the far west and east edges of this valley by steep valley walls of glacial till.

Visible on the 1994 orthophotos are subtle, sinuous depressions which likely represent the planform of the North Branch from several hundreds to thousands of years ago. More recent historic topographic maps and aerial photographs depict the channel planform in M15T1.07 to be in much the same location as it is today, cutting to the southeast across the valley to join the eastern (LB) valley wall. Some very recent planform changes are revealed by comparison of the 1994 orthophotos to the 2003 color aerial photography (see Figure 31 in main body of the Phase 2 report).

Hay fields are present along both LB / RB corridors. Sparse residential development is located along Ascutney Basin Rd to the north and Route 106 to the west. A large oval impression is visible on this 1994 orthophoto and a track is depicted on the 1983 topographic map and a 1980 aerial photograph of the region. This track is no longer present. Reportedly, this was a gravel track used by a former landowner to exercise and train horses (Willey, 2008: personal communication).

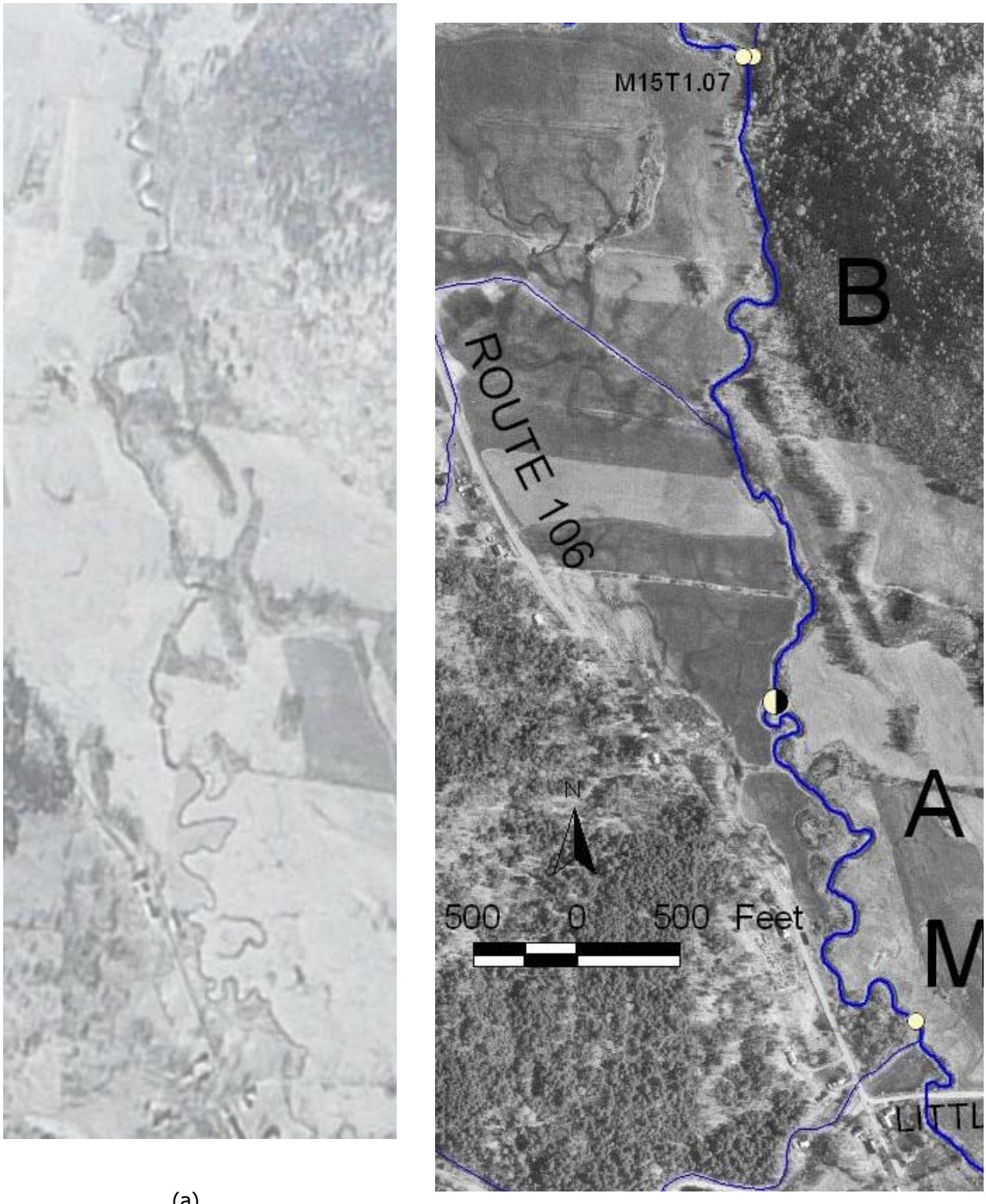
A riparian landowner reports historic dredging, channelization and berming, particularly following the 1973 flood (Willey, 2008). A more linear planform is evident in the upstream half of the reach on aerial photographs from 1980 and 1939. Remnants of berms were noted on both banks near the upstream end of the reach and along greater sections of the RB adjacent to the hay fields in the mid-portion of the reach. Several lengths of old rip-rap armoring were noted along both banks on the outside of meander bends; often pockets of the armoring had been eroded away or altogether abandoned by a shift in the planform. For a 140-ft length (approx) of channel near the upstream end of the reach, cedar revetments are cabled to the base of the LB. According to an adjacent landowner, theses revetments were installed by the NRCS and a YCC work crew perhaps 5 – 7 years ago (Duffey, 2008: personal communication). This section of revetments grades immediately downstream into a long section of high-bank erosion and meander extension.

Substantial planform adjustments and widening are ongoing, combined with a moderate degree of aggradation. A reduction in sediment transport capacity would be expected in this reach, governed by the decrease in valley gradient and confinement. Historic removal (or narrowing) of tree buffers to support agricultural uses in the corridor has likely contributed to lateral adjustments. The channel is regaining sinuosity. Meander width ratio is now 3.9; Wavelength 11.8. Landowners remarked at how the meander bends in the upstream half of the reach have grown substantially since the 1973 flood which is revealed by the overlay of past channel positions. Historically this channel has been managed to bring it back to more linear planform adjacent to actively farmed lands, as it was following the 1973 flood. In subsequent years, some RB lands have gone fallow, and this might present an opportunity of reduced land use conflicts where the channel could be allowed to return to a more natural sinuous (or even braided) pattern. This reach is a key sediment attenuation area and a Very High priority for river corridor protection. Future encroachments within this corridor would be at enhanced risk of erosion hazards.

**M15T1.06**

This reach crosses from the left valley wall toward the right valley wall just above the Little Ascutney Basin Road crossing near the historic village of Greenbush. Sediment types mapped in the floodplain include alluvial, glaciofluvial and some glaciolacustrine soils (USDA). Large areas of hydric soils are mapped within the reach corridor However, due to the prior-converted status of surrounding floodplain soils to agricultural use (hay and occasional corn), the aerial extent of mapped wetlands is limited. A reference stream type of sand-dominated E-dune/ripple is evident from the low W/D ratio and cohesive sediments comprising the banks.

From review of historic aerial photographs this reach was somewhat more sinuous in the early 1900s (see Figure 31), and has seen extensive channelization and dredging to facilitate farming and to respond to past major flood events.




(a) (b)

*Figure 31. Comparison of M15T1.06 planform in (a) 1939 versus (b) 1994.*

Cross sections reveal that the upper two-thirds of the reach has a moderate overall degree of incision, while the lower third of the reach has reverted to a more sinuous planform in recent decades and has good connection to the flood plain. Given these general differences in incision ratio and sinuosity, reach M15T1.06 was segmented.

**Segment B**

Channel follows the left valley wall at the upstream end. Hay and crop fields are present along the left and right corridors. A RB tributary has been regularly dredged/bermed according to landowner to facilitate drainage in hay field. Hydric soils are prevalent across the valley and contiguous with the channel. Limited wetlands are mapped in the valley due to prior-converted agricultural use (see Figure 14, main body of Phase 2 report).

One equipment ford mid-segment (with gravel- and cobble-reinforced bed) provides access to eastern fields. Channel was "flat-bottomed" (dredged) following the 1973 flood (Willey, 2008). Ongoing channel adjustments in recent years (including meander extension, meander migration and translation) have restored some degree of sinuosity to the channel. In some locations this lateral channel adjustment is at odds with adjacent farming uses of the lands. Some short sections of rip-rap armoring were noted along both banks

Lateral adjustments and aggradation are locally enhanced by beaver activity (Willey, 2008; Miller, 2007). One active beaver dam was noted on the 11 June 2008 assessment date, impounding approximately 800 feet of channel (control height 1.6 ft from bed). This dam was located at the point where the channel impinges upon the LVW comprised of coarser gravels and cobbles. Immediately below this point, was a short stretch (200 ft) of slightly steeper-gradient cobble bed form between high eroding terraces on both banks exposing sands and gravels. Accumulated fines (fine gravels and sand) were observed in the channel for approximately 500 ft downstream, which may have been generated from periodic washing out of beaver dams.

Cross section shows degree of channel incision (IR = 1.6). Probably related to past channelization and dredging.

