Town of Mount Holly
Planning Commission

Town Office & Remote Electronic – Special Work Meeting Minutes
Wednesday July 6, 2022
7:00 P.M.

Commission Members Present: Jon McCann (Chair), Jim Seward (Vice Chair), Brigid Sullivan, Andrew Seward, Andrew Schulz,
Also Present: Renee Sarmento (Clerk), Stephen Michel

1. Chair called the meeting to order at 7:02 pm.
2. Changes to the agenda
   a. Added Building Construction Registration Forms Update by Administrative Officer
   b. Added Email Correspondence
3. Building Construction Registration Forms Update by Administrative Officer
   a. Administrative Officer asked the Planning Commission members questions about missing information on three BCR forms.
      i. The Chair added an X to mark the location on the map for one BCR.
      ii. Recommendation was made for AO to follow up with applicants for missing information on the other two BCR forms.
      iii. Commissioner Schulz suggested making a note on the form that information was added based on conversations with the applicant.
4. Email Correspondence
   a. The Chair read an Email from Matt Burke @mbmcllc.com. Email stated Mr. Burke works for Verizon Wireless and is looking to improve cell coverage in Mount Holly. Exploring the co-location on a cell tower on 581 Steward Road South. What time of permitting is required at a local level? Chair read the email aloud to the Planning Commission members.
      i. Response: Planning Commission unanimously agreed a BCR should be filed with the Administrative Officer.
5. Town Plan Revisions
   a. Flood Resilience Plan
      i. Existing Town Plan does not have a substantial amount about flood resilience.
      ii. How do we make our town more resilient to flooding and more resilient in our response to disaster? The costs to prevent are lower than the costs to recover.
      iii. Chair gave some background on the Local Hazard Mitigation Plan: It used to be any type of disaster including terrorism, for example. It is now only for natural disasters (flooding, fire, storms). There was a group that worked on this back in 2020 and finished early 2021. Some towns refer to it in the Town Plan or copy/past relevant parts. Chair suggested referencing it in the Mount Holly Town Plan. Unanimously agreed to reference the current LHMP from the Town Plan Flood Resilience plan.
      iv. Commission Sullivan referenced the current Town Plan's Flood Resilience section and read the two goals and policies aloud. Commissioner Sullivan commented that the current plan did not reference the Local Hazard Mitigation Plan and that it should. The Chair explained there were two parts that

are now two different plans: Local Hazard Mitigation Plan and the Local Emergency Management Plan which is more operational.

v. Chair reviewed reimbursement for natural disasters. FEMA typically covers 75% and requires a 25% match. The State's Emergency Relief & Assistance Fund (ERAF) will contribute either 7.5%, 12.5%, or 17.5% toward that match if certain conditions are met.

vi. 12.5% ERAF rate if we have: 1) Road and Bridge Standards 2) Local Emergency Management Plan 3) National Flood Insurance Program 4) Local Hazard Mitigation Plan

vii. 17.5% ERAF rate if we also have River Corridor Protection.

viii. Up until June, for perhaps a few months, Mount Holly was at the 7.5% rate of reimbursement due to the Local Emergency Management Plan had expired. The Chair received a message from Jeff Chase (EMD) that the plan has been updated and accepted and Mount Holly is back up to a 12.5% reimbursement rate.

ix. Chair passed around sheets with FAQ's of river corridors to Planning Commission members. Chair explained that river corridor protections are usually implemented as an amendment to Flood Hazard Area Regulations in towns like ours.

x. The Local Hazard Mitigation Plan adopted by the Select Board has as a goal to "Manage Development in Erosion Hazard Areas by Adopting River Corridor Bylaws" by December 2021.

xi. Flood hazard areas are about inundation risks – generally slower moving waters, water levels rising, hydrostatic pressure. River corridor protections are for fluvial erosion. which is mentioned in the current Town Plan. They are assigned different regulations to cover broader types of flooding.

xii. Unanimously agreed to reference the Flood Hazard Area Regulations in the Town Plan.

xiii. Chair stated there are also a few Vermont statutes on stormwater. A stormwater mapping and plan has been done for the village.

xiv. Discussion about the requirements for the Municipal Roads General Permit with respect to hydrologically connected road segments. Information conveyed during the LHMP process included that if a homeowner installs an undersized culvert in their own driveway and water flow damages a town road – the town is liable for the costs of the damage. So, in other words, the Town is responsible for culverts installed on hydraulically connected roads. Chair wondered if the town could assist with costs to homeowners related to driveway culvert replacement to save the town money in the long run. Discussed updating the Road Access Policy with driveway design requirements.

xv. Chair stated that, with respect to the MRGP, was unsure if a policy in the Town Plan was necessary other than to support the foremen and/or commissioner on the highway team with grant funding. One of the big problems and costs moving forward is that spans over 36 inches, which used to be culverts, are now required to be box culverts or bridges.

xvi. River Corridors – Commissioner Andrew Seward said he would be curious what other towns do in their town plans. Wondering if it will impact individuals that own land along a river or if it is Town Land. Chair stated that only perennial streams with at least 0.5 square miles of watershed are included and will check with other towns.

xvii. Commissioners looked at a map of what would be affected by river corridor protection ordinance.

xviii. Chair stated if interested in investigating, could invite Barbara Noyes-Pulling (planner from RRPC) to one of our next meetings. Commissioner Andrew Seward stated he would be interested in learning what it entails and how much restriction it puts on everything around it. Unanimously agreed to invite RRPC planner to future meeting.

xix. It was noted that a 5% increase in reimbursement if satisfied all five categories of mitigation would be a huge advantage to the town and get us 92.5% reimbursement for any recovery costs.

xx. Chair gave an update on the status of new Flood Insurance Rate Map (FIRM) panels for the Black and West River watersheds. Current maps are from 2008. A discovery process for new FIRM panels was held last summer. At this point we are 2 years away from having new preliminary FIRM panels for review (after work maps are produced after engineering field study and flood plain mapping).

xxi. Chair asked Planning Commission for thoughts on the existing Flood Hazard Area ordinance. It was noted that the regulations could not be administered, until recently, due to the lack of a Board of Adjustment. The Board of Adjustment is not only responsible for appeals of the administrative review and permitting but also for issuing Conditional Use permits. Chair distributed screenshots of all places that have human activity within the FHA.

xxii. Chair noted that many individuals in town may not even know the ordinance exists. Noted that he thinks it is appropriate to educate and inform individuals about the flood hazard ordinance – especially if their land lies within it. Also noted that the Town does not even have a permit application form. At a future meeting the Commission will assist with the creation of permit application forms. Commissioner Sullivan also suggested including information in the Chit Chat.

xxiii. Agreed to next Steps: Invite Barbara Noyes-Pulling to a meeting, generate application form for working in Flood Hazard Area, get Jeff Chase's opinion on ERAF.

6. Public Comments: none
7. Upcoming meetings
    a. Regular meeting – July 20th, 7:00 pm (3rd Wednesday)
    b. Special Meeting (Flood Resilience Plan continued)– August 3rd, 7:00pm
8. Meeting adjourned at 8:19pm

For the Commission,
Renee Sarmento, Clerk

In draft form until approved on July 20th, 2022

CID	Community Name	Total Premium	V-Zone	A-Zone	No. Policies	Total Coverage	Total Claims Since 1978	Total Paid Since 1978
500260	IRA, TOWN OF	$ 3,595	0	2	2	$ 208,000	1	$ 11,500
500095	MENDON, TOWN OF	$ 928	0	1	2	$ 387,400	1	$ 2,300
500261	MIDDLETOWN SPRINGS, TOWN OF	$ 5,830	0	2	4	$ 852,400	1	$ 6,337
500096	MT. HOLLY, TOWN OF	$ 6,196	0	2	8	$ 2,208,600	3	$ 9,917
500097	PAWLET, TOWN OF	$ 14,365	0	5	11	$ 2,183,000	6	$ 70,107
500263	PITTSFIELD, TOWN OF	$ 3,779	0	4	6	$ 1,142,900	5	$ 191,194
500098	PITTSFORD, TOWN OF	$ 9,902	0	5	7	$ 970,300	4	$ 49,323
500099	POULTNEY, TOWN OF	$ 20,064	0	13	18	$ 3,142,400	7	$ 228,475
500266	POULTNEY, VILLAGE OF	$ 1,054	0	2	2	$ 76,000	2	$ 2,478
500265	PROCTOR, TOWN OF	$ 13,070	0	9	14	$ 1,647,600	12	$ 159,005
500101	RUTLAND, CITY OF	$ 110,368	0	39	78	$ 16,282,500	98	$ 1,122,227
500267	RUTLAND, TOWN OF	$ 7,782	0	5	7	$ 1,911,500	7	$ 176,504
500102	SHREWSBURY, TOWN OF	$ 25,359	0	14	18	$ 3,004,100	14	$ 164,551
500269	SUDBURY, TOWN OF	$ 1,393	0	1	1	$ 94,700	0	$ 0
500103	WALLINGFORD, TOWN OF	$ 43,387	0	22	35	$ 6,905,500	17	$ 604,828
500271	WELLS, TOWN OF	$ 16,779	0	7	9	$ 1,829,700	3	$ 7,088
500104	WEST RUTLAND, TOWN OF	$ 32,736	0	17	20	$ 3,181,000	8	$ 55,127
	County Total :	$ 374,157	0	185	298	$ 55,893,000	217	$ 3,430,671
	[WASHINGTON COUNTY]							
500105	BARRE, CITY OF	$ 324,645	0	137	167	$ 32,854,300	215	$ 4,715,828
500273	BARRE, TOWN OF	$ 7,517	0	2	9	$ 2,393,300	2	$ 10,754
500106	BERLIN, TOWN OF	$ 118,607	0	38	48	$ 13,081,200	43	$ 2,046,882
500108	CABOT, TOWN OF	$ 3,043	0	3	5	$ 1,073,700	3	$ 22,673
500109	CALAIS, TOWN OF	$ 6,456	0	3	10	$ 2,320,000	1	$ 4,728
500110	DUXBURY, TOWN OF	$ 12,036	0	5	12	$ 2,559,800	9	$ 304,472
500111	EAST MONTPELIER, TOWN OF	$ 38,642	0	11	15	$ 3,242,800	1	$ 43,733
500326	FAYSTON, TOWN OF	$ 3,731	0	2	7	$ 1,860,000	1	$ 0
500323	MARSHFIELD, TOWN OF	$ 2,542	0	1	3	$ 500,000	4	$ 19,770
500113	MARSHFIELD, VILLAGE OF	$ 2,703	0	3	5	$ 853,600	0	$ 0
500114	MIDDLESEX, TOWN OF	$ 18,404	0	9	12	$ 1,936,700	31	$ 321,040
505518	MONTPELIER, CITY OF	$ 508,642	0	162	215	$ 56,060,900	254	$ 3,125,558
500116	MORETOWN, TOWN OF	$ 48,755	0	26	46	$ 11,255,000	31	$ 2,736,904
500118	NORTHFIELD, TOWN OF	$ 45,367	0	26	43	$ 7,869,200	14	$ 251,445
500117	NORTHFIELD,VILLAGE OF	$ 0	0	0	0	$ 0	33	$ 1,797,608
500275	PLAINFIELD, TOWN OF	$ 19,426	0	10	13	$ 1,814,500	15	$ 143,783
500119	PLAINFIELD, VILLAGE OF	$ 0	0	0	0	$ 0	6	$ 31,777

Vermont Model Flood Hazard Bylaws
Frequently Asked Questions

1. **Do the regulations need to apply on a municipal-wide scale or can specific waterbodies be targeted for application of these regulations?**

Generally, towns have the discretion to regulate specific water bodies since hazard regulation is voluntary. These regulations are crafted to help towns meet and exceed federal minimum requirements under the National Flood Insurance Program(NFIP) and qualify for enhanced state cost share under the Emergency Relief and Assistance Fund.

For the ~90% of Vermont communities enrolled in the NFIP, or to be eligible to enroll in the NFIP, the inundation hazard regulations found in Section E must apply to all federally mapped Special Flood Hazard Areas as shown on the NFIP Flood Insurance Rate Map published for the community. However, communities do have the option to develop regulations that may apply in a certain flood zone that better addresses certain types of flooding. For example, a community can adopt standards for lake shore flood hazard areas that better address lake flooding issues like wave action.

With respect to river corridors, communities interested in obtaining the full 17.5% cost share under the Emergency Relief & Assistance Fund (ERAF), River Corridors need to be adopted for all perennial streams with more than 0.5 square miles of watershed.

2. **Why are there provisions for "designated centers" in the models? Do we have other options**?

Model bylaw Section D contains provisions for infill and redevelopment in designated centers recognizing that these are areas of significant pre-existing investment, are important to municipal growth and redevelopment plans, and areas where significant channel management activity will be pursued to protect those investments.

Communities may define their own urban overlay boundaries where the same river corridor infill/redevelopment provisions may apply. However, the State of Vermont encourages communities to utilize the designated center process because these programs work together to provide incentives, align policies and give communities the technical assistance needed to encourage new development and redevelopment in our compact, designated areas. The program's incentives are for both the public and private sector within the designated area, including tax credits for historic building rehabilitations and code improvements, permitting benefits for new housing, funding for transportation-related public improvements and priority consideration for other state grant programs.

More information on state designation programs may be found here:
http://accd.vermont.gov/sites/accdnew/files/documents/CD/CPR/DHCD-Planning-Manual-Module2.pdf

3. **The State is promoting higher regulatory standards via the model bylaws, but how do we know what the minimum requirements are, so we can decide what is appropriate for our community?**

   We have created a cross-walk that provides a side by side comparison of the significant higher standards contained in the model bylaws against the federal minimum standards. The cross-walk is available at the Municipal Assistance webpage: http://dec.vermont.gov/watershed/rivers/river-corridor-and-floodplain-protection/municipal-assistance

4. **What sections of the model bylaw must be adopted to qualify for enhanced state cost share under the Emergency Relief & Assistance Fund (ERAF)?**

   a. For the 12.5% ERAF cost share, communities must adopt and enforce National Flood Insurance Program minimum standards for their federally mapped Special Flood Hazard Areas. Section E. contains recommended standards that exceed federal minimum standards and will qualify. A model bylaw containing federal minimum standards is available upon request. Note, there are additional requirements that need to be met to be fully eligible for the 12.5% ERAF cost share: http://floodready.vermont.gov/find_funding/emergency_relief_assistance

   b. Section D – River Corridors must be adopted and enforced to qualify for the maximum 17.5% ERAF cost share. Alternatively, communities can enroll in the Community Rating System and adopt a standard the largely prohibits new buildings in flood hazard areas. More information on the 17.5% criteria are found here: http://floodready.vermont.gov/sites/floodready/files/documents/ERAF_Criteria_17%205%25_06.27.17.pdf

5. **Why is there not an option to adopt "river corridor protection areas" as referenced in statute and already regulated by many municipalities (as Fluvial Erosion Hazard corridors)?**

   Communities may adopt and regulate the River Corridor Protection Area (RCPA) and be eligible for the 17.5% cost share but should be aware that protecting the RCPA will not reduce erosion hazards over time, since it does not provide enough lateral space for a river to achieve a stable slope (meander geometry). As such, ANR does not promote the RCPA via the state model bylaws. If, after discussion of pros/cons of RC vs RCPA, a town decides that they do not want to adopt the full river corridor, it is as simple as replacing the term "river corridor" with "river corridor protection area" and modifying the map adoption text. Professional planners are welcome to take the river corridor module and create an RCPA model and/or customize it to address legacy Fluvial Erosion Hazard bylaws to meet unique town needs. http://floodready.vermont.gov/RCFAQ

Please note that ANR capacity to create customized RCPA maps for a town may take some time due to mapping requests in the queue and other program demands.

6. **The River Corridor Section D references refinements to the statewide river corridor layer. What is the notification process to towns and RPCs when River Corridor map changes are being proposed?**

   Generally speaking, notifications of proposed technical map updates will not be sent out. These changes are a result of improved data and done in accordance with [Flood Hazard Area & River Corridor Protection Procedure.]

   When the statewide river corridor is changed to reflect new data on river sensitivity or administrative changes, effected communities, RPCs, and Natural Resources Board District Commissions will be notified and provided the opportunity to view the changes between the old and updated river corridor layer. Both layers will be posted for a period of 60 days on the Flood Ready Atlas before being transferred to the Statewide Layer on the ANR Atlas.

   Anyone that believes the river corridor information is in error, may submit information to correct the error any time in accordance with the above-referenced procedure.

7. **What is the difference between a Letter of Map Amendment (LOMA) and a Letter of Map Revision(LOMR)?**

   A LOMA is an official amendment, by letter, to an effective NFIP flood hazard area map. A LOMA establishes a property's location in relation to the flood hazard area. FEMA typically issues LOMAs when a property has been inadvertently mapped as being in the flood hazard area and is located on natural high ground above the base flood elevation.

   LOMRs are generally based on the implementation of physical measures that affect the hydrologic or hydraulic characteristics of a flooding source and thus result in the modification of the existing FEMA-designated floodway, the effective base flood elevations (BFEs), or the mapped flood hazard area. The LOMR officially revises the flood hazard area, and sometimes the flood insurance study (FIS) report, and when appropriate, includes a description of the modifications. The LOMR is generally accompanied by an annotated copy of the affected portions of the flood hazard area map or FIS report.

   More information on LOMAs and LOMRs may be found here: https://www.fema.gov/letter-map-changes

8. **Can a 50-foot buffer setback suffice in place of the 50-foot River Corridor setback for small streams?**

   Yes, so long as the 50-foot buffer set-back regulations largely restrict new encroachments within the setback, since the intent is to provide space for lateral stream adjustments. Your regional floodplain manager can review existing buffer regulations to verify whether they are sufficiently restrictive.

9. **If a municipality does not have zoning (and therefore does not currently have any land use regulations), how do we identify an administrative officer (AO) and an appropriate municipal panel (AMP) to regulate the proposed bylaws.**

   While there are some provisions in Section C [Administration] that describe how to appoint an AO and AMP, there are resources available to help provide guidance and details. The following guidebook is a great resource for towns:
   http://vpic.info/Publications/Reports/ManualOfProcedures.pdf
   In addition, your Regional Planning Commission can provide additional technical assistance:
   https://www.vapda.org/

10. **If a municipality does not currently issue permits is ANR providing a mechanism for this to occur without the municipality establishing the regulatory component locally to issue permits?**

    No. To be eligible to participate in the NFIP and ERAF benefits, communities must regulate their adopted hazard areas. Vermont statute enables communities to adopt freestanding hazard area bylaws (see 24 V.S.A. § 4424). Section C provides the administrative framework for communities to issue and enforce permits.

11. **I live in a small town with part-time/volunteer staff. We are very concerned with the complexity of these regulations and our ability to administer them. Can these regulations be simplified?**

    Flood hazard regulation is complex, especially given the requirements of the National Flood Insurance Program. The simplest way to reduce the complexity of the bylaw, is to reduce the number of activities that are permitted within the flood hazard area and river corridor. However, this may or may not be an option depending on pre-existing settlement patterns and planned growth patterns.

    Technical resources exist to assist municipalities in flood hazard bylaw administration.

    - The regional planning commissions have Certified Floodplain Managers on staff.
    - The DEC River Corridor & Floodplain Protection Program offers Certified Floodplain Manager training and exams annually. The certification is highly recommended for municipal administrative officers. More information is available here: http://www.floods.org/index.asp?menuid=426
    - Vermont statute requires communities to send hazard area permit applications to the DEC River Corridor & Floodplain Protection Program for review and comment prior to issuing a permit (https://legislature.vermont.gov/statutes/section/24/117/04424). Permit application technical review and written comments provided by DEC Regional Floodplain Managers help communities navigate the complexities of hazard area

bylaw administration. Regional Floodplain Manager contact information is found here: http://dec.vermont.gov/watershed/rivers/river-corridor-and-floodplain-protection/floodplain-managers

12. The models require a lot of activities to go through Conditional Use review. Do we have the option to permit more activities administratively?

Yes. The model bylaws offer a starting point. We made every effort to create provisions for lower risk activities to be permitted through administrative review. Towns can certainly permit more activities administratively, based on their expertise and capacity to ensure compliance and enforcement.

13. Why can't the State regulate floodplains and river corridors, similar to other natural resources such as lake shorelands and wetlands?

Currently, the state has limited authority and only regulates activities exempt from municipal regulation and activities that are jurisdictional under Act 250. Vermont statute would have to be amended to expand the State's authority to regulate all development in flood hazard areas and river corridors.

14. The standards in these model bylaws appear to be consistent with the standards in the DEC FHARC Protection Procedure applied to Act 250 projects under Criterion 1D – Floodways. Our town has adopted zoning and subdivision bylaws so proposed development under 10 acres or 10 residential units will only be regulated under our local flood hazard bylaws – correct?

Not necessarily. Specific conditions need to be met to qualify as a "10 acre" town versus a "1 acre" town, with respect to triggering Act 250 jurisdiction. The following Jurisdictional Opinion provides more detail on the requirements: http://nrb.vermont.gov/sites/nrb/files/documents/5-20.pdf

We encourage communities to contact their regional planning commission to get further guidance: https://www.vapda.org/

County: Region:

District: Community: Mount Holly

Show All N

View Report

Municipal Road and Bridge Standards Summary Report

7/2/2022 10:22 PM Display: County = VTrans District = 0 Region = Community = Mount Holly Show All = N

Community	Municipal Road and Bridge Standards and Date	Standards Template Used	Meet or Exceed 2019Standards?	Certificate of Compliance and Date	Town Highway Network Inventory Date	State Match For Town Highway Structures (80% or 90%)	State Match For Class 2 Roadways (70% or 80%)	ERAF Rate (7.5%, 12.5%, 17.5%)	Town Highway Miles	VTrans District and Email Contact
Mount Holly	07/09/2019	2019	Yes	03/08/2022	04/14/2015	80%	70%	7.5%	69.920	District 3

Please note: If a recent update is missing please send a copy of the document to the VTrans District Project Manager (link above).

The Orange Book 2014 – 2016: A Handbook for Local Officials
Includes the 2013 Road and Bridge Standards Template on page 7 – 6VTrans Municipal Assistance Bureau
VTrans Better Back Roads Program
VTrans Local Roads Program
Vermont Online Bridge and Culvert Inventory Tool (VOBCIT)
VTrans Maintenance Districts

Emergency Relief and Assistance Fund (ERAF)
Flood Ready Vermont – Roads and Culverts, Rivers and Roads Training
Regional Planning Commissions

FLOOD READY VERMONT

Municipality: Mount Holly | View Report

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Expanded Community Report for Mount Holly

7/2/2022
10:40:33 PM

Emergency Relief and Assistance Fund (ERAF) - State Post-Disaster Funding

Flood Hazard Mitigation Actions	Action Dates		Responsible	ERAF Status
1. Road and Bridge Standards	07/09/2019		Mount Holly	Yes
2. Local Emergency Management Plan	04/13/2021		Mount Holly	No
3. National Flood Insurance Program	09/18/1985		Mount Holly	Yes
4. Local Hazard Mitigation Plan	01/12/2021		Mount Holly	Yes
5. River Corridor Protection				No
ERAF Rate for Actions 1 - 4:12.5%,	Actions 1 - 5: 17.5%	**ERAF Rate for:**	**Mount Holly**	**7.5%**

23	Buildings in the Special Flood Hazard Area (SFHA) (estimated from e911 sites).
2	Flood Insurance Policies in SFHA (Zone A, AE, AO, A 1- 30)
9%	Percent of buildings in the SFHA with flood insurance in force.
0	Critical or public structures in SFHA or 0.2% flood hazard area (est. from e911 sites.)
2%	Percent of buildings in the SFHA.
09/18/1985	National Flood Insurance Program (NFIP) (Enrollment Date)
DFIRM	Flood Insurance Rate Map Standard (Digital FIRM (DFIRM), Rough Digital, Paper)
Mount Holly	NFIP Status: Regular Program
0	Community Rating System (CRS) Class
No	Local Emergency Management Plan (LEMP) ERAF Status valid for Mount Holly?
04/13/2021	LEMP - annual update after Town Meeting and before May 1.
Yes	Local Hazard Mitigation Plan (LHMP) ERAF Status valid for Mount Holly?
01/12/2021	LHMP - Valid for 5 years from FEMA final approval date
FEMA Formal Approval	LHMP - Status of review (Plans currently in review are valid for ERAF).
No	River Corridor Protection in Mount Holly?
	River Corridor Interim Protection Status for ERAF valid for Mount Holly?
10/09/2018	Municipal Plan - Valid for 8 years from adoption date
06/24/2008	Zoning Adoption / Amendment Date
	Hazard Area Regulation Adoption / Amendment Date
Yes	Road and Bridge Standards
69.920	Town Highway Mileage in Mount Holly
07/09/2019	Mount Holly_Road and Bridge Standards and Adoption Date
3/8/2022	Mount Holly_Certificate of Compliance with Road and Bridge Standards and Date
4/14/2015 12:00:00 AM	Town Highway Network Inventory Date
80%	Town Highway Structures Grant Rate (State match 80% or 90%)
70%	Class 2 Roadways Grant Rate (State match 70% or 80%)
District 3	Project Manager email for VTrans Maintenance District 3

Note: if you have updated information - please let us know:

1. Road Standards and Certificates - contact your VTrans District Project Manager: District 3
2. Local Emergency Management Plans or Local Hazard Mitigation Plans contact your Regional Planner
3. For other questions please contact VT DEC **Flood Ready Atlas**- River Corridor and Flood Hazard Maps

FLOOD READY VERMONT

Town of Mount Holly

Stormwater Infrastructure Mapping Project

February 2017

VTDEC – CLEAN WATER INITIATIVE PROGRAM, WATERSHED MANAGEMENT DIVISION

https://dec.vermont.gov/water-investment/cwi/solutions/developed-lands/idde

Jim Pease, Jim.Pease@vermont.gov
David Ainley, David.Ainley@vermont.gov

Overview

This stormwater infrastructure mapping project was completed for the municipality by the Agency of Natural Resources Ecosystems Restoration program to supplement the existing drainage data collected by the town and with the intention of providing a tool for planning, maintenance, and inspection of the stormwater infrastructure.

The GIS maps and geodatabase are meant to provide an overall picture and understanding of the connectivity or connectedness of the storm system on both public and private properties. They can be used to: (1) raise the awareness of the need for regular maintenance, the generation and transport of nonpoint source pollution increases with increasing connectivity of a drainage system, (2) as a valuable tool for hazardous material spill planning and prevention, (3) for the detection and elimination of illicit discharges; outfall locations and system connectedness data are used as a base for locating illicit or illegal discharges of non-stormwater to the municipal storm system and tracing them up to the source, (4) better assist the municipality in planning and implementing combined stormwater-sewer separation projects, (5) inform options for cleaning up existing polluted stormwater discharges; this report provides information and guidance for potential retrofit treatment locations and opportunities, (6) assist municipalities and residents with emergency preparedness for large rainfall events (i.e. Tropical Storm or Hurricanes) or spring snowmelt runoff events, by keeping storm drains clean, clear and open a good deal of localized flooding could be prevented, and (7) the basis for a local stormwater ordinance or be used to help enhance an existing stormwater management program.

Project Summary

The principal goal of this project was to develop up to date municipal drainage maps. These drainage maps were created showing the paths that stormwater runoff travels from where it falls on impervious surfaces such as parking lots, roads, and rooftops, to the outfall points in various receiving waters. These maps show the stormwater infrastructure including features like pipes, manholes, catchbasins, and swales within a municipality. Data sources included data collected from field work, a mapping grade Trimble GPS unit, available state permit plans, record drawings, town plans, WWMD plans, existing GIS data from contractors, and the input and guidance of knowledgeable members from the municipalities.

A second goal of this project was to establish potential locations for Best Management Practice (BMP) stormwater retrofit sites. These are sites where stormwater treatment structures could be added and where they would be most cost effective and efficient for sediment and phosphorus or nitrogen removal. In order to develop a retrofit site list, drainage area subwatersheds were delineated around the drainage networks. Determining how the stormwater infrastructure was connected was necessary in determining the subwatershed drainage areas within the town.

Delineating the drainage areas was done using the stormwater infrastructure maps, along with satellite imagery, a Digital Elevation Model (DEM), and USGS topographic maps. These data sources were used to approximate where the land area within each municipality was draining to; as well as where the high points were that divided the sub-drainage areas. The completed maps show the drainage coverage for essentially the entire municipality, but with a focus on areas with greater concentrations of impervious cover.

Impervious cover layers were created by either hand digitization or by using a method of raster pixel calculation (with ArcGIS spatial analyst extension) to create a vegetation index from the National Agricultural Imagery Program (NAIP) 08 orthophotos. The area which contrasted with the vegetation represents impervious surfaces and was then modified with buffered water and roads layers to make it more accurate. A more detailed explanation of this process is available in a separate document. The impervious layer was used to calculate the percent of each delineated drainage area that would generate stormwater runoff. The percentage of impervious surface number for each subwatershed was then adjusted with a connectivity rating. A rating was assigned to each drainage area polygon describing how directly connected the impervious surfaces within that subwatershed are to the receiving water. By adjusting the percent impervious area numbers with this connectivity rating the effective impervious area (EIA) was established for each subwatershed (*Sutherland, 1995*). This effective impervious number is a more accurate description of the amount of runoff produced by each of the subwatersheds because it helps to take factors such as infiltration into account.

After the effective impervious numbers were calculated for the subwatersheds the Simple Method was used to estimate the annual sediment (TSS) and phosphorus (TP) or Nitrogen (TN) loads generated by each subwatershed. The Simple method uses information which includes the adjusted impervious value, average annual rainfall for the location, total subwatershed area, and a given pollutant concentration value to calculate an annual load for various pollutants (*Schueler,1987*). Pollutant loads estimated by the Simple Method in this project are planning level estimates and are meant to give a general idea of the amounts of sediment or nutrient wash-off produced by each subwatershed for prioritization purposes. Subwatersheds were then prioritized, using the loading calculations as well as other criteria, and given Action List numbers ranging from 1 to 3 (one being the highest priority). The Action List number depends both upon loading values and feasibility of potential retrofit treatment options. Potential retrofit options listed in the TARGET maps are based on field observations and not on actual availability of land or willingness of landowner.

Water Quality Volume (WQv – the amount of storage needed to treat stormwater from a 0.9-1.0-inch storm) and Channel Protection Volume (CPv – the volume of storage that is needed to hold and slowly release stormwater for a 2.1inch rain event) were also calculated for delineated subwatershed areas. CPv calculations are only applicable if the receiving water is not a large body of water and is therefore susceptible to channel erosion. These numbers were used in the retrofit recommendation process because the volume of water to be treated was a key factor in determining the type of retrofit.

Project References

Schueler, T. 1987. Technical Documentation of a Simple Method for Estimating Urban Storm Pollutant Export. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Appendix A.

Schueler, T. et.al., 2007. Urban Stormwater Retrofit Practices, Version 1.0. Manual 3, Center for Watershed Protection, August 2007.

Sutherland, R. 1995. Methodology for Estimating the Effective Impervious Area of Urban Watersheds. Technical Note 58 – Pervious Area Management. Watershed Protection Techniques. Vol. 2, No. 1

***All data was created in an ArcGIS 10 Geodatabase format and is available from VTDEC.**

Act 64 Municipal Roads General Permit (MRGP)

The 2015 Vermont Legislature adopted Act 64 which will require all municipalities to address stormwater runoff from all existing municipal roads. The time line for adopting this general permit is as follows: December 2016 – Draft general permit available for informal public review, Summer-Fall of 2017 public hearings and comments and review, January 2018 final general permit issued; municipalities must file notice of intents to comply with the permit, currently proposed for summer 2018. The permit will likely require:

- Municipalities will develop road Stormwater management plans (RSWMPs). RSWMPs will include a comprehensive road erosion inventory of hydrologically-connected road segments and Implementation Plan and Schedule.
- The inventory will include an evaluation municipal hydrologically-connected road segments to see if they meet new MRGP standards. Road erosion inventories will be conducted every 5 years.
- Road segments that do not currently meet MRGP standards and that can impact waterways will be prioritized for remediation within the Implementation Plan and Schedule DEC has developed an Implementation Table and Schedule Excel spread sheet template for this purpose.

Towns will submit semi-annual reports to DEC documenting progress in road BMP implementation and MRGP compliance. Municipalities will be able to use the Implementation Table and Schedule spread sheet, mentioned above, for semi-annual compliance reporting requirements. The Road Erosion Inventory and Implementation Plan and the mapping information contained in it can be used by municipalities to develop the plan for the directly connected paved with catchbasin segment outfalls of municipal roadways. A map(s) is provided on the following page(s) indicating where these outfalls are located, based on the best available information DEC has to date. While the general permit requirements for directly connected paved roads with catchbasins is currently under discussion and not final it is very likely that if these outfalls are eroded they will need to have a scheduled outfall erosion repair. As with other classes of roads covered by this permit the municipality should first check the maps provided. It is suggested (although not currently required) that the following steps be taken to check the maps to determine what outfalls will require municipal attention for erosion repair:

1. Using the provided maps and/or data as a guide confirm that the road draining to this outfall is paved, has at least a single side of curb, has catch basins or drop inlets, and the discharge pipe from those catchbasins is directly discharging to waters of the state. Include any outfall within 500 linear feet of surface waters.

2. Using the maps locate the outfall and note any level of erosion present in the outfall and/or the 500 foot or less long swale between the pipe outlet and waters of the state.

3. Prepare a list of all outfalls with notes pertaining to the erosion based on the Town's ability to repair the erosion (minor, moderate or severe), the extent of erosion (an estimate in linear feet of repair needed including private property if the erosion exists on that property, and a cost estimate if possible.

Outfalls draining municipal roads and within 500 feet of a waterbody
BELMONT RD
LAKE ST
CHURCH ST
PERKINS LN
TARBELLVILLE RD
MAPLE HILL RD
VCGI

South Lake and Otter Creek Nonpoint Phosphorus Overview

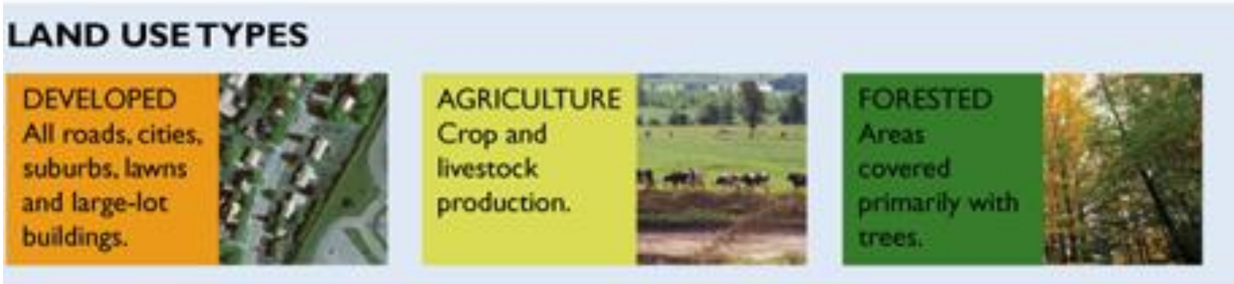
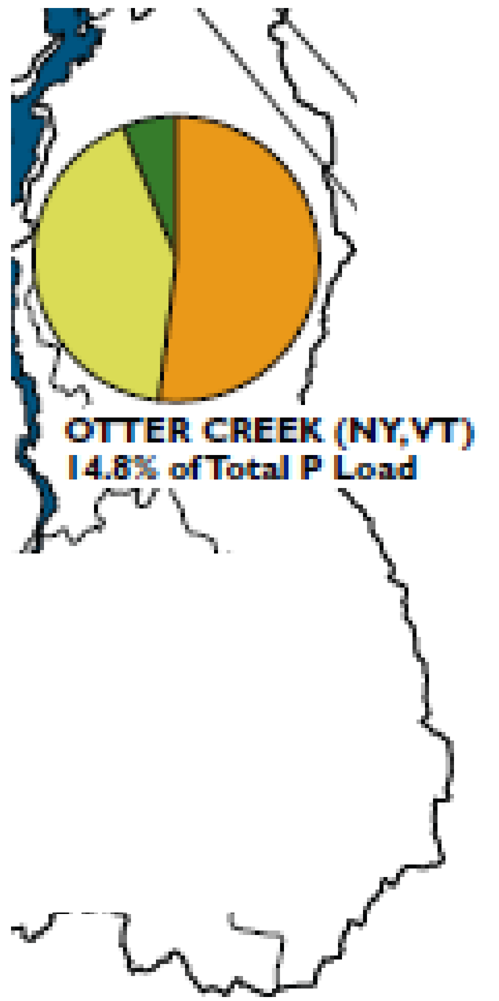


Figure shows the breakdown of contributions from developed, agricultural and forested land sources in the Otter Creek Watershed to Total Phosphorus loading of the South Lake segment.



STATUS	TREND	Indicator	
POOR	NO TREND	Phosphorus in Lake (p. 5)	PHOSPHORUS
POOR	NO TREND	Nonpoint source loading to Lake (p. 7-8)	
GOOD	IMPROVING	Wastewater facility loading to Lake (p. 10)	

STATUS	TREND	Indicator	
NO STATUS DATA*	NO TREND DATA	Beach closures from bacteria* (p. 12-13)	HUMAN HEALTH & TOXINS
GOOD	NO TREND DATA	Cyanobacteria blooms* (p. 14)	
FAIR	NO TREND DATA	Fish advisories for toxins* (p. 14)	

* The South Lake has no monitored public beaches.

STATUS	TREND
GOOD	IMPROVING
FAIR	NO TREND (neither improving nor deteriorating)
POOR	DETERIORATING
NO STATUS DATA IS AVAILABLE	NO TREND DATA IS AVAILABLE

* Figures taken from Lake Champlain Basin Program – *State of the Lake and Ecosystem Indicators Report (2012).*

http://www.lcbp.org/wp-content/uploads/2013/05/SOL2012-web.pdf

Subwatershed Data

Tables showing calculations and Priority drainage area retrofit possibilities

This is a key showing the abbreviations of the different funding programs listed in the calculation sheets.

Abbreviation Key	
Code	**Funding Program**
ERP/CWIP	VTDEC Clean Water Initiative Program
LCBP	Lake Champlain Basin Program
SRF	Clean Water State Revolving Loan Fund
VTrans	Vermont Agency of Transportation

This is a key showing the abbreviations of the different stormwater treatment structures or practices listed in the calculation sheets.

Abbreviation Key	
Code	**Structure Type**
BB	Baffle Box
BFCB	Baffled Catchbasin
BRA	Bioretention Area or Raingarden
BS	Buffer Strip (25' Min.)
CB	Catch Basin
CBI	Catch Basin Insert
CD	Check Dam
CR or ESRD	Impervious Disconnection Credits
DS	Dry Swale
DW	Drywell
EDPMP	Extended Detention Pond with Micropool
GS	Grass Swale
IB	Infiltration Basin
IG	Infiltration Gallery
MOD	Modifications/upgrade to 2002 SW standards
OF	Overland Flow
OGF	Organic Underground Filter
POP	Pocket Pond
PP	Perforated Pipe for infiltration
PS	Pump Station
RDD	Roof Drain Disconnect
RR	Rock Riprap
RS	Riprap Swale
SB	Sediment Basin
SF	Surface Sand Filter
SS-SF	Swirl Separator – Sand Filter
SS OR VS	Swirl Separator
SWPPP	Stormwater Pollution Prevention Plan
TT	Treatment Tank
UD	Underdrain in basin
WL	Wetland (Constructed)
WP	Wet Pond (Retention)
WS	Wet Swale

Mount Holly - Subwatershed Prioritization and Recommendations

Watershed Number	Action List #	Proposed Action	Proposed or Existing Stormwater Treatment Practice	Permit Number	Watershed Area (Acres)	Percent Mapped Impervious Area (MIA)	Sediment Load with Current Reductions (lbs.)	Sediment Load with Priority Action (lbs.)	Phosphorus Load with Current Reductions (lbs.)	Phosphorus Load with Priority Action (lbs.)
1 Mount Holly			OF/GS		31.8	4.6	2477	2477	20.64	20.64
2 Mount Holly			OF/GS/WP		51.8	4.1	708	708	17.71	17.71
3 Mount Holly			OF/GS		5.5	11.6	620	620	5.16	5.16
4 Mount Holly			GS/CB		27.8	8.7	2705	2705	22.54	22.54
5 Mount Holly			CB/GS/OF		33.0	5.5	2696	2696	22.46	22.46
6 Mount Holly			CB		9.7	32.0	3613	3613	30.11	30.11

Mount Holly - Subwatershed Prioritization and Recommendations

Watershed Number	Water Quality Volume (Acre-Feet)	Channel Protection (Acre-Feet)	Estimated Basin Construction Cost	Estimated Other BMP Construction Cost	Cost of Sediment Removal Per Pound (based on annual sediment load)	Cost of Nitrogen or Phosphorus Removal Per Pound (based on annual nutrient load)	Assistance Program	# LID-Roof Raingardens to Treat Water Quality Volume	Raingarden Cost
1 Mount Holly	0.14	FALSE					CWIP,SRF,LCBP	70	$32,230
2 Mount Holly	0.20	0.24					CWIP,SRF,LCBP	100	$46,085
3 Mount Holly	0.04	FALSE					CWIP,SRF,LCBP	18	$8,064
4 Mount Holly	0.15	0.27					CWIP,SRF,LCBP	77	$35,198
5 Mount Holly	0.15	FALSE					CWIP,SRF,LCBP	76	$35,079
6 Mount Holly	0.20	FALSE					CWIP,SRF,LCBP	102	$47,020

Spill Control

and

Vermont Hazardous Waste Management Regulations

Have a spill control plan for accidental spills at municipal facilities and on municipal streets

These stormwater infrastructure maps show the connectivity of the stormwater system for the municipality as accurately as it could be determined with the collected and existing data. In the event of a spill this can be a valuable tool for controlling spills and in spill response.

Towns should be equipped with suitable equipment to contain and clean up spills of hazardous materials. Accidental spills of materials can be sources of runoff pollution if not addressed appropriately. If possible Towns should be prepared to address spills on municipal streets while at the same time contacting the state Waste Management Division. DPW managers should be aware of all applicable requirements and should contact regulatory authorities if requirements are not known.

All spills should be cleaned up immediately after they occur. For municipal facilities the creation of a site specific spill control and response plan in combination with spill response training for designated on-site personnel can be effective in dealing with accidental spills and preventing the contamination of soil, water, and runoff. Preparation of a spill containment, control, and countermeasures (SPCC) plan might be required to meet regulatory requirements (e.g., requirements regarding storage of specified chemicals above certain volume thresholds).

Even if a formal plan is not required, preparing one is a good idea. In general, an SPCC plan should include guidance to site personnel on the following:

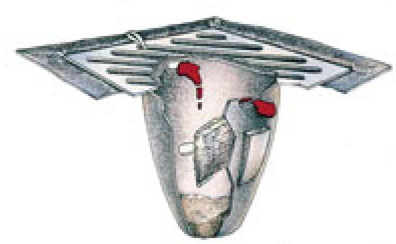
— Proper notification when a spill occurs;
— Site responsibility with respect to addressing the cleanup of a spill;
— Stopping the source of a spill;
— Cleaning up a spill;
— Proper disposal of materials contaminated by the spill;
— Location of spill response equipment programs; and
— Training for designated on-site personnel.

A periodic spill “fire drill” should be conducted to help prepare Town personnel in the event of a spill.

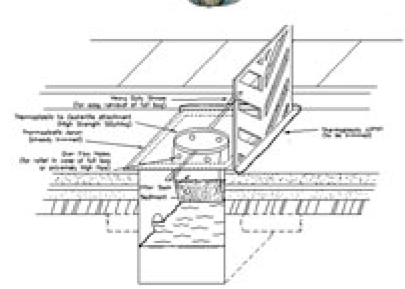
Spill Prevention and Response Measures

Catch Basin Inserts

Catch Basin Inserts (Drain Guards / Sediment Traps) protect our rivers and streams by capturing sediment, debris, oil and grease at storm water catch basins. Catch Basin Inserts are an economical and effective method to protect you from costly clean-up work.



The standard filter material is a non-woven geotextile with built-in overflow ports for cases of abnormally high water flow or over-filled filter bags. Catch Basin Inserts are available with a replaceable 5” x 15” oil absorbent boom that floats to absorb any oil, gas or diesel entering a storm water catch basin.



Urethane Drain Protector

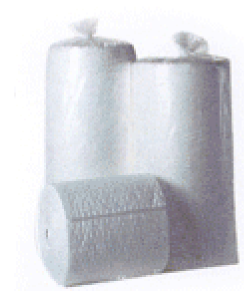
Urethane Drain Protectors are positive sealing drain covers that ensure spills do not enter drains. Drain Protectors are environmentally safe and resistant to chemicals, solvents and hydrocarbons. After use, the Drain Protector can be washed and stored in its tube storage container.

Absorbent Socks

Absorbent socks are flexible tubes used to contain and clean-up spilled fluids. Socks are widely used in industrial applications and are ideal for Spill Kits. Fast spreading spills are quickly stopped with a sock.

Drums & Intermediate Bulk Containers (IBC's)

New and reconditioned steel drums are ideal for storing solid and liquid waste. Poly drums available for durable outdoor storage or for building your own spill kits. Steel and poly drums are available in both tight-head (TH) and full open-head styles (FOH).



Pads & Rolls

Absorbent pads and rolls made from polypropylene fibers are the most popular form of absorbents on the market. Various types of absorbent pads and rolls can be used for different liquids and site applications.

The most widely used absorbent pads and rolls are oil-only (white) and universal (grey). Pads and rolls are great for spills on land, easily absorbing 20 to 25 times their own weight in recovered liquid. Rolls can easily be cut to the exact size required.

water or

Booms

Linkable Absorbent Booms

Absorbent booms are ideal for containing and cleaning up spills on water. Booms repel water and float even when completely saturated. Absorbent booms are constructed with a strong mesh outer skin encasing non-linting and highly absorbent polypropylene filler. Linkable booms come complete with end rings and clips attached to nylon rope running the length of the boom.

Collection basins
Collection basins are permanent structures in which large spills or contaminated storm water is contained and stored before cleanup or treatment. Collection basins are designed to receive spills, leaks, etc., and to prevent pollutants from being released into the environment. Unlike containment dikes, collection basins can receive and contain materials from many locations across a facility.

Containment diking
Containment dikes are temporary or permanent earth or concrete berms or retaining walls that are designed to hold spills. Diking can be used at any industrial facility, but is most common for controlling large spills or releases from liquid storage and transfer areas. Diking can provide one of the best protective measures against the contamination of storm water because it surrounds the area of concern and keeps spilled materials separated from the storm water outside of the diked area.

Curbing
Similar to containment diking, a curb is a barrier that surrounds an area of concern. Unlike diking, curbing is unable to contain large spills and is usually implemented on a small-scale basis. However, curbing is common at many facilities and in small areas where liquids are handled and transferred.

Granular Absorbents
A variety of granular and powdered absorbents are available for the effective clean-up of spills on streets, construction sites and in repair shops. These products absorb spilled liquids of various kinds to greatly lower the viscosity, aiding in the clean-up of the spill.

Sorbents, Gels, and Foams
Sorbents are compounds that immobilize materials by surface absorption or adsorption in the sorbent bulk. Gelling agents interact with the spilled chemical(s) by concentrating and congealing to form a rigid or viscous material more conducive to a mechanical cleanup. Foams are mixtures of air and aqueous solutions of proteins and surfactant-based foaming agents. The primary purpose of foams is to reduce the vapor concentration above the spill surface, thereby controlling the rate of evaporation.

§ **7-105** EMERGENCY AND CORRECTIVE ACTIONS
(a) Emergency actions
(1) In the event of a discharge of hazardous waste or a release of a hazardous material, the person in control of such waste or material shall:
(A) Take all appropriate immediate actions to protect human health and the environment including, but not limited to, emergency containment measures and notification as described below; and
(B) Take any further clean up actions as may be required and approved by federal, state, or local officials, or corrective actions as specified under **subsection (b)** of this section so that the discharged waste or released material and related contaminated materials no longer present a hazard to human health or the environment.
(2) Reporting
(A) All discharges and/or releases that meet any of the following criteria shall be immediately reported to the Secretary by the person or persons exercising control over such waste by calling the Waste Management Division at **(802) 241-3888**, Monday

through Friday, 7:45 a.m. to 4:30 p.m. or the Department of Public Safety, Emergency Management Division at **(800) 641-5005**, 24 hours/day:

(i) A discharge of hazardous waste, or release of hazardous material that exceeds 2 gallons;

(ii) A discharge of hazardous waste, or release of hazardous material that is less than or equal to 2 gallons and poses a potential or actual threat to human health or the environment; or

(iii) A discharge of hazardous waste, or release of hazardous material that equals or exceeds its corresponding reportable quantity under CERCLA as specified under **40 CFR § 302.4.**

Note: Under the Federal Water Pollution Control Act, certain spills of "oil" and/or "hazardous substances" are prohibited and must be reported pursuant to the requirements of **40 CFR Part 110** / Discharge of Oil. Certain spills of hazardous substances must also be reported pursuant to CERCLA. In both cases, the National Response Center must be notified at **(800) 424-8802**. Finally, in addition to federal and state spill reporting, EPCRA requires that spills are also reported to local authorities.

(B) A written report shall be submitted to the Secretary within ten (10) days following any discharge or release subject to **subsection (a)(1)** of this section. The report should be sent to: The Vermont Department of Environmental Conservation, Waste Management Division, 103 South Main Street, Waterbury, VT 05671-0404. The person responsible for submitting the written report may request that it not be submitted for small discharges and/or releases that were reported pursuant to subsection (a)(2)(A) of this section, and that have been entirely remediated within the ten (10) day period immediately following the discharge and/or release

(3) If the discharge or release occurred during transportation, the transporter shall, in addition to notifying the Secretary:

(A) Notify the National Response Center at (800) 424-8802 or (202) 426-2675, if required by **49 CFR § 171.15**; and

(B) Report in writing to the Director, Office of Hazardous Materials Regulations, Materials Transportation Bureau, Department of Transportation, Washington, D.C. 20590, if required by **49 CFR § 171.16**; and

(C) A water (bulk shipment) transporter who has discharged hazardous wastes must give the same notice as required by **33 CFR § 153.203** for oil and hazardous substances.

(4) If a discharge or release occurs and the Secretary determines that immediate removal of the waste is necessary to protect human health or the environment, the Secretary may authorize its removal by unpermitted transporters without the preparation of a manifest. Such hazardous waste may be transported to a site authorized by the Secretary under the provisions of **§ 7-503** to temporarily accept hazardous waste generated during an emergency cleanup of a discharge or release.

(5) In the case of an explosives or munitions emergency response, if a Federal, State, Tribal or local official acting within the scope of his or her official responsibilities, or an explosives or munitions emergency response specialist, determines that immediate removal of the material or waste is necessary to protect human health or the environment, that official or specialist may authorize the removal of the material or waste by transporters who do not have EPA identification numbers or hold Vermont hazardous waste transportation permits and without the preparation of a manifest. In the case of emergencies involving military munitions, the responding military emergency response specialist's organizational unit must retain records for three years identifying the dates of the response,

the responsible persons responding, the type and description of material addressed, and its disposition.

(6) All clean up debris and residues that are hazardous waste must be transported ultimately to either:

(A) A designated facility;

(B) A person authorized by the Secretary to use such waste if the waste has been delisted pursuant to **§ 7-218**;

(C) Some other location specified and authorized by the Secretary to receive clean up debris and residues if the waste has been delisted pursuant to **§ 7-218**; or

(D) For hazardous waste not defined as hazardous in 40 CFR Part 261 (i.e., waste regulated as hazardous by Vermont), to a facility, that is not a designated facility, located in a state other than Vermont provided the facility can receive such waste under applicable state and local laws, regulations and ordinances.

(b) Corrective actions

(1) If a discharge of hazardous waste, or a release of hazardous material has not been adequately addressed under **subsection (a)(1)(A)** of this section the Secretary may require that the person or persons responsible pursuant to **10 V.S.A. § 6615** complete the following:

(A) Engage the services of an environmental consultant experienced in the investigation and remediation of hazardous waste-contaminated sites; and

(B) Within thirty (30) days from either the date of the discharge/release or the date that the release was discovered if the date of discharge/release is not known, or within a period of time established by an alternative schedule approved by the Secretary, submit for approval by the Secretary a work plan for an investigation of the contaminated site (i.e., site investigation) prepared by the environmental consultant. The site investigation shall define the nature, degree and extent of the contamination; and shall assess potential impacts to human health and the environment (refer to the document titled: "Site Investigation Procedure" which is available from the Secretary upon request); and

(C) Perform the site investigation within either ninety (90) days of receiving written approval of the work plan by the Secretary, or a period of time established by an alternative schedule approved by the Secretary. A report detailing the findings of the site investigation shall be sent to the Secretary for review; and

(D) Within either thirty (30) days from the date of final acceptance of the site investigation report by the Secretary, or a period of time established by an alternative schedule approved by the Secretary, submit a corrective action plan prepared by the environmental consultant (refer to the document titled: "Corrective Action Guidance" which is available from the Secretary upon request); and

(E) Implement the corrective action plan within either ninety (90) days of receiving written approval of the plan by the Secretary, or a period of time established by an alternative schedule approved by the Secretary. The corrective action activity shall continue until the contamination is remediated to levels approved by the Secretary; and

(F) Submit to the Secretary all investigative, corrective action and monitoring reports, and all analytical results related to subsections (b)(1)(C) through (E) of this section, as they become available.

(2) A used or fired military munition is a waste and is potentially subject to corrective action authorities pursuant to 10 V.S.A. § 6615, and the process described by subsection (b)(1) of this section if the munition lands off-range and is not promptly rendered safe or retrieved. Any imminent and substantial threats associated with any remaining material must be addressed. If remedial action is infeasible, the operator of the range must maintain a record of the event for as long as any threat remains. The record must include the type of munition and its location (to the extent the location is known).

§ 7-106 LAND DISPOSAL RESTRICTIONS

(a) Certain hazardous wastes shall not be disposed of in or on the land. **40 CFR Part 268**, which is hereby incorporated by reference, except for 40 CFR §§ 268.5, 268.6, and 268.42(b), identifies those wastes which shall not be land disposed and describes the limited circumstances under which an otherwise prohibited waste may continue to be land disposed. The authority for implementing the CFR sections not incorporated by reference remains with the EPA.

> **Note**: A copy of 40 CFR Part 268 (the Land Disposal Restrictions rule), as incorporated by these regulations, is available from the Secretary upon request.

(b) In addition to the prohibitions of **40 CFR Part 268**, the Secretary may restrict the land disposal of any hazardous waste in the State of Vermont:

(1) Which may present an undue risk to human health or the environment, immediately or over a period of time; or

(2) Which would be incompatible with the **groundwater protection rule and strategy** of chapter 12 of the environmental protection rules.

(c) Dilution of hazardous waste subject to the land disposal restrictions of **40 CFR Part 268** is prohibited pursuant to **40 CFR § 268.3.**

§ 7-107 ENFORCEMENT

(a) Information that the generation, transportation, treatment, storage or disposal of hazardous waste may present an actual or potential threat to human health or the environment, or is a violation of the 10 V.S.A. chapter 159, or these regulations, or any term or condition of certification, order, or assurance, may serve as grounds for an enforcement action by the Secretary, including, but not limited to:

(1) After notice and opportunity for hearing, issuing an order directing any person to take such steps as are necessary to:

(A) Immediately cease and desist any operation or practice;

(B) Correct or prevent environmental damage likely to result from any deficiency in operation or practice;

(C) Suspend or revoke any certification and require temporary or permanent cessation of the operation of such facility;

(2) A request that the Attorney General or appropriate State's Attorney commence an action for injunctive relief, the imposition of penalties and fines provided in **10 V.S.A. § 6612** and other relief as may be appropriate.

(3) An order for reimbursement to any agency of federal, state, or local government from any person whose act caused governmental expenditures under **10 V.S.A § 1283**.

(4) All other powers of enforcement available to the Secretary through **10 V.S.A., chapter 201**.

(b) The hearing by the Secretary identified under **subsection (a)(1)** of this section shall be conducted as a contested case. Pursuant to **10 V.S.A. § 6610(b)**, the Secretary may issue an emergency order without a prior hearing when an ongoing violation presents an immediate threat of substantial harm to the environment or an immediate threat to public health. An emergency order shall be effective upon actual notice to the person against whom the order is issued. Any person to whom an emergency order is issued shall be given the opportunity for a hearing within five (5) business days of the date the order is issued.

(c) Inspections, investigations, and property access **(10 V.S.A. § 8005)**

(1) Inspections and investigations

(A) An investigator may perform routine inspections to determine compliance.

(B) An investigator may investigate upon receipt or discovery of information that an activity is being or has been conducted that may constitute or cause a violation.

(C) An investigator, upon presentation of credentials, may seek permission to inspect or investigate any portion of the property, fixtures, or other appurtenances belonging to or used by a person whose activity is required to be in compliance. The investigator shall state the purpose of the inspection or investigation. An inspection or investigation may include monitoring, sampling, testing, and copying of any records, reports, or other documents relating to the purposes to be served by compliance.

(D) If permission for an inspection or investigation is refused, the investigator may seek an access order from the district or superior court in whose jurisdiction the property is located enabling the investigator to perform the inspection or investigation.

(2) Access orders

(A) If access has been refused, an access order may be sought pursuant to either **10 V.S.A. § 80**05 or **10 V.S.A. § 6609**.

(B) Issuance of an access order shall not negate the Secretary's authority to initiate criminal proceedings in the same matter by referring the matter to the office of the attorney general or a state's attorney.

(d) In an action to enforce these regulations, anyone raising a claim that a certain material is not a hazardous waste, or is exempt from regulation as hazardous waste, must demonstrate that there is a known market or disposition for the material, and that they meet the terms of the exclusion or exemption. Appropriate documentation (such as contracts showing that a second person uses the material as an ingredient in a production process) to demonstrate that the material is not a waste, or is exempt from regulation, must be provided. Owners and operators of facilities claiming that they are actually recycling materials must show that they have the necessary equipment to do so.

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

Addendum 1: Patch Brook & Buffalo Brook Tributaries
Towns of Plymouth, Reading, Mount Holly, Ludlow

October 2010

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Southern Windsor County
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Field work was conducted with the cooperation of Plymouth, Reading, Mount Holly, and Ludlow landowners who granted permission to cross their property to access the river. Volunteer assistance was graciously provided by Sue Poirier and Peg Underwood.

EXECUTIVE SUMMARY

Phase 2 geomorphic assessments were completed in 2009 on 14 reaches (11.4 river miles) of the Patch Brook and Buffalo Brook tributaries to Black River, as well as one reach of the Black River main stem. This report serves as an addendum to the July 2009 Phase 2 Stream Geomorphic Assessment report for the Black River watershed completed by South Mountain Research & Consulting (SMRC) under contract to the Southern Windsor County Regional Planning Commission (SWCRPC). The reader is referred to this previous report for summaries of the regional geologic setting, hydrology, flood history, and land use as well as assessment results for surrounding reaches of Black River watershed.

In recent decades, residents in the vicinity of Lake Rescue have noted increasing volumes of sediment in a northern embayment of Lake Rescue known locally as Round Pond. Anecdotally, the aerial extent and thickness of these sand and silt deposits has increased markedly since the flood of June 1973. Patch Brook enters the Black River downstream of Echo Lake and approximately 0.6 mile upstream of Round Pond. A growing sediment delta has also been noted at Camp Plymouth State Park where the Buffalo Brook joins Echo Lake, approximately 1.2 miles upstream of Round Pond. This delta was observed to increase in size coincident with a June 2006 flood which impacted the Buffalo Brook tributary following sudden breaching of a dam at Reading Pond.

Assessment of the Patch Brook and Buffalo Brook tributaries was undertaken to: (1) evaluate the geology and land use history of the tributary watersheds; (2) identify sources of sediment in these watersheds that may be contributing to a build up of sediment deltas in Echo Lake and Round Pond; and (3) identify and prioritize restoration projects and practices to decrease sediment loading and increase flow and sediment attenuation in these tributary watersheds.

Field investigations and limited historical reviews have identified various watershed and channel disturbances that have impacted these Black River tributary reaches, 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 gold placer mining in the 1800s;
- Historic dams and diversions at multiple locations along the tributary reaches;
- Regulation of flows in the Black River including in-stream impoundments: Amherst Lake, Echo Lake, and Lake Rescue; and
- Upstream erosion and tributary sources of sediment.

Reach-scale Modifiers:

- Channelization (straightening) especially associated with development, bridge crossings and historic impoundments;
- Inferred gravel extraction, dredging and windrowing of the channel in response to the flood events of 1927, 1936 / 1938 and 1973, particularly along the Patch Brook through Tyson village;
- Reported gravel extraction, dredging, windrowing, impoundments, diversions, associated with historic gold placer mining along the Buffalo and Reading Pond Brook reaches in the 1800s;
- Berming along stream banks (along Dublin Road, Patch Brook; in vicinity of select bridge crossings on both tributaries);

- Streambank armoring (rip-rap) and retaining walls;
- Floodplain encroachment by roads and residential and commercial development;
- Undersized public bridges and in-stream culverts, serving as flow constrictors at bankfull flow or higher-magnitude flood events (particularly, Patch Brook Road culvert, Tatro Road bridge, and Library Road bridge on the Patch Brook; and Scout Camp Road bridge on the Buffalo Brook);
- Stormwater runoff from roads (particularly along Patch Brook Road on the Patch Brook and a network of forest roads along the Buffalo Brook, Reading Pond Brook and tributaries); and
- Sudden breaching of the dam on Reading Pond in a June 2006 flood event, resulting in impacts to downstream reaches of the Reading Pond Brook and Buffalo Brook.

The Patch Brook and Buffalo Brook / Reading Pond Brook 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.

In general, given the geologic and topographic setting, many of the Patch Brook and Buffalo Brook reaches are naturally transport-dominated due to the erosion resistance offered by bedrock in the channel bed or banks, the steepness of valley gradients, and/or close confinement of the channel by bedrock-controlled steep valley walls. Along some of the reaches where a limited degree of floodplain connection and deposition might have been expected, due to a locally broader valley section or reduced gradients, historic channel and floodplain modifications (straightening, berming, armoring) and encroachments (roads, bridges, homes, commercial buildings) in the river corridor have converted these reaches to a more transport-dominated condition. Due to increased erosional scour through these straightened and partly incised and entrenched reaches, they now serve as a source of sediment to downstream reaches. The Patch Brook reaches along Dublin Road are an example of this condition. Only a few segments in the Patch Brook watershed (and none in the Buffalo Brook watershed) have reasonable or partial access to the floodplain, and (where presently unconstrained by human-constructed features) may represent key sediment attenuation assets (three segments of Patch Brook reach M40T5.04 in the Calvin Coolidge State Forest). Overall, a more effective approach to address sedimentation in these tributary channels, may be to focus on mitigating point sources of increased stormwater and sediment loading - e.g., by controlling stormwater inputs along road lengths and at crossing locations, by re-wilding sections of abandoned forest roads in mid- to lower-reaches of the Buffalo Brook watershed where road segments now concentrate stormwater runoff and serve as a large source of sediment to downstream reaches.

A limited number of opportunities for river corridor 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

This report summarizes results of a Phase 2 geomorphic and habitat assessment and corridor planning recommendations for 14 reaches (11.4 river miles) of the Patch Brook and Buffalo Brook tributaries to Black River, as well as one reach of the Black River main stem. This report serves as an addendum to the July 2009 Phase 2 Stream Geomorphic Assessment report for the Black River watershed completed by South Mountain Research & Consulting (SMRC) under contract to the Southern Windsor County Regional Planning Commission (SWCRPC). The reader is referred to this previous report for summaries of the regional geologic setting, hydrology, flood history, and land use as well as assessment results for surrounding reaches of Black River watershed.

Phase 2 stream geomorphic assessments of the Patch Brook and Buffalo Brook were undertaken at the request of the Lake Rescue Association, in cooperation with SWCRPC. In recent decades, residents in the vicinity of Lake Rescue have noted increasing volumes of sediment in a northern embayment of Lake Rescue known locally as Round Pond. Anecdotally, the aerial extent and thickness of these sand and silt deposits has increased markedly since the flood of June 1973 (Figure 1). Patch Brook enters the Black River downstream of Echo Lake and approximately 0.6 mile upstream of Round Pond (Figure 2). A growing sediment delta has also been noted at Camp Plymouth State Park where the Buffalo Brook joins Echo Lake, approximately 1.2 miles upstream of Round Pond. This delta was observed to increase in size coincident with a June 2006 flood which impacted the Buffalo Brook tributary following sudden breaching of a dam at Reading Pond.

Assessment of the Patch Brook and Buffalo Brook tributaries was undertaken to:

- Evaluate the geology and land use history of the tributary watersheds;
- Identify sources of sediment in these watersheds that may be contributing to a build up of sediment deltas in Echo Lake and Round Pond; and
- Identify and prioritize restoration projects and practices to decrease sediment loading and increase flow and sediment attenuation in these tributary watersheds.

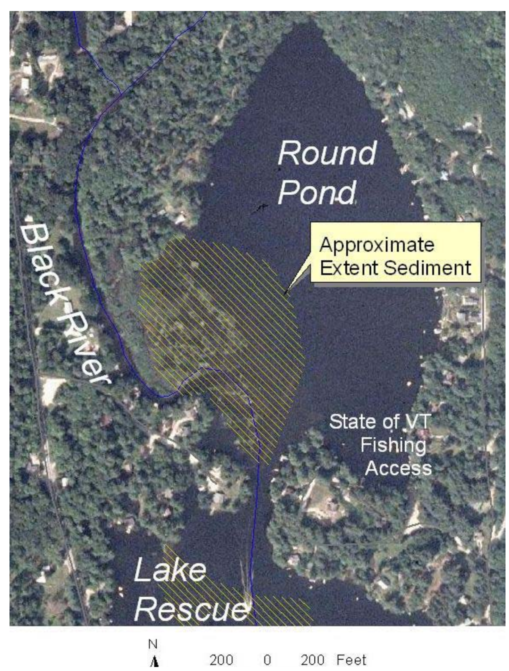


Figure 1. Approximate location of sediment accumulation in Round Pond

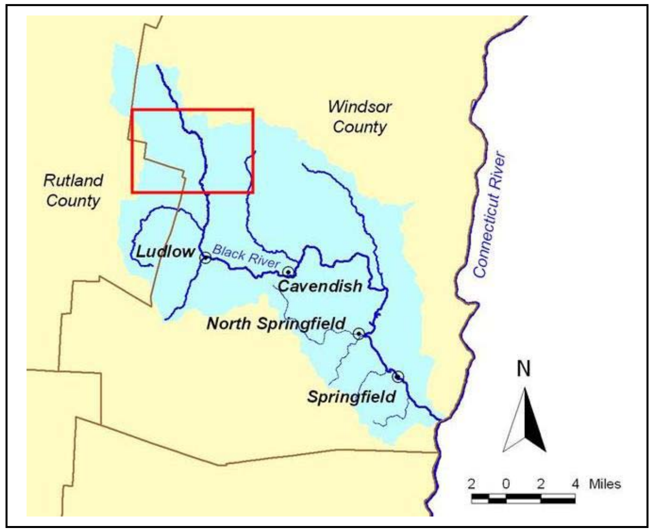
Assessments have been conducted utilizing the VTANR *Stream Geomorphic Assessment Protocols Handbooks* (2007a). Projects have been identified following the VTANR *River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects* (2007b). Assessment results can be used by landowners and other watershed stakeholders to:

- identify restoration and conservation projects intended to improve water quality and restore aquatic habitats;
- plan for future development which is more compatible with adjusting river channels; and
- reduce fluvial erosion hazards.

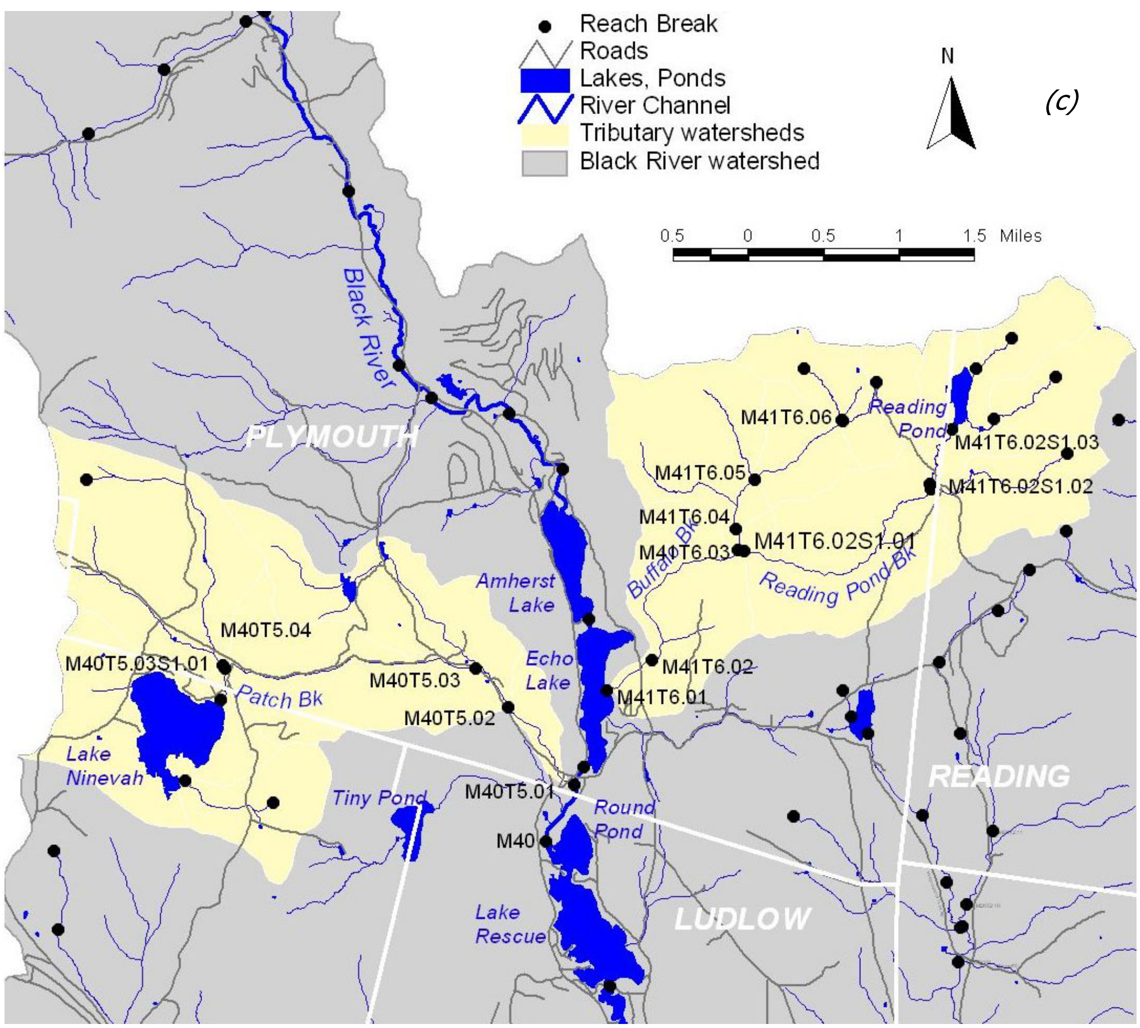
*Figure 2. Location map of:
(a) Black River watershed in Vermont; (b) Patch and Buffalo Brook watersheds in the Black River Watershed; and (c) study reaches in the Patch and Buffalo Brook watersheds.*

(a)

(b)



(c)



2.0 ASSESSMENT METHODOLOGY

This stream geomorphic assessment utilized the 2007 version of the protocols published by the Vermont Agency of Natural Resources, including selected updates published in 2008 (VTANR, 2007a; VTANR, 2008a, 2008b, 2008c). Reference is made to these protocols for a description of specific methods followed to complete Phase 2 Stream Geomorphic Assessments and Bridge and Culvert Assessments.

2.1 Phase 2 Stream Geomorphic Assessment

Reaches of the Patch Brook and Buffalo Brooks were assessed between August and October of 2009. The main stem reach, M40, was assessed by kayak while the remaining reaches were assessed on foot. Flow stages were low to moderate on the assessment dates. Specific features and channel positions were located using a Garmin™ 76CSx model 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 2.2). Phase 2 assessment data were entered into the online Data Management System (DMS, v.4.56) a custom database of Phase 1, 2, and 3 geomorphic data developed and maintained by the Vermont Agency of Natural Resources (VTANR). A Phase 2 reach summary report is presented in Appendix A (standard output from the DMS).

Fifteen bridge and culvert crossings were encountered during the 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 includes a summary of the bridge and culvert assessments completed for these structures in accordance with Appendix G of the VTANR protocols (2008c). Bridge and culvert data were entered into the Structures portion of the DMS (under the "Black River" database).

2.2 Phase 1 Updates

Original Phase 1 assessment data (SMRC, 2007) for the 14 reaches were reviewed and verified during field work as per VTANR protocols. As appropriate, GIS shape files were corrected or updated (using the Feature Indexing Tool). Phase 1 data in the DMS were updated, and the metadata for each Phase 1 step were reviewed and updated (where necessary) to reflect that data were supported by field observations. Updated Phase 1 reach summary reports are presented in Appendix A.

The reference stream type was updated as a result of field observation of valley confinement, sinuosity, channel gradient and dimensions. Elevation data for the downstream and upstream reach breaks were updated as a result of field-based observations and to correct for apparent interpolation or data entry errors in Phase 1 (see Appendix A). Accordingly, channel and valley gradient calculations were updated.

Based on field observations and following clarifications to valley wall delineation procedures articulated in protocol updates between 2004 and 2009, a shape file of the modified (Phase 2) valley wall was generated, representing modifications to the natural valley width caused by encroachments of artificial fill for semi-permanent structures such as major roads and railroads. An updated valley wall shape file is contained on the Project CD.

2.3 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.

Using the Feature Indexing Tool (FIT) in SGAT, select Phase 2 features were indexed to the available Vermont Hydrography Dataset (VHD). Locations and lengths of features indexed to the VHD should be considered approximate. In some locations, surface waters depicted on the VHD are considerably offset from their present position, as revealed by comparison to 2009 channel positions (recorded with a hand-held GPS receiver).

3.0 PHASE 2 ASSESSMENT RESULTS

Phase 2 assessment results are discussed below for Patch Brook reaches and Black River reach M40 in Section 3.1 and for Buffalo Brook (including Reading Pond Brook) in Section 3.2. 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/segment. 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)

3.1 Patch Brook and Black River main stem reach M40

Patch Brook drains a 5.4-square-mile area west of Route 100 in the towns of Plymouth and Mount Holly (Figure 3). The drainage divide for this watershed – which includes Lake Ninevah - is defined to the northwest by Salt Ash Mountain, to the west by Proctor Hill, and to the south by Tiny Mountain. Tiny Pond is a nearby surface water body that drains separately (via Tiny Pond Brook) to the Black River main stem, at a point approximately 1,000 feet downstream of the Patch Brook confluence.

The Patch Brook watershed is underlain predominantly by glacial till sediments. There are isolated deposits of alluvial and glaciofluvial sediments associated with Lake Ninevah and a wetland area just to the north of this lake. Extensive glaciofluvial deposits are also mapped in the somewhat broader valley of lower Patch Brook along the Dublin Road, extending from the intersection of Patch Brook Road downstream to the Black River. A few outcroppings of bedrock were observed along the Patch Brook as channel-spanning ledge in remote segments north of Patch Brook Road, and in a prominent waterfall southwest of the intersection of Patch Brook Road and Dublin Road.

Patch Brook joins the Black River between Echo Lake to the north and Lake Rescue to the south - within reach M40. A total of five reaches (5.2 miles) of the Patch Brook watershed were assessed in 2009 (Figure 3), including a tributary to the Patch Brook which is the outlet channel from Lake Ninevah. The half-mile reach M40 of the Black River was also assessed; the Black River has an upstream drainage area of 34 square miles at this location. Results are summarized in Table 1, below. Detailed reach narratives are presented in Appendix E.

3.1.1 Land Use and Channel Management History

Patch Brook watershed is approximately 86% forested and 4% urban. A sparse network of gravel roads and trails provides recreational access to the more remote forested headwaters in the Calvin Coolidge State Forest. A history of logging is evident in this upper reach of the Patch Brook. A small diversion of flow from the brook is directed to a constructed pond with earthen dam located between 100 and 150 feet west of the brook. This impoundment appears to have been constructed between 1955 and 1994 and may be related to recent logging and/or recreational activities (see Appendix E). Given the regional history, this dam may have been constructed in support of recent logging or recreational activities. History of this dam and the surrounding property was not available in the resources consulted for this study. It is not listed on the Vermont Dam Inventory.

Lake Ninevah is described as a natural pond with an earthen dam that artificially increases the elevation and aerial extent of the lake (VTDEC, 2005). Historically, this pond was identified as "Patch Pond" on the 1893 Wallingford, VT USGS topographic map, and the "S.I. Co" (Spaffic Iron Company) reservoir on the 1869 Beers Atlas of Windsor County. The current dam was reportedly installed in 1930 (VT Dam Inventory) on the approximate site of the former dam(s) operated previously by Spathic Iron Co. (perhaps breached in the 1927 flood). The present dam is owned by Wilderness Corporation who purchased it from Central Vermont Public Service in 1984. The current purpose of the dam is recreational (VT Dam Inventory: VCGI, 2005). The original purpose of the dam was noted as hydroelectric; CVPS "used the dam as a storage reservoir to augment flows in the Black River for its Cavendish hydroelectric project" (VTDEC, 2005).

The approximate aerial extent of Lake Ninevah is published as 237 acres; maximum depth is 12 feet; and the upstream drainage area is 1.2 square miles (VTDEC, 2005). The dam operates as a run-of-river structure. In the 1980s and early 1990s, the lake was customarily drawn down in the winter months (October through May) by 3 to 4 feet by draining lake waters through a sluiceway over a period of approximately 2 weeks. In later years the amount of drawdown was reduced to approximately 6 inches. Following a June 2004 order from the VT Agency of Natural Resources, artificial drawdowns of the lake were discontinued for the sake of in-lake aquatic habitats (VTDEC, 2004).

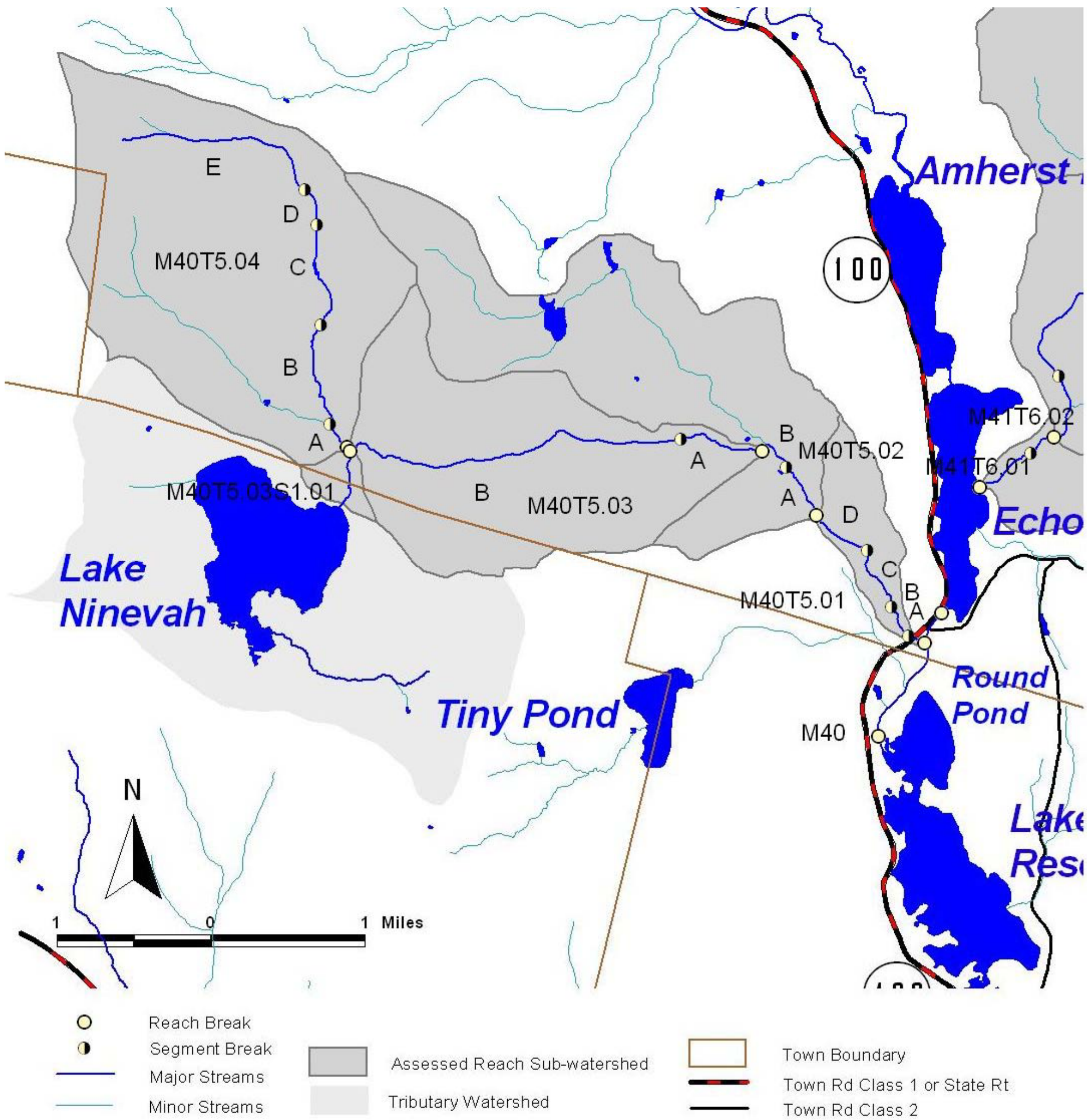


Figure 3. Location of Patch Brook and Black River main stem reaches assessed in 2009.

Table 1. Results of Phase 2 Geomorphic Assessments, 2009.
Patch Brook watershed and Black River main stem reach M40

Patch Brook - Plymouth, Mount Holly

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
M40T5.04	E	4,578	***9.7***		B4a-casc	1.0 [RAF]	11.2	0.82 Good	0.79 Good	Min wid (local), min PF	I [F]	None	Moderate
	D *	851	***4.6***		C4a-R/P	1.15 [RAF]	11.7	0.81 Good	0.76 Good	Min aggrad, PF	I [F]	None	High
	C *	2,297	***3.9***		C4b-S/P	1.64 [RAF]	13.6	0.79 Good	0.70 Good	Min aggrad, PF; Hist incis	II [F]	None	High
	B *	2,427	***2.0***		C4-R/P	1.18 [RAF]	12.1	0.70 Good	0.69 Good	Mod aggrad, Hist incis	II [F]	None	High
	A *	623	***0.3***	1.5	Not Assessed - Wetland dominated								
M40T5.03S1.01	--	1,221	2.3	1.7	B3-S/P	1.0 [RAF]	20.3	0.74 Good	0.85 Ref	None	I [F]	None	Moderate
M40T5.03	B	7,623	***5.0***		B3a-S/P	1.2 [RAF]	15.2	0.72 Good	0.68 Good	None. Historic incis.	V [F]	None	Moderate
	A *	1,856	***5.1***	4.2	F3a-PB	4.2 [HEF]	21.3	0.57 Fair	0.51 Fair	Minor aggrad	II [F]	Ca to Fa	Extreme
M40T5.02	B *	871	***2.9***		F3b-PB	4.0 [HEF]	15.7	0.61 Fair	0.61 Fair	Min PF, aggrad	II [F]	Cb to Fb	Extreme
	A	1,240	***3.2***	5.3	B4-PB	2.7 [RAF]	17.1	0.64 Fair	0.56 Fair	Min PF, aggrad	II [F]	B - Fb - B?	High
M40T5.01	D	1,382	***3.6***		F3b-PB	2.6 [RAF]	20.2	0.55 Fair	0.55 Fair	Mod wid; hist incis	III [F]	Cb to Fb	Extreme
	C	1,449	***3.8***		C3b-PB	1.4 [RAF]	37.7	0.61 Fair	0.55 Fair	Mod wid & PF; hist incis	III [F]	None	High
	B *	764	***3.3***		F3b-PB	3.7 [RAF]	23.4	0.43 Fair	0.50 Fair	Wid, min aggr; hist incis & PF	II [F]	Cb to Fb	Extreme
	A *	397	***2.5***	5.4	C3b-PB	1.5 [RAF]	17.6	0.45 Fair	0.53 Fair	PF, min Wid/Aggr, Hist incis	III [F]	None	Extreme **

Black River main stem - Plymouth, Ludlow

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
M40	--	3,131	0.5	34.1	C3-PB	1.85 [RAF]	35.1	0.59 Fair	0.48 Fair	None (Hist Incis, Wid, Aggr, PF)	III [F]	None	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.

** Sensitivity overridden to higher value due to setting of marked decrease in valley gradient and confinement ("alluvial fan").

Rural residential land use is evident in the Lake Ninevah area and along Dublin Road in the lower extent of the Patch Brook watershed. Commercial and residential developments are present near the downstream end of the tributary just west of VT Route 100, including the Echo Lake Inn, Tyson Library, and a church.

These buildings are located in the historic hamlet of Tyson Furnace. An iron works was established here circa 1837 by Isaac Tyson, Jr. Iron ore was obtained from several mines established generally within a a five-mile radius from the furnace (Thompson, 1842). This industrial center flourished for nearly 20 years, and produced a variety of products including farming implements, water pipes, and stoves (VT Historical Society, 2009; Thompson, 1842). The iron works were closed in 1855, but later re-opened during the Civil War and produced "iron for the building of the Monitor class gunboats" (Duffy *et al*, 2003). Following the war until 1872, the iron works were operated by Spathic Iron Company (Hartford, CT) for the production of steel cutlery (Ward, 1983; Duffy *et al*, 2003). It is likely that lumber was harvested from the headwaters of Patch Brook watershed (and the surrounding region) to supply charcoal to the iron furnace during its years of operation (Duffy *et al,* 2003).

Tyson constructed a mill dam and water works to power the furnace (Duffy *et al*, 2003). The Beers Atlas of Windsor County (1869) depicts a small mill pond and sawmill upstream of the village center. A flow diversion channel is depicted leading downstream from this mill pond and across Dublin Road and toward the Tyson furnace. Evidence of this historic flow diversion is also depicted on the 1859 Map of the Town of Plymouth (Scott, Stickney, & Pollard, publishers) (Figure 4). Presence of the former mill dam (now breached) and the diversion channel was confirmed by field observations during 2009 assessments. Remnants of the earth/stone dam are visible approximately 4,000 feet upstream of the confluence with Black River (segment M40T5.02-A). Just downstream of the former mill dam (near the upper end of reach M40T4.01), a small bypass channel has been constructed historically to convey a portion of the flow from Patch Brook to a culvert under Dublin Road and into a constructed channel that flows somewhat parallel to Patch Brook, but on the far side of residential homes to the west of Dublin Road. This "canal", as it is known locally, returns to the Patch Brook approximately 3,000 feet downstream, below the Dublin Road bridge (see also, Appendix E).

Figure 4. Excerpt from historic map of Tyson Furnace showing location of iron furnace and diversion canal from Patch Brook.

Source: Scott, Stickney & Pollard, publishers, 1859: Map of the Town of Plymouth.

Near the downstream end of Patch Brook, the channel is crossed by Library Road and VT Route 100. Based on historic topographic maps, sometime between 1932 and 1983, the alignment of Route 100 was straightened, possibly resulting in a shift in the bridge crossing site over Patch Brook. The bridge and culvert database maintained by VTrans suggests that the current VT Route 100 bridge was constructed in 1936. As viewed on the 1859 map of the town of Plymouth, the Patch Brook confluence with the Black River was historically located further south of its current position near the Ludlow town boundary. A local landowner indicates that the channel was reportedly diverted from a position approximately 50 yards south, to its current position in 1929 following the 1927 flood (Jefferies, 2009).

3.1.2 Assessment Results

Overall, the gradient of the Patch Brook decreases along the length of study, from 9.7% at the upper extent to 2.5% above the confluence with Black River (Figure 5). There is a local reduction in gradient in vicinity of Lake Ninevah above the valley pinch point that defines the beginning of the steep, confined reach along Patch Brook Road (M40T5.03). This reduction in gradient is also coincident with the wetland complex north of Lake Ninevah.

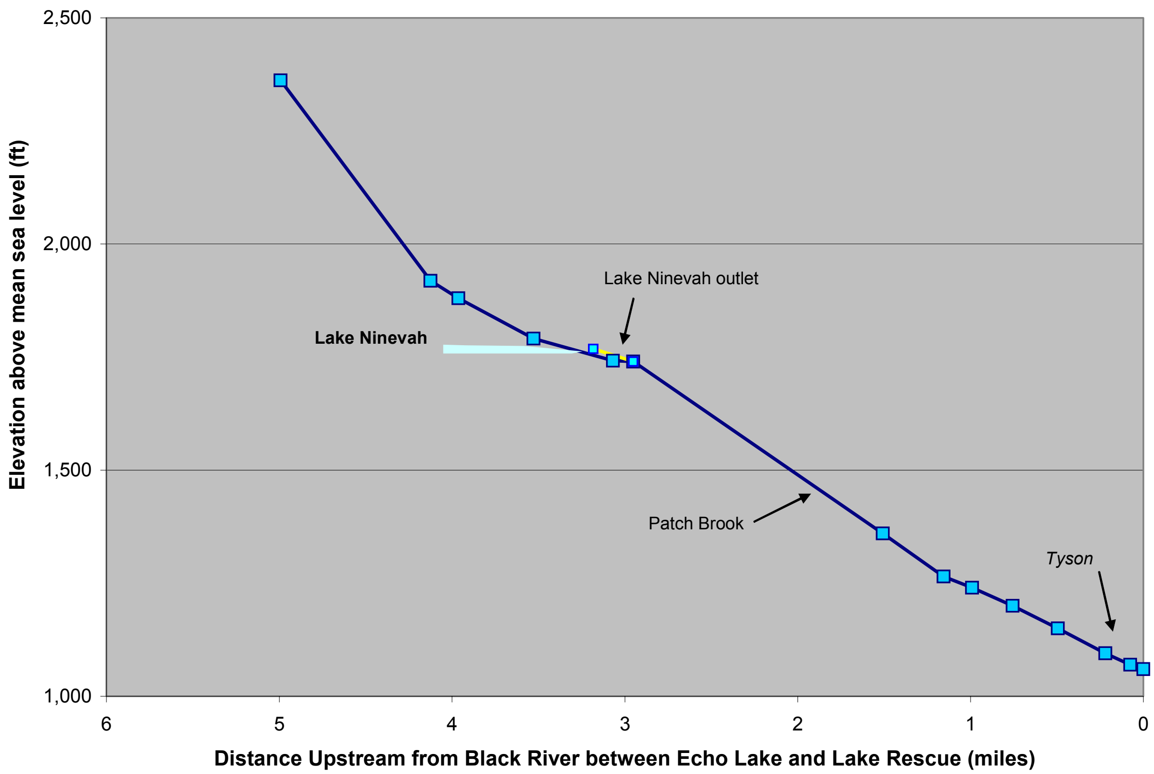


Figure 5. Longitudinal Profile of Patch Brook tributary.

Generally, the upper 3.7 miles of assessed channel (including the Lake Ninevah outlet) are in stable condition, with reasonable access to the floodplain (incision ratios less than 1.2), exhibiting minor degrees of aggradation and planform adjustment. One exception to this generalization is a 2,300-foot segment of the uppermost reach, M40T5.04-C, which appears to have undergone a moderate degree of historic incision (IR_{RAF} = 1.6) possibly related to historic channel management associated with the flow diversion to a nearby pond and/or recent or historic logging or mining activities. To the extent that ongoing channel adjustments in this segment yield sediments to the channel, downstream Segments M40T5.01-B and M40T5.01-A (wetland) offer opportunities for sediment attenuation.

Proceeding downstream from the wetlands above Townsend Barn Road crossing, Patch Brook shares a narrow stream valley with the gravel Patch Brook Road. Coarseness of bed and bank materials in this segment (M40T5.03-B) and occasional bedrock exposures offer stability to the channel despite the road encroachment which has lead to channel straightening and armoring in a few locations. Frequent cross culverts connect road ditches directly to the channel; and there are several locations of overland flow off the road. Erosion of the road can be extensive during heavy storms (Caduto, 2009). This steep, transport-dominated channel passes these road sediments downstream to lower reaches of the Patch Brook. In the 1980s to early 1990s, management of lake levels in Lake Ninevah may have lead to a marginal increase in sustained flows in Patch Brook during the Fall months that would enhance the transport function of this reach (temporarily).

In general, downstream of the Patch Brook Road / Dublin Road intersection, the Patch Brook is incised and entrenched below high terraces of glaciofluvial sediments – in part as a result of an extensive history of channel management including straightening, berming, armoring, inferred dredging, historic mill dam impoundments, and flow diversions. The upstream extent of historic incision is marked by a bedrock grade control (waterfall) at the segment break between M40T5.03-B and M40T5.03-A (Figure 6). At the lower end of reach M40T5.03, the natural valley confinement transitions from Semi-Confined to Broad, as the channel flows from glacial till deposits to glaciofluvial sediments. Increased lateral adjustment of the channel would be expected at such a transition. Instead the channel has been extensively managed in this location in response to past flood events (e.g., 1973, 1936/38, 1927) and to protect adjacent roads and residences. A high berm has been constructed along the left bank in two sections; these berms and the linear planform of the channel suggest a history of channelization with windrowing. The channel is now pinned along the right valley wall and is incised below the adjacent floodplain.