**Segment A**

Slight reduction in valley width due to Route 106 encroachment along west valley wall (RB corr). Valley type (V. Broad) and confinement status (Unconfined) remain unchanged. Extensive hydric soils are mapped in the floodplain; limited wetlands are mapped, probably due to prior-converted agriculture status. Hay and crop fields in the LB corridor; hay and wetland vegetation in the RB corridor. Historic and recent neck cutoffs with abandoned oxbow channels and sinuous isolated depressions in the landscape that concentrate runoff and collect snowmelt.

Straightening inferred in upstream half of the segment due to the linear planform and truncated meanders and close proximity of agricultural fields (hay and corn). Aerial photograph from 1939 depicts a more sinuous channel with large tortuous meanders which have apparently been straightened in subsequent decades.

Cross section indicates good floodplain connection (IR = 1.0). Evidence of recent bank overtopping (grasses flattened and aligned in direction of recent water flow, leaves stacked perpendicular to the flow direction; fine sediment accumulation) was identified on 7 November 2008 at the downstream side of the prominent meander approximately 700 ft to the north of XS-1. Discharge records for rivers in the region (i.e., Williams)

indicated an approximate bankfull event occurring on or about 10/27/08. Precipitation records for Springfield, VT indicated 2.06 inches of rain fell on October 25 (www.wunderground.com).

Restored (or maintained) floodplain access in this segment possibly due to aggradation induced by downstream valley pinch point and bedrock grade controls at Amsden. Transient beaver dams probably also contributing to aggradation and localized widening in the segment. While a D-stage CEM (Step 7) may be appropriate for segments such as this one with good floodplain connection (IR<1.2), moderate to severe active lateral adjustments, and fine-grained and relatively cohesive channel boundary sediments, this reach was classified in a F-stage CEM (Stage I) because an upstream segment (M15T1.06-B) in very similar setting exhibited an historic incision ratio of 1.6, suggesting the potential for incision/degradation in this segment (M15T1.06-A).

**M15T1.05**

Very broad valley setting gradually narrowing to the bedrock-controlled valley pinch point at Amsden Falls (downstream reach M15T1.04). Extensive wetlands are mapped spanning the channel in reach M15T1.05 (VSWI, NWI). Hydric soils (USDA) are more extensive spanning the full valley width; it is likely that reference wetland conditions span the valley width, but were not mapped as such due to the prior-conversion to agricultural uses.

Slight encroachment by roads along the left and right valley walls; however, this encroachment is not sufficient to result in a significant change to the valley type (Very Broad) or confinement status (unconfined). Sparse residential development is present along these roads at the valley edge. Floodplain areas within a 400 to 700 foot corridor surrounding the channel are vegetated by shrubs and saplings. Areas outside of this corridor are in agricultural use (hay, corn, fallow). One bridge crossing is located at the upstream end of the reach conveying Little Ascutney Basin Rd; this bridge was recently repaired to replace a timber/ steel I-beam deck with a concrete deck. The clearance of this structure was improved (from 8.3 to 8.7 feet above the channel bed); however, the abutments were not replaced. They form a bankfull-constricting span (17 feet, or 41% of the average measured bankfull width), and the approach angle of the channel to this bridge is markedly sharp. On the outside of the meander, the position of the upstream portion of the RB abutment appears to have shifted on the footer. Upstream aggradation and downstream scour are both associated with this bridge crossing. A second (flood-prone-constricting) bridge crossing is located in the downstream half of the reach. Based on signage, this bridge conveys a VAST trail, and is likely utilized for farm equipment access to adjacent fields. Short lengths of this grassy trail (possible snowmobile trail) follow the LB of the North Branch. White caution tape and signs warn the trail user to stay away from the eroding top of the river bank. Progressive lateral erosion has undermined the wooden stakes that support this trail.

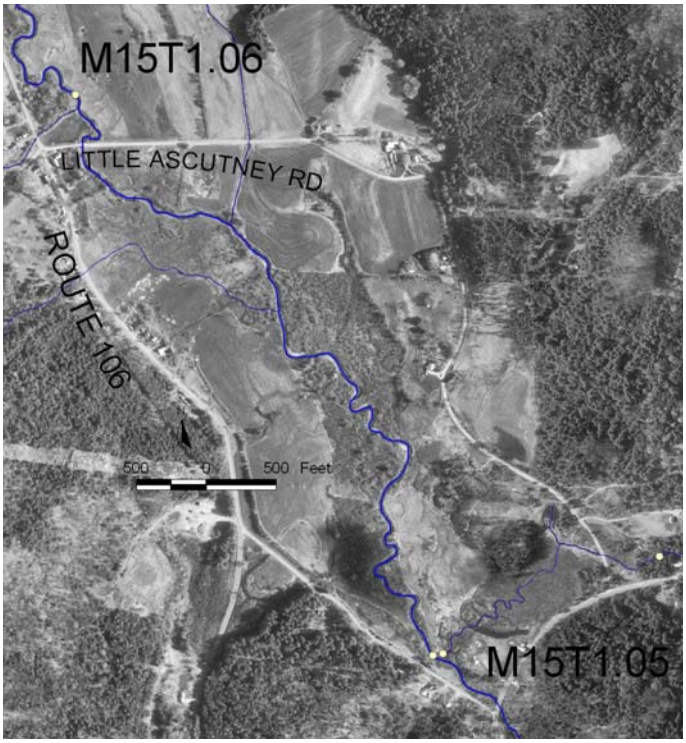
There is a history of extensive channelization of this reach and its contributing streams. The upper half of the reach was channelized (and probably dredged) post-1939, based on a comparison of historic aerial photographs (Figure 32). Perhaps through repeated periodic channel management (post-1973 flood?), the upper half of the reach still today has a mostly linear planform (although it appears to be developing some secondary sinuosity in the low-flow channel). The downstream half of the reach is more sinuous in planform, though not to the degree represented on 1939 aerial photographs.

A RB tributary joining the reach near the upstream end has a linear planform and large delta of gravels and sands at its confluence with the North Branch. Based on review of the USGS topographic map, it appears that this channel used to join the North Branch approximately 200 ft upstream of its current position (i.e, in reach M15T1.06). Based on comparison of 1994 aerial photographs and the 1980s topographic map, a LB tributary which once joined the North Branch in the downstream half of the reach was channelized / dredged through adjacent agricultural fields and now joins the main channel nearly ½ mile upstream of the former confluence.



*Figure 32. Comparison of M15T1.05 planform in (a) 1939 versus (b) 1994.*

(a)




(b)

Continuing the downstream-fining sequence of bed materials in this valley of the North Branch, reach M15T1.05 is dominated by sands with decreasing percentages of fine gravels. The natural valley constriction (from Very Broad to Semi-confined to Narrow confinement) at Amsden Falls has likely enhanced the sediment attenuation (aggradation) in M15T1.05.

Short section of channel in the upper half that suggests a slight degree of incision (IR = 1.36 at XS2) and a plane-bed form (Not Representative of the reach). It is possible that historic (post-1939) channelization local to this site mechanically deepened the channel (and/or elevated the top of bank) to result in this IR. Overall, however, the channel appears to have good floodplain access (IR = 1.0 to 1.2) and exhibits an E5-dune/ripple stream type, consistent with reference.

While a D-stage CEM (Step 7) may be appropriate for reaches such as this one with good floodplain connection (IR<1.2), moderate to severe active lateral adjustments, and fine-grained and relatively cohesive channel boundary sediments, this reach was classified in a F-stage CEM (Stage I) because an upstream segment (M15T1.06-B) in very similar setting exhibited an historic incision ratio of 1.6, suggesting the potential for incision/degradation in this reach M15T1.05)

**M15T1.04**

Due to the bedrock gorge (Amsden Falls), this reach was not assessed during this study. While the overall reach gradient is calculated as < 2%, windshield observations and remote sensing suggest that field assessment would confirm a short (~600 ft) subreach of E5-dune/ripple at the upstream end of the reach, and a C-riffle/pool at the downstream 1200 (+/-) feet of the reach, separated by a mid-section of A or B bedrock channel with a gradient steeper than 2%.

Bedrock controls within the reach cause a narrowing of the valley from Very Broad to Semi-confined or Narrow confinement. Historically, saw mills and grist mills were located along this reach at the village of Amsden (Beers, 1869). Two small impoundments are indicated within the reach on the Beers Map indicating historic presence of dams.

**M15T1.03**

Reach M15T1.03 runs through a broad valley of glacio-fluvial and alluvial sediments confined by steep bedrock-controlled, till-covered valley walls to the east and west of the channel. There are multiple sets of terraces within the valley, mapped as both glacio-fluvial and alluvial materials (USDA). Presence of these terraces complicated definition of the Phase 1 reference valley wall for purposes of estimating the reference stream type for the reach. The channel has reasonable access (IR = 1.13 to 1.39) to a recently-formed alluvial floodplain that ranges in width from approximately 80 ft in the upstream fifth of the reach to generally 300 to 500 ft wide in the remaining majority of the reach (except for a local, bedrock-controlled valley pinch point near the mid-point of the reach). This alluvial floodplain is bound on either side by a higher set of terraces provisionally mapped as glacio-fluvial sediments (USDA). This higher terrace is generally within 300 ft of, and sometimes coincident with, RB at a thalweg height ranging from 7.5 to 9 feet (1.9 to 2.3 times the average measured bankfull width). Along LB, this higher terrace is less prevalent, rarely coincident with LB, and is located at an approximate thalweg height of 11 feet (or 2.8 times the average measured bankfull width). The timing and nature of the formation of these terraces could not be defined within the limited scope of this study. Therefore, it is not known if these higher terraces resulted from incisional processes that occurred within the last 300 years, or if they formed during post-glacial times. VTANR protocols recommend that terraces higher than three times the bankfull depth can be ignored when estimating incision ratio, as they likely represent terraces that formed in post-glacial times. In a conservative approach, since the thalweg heights of these higher set of terraces are within three times the

bankfull depth, they were not mapped as the Phase 1 reference valley wall. Instead, the reference valley wall was defined farther away from the channel at the point where these terraces join the much steeper incline – sometimes mapped as glaciofluvial materials (an even higher terrace set) and sometimes mapped as glacial till with shallow underlying bedrock (USDA).