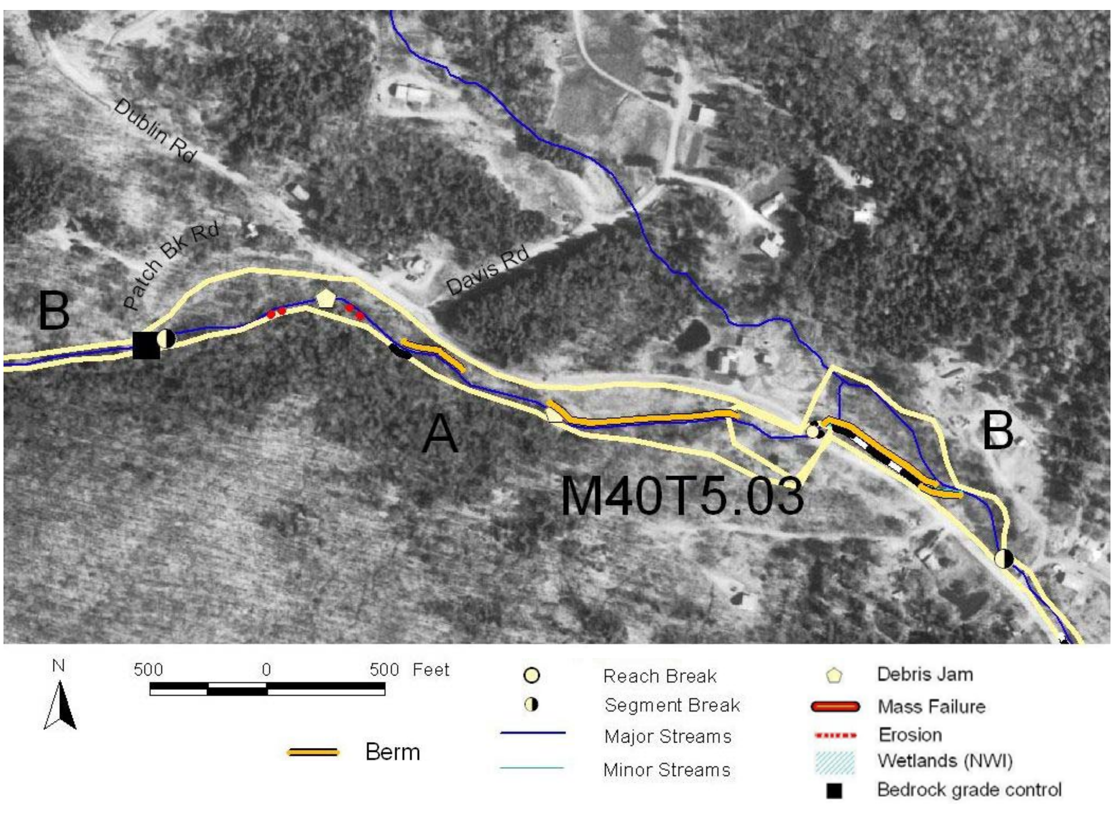


Figure 6. Features encountered along M40T5.03-A and upstream end of M40T5.02 (Segment B), 10 September 2009. (Pale yellow line indicates human-modified valley wall).

In downstream segment M40T5.02-B, the channel gradient begins to decrease, and a reduction in sediment transport capacity would be expected. Where this segment might ordinarily serve as a location for sediment attenuation, historic channelization, road encroachments and construction of berms have converted this segment to a transport-dominated condition. The channel has lost connection to the adjacent floodplain (in the LB corridor).

A similar incised and entrenched condition is evident in downstream segment M40T5.02-A. The Dublin Road and Tatro Road bridge crossings are undersized with respect to the bankfull width; stepped footers are evidence of historic incision affecting both structures. At present, the coarseness of bed and bank substrates, discrete sections of rip-rap armoring, and reasonably continuous tree buffers are moderating lateral adjustments in these segments along Dublin Road. They are not a significant source of sediments to downstream reaches. However, they remain highly susceptible to catastrophic erosion in a future flood due to the incised and entrenched nature of the channel cross section.

In reach M40T5.01, the Patch Brook pulls away from Dublin Road for approximately one half mile (Figure 7). Active widening and planform adjustments are more evident in Segments D and C which are severely to moderately incised, probably associated with historic channel management (straightening, flow diversion, mill dam impoundments). These reaches are producing sediment to downstream reaches as they adjust to build a new floodplain at a lower elevation. These segments presently have few encroachments. To the extent that floodplain-building channel adjustments can be supported through corridor protection strategies, over the long term these segments may offer some degree of sediment and flood attenuation upstream of the more densely populated lower segments in Tyson Furnace.

Within Segment B of M40T5.01, historic channel management (straightening, berming, armoring) and encroachments have resulted in a historically incised and entrenched channel. After the Patch Brook crosses under VT Route 100, it regains partial access to the floodplain, where the Brook has been known to jump its banks in past flood events. The landowner downstream of VT Route 100 has managed the channel and floodplain over the years, placing berms along the RB to prevent the channel from flowing out onto a cleared area.

Berms have also been constructed along reach M40 of the Black River main stem – at the confluence of Patch Brook and at the confluence of Tiny Pond Brook. These berms locally enhance the degree of channel entrenchment, in a reach that is historically moderately incised (IR_{RAF} = 1.85).

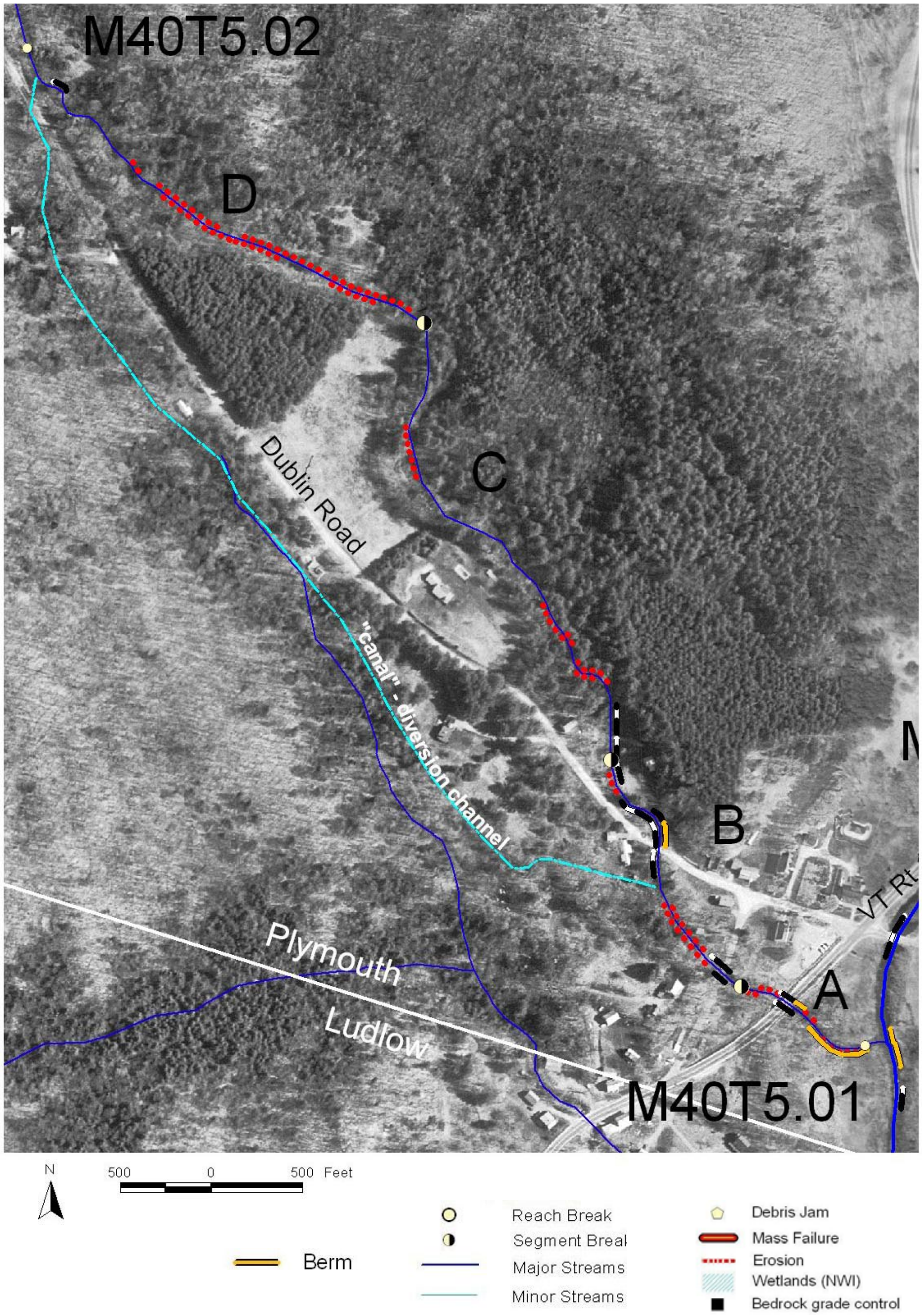


Figure 7. Diversion channel leading from the upstream end of reach M40T5.01 under Dublin Road, to the west of residential homes, and returning to the Patch Brook channel downstream of the Dublin Road bridge crossing.

3.2 Buffalo Brook and Reading Pond Brook

Buffalo Brook drains a 5.7-square-mile area east of Route 100 in the towns of Plymouth and Reading. The drainage divide at the headwaters for Buffalo Brook is defined by Mount Tom to the northeast, Blueberry Hill to the northwest, and Weaver Hill to the south. Reading Pond Brook is a major tributary to the Buffalo Brook, with its source near Reading Pond in the northeastern extent of the watershed. Reading Pond Brook drains a 2.9 square-mile area and joins the Buffalo Brook near the mid-point of the watershed.

The Buffalo Brook watershed is underlain by glacial till sediments, with isolated pockets of glaciofluvial sediments and alluvial sediments, particularly in the vicinity of Reading Pond. Bedrock controls the steep valley walls which closely confine the channels of Buffalo Brook and Reading Pond Brook for much of their length. Several outcroppings of bedrock were noted along the stream bed and banks during 2009 assessments.

Buffalo Brook joins the Black River at the eastern shore of Echo Lake. A total of eight reaches (5.6 miles) of the Buffalo Brook and Reading Pond Brook were assessed in 2009 (Figure 8). Results are summarized below in Table 2. Detailed reach narratives are presented in Appendix E.

3.2.1 Land Use and Channel Management History

Buffalo Brook watershed is approximately 94% forested and 1% residential. Much of the watershed is presently owned by the State of Vermont. There are a few private residences and camps accessed via Reading Pond Road. A sparse network of gravel forest roads and former skid trails provides recreational and logging access to the area, branching off the main roads (Reading Pond Road to the east and northeast, and Scout Camp Road to the west). Camp Plymouth State Park is developed along the eastern shore of Echo Lake near the confluence of Buffalo Brook.

By the early- to mid-1880s, it is likely that deforestation occurred across much of the watershed, consistent with statewide trends to support subsistence and sheep farming and the lumber industries (Thompson & Sorensen, 2000). More recent logging activity is suggested by a network of skidder trails and abandoned forest roads, as well as the relatively young age of some of the forest cover in the watershed.

Buffalo Brook and Reading Pond Brook watersheds were the location of extensive gold placer mining in the mid to late 1800s (Hitchcock *et al*, 1861; Child, 1884; Rutland Railroad Company, 1897; Smith, 1951; Ward, 1983). Reading Pond Brook and Buffalo Brook below its confluence were historically known as Gold Brook (Rutland Railroad Co., 1897; Hitchcock *et al*, 1861). Alluvial and glacial deposits of the river bed, banks and adjacent terraces were mined for gold flakes and nuggets. An 1859 map of the town of Plymouth (Scott, Stickney, & Pollard, publishers) indicates the extent of placer mining along the streams of Plymouth with a stippled pattern (Figure 9). Nearly the entire length of the Buffalo Brook and Reading Pond Brooks (as well as several tributaries) were mined for gold according to this historic map. In 1860 there were "seven companies at work on the Buffalo Brook…Miners take a lease on a certain number of lineal rods…along the stream with the right to dig in the 'dry' on either side… There are now sixteen dams." (Smith, 1951). Evidence of possible historic placer mining was observed in several reaches of the Buffalo and Reading Pond Brooks during 2009 assessments – including several breached earthen dams, decaying wooden platforms, and a few excavated depressions in stream terraces.

Mining of iron ore also occurred historically, on Weaver Hill at the southern extent of the Buffalo Brook watershed (Thompson, 1842; Beers, 1869). Ore was transported to the iron works at Tyson Furnace on the west side of Route 100.

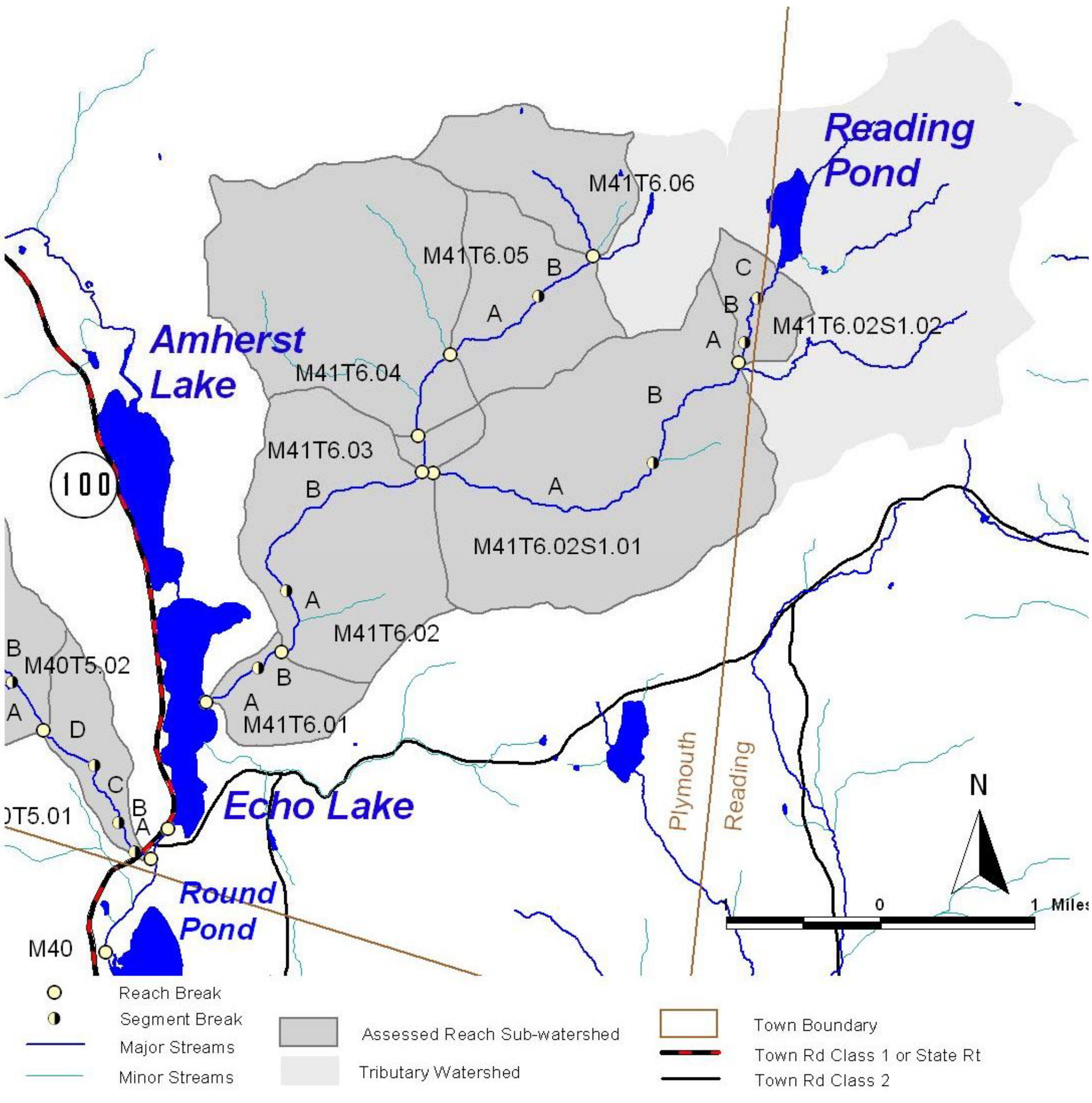


Figure 8. Location of Buffalo Brook and Reading Pond Brook reaches assessed in 2009.

Table 2. Results of Phase 2 Geomorphic Assessments, 2009.
Buffalo Brook reaches, including Reading Pond Brook tributary.

Buffalo Brook - Plymouth

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
M41T6.06	--	2,415	12.6	0.3	B1a-casc	Not Assessed - Bedrock Channel							Low
M41T6.05	B *	1,506	***8.0***		A1-casc	Not Assessed - Bedrock Channel							Low
	A	2,458	***4.5***	1.0	B4a-S/P	1.55[RAF]	55	0.74 Good	0.45 Fair	PF, Wid, Deg (hist)	IV [F]	No	High
M41T6.04	--	2,052	3.4	1.9	B3-S/P	1.0[RAF]	14.4	0.80 Good	0.70 Good	Minor (Hist Wid, PF)	IIc [D]	No	Moderate
M41T6.03	--	807	2.5	1.9	F4b-PB	2.4[RAF]	15.7	0.63 Fair	0.58 Fair	Min to mod PF; Hist incis	II [F]	Cb to Fb	Extreme
M41T6.02	B	5,083	***2.2***		F4b-PB	3.9[RAF]	26	0.69 Good	0.44 Fair	PF, min aggr; Hist incis, wid	II [F]	Cb to Fb	Extreme
	A *	1,556	***3.5***	5.6	B1-S/P	Not Assessed - Bedrock Channel							Low
M41T6.01	B *	649	***2.3***		C3b-PB	1.79[HEF]	19.4	0.55 Fair	0.69 Fair***	Minor aggrad; Hist incis	II [F]	None	Extreme **
	A	1,361	***1.4***	5.7	F4-R/P	2.75[RAF]	48.4	0.52 Fair	0.41 Fair	Mod aggr, wid, PF; Hist incis.	III [F]	C to F	Extreme

Reading Pond Brook - Reading, Plymouth

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
M41T6.02S1.02	C	765	***3.4***		F4b-PB	3.1 [RAF]	29.7	0.69 Good	0.46 Fair	Incis, Mod wid, PF.	II [F]	Cb to Fb	Extreme
	B	1,360	***2.2***		C4b-R/P	1.6 [RAF]	25.9	0.69 Good	0.50 Fair	PF, Min Aggr/Wid, Hist Incis	IV [F]	None	Very High
	A *	505	***4.0***	1.2	F3b-S/P	2.0 [RAF]	26.5	0.80 Good	0.49 Fair	Incis, Wid, PF; minor Aggr	III [F]	B to Fb	Extreme
M41T6.02S1.01	B	3,374	***5.3***		B3a-S/P	1.78 [RAF]	15.7	0.71 Good	0.36 Fair	Wid, Incis; aggr & PF (local)	III [F]	None	High
	A	5,564	***4.3***	2.9	F4a-PB	2.2 [RAF]	14.9	0.65 Good	0.40 Fair	Aggr, PF; Hist Wid & Incis	III [F]	Ba to Fa	Extreme

<u>Notes / Abbreviations:</u>

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.

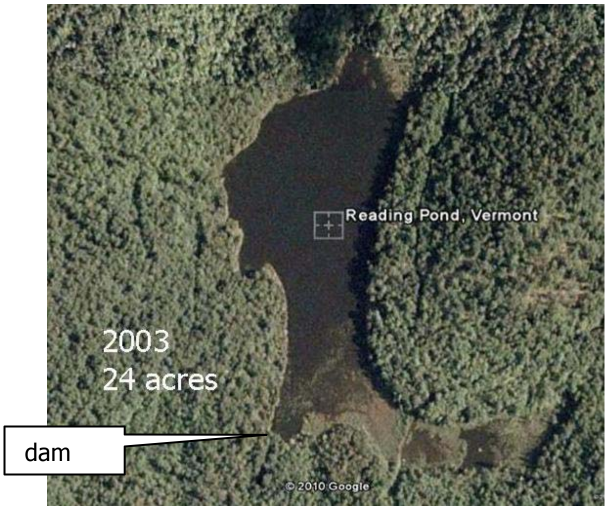
** Sensitivity overridden to higher value due to setting of marked decrease in valley gradient and confinement ("alluvial fan").

*** RGA condition rating overridden from Good to Fair, despite score of 0.69, due to human modifications (armoring, berming, straigtening) that have reduced functionality of the reach/floodplain and constrained the reach from adjusting toward a more natural form.

Figure 9. Excerpt from historic map showing location of gold placer mining in Buffalo Brook watershed. Source: Scott, Stickney & Pollard, publishers, 1859: Map of town of Plymouth. (Stippled pattern along river indicates location of gold placer mining).

At the headwaters of Buffalo Brook is Reading Pond. In the limited resources consulted for this study, little information was available about the history of this pond. Given the topographic setting and the nature of surficial sediments in the vicinity (mapped as glaciofluvial and alluvial), it is likely that this pond has a natural, post-glacial origin. However, in June 2006, a flood event resulted in the sudden breaching of a beaver dam at the downstream end of this pond, and revealed remnants of a stone and earthen dam. Thus, it is likely that the depth and aerial extent of this natural pond was enhanced by construction of an earthen and stone dam at some point in the past – possibly associated with the logging and/or gold mining history of the area. During field assessments, a second breached dam constructed of stone was located approximately 350 feet downstream of the main dam (see Appendix E). A stone foundation was located along the LB near this second dam, suggesting a possible mill history. No evidence of a mill or dam in this location was noted on the Beers Atlas of Windsor County (1869).

The sudden breaching of Reading Pond dam resulted in a significant volume of water being released to the Reading Pond Brook and lower reaches of the Buffalo Brook. As observed in September of 2009, the southern shore line of Reading Pond is now located more than 700 feet to the north of its former position. The aerial extent of this pond has been reduced by approximately 10 acres (Figures 10-a & -b). It is likely that volumes of fine and coarse sediments were released from behind the dam as the pond drained (Figures 10-c, 10-d, 10-e). Today, the southern extent of the former pond has begun to revegetate (Figure 10-f).



(a) Reading Pond prior to 2006 dam breach.

(b) Reading Pond after 2006 dam breach.

(c) breached dam, 22 June 2006 (Source: VTDEC).

(d) breached dam, 22 June 2006 (Source: VTDEC).

(e) view upstream from breached dam, 22 June 2006 (Source: VTDEC).

(f) view upstream from breached dam, 4 September 2009

Figure 10. Site of breached dam, Reading Pond, town of Reading.

3.2.2 Assessment Results

Generally speaking, the gradient of the Buffalo Brook decreases along the length of study, from 12.6% at the upper extent to 1.4% above the confluence with Echo Lake (Figure 11). The profile of the Reading Pond Brook is somewhat less steep, as this tributary channel originates near the Reading Pond where topography is gentler and a local accumulation of glaciofluvial deposits supported the formation of Reading Pond.

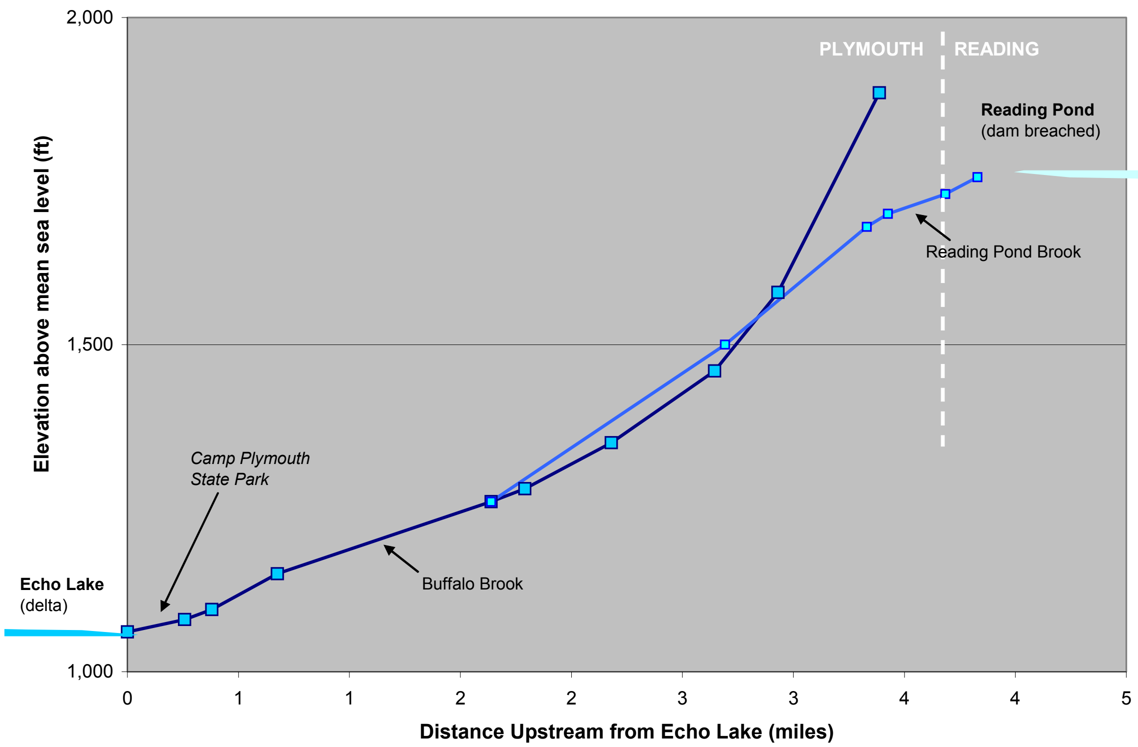


Figure 11. Longitudinal Profile of Buffalo Brook tributary.

The assessed reaches of Reading Pond Brook (downstream of Reading Pond) vary somewhat in their valley setting and reference stream type. From Reading Pond downstream to the Reading Pond Road culvert crossing (approximately 2100 feet), the channel is an unconfined, gravel–riffle/pool channel of moderate gradient (3.4 to 2.2%). Below the culvert crossing, this tributary transitions to a steep-gradient, cobble step/pool and cobble-cascade channel, semi-confined between extremely-steep, till-mantled bedrock valley walls. These upper reaches of Reading Pond Brook are exhibiting active incision in some locations, overprinted on historic (or post-glacial) incision, as well as system-wide planform adjustments and widening. Mass failures are prevalent within a mile downstream of the breached Reading Pond. Density of large woody debris is very high, with frequent channel-spanning debris jams or occasional boulder steps contributing to upstream sediment accumulation.

In contrast to the Reading Pond Brook, the upper 4,000 feet of Buffalo Brook is narrowly- to semi-confined between extremely-steep, bedrock controlled valley walls. Bedrock is exposed frequently in the channel bed and banks. These segments (M41T6.06, M41T6.05-B) are fairly stable, have good access to a very narrow floodplain, and have resistant boundary conditions (shallow bedrock) that moderate lateral adjustments. As gradients decrease in Segment M41T6.05-A, and M41T6.04, and a forest road (now abandoned) joins the narrow stream valley, a degree of historic (or post-glacial) incision below discontinuous stream terraces is evident, along with signs of moderate planform adjustment (flood chutes) and localized widening. Intermediate reach M41T6.04 is vertically and laterally stable. At reach M41T6.03, just above the confluence of Reading Pond Brook, there is a local accumulation of glaciofluvial sediments, and the channel has become historically (or post-glacially) entrenched below high terraces of unconsolidated sediments. Incision may reflect a tributary rejuvenation process extending upstream in the reach from historically-incised lower reaches of the Buffalo Brook.

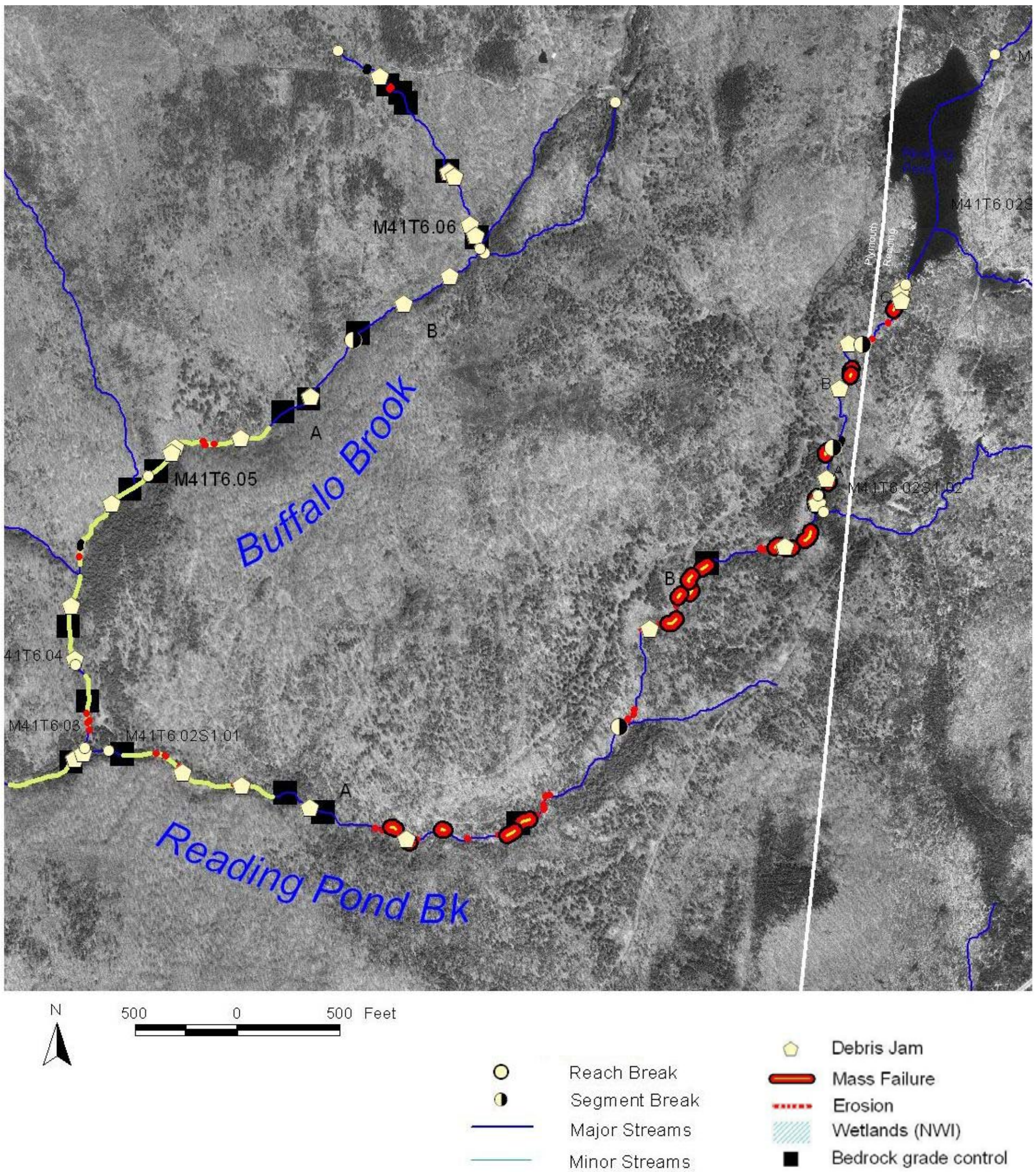


Figure 12. Observed features on upper reaches of Buffalo Brook and Reading Pond Brook. Pale green line indicates length of channel with abandoned forest road within one channel width to either side of stream.

Downstream of the confluence with Reading Pond Brook, the Buffalo Brook channel is characterized by historic (or post-glacial) incision, with localized aggradation, widening and planform adjustments (flood chutes, bifurcations) at sites of debris jams, or log steps. A forest road follows the channel for nearly the entire length down to a short bedrock gorge above Camp Plymouth State Park. Frequently, the channel has avulsed to erode a portion of the road bed or occupy the road as a flood chute during higher water. In this manner, the road bed has served as a source of sediments to downstream reaches (Figure 13).

Figure 13. View downstream, recent avulsion along the former path of the forest road in LB corridor, Segment B, M41T6.02, Buffalo Brook, 24 September 2009

At the lower extent of Buffalo Brook (where it flows through Camp Plymouth State Park), the gradient and valley confinement are notably less than in upper reaches. A decreased sediment transport capacity is expected due to the decreasing gradient on approach to the relatively fixed base level of Echo Lake. Where this segment / reach might ordinarily serve as a location for sediment attenuation, historic incision (channelization) and construction of berms and armoring of the channel have served to convert the upper end of reach M41T6.01 (Segment B) to a transport-dominated condition. Sediments are conveyed through the segment, under Scout Camp Road, to downstream Segment A.

Some lateral adjustments are occurring in the lower segment of M41T6.01 through the state park. A large sediment delta has accumulated – particularly since the June 2006 flood – in Echo Lake at the confluence of Buffalo Brook (Figure 14).

Figure 14. View downstream to delta of fine gravels and sands which extends out into Echo Lake from the mouth of Buffalo Brook, reach M41T6.01, Segment A, 7 August 2009. Kayak paddles mark approximate lateral extent of deposits.

4.0 DEPARTURE ANALYSIS, STRESSOR IDENTIFICATION & SENSITIVITY

Phase 1 and Phase 2 stream geomorphic assessments 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 (2007) 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 subject reach, T02.08, and its degree of departure from reference, or a pre-disturbed state.

4.1 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 4.1.1. Changes in sediment loading characteristics that influence sediment regime at both the watershed level and reach level are addressed in Section 4.1.2. 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 4.1.3 and 4.1.4). 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, 2007), 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".

4.1.1 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 Patch Brook and Buffalo Brook 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 3.

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. In the Patch Brook watershed (and likely in the Buffalo Brook watershed), lumber was harvested to produce charcoal to fuel the iron ore furnaces at Tyson village. Deforestation is inferred to have caused increased water and sediment loads to be mobilized from these watersheds. 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 Patch Brook and Buffalo Brook channel networks.

Table 3. Watershed Stressors, Assessed reaches of the Patch Brook and Buffalo Brook tributaries.

	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.
Gold Placer Mining	Localized Impacts on hydrologic regime expected related to potential impoundments and/or diversions	Changes in sediment regime expected related to excavations in the bed/banks, selective removal of larger clasts, and flow diversions and impoundments.
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 (0.0 to 4.0%) 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 (0.0 to 4.0%) are at or below the threshold of concern (5%) noted in VTANR guidance (11 July 2007).
Stormwater Inputs	**Localized increases** in hydrologic loading inferred due to road ditch and overland flow stormwater inputs.	**Localized increases** in sediment loading inferred due to road ditch and overland flow stormwater inputs.
Dams / Impoundments	Two dams are currently located immediately upstream of assessed reaches (one breached in June 2006). Present and 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.	Two dams are currently located immediately upstream of assessed reaches (one breached in June 2006). At present and historic dam sites, sediments may be trapped in impoundments and may have been released to downstream reaches upon dam breaching.
Diversions / Water Withdrawals	Unknown hydrological impacts of historic operation of flow diversions from Patch Brook along Dublin Road (reach M40T5.01) and possible historic diversion on Reading Pond Brook (reach M41T6.02S1.02).	**Minor** sediment regime impacts inferred from flow diversions from Patch Brook along Dublin Road (reach M40T5.01) and possible historic diversion on Reading Pond Brook (reach M41T6.02S1.02).
Loss of Wetlands	Neglible impacts to hydrologic regime as a result of conversion of wetlands (hydric soils). Very minor extent of mapped wetlands and hydric soils in the upstream watesheds of assessed reaches.	Neglible impacts to sediment regime as a result of conversion of wetlands (hydric soils). Very minor extent of mapped wetlands and hydric soils in the upstream watesheds of assessed reaches.
Crop Lands	Neglible impacts to hydrologic regime as a result of crop land uses. Less than 1% crop uses in the upstream watershed of assessed reaches.	Neglible impacts to sediment regime as a result of crop land uses. Less than 1% crop uses in the upstream watershed of assessed reaches.

Gold Placer Mining

As previously noted, Buffalo Brook and Reading Pond Brook watersheds were the location of extensive gold placer mining in the mid to late 1800s (Hitchcock *et al*, 1861; Child, 1884; Rutland Railroad Company, 1897; Smith, 1951; Ward, 1983). Gold placer mining involved a number of practices which could lead to destabilization of the channel (Madison, 1981), such as:

- Diversion of stream water into a network of wooden sluiceways to wash sediments and separate out the heavier gold flakes and nuggets;
- Damming of the channel to support diversion of water into the sluiceways;
- Excavation of channel bed, banks and adjacent terraces to mine the sediments for gold;
- Selective removal of larger boulders/ cobbles from the stream bed to facilitate excavations, resulting in an overall decreased size of bed materials; and
- Extensive sediment yields (and increased turbidity) to downstream reaches as a result of sluice operations and/or hydraulic mining.

A description of the gold mining methods in Plymouth is provided in *Report on the Geology of Vermont* (Hitchcock, *et al*, 1861, pp. 845-847) and *The Plymouth Gold Rush* published in Vermont Life magazine (Smith, 1951). Several historic photographs (copyrighted) of gold mining in the Plymouth area are available for viewing at the Perkins Landscape Change web site.

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. 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 of SMRC, 2009). These flood events would have episodically increased flows and sediment loading in the channels of the Black River watershed.

Recent trends indicate an increased frequency of larger floods. 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 19th century (UNH Climate Change Research Center, 2005).

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 of the Patch Brook and Buffalo Brook have urbanized land percentages ranging from approximately 0.0 to 4.0% (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 Patch Brook and Buffalo Brook tributaries.

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.

The upper reaches of both Patch Brook and Buffalo Brook watersheds contain a network of gravel roads and trails that have been used in the past to access logging operations (and possibly mining operations) and are presently used for recreational and residential access. In the Buffalo Brook watershed a network of abandoned roads closely follows the channel in many reaches and has facilitated channel avulsions and lead to increased sediment runoff to the channel.

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), and points of concentrated runoff from overland flow. 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. Each of the assessed reaches of the Patch Brook and Buffalo Brook watersheds has an upstream drainage areas less than 15 square miles. Several reaches had numerous stormwater inputs:

- In the Patch Brook watershed, reach M40T5.03 of shares a narrow, steep valley with the gravel Patch Brook Road. Road ditches were prevalent along the uphill (north) side of the road. These ditches receive not only shtormwater runoff but also tributary drainage off slopes to the north. At least 21 cross culverts were indexed along a channel length of 1.4 miles. Often, fine sand and gravels obstructed culvert inlets and culvert outlets were unstable (no headers). Road sediment was observed directly entering the channel at the outlet of several culverts. A few additional locations of direct sediment runoff by overland flow were indexed along the reach. No turn-outs or check dams were observed along the road ditches, although it should be noted that physical space to install and maintain such structures is limited in this narrow valley.

Figure 15. Examples of stormwater inputs to the Patch Brook reach M40T5.03 Segment B; 29 October 2009

- In the Buffalo Brook watershed, an abandoned road network shares a narrow valley with the stream channel in several reaches of the Buffalo Brook and Reading Pond Brook. In some locations evidence of the road has been eroded away as the stream has avulsed to flow in the path of the road. In other locations, the former road grade has been eroded to form a flood chute (Figure 16). As stormwater flows are concentrated along the road grade, sediments are eroded, and "sunken road" segments, or "dug-ways", have been created (see previous Figure 13).

Figure 16. View downstream, river crossing old road bed, which now functions as a flood chute during higher-flow conditions upstream of the crossing, Segment A, reach M41T6.05, Buffalo Brook, 22 October 2009

Dams / Impoundments

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).

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).

There are no existing dams/ impoundments on assessed reaches of the Patch Brook and Buffalo Brook tributaries. However, nearby dams /impoundments have influenced the base levels and sediment transport characteristics of these tributary channels to varying degrees.

- Lake Ninevah (tributary to Patch Brook: M40T5.03S1.02)
  This earthen dam is owned by Wilderness Corporation who purchased it from CVPS in 1984. The current purpose of the dam is recreational (VT Dam Inventory). The original purpose of the dam was noted as hydroelectric; former owner, Central Vermont Public Service, "used the dam as a storage reservoir to augment flows in the Black River for its Cavendish hydroelectric project" (VTDEC, 2005). The dam was reportedly installed in 1930 (VT Dam Inventory) on the

approximate site of a former dam (perhaps breached in the 1927 flood). A dam appears at this location on the 1869 Beers Atlas (with the impoundment labeled as "Spathic Iron Co.") as well as the 1893 topographic map (with the impoundment noted as "Patch's Pond"). The approximate aerial extent of Lake Ninevah is published as 237 acres; maximum depth is 12 feet; and the upstream drainage area of 1.2 square miles (VTDEC, 2005). This operates as a run-of-river dam. In the 1980s and early 1990s, the lake was customarily drawn down in the winter months (October through May) by 3 to 4 feet by draining lake waters through a sluiceway over a period of approximately 2 weeks. In later years the amount of drawdown was reduced to approximately 6 inches. Following a June 2004 order from the VT Agency of Natural Resources, artificial drawdowns of the lake were discontinued for the sake of in-lake aquatic habitats (VTDEC, 2004). Past breaching events, and artificial drawdowns of lake levels in the 1980s to early 1990s, would have caused event-based increases in flow that would enhance the transport function of the Lake Ninevah outlet channel and Patch Brook downstream of the Lake. It appears that the natural boundary conditions of these channels (bedrock, large boulders, forested buffers) were sufficient to moderate lateral or vertical adjustments for at least 1.7 miles downstream. Increased erosional energies may have been translated to downstream reaches of the Patch Brook along Dublin Road.

- <u>Reading Pond</u> (Reading Pond Brook: M41T6.02S1.03)
  This is a high-elevation, 22-acre pond (VTDEC, no date) at the headwaters of Buffalo Brook which drains to Echo Lake. In the limited resources consulted for this study, little information was available about the history of this pond. Given the topographic setting and the nature of surficial sediments in the vicinity (mapped as glaciofluvial and alluvial), it is likely that this pond has a natural, post-glacial origin. However, in June 2006, a flood event resulted in the sudden breaching of a beaver dam at the downstream end of this pond, and revealed remnants of a stone and earthen dam. Thus, it is likely that the depth and aerial extent of this natural pond was enhanced by construction of an earthen and stone dam at some point in the past. Construction of this historic dam may have contributed to downstream incision due to "hungry water" effects, depending on the nature of operations. Breaching of this dam in June 2006 resulted in the sudden release of water and sediment that has apparently contributed to active channel adjustments in at least 1.1 miles of the Reading Pond Brook channel downstream of the Pond.

- <u>Amherst Lake</u> (Black River: M42)
  This lake is approximately 81 acres in area (VTDEC, no date) and represents an impounded reach of the Black River. Water is impounded behind a concrete gravity dam on a bedrock and soil foundation, which is presently owned by Lakeside Associates, Inc. This dam was constructed by Central Vermont Public Service in 1950 (VT Dam Inventory) to replace a timber crib dam (Haybrook, 1953). A photograph in *A Plymouth Album* (Ward, 1983) depicts a horse and buggy on a timber bridge over a dam at the "Interlock Amherst and Echo, Tyson, VT". A saw mill and grist mill were noted at the approximate location of this dam on the Beers Atlas of Windsor County (1869). Prior to 1886, this lake was known as Upper Plymouth Pond. The historic red mill was located near the dam and contained three water wheels for grinding corn, wheat, and oats (Greene, 1997). Historic regulation of flows from Amherst Lake (or past breaching events) would affect, to some degree, the surface elevation of Echo Lake, which is the local base level for Buffalo Brook.

- <u>Echo Lake</u> (Black River: M41)
  This is a natural water body approximately 104 acres in area (VTDEC no date). Prior to the late 1800s, this lake was known as the Lower Plymouth Pond, or Tyson Pond, and once "provided waterpower for the mills in [Tyson] village" (Greene, 1997). A 1953 study indicates that the discharge capacity of the Echo Lake outlet is substantially less than that of the Lake Amherst

dam, so that the level of Echo Lake rises faster in a flood than does the level of Lake Amherst (Haybrook, 1953). Observations reported to the Vermont Department of Water Resources by Central Vermont Public Service in August of 1973 indicate that during the flood of July 1973, Lake Amherst rose to approximately 94 inches over the crest of the dam…[and] that Lake Echo had backed up into Amherst Dam. Leveling from an existing high water mark on the north shore of Lake Echo, [they] were able to determine that Echo's level was approximately 4 – 5 inches higher than Amherst's level" (Graham, 1973). While an exact accounting of historic lake levels is not available, it is likely that historic (and post-glacial) fluctuations in the elevation of Echo Lake have contributed to historic aggradation and historic incision in the lowest reach of Buffalo Brook. Today, the net result of post-glacial and historic channel adjustments is a partially incised and entrenched channel near the mouth of Buffalo Brook.

- Lake Rescue (Black River: M39)
  Lake Rescue is approximately 180 acres in area. This natural pond was reportedly "raised some 8 feet by an embankment and dam built by one of the woolen mill companies of Ludlow" (Gay, 1927). During the flood of 1927, "40 ft of the embankment at Lake Rescue, near the Plymouth line, broke away" and a wall of water moved downstream through Ludlow (Gay, 1927). According to the VT Dam Inventory, the town of Ludlow is listed as the current owner of this earth, concrete and stone dam constructed on a bedrock and soil foundation. The dam was refurbished in 1977 following damages sustained in the floods of 1976 and 1973 (Dufresne & Henry, 1994). Lake Rescue includes a small embayment at the northern end known as Round Pond. Historic regulation of lake levels, past breaching events, and past flood events would influence the surface elevation of Lake Rescue (Round Pond) which serves as the local base level for the short reach of Black River connecting Echo Lake to Round Pound and receiving Patch Brook. While it is unlikely that fluctuations of Lake Rescue surface elevations have directly caused significant vertical adjustments within the lower Patch Brook channel, the impact of such fluctuations on the Black River channel may have indirectly lead to vertical adjustments in the Patch Brook. Today, the net result of post-glacial and historic channel adjustments is a partially incised and entrenched channel in the Black River (reach M40) and lower reaches of the Patch Brook.

Several historic dams were present on the Buffalo Brook and Patch Brook tributaries. 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, 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.

Two diversion sites were noted on the assessed reaches:

- Patch Brook reach M40T5.04
  Within Segment C is a small flow diversion consisting of a 4-inch black flex hose leading from the channel to a nearby impoundment. The intake in the channel is a PVC pipe connected by a Fernco™ fitting to a flexible hose. The hose was traced through the woods to a narrow pond impounded by a horse-shoe shaped earthen dam approximately 8 feet high and 270 feet long. A culvert was located at the downstream end of the pond and apparently drains the pond. Matted vegetation patterns indicated that the pond had overtopped the dam crest in a few locations east of the culvert outlet, in days prior to the assessment date. The exact outlet location of the culvert could not be located, although seepage was evident at the base of the dam along a majority of its length. A return channel joins the main Patch Brook channel approximately 650 feet downstream of the intake location.

- Patch Brook reach M40T5.01
  Near the upper end of Segment D, a small bypass channel has been constructed historically to convey a portion of the flow from Patch Brook to a culvert under Dublin Road and into a constructed channel that flows somewhat parallel to Patch Brook, but on the far side of residential homes to the west of Dublin Road. This "canal", as it is known locally, returns to the Patch Brook approximately 3,000 feet downstream in Segment B. This diversion channel was constructed historically to support operations at Tyson Furnace (Scott, Stickney, & Pollard, 1859). (See Figure 9, Section 3.1.2).

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 more recent channel adjustments.

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 or to support residential land uses. 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.

Conversion of wetlands in the Patch and Buffalo Brook watersheds is not expected to be a significant watershed stressor. The aerial extent of mapped wetlands and hydric soils is minor in the study area.

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 Patch Brook and Buffalo Brook is negligible (less than 1%) and less than the threshold (5%) considered to be of significance in VTANR guidance (2007b).

4.1.2 Sediment Regime Stressors (Watershed and Reach Scale)

Sediment regime stressors for the assessed reaches are summarized in Table 3 (Watershed Level Stressors) and in 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 Patch Brook channel, three segments show a relatively high density of depositional and planform migration features:

- Segment M40T5.04-D where the channel transitions from upstream semi-confined sections of steeper gradient, to a lesser confinement and gradient.

- Segment M40T5.04-C where channel gradient continues to decrease (i.e., reduced sediment transport capacity) and which may be influenced by a flow diversion.

- Segment M40T5.04-B where the channel gradient continues to decrease on approach to a wetland-dominated downstream segment.

In the Buffalo Brook watershed, five segments show a relatively high density of depositional and planform migration features:

- Segment M41T6.02-B where the channel transitions to a slightly less-confined, and lower-gradient setting. Increased deposition and lateral adjustments in this segment may also be related to increased sediment production in upstream reaches of the Reading Pond Brook tributary.

- Segment M41T6.01-A where the valley gradient has decreased substantially at the base of Semi-confined, steeper-gradient reaches, on approach to the fixed base level of Echo Lake.

- Segment M41T6.02S1.02-B (Reading Pond Brook) which is a location of reduced valley gradient downstream of an actively incising segment (S1.02-A).