This reach has undergone many anthropogenic changes. The downstream channel (M15T1.02) was impounded to form Stoughton Pond in the 1960s by the Army Corps of Engineers. Impoundment effects appear to extend upstream into reach M15T1.03; therefore, the reach was segmented to account for this change in flow characteristics.

**Segment B**

Slight human-caused change in valley width, by Branch Brook Rd along RB corridor. Not sufficient to cause change in valley type (Broad) or confinement status (Unconfined). Sparse residential and agricultural land use in the valley prior to the 1960 impoundment to create the Stoughton Pond reservoir (ins downstream reach T2.02). Historic residential / agricultural land uses in the valley mostly abandoned (taken by eminent domain) during construction of Stoughton Pond and downstream North Springfield Reservoir. Active sand and gravel quarrying has been ongoing in the valley (both LB and RB corridors) since prior to 1977, starting on the eastern valley margins. Adjacent gravel pits are excavated at elevations 40 to 220 feet above the channel. Forested buffers are present between the channel and the active working face of these pits (generally greater than 200 feet in width, as measured on the 2003 aerial photo) – except for one point location along LB of a 80-foot mass failure, where channel impinges against left valley wall. This mass wasting of sands and fine gravels impacts approximately 50 feet of channel length.

Channelization is inferred due to linear planform, and historically close encroachment of agricultural fields along RB. Old channel meander is visible along RB - abandoned either by avulsion during a flood (possibly 1927 flood) or by channel management. River has essentially the same planform as today when viewed on the 1939, 1977, 1980, 1994 and 2003 aerial images.

A reduction in sediment transport capacity is apparent, associated with impounding effects in the downstream Stoughton Pond. This segment has reasonable access to a narrow floodplain and is dominated by moderate aggradation and planform adjustments (meander extension, flood chutes, one avulsion). Segment B represents an attenuation asset in the North Branch river network.

**Segment A**

Segment A consists of the downstream 1428 feet of the reach, affected by the impoundment of Stoughton Pond in the downstream reach. Consistent with VTANR protocols, this segment was not assessed due to the impoundment effects.

Branch Brook Rd follows along the right valley wall, and is occasionally coincident with the RB of the North Branch channel. The linear planform of the North Branch near the upstream end of Stoughton Pond suggests historic channelization. A sediment delta has prograded out into the Stoughton Pond reservoir in the years since construction of the reservoir (c. 1960) (see Figures 33). VT River Management databases maintained by the Stream Alteration Engineer for the region indicated that on or about 19 June 1997 "lots" of sediment was extracted from Stoughton Pond by the Army Corps of Engineers (Nicholson, 2007; see Phase 1 report). Dredging may have triggered incisional processes at the downstream end of reach M15T1.03.

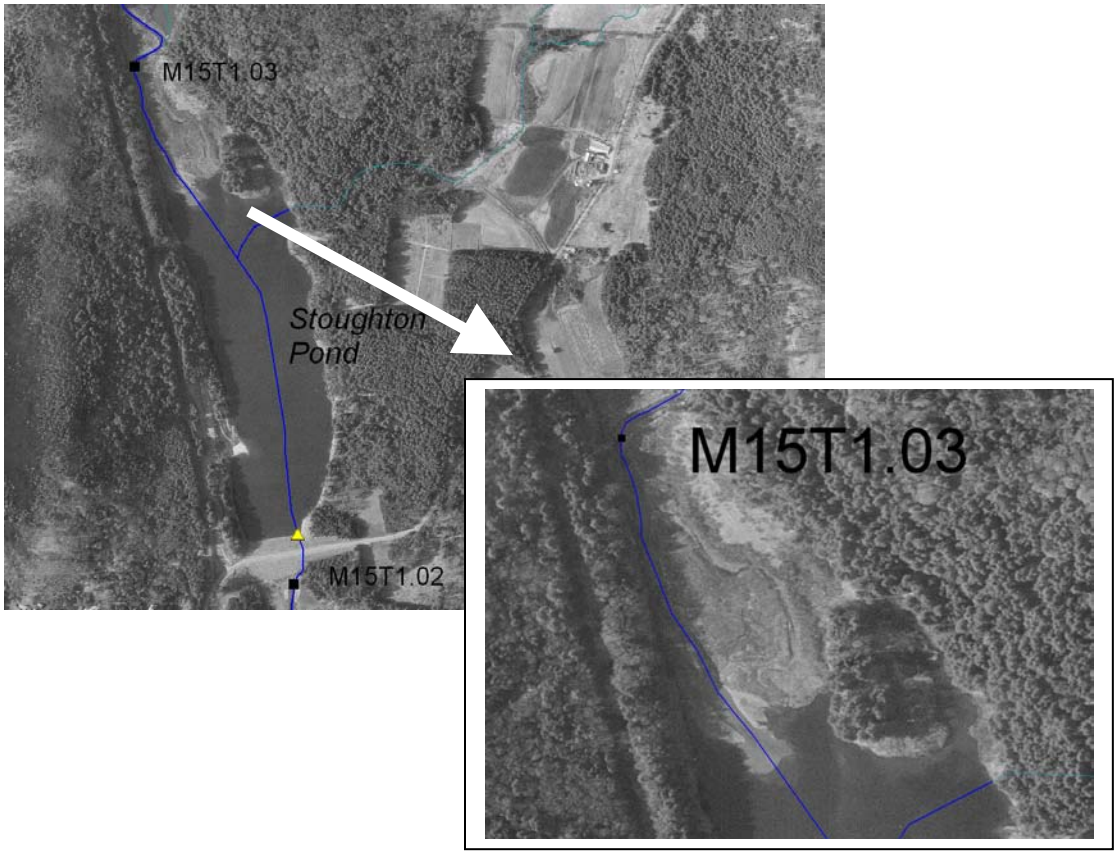



*Figure 33. Delta of fine sediments extending into upstream end of Stoughton Pond from the North Branch of the Black River (base map: 1994 orthophoto).*

# APPENDIX F

## Stressor Tables, Reach-Scale

Abbreviations used in the following tables:

| | |
|---|---|
| BFL | Bankfull |
| FPW | Flood Prone Width |
| RB | Right Bank |
| LB | Left Bank |

| | |
|---|---|
| I | Increase (of Stream Power or Boundary Resistance) |
| D | Decrease (of Stream Power or Boundary Resistance) |

Text in blue denotes a natural stressor or modifier.
Text in black indicates a human-caused modification.