- Segments M41T6.02S1.01-B and S1.01-A (Reading Pond Brook) which are Semi-confined, steep-gradient reaches undergoing active lateral and vertical adjustments (including substantial mass wasting) in response to June 2006 flooding impacts.

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 coarse-grained bank sediments, occasional lateral bedrock grade controls, and forested buffers. Through the village area in the lower Patch Brook watershed, 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:

- Patch Brook segments M40T5.01-D, and -C;

- Reading Pond Brook segments M41T6.02S1.02-A, and S1.01-B which have been impacted by the sudden breaching of Reading Pond in June 2006; and

- Buffalo Brook segment M40T6.01-A in the Camp Plymouth State Park, where increased sedimentation since the June 2006 flood has lead to lateral adjustments.

Mass wasting and gully sites or rejuvenating tributaries

Several mass wasting sites and rejuvenating tributaries were identified on Reading Pond Brook segments M41T6.02S1.02-A, and S1.01-B which have been impacted by the sudden breaching of Reading Pond in June 2006 (See previous Figure 12).

4.1.3 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-3 (in Appendix F) present a summary of the reach-scale modifiers catalogued for the assessed reaches, 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.

4.1.4 Sediment Regime Departure, Constraints to Sediment Transport & Attenuation

Within a given reach, the watershed-level and reach-level flow and sediment load modifications, combined with the reach-scale modifiers of stream power and boundary resistance, together 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-3) in Appendix G summarize the apparent status of the assessed reaches as either transport- or attenuation-dominated. These tables also indicate the natural constraints (e.g., bedrock) and human constraints (e.g., roads, development, land uses) 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 and the steepness of gradient that is typical for reaches of this type. 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). Three of the assessed channel segments were classified as bedrock channels (M41T6.06, M41T6.05-B and M41T6.02-A). 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 river network (over recent history).

Nine 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 these reaches results in a Semi-confined status and governs the transport-dominated condition (M40T5.04-E, M40T5.03S1.01, M40T5.03-B, M40T5.02-A in the Patch Brook watershed; M41T6.05-A, M41T6.04, M41T6.02S1.02-A, M41T6.02S1.01-B, and M41T6.02S1.01-A in the Buffalo Brook watershed).

Three segments are located in unconfined, low- to moderate-gradient (<2%) valley settings, and contain few or no channel-spanning exposures of bedrock (M40T5.04-B, M40, and M41T6.01-A). Under dynamic equilibrium conditions these (reference C stream type) segments 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.

The remaining fourteen segments are transitional between upstream bedrock-controlled, confined channels and downstream, lower-gradient, unconfined settings. They are generally unconfined by valley walls, but have moderate to steep slopes (2.2% to 5.1%) - reference Ca or Cb stream types. Due to the relaxed valley confinement, these fourteen segments are expected to represent locations of increased lateral migration. Depending on the gradient these fourteen segments are expected to represent locations of decreased sediment transport capacity (to varying degrees) and to be natural attenuation-dominated segments. Six segments 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). Segments M40T5.03-A, M40T5.01-B, and M40T5.01-A in the Patch Brook watershed and M41T6.03, M41T6.01-B, and M41T6.01-A in the Buffalo Brook watershed 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 widespread deforestation of upland slopes in the 1800s (Bierman *et al*, 1997).

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-3, 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); and
- corridor development (residential, commercial, municipal – particularly in the historic village area of Tyson Furnace).

Only a few segments in the Patch Brook watershed (and none in the Buffalo Brook watershed) have reasonable or partial access to the floodplain (IR < 1.4), and (where presently unconstrained by human-constructed features) may represent key attenuation assets:

- M40T5.04-D, M40T5.04-B, and M40T5.01-C in the Patch Brook.

The current geomorphic condition of these reaches/segments, as modified by human factors, is summarized in the following Sediment Regime Departure Maps in Figures 17 and 18. These classifications are based on guidance contained in the VTANR River Corridor Planning Guide (2007).

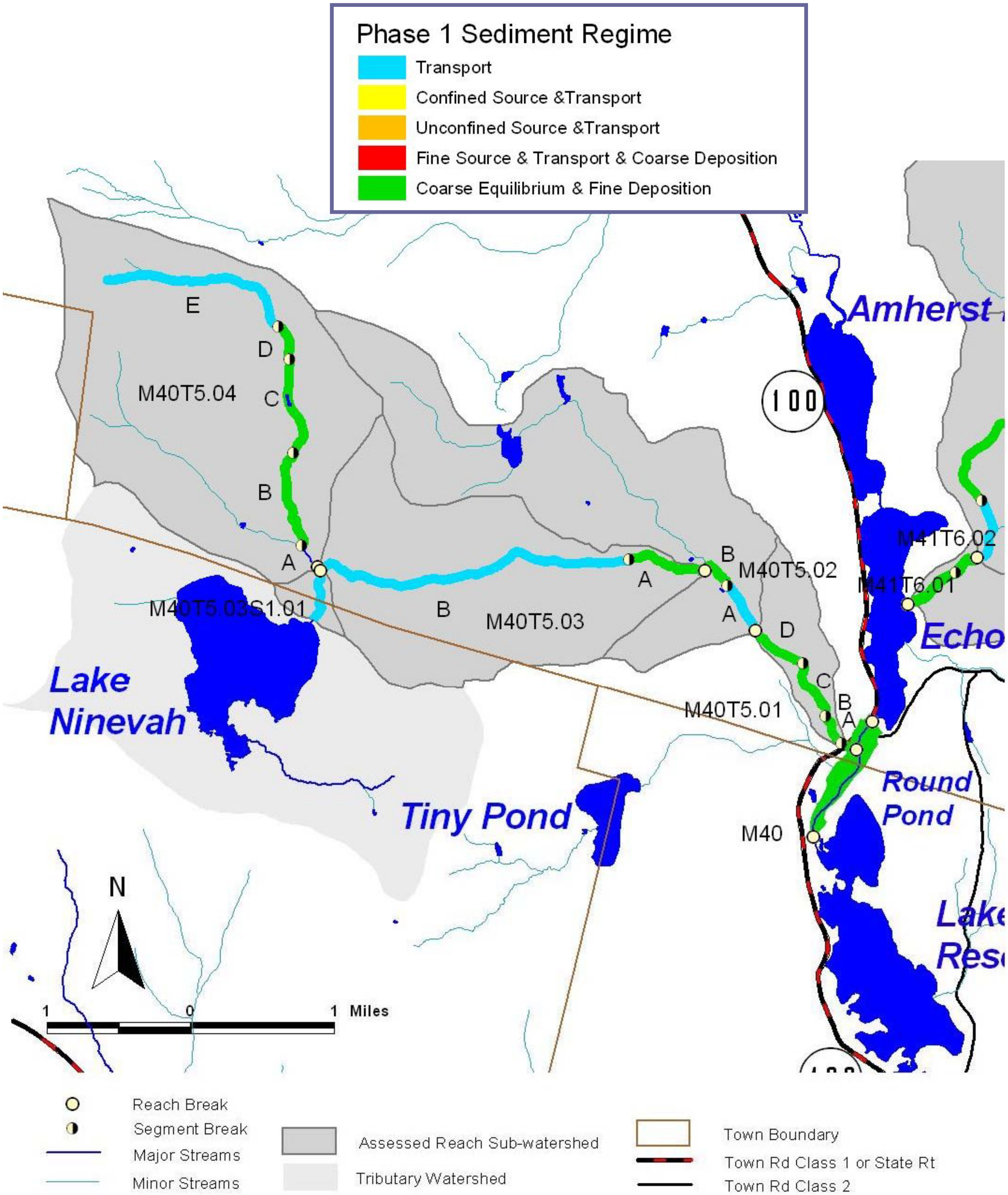


Figure 17-a. Phase 1 (Reference) Sediment Regime Map
Assessed Reaches of the Patch Brook & Black River main stem.

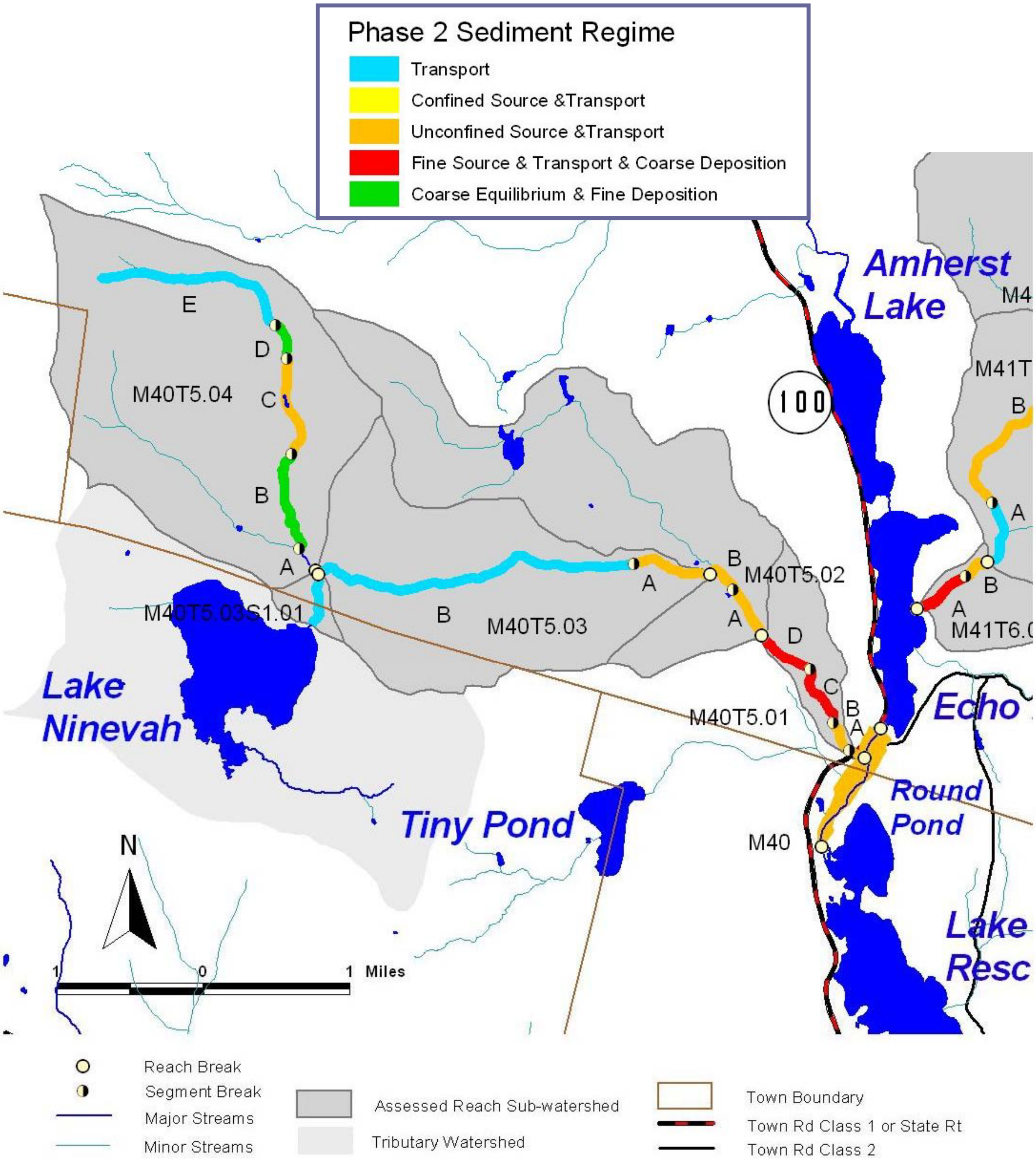


Figure 17-b. Phase 2 (Existing) Sediment Regime Map
Assessed Reaches of the Patch Brook & Black River main stem.

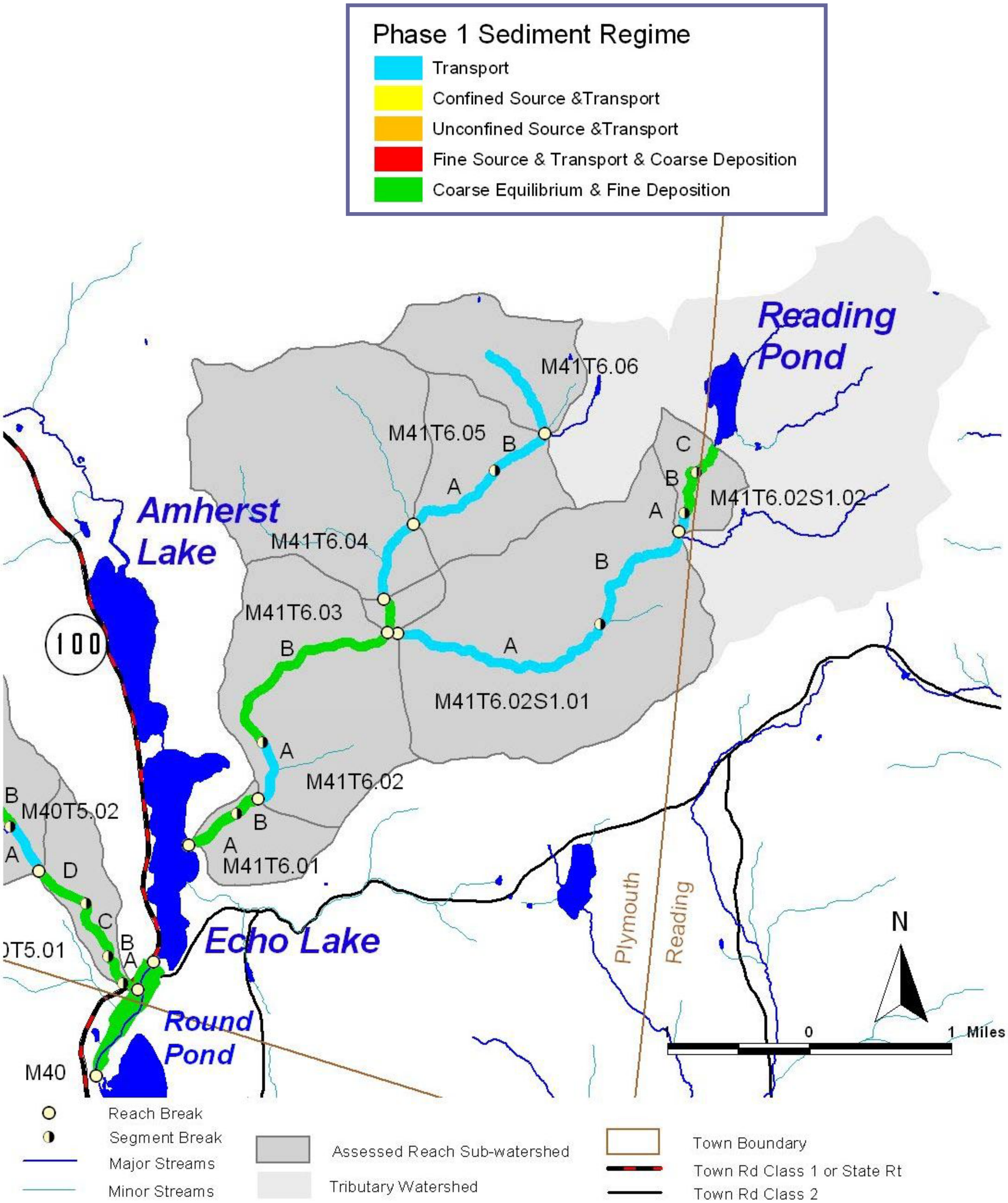


Figure 18-a. Phase 1 (Reference) Sediment Regime Map
Assessed Reaches of the Buffalo Brook and Reading Pond Brook.

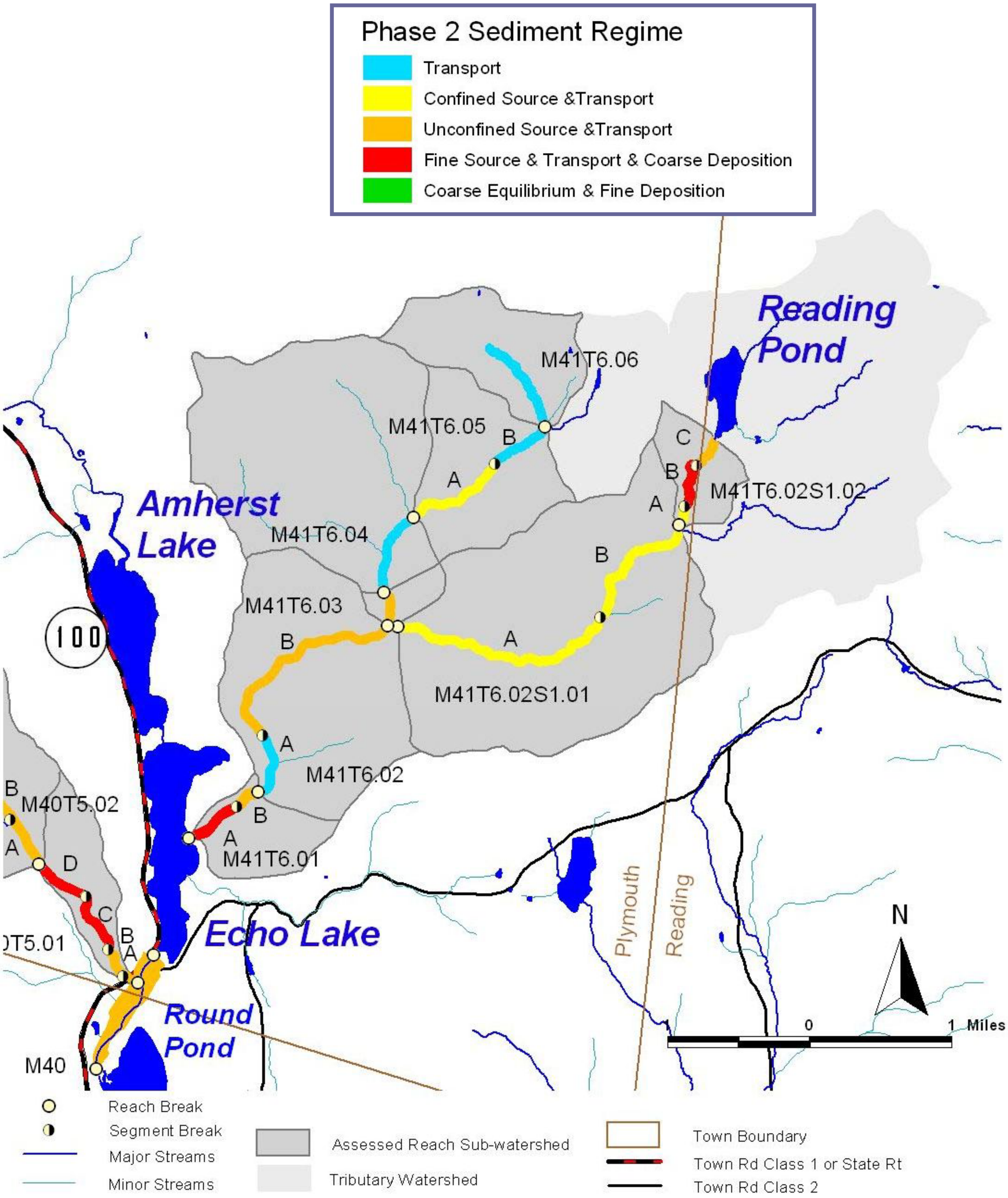


Figure 18-b. Phase 2 (Existing) Sediment Regime Map
Assessed Reaches of the Buffalo Brook and Reading Pond Brook.

Phase 1 (Reference) Sediment Regime

Figures 17-a and 18-a display the ***reference*** sediment regimes that are theorized to be characteristic of the assessed reaches of Patch Brook and Buffalo Brook (respectively) prior to widespread human disturbance of the watershed (approximately, 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
Buffalo Brook	M41T6.06	B1a-cascade
Buffalo Brook	M41T6.05-B	A1-cascade
Buffalo Brook	M41T6.02-A	B1-step/pool

Nine additional segments, while not characterized by fully-exposed bedrock in the channel bed and banks, are confined by steep, bedrock-controlled valley walls. The natural steepness of the channel gradient and close valley confinement results in a somewhat linear planform with limited available floodplain or meanders for storage of sediment. Also, the erosion resistance offered by the occasional exposures of bedrock in the channel boundaries, as well as forested buffers, means that these channels 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
Patch Brook	M40T5.04-E	B4a-cascade
Lake Ninevah outlet	M40T5.03S1.01	B3-step/pool
Patch Brook	M40T5.03-B	B3a-step/pool
Patch Brook	M40T5.02-A	B4-step/pool
Buffalo Brook	M41T6.05-A	B4a-step/pool
Buffalo Brook	M41T6.04	B3-step/pool
Reading Pond Brook	M41T6.02S1.02-A	B3-step/pool
Reading Pond Brook	M41T6.02S1.01-B	B3a-step/pool
Reading Pond Brook	M41T6.02S1.01-A	B4a-step/pool

Coarse Equilibrium & Fine Deposition (coded green in figures)
Between these bedrock and transport reaches, the Patch Brook, Buffalo Brook and Reading Pond Brook tributary channels are less confined by the valley walls, and have a generally lesser gradient. Pockets of floodplain are available to most of these segments – either as terraces within Narrow to Semi-confined valley walls – or (in the case of M41T6.01 and M40T5.01 and M41T6.03) as a broader floodplain surface at an alluvial-fan-like setting. Theoretically, in a pre-disturbed condition, these channels would be connected to their surrounding floodplains. Fine sediments would be deposited through periodic overbank 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.

Phase 2 (Existing) Sediment Regime

Figures 17-b and 18-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 bedrock-channel segments and some of the semi-confined segments of the Patch Brook and Buffalo Brook 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, and they have not undergone a sediment regime departure.

Tributary	Reach/Segment	Phase 1 Reference Stream Type	Phase 2 Reference Stream Type
Patch Brook	M40T5.04-E	B4a-cascade	B4a-cascade
Lake Ninevah outlet	M40T5.03S1.01	B3-step/pool	B3-step/pool
Patch Brook	M40T5.03-B	B3a-step/pool	B3a-step/pool
Buffalo Brook	M41T6.06	B1a-cascade	B1a-cascade
Buffalo Brook	M41T6.05-B	A1-cascade	A1-cascade
Buffalo Brook	M41T6.04	B3-step/pool	B3-step/pool
Buffalo Brook	M41T6.02-A	B1-step/pool	B1-step/pool

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
Patch Brook	M40T5.04-D	C4a-riffle/pool	C4a-riffle/pool
Patch Brook	M40T5.04-B	C4-riffle/pool	C4-riffle/pool

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. These segments were identified as sediment attenuation assets (see Section 4.1.4 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 (sometimes 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 Patch Brook and Buffalo Brook tributaries:

Confined Source & Transport (coded yellow in figures)

Four (4) of the assessed segments are classified in this category (listed below). Each were inferred to have undergone a sediment regime departure from *Transport* category to *Confined Source & Transport* by virtue of a moderate to severe degree of channel incision (IR_{RAF} values ranging from 1.5 to 2.2). For two of the four segments, incision has lead to a vertical stream type departure (highlighted in yellow, below).

In the case of the Buffalo Brook segment (M41T6.05-A), incision is regarded as historic and may be related to historic logging activities and/or gold placer mining in the watershed. Along the Reading Pond Brook segments, there is evidence of both active and historic incision. Active incision is likely related to the flood of June 2006 and the sudden breaching of the Reading Pond dam. Whereas, historic incision is probably related to a history of gold placer mining which involved direct manipulation of the channel and close floodplain including gravel mining, earthen dams, short channel diversions, and selective removal of larger boulders/cobbles. It is likely that there is some degree of postglacial incision recorded in the moderate-height terraces along the channel floodplain. Surficial geologic studies to ascertain the origin, age and composition of the stream terraces was beyond the scope of this stream geomorphic assessment.

Tributary	Reach/Segment	Phase 1 Reference Stream Type	Phase 2 Reference Stream Type
Buffalo Brook	M41T6.05-A	B4a-step/pool	B4a-step/pool
Reading Pond Brook	M41T6.02S1.02-A	B3-step/pool	F3b-step/pool
Reading Pond Brook	M41T6.02S1.01-B	B3a-step/pool	B3a-step/pool
Reading Pond Brook	M41T6.02S1.01-A	B4a-step/pool	F4a-plane bed

Unconfined Source & Transport (coded orange in figures)

Eleven (11) of the assessed reaches/segments are classified in this category (listed below). Due to the vertical stream type departure (C-to-F or Ca-to-Fa or Cb-to-Fb) of eight segments and loss of floodplain connection (IR_{RAF} values ranging from 1.5 to 4.2) in all eleven segments, these channels have been converted from a deposition-dominated condition 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, windrowing, gravel mining, armoring, and/or berming. Following flood episodes, select segments have been managed (through continued channelization and berming) to maintain a transport-dominated function. Presence of historic dams along the Patch Brook and Buffalo Brook tributaries 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.

Plane-bed and weak step/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
Patch Brook	M40T5.04-C	C4b-step/pool	C4b-step/pool
Patch Brook	M40T5.03-A	C3a-step/pool	F3a-plane bed
Patch Brook	M40T5.02-B	C3b-step/pool	F3b-plane bed
Patch Brook	M40T5.02-A	B4-step/pool	B4-plane bed
Patch Brook	M40T5.01-B	C3b-step/pool	F3b-plane bed
Patch Brook	M40T5.01-A	C3b-riffle/pool	C3b-step/pool
Black River main stem	M40	C3-riffle/pool	C3-plane bed
Buffalo Brook	M41T6.03	C4b-step/pool	F4b-plane bed
Buffalo Brook	M41T6.02-B	C3b-step/pool	F4b-plane bed
Buffalo Brook	M41T6.01-B	C3b-riffle/pool	C3b-plane bed
Reading Pond Brook	M41T6.02S1.02-C	C4b-riffle/pool	F4b-plane bed

Fine Source & Transport / Coarse Deposition (coded red in figures)

Four of the assessed segments of Patch Brook and Buffalo Brook tributaries were classified in this category. These segments are moderately to substantially incised (IR_{RAF} values ranging from 1.4 to 2.8). Two of these four segments have undergone a vertical stream type departure (C-to-F or Cb-to-Fb). This sediment regime category includes segments classified in stage III [F] or IV [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, and (2) the presence of more erodible sediments in the channel boundaries. Historic and active widening and planform adjustments (flood chutes, bifurcations, meander extension) have begun to create narrow, discontinuous pockets of floodplain at an elevation below the recently abandoned floodplain in some segments. Well-developed tree buffers are frequently present along both banks of these segments and 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 locally 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 20 to 48). 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, debris jams). 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
Patch Brook	M40T5.01-D	C3b-step/pool	F3b-plane bed
Patch Brook	M40T5.01-C	C3b-step/pool	C3b-plane bed
Buffalo Brook	M41T6.01-A	C4-riffle/pool	F4-riffle/pool
Reading Pond Brook	M41T6.02S1.02-B	C4b-riffle/pool	C4b-riffle/pool

4.2 Sensitivity Analysis

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 (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).

Figure 19 and 20, respectively, illustrate the sensitivity classifications assigned to Patch Brook and Buffalo Brook reaches. These stream sensitivity data were utilized during subsequent planning steps to inform the identification and prioritization of restoration and protection projects and practices (Section 5).

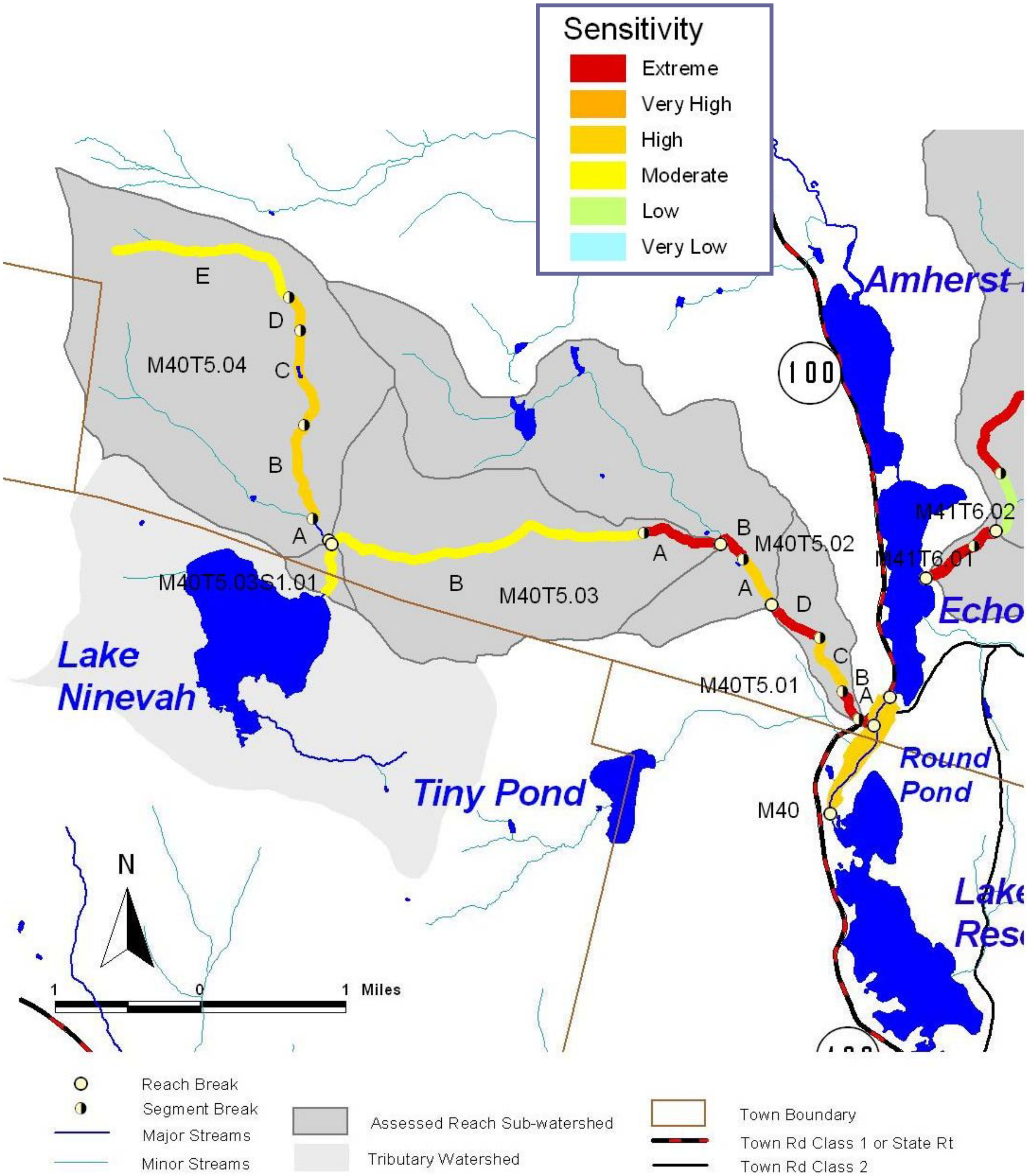


Figure 19. Stream Sensitivity Map
Assessed Reaches of the Patch Brook and Black River Main Stem.

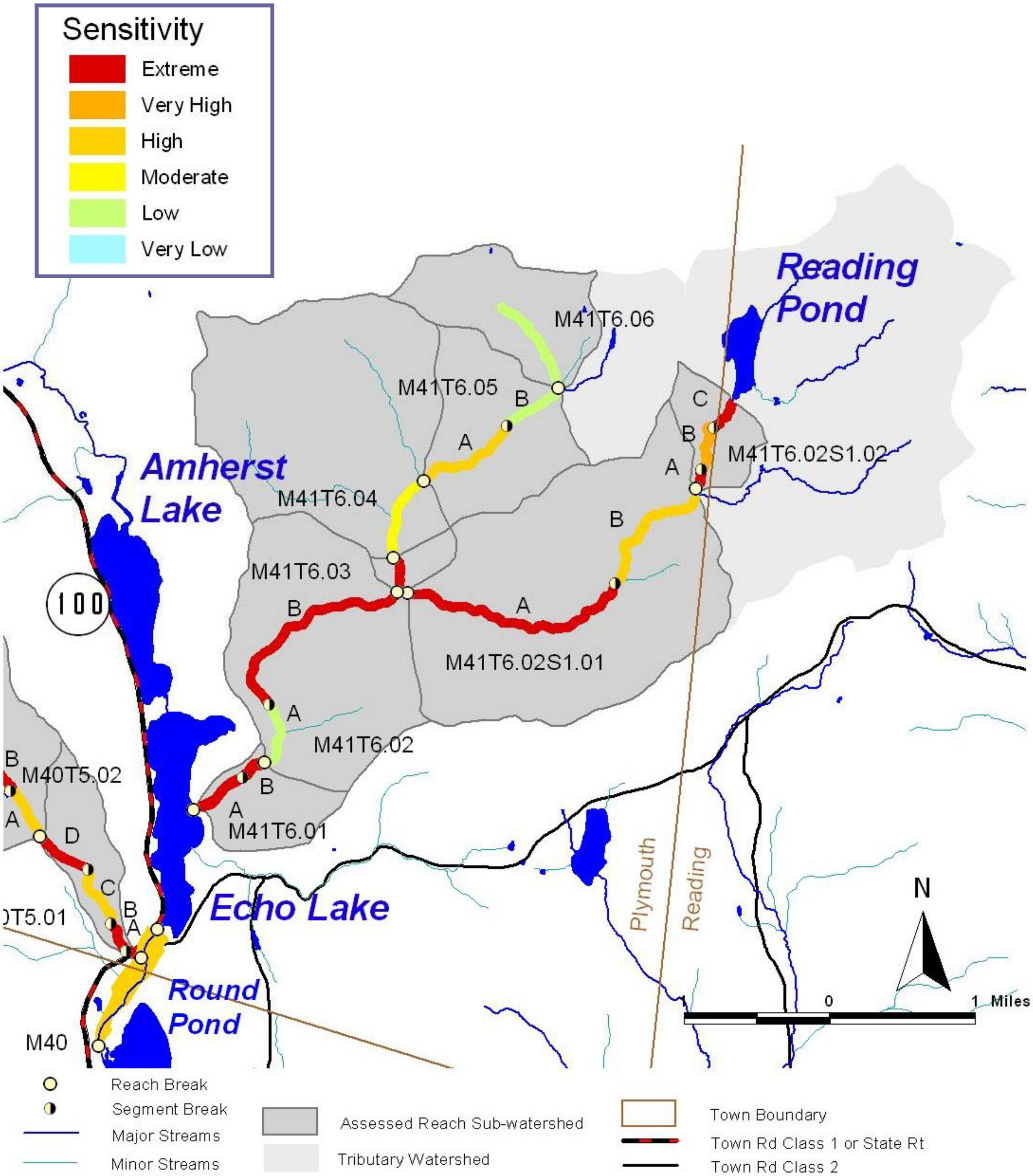


Figure 20. Stream Sensitivity Map
Assessed Reaches of the Buffalo Brook & Reading Pond Brook.

5.0 PRELIMINARY PROJECT IDENTIFICATION (Reach & Corridor Scale)

A listing of preliminary projects and practices for the Patch Brook and Buffalo Brook watersheds has been developed, following the *Step-Wise Procedure for Identifying Technically Feasible River Corridor Restoration and Protection Projects* included in VTANR guidance (2007b).

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 4.

Each category of restoration and conservation strategies identified in VTANR guidance (2007b) is discussed in Sections 5.1 through 5.8. An additional category (mitigating point sources of stormwater and sediment loading) is presented in Section 5.9.

For a more detailed background explanation on the purpose and need for various restoration and conservation strategies, the reader is referred to the companion report to which this report is an addendum (Section 5 of the July 2009 *Phase 2 Stream Geomorphic Assessment of the Black River Watershed*). Section 7 of the Black River report also provides important recommendations for watershed strategies to support passive restoration, reduce sedimentation and avoid fluvial erosion hazards – that are applicable to the Patch Brook and Buffalo Brook watersheds.

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.

5.1 Protecting River Corridors

River corridor protection is recommended as a high priority along the following reaches:

In the Patch Brook watershed:

- Segments M40T5.03-A, M40T5.02-B and M40T5.01-A where reduced valley confinement (entrenchment) and gradient make these locations particularly prone to lateral adjustments.

- Segments M40T5.01-D, and –C to support ongoing lateral adjustments that are building floodplain capacity to attenuate future flows and sediment upstream of the village area of Tyson Furnace – and where there is the potential for increased residential or commercial development.

In the Buffalo Brook watershed:

- Segment M41T6.01-B, where reduced valley confinement and gradient make this location particularly prone to lateral adjustments and potential catastrophic erosion in a future flood.

5.2 Planting Stream Buffers

Forested buffers are present along a majority of the reaches, even where narrower than optimal due to close encroachment of a road or occasional residential land use. Thus, restoration of stream buffers is not a high-priority practice recommended at this time for the Patch Brook or Buffalo Brook reaches.

5.3 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 that are vertically stable and have good floodplain access are located in remote settings with relatively limited encroachments (and little potential for future development – i.e., state forest land). It is important to allow lateral adjustments to proceed unconstrained in these reaches in order to support passive channel restoration and a return toward dynamic equilibrium that will result in greater channel stability and reduced sediment production over the long term.

5.4 Arresting Head Cuts and Nick Points

Possible head cuts and rejuvenating tributaries were identified in segments of the Reading Pond Brook (M41T6.02S1.01-B and M41T6.02S1.02-A), as well as in the upper end of reach M41T6.02S1.02 in Segment C (just downstream of the breached dam at Reading Pond). Active incision in these segments is likely related to the June 2006 sudden breaching of the upstream dam at Reading Pond.

Segment M41T6.02S1.01-B contains channel-spanning exposures of bedrock that may serve to limit headward migration of incision. The Reading Pond Road culvert crossing at the upstream end of this segment may be at risk in the unlikely event that incisional processes continue to work headward in this reach.

Given the valley setting and adjustment processes within and upstream of the segments in question, it is expected that these headcuts will stabilize within a short upstream distance. Colluvial and mass wasting processes are actively contributing coarse sediments and woody debris to the channel to offset the localized incision that is occurring. For these reasons, no active restoration projects are recommended at this time to arrest head cuts within these segments. The Reading Pond Road culvert should continue to be monitored for signs of nearby incisional processes that may result in undermining of this structure.

5.5 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 to moderate priority in each case (following VTANR guidance) due to the fact that:

- the channel was already incised below the floodplain (IR_{RAF} greater than 1.5) such that berm removal alone would not result in greater floodplain access except in infrequent, flooding events. For example:
  - Left-bank (LB) berms along Patch Brook downstream of the Patch Brook Road / Dublin Road intersection;
  - LB berm along Patch Brook downstream of the upper Dublin Road bridge crossing;
  - LB berm along Buffalo Brook in segment M41T6.01-B just upstream of the Scout Camp Road crossing;
  - LB berm along lower end of Black River main stem reach M40.
- residential (State Park) infrastructure was present close to the channel and would be placed at greater risk of flooding if the berm were removed (e.g., RB berm along Buffalo Brook in segment M41T6.01-B);
- 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., LB berm on the upstream side of the lower Dublin Road bridge crossing of Patch Brook, M40T5.01-B, just upstream from the Echo Lake Inn); 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 (true of each of the above-listed berms).

One RB berm along Patch Brook segment M40T5.01-A just above the confluence with Black River reach M40 is of relatively recent construction (no well-established trees). The channel has moderate access to the adjacent flood plain, such that berm removal might permit some flow attenuation and sediment accumulation on adjacent lands. This same location might also serve as a flow and fine-sediment attenuation location for the Black River main stem.

Further evaluation would be required to understand the potential costs and benefits of a berm removal project in this location, as well as to ascertain the degree of landowner support. Ideally, sediment and flow attenuation should occur further upstream in the watershed, closer to the source of sediments. Given the topography, geology, and history of channel management in upstream reaches, however, opportunities for upstream sediment attenuation are quite limited.

5.6 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 5.6.1), and old dam abutments (section 5.6.2).

5.6.1 Bridge and Culvert Crossings

A total of 15 bridge and culvert crossings were encountered on the assessed reaches: 12 bridges and 3 instream culverts. Thirteen structures (including the 3 culverts) supported public road or logging road crossings. Two structures (both bridges) supported a trail or footpath 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). Thirteen of the 15 crossings were bankfull-constricting structures.

Table 5 below presents a listing of the 15 bridges and culverts, along with an indication of relative 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. 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.

5.6.2 Other constrictions

Other constrictions encountered in the Patch and Buffalo Brook watersheds included remnants of three breached dams: at the upper end of Patch Brook segment M40T5.03-B; at the downstream end of Patch Brook segment M40T5.02-A and at the upstream end of Reading Pond Brook segment M41T6.02S1.02-C. Each of these abutments (as a result of breaching events) is no longer a significant constrictor of the bankfull width. Therefore, they are not recommended for removal at this time.

5.7 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 (and post-glacially) incised and many have undergone a vertical stream type departure, losing access to the surrounding floodplain. Generally, historic incision on the lower reaches of the Patch Brook 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. In the Tyson Furnace village area, development and encroachments have contributed to the incised and entrenched status of the channel. None of the Patch Brook study reaches/segments was noted as having undergone active or recently-occurring incision.

In the Buffalo Brook watershed, there is a degree of active incision (related to June 2006 breaching of the Reading Pond dam) that is overprinted on historic (and post-glacial) incision – in part related to a history of deforestation and gold placer mining.

Table 5. Bridge and Culvert Crossings Encountered on assessed reaches of the Patch Brook and Buffalo Brook, 2009.

Channel	Reach/Segment	Town	Road	Structure Type	Constriction Status	Other Issues	Priority
Patch Brook	M40T5.04-E	Plymouth	Unknown Soldier Rd	bridge	55%		Low
Patch Brook	M40T5.04-C	Plymouth	Catamount Trail	bridge	40%	DA	Low
Patch Brook	M40T5.04-B	Plymouth	Patch Brook Road	culvert	24%	SB	Very High
Lake Ninevah outlet	M40T5.03S1.01	Plymouth	Loop Road	bridge	41%	A	Low
Patch Brook	M40T5.03-B	Plymouth	Townsend Barn Rd	bridge	62%	stepped footers	Medium
Patch Brook	M40T5.03-A	Plymouth	Dublin Road	bridge	53%	stepped footers, A, DA	Very High
Patch Brook	M40T5.02-A	Plymouth	Tatro Road	bridge	46%	stepped footers, DA, SB	Very High
Patch Brook	M40T5.01-B	Plymouth	Dublin Road	bridge	87%	A, DA, SA, SB	Very High
Patch Brook	M40T5.01-B	Plymouth	Library Road	bridge	48%	DA	Very High
Patch Brook	M40T5.01-A	Plymouth	VT Route 100	bridge	155%		Low
Black River	M40	Plymouth	Kingdom Road	bridge	81%	SB	Medium
Buffalo Brook	M41T6.06	Plymouth	forest road	culvert	49%	perched	Very High
Buffalo Brook	M41T6.01-B	Plymouth	Scout Camp Road	bridge	46%	A, DA, DB, SB	Very High
Buffalo Brook	M41T6.01-A	Plymouth	footpath	bridge	120%		Low
Reading Pond Bk	M41T6.02S1.02-B	Plymouth	Reading Pond Road	culvert	58%	DA, SB	Very High

Note: Constriction status is calculated as structure span divided by bankfull width, expressed as percent.
Abbreviations: A = Alignment; DA = Deposition above; DB - Deposition below; SA = Scour above; SB = Scour below

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

- Given the topographic and geologic setting, the natural floodplains available to the channel are quite narrow, and would offer little opportunity for sediment and flow attenuation should floodplain connection be restored.
- In the lower segments of Patch Brook there is a relatively high density of commercial and residential development and related encroachments that will likely require ongoing management of the entrenched and transport-dominated condition of the channel through the village area (e.g., M40T5.01-B, -A);
- On the Patch Brook there are relatively intractable constraints of infrastructure (roads, bridge / culvert crossings) that limit the full expression of meanders and floodplain access and would reduce the technical feasibility or effectiveness of active channel restoration (e.g., M40T5.03-A, M40T5.02-B, M40T5.02-A).

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 5.1) to support meander redevelopment and floodplain building. Naturally-enhanced attenuation at transition points of reduced valley gradient and/or confinement (enhanced by natural LWD recruitment) 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., M40T5.01-D, M40T5.01-C).

5.8 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.

Four of the study segments were identified with locally aggrading conditions (M40T5.04-D, M40T5.04-B, and M40T5.01-C in the Patch Brook and M41T6.01-A in the Buffalo Brook). 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. Instead of active restoration measures in these segments, a return toward equilibrium conditions can be supported through passive restoration techniques in the context of river corridor protection (Section 5.1 above).

5.9 Mitigating Point Sources of Increased Stormwater and Sediment Loading

There are opportunities to improve management of stormwater runoff and reduce erosion along abandoned forest roads and Class 4 roads in the Buffalo Brook watershed and along road ditches and at culvert outlets in the Patch Brook watershed.

Specifically, the following projects are recommended:

In the Patch Brook watershed:

- Review the potential for improved road maintenance and drainage practices along Patch Brook Road between Townsend Barn Road intersection and Dublin Road. 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.

  Given the constraints of this narrow valley setting, which may limit the feasibility of stormwater retention practices, this evaluation should consider abandonment or relocation of Patch Brook Road out of the Patch Brook valley – through connections to other existing roads or redevelopment of Class 4 road segments, where feasible.

In the Buffalo Brook watershed:

- Work with landowners, including the State of Vermont Forest & Parks, to evaluate the potential for reduced sediment production and improved sediment retention within the lower reaches of Buffalo Brook (M41T6.02-B) and Reading Pond Brook (M41T6.02S1.01-A) through implementation of stormwater management practices along the abandoned forest road sections. Projects could include:

  - Construction of water bars, broad-based dips, and turn-outs to direct surface water off the road (and away from the channel) onto terraces where stormwater can slowly infiltrate;
  - Other projects consistent with Vermont's Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont (2006);
  - Possible "re-wilding" of these mostly abandoned forest road segments on State and private lands, where landowners are willing; and
  - Possible introduction of boulders or large woody debris or other engineered structures in eroded sections of road which have been periodically occupied by the river – in order to increase roughness elements, slow flood waters and trap sediments.

5.10 Additional Recommendation

<u>Re: dam / diversion channel identified on the upper Patch Brook (Segment M40T5.04-C):</u>
The landowner should be contacted to determine the construction details and purpose of the dam. As appropriate, the Dam Safety & Hydrology Section of the VT Agency of Natural Resources, Department of Environmental Conservation should be notified of the existence and location of the dam, so that it can be inspected and a hazard rating assigned. In the event of dam failure, a considerable volume of water and sediment would be released to downstream reaches of the Patch Brook.

Dams that are currently not serving a useful purpose should be considered for removal to restore the natural flow and sediment transport functions of the channels that they now impound and for the associated benefits to instream and riparian habitats.

Dam removal options should carefully consider the:

- Impacts to flow and sediment regimes in the upstream and downstream channels, and the potential for increased fluvial erosion;
- Impacts to instream and riparian habitats that may affect fish and other aquatic organisms;
- Consequences related to flooding of upstream or downstream communities;
- Consequences of potential groundwater elevation changes upstream and downstream of the structure;
- Potential contaminant legacy of impounded sediments; and
- Impacts to cultural / historical / archaeological resources.