# Table F-1. Stressor Tables, Reach-Scale – Black River main stem Upstream of Cavendish Gorge

| | Reach-Scale Stressors | | | | | |
|---|---|---|---|---|---|---|
| **Reach / Segment** | **Stream Power** | | | **Boundary Resistance** | | |
| M37-B | I | Slope | Local flow increase resulting in moderate scour under & downstream of East Lake Rd bridge | I | Bank | Maintenance of tree buffers, limited encroachments. |
| | I | Slope | Historic channelization, dredging. | I | Bank | Bedrock exposures in channel bank (RB). |
| | I | Slope | Encroachment: berm, RB | D | Bed, Banks | Reported historic dredging |
| | I | Slope | Historic localized reduction in sediment supply below dam at upstream end segment (Lake Pauline, and 5+ miles reservoirs/lakes upstream). | | | |
| | D | Slope | Pair of old abutments constructed on bedrock represent a bankfull constriction with significant upstream aggradation (localized). | | | |
| M37-A (Not Assessed) | I | Slope | Historic channelization | I | Bank | Maintenance of tree buffers, limited encroachments. |
| | D | Depth | Sediment accumulation at downstream end of segment due to Branch Brook tributary confluence bar. | I | Bed, Banks | Cohesive sediments |
| | D | Depth | Beaver dams (transient, localized, but cumulative) | D | Bank | Localized removal of woody vegetation related to residential use (RB). |
| M36T4.01 (Branch Bk) | I | Slope | Historic channelization | I | Bank | Revetments (extensive, both banks) |
| | I | Slope | Encroachment: Route 103, RB | I | Bank | Regeneration of tree buffers, limited encroachments (downstream third) |
| | I | Slope | Encroachment: berms, both banks | I | Bed | Channel-spanning bedrock exposure (mid-reach). |
| | I | Slope | Encroachment: parking lot, commercial property, RB (upstream third) | D | Bed, Banks | Reported historic dredging |
| | I | Depth | Historic dredging (inferred) | | | |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls (minor) | | | |
| | I | Depth | Stormwater: increased flow from Coleman Brook, RB trib | | | |
| M36-B | I | Slope | Historic channelization | I | Bank | Regeneration of tree buffers, limited encroachments. |
| | I | Slope | Encroachment: Route 103, RB (minor) | I | Bed, Banks | Cohesive sediments |
| | | | | D | Bank | Removal of Tree Buffers (historic clearing, RB) |
| M36-A | I | Slope | Historic channelization | I | Bank | Armoring (some, LB) |
| | I | Slope | Encroachment: Route 103, RB (minor) | I | Bank | Regeneration of tree buffers, limited encroachments. |
| | D | Slope | Valley constriction at downstream end enhanced by degree of encroachment by roads resulting in Narrowly-Confined channel in M35. | I | Bed, Banks | Cohesive sediments |
| | | | | D | Bank | Historic Removal of Tree Buffers (RB) |
| M35 | I | Slope | Encroachment: Route 103, RB; Dug Road, LB | I | Bank | Armoring (extensive, RB; some, LB) |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls (3, RB) | I | Bank | Maintenance of tree buffers, limited encroachments (LB). |
| | D | Depth | Beaver dams (transient, localized, minor) | I | Bed, Banks | Cohesive sediments |
| M34 | I | Slope | Historic channelization, Windrowing | I | Bank | Armoring (extensive, RB) |
| | I | Slope | Encroachment: berms, RB | I | Bank | Maintenance of tree buffers, limited encroachments, LB. |
| | I | Slope | Encroachment: parking lot, commercial property, RB | D | Bed, Banks | Reported historic windrowing, dredging |
| | I | Slope | Historic breaching of downstream dam, Ludlow Woolen Mill | | | |
| | I | Depth | Historic dredging & local gravel extraction. | | | |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls (minor) | | | |
| | D | Depth | Localized increase in sediment supply at Jewell Brook confluence, RB, just below downstream end of reach. | | | |
| | D | Slope | Armored/ modified channel in M33-B (upstream of Rt 103) is bankfull constrictor w/ moderate upstream aggradation. | | | |

## Table F-1. Stressor Tables, Reach-Scale – Black River main stem Upstream of Cavendish Gorge (CONTINUED)

| | Reach-Scale Stressors | | | | | |
|---|---|---|---|---|---|---|
| **Reach / Segment** | **Stream Power** | | | **Boundary Resistance** | | |
| M33-B | I | Slope | Historic channelization, dredging, possible windrowing. | I | Bank | Armoring (extensive, both banks) |
| | I | Slope | Encroachment: berms, LB, downstream of Rt 103 bridge | I | Bank | Maintenance of tree buffers, limited encroachments (LB). |
| | I | Slope | Encroachment: roads, retaining walls, both banks | D | Bed, Banks | Reported historic dredging, possible windrowing, |
| | I | Slope | Encroachment: commerc. / resid. development, LB, RB | D | Bank | Removal of Tree Buffers (RB), local to residential / commercial use & roads. |
| | I | Slope | Historic breaching of downstream dam, Mill St crossing. | | | |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls (minor) | | | |
| | D | Slope | Route 103 (Main St) bridge is bankfull constrictor with some upstream aggradation (localized). | | | |
| | D | Slope | Historic dam remnants at Mill Street crossing serve as grade control (low head). | | | |
| | D | Depth | Sediment accumulation at upstream end segment due to Jewell Brook tributary confluence bar. | | | |
| M33-A | I | Slope | Historic channelization, dredging, possible windrowing. | I | Bank | Armoring (extensive, both banks) |
| | I | Slope | Encroachment: berms, both banks, discontinuous | D | Bed, Banks | Reported historic dredging, possible windrowing, |
| | I | Slope | Encroachment: roads, Main St (Route 103), (LB) | D | Bank | Removal of Tree Buffers (both banks), local to residential / commercial/ municipal use & roads. |
| | I | Slope | Encroachment: commerc. / resid. development, LB, RB | | | |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls (minor) | | | |
| | D | Slope | Pleasant Street Ext bridge is FPW-constrictor with significant upstream aggradation (localized). | | | |
| | D | Slope | Constriction between LB road/armoring berm & RB fill/armoring at WWTF, increases upstream aggradation | | | |
| | D | Depth | Localized increase in sediment supply, LB tributary confluence (coincident w/ Pleas. St Ext bridge constriction). | | | |
| M32-C | I | Slope | Historic channelization, dredging. | I | Bank | Armoring (some, both banks) |
| | I | Slope | Historic localized reduction in sediment supply below Smithville dam when operational, downstream end. | I | Bank | Maintenance of tree buffers, limited encroachments (RB). |
| | I | Slope | Historic breaching of Smithville dam when operational, upstream end of segment. | I | Bed, Banks | Localized bedrock exposures in bed and banks, (RB) - not channel-spanning. |
| | | | | I | Bed, Banks | Somewhat cohesive sediments |
| | | | | D | Bed, Banks | Reported historic dredging |
| | | | | D | Bank | Removal of Tree Buffers (LB) associated with agriculture. |
| M32-B | I | Slope | Historic channelization, dredging. | I | Bank | Maintenance of tree buffers, limited encroachments (RB). |
| | I | Slope | Encroachment: berms, LB, discontinuous (minor, low elev) | I | Bed, Banks | Somewhat cohesive sediments |
| | I | Slope | Historic localized reduction in sediment supply below Smithville dam (M32-C) when operational. | I | Bank | Bedrock exposures in channel bank (RB). |
| | D | Slope | Sharp approach angle and constriction between LB armored road and RB armoring in downstream segment M32-A has contributed to upstream aggradation. | D | Bed, Banks | Reported historic dredging |
| | D | Depth | Beaver dams (transient, localized, but cumulative) | D | Bank | Removal of Tree Buffers (LB) associated with agriculture. |

## Table F-1. Stressor Tables, Reach-Scale – Black River main stem Upstream of Cavendish Gorge (CONTINUED)

| | Reach-Scale Stressors | | | | | |
|---|---|---|---|---|---|---|
| **Reach / Segment** | **Stream Power** | | | **Boundary Resistance** | | |
| M32-A | I | Slope | Historic channelization, dredging. | I | Bank | Armoring (some, both banks) |
| | I | Slope | Encroachment: roads, Rt 103, Greven Rd Ext (LB) | I | Bed, Banks | Cohesive sediments, some sections |
| | I | Slope | Encroachment: railroad, LB, RB | D | Bed, Banks | Reported historic dredging |
| | I | Slope | Encroachment: commerc. / resid. development, LB, RB - localized | D | Bank | Localized removal of woody vegetation related to commerc./ resid. use and road encroachments (RB, LB). |
| | I | Slope | Localized flow increase downstream of bridge, abutment, and armoring constrictions | | | |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls (minor) | | | |
| | D | Slope | Localized upstream aggradation at BFL and FPW constrictions. | | | |
| M31 | I | Slope | Historic channelization, along Railroad | I | Bank | Armoring (some, both banks) |
| | I | Slope | Encroachment: railroad, LB, RB | I | Bank | Maintenance of tree buffers, limited encroachments (RB, LB), discontinuous sections. |
| | I | Slope | Localized flow increase resulting in scour pool downstream of Depot St and Railroad bridges (minor) | D | Bank | Localized removal of woody vegetation related to development and railroad encroachments (RB, LB). |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls (minor) | | | |
| | D | Slope | Localized upstream aggradation (moderate) at FPW constriction of Railroad bridge. | | | |
| M30 | I | Slope | Historic channelization, dredging | I | Bank | Armoring (some, both banks) |
| | I | Slope | Encroachment: railroad, RB, upstream end; elsewhere usually elevated above FPW elevation on valley side slope. | I | Bank | Maintenance of tree buffers, limited encroachments (particularly RB) |
| | I | Slope | Encroachment: berm, LB, discontinuous & short in length | | | |
| | I | Slope | Residential development, LB, (limited in extent) | | | |
| | I | Slope | Historic breaching of downstream dam at Litton Mill and avulsion bypassing Cavendish Gorge in 1927 flood. | | | |
| | D | Slope | Impoundment effects of CVPS dam appear to extend upstream into the reach (to a limited degree). | | | |
| | D | Slope | Moderate constriction in downstream reach(es) as channel transitions from Broad to Narrowly-Confined bedrock gorge in M28. | | | |
| M29 (Not Assessed) | I | Slope | Historic channelization, dredging | | | |
| | D | Slope | Downstream bedrock grade controls | | | |
| | D | Slope | Impoundment effects of CVPS dam. | | | |
| M28 (Not Assessed) | I | Slope | Steep bedrock gorge (Cavendish gorge) | | | |
| | | | | | | |