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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: **Black River**
Topo Maps: **LUDLOW**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M40**
SGAT Version: **4.56**
Date Last Edited: **November, 15 2010**
QA Status: **Step 2 done**
Is Reach An Impoundment?: **No**

Step 1. Reach Location **Channel between Echo Lake and Lake Rescue**

1.1 Reach Description:
1.2 Towns: **Ludlow, Plymouth**
1.3 Downstream Latitude: **43.4588933889**
1.3 Downstream Longitude: **-72.7072837659**

Step 2. Stream Type

2.1 Elevation Upstream: **1,061**
2.1 Elevation Downstream: **1,044**
2.1 Is Gradient Gentle?: **No**
2.2 Valley Length: **3,010.0** ft. **0.57** Miles
2.3 Valley Slope: **0.6**
2.4 Channel Length: **3,131.0** ft. **0.59** Miles
2.5 Channel Slope: **0.54 %**
2.6 Sinuosity: **1.04**
2.7 Watershed Area: **34.1** Square Miles
2.8 Channel Width: **61.9** feet
2.9 Valley Width: **510.0** feet
2.10 Confinement Ratio: **8.2**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-Class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Charateristicts

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geological Mat.: **Ice-Contact** **71.0** %
3.3 Sub-dom. Geological Mat.: **Alluvial**
3.4 Valley Slope Left: **Very Steep**
3.4 Valley Slope Right: **Steep**
3.5 Soils
Hydrologic Group: **B** **68.0** %
Flooding: **None/Rare** **71.0** %
Water Table Deep: **2.5** **40.0** %
Water Table Shallow: **1.5** **68.0** %
Erodibility: **Moderate** **31.0** %

7.4 Comments:
Phase 1 updated (October 2010) based on field observations in Phase 2 (8/7/2009).
Historic maps (Beers, 1869) note iron furnaces at Tyson.

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** **49.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**51-100**
Sub-dominant:	**51-100**	**0-25**
Length w / less than 25 ft.:	**321.0** ft.	**991.0** ft.

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** **4.8** %
5.3 Bank Armoring: **181.6** **5.8** %
Left: **57.5** ft. Right: **124.2** ft.
5.4 Channel Straightening: **3,036.1** **97.0** %
5.5 Dredging History: **Dredging**

Step 6. Floodplain Modifications
6.1 Berms & Roads - old: **1,523.8** ft. **48.7**

	One Side	Both Sides
Road:	**567.9** ft.	**460.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**495.8** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.

6.2 Development: **724.2** ft. **56.8** ft.
6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Flood Chute**
6.5 Meander Width: **61 ft.** Rato: **1.0**
6.6 Wavelength: **61 ft.** Ratio: **1.0**

Step 7. Windshield Survey
7.1 Bank Erosion: **0** ft
7.2 Bank Height: **No Data** 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	7.3	Total
1 Low	2 High	2 High	0 N.S.	0 N.S.	1 Low	2 High	2 High	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: **Patch Brook**
Topo Maps: **LUDLOW**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M40T5.01**
SGAT Version: **4.56**
Date Last Edited: **November, 15 2010**
QA Status: **Step 2 done**
Is Reach An Impoundment?: **No**

Step 1. Reach Location **Along northeast side Dublin Rd u/s from Tyson at southern end Echo Lake**

1.1 Reach Description:
1.2 Towns: **Plymouth**
1.3 Downstream Latitude: **43.4643246084**
1.3 Downstream Longitude: **-72.7036645556**

Step 2. Stream Type

2.1 Elevation Upstream: **1,200**
2.1 Elevation Downstream: **1,060**
2.1 Is Gradient Gentle?: **No**
2.2 Valley Length: **3,820.0** ft. **0.72** Miles
2.3 Valley Slope: **3.7**
2.4 Channel Length: **3,992.0** ft. **0.76** Miles
2.5 Channel Slope: **3.51 %**
2.6 Sinuosity: **1.05**
2.7 Watershed Area: **5.4** Square Miles
2.8 Channel Width: **27.6** feet
2.9 Valley Width: **80.0** feet
2.10 Confinement Ratio: **2.9**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **C**
Bedform: **Step-Pool**
Sub-Class Slope: **b**
Bed Material: **Cobble**

Step 3. Basin Charateristicts

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **None**
3.3 Dominant Geological Mat.: **Ice-Contact** **99.0** %
3.3 Sub-dom. Geological Mat.: **Other**
3.4 Valley Slope Left: **Steep**
3.4 Valley Slope Right: **Steep**
3.5 Soils
Hydrologic Group: **A** **59.0** %
Flooding: **None/Rare** **100.0** %
Water Table Deep: **6.0** **59.0** %
Water Table Shallow: **6.0** **59.0** %
Erodibility: **Severe** **59.0** %
7.4 Comments:
Updated (Oct 2010) based on Phase 2 field data (Sept 2009)

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** **39.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**0-25**
Sub-dominant:	**0-25**	**51-100**
Length w / less than 25 ft.:	**676.0** ft.	**2,346.0** ft.

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications
5.1 Flow Regulation - (old):
Type: **Small Bypass**
Use: **Other**
5.2 Bridges and Culverts: **3** **10.0** %
5.3 Bank Armoring: **807.5** **20.2** %
Left: **475.0** ft. Right: **332.5** ft.
5.4 Channel Straightening: **1,730.4** **43.3** %
5.5 Dredging History: **Dredging**

Step 6. Floodplain Modifications
6.1 Berms & Roads - old: **795.6** ft. **19.9**

	One Side	Both Sides
Road:	**534.2** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**261.4** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.

6.2 Development: **279.9** ft. **242.8** 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: **2444.7** ft
7.2 Bank Height: **3** 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	7.3	Total
1 Low	2 High	2 High	1 Low	1 Low	2 High	2 High	2 High	1 Low	1 Low	0 N.S.	1 Low	0 N/A	0 N/A	2 High	1 Low	19

Black River

Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**

Stream Name: **Patch Brook**

Topo Maps: **LUDLOW**

Watershed: **Black & Otttauquechee Rivers**

Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M40T5.02**

SGAT Version: **4.56**

Date Last Edited: **November, 15 2010**

QA Status: **Step 2 done**

Is Reach An Impoundment?: **No**

Step 1. Reach Location **Along northeast side Dublin Rd**

1.1 Reach Description:

1.2 Towns: **Plymouth**

1.3 Downstream Latitude: **43.4717829302**

1.3 Downstream Longitude: **-72.7123171631**

Step 2. Stream Type

2.1 Elevation Upstream: **1,265**

2.1 Elevation Downstream: **1,200**

2.1 Is Gradient Gentle?: **No**

2.2 Valley Length: **1,879.0** ft. **0.36** Miles

2.3 Valley Slope: **3.5**

2.4 Channel Length: **2,111.0** ft. **0.40** Miles

2.5 Channel Slope: **3.08 %**

2.6 Sinuosity: **1.12**

2.7 Watershed Area: **5.3** Square Miles

2.8 Channel Width: **27.2** feet

2.9 Valley Width: **45.0** feet

2.10 Confinement Ratio: **1.7**

2.10 Confinement Type: **Narrowly Confined**

2.11 Reference Stream Type: **B**

Bedform: **Step-Pool**

Sub-Class Slope: **None**

Bed Material: **Cobble**

Step 3. Basin Charateristicts

3.1 Alluvial Fan: **None**

3.2 Grade Control: **None**

3.3 Dominant Geological Mat.: **Ice-Contact** **97.0** %

3.3 Sub-dom. Geological Mat.: **Till**

3.4 Valley Slope Left: **Very Steep**

3.4 Valley Slope Right: **Steep**

3.5 Soils

Hydrologic Group: **B** **98.0** %

Flooding: **None/Rare** **100.0** %

Water Table Deep: **2.5** **95.0** %

Water Table Shallow: **1.5** **95.0** %

Erodibility: **slight** **3.0** %

7.4 Comments:

Update (oct 2010) based on Phase 2 field observations (Sept 2009).

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** **37.0** %

Current Sub-Dominant Land Cover: **Forest**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**51-100**
Sub-dominant:	**0-25**	**0-25**
Length w / less than 25 ft.:	**572.0** ft.	**1,007.0** ft.

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** **3.6** %

5.3 Bank Armoring: **992.6** **47.0** %

Left: **333.4** ft. Right: **659.2** ft.

5.4 Channel Straightening: **1,963.1** **93.0** %

5.5 Dredging History: **Dredging**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **2,392.9** ft. **113.4**

	One Side	Both Sides
Road:	**1,624.2** ft.	**213.4** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**482.4** ft.	**72.8** ft.
Improved Path:	**0.0** ft.	**0.0** ft.
6.2 Development:	**53.6** ft.	**172.7** ft.

6.3 Channel Bars: **Point**

6.4 Meander Migration: **Flood Chute**

6.5 Meander Width: **N/A** Rato: **0.0**

6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **108.08** ft

7.2 Bank Height: **4** 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	7.3	Total
1 Low	2 High	2 High	0 N.S.	0 N.S.	2 High	2 High	2 High	2 High	1 Low	0 N.S.	1 Low	0 N/A	0 N/A	1 Low	1 Low	17

Black River

Phase 1 - Reach Summary Report

Basin:	**Ottauquechee, Black**
Stream Name:	**Patch Brook**
Topo Maps:	**LUDLOW**
Watershed:	**Black & Otttauquechee Rivers**
Sub-watershed:	**Black River (Connecticut River drainage)**

Reach ID:	**M40T5.03**
SGAT Version:	**4.56**
Date Last Edited:	**November, 15 2010**
QA Status:	**Step 2 done**
Is Reach An Impoundment?:	**No**

Step 1. Reach Location **Along Patch Brook Rd**

1.1 Reach Description:

1.2 Towns: **Plymouth**

1.3 Downstream Latitude:	**43.4755205329**		
1.3 Downstream Longitude:	**-72.7166595253**		
Step 2. Stream Type			
2.1 Elevation Upstream:	**1,740**		
2.1 Elevation Downstream:	**1,265**		
2.1 Is Gradient Gentle?:	**No**		
2.2 Valley Length:	**9,200.0** ft.	**1.74**	Miles
2.3 Valley Slope:	**5.2**		
2.4 Channel Length:	**9,479.0** ft.	**1.80**	Miles
2.5 Channel Slope:	**5.01 %**		
2.6 Sinuosity:	**1.03**		
2.7 Watershed Area:	**4.2** Square Miles		
2.8 Channel Width:	**24.6** feet		
2.9 Valley Width:	**40.0** feet		
2.10 Confinement Ratio:	**1.6**		
2.10 Confinement Type:	**Narrowly Confined**		
2.11 Reference Stream Type:	**B**		
Bedform:	**Step-Pool**		
Sub-Class Slope:	**a**		
Bed Material:	**Cobble**		
Step 3. Basin Charateristicts			
3.1 Alluvial Fan:	**Yes**		
3.2 Grade Control:	**Waterfall**		
3.3 Dominant Geological Mat.:	**Till**	**81.0** %	
3.3 Sub-dom. Geological Mat.:	**Ice-Contact**		
3.4 Valley Slope Left:	**Ext. Steep**		
3.4 Valley Slope Right:	**Ext. Steep**		
3.5 Soils			
Hydrologic Group:	**C**	**76.0** %	
Flooding:	**None/Rare**	**97.0** %	
Water Table Deep:	**3.5**	**59.0** %	
Water Table Shallow:	**2.0**	**59.0** %	
Erodibility:	**Very Severe**	**90.0** %	

7.4 Comments:

Updated (Oct 2010) based on Phase 2 field observations (Oct 2009).

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**	**41.0** %
Current Sub-Dominant Land Cover:	**Forest**	

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**0-25**	**>100**
Sub-dominant:	**26-50**	**0-25**
Length w / less than 25 ft.:	**8,692.0** ft.	**209.0** ft.

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**	**2.1** %
5.3 Bank Armoring:	**2,019.1**	**21.3** %
Left: **1,478.9** ft.	Right:	**540.2** ft.
5.4 Channel Straightening:	**1,495.1**	**15.8** %
5.5 Dredging History:	**None**	

Step 6. Floodplain Modifications

6.1 Berms & Roads - old:	**9,246.9** ft.	**97.6**
	One Side	Both Sides
Road:	**8,397.5** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**849.4** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.
6.2 Development:	**50.0** ft.	**59.9** ft.
6.3 Channel Bars:	**Multiple**	
6.4 Meander Migration:	**Multiple**	
6.5 Meander Width:	**N/A** Rato:	**0.0**
6.6 Wavelength:	**N/A** Ratio:	**0.0**

Step 7. Windshield Survey

7.1 Bank Erosion:	**242.21**	ft
7.2 Bank Height:	**4**	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	7.3	Total
1 Low	2 High	2 High	0 N.S.	0 N.S.	2 High	1 Low	0 N.S.	2 High	0 N.S.	1 Low	1 Low	0 N/A	0 N/A	0 N.S.	1 Low	13

Black River

Phase 1 - Reach Summary Report

Basin:	**Ottauquechee, Black**
Stream Name:	**Unnamed trib to Patch Brook**
Topo Maps:	**LUDLOW, MOUNT HOLLY**
Watershed:	**Black & Otttauquechee Rivers**
Sub-watershed:	**Black River (Connecticut River drainage)**
Reach ID:	**M40T5.03S1.01**
SGAT Version:	**4.56**
Date Last Edited:	**October, 15 2010**
QA Status:	**Step 2 done**
Is Reach An Impoundment?:	**No**

Step 1. Reach Location **Outlet from Lake Ninevah**

1.1 Reach Description:

1.2 Towns: **Mount Holly, Plymouth**

1.3 Downstream Latitude: **43.475445996**

1.3 Downstream Longitude: **-72.7496037291**

Step 2. Stream Type

2.1 Elevation Upstream:	**1,768**		
2.1 Elevation Downstream:	**1,740**		
2.1 Is Gradient Gentle?:	**No**		
2.2 Valley Length:	**1,170.0** ft.	**0.22**	Miles
2.3 Valley Slope:	**2.4**		
2.4 Channel Length:	**1,221.0** ft.	**0.23**	Miles
2.5 Channel Slope:	**2.29 %**		
2.6 Sinuosity:	**1.04**		
2.7 Watershed Area:	**1.7** Square Miles		
2.8 Channel Width:	**16.7** feet		
2.9 Valley Width:	**30.0** feet		
2.10 Confinement Ratio:	**1.8**		
2.10 Confinement Type:	**Narrowly Confined**		
2.11 Reference Stream Type:	**B**		
Bedform:	**Step-Pool**		
Sub-Class Slope:	**None**		
Bed Material:	**Cobble**		

Step 3. Basin Charateristicts

3.1 Alluvial Fan:	**None**	
3.2 Grade Control:	**None**	
3.3 Dominant Geological Mat.:	**Till**	**81.0** %
3.3 Sub-dom. Geological Mat.:	**Alluvial**	
3.4 Valley Slope Left:	**Ext. Steep**	
3.4 Valley Slope Right:	**Very Steep**	
3.5 Soils		
Hydrologic Group:	**C**	**57.0** %
Flooding:	**None/Rare**	**82.0** %
Water Table Deep:	**1.5**	**52.0** %
Water Table Shallow:	**0.0**	**52.0** %
Erodibility:	**Very Severe**	**82.0** %

7.4 Comments:

Updated (Oct 2010) based on Phase 2 field data (Sept 2009)

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover:		
Current Dominant Land Cover:	**Forest**	**76.0** %
Current Sub-Dominant Land Cover:	**Urban**	

4.2 Corridor

Historic Land Cover::		
Current Dominant Land Cover:	**Forest**	**38.0** %
Current Sub-Dominant Land Cover:	**Urban**	

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**None**	**51-100**
Length w / less than 25 ft.:	**0.0** ft.	**0.0** ft.

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**	**4.1** %
5.3 Bank Armoring:	**131.6**	**10.8** %
Left: **0.0** ft.	Right:	**131.6** ft.
5.4 Channel Straightening:	**0.0**	**0.0** %
5.5 Dredging History:	**None**	

Step 6. Floodplain Modifications

6.1 Berms & 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:	**58.0** ft.	**26.2** ft.
6.3 Channel Bars:	**None**	
6.4 Meander Migration:	**Flood Chute**	
6.5 Meander Width:	**N/A** Rato:	**0.0**
6.6 Wavelength:	**N/A** Ratio:	**0.0**

Step 7. Windshield Survey

7.1 Bank Erosion:	**0**	ft
7.2 Bank Height:	**No Data**	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	7.3	Total
1	2	0	0	0	1	0	0	0	1	0	0	0	0	0	1	6
Low	High	N.S.	N.S.	N.S.	Low	N.S.	N.S.	Unk.	Low	N.S.	N.S.	N/A	N/A	N.S.	Low	

Black River

Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Patch Brook**
Topo Maps: **LUDLOW, MOUNT HOLLY**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M40T5.04**
SGAT Version: **4.56**
Date Last Edited: **November, 15 2010**
QA Status: **Step 2 done**
Is Reach An Impoundment?: **No**

Step 1. Reach Location **Upper extent of Patch Brook, flows along recreational trail to confluence with Lake Ninevah outlet**

1.1 Reach Description:
1.2 Towns: **Plymouth**
1.3 Downstream Latitude: **43.4756900577**
1.3 Downstream Longitude: **-72.7498439039**

Step 2. Stream Type

2.1 Elevation Upstream: **2,362**
2.1 Elevation Downstream: **1,740**
2.1 Is Gradient Gentle?: **No**
2.2 Valley Length: **10,770.0** ft. **2.04** Miles
2.3 Valley Slope: **5.8**
2.4 Channel Length: **10,776.0** ft. **2.04** Miles
2.5 Channel Slope: **5.77 %**
2.6 Sinuosity: **1.00**
2.7 Watershed Area: **1.5** Square Miles
2.8 Channel Width: **15.5** feet
2.9 Valley Width: **30.0** feet
2.10 Confinement Ratio: **1.9**
2.10 Confinement Type: **Narrowly Confined**
2.11 Reference Stream Type: **B**
Bedform: **Cascade**
Sub-Class Slope: **a**
Bed Material: **Gravel**

Step 3. Basin Charateristicts

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Multiple**
3.3 Dominant Geological Mat.: **Till** **92.0** %
3.3 Sub-dom. Geological Mat.: **Alluvial**
3.4 Valley Slope Left: **Very Steep**
3.4 Valley Slope Right: **Very Steep**
3.5 Soils
Hydrologic Group: **C** **79.0** %
Flooding: **None/Rare** **93.0** %
Water Table Deep: **2.5** **51.0** %
Water Table Shallow: **1.0** **51.0** %
Erodibility: **Very Severe** **92.0** %
7.4 Comments:
Updated (Oct 2010) based on Phase 2 field observations (Sept 2009).

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover:
Current Dominant Land Cover: **Forest** **92.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover::
Current Dominant Land Cover: **Forest** **76.0** %
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.:	**123.0** ft.	**252.0** ft.

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications
5.1 Flow Regulation - (old):
Type: **Small Bypass**
Use: **Other**
5.2 Bridges and Culverts: **4** **1.6** %
5.3 Bank Armoring: **155.2** **1.4** %
Left: **77.4** ft. Right: **77.8** ft.
5.4 Channel Straightening: **553.1** **5.1** %
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

	One Side	Both Sides
6.1 Berms & Roads - old:	**0.0** ft.	**0.0**
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:	**48.5** ft.	**174.7** ft.

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

Step 7. Windshield Survey
7.1 Bank Erosion: **510.83** ft
7.2 Bank Height: **2** 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	7.3	Total
1 Low	**0 N.S.**	**0 N.S.**	**1 Low**	**0 N.S.**	**0 N.S.**	**1 Low**	**0 N.S.**	**0 Unk.**	**0 N.S.**	**2 High**	**2 High**	**0 N/A**	**0 N/A**	**0 N.S.**	**1 Low**	**8**

Black River

Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**

Stream Name: **Buffalo Brook**

Topo Maps: **LUDLOW**

Watershed: **Black & Otttauquechee Rivers**

Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M41T6.01**

SGAT Version: **4.56**

Date Last Edited: **November, 15 2010**

QA Status: **Step 2 done**

Is Reach An Impoundment?: **No**

Step 1. Reach Location **Through Camp Plymouth; from eastern valley wall of Black River valley to confluence with Echo Lake**

1.1 Reach Description:

1.2 Towns: **Plymouth**

1.3 Downstream Latitude: **43.4734487003**

1.3 Downstream Longitude: **-72.6992798805**

Step 2. Stream Type

2.1 Elevation Upstream: **1,095**

2.1 Elevation Downstream: **1,061**

2.1 Is Gradient Gentle?: **No**

2.2 Valley Length: **1,910.0** ft. **0.36** Miles

2.3 Valley Slope: **1.8**

2.4 Channel Length: **2,010.0** ft. **0.38** Miles

2.5 Channel Slope: **1.69 %**

2.6 Sinuosity: **1.05**

2.7 Watershed Area: **5.7** Square Miles

2.8 Channel Width: **28.3** feet

2.9 Valley Width: **470.0** feet

2.10 Confinement Ratio: **16.6**

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 Charateristicts

3.1 Alluvial Fan: **Yes**

3.2 Grade Control: **None**

3.3 Dominant Geological Mat.: **Ice-Contact** **43.0** %

3.3 Sub-dom. Geological Mat.: **Alluvial**

3.4 Valley Slope Left: **Flat**

3.4 Valley Slope Right: **Steep**

3.5 Soils

Hydrologic Group: **A** **43.0** %

Flooding: **None/Rare** **57.0** %

Water Table Deep: **6.0** **56.0** %

Water Table Shallow: **6.0** **56.0** %

Erodibility: **slight** **13.0** %

7.4 Comments:

Updated (Oct 2010) based on Phase 2 field based data (Sept 2009).

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover:

Current Dominant Land Cover: **Forest** **94.0** %

Current Sub-Dominant Land Cover: **Urban**

4.2 Corridor

Historic Land Cover::

Current Dominant Land Cover: **Forest** **61.0** %

Current Sub-Dominant Land Cover: **Wetland**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**0-25**
Sub-dominant:	**26-50**	**>100**
Length w / less than 25 ft.:	**362.0** ft.	**1,811.0** ft.

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** **12.4** %

5.3 Bank Armoring: **617.1** **30.7** %

Left: **80.3** ft. Right: **536.9** ft.

5.4 Channel Straightening: **1,580.5** **78.6** %

5.5 Dredging History: **Gravel Mining**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **1,274.7** ft. **63.4**

	One Side	Both Sides
Road:	**0.0** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**0.0** ft.	**411.3** ft.
Improved Path:	**574.8** ft.	**288.7** ft.
6.2 Development:	**630.8** ft.	**230.6** ft.

6.3 Channel Bars: **Multiple**

6.4 Meander Migration: **Flood Chute**

6.5 Meander Width: **28 ft.** Rato: **1.0**

6.6 Wavelength: **28 ft.** Ratio: **1.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **982.51** ft

7.2 Bank Height: **3** 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	7.3	Total
0 N.S.	**1** Low	**2** High	**0** N.S.	**1** Low	**2** High	**2** High	**1** Low	**2** High	**2** High	**2** High	**1** Low	**2** High	**2** High	**2** High	**1** Low	**23**

Black River

Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Buffalo Brook**
Topo Maps: **LUDLOW**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M41T6.02**
SGAT Version: **4.56**
Date Last Edited: **November, 15 2010**
QA Status: **Step 2 done**
Is Reach An Impoundment?: **No**

Step 1. Reach Location **From Reading Pond confluence to Camp Plymouth**

1.1 Reach Description:
1.2 Towns: **Plymouth**
1.3 Downstream Latitude: **43.4763524457**
1.3 Downstream Longitude: **-72.6933528355**

Step 2. Stream Type

2.1 Elevation Upstream: **1,260**
2.1 Elevation Downstream: **1,095**
2.1 Is Gradient Gentle?: **No**
2.2 Valley Length: **6,340.0** ft. **1.20** Miles
2.3 Valley Slope: **2.6**
2.4 Channel Length: **6,639.0** ft. **1.26** Miles
2.5 Channel Slope: **2.49 %**
2.6 Sinuosity: **1.05**
2.7 Watershed Area: **5.6** Square Miles
2.8 Channel Width: **27.9** feet
2.9 Valley Width: **85.0** feet
2.10 Confinement Ratio: **3.0**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **C**
Bedform: **Step-Pool**
Sub-Class Slope: **b**
Bed Material: **Cobble**

Step 3. Basin Charateristicts

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Multiple**
3.3 Dominant Geological Mat.: **Till** **97.0** %
3.3 Sub-dom. Geological Mat.: **Ice-Contact**
3.4 Valley Slope Left: **Ext. Steep**
3.4 Valley Slope Right: **Ext. Steep**
3.5 Soils
Hydrologic Group: **C** **90.0** %
Flooding: **None/Rare** **100.0** %
Water Table Deep: **6.0** **97.0** %
Water Table Shallow: **6.0** **97.0** %
Erodibility: **Very Severe** **97.0** %
7.4 Comments:
Updated (Oct 2010) based on Phase 2 field-based data (Oct 2009).

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover:
Current Dominant Land Cover: **Forest** **95.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover::
Current Dominant Land Cover: **Forest** **61.0** %
Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**0-25**	**0-25**
Length w / less than 25 ft.:	**2,041.0** ft.	**1,972.0** ft.

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** **0.0** %
5.3 Bank Armoring: **33.7** **0.5** %
Left: **0.0** ft. Right: **33.7** ft.
5.4 Channel Straightening: **0.0** **0.0** %
5.5 Dredging History: **Gravel Mining**

Step 6. Floodplain Modifications
6.1 Berms & Roads - old: **4,358.2** ft. **65.6**

	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:	**3,938.5** ft.	**419.7** ft.
6.2 Development:	**0.0** ft.	**0.0** ft.

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

Step 7. Windshield Survey
7.1 Bank Erosion: **615.17** ft
7.2 Bank Height: **2** 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	7.3	Total
0 N.S.	0 N.S.	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	1 Low	2 High	0 N.S.	1 Low	2 High	0 N/A	0 N/A	1 Low	1 Low	10

Black River

Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Reading Pond Brook**
Topo Maps: **LUDLOW**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M41T6.02S1.01**
SGAT Version: **4.56**
Date Last Edited: **November, 15 2010**
QA Status: **Step 2 done**
Is Reach An Impoundment?: **No**

Step 1. Reach Location **From Barker Brook confluence d/s to Buffalo Brook confluence**

1.1 Reach Description:
1.2 Towns: **Plymouth**
1.3 Downstream Latitude: **43.4868285113**
1.3 Downstream Longitude: **-72.6812893172**

Step 2. Stream Type

2.1 Elevation Upstream: **1,680**
2.1 Elevation Downstream: **1,260**
2.1 Is Gradient Gentle?: **No**
2.2 Valley Length: **8,350.0** ft. **1.58** Miles
2.3 Valley Slope: **5.0**
2.4 Channel Length: **8,938.0** ft. **1.69** Miles
2.5 Channel Slope: **4.70 %**
2.6 Sinuosity: **1.07**
2.7 Watershed Area: **2.9** Square Miles
2.8 Channel Width: **21.0** feet
2.9 Valley Width: **40.0** feet
2.10 Confinement Ratio: **1.9**
2.10 Confinement Type: **Narrowly Confined**
2.11 Reference Stream Type: **B**
Bedform: **Step-Pool**
Sub-Class Slope: **a**
Bed Material: **Cobble**

Step 3. Basin Charateristicts

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Waterfall**
3.3 Dominant Geological Mat.: **Till** **98.0** %
3.3 Sub-dom. Geological Mat.: **Ice-Contact**
3.4 Valley Slope Left: **Ext. Steep**
3.4 Valley Slope Right: **Ext. Steep**
3.5 Soils
Hydrologic Group: **C** **54.0** %
Flooding: **None/Rare** **100.0** %
Water Table Deep: **3.5** **48.0** %
Water Table Shallow: **2.0** **48.0** %
Erodibility: **Very Severe** **98.0** %
7.4 Comments:
Updated (oct 2010) based on Phase 2 field observations (Sept 2009).

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover:
Current Dominant Land Cover: **Forest** **93.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover::
Current Dominant Land Cover: **Forest** **61.0** %
Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**0-25**	**0-25**
Length w / less than 25 ft.:	**1,210.0** ft.	**166.0** ft.

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** **0.0** %
5.3 Bank Armoring: **0.0** **0.0** %
Left: **0.0** ft. Right: **0.0** ft.
5.4 Channel Straightening: **0.0** **0.0** %
5.5 Dredging History: **Gravel Mining**

Step 6. Floodplain Modifications
6.1 Berms & Roads - old: **1,465.1** ft. **16.4**

	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:	**1,465.1** 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: **N/A** Rato: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey
7.1 Bank Erosion: **3043.89** ft
7.2 Bank Height: **3** 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	7.3	Total
0	0	1	0	0	0	0	1	1	0	2	2	0	0	2	1	10
N.S.	N.S.	Low	N.S.	N.S.	N.S.	N.S.	Low	Low	N.S.	High	High	N/A	N/A	High	Low	

Black River

Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Reading Pond Brook**
Topo Maps: **LUDLOW**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M41T6.02S1.02**
SGAT Version: **4.56**
Date Last Edited: **November, 15 2010**
QA Status: **Step 2 done**
Is Reach An Impoundment?: **No**

Step 1. Reach Location **Outlet channel from Reading Pond to confluence Barker Brook**

1.1 Reach Description:
1.2 Towns: **Plymouth, Reading**
1.3 Downstream Latitude: **43.49326456**
1.3 Downstream Longitude: **-72.6569001529**

Step 2. Stream Type

2.1 Elevation Upstream: **1,756**
2.1 Elevation Downstream: **1,680**
2.1 Is Gradient Gentle?: **No**
2.2 Valley Length: **2,140.0** ft. **0.41** Miles
2.3 Valley Slope: **3.6**
2.4 Channel Length: **2,630.0** ft. **0.50** Miles
2.5 Channel Slope: **2.89 %**
2.6 Sinuosity: **1.23**
2.7 Watershed Area: **1.2** Square Miles
2.8 Channel Width: **14.0** feet
2.9 Valley Width: **70.0** feet
2.10 Confinement Ratio: **5.0**
2.10 Confinement Type: **Narrow**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-Class Slope: **b**
Bed Material: **Gravel**

Step 3. Basin Charateristicts

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geological Mat.: **Ice-Contact** **74.0** %
3.3 Sub-dom. Geological Mat.: **Till**
3.4 Valley Slope Left: **Very Steep**
3.4 Valley Slope Right: **Very Steep**
3.5 Soils
Hydrologic Group: **B** **74.0** %
Flooding: **None/Rare** **97.0** %
Water Table Deep: **2.5** **97.0** %
Water Table Shallow: **1.5** **74.0** %
Erodibility: **slight** **22.0** %

7.4 Comments:
Updated (October 2010) with Phase 2 field based observations (Sept 2009).

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover:
Current Dominant Land Cover: **Forest** **92.0** %
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:	**>100**	**>100**
Sub-dominant:	**None**	**0-25**
Length w / less than 25 ft.:	**69.0** ft.	**217.0** ft.

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications
5.1 Flow Regulation - (old):
Type: **Small Bypass**
Use: **Other**
5.2 Bridges and Culverts: **1** **3.8** %
5.3 Bank Armoring: **54.6** **2.1** %
Left: **54.6** ft. Right: **0.0** ft.
5.4 Channel Straightening: **463.0** **17.6** %
5.5 Dredging History: **Gravel Mining**

Step 6. Floodplain Modifications
6.1 Berms & 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: **0.0** ft. **63.4** ft.
6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **N/A** Rato: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey
7.1 Bank Erosion: **606.03** ft
7.2 Bank Height: **2** 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	7.3	Total
0 N.S.	**1** Low	**1** Low	**1** Low	**0** N.S.	**0** N.S.	**1** Low	**1** Low	**0** Unk.	**0** N.S.	**2** High	**2** High	**0** N/A	**0** N/A	**2** High	**1** Low	**12**

Black River

Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Buffalo Brook**
Topo Maps: **LUDLOW**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M41T6.03**
SGAT Version: **4.56**
Date Last Edited: **November, 15 2010**
QA Status: **Step 2 done**
Is Reach An Impoundment?: **No**

Step 1. Reach Location **short reach of broader valley setting upstream of Reading Pond Brook confluence**

1.1 Reach Description:
1.2 Towns: **Plymouth**
1.3 Downstream Latitude: **43.4868961015**
1.3 Downstream Longitude: **-72.6821208875**

Step 2. Stream Type

2.1 Elevation Upstream: **1,280**
2.1 Elevation Downstream: **1,260**
2.1 Is Gradient Gentle?: **No**
2.2 Valley Length: **780.0** ft. **0.15** Miles
2.3 Valley Slope: **2.6**
2.4 Channel Length: **807.0** ft. **0.15** Miles
2.5 Channel Slope: **2.48 %**
2.6 Sinuosity: **1.03**
2.7 Watershed Area: **1.9** Square Miles
2.8 Channel Width: **17.5** feet
2.9 Valley Width: **160.0** feet
2.10 Confinement Ratio: **9.1**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Step-Pool**
Sub-Class Slope: **b**
Bed Material: **Gravel**

Step 3. Basin Charateristicts

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **Ledge**
3.3 Dominant Geological Mat.: **Ice-Contact** **84.0** %
3.3 Sub-dom. Geological Mat.: **Till**
3.4 Valley Slope Left: **Ext. Steep**
3.4 Valley Slope Right: **Ext. Steep**
3.5 Soils
Hydrologic Group: **B** **85.0** %
Flooding: **None/Rare** **100.0** %
Water Table Deep: **2.5** **84.0** %
Water Table Shallow: **1.5** **84.0** %
Erodibility: **slight** **15.0** %

7.4 Comments:
Updated (Oct 2010) based on Phase 2 field-based observations (Oct 2009).

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover:
Current Dominant Land Cover: **Forest** **96.0** %
Current Sub-Dominant Land Cover: **Crop**
4.2 Corridor
Historic Land Cover::
Current Dominant Land Cover: **Forest** **72.0** %
Current Sub-Dominant Land Cover:

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**0-25**	**0-25**
Length w / less than 25 ft.:	**127.0** ft.	**150.0** ft.

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** **0.0** %
5.3 Bank Armoring: **0.0** **0.0** %
Left: **0.0** ft. Right: **0.0** ft.
5.4 Channel Straightening: **0.0** **0.0** %
5.5 Dredging History: **Gravel Mining**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old:	**442.4** ft.	**54.8**
	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:	**268.9** ft.	**173.5** ft.
6.2 Development:	**0.0** ft.	**0.0** ft.

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

Step 7. Windshield Survey
7.1 Bank Erosion: **224.49** ft
7.2 Bank Height: **2** 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	7.3	Total
0 N.S.	0 N.S.	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	1 Low	2 High	0 N.E.	1 Low	1 Low	0 N/A	0 N/A	2 High	1 Low	10

Black River

Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Buffalo Brook**
Topo Maps: **LUDLOW**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M41T6.04**
SGAT Version: **4.56**
Date Last Edited: **November, 15 2010**
QA Status: **Step 2 done**
Is Reach An Impoundment?: **No**

Step 1. Reach Location **remote, steep, forested reach**
1.1 Reach Description:
1.2 Towns: **Plymouth**
1.3 Downstream Latitude: **43.4889746276**
1.3 Downstream Longitude: **-72.6824286161**

Step 2. Stream Type
2.1 Elevation Upstream: **1,350**
2.1 Elevation Downstream: **1,280**
2.1 Is Gradient Gentle?: **No**
2.2 Valley Length: **1,990.0** ft. **0.38** Miles
2.3 Valley Slope: **3.5**
2.4 Channel Length: **2,052.0** ft. **0.39** Miles
2.5 Channel Slope: **3.41 %**
2.6 Sinuosity: **1.03**
2.7 Watershed Area: **1.9** Square Miles
2.8 Channel Width: **17.3** feet
2.9 Valley Width: **40.0** feet
2.10 Confinement Ratio: **2.3**
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 Charateristicts
3.1 Alluvial Fan: **None**
3.2 Grade Control: **Ledge**
3.3 Dominant Geological Mat.: **Till** **99.0** %
3.3 Sub-dom. Geological Mat.: **Ice-Contact**
3.4 Valley Slope Left: **Ext. Steep**
3.4 Valley Slope Right: **Ext. Steep**
3.5 Soils
Hydrologic Group: **B** **93.0** %
Flooding: **None/Rare** **100.0** %
Water Table Deep: **6.0** **99.0** %
Water Table Shallow: **6.0** **99.0** %
Erodibility: **Very Severe** **99.0** %
7.4 Comments:
Updated (Oct 2010) based on Phase 2 field observations (Oct 2009). Unknown source of "crop" as subdominant land cover / land use (both in corridor and upstream watershed). No evidence of crop in field reconnaissance.

Step 4. Land Cover - Reach Hydrology
4.1 Watershed
Historic Land Cover:
Current Dominant Land Cover: **Forest** **96.0** %
Current Sub-Dominant Land Cover: **Crop**
4.2 Corridor
Historic Land Cover::
Current Dominant Land Cover: **Forest** **61.0** %
Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**0-25**	**0-25**
Length w / less than 25 ft.:	**1,484.0** ft.	**383.0** ft.

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** **0.0** %
5.3 Bank Armoring: **53.9** **2.6** %
Left: **0.0** ft. Right: **53.9** ft.
5.4 Channel Straightening: **0.0** **0.0** %
5.5 Dredging History: **None**

Step 6. Floodplain Modifications
6.1 Berms & Roads - old: **1,879.7** ft. **91.6**

	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:	**1,879.7** ft.	**0.0** ft.
6.2 Development:	**0.0** ft.	**0.0** ft.

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

Step 7. Windshield Survey
7.1 Bank Erosion: **40.64** ft
7.2 Bank Height: **3** 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	7.3	Total
0	0	2	0	0	0	0	0	2	0	0	1	0	0	0	1	6
N.S.	N.S.	High	N.S.	N.S.	N.S.	N.S.	N.S.	High	N.S.	N.S.	Low	N/A	N/A	N.S.	Low	

Black River

Phase 1 - Reach Summary Report

Basin:	**Ottauquechee, Black**
Stream Name:	**Buffalo Brook**
Topo Maps:	**LUDLOW**
Watershed:	**Black & Otttauquechee Rivers**
Sub-watershed:	**Black River (Connecticut River drainage)**

Reach ID:	**M41T6.05**
SGAT Version:	**4.56**
Date Last Edited:	**November, 15 2010**
QA Status:	**Step 2 done**
Is Reach An Impoundment?:	**No**

Step 1. Reach Location **remote, steep, forested reach**

1.1 Reach Description:

1.2 Towns: **Plymouth**

1.3 Downstream Latitude:	**43.4937043763**		
1.3 Downstream Longitude:	**-72.6799444548**		

Step 2. Stream Type

2.1 Elevation Upstream:	**1,580**		
2.1 Elevation Downstream:	**1,350**		
2.1 Is Gradient Gentle?:	**No**		
2.2 Valley Length:	**3,810.0** ft.	**0.72**	Miles
2.3 Valley Slope:	**6.0**		
2.4 Channel Length:	**3,964.0** ft.	**0.75**	Miles
2.5 Channel Slope:	**5.80 %**		
2.6 Sinuosity:	**1.04**		
2.7 Watershed Area:	**1.0** Square Miles		
2.8 Channel Width:	**12.9** feet		
2.9 Valley Width:	**35.0** feet		
2.10 Confinement Ratio:	**2.7**		
2.10 Confinement Type:	**Semi-confined**		
2.11 Reference Stream Type:	**B**		
Bedform:	**Step-Pool**		
Sub-Class Slope:	**a**		
Bed Material:	**Gravel**		

Step 3. Basin Charateristicts

3.1 Alluvial Fan:	**None**	
3.2 Grade Control:	**Multiple**	
3.3 Dominant Geological Mat.:	**Till**	**87.0** %
3.3 Sub-dom. Geological Mat.:	**Ice-Contact**	
3.4 Valley Slope Left:	**Ext. Steep**	
3.4 Valley Slope Right:	**Ext. Steep**	
3.5 Soils		
Hydrologic Group:	**C**	**80.0** %
Flooding:	**None/Rare**	**100.0** %
Water Table Deep:	**3.5**	**59.0** %
Water Table Shallow:	**2.0**	**59.0** %
Erodibility:	**Very Severe**	**99.0** %

7.4 Comments:

Updated (Oct 2010) with field-based observations from Phase 2 (Oct 2009).

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover:		
Current Dominant Land Cover:	**Forest**	**95.0** %
Current Sub-Dominant Land Cover:	**Crop**	

4.2 Corridor

Historic Land Cover::		
Current Dominant Land Cover:	**Forest**	**56.0** %
Current Sub-Dominant Land Cover:		

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**0-25**	**0-25**
Length w / less than 25 ft.:	**874.0** ft.	**135.0** ft.

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**	**0.0** %
5.3 Bank Armoring:	**0.0**	**0.0** %
Left: **0.0** ft.	Right:	**0.0** ft.
5.4 Channel Straightening:	**0.0**	**0.0** %
5.5 Dredging History:	**None**	

Step 6. Floodplain Modifications

6.1 Berms & Roads - old:	**1,301.8** ft.	**32.8**
	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:	**1,301.8** 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:	**N/A** Rato:	**0.0**
6.6 Wavelength:	**N/A** Ratio:	**0.0**

Step 7. Windshield Survey

7.1 Bank Erosion:	**173.52**	ft
7.2 Bank Height:	**2**	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	7.3	Total
0	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**1**	**0**	**0**	**0**	**1**	**7**
N.S.	**N.S.**	**High**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**High**	**N.S.**	**Low**	**Low**	**N/A**	**N/A**	**N.S.**	**Low**	

Black River

Phase 1 - Reach Summary Report

Basin: **Ottauquechee, Black**
Stream Name: **Buffalo Brook**
Topo Maps: **LUDLOW, PLYMOUTH**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Black River (Connecticut River drainage)**

Reach ID: **M41T6.06**
SGAT Version: **4.56**
Date Last Edited: **October, 15 2010**
QA Status: **Step 2 done**
Is Reach An Impoundment?: **No**

Step 1. Reach Location **remote, steep, forested reach**

1.1 Reach Description:
1.2 Towns: **Plymouth**
1.3 Downstream Latitude: **43.499421758**
1.3 Downstream Longitude: **-72.6685561183**

Step 2. Stream Type

2.1 Elevation Upstream: **1,885**
2.1 Elevation Downstream: **1,580**
2.1 Is Gradient Gentle?: **No**
2.2 Valley Length: **2,370.0** ft. **0.45** Miles
2.3 Valley Slope: **12.9**
2.4 Channel Length: **2,415.0** ft. **0.46** Miles
2.5 Channel Slope: **12.63 %**
2.6 Sinuosity: **1.02**
2.7 Watershed Area: **0.3** Square Miles
2.8 Channel Width: **7.8** feet
2.9 Valley Width: **30.0** feet
2.10 Confinement Ratio: **3.8**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **B**
Bedform: **Cascade**
Sub-Class Slope: **a**
Bed Material: **Bedrock**

Step 3. Basin Charateristicts

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Multiple**
3.3 Dominant Geological Mat.: **Till** **92.0** %
3.3 Sub-dom. Geological Mat.: **Other**
3.4 Valley Slope Left: **Ext. Steep**
3.4 Valley Slope Right: **Ext. Steep**
3.5 Soils
Hydrologic Group: **C** **92.0** %
Flooding: **None/Rare** **100.0** %
Water Table Deep: **6.0** **92.0** %
Water Table Shallow: **6.0** **92.0** %
Erodibility: **Very Severe** **92.0** %
7.4 Comments:
Updated (Oct 2010) with results of Phase 2 field assessment (Oct 2009).

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover:
Current Dominant Land Cover: **Forest** **98.0** %
Current Sub-Dominant Land Cover: **Crop**
4.2 Corridor
Historic Land Cover::
Current Dominant Land Cover: **Forest** **96.0** %
Current Sub-Dominant Land Cover:

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**None**	**0-25**
Length w / less than 25 ft.:	**50.0** ft.	**150.0** ft.

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** **1.0** %
5.3 Bank Armoring: **33.7** **1.4** %
Left: **18.0** ft. Right: **15.7** ft.
5.4 Channel Straightening: **0.0** **0.0** %
5.5 Dredging History: **Gravel Mining**

Step 6. Floodplain Modifications

6.1 Berms & 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:	**0.0** ft.	**10.6** ft.

6.3 Channel Bars: **None**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **N/A** Rato: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey
7.1 Bank Erosion: **89.66** ft
7.2 Bank Height: **2** 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	7.3	Total
0	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**4**
N.S.	**N.S.**	**Low**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**Low**	**Unk.**	**N.S.**	**N.S.**	**Low**	**N/A**	**N/A**	**N.S.**	**Low**	

Phase 2 Segment Summary Report Black River

Stream: **Black River**
Reach: **M40-0**

Segment Length(ft): **3,131**
Rain: **Yes**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **8/7/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Channel between Echo Lake and Lake Rescue, receiving Patch Brook.**

Step 5 - Notes: **Slight reduction in valley width due to Vt Rt 100 along RB, driveway along LB corridor. Valley type (Broad confinement) and status (unconfined) remain unchanged. Reach receives Patch Brook as RB tributary. Position of confluence was reportedly altered over the years (see Ph2 report). Kingdom Road crosses the reach via a bankfull-constricting bridge. Former bridge in this position was washed out in the 1927 flood (Ward, 1983). Two discrete sections of berms along LB enhance the degree of channel entrenchment and cut off portions of the floodplain. One short section located near the Patch Brook confluence (Patch Bk itself is bermed just upstream of the confluence; sediment "delta" protrudes from Patch Brook). Second longer, higher berm is located spanning Tiny Brook confluence. Upstream flow regulation = run-of-river dam at Amherst Lake (reach M42, ~1 mile upstream). Downstream flow regulation = run-of-river dam at Lake Rescue (reach M39, ~1.1 mile downstream). Reach M40 flows into Round Pond, a small embayment at the north end of Lake Rescue where a large sediment delta has formed over recent decades. Historic straightening and dredging of M40 is inferred due to linear planform and presence of berms. Also anecdotal evidence indicates channel and floodplain management following flood events of 1973 and 1927. Valley width entered in step 1.5 represents an average for the segment. Cross section location had a locally higher valley width. Also, valley width is measured perpendicular to the long-valley axis. To be perpendicular to the channel, cross sections XS-3 and XS-2 were oriented at an angle to the long-valley axis. The departure analysis of the Phase 2 report includes discussion of the upstream natural impoundment (Echo Lake) and the downstream regulated impoundment (Lake Rescue). Effects of these impoundments on reach M40 not possible to characterize based on currently available data. One might expect that upstream impoundment effects could lead to "hungry water" conditions and incision in M40. However, Patch Brook provides a significant source of sediments to M40. Fluctuations in water levels of the downstream Lake Rescue impoundment over historic times may have alternately induced incision (from a drop in base levels) or aggradation (from a rise in base levels). Today, the net result of historic (and post-glacial) channel adjustments and historic channel modifications is a partially incised and entrenched channel in reach M40.**

Step 7 - Narrative: **Minor present adjustments. Reach persists in partly incised and somewhat overwidened state, with entrenchment locally enhanced at discrete sections of berming that cause IRhef > 2.0. Lateral adjustments moderated by rip-rap armoring, berms, tree buffers. Vertical adjustments moderated by impoundments that control local base levels at upstream and downstream ends of the reach (and possibly by armored stream bed).**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft) One	Height	Both	Height
Berm:	496	6	0	
Road:	568	4	460	8
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	724		57	

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

1.5 Valley Features

Valley Width (ft): **440**
Width Determination: **Estimated**
Confinement Type: **BD**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **Yes**

1.6 Grade Controls: **None**

Stream: **Black River** Reach: **M40-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**63.90**	2.11 Riffle/Step Spacing:	**610 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**3.30**	2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):	**1.80**	Bedrock:	**0.0 %**	Bar:	
2.4 Floodprone Width (ft.):	**650.00**	Boulder:	**3.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**6.10**	Cobble:	**51.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**35.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**35.50**	Fine Gravel:	**6.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**10.17**	Sand:	**5.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.85**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**23**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Undercut**

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**	**0.0**
Erosion Height (ft.):	**0.0**	**0.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**57.5**	**124.2**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
Canopy %:	**76-100**	**51-75**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**51-100**
Sub-Dominant	**51-100**	**0-25**
W less than 25	**321**	**991**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

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

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

Stream: **Black River**   Reach: **M40-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**

4.2 Adjacent Wetlands: **Minimal**

4.3 Flow Status: **Moderate**

4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**

Flow Reg. Use:

Impoundments:

Impoundment Loc.:

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

(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs **None**

Field Ditch: Road Ditch:

Other: Tile Drain:

Overland Flow: Urb Strm Wtr Pipe:

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**52**	**Yes**	**Yes**	**Yes**	**Yes**	**Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

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

5.2 Other Features

Flood chutes: **1**

Neck Cutoff: **0**

Avulsion: **0**

5.3 Steep Riffles and Head Cuts

Head Cuts: **0**

Steep Riffles: **0**

Trib Rejuv.: **No**

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

5.5 Straightening: **Straightening**

Straightening Length (ft.): **3,036**

5.5 Dredging: **Dredging**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**8**
6.2 Pool Substrate:	**11**
6.3 Pool Variability:	**10**
6.4 Sediment Deposition:	**13**
6.5 Channel Flow Status:	**16**
6.6 Channel Alteration:	**1**
6.7 Channel Sinuosity:	**5**
Total Score:	**118**
Habitat Rating:	**0.59**
Habitat Stream Condition:	**Fair**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**10**	**10**
6.9 Bank Vegetation Protection	**10**	**9**
6.10 Riparian Veg. Zone Width:	**9**	**6**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	**7**	**None**	**Yes**
7.2 Channel Aggradation	**13**	**None**	**Yes**
7.3 Widening Channel	**8**	**None**	**Yes**
7.4 Change in Planforml	**10**	**None**	**Yes**
Total Score	**38**		

Geomorphic Rating	**0.47**
Channel Evolution Model	**F**
Channel Evolution Stage	**III**
Geomorphic Condition	**Fair**
Stream Sensitivity	**High**

Phase 2 Segment Summary Report   Black River

Stream:	**Buffalo Brook**	SGAT Version:	**4.56**
Reach:	**M41T6.01-A**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**1,361**	Observers:	**KLU, BOS - SMRC**
Rain:	**Yes**	Completion Date:	**9/18/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Downstream from Scout Camp Road bridge to the confluence with Echo Lake**

Step 5 - Notes: **Improved paths are gravel park roads at grade. Development includes park buildings. Weak riffle/pool bedform; plane bed is evident especially in upper end of segment. Downstream flow regulation is natural impoundment of Echo Lake. Timber footbridge is a floodprone width constrictor. Historic map (and park history) indicates historic gold placer mining (i.e., gravel mining). Straightening inferred from linear planform. 10 largest on bar value assessed at side bar near upstream end of segment whereas bed value assessed at cross section near mid-point of segment. Bed substrates exhibit fining-downstream sequence.**

Step 7 - Narrative: **Moderate aggradation, especially lower half. Mod to substantial widening w/ localized planform adjustment. Historic incision. Lateral migration moderated by tree buffers & some streambank armoring. Early stage III[F].**

Step 1. Valley and Floodplain

1.1 Segmentation: **Subreach**

1.2 Alluvial Fan: **Yes**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**0**		**0**	
Railroad:	**0**		**0**	
Imp. Path:	**575**	**5**	**219**	**4**
Dev.:	**443**		**200**	

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

1.5 Valley Features

Valley Width (ft):	**470**
Width Determination:	**Estimated**
Confinement Type:	**VB**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**No**

1.6 Grade Controls: **None**

Stream: **Buffalo Brook** Reach: **M41T6.01-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**32.60**	2.11 Riffle/Step Spacing:	**200 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.60**	2.12 Substrate Composition		Bed:	**180 mm**
2.3 Mean Depth (tf):	**0.67**	Bedrock:	**0.0 %**	Bar:	**170 mm**
2.4 Floodprone Width (ft.):	**35.00**	Boulder:	**1.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**4.40**	Cobble:	**49.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**33.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**48.66**	Fine Gravel:	**12.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.07**	Sand:	**5.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**2.75**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Moderate**	Detritus:	**5.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**10**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **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.):	**399.6**	**409.8**
Erosion Height (ft.):	**3.6**	**3.2**
Revetment Type:	**None**	**Rip-Rap**
Revetment Length:	**0.0**	**55.2**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Herbaceous**	**Herbaceous**
Bank Canopy		
Canopy %:	**76-100**	**51-75**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

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

3.3 Riparian Corridor

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

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

Stream: **Buffalo Brook** Reach: **M41T6.01-A**

Step 4. Flow & Flow Modifiers

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

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

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

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**39**	**Yes**	**Yes**	**No**	**Yes**	**None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **1** Point: **0** Side: **8**
Diagonal: **1** Delta: **0** Island: **0** Braiding: **0**

5.2 Other Features
Flood chutes: **1**
Neck Cutoff: **0** Avulsion: **0**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **3** Head Cuts: **0** Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **957**
5.5 Dredging: **Gravel Mining**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **6**
6.2 Pool Substrate: **10**
6.3 Pool Variability: **11**
Total Score: **104**
Habitat Rating: **0.52**
Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **13**
6.5 Channel Flow Status: **8**
6.6 Channel Alteration: **5**
6.7 Channel Sinuosity: **17**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**6**	**6**
6.9 Bank Vegetation Protection	**6**	**6**
6.10 Riparian Veg. Zone Width:	**8**	**2**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	**3**	**C to F**	**Yes**
7.2 Channel Aggradation	**11**	**None**	**No**
7.3 Widening Channel	**8**	**None**	**No**
7.4 Change in Planforml	**11**	**None**	**No**
Total Score	**33**		

Geomorphic Rating	**0.41**
Channel Evolution Model	**F**
Channel Evolution Stage	**III**
Geomorphic Condition	**Fair**
Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report **Black River**

Stream: **Buffalo Brook**
Reach: **M41T6.01-B**

Segment Length(ft): **649**
Rain: **Yes**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU - SMRC**
Completion Date: **9/18/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **From base bedrock gorge past cabins of Camp Plymouth State Park to Scout Camp Road bridge.**

Step 5 - Notes: **Berms along both banks. State Park cabins along RB. Bankfull-constricting bridge crossing (Scout Camp Road). Sharp approach angle with stepped footer (LB) and cracked, spalling abutment (RB). Downstream flow regulation is natural impoundment of Echo Lake. Channelization suspected given linear planform and berms on either bank. Historic gold placer mining.**

Step 7 - Narrative: **Historic incision leading to partial entrenchment, accentuated by berm installments on both banks. Minor (neglible) lateral adjustments - moderated (under most flows) by erosion-resistance of bed & banks, armoring, tree buffers. However, susceptible to catastrophic erosion in future flood due to partially incised and entrenched condition. Overrode RGA classification to Fair due to human modifications (armoring, berming, straigtening) that have reduced functionality of the reach/floodplain and constrained the reach from adjusting toward a more natural form, despite metrics and feature observations that suggest minor to moderate present (and/or historic) net state of adjustment and/or departure, resulting in an overall ranking in the "Good" quadrant of the RGA. Overrode sensitivity classification to Extreme due to location at marked reduction in valley gradient & confinement ("alluvial fan").**

Step 1. Valley and Floodplain

1.1 Segmentation: **Subreach**

1.2 Alluvial Fan: **Yes**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	0		411	4
Road:	0		0	
Railroad:	0		0	
Imp. Path:	0		69	4
Dev.:	188		30	

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

1.5 Valley Features

Valley Width (ft): **290**
Width Determination: **Estimated**
Confinement Type: **VB**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls: **None**

Stream: **Buffalo Brook** Reach: **M41T6.01-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**20.00**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.40**	2.12 Substrate Composition		Bed:	**N/A**
2.3 Mean Depth (tf):	**1.03**	Bedrock:	**0.0 %**	Bar:	**N/A**
2.4 Floodprone Width (ft.):	**150.00**	Boulder:	**11.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**2.30**	Cobble:	**44.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):	**2.50**	Coarse Gravel:	**29.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**19.42**	Fine Gravel:	**10.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**7.50**	Sand:	**6.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.64**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**1.79**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	**C**
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**4**	Reference Bed Material:	**Cobble**
				Reference Subclass Slope:	**b**
				Reference Bedform:	**Riffle-Pool**

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.):	**69.6**	**103.5**
Erosion Height (ft.):	**2.0**	**2.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**80.3**	**481.7**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**0-25**
Sub-Dominant	**0-25**	**26-50**
W less than 25	**56**	**418**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

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

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

Stream: **Buffalo Brook**   Reach: **M41T6.01-B**

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

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

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**15**	**Yes**	**Yes**	**Yes**	**Yes**	**Deposition Above,Deposition Below,Scour Below,Alignment**

Step 5. Channel Bed and Planform Changes

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

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

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **623**
5.5 Dredging: **Gravel Mining**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **8**
6.2 Pool Substrate: **11**
6.3 Pool Variability: **10**
Total Score: **109**
Habitat Rating: **0.55**
Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **14**
6.5 Channel Flow Status: **13**
6.6 Channel Alteration: **6**
6.7 Channel Sinuosity: **5**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**7**	**7**
6.9 Bank Vegetation Protection	**9**	**7**
6.10 Riparian Veg. Zone Width:	**10**	**2**

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	**16**	**None**	**No**
7.4 Change in Planforml	**16**	**None**	**Yes**
Total Score	**55**		

Geomorphic Rating **0.69**
Channel Evolution Model **F**
Channel Evolution Stage **II**
Geomorphic Condition **Fair**
Stream Sensitivity **Extreme**

Phase 2 Segment Summary Report **Black River**

Stream: **Buffalo Brook**
Reach: **M41T6.02-A**

Segment Length(ft): **1,556**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/24/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**
Why Not Assessed: **bedrock gorge**

Step 0 - Location: **Downstream end of reach ending at base of bedrock gorge, Camp Plymouth State Park, east of Scout Camp Road.**

Step 5 - Notes:

Step 7 - Narrative:

Step 1. Valley and Floodplain

1.1 Segmentation: **Subreach**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft) One	Height	Both	Height
Berm:	0		0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	512	12	0	
Dev.:	0		0	

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

1.5 Valley Features

Valley Width (ft): **35**
Width Determination: **Estimated**
Confinement Type: **SC**
In Rock Gorge: **Yes**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Waterfall	Mid-segment	4.0	2.0	Yes	
Waterfall	Mid-segment	50.0	48.0	Yes	

Stream: **Buffalo Brook** Reach: **M41T6.02-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):		2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):		2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):		Bedrock:	%	Bar:	
2.4 Floodprone Width (ft.):		Boulder:	%	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):		Cobble:	%	Stream Type:	
Human Elev FloodPln (ft.):		Coarse Gravel:	%	Bed Material:	
2.6 Width/Depth Ratio:	**0.00**	Fine Gravel:	%	Subclass Slope:	
2.7 Entrenchment Ratio:	**0.00**	Sand:	%	Bed Form:	
2.8 Incision Ratio:	**0.00**	Silt and Smaller:	%	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:		2.15 Sub-reach Stream Type	
2.9 Sinuosity:		Detritus:	%	Reference Stream Type:	
2.10 Riffles Type:		# Large Woody Debris:		Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**298.8**	**60.8**
Erosion Height (ft.):	**2.0**	**2.0**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Coniferous**	**Coniferous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**26-50**	**26-50**
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Coniferous**	**Coniferous**
Sub-Dominant	**Deciduous**	**Deciduous**

3.3 Riparian Corridor

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

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

Stream: **Buffalo Brook** Reach: **M41T6.02-A**

Step 4. Flow & Flow Modifiers

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

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

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

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

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

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

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

Step 6. Rapid Habitat Assessment Data

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

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

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

Step 7. Rapid Geomorphic Assessment Data

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

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

Phase 2 Segment Summary Report Black River

Stream:	**Buffalo Brook**	SGAT Version:	**4.56**
Reach:	**M41T6.02-B**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**5,083**	Observers:	**KLU, BOS - SMRC**
Rain:	**No**	Completion Date:	**9/24/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Extends nearly one mile downstream from confluence of Reading Pond Brook**

Step 5 - Notes: **Bedrock is exposed along the banks in a few locations; three locations of channel-spanning ledge. Abandoned forest road follows along either bank or both for a majority of the segment length. Generally, the road follows the grade of a terrace on either side of the channel, or is occasionally notched into the valley wall. In a few locations where bedrock creates a valley pinch point, the road climbs the valley wall up and over the bedrock outcrop. Overland flow from road segments. Likely gravel mining associated with historic gold mining.**

Step 7 - Narrative: **Substantial planform adjustments (avulsions, flood chutes) facilitated by abandoned forest road network (removal of trees, concentration of runoff). Minor aggradation. Historic incision leading to stream type departure. Moderate historic widening moderated by erosion-resistance of bed and banks, including some vertical and lateral bedrock controls. Extreme Sens due to Cb to Fb STD.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**0**		**0**	
Railroad:	**0**		**0**	
Imp. Path:	**3,427**	**6**	**420**	**7**
Dev.:	**0**		**0**	

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

1.5 Valley Features

Valley Width (ft):	**85**
Width Determination:	**Estimated**
Confinement Type:	**SC**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	**Mid-segment**	**1.0**	**1.0**	**Yes**	
Ledge	**Mid-segment**	**1.0**	**0.0**	**No**	
Ledge	**Mid-segment**	**1.0**	**1.0**	**No**	

Stream: **Buffalo Brook** Reach: **M41T6.02-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**24.40**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on		
2.2 Max Depth (ft.):	**1.35**	2.12 Substrate Composition		Bed:	**450**	**mm**
2.3 Mean Depth (tf):	**0.94**	Bedrock:	**4.0 %**	Bar:	**135**	**mm**
2.4 Floodprone Width (ft.):	**28.00**	Boulder:	**7.0 %**	2.14 Stream Type		
2.5 Aband. Floodpn (ft.):	**5.30**	Cobble:	**36.0 %**	Stream Type:	**F**	
Human Elev FloodPln (ft.):		Coarse Gravel:	**38.0 %**	Bed Material:	**Gravel**	
2.6 Width/Depth Ratio:	**25.96**	Fine Gravel:	**8.0 %**	Subclass Slope:	**b**	
2.7 Entrenchment Ratio:	**1.15**	Sand:	**7.0 %**	Bed Form:	**Plane Bed**	
2.8 Incision Ratio:	**3.93**	Silt and Smaller:	**0.0 %**	Field Measured Slope:		
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type		
2.9 Sinuosity:	**Low**	Detritus:	**3.0 %**	Reference Stream Type:		
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**62**	Reference Bed Material:		
				Reference Subclass Slope:		
				Reference Bedform:		

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Undercut**

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.):	**70.1**	**185.6**
Erosion Height (ft.):	**2.0**	**3.0**
Revetment Type:	**None**	**Rip-Rap**
Revetment Length:	**0.0**	**33.7**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
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	**2,041**	**1,972**
Buffer Vegitation Type		
Dominant	**Coniferous**	**Coniferous**
Sub-Dominant	**Deciduous**	**Deciduous**

3.3 Riparian Corridor

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

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

Stream: **Buffalo Brook**　Reach: **M41T6.02-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**
4.2 Adjacent Wetlands: **None**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **5**

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

4.7 Stormwater Inputs
Field Ditch: **0**　Road Ditch: **1**
Other: **0**　Tile Drain: **0**
Overland Flow: **11**　Urb Strm Wtr Pipe: **0**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types　Diagonal: **0**
Mid: **4**　Delta: **0**
Point: **3**　Island: **0**
Side: **5**　Braiding: **0**

5.2 Other Features　Neck Cutoff: **0**
Flood chutes: **7**　Avulsion: **3**
5.3 Steep Riffles and Head Cuts　Head Cuts: **0**
Steep Riffles: **0**　Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **Yes**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **Gravel Mining**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **8**
6.2 Pool Substrate: **13**
6.3 Pool Variability: **11**
Total Score: **137**
Habitat Rating: **0.69**
Habitat Stream Condition: **Good**

6.4 Sediment Deposition: **14**
6.5 Channel Flow Status: **13**
6.6 Channel Alteration: **18**
6.7 Channel Sinuosity: **6**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**8**	**8**
6.9 Bank Vegetation Protection	**10**	**10**
6.10 Riparian Veg. Zone Width:	**9**	**9**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	**3**	**C to F**	**Yes**
7.2 Channel Aggradation	**13**	**None**	**No**
7.3 Widening Channel	**11**	**None**	**No**
7.4 Change in Planforml	**8**	**None**	**No**
Total Score	**35**		

Geomorphic Rating	**0.44**
Channel Evolution Model	**F**
Channel Evolution Stage	**II**
Geomorphic Condition	**Fair**
Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report Black River

Stream: **Reading Pond Brook**
Reach: **M41T6.02S1.01-A**

Segment Length(ft): **5,564**
Rain: **Yes**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/17/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Downstream segment of reach beginning downstream of Reading Pond Road and ending at confluence with Buffalo Brook**

Step 5 - Notes: **Valley width somewhat narrower in this segment as compared to upstream Segment B. Channel confined by higher terraces ranging in thalweg height from 8 to 18 feet and higher. Fewer discontinuous lower terraces than Segment B - at thalweg heights of 4 to 5 feet, or 2 to 2.5 times the bankfull height. Fewer occurrences of mass failures and bank erosion generally. Four occurrences of bedrock grade controls (waterfalls); few exposures of bedrock along the valley walls. Often fine to medium gravels have accumulated upstream of large boulder steps or entrained LWD in forced bars. A few leaning trees or saplings, suggesting ongoing planform adjustments or localized widening. But overall less actively adjusting than upstream Segment B. Abandoned forest road joins the stream valley from the LB corridor near the downstream end of the segment and crosses at one location to the RB. Uncertain whether the nickpoint observed was in fact a head cut. There appeared to be a little recent incision in the vicinity with erosion evident along both banks in a somewhat straight section of channel. But this location at the head of the segment was not representative of Segment A as a whole. In hind sight, the Segment break could have been located a little bit further downstream. In contrast to the upstream segment B, no rejuvenating tributaries were noted in Segment A; exposed tree roots along the banks were infrequent and weathered; LWD in the channel was weathered and stripped of small, leafed branches; trees leaning into the channel were fairly rare. If it is a headcut, it is likely to "wash out" within a fairly short distance upstream, due to steepness of the channel, and ongoing colluvial processes that are resulting in local sediment production.**

Step 7 - Narrative: **Aggradation and planform adjustments (flood chutes) - localized, forced at entrained LWD or boulder steps. Historic widening; historic incision. Lateral and vertical adjustments moderated by occasional bedrock exposures, coarseness of bed/bank materials, and closely-confining valley walls. Historic incision may be partly historical, partly post-glacial. Extreme sens due to Ba to Fa STD.**

Step 1. Valley and Floodplain

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

	Length (ft) One	Height	Length (ft) Both	Height
Berm:	0		0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	1,465	7	0	
Dev.:	0		0	

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

1.5 Valley Features
Valley Width (ft): **40**
Width Determination: **Estimated**
Confinement Type: **NC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Waterfall	Mid-segment	9.0	7.0	Yes	
Waterfall	Mid-segment	9.0	6.0	Yes	
Waterfall	Mid-segment	12.0	10.0	No	
Waterfall	Mid-segment	4.0	4.0	Yes	

Stream: **Reading Pond Brook** Reach: **M41T6.02S1.01-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**23.40**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.20**	2.12 Substrate Composition		Bed:	**250** mm
2.3 Mean Depth (tf):	**1.56**	Bedrock:	**0.0 %**	Bar:	**94** mm
2.4 Floodprone Width (ft.):	**24.00**	Boulder:	**7.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**4.80**	Cobble:	**33.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**44.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**15.00**	Fine Gravel:	**4.0 %**	Subclass Slope:	**a**
2.7 Entrenchment Ratio:	**1.03**	Sand:	**12.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**2.18**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**44**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Undercut**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**368.5**	**793.7**
Erosion Height (ft.):	**2.5**	**3.2**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
Canopy %:	**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	**1,210**	**166**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**Multiple**	**18.0**
Gullies	**None**	

	Left	Right
Mass Failures	**216.3**	**92.16**
Height	**17.3**	**16.8**
Gullies Number	**0**	
Gullies Length	**0**	

Phase 2 Segment Summary Report   Black River

Stream: **Reading Pond Brook**   Reach: **M41T6.02S1.01-A**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Abundant**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs			
4.2 Adjacent Wetlands:	**None**	Flow Reg. Use:		Field Ditch:	**0**	Road Ditch:	**0**
4.3 Flow Status:	**Moderate**	Impoundments:		Other:	**0**	Tile Drain:	**0**
4.4 # of Debris Jams:	**4**	Impoundment Loc.:		Overland Flow:	**1**	Urb Strm Wtr Pipe:	**0**
		4.6 Up/Down Strm flow reg.:	**None**	4.9 # of Beaver Dams:			**0**
		(old) Upstrm Flow Reg.:		Affected Length (ft):			**0**

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**0**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**Yes**
Mid:	**7**	Delta:	**1**	Flood chutes:	**7**	Avulsion:	**0**	5.5 Straightening:	**None**
Point:	**4**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**1**	Straightening Length (ft.):	**0**
Side:	**8**	Braiding:	**0**	Steep Riffles:	**0**	Trib Rejuv.:	**No**	5.5 Dredging:	**Gravel Mining**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**11**	6.4 Sediment Deposition:	**13**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**13**	6.5 Channel Flow Status:	**10**	6.8 Bank Stability:	**8**	**7**
6.3 Pool Variability:	**13**	6.6 Channel Alteration:	**18**	6.9 Bank Vegetation Protection	**8**	**7**
Total Score:	**131**	6.7 Channel Sinuosity:	**6**	6.10 Riparian Veg. Zone Width:	**8**	**9**
Habitat Rating:	**0.65**					
Habitat Stream Condition:	**Good**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Confined** Score	STD	Historic		
7.1 Channel Degradation	**5**	**B to F**	**Yes**	Geomorphic Rating	**0.40**
7.2 Channel Aggradation	**8**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**11**	**None**	**Yes**	Channel Evolution Stage	**III**
7.4 Change in Planforml	**8**	**None**	**No**	Geomorphic Condition	**Fair**
Total Score	**32**			Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report **Black River**

Stream: **Reading Pond Brook**
Reach: **M41T6.02S1.01-B**

Segment Length(ft): **3,374**
Rain: **Yes**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/17/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Upstream segment of reach beginning downstream of Reading Pond Road and ending at confluence with Buffalo Brook**

Step 5 - Notes: **Valley walls are defined by high terraces ranging from 7 to 20 feet high (or 3.5 to 10 times bankfull depth). Set of discontinuous lower terraces from 1.5 to 4 feet high (or 1 to 2 times bankfull depth - may represent RAF. One waterfall grade control indexed mid-reach. Couple other exposures of lateral bedrock grade controls. Several mass failures in glacial till are exposed where channel impinges upon the higher terraces. Reference B3a-S/P which is undergoing considerable vertical and lateral adjustments, presumably as a response to the 2006 flood event and sudden breaching of the Reading Pond. Bedform departure is evident in several sections from step/pool to cascade flows around LWD and boulders and large cobbles liberated by mass failures and high bank erosion. Frequent side and point bars forced at debris jams, LWD and detritus; frequent flood chutes and bifurcated channel sections around these obstacles. Width / depth ratio (26) is quite large for a semi-confined, steep-gradient channel, suggesting active widening. Widening is also suggested in several locations by trees freshly uprooted and leaning into the channel from both banks. Evidence of rejuvenating tributaries. Evidence of three possible breached earthen dams and partially excavated terraces - possibly associated with historic gold placer mining.**

Step 7 - Narrative: **Localized active incision overlapping historic incision; significant widening, localized aggradation and planform adjustment. Incision and widening moderated by coarseness of bed substrates, and closely confining, somewhat cohesive valley walls. Colluvial processes contributing sediments and large woody debris, resulting in lesser degree of net incision, perhaps.**

Step 1. Valley and Floodplain

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

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

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

1.5 Valley Features
Valley Width (ft): **55**
Width Determination: **Estimated**
Confinement Type: **SC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Waterfall	Mid-segment	6.0	5.0	Yes	

Stream:	**Reading Pond Brook**	Reach:	**M41T6.02S1.01-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**18.50**
2.2 Max Depth (ft.):	**1.80**
2.3 Mean Depth (tf):	**1.18**
2.4 Floodprone Width (ft.):	**38.00**
2.5 Aband. Floodpn (ft.):	**3.20**
Human Elev FloodPln (ft.):	
2.6 Width/Depth Ratio:	**15.68**
2.7 Entrenchment Ratio:	**2.05**
2.8 Incision Ratio:	**1.78**
Human Elevated Inc. Rat.:	**0.00**
2.9 Sinuosity:	**Low**
2.10 Riffles Type:	**Eroded**

2.11 Riffle/Step Spacing:	**10 ft.**
2.12 Substrate Composition	
Bedrock:	**0.0 %**
Boulder:	**10.0 %**
Cobble:	**52.0 %**
Coarse Gravel:	**22.0 %**
Fine Gravel:	**8.0 %**
Sand:	**8.0 %**
Silt and Smaller:	**0.0 %**
Silt/Clay Present:	**No**
Detritus:	**5.0 %**
# Large Woody Debris:	**38**

2.13 Average Largest Particle on		
Bed:	**250**	**mm**
Bar:	**100**	**mm**
2.14 Stream Type		
Stream Type:	**B**	
Bed Material:	**Cobble**	
Subclass Slope:	**a**	
Bed Form:	**Step-Pool**	
Field Measured Slope:		
2.15 Sub-reach Stream Type		
Reference Stream Type:		
Reference Bed Material:		
Reference Subclass Slope:		
Reference Bedform:		

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:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**1,033.8**	**847.8**
Erosion Height (ft.):	**4.7**	**4.3**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**Multiple**	**13.9**
Gullies	**None**	

	Left	Right
Mass Failures	**364.3**	**264.98**
Height	**13.4**	**15.0**
Gullies Number	**0**	
Gullies Length	**0**	

Phase 2 Segment Summary Report — Black River

Stream: **Reading Pond Brook** Reach: **M41T6.02S1.01-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Abundant**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs	**None**
4.2 Adjacent Wetlands:	**None**	Flow Reg. Use:		Field Ditch:	Road Ditch:
4.3 Flow Status:	**Moderate**	Impoundments:		Other:	Tile Drain:
4.4 # of Debris Jams:	**3**	Impoundment Loc.:		Overland Flow:	Urb Strm Wtr Pipe:
		4.6 Up/Down Strm flow reg.:	**None**	4.9 # of Beaver Dams:	**0**
		(old) Upstrm Flow Reg.:		Affected Length (ft):	**0**

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**0**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**No**
Mid:	**3**	Delta:	**1**	Flood chutes:	**9**	Avulsion:	**0**	5.5 Straightening:	**None**
Point:	**3**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**0**
Side:	**5**	Braiding:	**2**	Steep Riffles:	**2**	Trib Rejuv.:	**Yes**	5.5 Dredging:	**Gravel Mining**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**11**	6.4 Sediment Deposition:	**13**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**13**	6.5 Channel Flow Status:	**10**	6.8 Bank Stability:	**8**	**7**
6.3 Pool Variability:	**13**	6.6 Channel Alteration:	**18**	6.9 Bank Vegetation Protection	**8**	**7**
Total Score:	**131**	6.7 Channel Sinuosity:	**6**	6.10 Riparian Veg. Zone Width:	**8**	**9**
Habitat Rating:	**0.65**					
Habitat Stream Condition:	**Good**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Confined** Score	STD	Historic		
7.1 Channel Degradation	**7**	**None**	**No**	Geomorphic Rating	**0.36**
7.2 Channel Aggradation	**8**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**6**	**None**	**No**	Channel Evolution Stage	**III**
7.4 Change in Planforml	**8**	**None**	**No**	Geomorphic Condition	**Fair**
Total Score	**29**			Stream Sensitivity	**High**

Phase 2 Segment Summary Report Black River

Stream:	**Reading Pond Brook**	SGAT Version:	**4.56**
Reach:	**M41T6.02S1.02-A**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**505**	Observers:	**KLU, BOS - SMRC**
Rain:	**Yes**	Completion Date:	**9/4/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Downstream segment of reach, located downstream of Reading Pond Road culvert crossing.**

Step 5 - Notes: **Short subreach of alternative reference stream type: Semi-confined, steep gradient B3-S/P channel downstream of the Reading Pond Road culvert, in an otherwise Unconfined, lesser-gradient reach. Segment appears to have undergone recent incision - possibly related to the June 2006 flood. Widening may have been moderated by the close confinement of forested valley walls comprised of glacial till.**

Step 7 - Narrative: **Recent incision overprinted on historic or postglacial incision. Substantial widening; moderate planform adjustment, minor aggradation (transport reach). B to Fb stream type departure.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Subreach**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

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

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

1.5 Valley Features

Valley Width (ft):	**30**
Width Determination:	**Estimated**
Confinement Type:	**SC**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**No**

1.6 Grade Controls: **None**

Stream: **Reading Pond Brook** Reach: **M41T6.02S1.02-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**15.20**	2.11 Riffle/Step Spacing:	**10 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.10**	2.12 Substrate Composition		Bed:	**250 mm**
2.3 Mean Depth (tf):	**0.57**	Bedrock:	**0.0 %**	Bar:	**N/A mm**
2.4 Floodprone Width (ft.):	**16.00**	Boulder:	**11.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**2.20**	Cobble:	**40.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**20.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**26.67**	Fine Gravel:	**15.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**1.05**	Sand:	**14.0 %**	Bed Form:	**Cascade**
2.8 Incision Ratio:	**2.00**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**5.0 %**	Reference Stream Type:	**B**
2.10 Riffles Type:	**Not Applicable**	# Large Woody Debris:	**19**	Reference Bed Material:	**Cobble**
				Reference Subclass Slope:	**None**
				Reference Bedform:	**Step-Pool**

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**80.2**	**42.8**
Erosion Height (ft.):	**3.0**	**3.0**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**None**	**None**
W less than 25	**4**	**63**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Coniferous**	**Coniferous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**Multiple**	**7.5**
Gullies	**None**	

	Left	Right
Mass Failures	**22.8**	**47.63**
Height	**6.0**	**9.0**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Reading Pond Brook** Reach: **M41T6.02S1.02-A**

Step 4. Flow & Flow Modifiers

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

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**1**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**No**
Mid:	**0**	Delta:	**0**	Flood chutes:	**0**	Avulsion:	**0**	5.5 Straightening:	**Straightening**
Point:	**1**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**16**
Side:	**0**	Braiding:	**0**	Steep Riffles:	**1**	Trib Rejuv.:	**No**	5.5 Dredging:	**None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**15**	6.4 Sediment Deposition:	**15**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**15**	6.5 Channel Flow Status:	**13**	6.8 Bank Stability:	**7**	**8**
6.3 Pool Variability:	**16**	6.6 Channel Alteration:	**18**	6.9 Bank Vegetation Protection	**7**	**8**
Total Score:	**160**	6.7 Channel Sinuosity:	**18**	6.10 Riparian Veg. Zone Width:	**10**	**10**
Habitat Rating:	**0.80**					
Habitat Stream Condition:	**Good**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Confined** Score	STD	Historic		
7.1 Channel Degradation	**5**	**B to F**	**No**	Geomorphic Rating	**0.49**
7.2 Channel Aggradation	**15**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**8**	**None**	**No**	Channel Evolution Stage	**III**
7.4 Change in Planforml	**11**	**None**	**No**	Geomorphic Condition	**Fair**
Total Score	**39**			Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report   Black River

Stream:	**Reading Pond Brook**	SGAT Version:	**4.56**
Reach:	**M41T6.02S1.02-B**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**1,360**	Observers:	**KLU, BOS - SMRC**
Rain:	**Yes**	Completion Date:	**9/4/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Middle segment of the reach, located upstream of Reading Pond Road culvert crossing**

Step 5 - Notes: **Given the documented gold mining and logging history in the area, floodplain features within this segment, suggest an abandoned small flow diversion to an adjacent pond, associated with two possibly straightened channel sections - one of which the river has now abandoned as a result of an avulsion. Upstream flow regulation is the former Reading Pond run-of-river dam that breached in June 2006. Reading Pond Road crosses at a bankfull-constricting culvert. Road ditches drain directly to the brook (stormwater inputs).**

Step 7 - Narrative: **Substantial planform adjustments (avulsions, flood chutes) in response to historic incision, and historic planform adjustment.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**0**		**0**	
Railroad:	**0**		**0**	
Imp. Path:	**0**		**0**	
Dev.:	**0**		**47**	

1.4 Adjacent Side

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

1.5 Valley Features

Valley Width (ft):	**170**
Width Determination:	**Estimated**
Confinement Type:	**VB**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**No**

1.6 Grade Controls: **None**

Stream: **Reading Pond Brook**   Reach: **M41T6.02S1.02-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**15.50**	2.11 Riffle/Step Spacing:	**80 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.00**	2.12 Substrate Composition		Bed:	**170 mm**
2.3 Mean Depth (tf):	**0.60**	Bedrock:	**0.0 %**	Bar:	**120 mm**
2.4 Floodprone Width (ft.):	**40.00**	Boulder:	**5.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**1.60**	Cobble:	**29.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**58.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**25.83**	Fine Gravel:	**5.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**2.58**	Sand:	**2.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.60**	Silt and Smaller:	**1.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Moderate**	Detritus:	**3.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**15**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**148.2**	**61.6**
Erosion Height (ft.):	**2.0**	**2.0**
Revetment Type:	**Rip-Rap**	**None**
Revetment Length:	**54.6**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
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	**64**	**153**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Coniferous**	**Coniferous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**Multiple**	**9.5**
Gullies	**None**	

	Left	Right
Mass Failures	**50.5**	
Height	**9.5**	
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Reading Pond Brook** Reach: **M41T6.02S1.02-B**

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: **2**

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

4.7 Stormwater Inputs
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**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Instream Culvert	9	Yes	Yes	Yes	Yes	Deposition Above,Scour Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **1** Diagonal: **0**
Point: **8** Delta: **0**
Side: **5** Island: **0**
Braiding: **0**

5.2 Other Features
Flood chutes: **5** Neck Cutoff: **0**
Avulsion: **2**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **2** Head Cuts: **0**
Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **447**
5.5 Dredging: **Gravel Mining**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **11**
6.2 Pool Substrate: **13**
6.3 Pool Variability: **13**
Total Score: **137**
Habitat Rating: **0.69**
Habitat Stream Condition: **Good**

6.4 Sediment Deposition: **13**
6.5 Channel Flow Status: **13**
6.6 Channel Alteration: **10**
6.7 Channel Sinuosity: **15**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	7	8
6.9 Bank Vegetation Protection	7	7
6.10 Riparian Veg. Zone Width:	10	10

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	13	None	No
7.4 Change in Planforml	6	None	No
Total Score	40		

Geomorphic Rating **0.50**
Channel Evolution Model **F**
Channel Evolution Stage **IV**
Geomorphic Condition **Fair**
Stream Sensitivity **Very High**

Phase 2 Segment Summary Report Black River

Stream:	**Reading Pond Brook**	SGAT Version:	**4.56**
Reach:	**M41T6.02S1.02-C**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**765**	Observers:	**KLU, BOS - SMRC**
Rain:	**Yes**	Completion Date:	**9/4/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Uppermost segment of the reach beginning at the outlet from Reading Pond and extending 765 feet downstream.**

Step 5 - Notes: **Upstream flow regulation is the previously dammed Reading Pond. Dam breached during a June 2006 storm, and the pond is now significantly smaller in aerial extent. "Other" constriction in Step 4.8 is a breached stone dam located near the upstream end of the reach in close proximity to an old stone foundation (possible mill?). This breached dam is a second structure located approx 350 ft downstream of the dam which until June 2006 controlled the level of Reading Pond.**

Step 7 - Narrative: **Active incision (related to 2006 flood and dam release) perhaps overprinted on historic incision due to historic impoundment effects (Reading Pond). Moderate widening and minor to moderate planform adjustment (flood chutes, bifurcations).**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**0**		**0**	
Railroad:	**0**		**0**	
Imp. Path:	**0**		**0**	
Dev.:	**0**		**16**	

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

1.5 Valley Features	
Valley Width (ft):	**75**
Width Determination:	**Estimated**
Confinement Type:	**NW**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**No**

1.6 Grade Controls: **None**

Stream: **Reading Pond Brook** Reach: **M41T6.02S1.02-C**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**17.70**	2.11 Riffle/Step Spacing:	**220 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.10**	2.12 Substrate Composition		Bed:	**180 mm**
2.3 Mean Depth (tf):	**0.59**	Bedrock:	**0.0 %**	Bar:	**100 mm**
2.4 Floodprone Width (ft.):	**22.50**	Boulder:	**4.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**3.40**	Cobble:	**30.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**36.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**30.00**	Fine Gravel:	**12.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**1.27**	Sand:	**16.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**3.09**	Silt and Smaller:	**2.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Moderate**	Detritus:	**5.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**28**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Undercut**

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.):	**207.9**	**65.4**
Erosion Height (ft.):	**2.9**	**2.0**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**One**	**9.0**
Gullies	**None**	

	Left	Right
Mass Failures		**30.49**
Height		**9.0**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Reading Pond Brook** Reach: **M41T6.02S1.02-C**

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: **3**

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

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

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Other	**16**	**Yes**	**Yes**	**Yes**	**Yes**	**Deposition Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **1** Point: **3** Side: **1**
Diagonal: **1** Delta: **0** Island: **1** Braiding: **2**

5.2 Other Features
Flood chutes: **2**
Neck Cutoff: **0**
Avulsion: **0**

5.3 Steep Riffles and Head Cuts
Steep Riffles: **1**
Head Cuts: **0**
Trib Rejuv.: **No**

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

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **11**
6.2 Pool Substrate: **13**
6.3 Pool Variability: **13**
Total Score: **137**
Habitat Rating: **0.69**
Habitat Stream Condition: **Good**

6.4 Sediment Deposition: **13**
6.5 Channel Flow Status: **13**
6.6 Channel Alteration: **10**
6.7 Channel Sinuosity: **15**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**7**	**8**
6.9 Bank Vegetation Protection	**7**	**7**
6.10 Riparian Veg. Zone Width:	**10**	**10**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	**3**	**C to F**	**No**
7.2 Channel Aggradation	**13**	**None**	**No**
7.3 Widening Channel	**11**	**None**	**No**
7.4 Change in Planforml	**10**	**None**	**No**
Total Score	**37**		

Geomorphic Rating **0.46**
Channel Evolution Model **F**
Channel Evolution Stage **II**
Geomorphic Condition **Fair**
Stream Sensitivity **Extreme**

Phase 2 Segment Summary Report   Black River

Stream:	**Buffalo Brook**	SGAT Version:	**4.56**
Reach:	**M41T6.03-0**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**807**	Observers:	**KLU, BOS - SMRC**
Rain:	**No**	Completion Date:	**10/22/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Short reach of lesser gradient just above the confluence with Reading Pond Brook.**

Step 5 - Notes: **Indexed as an “alluvial fan” following protocols to capture the marked decrease in valley gradient, and valley confinement. Bedrock is occasionally exposed along the right valley wall; one occurrence of channel-spanning ledge. Given the history of gold mining in the area, it is possible that gravel mining occurred in this reach in the late 1800s, leading to possible incision. Headwater migration of incision was likely arrested at the channel-spanning exposure of bedrock. Degree of incision is less pronounced in the upstream third of the reach, possibly due to moderation by the bedrock exposures. May also reflect overprinting of aggradational processes from upstream sediment sources at this local decrease in gradient (and therefore decrease in sediment transport capacity). Abandoned forest road (Improved Path) crosses the channel at a ford.**

Step 7 - Narrative: **Minor to moderate planform adjustment (meander migration, one bifurcation). Susceptible to catastrophic erosion in flood event due to incised and entrenched channel status. Extreme sens due to Cb to Fb STD.**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**

1.2 Alluvial Fan: **Yes**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**0**		**0**	
Railroad:	**0**		**0**	
Imp. Path:	**269**	**4**	**174**	**4**
Dev.:	**0**		**0**	

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

1.5 Valley Features

Valley Width (ft):	**160**
Width Determination:	**Estimated**
Confinement Type:	**BD**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	**Mid-segment**	**1.0**	**0.0**	**No**	

Stream: **Buffalo Brook** Reach: **M41T6.03-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**16.80**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.40**	2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):	**1.07**	Bedrock:	**0.0 %**	Bar:	
2.4 Floodprone Width (ft.):	**27.00**	Boulder:	**5.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**3.30**	Cobble:	**41.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**45.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**15.70**	Fine Gravel:	**6.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**1.61**	Sand:	**3.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**2.36**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**3.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**0**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**90.2**	**134.3**
Erosion Height (ft.):	**2.0**	**2.0**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
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	**127**	**150**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Coniferous**	**Coniferous**

3.3 Riparian Corridor

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

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

Stream: **Buffalo Brook** Reach: **M41T6.03-0**

Step 4. Flow & Flow Modifiers

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

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

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

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**8**	6.4 Sediment Deposition:	**15**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**11**	6.5 Channel Flow Status:	**16**	6.8 Bank Stability:	**7**	**7**
6.3 Pool Variability:	**10**	6.6 Channel Alteration:	**16**	6.9 Bank Vegetation Protection	**7**	**7**
Total Score:	**126**	6.7 Channel Sinuosity:	**6**	6.10 Riparian Veg. Zone Width:	**8**	**8**
Habitat Rating:	**0.63**					
Habitat Stream Condition:	**Fair**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Unconfined** Score	STD	Historic		
7.1 Channel Degradation	**5**	**C to F**	**Yes**	Geomorphic Rating	**0.57**
7.2 Channel Aggradation	**15**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**15**	**None**	**No**	Channel Evolution Stage	**II**
7.4 Change in Planforml	**11**	**None**	**No**	Geomorphic Condition	**Fair**
Total Score	**46**			Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report   Black River

Stream: **Buffalo Brook**
Reach: **M41T6.04-0**
Segment Length(ft): **2,052**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **10/22/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Remote reach downstream of forest road leading west from terminus of Reading Pond Road, and upstream from Reading Pond Brook confluence.**

Step 5 - Notes: **Improved path is abandoned forest road which follows along one side or the other of the channel for nearly the entire length. Often, the road has been cut into the valley wall. In other cases, it follows a discontinuous terrace at grade; occasionally, the road appears to have been excavated below the terrace level. Three road crossings were indexed within the reach. Some sections of the old road serve as flood chutes during high flows. The former road grade serves to concentrate stormwater runoff and convey it to the river channel at locations of flood chute returns or channel crossings. At the downstream end of the reach, the road segment has been eroded to function as an active part of a bifurcated channel that extends into the next downstream reach. Several tributaries join the channel in this reach. Roads were observed along the banks of two of the larger tributaries. These road networks may be associated with historic logging activity and /or gold placer mining.**

Step 7 - Narrative: **Minor present adjustment. Evidence of historic widening (slightly bent trees). Historic planform adjustment as evidenced by eroded, short sections of forest road (avulsions).**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft) One	Height	Both	Height
Berm:	0		0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	1,880	2	0	
Dev.:	0		0	

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

1.5 Valley Features

Valley Width (ft): **40**
Width Determination: **Estimated**
Confinement Type: **SC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	Mid-segment	1.0	1.0	Yes	
Ledge	Mid-segment	1.0	0.0	No	

Stream: **Buffalo Brook** Reach: **M41T6.04-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**12.50**	2.11 Riffle/Step Spacing:	**45 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.30**	2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):	**0.87**	Bedrock:	**0.0 %**	Bar:	
2.4 Floodprone Width (ft.):	**24.00**	Boulder:	**10.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**1.30**	Cobble:	**46.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**35.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**14.37**	Fine Gravel:	**8.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.92**	Sand:	**1.0 %**	Bed Form:	**Step-Pool**
2.8 Incision Ratio:	**1.00**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**5.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**8**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**0.0**	**40.6**
Erosion Height (ft.):	**0.0**	**3.0**
Revetment Type:	**None**	**Rip-Rap**
Revetment Length:	**0.0**	**53.9**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
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	**1,484**	**383**
Buffer Vegitation Type		
Dominant	**Coniferous**	**Deciduous**
Sub-Dominant	**Deciduous**	**Coniferous**

3.3 Riparian Corridor

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

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

Stream: **Buffalo Brook** Reach: **M41T6.04-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Abundant**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs			
4.2 Adjacent Wetlands:	**None**	Flow Reg. Use:		Field Ditch:	**0**	Road Ditch:	**0**
4.3 Flow Status:	**Moderate**	Impoundments:		Other:	**0**	Tile Drain:	**0**
4.4 # of Debris Jams:	**3**	Impoundment Loc.:		Overland Flow:	**5**	Urb Strm Wtr Pipe:	**0**
		4.6 Up/Down Strm flow reg.:	**None**	4.9 # of Beaver Dams:			**0**
		(old) Upstrm Flow Reg.:		Affected Length (ft):			**0**

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

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

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**13**	6.4 Sediment Deposition:	**15**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**15**	6.5 Channel Flow Status:	**13**	6.8 Bank Stability:	**10**	**9**
6.3 Pool Variability:	**13**	6.6 Channel Alteration:	**16**	6.9 Bank Vegetation Protection	**10**	**9**
Total Score:	**159**	6.7 Channel Sinuosity:	**18**	6.10 Riparian Veg. Zone Width:	**9**	**9**
Habitat Rating:	**0.80**					
Habitat Stream Condition:	**Good**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Confined**	Score	STD	Historic		
7.1 Channel Degradation		**16**	**None**	**No**	Geomorphic Rating	**0.70**
7.2 Channel Aggradation		**16**	**None**	**No**	Channel Evolution Model	**D**
7.3 Widening Channel		**16**	**None**	**Yes**	Channel Evolution Stage	**IIc**
7.4 Change in Planforml		**8**	**None**	**Yes**	Geomorphic Condition	**Good**
Total Score		**56**			Stream Sensitivity	**Moderate**

Phase 2 Segment Summary Report **Black River**

Stream: **Buffalo Brook**
Reach: **M41T6.05-A**

Segment Length(ft): **2,458**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **10/22/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Downstream segment of remote reach downstream of forest road leading west from terminus of Reading Pond Road, and upstream from Reading Pond Brook confluence.**

Step 5 - Notes: **Valley confinement varies from Narrowly-confined to Narrow, but overall is dominantly Semi-confined. Improved path is mostly abandoned forest road that follows the channel in the downstream half of the segment. Less than 25 ft buffer was indexed along these improved path sections. Abandoned forest road fords the channel in three locations. The road appears to have been installed at grade on occasional terraces and along the base of the valley wall to either side of the channel. The road height above the channel varies but averages 2.5 feet above the thalweg. Over the years, the river appears to have avulsed to flow in the path of the road. In some locations evidence of the road has been eroded away. In other locations the former road grade has been eroded to form a flood chute.**

Step 7 - Narrative: **Significant planform adjustment and channel widening probably ocurring episodically during flood events. Minor aggradation due to steepness of gradient and semi-confined valley setting. Moderate historic incision, probably moderated by shallow bedrock.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft) One	Height	Length (ft) Both	Height
Berm:	**0**		**0**	
Road:	**0**		**0**	
Railroad:	**0**		**0**	
Imp. Path:	**1,302**	**3**	**0**	
Dev.:	**0**		**0**	

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

1.5 Valley Features

Valley Width (ft): **35**
Width Determination: **Estimated**
Confinement Type: **SC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	**Mid-segment**	**1.0**	**0.0**	**No**	
Ledge	**Mid-segment**	**1.0**	**0.0**	**No**	
Waterfall	**Mid-segment**	**4.0**	**3.0**	**Yes**	