# Table F-2. Stressor Tables, Reach-Scale – Black River main stem Downstream of Cavendish Gorge

| | Reach-Scale Stressors | | | | | |
|---|---|---|---|---|---|---|
| **Reach / Segment** | **Stream Power** | | | **Boundary Resistance** | | |
| M27 | I | Slope | Historic channelization, dredging | I | Bank | Regeneration of tree buffers, limited encroachments. |
| | I | Slope | Localized reduction in sediment supply below dam in upstream reach. | I | Bed, Banks | Cohesive sediments |
| | D | Slope | Moderate constriction at downstream end of reach as channel transitions from Broad to Narrow (bedrock-controlled) confinement. | D | Bed, Banks | Reported historic dredging |
| | D | Slope | Downstream bedrock grade controls (falls below Carlton Rd crossing). | D | Bank | Localized removal of woody vegetation related to residential use and road encroachments. |
| M26T2.01 (Twentymile Stream) | I | Slope | Historic channelization | I | Bank | Armoring (extensive, both banks) |
| | I | Slope | Encroachment: berm, LB, short section | I | Bank | Maintenance of tree buffers, limited encroachments (RB, downstream half). |
| | I | Slope | Encroachment: roads, LB, RB | I | Bank | Bedrock exposures in channel bank (RB). |
| | I | Slope | Encroachment: parking lot, commercial property, RB | D | Bank | Localized removal of woody vegetation related to residential / comm. use and road encroachments (RB). |
| | D | Slope | VT Route 131 bridge is FPW constrictor with upstream aggradation (localized). | | | |
| | D | Slope | Constriction between LB armor and RB bedrock has contributed to upstream aggradation. | | | |
| M26 | I | Slope | Historic channelization, dredging | I | Bank | Armoring (some, LB) |
| | I | Slope | Encroachment: berm, LB, low in elevation | I | Bank | Maintenance of tree buffers (RB), limited encroachments. |
| | I | Slope | Encroachment: road (Route 131), LB (minor) | I | Bed, Banks | Cohesive sediments |
| | D | Slope | Moderate constriction at downstream end of reach as channel transitions from Broad to Semi-confined (bedrock-controlled) confinement. | D | Bed, Banks | Reported historic dredging |
| | D | Slope | Downstream bedrock grade controls. | D | Bank | Removal of Tree Buffers (LB) |
| M19-B | I | Slope | Historic channelization, dredging | I | Bank | Maintenance of tree buffers, limited encroachments (LB). |
| | I | Slope | Encroachment: berm, RB | I | Bank | Bedrock exposures in channel bank (limited, LB). |
| | | | | D | Bed, Banks | Reported historic dredging |
| | | | | D | Bank | Localized historic removal of woody vegetation related to agricultural use (RB). |
| M19-A | I | Slope | Historic channelization, dredging | I | Bank | Armoring (limited, LB) |
| | I | Slope | Possible impacts from historic breaching of downstream Soapstone dam at Perkinsville. | I | Bank | Maintenance of tree buffers, limited encroachments (LB). |
| | D | Slope | Moderate constriction at downstream end of reach as channel transitions from Broad to Semi-confined (bedrock-controlled) confinement. | I | Bank | Bedrock exposures in channel bank. |
| | D | Slope | Sharp turn of channel at downstream end forced by lateral bedrock constraints. | D | Bed, Banks | Reported historic dredging |
| | D | Slope | Downstream bedrock grade controls (at former location Soapstone Dam). | D | Bank | Localized historic removal of woody vegetation related to agricultural use (RB) and driveway (former road) encroachment (LB). |

# Table F-3. Stressor Tables, Reach-Scale – Twentymile Stream Tributary

| | Reach-Scale Stressors | | | | | |
|---|---|---|---|---|---|---|
| **Reach / Segment** | **Stream Power** | | | **Boundary Resistance** | | |
| M26T2.10-C | I | Slope | Historic channelization (inferred from linear planform) | I | Bank | Armoring (some, both banks) |
| | I | Slope | Encroachment: berm, LB | I | Bank | Maintenance of tree buffers, limited encroachments. |
| | I | Slope | Encroachment: road: Twentymile Stream Rd, RB, LB | I | Bed, Banks | Cohesive sediments |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls | I | Bed, Banks | Localized bedrock exposures in bed and banks. |
| | D | Slope | Sharp approach angle and constriction at instream culvert near downstream end of segment has contributed to upstream aggradation. | D | Bank | Localized removal of woody vegetation related to residential use and road encroachments. |
| | D | Slope | Bedrock grade controls at downstream end of reach. | | | |
| M26T2.10-B | I | Slope | Encroachment: Twentymile Stream Rd, LB, upstream end | I | Bank | Maintenance of tree buffers, limited encroachments. |
| | D | Slope | Driveway culvert in downstream Seg A is bankfull-constrictor w/ significant upstream aggradation (localized). | I | Bed, Banks | Cohesive sediments |
| | | | | I | Bed, Banks | Localized bedrock exposures in bed and banks. |
| M26T2.10-A | D | Slope | Driveway culvert near upstream end of segment is bankfull-constrictor w/ significant upstream aggradation (localized). | I | Bank | Armoring (some, both banks) |
| | | | | I | Bank | Maintenance of tree buffers, limited encroachments. |
| | | | | I | Bed, Banks | Cohesive sediments |
| M26T2.09 | I | Slope | Historic channelization (localized) | I | Bank | Regenerating woody buffers; limited encroachments. |
| | D | Slope | Meadowbrook Farm Rd culvert near downstream end of reach is bankfull-constrictor w/ some upstream aggradation (localized). | I | Bed, Banks | Cohesive sediments |
| | D | Slope | Moderate constriction below downstream end of reach as channel transitions from Very Broad confinement to localized valley pinch point in downstream reach M26T2.08. | D | Bank | Localized removal of woody vegetation related to agricultural use and road encroachments (RB). |
| | D | Depth | Beaver dams (transient, localized) | | | |
| M26T2.08-B | I | Slope | Localized, historic channelization possible at upstream end associated with culvert crossing in T2.09 | I | Bank | Maintenance of tree buffers, limited encroachments. |
| | D | Slope | Twentymile Stream Rd culvert is bankfull constrictor with minor upstream aggradation (local to structure). | I | Bed, Banks | Cohesive sediments |
| M26T2.08-A | I | Slope | Local flow increase at bankfull-constricting Twentymile Road instream culvert perhaps contributing to downstream historic incision. | I | Bank | Armoring (some, each bank) |
| | I | Slope | Historic channelization (partial segment). | I | Bank | Maintenance of very narrow, but continuous, shrub buffers. |
| | I | Slope | Encroachment: berm, RB | I | Bed, Banks | Cohesive sediments |
| | | | | D | Bank | Removal of Tree Buffers (historically, for agriculture) |

# Table F-3. Stressor Tables, Reach-Scale – Twentymile Stream Tributary (CONTINUED)

| | Reach-Scale Stressors | | | | | |
|---|---|---|---|---|---|---|
| **Reach / Segment** | **Stream Power** | | | **Boundary Resistance** | | |
| M26T2.07 | I | Slope | Local flow increase resulting in scour pool downstream of bankfull-constricting VAST trail bridge. | I | Bank | Armoring (some, each bank) |
| | I | Slope | Historic channelization (limited sections). | I | Bed, Banks | Cohesive sediments |
| | I | Slope | Encroachment: berm, localized to bridge | D | Bank | Removal of Tree Buffers (for agricultural purposes) |
| | D | Slope | VAST trail bridge is bankfull constrictor with upstream aggradation (localized). | | | |
| | D | Depth | Beaver dams (transient, localized, but cumulative) | | | |
| M26T2.06-B | I | Slope | Local flow increase resulting in scour pool downstream of bankfull-constricting farm road bridge. | I | Bed, Banks | Cohesive sediments |
| | I | Slope | Historic channelization (limited sections). | I | Bed, Banks | Localized bedrock exposures in bed. |
| | I | Slope | Encroachment: Twentymile Stream Road, RB | D | Bank | Localized removal of woody vegetation related to residential use, road encroachments, and agric. use. |
| | D | Slope | Localized increases in sediment supply at tributary confluences. | | | |
| | D | Depth | Beaver dams (transient, localized, but cumulative) | | | |
| M26T2.06-A | I | Slope | Local flow increase resulting in scour pool downstream of bankfull-constricting farm road bridge. | I | Bank | Armoring (some, each bank) |
| | I | Slope | Historic channelization (limited sections). | I | Bed, Banks | Cohesive sediments |
| | D | Depth | Beaver dams (transient, localized, but cumulative) | D | Bank | Localized removal of woody vegetation related to agricultural use. |
| M26T2.05 | I | Slope | Local flow increase resulting in scour pools downstream of Heald Rd and Davis Rd bankfull-constricting bridges. | I | Bank | Maintenance of tree buffers, limited encroachments. |
| | I | Slope | Historic channelization (limited sections). | I | Bed, Banks | Localized bedrock exposures in bed and banks. |
| | I | Slope | Possible, historic, localized reduction in sediment supply below mill pond at upstream end of reach. | D | Bank | Localized removal of woody vegetation related to residential use and road encroachments. |
| | I | Slope | Possible, historic, breaching of impoundment (mill pond) at upstream end of reach. | | | |
| | D | Slope | Moderate constriction at downstream end of reach as channel transitions from Broad to Semi-Confined (bedrock-controlled) confinement. | | | |
| | D | Slope | Bedrock constraints coincident with Heald Rd crossing. | | | |
| M26T2.01 | I | Slope | Historic channelization | I | Bank | Armoring (extensive, both banks) |
| | I | Slope | Encroachment: berm, LB, short section | I | Bank | Maintenance of tree buffers, limited encroachments (RB, downstream half). |
| | I | Slope | Encroachment: roads, LB, RB | I | Bank | Bedrock exposures in channel bank (RB). |
| | I | Slope | Encroachment: parking lot, commercial property, RB | D | Bank | Localized removal of woody vegetation related to residential / comm. use and road encroachments (RB). |
| | D | Slope | VT Route 131 bridge is FPW constrictor with upstream aggradation (localized). | | | |
| | D | Slope | Constriction between LB armor and RB bedrock has contributed to upstream aggradation. | | | |