Stream: **Buffalo Brook** Reach: **M41T6.05-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**31.90**	2.11 Riffle/Step Spacing:	**45 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.10**	2.12 Substrate Composition		Bed:	**65** mm
2.3 Mean Depth (tf):	**0.58**	Bedrock:	**0.0 %**	Bar:	**N/A** mm
2.4 Floodprone Width (ft.):	**48.00**	Boulder:	**1.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**1.70**	Cobble:	**14.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**56.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**55.00**	Fine Gravel:	**22.0 %**	Subclass Slope:	**a**
2.7 Entrenchment Ratio:	**1.50**	Sand:	**5.0 %**	Bed Form:	**Step-Pool**
2.8 Incision Ratio:	**1.55**	Silt and Smaller:	**2.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**5.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**25**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**64.9**	**108.7**
Erosion Height (ft.):	**3.0**	**2.4**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Herbaceous**	**Herbaceous**
Bank Canopy		
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	**874**	**135**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Coniferous**	**Coniferous**

3.3 Riparian Corridor

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

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

Stream: **Buffalo Brook** Reach: **M41T6.05-A**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Minimal**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs			
4.2 Adjacent Wetlands:	**None**	Flow Reg. Use:		Field Ditch:	**0**	Road Ditch:	**0**
4.3 Flow Status:	**Moderate**	Impoundments:		Other:	**0**	Tile Drain:	**0**
4.4 # of Debris Jams:	**4**	Impoundment Loc.:		Overland Flow:	**4**	Urb Strm Wtr Pipe:	**0**
		4.6 Up/Down Strm flow reg.:	**None**	4.9 # of Beaver Dams:	**0**		
		(old) Upstrm Flow Reg.:		Affected Length (ft):	**0**		

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

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

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**11**	6.4 Sediment Deposition:	**15**	Stream Gradiant Type	<u>Left</u>	<u>Right</u>
6.2 Pool Substrate:	**15**	6.5 Channel Flow Status:	**10**	6.8 Bank Stability:	**8**	**8**
6.3 Pool Variability:	**11**	6.6 Channel Alteration:	**16**	6.9 Bank Vegetation Protection	**9**	**9**
Total Score:	**148**	6.7 Channel Sinuosity:	**18**	6.10 Riparian Veg. Zone Width:	**9**	**9**
Habitat Rating:	**0.74**					
Habitat Stream Condition:	**Good**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Confined** Score	STD	Historic		
7.1 Channel Degradation	**11**	**None**	**Yes**	Geomorphic Rating	**0.45**
7.2 Channel Aggradation	**15**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**5**	**None**	**No**	Channel Evolution Stage	**IV**
7.4 Change in Planforml	**5**	**None**	**No**	Geomorphic Condition	**Fair**
Total Score	**36**			Stream Sensitivity	**High**

Phase 2 Segment Summary Report   Black River

Stream: **Buffalo Brook**
Reach: **M41T6.05-B**

Segment Length(ft): **1,506**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **10/22/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**
Why Not Assessed: **bedrock gorge**

Step 0 - Location: **Upstream segment of remote reach downstream of forest road leading west from terminus of Reading Pond Road, and upstream from Reading Pond Brook confluence.**

Step 5 - Notes:

Step 7 - Narrative:

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

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

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

1.5 Valley Features

Valley Width (ft): **15**
Width Determination: **Estimated**
Confinement Type: **NC**
In Rock Gorge: **Yes**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Waterfall	**Mid-segment**	**100.0**	**99.0**	**Yes**	

Stream: **Buffalo Brook**   Reach: **M41T6.05-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):		2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on		
2.2 Max Depth (ft.):		2.12 Substrate Composition		Bed:		
2.3 Mean Depth (tf):		Bedrock:	%	Bar:		
2.4 Floodprone Width (ft.):		Boulder:	%	2.14 Stream Type		
2.5 Aband. Floodpn (ft.):		Cobble:	%	Stream Type:		
Human Elev FloodPln (ft.):		Coarse Gravel:	%	Bed Material:		
2.6 Width/Depth Ratio:	**0.00**	Fine Gravel:	%	Subclass Slope:		
2.7 Entrenchment Ratio:	**0.00**	Sand:	%	Bed Form:		
2.8 Incision Ratio:	**0.00**	Silt and Smaller:	%	Field Measured Slope:		
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:		2.15 Sub-reach Stream Type		
2.9 Sinuosity:		Detritus:	**0.0 %**	Reference Stream Type:	**A**	
2.10 Riffles Type:		# Large Woody Debris:	**9**	Reference Bed Material:	**Bedrock**	
				Reference Subclass Slope:	**None**	
				Reference Bedform:	**Cascade**	

Step 3. Riparian Features

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

Bank Texture			Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper	Left	Right	Erosion Length (ft.):	**0.0**	**0.0**	Dominant:	**Deciduous**	**Deciduous**
Material Type:	**Bedrock**	**Bedrock**	Erosion Height (ft.):	**0.0**	**0.0**	Sub-dominant:	**Coniferous**	**Coniferous**
Consistency:	**Cohesive**	**Cohesive**	Revetment Type:	**None**	**None**	Bank Canopy		
Lower			Revetment Length:	**0.0**	**0.0**	Canopy %:	**76-100**	**76-100**
Material Type:	**Bedrock**	**Bedrock**				Mid-Channel Canopy:	**Closed**	
Consistency:	**Cohesive**	**Cohesive**						

3.2 Riparian Buffer

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

3.3 Riparian Corridor

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

Stream: **Buffalo Brook** Reach: **M41T6.05-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**

4.2 Adjacent Wetlands: **None**

4.3 Flow Status: **Moderate**

4.4 # of Debris Jams: **2**

4.5 Flow Regulation Type **None**

Flow Reg. Use:

Impoundments:

Impoundment Loc.:

4.6 Up/Down Strm flow reg.: **None**

(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs **None**

Field Ditch: Road Ditch:

Other: Tile Drain:

Overland Flow: Urb Strm Wtr Pipe:

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid: **0** Point: **0** Side: **0**

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

5.2 Other Features

Flood chutes: **3**

Neck Cutoff: **0** Avulsion: **0**

5.3 Steep Riffles and Head Cuts

Steep Riffles: **0**

Head Cuts: **0** Trib Rejuv.: **No**

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

5.5 Straightening: **None**

Straightening Length (ft.): **0**

5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:

6.2 Pool Substrate:

6.3 Pool Variability:

Total Score:

Habitat Rating:

Habitat Stream Condition:

6.4 Sediment Deposition:

6.5 Channel Flow Status:

6.6 Channel Alteration:

6.7 Channel Sinuosity:

Stream Gradiant Type Left Right

6.8 Bank Stability:

6.9 Bank Vegetation Protection

6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

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

Geomorphic Rating

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition

Stream Sensitivity

Phase 2 Segment Summary Report Black River

Stream: **Buffalo Brook**
Reach: **M41T6.06-0**

Segment Length(ft): **2,415**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **10/22/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**
Why Not Assessed: **bedrock gorge**

Step 0 - Location: **Remote reach beginning near culvert crossing of forest road leading west from terminus of Reading Pond Road.**

Step 5 - Notes: **Essentially a bedrock gorge. Steep bedrock slopes closely confine the channel. Overall Semi-confined, although there are some sections of Narrowly-confined. Occasional sections of alluvial veneer over bedrock. One perched culvert crosses the channel near the upstream end of the reach (gravel forest road). Overland flow stormwater input from this road to the channel at the culvert crossing. Upper end of the reach has a somewhat lesser gradient and more relaxed valley confinement. Some limited wetlands in vicinity of the culvert crossing. Three fords within the reach, including one collapsed timber bridge (very old), and two apparent former logging roads. One apparent breached earthen dam and spoil piles possibly associated with historic gold mining in the area. Since the channel was classified as a bedrock gorge, RGA and RHA were not completed, consistent with protocols.**

Step 7 - Narrative:

Step 1. Valley and Floodplain

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

Length (ft)	One	Height	Both	Height
Berm:	0		0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	0		11	

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

1.5 Valley Features
Valley Width (ft): **30**
Width Determination: **Estimated**
Confinement Type: **SC**
In Rock Gorge: **Yes**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	Mid-segment	1.0	0.0	Yes	
Waterfall	Mid-segment	5.0	4.0	Yes	
Waterfall	Mid-segment	4.0	4.0	No	
Waterfall	Mid-segment	160.0	159.0	Yes	
Waterfall	Mid-segment	60.0	59.0	Yes	

Stream: **Buffalo Brook** Reach: **M41T6.06-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):		2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):		2.12 Substrate Composition		Bed:	**N/A**
2.3 Mean Depth (tf):		Bedrock:	**%**	Bar:	**N/A**
2.4 Floodprone Width (ft.):		Boulder:	**%**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):		Cobble:	**%**	Stream Type:	
Human Elev FloodPln (ft.):		Coarse Gravel:	**%**	Bed Material:	
2.6 Width/Depth Ratio:	**0.00**	Fine Gravel:	**%**	Subclass Slope:	
2.7 Entrenchment Ratio:	**0.00**	Sand:	**%**	Bed Form:	
2.8 Incision Ratio:	**0.00**	Silt and Smaller:	**%**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:		2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**0.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Not Applicable**	# Large Woody Debris:	**32**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	**46.8**	**42.9**	Dominant:	**Deciduous**	**Deciduous**
Material Type:	**Bedrock**	**Bedrock**	Erosion Height (ft.):	**2.0**	**2.5**	Sub-dominant:	**Bare**	**Bare**
Consistency:	**Cohesive**	**Cohesive**	Revetment Type:	**Rip-Rap**	**Rip-Rap**	Bank Canopy		
Lower			Revetment Length:	**18.0**	**15.7**	Canopy %:	**76-100**	**76-100**
Material Type:	**Bedrock**	**Bedrock**				Mid-Channel Canopy:	**Closed**	
Consistency:	**Cohesive**	**Cohesive**						

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**None**	**0-25**
W less than 25	**50**	**150**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Coniferous**	**Coniferous**

3.3 Riparian Corridor

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

Stream: **Buffalo Brook** Reach: **M41T6.06-0**

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: **5**

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

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

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Instream Culvert	**3.9**	**Yes**	**Yes**	**Yes**	**Yes**	**Scour Below,Alignment**

Step 5. Channel Bed and Planform Changes

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

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

5.4 Stream Ford or Animal Crossing: **Yes**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **Gravel Mining**

Step 6. Rapid Habitat Assessment Data

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

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

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

Step 7. Rapid Geomorphic Assessment Data

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

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

Phase 2 Segment Summary Report Black River

Stream: **Patch Brook**
Reach: **M40T5.01-A**

Segment Length(ft): **397**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/10/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **From point between Library Rd bridge and Rt 100 bridge, downstream to confluence with Black River.**

Step 5 - Notes: **Dublin Rd and Kingdom Rd in the LB corridor encroach upon the floodplain and slightly reduce the available valley width; no significant change in confinement status (Unconfined). Gravel/cobble berm along the RB at a thalweg height ranging from 3 to 6 feet (IRhef = 3, average), downstream of Route 100 bridge crossing. Floodplain still available along the LB (IRraf = 1.5). Historic channelization is inferred due to linear planform, and based on historic maps which indicate position of the Patch Brook confluence was relocated over time. Historic dredging is inferred due to berms along RB and berms in main stem near confluence. Downstream flow regulation is dam at Lake Rescue which influences base level of Round Pond at northern extent of Lake Rescue and approx 0.5 mile downstream from confluence of Patch Brook.**

Step 7 - Narrative: **Moderate planform adjustment, minor to moderate widening and aggradation. Historic incision. Sensitivity upgraded to Extreme due to "alluvial fan" setting.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Valley Width**

1.2 Alluvial Fan: **Yes**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**199**	**5**	**0**	
Road:	**0**		**0**	
Railroad:	**0**		**0**	
Imp. Path:	**0**		**0**	
Dev.:	**0**		**81**	

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

1.5 Valley Features

Valley Width (ft): **160**
Width Determination: **Estimated**
Confinement Type: **BD**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **Yes**

1.6 Grade Controls: **None**

Stream: **Patch Brook**   Reach: **M40T5.01-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**25.20**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.90**	2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):	**1.43**	Bedrock:	**0.0 %**	Bar:	
2.4 Floodprone Width (ft.):	**310.00**	Boulder:	**4.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**2.90**	Cobble:	**48.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**29.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**17.62**	Fine Gravel:	**17.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**12.30**	Sand:	**2.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.53**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**3.0 %**	Reference Stream Type:	**C**
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**0**	Reference Bed Material:	**Cobble**
				Reference Subclass Slope:	**b**
				Reference Bedform:	**Riffle-Pool**

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/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**96.2**	**177.2**
Erosion Height (ft.):	**3.0**	**3.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**52.2**	**55.4**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Shrubs/Sapling**	**Bare**
Bank Canopy		
Canopy %:	**76-100**	**26-50**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**0-25**
Sub-Dominant	**26-50**	**>100**
W less than 25	**154**	**152**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

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

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

Stream: **Patch Brook**   Reach: **M40T5.01-A**

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 Reg. Use:

Impoundments:

Impoundment Loc.:

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

(old) Upstrm Flow Reg.: **Run-of-river Dam**

4.7 Stormwater Inputs **None**

Field Ditch: Road Ditch:

Other: Tile Drain:

Overland Flow: Urb Strm Wtr Pipe:

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**39**	**Yes**	**Yes**	**No**	**Yes**	**None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid:	**0**	Diagonal:	**0**
Point:	**1**	Delta:	**0**
Side:	**0**	Island:	**0**
		Braiding:	**0**

5.2 Other Features

Flood chutes: **0**

Neck Cutoff: **0**

Avulsion: **0**

5.3 Steep Riffles and Head Cuts

Steep Riffles: **0**

Head Cuts: **0**

Trib Rejuv.: **No**

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

5.5 Straightening: **Straightening**

Straightening Length (ft.): **282**

5.5 Dredging: **Dredging**

Step 6. Rapid Habitat Assessment Data

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

6.2 Pool Substrate: **13**

6.3 Pool Variability: **8**

Total Score: **90**

Habitat Rating: **0.45**

Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **13**

6.5 Channel Flow Status: **10**

6.6 Channel Alteration: **3**

6.7 Channel Sinuosity: **5**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**6**	**4**
6.9 Bank Vegetation Protection	**5**	**4**
6.10 Riparian Veg. Zone Width:	**2**	**9**

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	**13**	**None**	**No**
7.4 Change in Planforml	**8**	**None**	**No**
Total Score	**42**		

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

Phase 2 Segment Summary Report **Black River**

Stream: **Patch Brook**
Reach: **M40T5.01-B**

Segment Length(ft): **764**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/10/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **From just above Dublin Road bridge crossing, downstream to point between Library Rd bridge and Rt 100 bridge.**

Step 5 - Notes: **This segment was indexed as an “alluvial fan” in accordance with protocols to capture the reduced valley gradient and reduced confinement. Dublin Road has been elevated above the floodplain and now forms a berm along the RB of the channel upstream of the crossing and in the LB corridor downstream of the crossing. The road has reduced the valley width, but confinement status of the channel (Unconfined) is unchanged. The Dublin Road bridge crossing reportedly was washed out in the 1973 flood and a large cobble / earthen berm is now present along the LB of the channel at a thalweg height of 12.5 feet on the upstream approach to this Dublin Road bridge. Stepped footers of the LB abutment supporting this bridge are being scoured by the channel. The Dublin Rd bridge crossing and the Library Rd crossing are bankfull constrictors. Upstream flow regulation is the small diversion originating in Segment D; flow is returned to the channel from the "canal" within this segment B, just downstream of the Dublin Rd bridge crossing.**

Step 7 - Narrative: **Minor to moderate widening (modified by tree buffers, armoring). Minor aggradation. Historic planform adjustment (channelization) and historic incision / entrenchment. Extreme sens due to Cb to Fb STD.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **Yes**

1.3 Corridor Encroachments:

	Length (ft) One	Height	Both	Height
Berm:	62	13	0	
Road:	285	7	0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	208		161	

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

1.5 Valley Features

Valley Width (ft): **130**
Width Determination: **Estimated**
Confinement Type: **NW**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **Yes**

1.6 Grade Controls: **None**

Stream: **Patch Brook** Reach: **M40T5.01-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**33.30**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.80**	2.12 Substrate Composition		Bed:	**N/A**
2.3 Mean Depth (tf):	**1.40**	Bedrock:	**0.0 %**	Bar:	**N/A**
2.4 Floodprone Width (ft.):	**38.00**	Boulder:	**7.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**6.70**	Cobble:	**54.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**22.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**23.79**	Fine Gravel:	**7.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**1.14**	Sand:	**10.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**3.72**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**4**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**142.8**	**268.0**
Erosion Height (ft.):	**5.0**	**3.2**
Revetment Type:	**Multiple**	**Multiple**
Revetment Length:	**235.5**	**277.0**

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

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**0-25**
Sub-Dominant	**51-100**	**>100**
W less than 25		
Buffer Vegitation Type		
Dominant	**Shrubs/Sapling**	**Mixed Trees**
Sub-Dominant	**Mixed Trees**	**Shrubs/Sapling**

3.3 Riparian Corridor

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

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

Stream: **Patch Brook** Reach: **M40T5.01-B**

Step 4. Flow & Flow Modifiers

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

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

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

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**29**	**Yes**	**Yes**	**Yes**	**Yes**	**Deposition Above,Scour Above,Scour Below,Alignment**
Bridge	**16**	**Yes**	**Yes**	**Yes**	**Yes**	**Deposition Above**

Step 5. Channel Bed and Planform Changes

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

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

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **560**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **8**
6.2 Pool Substrate: **13**
6.3 Pool Variability: **8**
Total Score: **85**
Habitat Rating: **0.43**
Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **13**
6.5 Channel Flow Status: **11**
6.6 Channel Alteration: **3**
6.7 Channel Sinuosity: **3**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**7**	**5**
6.9 Bank Vegetation Protection	**3**	**2**
6.10 Riparian Veg. Zone Width:	**1**	**8**

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	**11**	**None**	**No**
7.4 Change in Planforml	**13**	**None**	**Yes**
Total Score	**40**		

Geomorphic Rating **0.50**
Channel Evolution Model **F**
Channel Evolution Stage **II**
Geomorphic Condition **Fair**
Stream Sensitivity **Extreme**

Phase 2 Segment Summary Report Black River

Stream: **Patch Brook**
Reach: **M40T5.01-C**

Segment Length(ft): **1,449**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/10/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Approx 1400 ft segment above Dublin Road bridge crossing**

Step 5 - Notes: **Moderately high terraces (6 to 8 feet thalweg height) and a set of much higher terraces (15 to 25 feet high) along the RB comprised of glaciofluvial sediments define a natural valley width that ranges between 80 and 130 feet wide, or 2.9 to 4.6 times the channel width. Upstream flow regulation is small diversion that directs a small portion of flow to "canal" along west side of Dublin Road and returns water to downstream Segment B.**

Step 7 - Narrative: **Moderate widening and planform adjustment (flood chutes, bifurcations); minor localized aggradation. Historic incision.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft) One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**15**	**7**	**0**	
Railroad:	**0**		**0**	
Imp. Path:	**0**		**0**	
Dev.:	**72**		**0**	

1.4 Adjacent Side

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

1.5 Valley Features

Valley Width (ft): **100**
Width Determination: **Estimated**
Confinement Type: **SC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls: **None**

Stream: **Patch Brook** Reach: **M40T5.01-C**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**38.50**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.40**	2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):	**1.02**	Bedrock:	**0.0 %**	Bar:	
2.4 Floodprone Width (ft.):	**75.00**	Boulder:	**10.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**2.00**	Cobble:	**60.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**13.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**37.75**	Fine Gravel:	**6.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**1.95**	Sand:	**11.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.43**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**3.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**27**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**145.9**	**338.2**
Erosion Height (ft.):	**3.0**	**5.8**
Revetment Type:	**Other**	**None**
Revetment Length:	**140.8**	**0.0**

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

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**0-25**
Sub-Dominant	**None**	**>100**
W less than 25	**73**	**1,173**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Deciduous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

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

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

Stream: **Patch Brook** Reach: **M40T5.01-C**

Step 4. Flow & Flow Modifiers

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

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

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

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**10**	6.4 Sediment Deposition:	**15**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**15**	6.5 Channel Flow Status:	**10**	6.8 Bank Stability:	**7**	**6**
6.3 Pool Variability:	**8**	6.6 Channel Alteration:	**16**	6.9 Bank Vegetation Protection	**6**	**6**
Total Score:	**121**	6.7 Channel Sinuosity:	**6**	6.10 Riparian Veg. Zone Width:	**10**	**6**
Habitat Rating:	**0.61**					
Habitat Stream Condition:	**Fair**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Confined** Score	STD	Historic		
7.1 Channel Degradation	**10**	**None**	**Yes**	Geomorphic Rating	**0.55**
7.2 Channel Aggradation	**13**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**10**	**None**	**No**	Channel Evolution Stage	**III**
7.4 Change in Planforml	**11**	**None**	**No**	Geomorphic Condition	**Fair**
Total Score	**44**			Stream Sensitivity	**High**

Phase 2 Segment Summary Report **Black River**

Stream:	**Patch Brook**	SGAT Version:	**4.56**
Reach:	**M40T5.01-D**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**1,382**	Observers:	**KLU, BOS - SMRC**
Rain:	**No**	Completion Date:	**9/10/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **East of Dublin Road.**

Step 5 - Notes: **Generally valley walls are comprised of coarse-grained glaciofluvial terraces between 2 and 4 times the channel width, and ranging in height from a thalweg height of 10 to 12 feet, or 5 to 6 times the thalweg depth of the channel. Straightening of the channel is apparent from the linear planform with abandoned meanders on either side of the straightened channel. Near the upper end of the segment, a small bypass channel has been constructed historically to convey a portion of the flow from Patch Brook to a culvert under Dublin Road and into a constructed channel that flows somewhat parallel to Patch Brook, but on the far side of residential homes to the west of Dublin Road. This "canal", as it is known locally, returns to the Patch Brook approximately 3000 feet downstream in Segment B. This diversion channel was constructed historically to support operations at Tyson Furnace**

Step 7 - Narrative: **Historic incision; early widening. Historic planform adjustment (straightening). Lateral adjustments moderated by coarseness of bed/bank material of glaciofluvial origin and regenerating tree buffers.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**234**	**7**	**0**	
Railroad:	**0**		**0**	
Imp. Path:	**0**		**0**	
Dev.:	**0**		**0**	

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

1.5 Valley Features

Valley Width (ft):	**65**
Width Determination:	**Estimated**
Confinement Type:	**SC**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**Yes**

1.6 Grade Controls: **None**

Stream: **Patch Brook**　　Reach: **M40T5.01-D**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**23.80**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.00**	2.12 Substrate Composition		Bed:	**N/A**
2.3 Mean Depth (tf):	**1.18**	Bedrock:	**0.0 %**	Bar:	**N/A**
2.4 Floodprone Width (ft.):	**30.00**	Boulder:	**21.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**5.10**	Cobble:	**41.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**19.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**20.17**	Fine Gravel:	**6.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**1.26**	Sand:	**13.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**2.55**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**3.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**6**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

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

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**769.7**	**506.8**
Erosion Height (ft.):	**3.3**	**2.7**
Revetment Type:	**Rip-Rap**	**None**
Revetment Length:	**46.6**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**None**	**51-100**
W less than 25	**0**	**381**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

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

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

Stream: **Patch Brook** Reach: **M40T5.01-D**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**
4.2 Adjacent Wetlands: **None**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **1**

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

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

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

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

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

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **888**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **13**
6.2 Pool Substrate: **18**
6.3 Pool Variability: **11**
Total Score: **110**
Habitat Rating: **0.55**
Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **16**
6.5 Channel Flow Status: **11**
6.6 Channel Alteration: **6**
6.7 Channel Sinuosity: **5**

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

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	**3**	**C to F**	**Yes**
7.2 Channel Aggradation	**15**	**None**	**No**
7.3 Widening Channel	**13**	**None**	**No**
7.4 Change in Planforml	**13**	**None**	**Yes**
Total Score	**44**		

Geomorphic Rating **0.55**
Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Fair**
Stream Sensitivity **Extreme**

Phase 2 Segment Summary Report Black River

Stream: **Patch Brook**
Reach: **M40T5.02-A**

Segment Length(ft): **1,240**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/10/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **1200 feet downstream of Tatro Road bridge, east of Dublin Road**

Step 5 - Notes: **Valley widths have been reduced somewhat by the encroachment of the Dublin Road, resulting in a modified valley width that varies between 30 and 75 feet, or 1.1 to 2.7 times the measured bankfull width. Uncertain degree of historic incision versus postglacial; reported degree of incision may be overstated. But some degree of historic incision is indicated by the stepped footers on Tatro Road bridge crossing (and upstream Dublin Road crossing), and the history of straightening and berming. It is also possible that the degree of incision at cross section site for Segment A has been influenced locally by the presence and later breaching of ahistoric mill dam – which apparently was located approximately 180 feet upstream according to historic maps. No signs of current incision (headcuts, rejuvenating tribs, eroding banks, and scour along both banks in the straightaways). Flow regulation in downstream segment is diversion (small) established historically for hydropower (see Phase 2 report). Tatro Road bridge is bankfull constrictor. Remnants of former earthen/ stone dam (Old Abutments) are floodprone constrictor.**

Step 7 - Narrative: **Historic incision (perhaps less than indicated; some postglacial). Historic planform adjustment (channelization). Minor aggradation. Possible B to Fb to B STD historically.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Subreach**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	112	4	0	
Road:	1,031	9	165	7
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	54		155	

1.6 Grade Controls: **None**

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

1.5 Valley Features

Valley Width (ft): **40**
Width Determination: **Estimated**
Confinement Type: **NC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **Yes**

Stream: **Patch Brook** Reach: **M40T5.02-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**28.00**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.40**	2.12 Substrate Composition		Bed:	**N/A**
2.3 Mean Depth (tf):	**1.60**	Bedrock:	**0.0 %**	Bar:	**N/A**
2.4 Floodprone Width (ft.):	**44.00**	Boulder:	**9.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**6.40**	Cobble:	**40.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**30.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**17.50**	Fine Gravel:	**5.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.57**	Sand:	**16.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**2.67**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**5.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**7**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**108.1**	**0.0**
Erosion Height (ft.):	**4.3**	**0.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**46.4**	**265.8**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**51-100**
Sub-Dominant	**0-25**	**0-25**
W less than 25	**539**	**504**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

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

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

Stream: **Patch Brook**   Reach: **M40T5.02-A**

Step 4. Flow & Flow Modifiers

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

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

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

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**12.8**	**Yes**	**Yes**	**Yes**	**Yes**	**Deposition Above,Scour Below**
Old Abutment	**42**	**Yes**	**Yes**	**No**	**Yes**	**None**

Step 5. Channel Bed and Planform Changes

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

5.2 Other Features
Flood chutes: **1**
Neck Cutoff: **0**
Avulsion: **0**

5.3 Steep Riffles and Head Cuts
Steep Riffles: **0**
Head Cuts: **0**
Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **1,210**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **13**
6.2 Pool Substrate: **13**
6.3 Pool Variability: **11**
Total Score: **128**
Habitat Rating: **0.64**
Habitat Stream Condition: **Fair**

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

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**8**	**8**
6.9 Bank Vegetation Protection	**10**	**8**
6.10 Riparian Veg. Zone Width:	**8**	**3**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	**3**	**Other**	**Yes**
7.2 Channel Aggradation	**13**	**None**	**No**
7.3 Widening Channel	**16**	**None**	**No**
7.4 Change in Planforml	**13**	**None**	**Yes**
Total Score	**45**		

Geomorphic Rating **0.56**
Channel Evolution Model **F**
Channel Evolution Stage **II**
Geomorphic Condition **Fair**
Stream Sensitivity **High**

Phase 2 Segment Summary Report   Black River

Stream:	**Patch Brook**	SGAT Version:	**4.56**
Reach:	**M40T5.02-B**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**871**	Observers:	**KLU, BOS - SMRC**
Rain:	**No**	Completion Date:	**9/10/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **From Dublin Road bridge crossing downstream nearly to Tatro Road crossing.**

Step 5 - Notes: **Natural valley width varies from 5 to greater than 10 times the channel width (Narrow to Very Broad). Historic encroachment of Dublin Road within the RB corridor has reduced the valley width to a degree, to approximately 3 to 7 times the channel width, averaging a Narrow confinement. However, the valley type (Unconfined) remained unchanged. Actual channel position does not match VHD (see Phase 2 report). Channel has been straightened along the Dublin Road; windrowing and berming are apparent. A cobble/gravel berm is present along the LB ranging from a thalweg height of 9.7 feet (near the Dublin Road bridge crossing) to 3 feet at its downstream end, where a 4-foot berm is also present along the RB for a short length. This LB berm effectively cuts off the river's access to the floodplain along the LB corridor, resulting in a Cb to F vertical stream type departure. A Human-elevated Floodplain incision ratio (IRHEF) of 4.0 was estimated. Historic straightening w/ windrowing is inferred due to linear planform and berms.**

Step 7 - Narrative: **Minor widening, aggradation, and planform adjustment. Extensive historic channelization (planform adjustment). Historic incision and berm/road encroachment leading to entrenchment and vertical stream type departure from Cb to Fb. Extreme sens due to STD.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Subreach**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft) One	Height	Both	Height
Berm:	**370**	**9**	**73**	**3**
Road:	**593**	**8**	**48**	**7**
Railroad:	**0**		**0**	
Imp. Path:	**0**		**0**	
Dev.:	**0**		**17**	

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

1.5 Valley Features	
Valley Width (ft):	**120**
Width Determination:	**Estimated**
Confinement Type:	**NW**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**Yes**

1.6 Grade Controls: **None**

Stream: **Patch Brook** Reach: **M40T5.02-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**24.10**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.40**	2.12 Substrate Composition		Bed:	**N/A**
2.3 Mean Depth (tf):	**1.53**	Bedrock:	**0.0 %**	Bar:	**N/A**
2.4 Floodprone Width (ft.):	**33.00**	Boulder:	**22.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**4.10**	Cobble:	**39.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):	**9.70**	Coarse Gravel:	**24.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**15.75**	Fine Gravel:	**10.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**1.37**	Sand:	**5.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.71**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**4.04**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	**C**
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**5**	Reference Bed Material:	**Cobble**
				Reference Subclass Slope:	**b**
				Reference Bedform:	**Step-Pool**

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/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**0.0**	**0.0**
Erosion Height (ft.):	**0.0**	**0.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**287.1**	**393.4**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**51-75**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**0-25**
Sub-Dominant	**51-100**	**26-50**
W less than 25	**33**	**503**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**None**	**Shrubs/Sapling**

3.3 Riparian Corridor

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

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

Stream: **Patch Brook** Reach: **M40T5.02-B**

Step 4. Flow & Flow Modifiers

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

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**0**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**No**
Mid:	**0**	Delta:	**0**	Flood chutes:	**1**	Avulsion:	**0**	5.5 Straightening:	**With Windrowing**
Point:	**0**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**753**
Side:	**1**	Braiding:	**0**	Steep Riffles:	**0**	Trib Rejuv.:	**No**	5.5 Dredging:	**Dredging**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**13**	6.4 Sediment Deposition:	**15**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**13**	6.5 Channel Flow Status:	**15**	6.8 Bank Stability:	**8**	**8**
6.3 Pool Variability:	**11**	6.6 Channel Alteration:	**8**	6.9 Bank Vegetation Protection	**10**	**8**
Total Score:	**128**	6.7 Channel Sinuosity:	**8**	6.10 Riparian Veg. Zone Width:	**8**	**3**
Habitat Rating:	**0.64**					
Habitat Stream Condition:	**Fair**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	Unconfined	Score	STD	Historic		
7.1 Channel Degradation		**3**	**C to F**	**Yes**	Geomorphic Rating	**0.61**
7.2 Channel Aggradation		**15**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel		**16**	**None**	**No**	Channel Evolution Stage	**II**
7.4 Change in Planforml		**15**	**None**	**Yes**	Geomorphic Condition	**Fair**
Total Score		**49**			Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report Black River

Stream:	**Patch Brook**	SGAT Version:	**4.56**
Reach:	**M40T5.03-A**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**1,856**	Observers:	**KLU, BOS - SMRC**
Rain:	**No**	Completion Date:	**9/10/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **From bedrock gorge southwest of Patch Rd intersection with Dublin Rd to Dublin Rd bridge crossing.**

Step 5 - Notes: **An alluvial fan was indexed in this segment to capture the marked reduction in natural valley confinement. Human encroachments along the left bank (Dublin Road and high gravel berms) have reduced the available valley width and lead to a stream type departure. Channel straightening with windrowing in the downstream half is inferred due to the linear planform and presence of berms. A residence is located in the RB floodplain at the downstream end of the segment. Due to modifications of the floodplain and berm construction, the location and elevation of the "recently-abandoned floodplain" were not easily discerned. Between the berm and a terrace along Dublin Road there is a low spot at an elevation of 2 feet above the thalweg. It is very possible that this area was excavated in the past to produce gravel and cobble material for construction of the berm. This area may also have been occupied by floodwaters during an avulsion of the channel and may represent a historic flood chute. The terrace to the north of this flood chute along Dublin Road was likely graded at some time during flood recovery efforts and may not represent the natural, abandoned floodplain elevation. Therefore, the IRraf value (of 3.7) may be overstated for this cross section location. Based on quick measurements, low bank heights (RAF) were approximately 2.9 times the measured bankfull depth in locations upstream of the cross section, closer to the short bedrock gorge. Upstream flow regulation is Lake Ninevah dam. Stream ford is ATV trail crossing.**

Step 7 - Narrative: **Minor localized aggradation. Major historic planform adjustment and incision (with degree of entrenchment enhanced by berms) - leading to vertical stream type departure from Ca to Fa. Widening moderated by steepness of slope, coarseness of boundary material, forested buffers. Still, susceptible to catastrophic erosion in future flood due to incised and entrenched channel status.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Subreach**

1.2 Alluvial Fan: **Yes**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**687**	**7**	**0**	
Road:	**1,213**	**9**	**0**	
Railroad:	**0**		**0**	
Imp. Path:	**0**		**0**	
Dev.:	**50**		**0**	

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

1.5 Valley Features

Valley Width (ft):	**100**
Width Determination:	**Estimated**
Confinement Type:	**NW**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**Yes**

1.6 Grade Controls: **None**

Stream: **Patch Brook** Reach: **M40T5.03-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**27.13**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.90**	2.12 Substrate Composition		Bed:	**N/A**
2.3 Mean Depth (tf):	**1.26**	Bedrock:	**0.0 %**	Bar:	**N/A**
2.4 Floodprone Width (ft.):	**39.00**	Boulder:	**15.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**7.00**	Cobble:	**36.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):	**8.00**	Coarse Gravel:	**25.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**21.53**	Fine Gravel:	**12.0 %**	Subclass Slope:	**a**
2.7 Entrenchment Ratio:	**1.44**	Sand:	**12.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**3.68**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**4.21**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	**C**
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**15**	Reference Bed Material:	**Cobble**
				Reference Subclass Slope:	**a**
				Reference Bedform:	**Step-Pool**

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Moderate**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**0.0**	**101.6**
Erosion Height (ft.):	**0.0**	**4.0**
Revetment Type:	**None**	**Rip-Rap**
Revetment Length:	**0.0**	**47.8**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**>100**
Sub-Dominant	**26-50**	**0-25**
W less than 25	**1,414**	**209**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Herbaceous**	**Herbaceous**

3.3 Riparian Corridor

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

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

Stream: **Patch Brook**   Reach: **M40T5.03-A**

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

4.7 Stormwater Inputs
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**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**14.4**	**Yes**	**Yes**	**Yes**	**Yes**	**Deposition Above,Alignment**

Step 5. Channel Bed and Planform Changes

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

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

5.4 Stream Ford or Animal Crossing: **Yes**
5.5 Straightening: **With Windrowing**
Straightening Length (ft.): **1,328**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **8**
6.2 Pool Substrate: **13**
6.3 Pool Variability: **10**
Total Score: **114**
Habitat Rating: **0.57**
Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **15**
6.5 Channel Flow Status: **10**
6.6 Channel Alteration: **8**
6.7 Channel Sinuosity: **5**

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

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	**14**	**None**	**Yes**
7.4 Change in Planforml	**11**	**None**	**Yes**
Total Score	**41**		

Geomorphic Rating **0.51**
Channel Evolution Model **F**
Channel Evolution Stage **II**
Geomorphic Condition **Fair**
Stream Sensitivity **Extreme**

Phase 2 Segment Summary Report Black River

Stream: **Patch Brook**
Reach: **M40T5.03-B**

Segment Length(ft): **7,623**
Rain: **Yes**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **10/29/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Along south side of Patch Road from Townsend Barn Rd bridge crossing downstream to bedrock gorge southwest of junction with Dublin Rd.**

Step 5 - Notes: **Patch Brook Road encroaches within the valley, along LB, and is elevated above the brook (cut into the left valley wall) at heights generally ranging from 6 to 15 feet (or 3 to nearly 8 times the bankfull depth of the channel). In one location mid-segment, where the height of the road is approximately 3.5 times the bankfull depth, presence of a short berm (between the road and the channel) and left-bank armoring suggests that the river may have avulsed in a past flood to wash out a section of the Patch Brook Road and temporarily occupy a small floodplain on the far side of the road. Encroachment by the road has resulted in human-modication of the valley width, such that the floodplain is now generally less than two channel widths (i.e., Narrowly-Confined). The natural valley width, prior to the road, was probably not much wider (between 1.5 to 2.5 times the channel width, or Narrowly-Confined to Semi-Confined valley type). No significant change in the reference stream type (Ba-S/P) is inferred as a result of the road encroachment. 21 cross culverts were indexed, most often 16 or 18 inches in diameter, but a few of 12- to 14-inch diameter and a few 2 feet in diameter. Often fine sand and gravels obstructed culvert inlets and culvert outlets were unstable (no headers). Road sediment was observed directly entering the channel at the outlet of several culverts. A few additional locations of direct sediment runoff by overland flow were indexed along the reach. Remnants of a possible instream dam were noted near the upstream end of the reach in the vicinity of historic mills depicted on the Beers Atlas (1869). This dam appears to have been breached long ago (perhaps in the 1927 flood or prior events). Upstream flow regulation is Lake Ninevah dam; outlet channel for this lake joins Patch Brook just above the upstream end of the reach. Townsend Barn Road bridge crosses the channel at the upstream end of the reach; bankfull-constrictor.**

Step 7 - Narrative: **Negligible active adjustment. Minor historic incision, Widening, planform adjustment. Lateral & vertical adjustments likely moderated by coarseness & erosion resistance of bed and bank materials, bedrock grade controls, and forested buffers.**

Step 1. Valley and Floodplain

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

	Length (ft) One	Height	Both	Height
Berm:	162	7	0	
Road:	7,185	8	0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	0		60	

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

1.5 Valley Features
Valley Width (ft): **35**
Width Determination: **Estimated**
Confinement Type: **NC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **Yes**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Waterfall	Mid-segment	20.0	19.0	Yes	

Stream: **Patch Brook** Reach: **M40T5.03-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**19.40**	2.11 Riffle/Step Spacing:	**40 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.20**	2.12 Substrate Composition		Bed:	**450** mm
2.3 Mean Depth (tf):	**1.27**	Bedrock:	**0.0 %**	Bar:	**N/A** mm
2.4 Floodprone Width (ft.):	**31.00**	Boulder:	**45.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**2.70**	Cobble:	**34.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**16.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**15.28**	Fine Gravel:	**2.0 %**	Subclass Slope:	**a**
2.7 Entrenchment Ratio:	**1.60**	Sand:	**3.0 %**	Bed Form:	**Step-Pool**
2.8 Incision Ratio:	**1.23**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**39**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**18.2**	**122.4**
Erosion Height (ft.):	**3.0**	**4.3**
Revetment Type:	**Rip-Rap**	**Multiple**
Revetment Length:	**1,478.9**	**492.4**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Shrubs/Sapling**	**Coniferous**
Bank Canopy		
Canopy %:	**51-75**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**>100**
Sub-Dominant	**26-50**	**None**
W less than 25	**7,278**	**0**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Coniferous**	**Coniferous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**One**	**15.0**
Gullies	**None**	

	Left	Right
Mass Failures		**34.6**
Height		**15.0**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Patch Brook** Reach: **M40T5.03-B**

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: **2**

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

4.7 Stormwater Inputs
Field Ditch: **0** Road Ditch: **18**
Other: **0** Tile Drain: **0**
Overland Flow: **2** Urb Strm Wtr Pipe: **0**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**12**	**Yes**	**Yes**	**Yes**	**Yes**	**None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **2** Point: **0** Side: **0**
Diagonal: **1** Delta: **0** Island: **3** Braiding: **3**

5.2 Other Features
Flood chutes: **6**
Neck Cutoff: **0** Avulsion: **0** Head Cuts: **0** Trib Rejuv.: **No**

5.3 Steep Riffles and Head Cuts
Steep Riffles: **0**

5.4 Stream Ford or Animal Crossing: **Yes**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **167**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **13**
6.2 Pool Substrate: **15**
6.3 Pool Variability: **13**
Total Score: **144**
Habitat Rating: **0.72**
Habitat Stream Condition: **Good**

6.4 Sediment Deposition: **15**
6.5 Channel Flow Status: **11**
6.6 Channel Alteration: **13**
6.7 Channel Sinuosity: **18**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**10**	**9**
6.9 Bank Vegetation Protection	**7**	**8**
6.10 Riparian Veg. Zone Width:	**2**	**10**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	**13**	**None**	**Yes**
7.2 Channel Aggradation	**15**	**None**	**Yes**
7.3 Widening Channel	**13**	**None**	**Yes**
7.4 Change in Planforml	**13**	**None**	**Yes**
Total Score	**54**		

Geomorphic Rating **0.68**
Channel Evolution Model **F**
Channel Evolution Stage **V**
Geomorphic Condition **Good**
Stream Sensitivity **Moderate**

Phase 2 Segment Summary Report   Black River

Stream: **Patch Brook**
Reach: **M40T5.04-A**

Segment Length(ft): **623**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/11/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**
Why Not Assessed: **wetland**

Step 0 - Location: **Wetland segment from Patch Road culvert downstream to reach break.**

Step 5 - Notes: **Segment is dominated by wetland conditions. Slight reduction in valley width due to encroachment of Patch Brook Rd (gravel) along LB. No change in valley type (Very Broad) or confinement status (Unconfined). Beaver activity. Short section of straightening is associated with culvert under Patch Brook Road (in upstream Segment B).**

Step 7 - Narrative:

Step 1. Valley and Floodplain

1.1 Segmentation: **Flow Status**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

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

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

1.5 Valley Features

Valley Width (ft): **290**
Width Determination: **Estimated**
Confinement Type: **VB**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **Yes**

1.6 Grade Controls: **None**

Phase 2 Segment Summary Report — Black River

Stream: **Patch Brook** Reach: **M40T5.04-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):		2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):		2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):		Bedrock:	%	Bar:	
2.4 Floodprone Width (ft.):		Boulder:	%	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):		Cobble:	%	Stream Type:	
Human Elev FloodPln (ft.):		Coarse Gravel:	%	Bed Material:	
2.6 Width/Depth Ratio:	**0.00**	Fine Gravel:	%	Subclass Slope:	
2.7 Entrenchment Ratio:	**0.00**	Sand:	%	Bed Form:	
2.8 Incision Ratio:	**0.00**	Silt and Smaller:	%	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:		2.15 Sub-reach Stream Type	
2.9 Sinuosity:		Detritus:	%	Reference Stream Type:	
2.10 Riffles Type:		# Large Woody Debris:		Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **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.):	**0.0**	**0.0**
Erosion Height (ft.):	**0.0**	**0.0**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

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

3.2 Riparian Buffer

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

3.3 Riparian Corridor

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

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

Stream: **Patch Brook**   Reach: **M40T5.04-A**

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

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

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

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

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

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **41**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

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

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

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

Step 7. Rapid Geomorphic Assessment Data

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

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

Phase 2 Segment Summary Report Black River

Stream: **Patch Brook**
Reach: **M40T5.04-B**

Segment Length(ft): **2,427**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/11/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **East of Unknown Soldier Road, from old gravel pits downstream to Patch Brook Rd culvert.**

Step 5 - Notes: **Valley walls are comprised of terraces ranging in height from 4 to 10 feet (or approximately 2.5 to 6 times the thalweg height). The valley defined by these terraces ranges in width from 45 to more than 250 feet. Low-bank heights along the channel were generally less than in upstream Segment C, ranging from approximately 1.2 to 1.6 times the thalweg height. Incision appeared historic in nature. Near the downstream end of the segment was a short section of moderately-steep, narrowly-confined bedrock gorge. This section of B2-step/pool channel underlain by bedrock was indexed as a vertical grade control, but was not segmented due to its short overall length (less than 75 feet). Between the bedrock outcroppings was a short, linear section of channel confined between a left-bank terrace with a thalweg height of approximately 7 feet and a right-bank terrace approx 15 feet above the thalweg. The channel had access to a narrow floodplain approximately 20 to 30 feet wide between these two terraces. A cross section measured here (XS-1) indicated an incision ratio of 1.3 and an entrenchment ratio of 1.8. This gravel-dominated Bc-riffle/pool channel was not characteristic of the segment as a whole, but was not segmented due to its very short length. The linear nature of the channel and its unusual setting suggested historic channel modifications - possibly associated with the history of iron ore mining in the region. Proximity to the upstream bedrock gorge suggests possible mill dam operations. A black smith shop and saw mill were noted in the vicinity on the 1869 Beers Atlas of Windsor County (near the Patch Brook Road crossing).**

Step 7 - Narrative: **Moderate aggradation. Historic incision.**

Step 1. Valley and Floodplain

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

	Length (ft) One	Height	Length (ft) Both	Height
Berm:	0		0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	49		74	

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

1.5 Valley Features
Valley Width (ft): **80**
Width Determination: **Estimated**
Confinement Type: **NW**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Waterfall	Mid-segment	8.0	8.0	Yes	
Ledge	Mid-segment	1.0	1.0	No	

Stream: **Patch Brook** Reach: **M40T5.04-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**14.70**	2.11 Riffle/Step Spacing:	**50 ft.**	2.13 Average Largest Particle on			
2.2 Max Depth (ft.):	**1.70**	2.12 Substrate Composition			Bed:	**35**	**mm**
2.3 Mean Depth (tf):	**1.21**	Bedrock:	**0.0 %**		Bar:	**44**	**mm**
2.4 Floodprone Width (ft.):	**55.00**	Boulder:	**0.0 %**	2.14 Stream Type			
2.5 Aband. Floodpn (ft.):	**2.00**	Cobble:	**0.0 %**	Stream Type:	**C**		
Human Elev FloodPln (ft.):		Coarse Gravel:	**44.0 %**	Bed Material:	**Gravel**		
2.6 Width/Depth Ratio:	**12.15**	Fine Gravel:	**30.0 %**	Subclass Slope:	**None**		
2.7 Entrenchment Ratio:	**3.74**	Sand:	**25.0 %**	Bed Form:	**Riffle-Pool**		
2.8 Incision Ratio:	**1.18**	Silt and Smaller:	**1.0 %**	Field Measured Slope:			
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type			
2.9 Sinuosity:	**Moderate**	Detritus:	**2.0 %**	Reference Stream Type:	**C**		
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**12**	Reference Bed Material:	**Gravel**		
				Reference Subclass Slope:	**None**		
				Reference Bedform:	**Riffle-Pool**		