# Table F-4. Stressor Tables, Reach-Scale – North Branch of Black River Tributary

| | Reach-Scale Stressors | | | | | |
|---|---|---|---|---|---|---|
| **Reach / Segment** | **Stream Power** | | | **Boundary Resistance** | | |
| M15T1.11-C | I | Slope | Steep bedrock falls | I | Bank | Maintenance of tree buffers, limited encroachments. |
| (Not Assessed) | | | | I | Bed, Banks | Frequent bedrock exposures in bed and banks. |
| | | | | D | Bank | Localized removal of woody vegetation related to residential use and road encroachments (LB). |
| M15T1.11-B | I | Slope | Historic channelization | I | Bank | Armoring (extensive, both banks) |
| | I | Slope | Encroachment: berm, RB | D | Bank | Localized removal of woody vegetation related to residential use and road encroachments (LB). |
| | I | Slope | Encroachment: road, LB | | | |
| | I | Slope | Encroachment: residential, commercial properties | | | |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls | | | |
| | D | Slope | Natural reduction in sediment transport capacity downstream of bedrock falls due to reduction in valley confinement and gradient - appears moderated by channel modification to transport-dominated condition. | | | |
| M15T1.11-A | I | Slope | Historic channelization, dredging | I | Bank | Armoring (extensive, both banks) |
| | I | Slope | Encroachment: berm, both banks | D | Bed, Banks | Reported historic dredging |
| | I | Slope | Encroachment: residential properties | D | Bank | Localized removal of woody vegetation related to residential use and road encroachments (RB). |
| | I | Depth | Stormwater: localized flow increases from stormwater outfalls | | | |
| | D | Slope | Natural reduction in sediment transport capacity downstream of bedrock falls due to reduction in valley confinement and gradient - appears moderated by channel modification to transport-dominated condition. | | | |
| M15T1.10 | I | Slope | Historic channelization, dredging | I | Bank | Armoring (some, RB) |
| | I | Slope | Encroachment: berms, extensive, both banks | I | Bank | Maintenance of narrow tree buffers, both banks. |
| | I | Depth | Stormwater: localized flow increases from field ditch outfalls | D | Bed, Banks | Reported historic dredging |
| | D | Slope | Farm road bridge is FPW constrictor with minimal upstream aggradation (minor). | D | Bank | Removal of woody vegetation beyond a narrow buffer, related to agricultural use. |
| | D | Slope | Sharp turn of channel forced at RB armored berm near downstream end of reach has contributed to localized upstream aggradation. | | | |
| | D | Depth | Beaver dams (transient, localized, downstream end) | | | |
| M15T1.09 | I | Slope | Historic channelization | I | Bank | Armoring (extensive, both banks) |
| | I | Slope | Encroachment: berm, (RB, minor) | I | Bank | Maintenance of tree buffers, limited encroachments (LB). |
| | I | Slope | Encroachment: road - Route 106, RB | I | Bed, Banks | Localized bedrock exposures in bed and banks. |
| | I | Slope | Sediment accumulation at upstream end of reach due to Felchville Gulf Rd tributary confluence bar (localized). | D | Bank | Localized removal of woody vegetation related to residential use, and road encroachments |
| | D | Slope | Old abutment pair #1 is bankfull constrictor with some upstream aggradation (local). | | | |
| | D | Slope | Old abutment pair #2 is bankfull constrictor (negligible upstream aggradation). | | | |
| | D | Slope | Driveway bridge is bankfull constrictor with minor upstream aggradation (local). | | | |

# Table F-4. Stressor Tables, Reach-Scale – North Branch of Black River Tributary (CONTINUED)

| | Reach-Scale Stressors | | | | | |
|---|---|---|---|---|---|---|
| **Reach / Segment** | **Stream Power** | | | **Boundary Resistance** | | |
| M15T1.08 | I | Slope | Local flow increase resulting in scour pool downstream of old abutments. | I | Bank | Armoring (some, each bank) |
| | I | Slope | Historic channelization, dredging. | I | Bed, Banks | Localized bedrock exposures in bed and banks (LB). |
| | I | Slope | Encroachment: berm, each bank, limited sections | D | Bank | Localized removal of woody vegetation related to residential use, agricultural use and road encroachments |
| | D | Slope | Ascutney Basin Rd bridge and old abutments are bankfull constrictors with moderate upstream aggradation | | | |
| M15T1.07 | I | Slope | Historic channelization, dredging. | I | Bank | Armoring (some, each bank) |
| | I | Slope | Encroachment: berms, LB, RB (upstream end) | I | Bank | Revetments (cedar, LB) |
| | | | | D | Bed, Banks | Reported historic dredging |
| | | | | D | Bank | Removal of tree buffers for agricultural use. |
| M15T1.06-B | I | Slope | Historic channelization, dredging. | I | Bank | Armoring (some, each bank) |
| | I | Depth | Stormwater: localized flow increases from field ditches | I | Bed, Banks | Cohesive sediments |
| | D | Depth | Beaver dams (transient, localized, but cumulative) | D | Bed, Banks | Reported historic dredging |
| | | | | D | Bank | Localized removal of woody vegetation related to agricultural use. |
| M15T1.06-A | I | Slope | Historic channelization, dredging. | I | Bank | Armoring (some, each bank) |
| | I | Slope | Encroachment: Route 106, RB | I | Bed, Banks | Cohesive sediments |
| | | | | D | Bed, Banks | Reported historic dredging |
| | | | | D | Bank | Localized removal of woody vegetation related to agricultural use. |
| M15T1.05 | I | Slope | Local flow increase resulting in scour pool downstream of Little Ascutney Basin Rd bridge. | I | Bank | Armoring (some, each bank) |
| | I | Slope | Historic channelization, dredging. | I | Bank | Maintenance of tree buffers, limited encroachments (some sections). |
| | I | Slope | Encroachment: Route 106, RB (minor) | I | Bed, Banks | Cohesive sediments |
| | D | Slope | Little Ascutney Basin Rd bridge is bankfull constrictor with moderate upstream aggradation (localized). | D | Bed, Banks | Reported historic dredging |
| | D | Slope | VAST trail bridge is flood-prone-width constrictor with moderate upstream and downstream aggradation | D | Bank | Localized removal of woody vegetation related to agricultural uses and bridge encroachments. |
| | D | Depth | Localized increases in sediment supply at tributary confluences: one at upstream end; one mid-reach. | | | |
| | D | Slope | Moderate constriction at downstream end of reach as channel transitions from Very Broad to Semi-Confined (bedrock-controlled) confinement (Amsden Falls). | | | |
| | D | Depth | Beaver dams (transient, localized, but cumulative); evidence of breached dams. | | | |
| M15T1.03-B | I | Slope | Historic channelization. | I | Bank | Maintenance of tree buffers, limited encroachments. |
| | D | Slope | Impoundment effects of Stoughton Pond dam appear to extend upstream into the reach (Segment A) and have reduced sediment transport capacity of Seg B. | I | Bank | Bedrock exposures in channel bank (LB). |
| | | | | D | Bank | Localized reduction in buffer widths related to agricultural use and road encroachment (RB). |
| M15T1.03-A (Not Assessed) | I | Slope | Historic channelization. | I | Bank | Maintenance of tree buffers, limited encroachments. |
| | D | Slope | Impoundment effects of Stoughton Pond dam appear to extend upstream into the segment and have reduced sediment transport capacity and contribute to wetland-like conditions. | D | Bed, Banks | Periodic dredging at downstream end. |

# APPENDIX G

## Departure Analysis Tables

Abbreviations used in the following tables:

| | |
|---|---|
| BFL | Bankfull |
| FPW | Flood Prone Width |
| RB | Right Bank |
| LB | Left Bank |
| WWTF | Waste Water Treatment Facility |
| H | Human-constructed Constraint |
| N | Natural Constraint |
| **X** | Significant |
| (X) | Somewhat Significant |

## Table G-1. Departure Analysis Tables, Black River main stem – Upstream of Cavendish Gorge

| | Constraints | | Transport | | Attenuation (storage) | | | |
|---|---|---|---|---|---|---|---|---|
| **Reach / Segment** | Vertical | Lateral | Natural | Converted | Natural | Decreased | Increased | Asset |
| **M37-B** | Low-head dam directly upstream | H: Road - Rt 100 (minor, upstream end only)<br>H: Berm - RB<br>H: Bridge - East Lake Rd (BFL)<br>H: Old Abuts - historic bridge site (BFL)<br><br>N: Bedrock lateral control, RB (localized) | | **X** | | (X)<br>Due to upstream impoundment of sediments in lakes, reservoirs; historic channelization. | | |
| M37-A<br>(Not Assessed) | | | | | | | (X)<br>Due to beaver impoundments; possibly due to sediment accumulation at Branch Brook tributary confluence. | |
| **M36T4.01 (Branch Bk)** | Channel-spanning bedrock mid-reach | H: Road - Route 103 (RB)<br>H: Berms - one or both banks, 62% of reach<br>H: Residential Development (minor)<br>H: Commercial Development (minor)<br>H: Bridge - Commercial driveway (FPW)<br>H: Bridge - Route 100 (FPW) | | **X** | | X<br>Due to straightening, berms. | | |
| M36-B<br>(Not Assessed) | | H: Road - Route 103 (RB) | | | | | | **X** |
| **M36-A** | | H: Road - Route 103 (RB)<br>H: Bridge - Fox Lane (BFL) | | | Locally, above natural valley pinch point. | (X)<br>Locally, due to limited inferred channelization. Good floodplain access overall. | | **X** |
| **M35** | | H: Road - Route 103 (RB); Dug Rd (LB)<br>H: Residential Development (minor, RB)<br>H: Bridge - Dug Road (BFL) | **X** | | | (X)<br>Slightly, by road encroachments on either bank. | | |

## Table G-1. Departure Analysis Tables, Black River main stem – Upstream of Cavendish Gorge (CONTINUED)

| | Constraints | | Transport | | Attenuation (storage) | | | |
|---|---|---|---|---|---|---|---|---|
| **Reach / Segment** | Vertical | Lateral | Natural | Converted | Natural | Decreased | Increased | Asset |
| **M34** | Weir & Parshall Flume, upstream end reach | H: Berms - RB<br>H: Commercial Development, RB<br>N: High glaciofluvial terrace, LB | | **X** | | **X**<br>Due to channel dredging, berming, commercial encroachments (fill); including loss of channel-contiguous wetlands. | | |
| **M33-B** | Remant, low-head dam, Mill St | H: Roads- Main, Pleasant, Meadow St, (LB,RB)<br>H: Berms - LB, downstream of Rt 103 bridge<br>H: Residential/ Comm. Development (RB,LB)<br>H: Bridge - Depot St (FPW)<br>H: Bridge - Main Street (Route 103) (BFL)<br>H: Bridge - Mill Street (BFL)<br>N: High glaciofluvial terrace, LB | | **X** | | **X**<br>Due to channel dredging, berming, commercial & residential encroachments (fill). | | |
| **M33-A** | | H: Roads- Main St (LB), Pleasant St (RB)<br>H: Berms - LB, discontinuous<br>H: Residential/ Comm. Development (RB,LB)<br>H: Bridge - Pleasant St Ext (FPW)<br>H: Constriction, armored channel at WWTF | | **X** | | **X**<br>Due to channel dredging, berming, commercial & residential encroachments (fill). | | |
| **M32-C** | Remant, low-head dam, Smith-ville | H: Roads- Main St (Route 103) (LB)<br>H: Residential/ Comm. Development (RB,LB)<br>H: Remnant mill foundations (LB, localized)<br>H: Bridge - East Hill Road (BFL) | | **X** | | **X**<br>Due to channelization, historic incision. | | |
| **M32-B** | | H: Roads- Main St (Route 103) (LB) (minor)<br>H: Berms - LB, discontinuous, low elevation<br>H: Railroad - RB, minor (usually elevated above floodprone width on valley side slope)<br>H: Recreational Fields, LB<br>N: Bedrock lateral control, RB (localized) | | **X** | | **X**<br>Due to channelization, historic incision. | | |

## Table G-1. Departure Analysis Tables, Black River main stem – Upstream of Cavendish Gorge (CONTINUED)

| | Constraints | | Transport | | Attenuation (storage) | | | |
|---|---|---|---|---|---|---|---|---|
| **Reach / Segment** | Vertical | Lateral | Natural | Converted | Natural | Decreased | Increased | Asset |
| **M32-A** | | H: Roads- Rt 103 (LB); Greven Rd Ext (RB)<br>H: Railroad - RB upstream end of segment; LB downstream end of segment.<br>H: Residential Development (RB)<br>H: Commercial Development (LB, RB)<br>H: Sand & Gravel Quarry (RB)<br>H: armored, undersized channel at Route 103 encroachment just upstream of Winery Rd<br>H: Bridge - Winery Rd (BFL)<br>H: Old Bridge Abutments - (BFL)<br>H: Bridge - Railroad (FPW)<br>H: Old Abutments (dam? and historic diversion channel inlet - (BFL)<br>H: Bridge - Route 103 (FPW) | | **X** | | **X**<br>Due to channelization, historic incision, encroachments. | | **X** |
| **M31** | | H: Railroad - LB, RB<br>H: Residential/ Comm. Development (RB,LB)<br>H: Recreational Fields, RB<br>H: Bridge - Depot St. (Proctorsville) (FPW)<br>H: Bridge - Railroad (FPW) | | **(X)** | | **(X)**<br>Due to channelization, historic incision, encroachments. | | |
| **M30** | | H: Roads- Rt 131 (LB) (minor)<br>H: Railroad - RB (minor - often elevated above FPW on valley side slope.<br>H: Residential/ Comm. Development (LB)<br>H: Abutments - former (breached) dam (BFL)<br>H: Bridge - Mill Street (Cavendish) (FPW) | | **(X)** | | **(X)**<br>Due to channelization, historic incision | | |

## Table G-2. Departure Analysis Tables, Black River main stem – Downstream of Cavendish Gorge

| | Constraints | | Transport | | Attenuation (storage) | | | |
|---|---|---|---|---|---|---|---|---|
| **Reach / Segment** | Vertical | Lateral | Natural | Converted | Natural | Decreased | Increased | Asset |
| **M27** | Bedrock falls down-stream end. Ledge upstream end. | H: Residential/ Comm. Development (LB)<br>H: Bridge - Carlton Rd (FPW)<br>N: Bedrock lateral control, both banks. | | **X** | | **(X)**<br>Due to channelization, historic incision | | |
| **M26T2.01**<br>(Twentymile Stream) | | H: Roads- Rt 131 (LB); Whitesville Rd (RB)<br>H: Berms (LB, minor)<br>H: Residential Development (LB)<br>H: Commercial Development (RB)<br>H: Bridge - Route 131 (FPW)<br>N: Bedrock lateral control (RB, localized) | | **X** | | **(X)**<br>Due to channelization, historic incision | | |
| **M26** | | H: Road- Rt 131 (LB)<br>H: Berms (LB, low elevation) | | **X** | | **(X)**<br>Due to channelization, historic incision | | |
| **M19 - B** | | H: Road- Upper Falls Rd (RB)<br>H: Berms (RB)<br>H: Residential Development (sparse, RB)<br>N: Bedrock lateral control, LB (localized) | | **X** | | **(X)**<br>Due to channelization, historic incision | | |
| **M19 - A** | | H: Road- Upper Falls Rd (RB)<br>H: Driveway - LB (localized)<br>H: Residential Development (sparse, RB; localized, LB)<br>N: Bedrock lateral control, LB (localized) | | **(X)** | | **(X)**<br>Due to channelization, historic incision | | **X** |

## Table G-3. Departure Analysis Tables, Twentymile Stream Tributary

| | Constraints | | Transport | | Attenuation (storage) | | | |
|---|---|---|---|---|---|---|---|---|
| **Reach / Segment** | Vertical | Lateral | Natural | Converted | Natural | Decreased | Increased | Asset |
| **M26T2.10-C** | | H: Road- Twentymile Stream Rd (LB, RB)<br>H: Berms (LB)<br>H: Residential Development (LB, RB)<br>H: Culvert - Twentymile Stream Rd (BFL)<br>N: Bedrock lateral control, LB (localized) | | **X** | | **(X)**<br>Due to channelization, historic incision | | |
| **M26T2.10-B** | Two bedrock ledge | H: Road- Twentymile Stream Rd (LB)<br>H: remant mill foundations (potential)<br>N: Bedrock lateral control, LB, RB (localized) | **X** | | | | | |
| **M26T2.10-A** | | H: Residential Development (LB, RB, sparse)<br>H: remant mill foundations (potential)<br>H: Culvert - driveway (BFL) | | **X** | | **(X)**<br>Due to historic incision | | |
| **M26T2.09** | | H: Road- Twentymile Stream Rd (LB) (minor)<br>H: Residential Development (LB, minor)<br>H: Culvert - Meadowbrook Farm Rd (BFL) | | **X** | Locally, above natural valley narrowing. | (x)<br>Due to historic channelization, incision | (x)<br>Increased somewhat by constriction of channel due to fill / culvert crossing for Meadowbrook Farm Rd; increased locally by beaver dams.<br>(Could be enhanced with wetland restoration.) | **X** |
| **M26T2.08-B** | None | | | | | | (x)<br>Increased slightly by constriction of valley and channel due to fill / culvert crossing for Twentymile Stream Rd | **X** |
| **M26T2.08-A** | | H: Road - Twentymile Rd (alternating LB, RB)<br>H: driveway (RB)<br>H: berms (RB)<br>H: Culvert - Twentymile Stream Rd (BFL) | | **(X)** | | **(X)**<br>Due to channelization, historic incision | | |

## Table G-3. Departure Analysis Tables, Twentymile Stream Tributary (CONTINUED)

| | Constraints | | Transport | | Attenuation (storage) | | | |
|---|---|---|---|---|---|---|---|---|
| **Reach / Segment** | Vertical | Lateral | Natural | Converted | Natural | Decreased | Increased | Asset |
| **M26T2.07** | | H: Road - Twentymile Rd (RB)<br>H: berms (RB, minor)<br>H: Bridge - VAST Trail (BFL) | | **(X)** | | **(X)**<br>Due to historic incision, limited channelization | | |
| **M26T2.06-B** | Channel-spanning bedrock mid-segment | H: Road - Twentymile Rd (RB)<br>H: Residential Development (RB)<br>H: Bridge - farm road (BFL)<br>H: Old Bridge Abuts (BFL) | | | | | | |
| **M26T2.06-A** | | H: Bridge - farm road (BFL) | | | Locally, above natural valley narrowing. | | | **X** |
| **M26T2.05** | | H: driveway (LB, RB)<br>H: Residential Development (minor, LB, RB)<br>H: Bridge - Heald Rd (BFL)<br>H: Bridge - Davis Rd (BFL)<br>N: Bedrock lateral control, RB (localized) | | | Locally, above natural valley pinch point. | | (x)<br>Increased slightly by constriction of valley and channel due to fill / bridge crossings for Heald & Davis Roads | **X** |
| **M26T2.01** | | H: Roads- Rt 131 (LB); Whitesville Rd (RB)<br>H: Berms (LB, minor)<br>H: Residential Development (LB)<br>H: Commercial Development (RB)<br>H: Bridge - Route 131 (FPW)<br>N: Bedrock lateral control (RB, localized) | | **X** | | **(X)**<br>Due to channelization, historic incision | | |

## Table G-4. Departure Analysis Tables, North Branch Black River Tributary

| | Constraints | | Transport | | Attenuation (storage) | | | |
|---|---|---|---|---|---|---|---|---|
| **Reach / Segment** | Vertical | Lateral | Natural | Converted | Natural | Decreased | Increased | Asset |
| M15T1.11-C (Not Assessed) | Bedrock Falls large | N: Bedrock lateral controls, both banks | **X** | | | | | |
| **M15T1.11-B** | | H: Road - Niagara St. (LB)<br>H: berm - RB<br>H: Residential development (each bank)<br>H: Constriction (BFL) - LB armored road, RB berm | | **X** | | **X**<br>Due to historic encroachments, channelization, incision | | |
| **M15T1.11-A** | | H: Road - Route 106 (RB, minor)<br>H: berms - both banks<br>H: Residential development (each bank)<br>H: Bridge - Rt 106 - (BFL) | | **X** | | **X**<br>Due to historic encroachments, channelization, incision | | |
| **M15T1.10** | | H: Road - Route 106 (RB, minor)<br>H: berms - extensive, both banks | | **X** | | **X**<br>Due to historic encroachments (berms), channelization, incision | | |
| **M15T1.09** | 60 ft long waterfall mid-reach | H: Road - Route 106 (RB)<br>H: berm - RB, short section<br>H: Residential development (sparse, ea.bank)<br>H: old abut pair (BFL) - #1<br>H: old abut pair (BFL) - #2<br>H: Bridge - Rt 106 - (BFL) | | **X** | | **X**<br>Due to historic encroachments (road), channelization, incision | | |
| **M15T1.08** | Channel-spanning bedrock upstream end | H: Road - Route 106<br>H: Berms - both banks, downstream end<br>H: Residential Development (minor, LB, RB)<br>H: Bridge - farm/ VAST trail (BFL)<br>H: Old Abutments (BFL)<br>H: Bridge - Ascutney Basin Rd (BFL)<br>N: Bedrock lateral control, LB (upstream end) | | **(X)** | | **(X)**<br>Somewhat, due to inferred historic incision. | | |

## Table G-4. Departure Analysis Tables, North Branch Black River Tributary (CONTINUED)

| | Constraints | | Transport | | Attenuation (storage) | | | |
|---|---|---|---|---|---|---|---|---|
| **Reach / Segment** | Vertical | Lateral | Natural | Converted | Natural | Decreased | Increased | Asset |
| **M15T1.07** | | H: Road - Route 106, RB (minor)<br>H: Road - Ascutney Basin Rd, LB (minor)<br>H: Berms - both banks, upstream end | | **(X)** | | **(X)**<br>Somewhat, due to inferred historic incision. | | |
| **M15T1.06-B** | | H: Road - Route 106, RB (minor)<br>H: historic cemetery, RB (localized) | | **(X)** | | **(X)**<br>Somewhat, due to inferred historic incision. | | |
| **M15T1.06-A** | | H: Road - Route 106, RB | | **(X)** | | **(X)**<br>Somewhat, due to channelization locally, but good floodplain connection overall. | (Could be enhanced with wetland restoration.) | **X** |
| **M15T1.05** | | H: Road - Route 106, RB<br>H: Residential Development (minor, RB)<br>H: Bridge - Little Ascutney Basin Rd (BFL)<br>H: Bridge - VAST trail (FPW) | | | Locally, above natural valley pinch point at Amsden Falls. | | (Could be enhanced with wetland restoration.) | **X** |
| M15T1.04<br>(Not Assessed) | Amsden Falls (bedrock) | N: Bedrock lateral controls, LB, RB | | | | | | |
| **M15T1.03-B** | | H: Road - Branch Brook, RB, minor<br>N: Bedrock lateral controls, LB | | | | (X)<br>Sightly, due to local channelization or avulsion, but good floodplain connection overall. | **(X)**<br>Increased by impoundment effects extending from downstream Stoughton Pond dam. | **X** |
| M15T1.03-A<br>(Not Assessed) | | H: Road - Branch Brook, RB | | | | | **X**<br>Increased by impoundment effects extending from downstream Stoughton Pond dam. | **X** |

# APPENDIX H

# Valley Wall Updates

South Mountain Research & Consulting (SMRC) has updated the Phase 1 valley wall shape file and created a Phase 2 valley wall shape file for the purposes of: (1) defining reference (Phase 1) and existing (Phase 2) stream types after Rosgen (1996) and Montgomery & Buffington (1997); and (2) to define locations where human infrastructure has encroached within the natural valley wall to constrain hydraulics of the channel and floodplain and/or change the confinement of the channel as captured under Phase 2 Step 1.5. This valley wall delineation relied on remote sensing resources (USGS topographic maps, published soils data, published surficial geologic data) and limited visual observations. No detailed assessments (such as subsurface geologic investigations, geotechnical evaluations, licensed land surveys, hydrologic or hydraulic assessments) were conducted to estimate the degree that human encroachments will laterally constrain the channel or the degree that human encroachments will change hydraulics of channel and floodplain flow during a flood event.

While SMRC was not contracted to evaluate fluvial erosion hazard boundaries in the Black River watershed, SMRC is aware that these updated Phase 1 and Phase 2 valley walls may be utilized by others in the process of defining what are termed Fluvial Erosion Hazard (FEH) corridors or areas, following procedures prescribed by VT Agency of Natural Resources. The updated Phase 1 and Phase 2 valley wall shapefiles prepared by SMRC do not necessarily represent lateral extents of fluvial erosion hazard along these Black River watershed channels.

It is possible that a future migration or avulsion of the channel could occur beyond the Phase 1 valley wall - (for example, the large avulsion of 1927 that occurred through Cavendish village bypassing the Cavendish Gorge). Often the Phase 1 valley wall has been delineated along high terraces inferred to be of pre-colonial (glacial or post-glacial) age and origin. In these cases, the terrace is inferred to define a valley side slope (and valley width) of the reference (and sometimes existing) channel for purposes of assigning stream types under the current hydrologic and sediment regimes. However, sediments comprising these terraces generally are unconsolidated gravels, cobbles, and/or boulders, and would possibly be subject to fluvial erosion hazards and/or landslide hazards where scour velocities exceed the threshold for erosion and/or where bank heights or slopes exceed stable conditions.

While encroachments may be significant enough to theoretically constrain channel or floodplain hydraulics and/or cause a change in confinement that affects stream type designations - thus warranting delineation as the Phase 2 valley wall - this human infrastructure (e.g., roads, railroads, engineered levees) may still be susceptible to erosion hazards.

Starting Point: (stored in folder: Black Ph2 FIT SGAT457\BaseData)
"**vwqa061307.shp**" - shape file created in Phase 1 SGAT project (SMRC, 2007) – dated 6/20/2007.

Deliverables: (stored in folder: Black Ph2 FIT SGAT457\Additional Ph2 Shape Files)
"**ph1vw.shp**" - the updated (field-truthed) Phase 1 (reference) valley wall, based on limited field observations and available remote sensing resources. (dated 12/22/2008)

**"ph2vw.shp"** - a documentation of human-caused change in valley width as per Phase 2 protocols (2007), Step 1.5 (dated 5/19/2009). Generally, these include roads or railroads that encroach within the phase 1 valley width and are oriented subparallel to the channel and which are elevated to a degree above the floodplain (generally greater than two times the bankfull depth), such that a portion of the natural valley floodplain has been cut off by this artificial valley wall and/or channel and floodplain hydraulics are inferred to have been constrained. This encroachment delineation is offered without a classification of "major" or "minor" and without regard for whether or not the feature will ultimately be identified by the community as an "Encroachment" worthy of FEH-area modification as prescribed on page 13 of the November 12, 2008 *Technical Appendix to the Vermont River Corridor Protection Guide* published by the VT Agency of Natural Resources.