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	**160.1**	**42.3**	Dominant:	**Herbaceous**	**Herbaceous**
Material Type:	**Mix**	**Mix**	Erosion Height (ft.):	**2.0**	**2.0**	Sub-dominant:	**Deciduous**	**Deciduous**
Consistency:	**Cohesive**	**Cohesive**	Revetment Type:	**None**	**None**	Bank Canopy		
Lower			Revetment Length:	**0.0**	**0.0**	Canopy %:	**76-100**	**76-100**
Material Type:	**Mix**	**Mix**				Mid-Channel Canopy:	**Closed**	
Consistency:	**Cohesive**	**Cohesive**						

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**None**	**0-25**
W less than 25	**56**	**185**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Deciduous**
Sub-Dominant	**Coniferous**	**Coniferous**

3.3 Riparian Corridor

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

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

Stream: **Patch Brook** Reach: **M40T5.04-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Minimal**	4.5 Flow Regulation Type	**Small Withdrawal**	4.7 Stormwater Inputs	**None**
4.2 Adjacent Wetlands:	**Minimal**	Flow Reg. Use:	**Other**	Field Ditch:	Road Ditch:
4.3 Flow Status:	**Moderate**	Impoundments:		Other:	Tile Drain:
4.4 # of Debris Jams:	**6**	Impoundment Loc.:		Overland Flow:	Urb Strm Wtr Pipe:
		4.6 Up/Down Strm flow reg.:	**None**	4.9 # of Beaver Dams:	**0**
		(old) Upstrm Flow Reg.:		Affected Length (ft):	**0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Instream Culvert	**3.5**	**Yes**	**Yes**	**Yes**	**Yes**	**Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**3**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**No**
Mid:	**6**	Delta:	**1**	Flood chutes:	**3**	Avulsion:	**0**	5.5 Straightening:	**Straightening**
Point:	**20**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**512**
Side:	**16**	Braiding:	**0**	Steep Riffles:	**0**	Trib Rejuv.:	**No**	5.5 Dredging:	**None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**10**	6.4 Sediment Deposition:	**13**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**11**	6.5 Channel Flow Status:	**11**	6.8 Bank Stability:	**8**	**9**
6.3 Pool Variability:	**11**	6.6 Channel Alteration:	**15**	6.9 Bank Vegetation Protection	**8**	**9**
Total Score:	**140**	6.7 Channel Sinuosity:	**16**	6.10 Riparian Veg. Zone Width:	**10**	**9**
Habitat Rating:	**0.70**					
Habitat Stream Condition:	**Good**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic		
7.1 Channel Degradation	**13**	**None**	**Yes**	Geomorphic Rating	**0.69**
7.2 Channel Aggradation	**11**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**16**	**None**	**No**	Channel Evolution Stage	**II**
7.4 Change in Planforml	**15**	**None**	**Yes**	Geomorphic Condition	**Good**
Total Score	**55**			Stream Sensitivity	**High**

Phase 2 Segment Summary Report **Black River**

Stream:	**Patch Brook**	SGAT Version:	**4.56**
Reach:	**M40T5.04-C**	Organization:	**South Windsor County Regional Planning Commission**
Segment Length(ft):	**2,297**	Observers:	**KLU, BOS - SMRC**
Rain:	**No**	Completion Date:	**9/11/2009**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **East of Unknown Soldier Road from above the Catamount Trail bridge crossing downstream to vicinity of old gravel pits.**

Step 5 - Notes: **subreach of slightly lesser gradient than upstream Segment D, but located in a Semi-confined to Narrow confinement setting. Valley walls are comprised of terraces ranging in height from 5 to 7 feet (or approximately 3 to 5 times the thalweg height). The valley defined by these terraces ranges in width from 15 to 80 feet. Low-bank heights along the channel generally increased with distance downstream, ranging from approximately 1.2 to 1.7 times the thalweg height. Incision appeared historic in nature. small flow diversion consisting of a 4-inch black flex hose leading from the channel to a nearby impoundment. The intake in the channel is a PVC pipe connected by a Fernco fitting to a flexible hose. The hose was traced through the woods to a narrow pond impounded by a horse-shoe shaped earthen dam approximately 8 feet high and 270 feet long. A culvert was located at the downstream end of the pond and apparently drains the pond. The exact outlet location of the culvert could not be located, although seepage was evident at the base of the dam along a majority of its length. A return channel joins the main Patch Brook channel approximately 650 feet downstream of the intake location. While the VHD indicates that Patch Brook flows through this pond, actual conditions on the ground indicate that the Patch Brook flows alongside the pond between 100 and 150 feet to the east (and 5 to 15 feet lower in elevation). Catamount Trail timber bridge is bankfull constrictor. Overland flow from the trail enters the stream at this crossing. Additional ford crossing in the segment appears to be from an old logging access.**

Step 7 - Narrative: **Minor aggradation and planform adjustment. Historic incision.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Subreach**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**0**		**0**	
Railroad:	**0**		**0**	
Imp. Path:	**0**		**0**	
Dev.:	**0**		**46**	

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

1.5 Valley Features

Valley Width (ft):	**30**
Width Determination:	**Estimated**
Confinement Type:	**SC**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**No**

1.6 Grade Controls: **None**

Stream: **Patch Brook** Reach: **M40T5.04-C**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**12.48**	2.11 Riffle/Step Spacing:	**25 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.40**	2.12 Substrate Composition		Bed:	**170 mm**
2.3 Mean Depth (tf):	**0.92**	Bedrock:	**0.0 %**	Bar:	**83 mm**
2.4 Floodprone Width (ft.):	**30.00**	Boulder:	**5.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**2.30**	Cobble:	**27.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**35.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**13.57**	Fine Gravel:	**16.0 %**	Subclass Slope:	**b**
2.7 Entrenchment Ratio:	**2.40**	Sand:	**14.0 %**	Bed Form:	**Step-Pool**
2.8 Incision Ratio:	**1.64**	Silt and Smaller:	**3.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Moderate**	Detritus:	**3.0 %**	Reference Stream Type:	**C**
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**35**	Reference Bed Material:	**Gravel**
				Reference Subclass Slope:	**b**
				Reference Bedform:	**Step-Pool**

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.):	**259.9**	**48.5**
Erosion Height (ft.):	**2.4**	**4.0**
Revetment Type:	**Other**	**Other**
Revetment Length:	**39.5**	**36.6**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**Multiple**	**6.5**
Gullies	**None**	

	Left	Right
Mass Failures		**61.47**
Height		**6.5**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Patch Brook** Reach: **M40T5.04-C**

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: **15**

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

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

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**5**	**Yes**	**Yes**	**Yes**	**Yes**	**Deposition Above,Alignment**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **4** Point: **7** Side: **7**
Diagonal: **2** Delta: **0** Island: **3** Braiding: **0**

5.2 Other Features
Flood chutes: **7**
Neck Cutoff: **0** Avulsion: **0**
5.3 Steep Riffles and Head Cuts
Head Cuts: **0**
Steep Riffles: **0** Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **Yes**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **10**
6.2 Pool Substrate: **11**
6.3 Pool Variability: **11**
Total Score: **140**
Habitat Rating: **0.70**
Habitat Stream Condition: **Good**

6.4 Sediment Deposition: **13**
6.5 Channel Flow Status: **11**
6.6 Channel Alteration: **15**
6.7 Channel Sinuosity: **16**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**8**	**9**
6.9 Bank Vegetation Protection	**8**	**9**
6.10 Riparian Veg. Zone Width:	**10**	**9**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	**8**	**None**	**Yes**
7.2 Channel Aggradation	**15**	**None**	**No**
7.3 Widening Channel	**18**	**None**	**No**
7.4 Change in Planforml	**15**	**None**	**No**
Total Score	**56**		

Geomorphic Rating **0.70**
Channel Evolution Model **F**
Channel Evolution Stage **II**
Geomorphic Condition **Good**
Stream Sensitivity **High**

Phase 2 Segment Summary Report Black River

Stream: **Patch Brook**
Reach: **M40T5.04-D**

Segment Length(ft): **851**
Rain: **Yes**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/3/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **East of Unknown Soldier class 4 road, from downstream of Unknown Soldier bridge crossing to a point upstream from the Catamount Trail bridge crossing.**

Step 5 - Notes: **Generally the river channel as depicted on the VHD does not match up well with the actual planform (as measured with the GPS on assessment dates in Sept 2009). The channel is actually more sinuous than that depicted by the VHD. Subreach of somewhat lesser gradient in an unconfined setting, with typical valley widths ranging from 100 feet to more than 200 feet. Good floodplain connection. A natural reduction in valley confinement and gradient (from approximately 10% in Segment E to 4.4% in Segment D) may be contributing to the minor degree of aggradation and planform adjustment. Lateral and vertical adjustments are probably moderated by the dense, young-growth forest cover, and erosion resistance of glacial till parent material in the bed and banks of the channel. Also, limited degree of sediment from upstream sources. Lots of LWD recruitment and a frequent spacing of channel-spanning debris jams. Entrained woody material contributes to pool formation. Generally closed canopy – offering shading and ample organic material and detritus**

Step 7 - Narrative: **Minor aggradation and planform adjustment. Lateral / vertical adjustment moderated by erosion resistance of bed and bank sediments.**

Step 1. Valley and Floodplain

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

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

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

1.5 Valley Features
Valley Width (ft): **250**
Width Determination: **Estimated**
Confinement Type: **VB**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls: **None**

Stream: **Patch Brook** Reach: **M40T5.04-D**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**10.98**	2.11 Riffle/Step Spacing:	**70 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.30**	2.12 Substrate Composition		Bed:	**125** mm
2.3 Mean Depth (tf):	**0.94**	Bedrock:	**0.0 %**	Bar:	**29** mm
2.4 Floodprone Width (ft.):	**200.00**	Boulder:	**3.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**1.50**	Cobble:	**41.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**33.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**11.68**	Fine Gravel:	**10.0 %**	Subclass Slope:	**a**
2.7 Entrenchment Ratio:	**18.21**	Sand:	**6.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.15**	Silt and Smaller:	**7.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Moderate**	Detritus:	**2.0 %**	Reference Stream Type:	**C**
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**45**	Reference Bed Material:	**Gravel**
				Reference Subclass Slope:	**a**
				Reference Bedform:	**Riffle-Pool**

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:	**Gravel**	**Gravel**
Consistency:	**Non-cohesive**	**Non-cohesive**

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

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

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

3.3 Riparian Corridor

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

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

Stream: **Patch Brook** Reach: **M40T5.04-D**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Minimal**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs	**None**
4.2 Adjacent Wetlands:	**Abundant**	Flow Reg. Use:		Field Ditch:	Road Ditch:
4.3 Flow Status:	**Moderate**	Impoundments:		Other:	Tile Drain:
4.4 # of Debris Jams:	**8**	Impoundment Loc.:		Overland Flow:	Urb Strm Wtr Pipe:
		4.6 Up/Down Strm flow reg.:	**None**	4.9 # of Beaver Dams:	**0**
		(old) Upstrm Flow Reg.:		Affected Length (ft):	**0**

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**0**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**No**
Mid:	**4**	Delta:	**0**	Flood chutes:	**1**	Avulsion:	**0**	5.5 Straightening:	**None**
Point:	**8**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**0**
Side:	**2**	Braiding:	**0**	Steep Riffles:	**0**	Trib Rejuv.:	**No**	5.5 Dredging:	**None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**10**	6.4 Sediment Deposition:	**13**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**11**	6.5 Channel Flow Status:	**11**	6.8 Bank Stability:	**8**	**9**
6.3 Pool Variability:	**11**	6.6 Channel Alteration:	**15**	6.9 Bank Vegetation Protection	**8**	**9**
Total Score:	**140**	6.7 Channel Sinuosity:	**16**	6.10 Riparian Veg. Zone Width:	**10**	**9**
Habitat Rating:	**0.70**					
Habitat Stream Condition:	**Good**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Unconfined** Score	STD	Historic		
7.1 Channel Degradation	**16**	**None**	**No**	Geomorphic Rating	**0.76**
7.2 Channel Aggradation	**13**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**18**	**None**	**No**	Channel Evolution Stage	**I**
7.4 Change in Planforml	**14**	**None**	**No**	Geomorphic Condition	**Good**
Total Score	**61**			Stream Sensitivity	**High**

Phase 2 Segment Summary Report **Black River**

Stream: **Patch Brook**
Reach: **M40T5.04-E**

Segment Length(ft): **4,578**
Rain: **Yes**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/3/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **From upstream reach break to downstream of the Unknown Soldier Rd (class 4) bridge crossing.**

Step 5 - Notes: **Colluvial processes leading to disorganized bed structure (cascade), with some sections of step/pool (subdominant bedform). Valley confinement varies from Semi-confined to Narrowly-confined, but dominated by Semi-confined. Cross section happened to be located in Narrowly-confined spot. Timber bridge on stone abutments at Unknown Soldier Rd crossing is bankfull constrictor. Overland flow from road joins channel at this crossing. Two fords in the reach: one log crossing for footpath, and one upstream trail crossing.**

Step 7 - Narrative: **Minor localized widening; minor planform adjustment.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	0		0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	0		55	

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

1.5 Valley Features

Valley Width (ft): **20**
Width Determination: **Estimated**
Confinement Type: **SC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls: **None**

Stream: **Patch Brook** Reach: **M40T5.04-E**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**9.10**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.80**	2.12 Substrate Composition		Bed:	**N/A**
2.3 Mean Depth (tf):	**0.81**	Bedrock:	**0.0 %**	Bar:	**N/A**
2.4 Floodprone Width (ft.):	**17.00**	Boulder:	**17.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**1.80**	Cobble:	**27.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**25.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**11.23**	Fine Gravel:	**16.0 %**	Subclass Slope:	**a**
2.7 Entrenchment Ratio:	**1.87**	Sand:	**1.0 %**	Bed Form:	**Cascade**
2.8 Incision Ratio:	**1.00**	Silt and Smaller:	**14.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**5.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Not Applicable**	# Large Woody Debris:	**67**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Moderate**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**0.0**	**0.0**
Erosion Height (ft.):	**0.0**	**0.0**
Revetment Type:	**Other**	**Other**
Revetment Length:	**37.9**	**41.2**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Coniferous**	**Coniferous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**None**	**None**
W less than 25	**66**	**66**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

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

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

Stream: **Patch Brook** Reach: **M40T5.04-E**

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: **7**

4.5 Flow Regulation Type **None**

Flow Reg. Use:

Impoundments:

Impoundment Loc.:

4.6 Up/Down Strm flow reg.: **None**

(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs

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

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

Overland Flow: **2** Urb Strm Wtr Pipe: **0**

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**5**	**Yes**	**Yes**	**Yes**	**Yes**	**None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid:	**2**	Diagonal:	**0**
Point:	**0**	Delta:	**0**
Side:	**0**	Island:	**3**
		Braiding:	**0**

5.2 Other Features

Flood chutes: **5**

Neck Cutoff: **0**

Avulsion: **0**

5.3 Steep Riffles and Head Cuts

Steep Riffles: **0**

Head Cuts: **0**

Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **Yes**

5.5 Straightening: **None**

Straightening Length (ft.): **0**

5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**10**
6.2 Pool Substrate:	**11**
6.3 Pool Variability:	**11**
Total Score:	**140**
Habitat Rating:	**0.70**
Habitat Stream Condition:	**Good**

6.4 Sediment Deposition:	**13**
6.5 Channel Flow Status:	**11**
6.6 Channel Alteration:	**15**
6.7 Channel Sinuosity:	**16**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**8**	**9**
6.9 Bank Vegetation Protection	**8**	**9**
6.10 Riparian Veg. Zone Width:	**10**	**9**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	**18**	**None**	**No**
7.2 Channel Aggradation	**16**	**None**	**No**
7.3 Widening Channel	**15**	**None**	**No**
7.4 Change in Planforml	**16**	**None**	**No**
Total Score	**65**		

Geomorphic Rating	**0.81**
Channel Evolution Model	**F**
Channel Evolution Stage	**I**
Geomorphic Condition	**Good**
Stream Sensitivity	**Moderate**

Phase 2 Segment Summary Report   Black River

Stream: **Unnamed trib to Patch Brook**
Reach: **M40T5.03S1.01-0**

Segment Length(ft): **1,221**
Rain: **No**

SGAT Version: **4.56**
Organization: **South Windsor County Regional Planning Commission**
Observers: **KLU, BOS - SMRC**
Completion Date: **9/11/2009**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Outlet from Lake Ninevah, crossing under Loop Road (pvt) at Mount Holly / Plymouth town line.**

Step 5 - Notes: **Semi- to Narrowly-confined by moderately sloping valley walls comprised of glacial till. Joins the Patch Brook in a wetlands upstream of the Townsend Barn Road. The downstream end (~125 feet) of the Lake Ninevah outlet channel is also characterized by wetland conditions and backwater effects from this wetland. Bedform is transitional from S/P to R/P with distance downstream and decreasing gradient on approach to wetlands. Loop Road, a private gravel road, crosses the channel near its mid-point via a timber frame bridge on laid-up-stone foundation. The span of this bridge is bankfull constricting. Upstream flow regulation is Lake Ninevah run-of-river dam. Current use: recreational; historic use: hydroelectric. Records reviewed at VTDEC indicate that historically, lake levels were lowered in the Fall of each year resulting in increased flows to outlet channel (and downstream Patch Brook).**

Step 7 - Narrative: **Negligible.**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**0**		**0**	
Railroad:	**0**		**0**	
Imp. Path:	**0**		**0**	
Dev.:	**58**		**26**	

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

1.5 Valley Features

Valley Width (ft): **30**
Width Determination: **Estimated**
Confinement Type: **NC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls: **None**

Stream: **Unnamed trib to Patch Brook**   Reach: **M40T5.03S1.01-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**17.00**	2.11 Riffle/Step Spacing:	**120 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.30**	2.12 Substrate Composition		Bed:	**350** mm
2.3 Mean Depth (tf):	**0.84**	Bedrock:	**0.0 %**	Bar:	**N/A** mm
2.4 Floodprone Width (ft.):	**26.00**	Boulder:	**15.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**1.30**	Cobble:	**40.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**4.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**20.24**	Fine Gravel:	**7.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.53**	Sand:	**21.0 %**	Bed Form:	**Step-Pool**
2.8 Incision Ratio:	**1.00**	Silt and Smaller:	**13.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**5.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**2**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Moderate**

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

Bank Erosion	Left	Right
Erosion Length (ft.):	**0.0**	**0.0**
Erosion Height (ft.):	**0.0**	**0.0**
Revetment Type:	**None**	**Rip-Rap**
Revetment Length:	**0.0**	**131.6**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Herbaceous**	**Herbaceous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

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

3.3 Riparian Corridor

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

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

Stream: **Unnamed trib to Patch Brook** Reach: **M40T5.03S1.01-0**

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: **2**

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

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

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**7**	**Yes**	**Yes**	**Yes**	**Yes**	**Alignment**

Step 5. Channel Bed and Planform Changes

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

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

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

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **15**
6.2 Pool Substrate: **13**
6.3 Pool Variability: **11**
Total Score: **148**
Habitat Rating: **0.74**
Habitat Stream Condition: **Good**

6.4 Sediment Deposition: **15**
6.5 Channel Flow Status: **10**
6.6 Channel Alteration: **16**
6.7 Channel Sinuosity: **15**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**8**	**8**
6.9 Bank Vegetation Protection	**9**	**9**
6.10 Riparian Veg. Zone Width:	**10**	**9**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	**18**	**None**	**No**
7.2 Channel Aggradation	**16**	**None**	**No**
7.3 Widening Channel	**18**	**None**	**No**
7.4 Change in Planforml	**16**	**None**	**No**
Total Score	**68**		

Geomorphic Rating **0.85**
Channel Evolution Model **F**
Channel Evolution Stage **I**
Geomorphic Condition **Reference**
Stream Sensitivity **Moderate**

APPENDIX B

Bridge and Culvert Assessment Summary Reports

Stream Geomorphic Assessment

VT DEC

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November. 07

Bridge Summary Report

Black River

General Information

SgaID	**990048000014121**	Local SgaID		VOBCIT struct_num	
Observers	**K.Underwood, B.O'Shea**	Assessment Date	**00/03/2009**	Project Name	**Black River**
Town	**Plymouth**	Latitude	**43.49342**	Longitude	**-72.75667**
Location	**1.1 mile north of Jct w/ Patch Brook Rd**			Reach VTID	**M40T5.04**
Road Name	**UNKNOWN SOLDIER RD**	Road Type	**Gravel**	Stream Name	**Patch Brook**
High Flow Stage	**No**	Channel Width	**9.1**		

Bridge Information

Bridge Width	**9.1**	Material	**Timber**
Bridge Clearance	**2.5**	Number of bridge piers/arches	
Bridge/Arch Span	**5**		
		Skewed to roadway?	**No**

Geomorphic Information

General

Floodplain filled by roadway approaches	**Not Significant**	Structure is located at significant break in valley slope	**Yes**

Upstream

Obstructions at the opening of the structure	**None**	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	**No**	Angle of stream flow approaching structure	**Mild Bend**
If channel avulses, stream will	**Cross Road**		

Downstream

Pool present immediately downstream of structure	**No**
Downstream bank heights are substantially higher than upstream bank heights	**No**
Pool Depth at point of streamflow entry	**No**

	Upstream	Downstream	In Structure
Dominant Bed Material	**Cobble**	**Cobble**	**Boulder**
Bedrock Present	**No**	**No**	**No**
Type of Sediment Deposits	**None**	**None**	**None**
Elevation of sediment deposits >= 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?

Vegitation Band - Left	**No**	**No**	
Vegitation Band -Right	**No**	**No**	

Wildlife

	Roadkill	Outside Structure	Inside Structure
Species	**None**	**Deer - Scat**	**None**

Other Information

Spatial location data collected with GPS?	**Yes**	Photos taken?	**Yes**

Comments **TRANS_RDS layer shows incorrect path of road and location of crossing as compared to 1994 ortho and GPS waypoints from assessment date. Structure span measured at approx bankfull elevation between stone abutments. Span measured at bridge elevation = 11.7 ft.**

Bridge Summary Report

Black River

General Information

SgaID	**990000000114123**	Local SgaID		VOBCIT struct_num	
Observers	**K.Underwood, B.O'Shea**	Assessment Date	**00/03/2009**	Project Name	**Black River**
Town	**Plymouth**	Latitude	**43.48644**	Longitude	**-72.75201**
Location	**On Catamount Trail, 550 East of Unknown Soldier Rd; 3500 ft upstream of Patch Brook Rd crossing.**			Reach VTID	**M40T5.04**
Road Name		Road Type	**Trail**	Stream Name	**Patch Brook**
High Flow Stage	**No**	Channel Width	**12.5**		

Bridge Information

Bridge Width	**5**	Material	**Timber**
Bridge Clearance	**2.2**	Number of bridge piers/arches	
Bridge/Arch Span	**5**		
		Skewed to roadway?	**No**

Geomorphic Information

General

Floodplain filled by roadway approaches	**Not Significant**	Structure is located at significant break in valley slope	**Yes**

Upstream

Obstructions at the opening of the structure	**Wood debris**	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	**No**	Angle of stream flow approaching structure	**Sharp Bend**
If channel avulses, stream will	**Cross Road**		

Downstream

Pool present immediately downstream of structure	**Yes**
Downstream bank heights are substantially higher than upstream bank heights	**No**
Pool Depth at point of streamflow entry	**No**

	Upstream	Downstream	In Structure
Dominant Bed Material	**Cobble**	**Boulder**	**Boulder**
Bedrock Present	**No**	**No**	**No**
Type of Sediment Deposits	**Side**	**None**	**None**
Elevation of sediment deposits >= 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	**Mixed 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?

	Upstream	Downstream	In Structure
Vegitation Band - Left	**Yes**	**Yes**	
Vegitation Band -Right	**Yes**	**Yes**	

Wildlife

	Roadkill	Outside Structure	Inside Structure
Species	**None**	**None**	**None**

Other Information

Spatial location data collected with GPS?	**Yes**	Photos taken?	**Yes**

Comments **Wooden planks (partially collapsed) over boulder abutments. Apparent ford on upstream side of crossing. Stormwater runoff from trail to right-bank upstream, conveying sands / silts into stream. Wood debris obstructions = collapsing bridge timbers. Armoring = stone abutments.**

Stream Geomorphic Assessment

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November. 07

Culvert Summary Report

Black River

General Information

SgaID	**600015000014121**	Local SgaID		VOBCIT struct_num	
Observers	**K.Underwood, B.O'Shea**	Assessment Date	**00/11/2009**	Project Name	**Black River**
Town	**Plymouth**	Latitude	**43.47725**	Longitude	**-72.75146**
Location	**910 ft northwest of Jct w/ Townsend Barn Rd**			Reach VTID	**M40T5.04**
Road Name	**PATCH BROOK RD**	Road Type	**Gravel**	Stream Name	**Patch Brook**
High Flow Stage	**No**	Channel Width			**14.7**

Culvert Information

Culvert Length	**24**	Material	**Steel Corrugated**
Culvert Height	**3.5**	Number of culverts	**1**
Culvert Width	**3.5**	Culvert Overflow Pipe	**No**
		Skewed to roadway?	**No**

Geomorphic Information

General

Floodplain filled by roadway approaches	**Partially**	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**	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	**No**	Angle of stream flow approaching structure	**Mild Bend**
If channel avulses, stream will	**Cross Road**		

Downstream

Pool present immediately downstream of structure	**Yes**	Water depth in culvert (at outlet)	**1.3**
Downstream bank heights are substantially higher than upstream bank heights	**No**	Culvert outlet invert	**Entirely Backwatered**
Stepped Footers	**1.3 ft.**	Backwater Length (measured from outlet)	**24**
Maximum pool depth	**2 ft.**	Backwater Length (measured from outlet)	**0**

	Upstream	Downstream	In Structure
Dominant Bed Material	**Gravel**	**Gravel**	**Gravel**
Bedrock Present	**No**	**No**	
Type of Sediment Deposits	**None**	**Point**	**None**
Material Present throughout			**No**
Elevation of sediment deposits >= 1/2 bankfull	**No**	**No**	**No**
Bank Erosion	**Low**	**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	**Mixed Forest**	**Shrub/Sapling**	
Dominant Vegetation Type - Right	**Mixed 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?

	Upstream	Downstream
Vegitation Band - Left	**Yes**	**Yes**
Vegitation Band -Right	**Yes**	**Yes**

Wildlife

	Roadkill	Outside Structure	Inside Structure
Species	**None**	**None**	**None**

Other Information

Spatial location data collected with GPS? **Yes** Photos taken? **Yes**

Comments **Wetland downstream of culvert.**

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Stream Geomorphic Assessment

VT DEC

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Bridge Summary Report

Black River

General Information

SgaID	**700000000214123**	Local SgaID		VOBCIT struct_num	
Observers	**K.Underwood, B.O'Shea**	Assessment Date	**00/11/2009**	Project Name	**Black River**
Town	**Plymouth**	Latitude	**43.4736**	Longitude	**-72.74955**
Location	**185 ft southwest of Jct w/ Townsend Barn Rd**			Reach VTID	**M40T5.03S1.01**
Road Name	**LOOP RD (PVT)**	Road Type	**Gravel**	Stream Name	**Unnamed trib to Patch Bk (Lake Ninevah outlet)**

High Flow Stage **No** | Channel Width **17**

Bridge Information

Bridge Width	**12.5**	Material	**Timber**
Bridge Clearance	**3.3**	Number of bridge piers/arches	
Bridge/Arch Span	**7**		
		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**	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	**No**	Angle of stream flow approaching structure	**Naturally Straight**
If channel avulses, stream will	**Cross Road**		

Downstream

Pool present immediately downstream of structure	**No**
Downstream bank heights are substantially higher than upstream bank heights	**No**
Pool Depth at point of streamflow entry	**No**

	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 >= 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	**Mixed 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?

Vegitation Band - Left	**Yes**	**Yes**	
Vegitation Band -Right	**Yes**	**Yes**	

Wildlife

	Roadkill	Outside Structure	Inside Structure
Species	**None**	**Deer - Tracks**	**None**

Other Information

Spatial location data collected with GPS? **Yes** | Photos taken? **Yes**

Comments **Structure is on the town line with Mount Holly. Timber deck on stone abutments.**

VERMONT

Stream Geomorphic Assessment

VT DEC

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November. 07

Bridge Summary Report

Black River

General Information

SgaID	400026000014121	Local SgaID		VOBCIT struct_num	
Observers	K.Underwood, B.O'Shea	Assessment Date	00/29/2009	Project Name	Black River
Town	Plymouth	Latitude	43.47587	Longitude	-72.74855
Location	100 ft south of Jct w/ Patch Brook Rd			Reach VTID	M40T5.03
Road Name	TOWNSEND BARN RD	Road Type	Gravel	Stream Name	Patch Brook
High Flow Stage	No		Channel Width		19.4

Bridge Information

Bridge Width	17.5	Material	Concrete
Bridge Clearance	10	Number of bridge piers/arches	
Bridge/Arch Span	12		
		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	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	No	Angle of stream flow approaching structure	Mild Bend
If channel avulses, stream will	Unsure		

Downstream

Pool present immediately downstream of structure	No
Downstream bank heights are substantially higher than upstream bank heights	No
Pool Depth at point of streamflow entry	Yes

	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 >= 1/2 bankfull	No	No	No
Bank Erosion	None	None	
Hard Bank Armoring	Intact	Intact	
Stream bed scour causing undermining around or under structure	Footers	Footers	
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?

	Upstream	Downstream
Vegitation Band - Left	Yes	No
Vegitation Band -Right	Yes	Yes

Wildlife

	Roadkill	Outside Structure	Inside Structure
Species	None	None	None

Other Information

Spatial location data collected with GPS?	Yes	Photos taken?	Yes

Comments **From bc_localinventorytable_points.shp, structure number = 990026001614121**

Bridge Summary Report

Black River

General Information

SgaID	400015000114121	Local SgaID		VOBCIT struct_num	
Observers	K.Underwood, B.O'Shea	Assessment Date	00/10/2009	Project Name	Black River
Town	Plymouth	Latitude	43.47548	Longitude	-72.71668
Location	1000 ft East of Jct w/ Davis Road			Reach VTID	M40T5.03
Road Name	DUBLIN RD	Road Type	Paved	Stream Name	Patch Brook
High Flow Stage	No	Channel Width			27.1

Bridge Information

Bridge Width	18.9	Material	Concrete
Bridge Clearance	7.5	Number of bridge piers/arches	
Bridge/Arch Span	14.4		
		Skewed to roadway?	Yes

Geomorphic Information

General

Floodplain filled by roadway approaches	Partially	Structure is located at significant break in valley slope	Yes

Upstream

Obstructions at the opening of the structure	Sediment	Estimated distance avulsion would follow road	1000
Steep riffle present immediately upstream of structure	Yes	Angle of stream flow approaching structure	Sharp Bend
If channel avulses, stream will	Follow Road		

Downstream

Pool present immediately downstream of structure	No
Downstream bank heights are substantially higher than upstream bank heights	No
Pool Depth at point of streamflow entry	Yes

	Upstream	Downstream	In Structure
Dominant Bed Material	Cobble	Cobble	Cobble
Bedrock Present	No	No	Yes
Type of Sediment Deposits	None	None	None
Elevation of sediment deposits >= 1/2 bankfull	No	No	No
Bank Erosion	None	None	
Hard Bank Armoring	Intact	Intact	
Stream bed scour causing undermining around or under structure	Footers	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	Shrub/Sapling	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?

	Upstream	Downstream
Vegitation Band - Left	No	Yes
Vegitation 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 **Apparent boulder grade control immediately upstream of structure. Left-bank high berm and channel relocation downstream. Stepped footers both banks. Structure number in bc_localinvertorytable_points.shp = 990015001414121**

Bridge Summary Report

Black River

General Information

SgaID	400036000014121	Local SgaID		VOBCIT struct_num	
Observers	K.Underwood, B.O'Shea	Assessment Date	00/10/2009	Project Name	Black River
Town	Plymouth	Latitude	43.47449	Longitude	-72.71455
Location	40 ft Northeast of Jct w/ Dublin Road			Reach VTID	M40T5.02
Road Name	DUBLIN RD	Road Type	Gravel	Stream Name	Patch Brook
High Flow Stage	No		Channel Width		28

Bridge Information

Bridge Width	16	Material	Concrete
Bridge Clearance	6.1	Number of bridge piers/arches	
Bridge/Arch Span	12.8		
		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	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	Yes	Angle of stream flow approaching structure	Mild Bend
If channel avulses, stream will	Cross Road		

Downstream

Pool present immediately downstream of structure	Yes
Downstream bank heights are substantially higher than upstream bank heights	Yes
Pool Depth at point of streamflow entry	Yes

	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 >= 1/2 bankfull	No	No	No
Bank Erosion	None	None	
Hard Bank Armoring	Intact	Intact	
Stream bed scour causing undermining around or under structure	Wing walls	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	Shrub/Sapling	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?

	Upstream	Downstream
Vegitation Band - Left	No	No
Vegitation 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 **Recorded span is between stepped footers within the bankfull elevation. Above the stepped footers, the span between abutments is 19 feet. Max pool depth = 1.2 feet.**

Bridge Summary Report

Black River

General Information

SgaID	400015000014121	Local SgaID		VOBCIT struct_num	
Observers	KLU, BOS- SMRC	Assessment Date	00/10/2009	Project Name	Black River
Town	Plymouth	Latitude	43.46571	Longitude	-72.70573
Location	570 ft west of Jct w/ VT Route 100			Reach VTID	M40T5.01
Road Name	DUBLIN RD	Road Type	Paved	Stream Name	Patch Brook
High Flow Stage	No		Channel Width		33.3

Bridge Information

Bridge Width	29	Material	Concrete
Bridge Clearance	7	Number of bridge piers/arches	
Bridge/Arch Span	19		
		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	Wood debris	Estimated distance avulsion would follow road	2000
Steep riffle present immediately upstream of structure	Yes	Angle of stream flow approaching structure	Sharp Bend
If channel avulses, stream will	Follow Road		

Downstream

Pool present immediately downstream of structure	No
Downstream bank heights are substantially higher than upstream bank heights	No
Pool Depth at point of streamflow entry	Yes

	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 >= 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	Footers	
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	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?

Vegitation Band - Left	No	No	
Vegitation 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 **Stormwater pipe (4-inch corrugated plastic) drains to channel near bridge outlet (RB, d/s). Bridge is located in Segment B of the indicated reach. Stepped footer (and scour) is along LB. Nearby landowner indicates bridge was washed out in 1973 flood.**

Bridge Summary Report

Black River

General Information

SgaID	**400035000014121**	Local SgaID		VOBCIT struct_num	
Observers	**K.Underwood, B.O'Shea**	Assessment Date	**00/10/2009**	Project Name	**Black River**
Town	**Plymouth**	Latitude	**43.46483**	Longitude	**-72.70498**
Location	**230 ft South of Jct w/ Dublin Rd**			Reach VTID	**M40T5.01**
Road Name	**LIBRARY RD**	Road Type	**Gravel**	Stream Name	**Patch Brook**
High Flow Stage	**No**	Channel Width			**33.3**

Bridge Information

Bridge Width	**16**	Material	**Timber**
Bridge Clearance	**8.6**	Number of bridge piers/arches	
Bridge/Arch Span	**16**		
		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**	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	**Yes**	Angle of stream flow approaching structure	**Channelized Straight**
If channel avulses, stream will	**Unsure**		

Downstream

Pool present immediately downstream of structure	**No**
Downstream bank heights are substantially higher than upstream bank heights	**No**
Pool Depth at point of streamflow entry	**No**

	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 >= 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	**Mixed 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?

Vegitation Band - Left	**No**	**No**	
Vegitation 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 supported by steel I-beams, on laid-up stone abutments.**

Bridge Summary Report

Black River

General Information

SgaID	200100000214122	Local SgaID		VOBCIT struct_num	
Observers	K.Underwood, B.O'Shea	Assessment Date	00/10/2009	Project Name	Black River
Town	Plymouth	Latitude	43.46428	Longitude	-72.70444
Location	285 ft Southwest of Jct w/ Dublin Rd at Echo Lake Inn			Reach VTID	M40T5.01
Road Name	ROUTE 100	Road Type	Paved	Stream Name	Patch Brook
High Flow Stage	No	Channel Width	25.2		

Bridge Information

Bridge Width	34	Material	Concrete
Bridge Clearance	6.8	Number of bridge piers/arches	
Bridge/Arch Span	39		
		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	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	No	Angle of stream flow approaching structure	Channelized Straight
If channel avulses, stream will	Unsure		

Downstream

Pool present immediately downstream of structure	No
Downstream bank heights are substantially higher than upstream bank heights	No
Pool Depth at point of streamflow entry	No

	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 >= 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?

Vegitation Band - Left	No	Yes	
Vegitation 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 Summary Report

Black River

General Information

SgaID	**100002000014121**	Local SgaID		VOBCIT struct_num	
Observers	**K.Underwood, B.O'Shea**	Assessment Date	**00/07/2009**	Project Name	**Black River**
Town	**Plymouth**	Latitude	**43.46511**	Longitude	**-72.70334**
Location	**110 ft East of Jct w/ Route 100**			Reach VTID	**M40**
Road Name	**KINGDOM RD**	Road Type	**Paved**	Stream Name	**Black River**
High Flow Stage	**No**		Channel Width		**61.9**

Bridge Information

Bridge Width	**25**	Material	**Concrete**
Bridge Clearance	**7**	Number of bridge piers/arches	
Bridge/Arch Span	**52**		
		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**	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	**No**	Angle of stream flow approaching structure	**Channelized Straight**
If channel avulses, stream will	**Unsure**		

Downstream

Pool present immediately downstream of structure	**Yes**
Downstream bank heights are substantially higher than upstream bank heights	**No**
Pool Depth at point of streamflow entry	**No**

	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 >= 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	**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?

Vegitation Band - Left	**No**	**Yes**
Vegitation 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 replaced after washed out in 1927 flood. Max pool depth > 4 ft.**

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resouces

VT DEC

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October. 25 2010

Culvert Summary Report

Black River

General Information

SgaID	**990000000014123**	Local SgaID		VOBCIT struct_num	
Observers	**K.Underwood, B.O'Shea**	Assessment Date	**00/22/2009**	Project Name	**Black River**
Town	**Plymouth**	Latitude	**43.50409**	Longitude	**-72.67231**
Location	**Approx 0.44 mile west of terminus of Reading Pond Road.**			Reach VTID	**M41T6.06**
Road Name		Road Type	**Gravel**	Stream Name	**Buffalo Brook**
High Flow Stage	**No**			Channel Width	**8**

Culvert Information

Culvert Length	**19**	Material	**Steel Corrugated**
Culvert Height	**4.1**	Number of culverts	**1**
Culvert Width	**3.9**	Culvert Overflow Pipe	**No**
		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	**Lower**

Upstream

Obstructions at the opening of the structure	**Sediment**	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	**No**	Angle of stream flow approaching structure	**Sharp Bend**
If channel avulses, stream will	**Cross Road**		

Downstream

Pool present immediately downstream of structure	**Yes**	Water depth in culvert (at outlet)	**0.15**
Downstream bank heights are substantially higher than upstream bank heights	**No**	Culvert outlet invert	**Cascade**
Stepped Footers	**0.4 ft.**	Backwater Length (measured from outlet)	**0**
Maximum pool depth	**0.7 ft.**	Backwater Length (measured from outlet)	**1.7**

	Upstream	Downstream	In Structure
Dominant Bed Material	**Gravel**	**Gravel**	**Gravel**
Bedrock Present	**No**	**No**	
Type of Sediment Deposits	**None**	**None**	**None**
Material Present throughout			**No**
Elevation of sediment deposits >= 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**	**Culvert**	
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**	**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?

	Upstream	Downstream
Vegitation Band - Left	**Yes**	**Yes**
Vegitation Band -Right	**Yes**	**Yes**

Wildlife

	Roadkill	Outside Structure	Inside Structure
Species	**None**	**None**	**None**

Other Information

Spatial location data collected with GPS? **Yes** Photos taken? **Yes**

Comments

Bridge Summary Report

Black River

General Information

SgaID	400042000014121	Local SgaID		VOBCIT struct_num	
Observers	K.Underwood - SMRC	Assessment Date	00/18/2009	Project Name	Black River
Town	Plymouth	Latitude	43.47546	Longitude	-72.69503
Location	420 ft south of Camp Plymouth State Park entrance.			Reach VTID	M41T6.01
Road Name	SCOUT CAMP RD	Road Type	Paved	Stream Name	Buffalo Brook
High Flow Stage	No	Channel Width	32.6		

Bridge Information

Bridge Width	17.5	Material	Concrete
Bridge Clearance	6	Number of bridge piers/arches	
Bridge/Arch Span	15		
		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	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	Yes	Angle of stream flow approaching structure	Sharp Bend
If channel avulses, stream will	Unsure		

Downstream

Pool present immediately downstream of structure	Yes
Downstream bank heights are substantially higher than upstream bank heights	No
Pool Depth at point of streamflow entry	Yes

	Upstream	Downstream	In Structure
Dominant Bed Material	Cobble	Gravel	Gravel
Bedrock Present	No	No	No
Type of Sediment Deposits	Side	None	Side
Elevation of sediment deposits >= 1/2 bankfull	No	No	No
Bank Erosion	None	None	
Hard Bank Armoring	Intact	Intact	
Stream bed scour causing undermining around or under structure	Culvert	Culvert	
Beaver Dam near Structure	No		
Beaver Dam distance (ft.)			

Vegetation

	Upstream	Downstream	In Structure
Dominant Vegetation Type - Left	Deciduous Forest	Deciduous Forest	
Dominant Vegetation Type - Right	Road Embankment	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?

	Upstream	Downstream
Vegitation Band - Left	No	No
Vegitation 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 **"Culvert" choice selected under Step 4, for the question of Streambed scour causing undermining? because choice of "abutments" was not available. Max pool depth = 2.3 feet. Stepped footer along the LB abutment. RB abutment shows cracking, spalling.**

VERMONT

Stream Geomorphic Assessment

VT DEC

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Vermont.gov

November, 07

Bridge Summary Report

Black River

General Information

SgaID	**700000000114123**	Local SgaID		VOBCIT struct_num	
Observers	**K.Underwood - SMRC**	Assessment Date	**00/18/2009**	Project Name	**Black River**
Town	**Plymouth**	Latitude	**43.47507**	Longitude	**-72.69616**
Location	**Timber footbridge 370 ft downstream from Scout Camp Road bridge.**			Reach VTID	**M41T6.01**
Road Name		Road Type	**Trail**	Stream Name	**Buffalo Brook**
High Flow Stage	**No**	Channel Width	**32.6**		

Bridge Information

Bridge Width	**4.5**	Material	**Timber**
Bridge Clearance	**6.4**	Number of bridge piers/arches	
Bridge/Arch Span	**39**		
		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**	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	**Yes**	Angle of stream flow approaching structure	**Channelized Straight**
If channel avulses, stream will	**Unsure**		

Downstream

Pool present immediately downstream of structure	**No**
Downstream bank heights are substantially higher than upstream bank heights	**No**
Pool Depth at point of streamflow entry	**No**

	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 >= 1/2 bankfull	**No**	**No**	**No**
Bank Erosion	**Low**	**Low**	
Hard Bank Armoring	**Failing**	**Failing**	
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?

	Upstream	Downstream
Vegitation Band - Left	**No**	**Yes**
Vegitation 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 **Bridge on footpath at Camp Plymouth State Park. Structure & path owned by state, but SGA ID # assigned using "private" classification so as not to suggest a vehicle-worthy transportation system and structure.**

VERMONT

Stream Geomorphic Assessment

Agency of Natural Resouces

VT DEC

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November. 07

Culvert Summary Report

Black River

General Information

SgaID	400027000014121	Local SgaID		VOBCIT struct_num	
Observers	K.Underwood, B.O'Shea	Assessment Date	00/04/2009	Project Name	Black River
Town	Plymouth	Latitude	43.49437	Longitude	-72.65611
Location	1.6 mi north of Jct w/ Kingdom Road			Reach VTID	M41T6.02S1.02
Road Name	READING POND RD	Road Type	Gravel	Stream Name	Reading Pond Brook
High Flow Stage	No	Channel Width			15.5

Culvert Information

Culvert Length	20	Material	Steel Corrugated
Culvert Height	7	Number of culverts	1
Culvert Width	9	Culvert Overflow Pipe	No
		Skewed to roadway?	No

Geomorphic Information

General

Floodplain filled by roadway approaches	Entirely	Structure is located at significant break in valley slope	No

Upstream

		Culvert slope as compared with channel slope is significantly	Lower
Obstructions at the opening of the structure	Sediment	Estimated distance avulsion would follow road	
Steep riffle present immediately upstream of structure	Yes	Angle of stream flow approaching structure	Sharp Bend
If channel avulses, stream will	Cross Road		

Downstream

Pool present immediately downstream of structure	Yes	Water depth in culvert (at outlet)	0.2
Downstream bank heights are substantially higher than upstream bank heights	No	Culvert outlet invert	At Grade
Stepped Footers	0.6 ft.	Backwater Length (measured from outlet)	0
Maximum pool depth	2.5 ft.	Backwater Length (measured from outlet)	0

	Upstream	Downstream	In Structure
Dominant Bed Material	Gravel	Gravel	None
Bedrock Present	No	No	
Type of Sediment Deposits	Side	Side	None
Material Present throughout			No
Elevation of sediment deposits >= 1/2 bankfull	No	No	No
Bank Erosion	None	High	
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	Mixed 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?

Vegitation Band - Left	Yes	Yes
Vegitation Band -Right	Yes	Yes

Wildlife

	Roadkill	Outside Structure	Inside Structure
Species			

Other Information

Spatial location data collected with GPS? Yes

Photos taken? Yes

Comments **Minimal fill over the culvert.**

APPENDIX C

QA Documentation

To: Kristen Underwood, South Mountain Research & Consulting
From: Sacha Pealer, VT DEC River Management
Date: 11/03/2010

Black River Phase 2 QA, 2009

Note: This Quality Assurance document covers these ph. 2 segments: **M40-0 (Black River), M40T5.01 to M40T5.04 (Patch Brook), M40T5.03s1.01 (trib to Patch), M41T6.01 to M41T6.06 (Buffalo Brook), and M41T6.02s1.01 to M41T6.02s1.02 (Reading Pond Brook).** The questions raised below 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. 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. Please update this document (preferably in a second color) with what steps were (or were not) taken to address each item below.

South Mountain Research & Consulting Services (SMRC) appreciates the opportunity to enhance data accuracy, clarify data limitations, and maximize the utility of the Black River (Patch & Buffalo Bk tribs) Phase 2 (2009) data set. This response to VT River Management Section QA Review Comments has been completed by Kristen L. Underwood, PG, on 11/15/2010. 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, 11/17/2010. Remaining items are highlighted in blue.

K. Underwood, 11/22/2010. Thank you for your comments. Responses are added in yellow.

General Comments:

- Please address automated QC checks in DMS (some segments still "provisional"). See https://anrnode.anr.state.vt.us/SGA/projects/phase2/dataEntry.aspx?pid=118 for list.
- Please label RAF feature in x-section spreadsheets. Have been added, and cross sections uploaded. See M40-0 (for XS-1, see notes), M41T6.02S1.01A, M41T6.02S1.02C
- Step 2.13 largest particles. Why Not Applicable? There are bars noted. Try to get these measurements even where bedform is altered to plane bed. Use N/A on reference plane beds. See M40-0 (NE), M40T5.01A (NE), M40T5.01C (NE), M41T6.02B (bd:450; br:135) , M41T6.04-0 (NE), M41T6.02S1.02-C (bd:180; br:100). OK. I thought in the past that an internal QC check would instruct us to not enter a value here if the bedform was classified as plane bed. Often the bars were not located proximal to the XS (e.g., the relationship of bar to bed particles might not be valid if the channel exhibits a fining downstream sequence)
- Step 4.6. Did you mean to enter "None" for the following reaches? M40-0, M40T5.01A, M40T5.01B, M40T5.01C, M40T5.02A, M40T5.03S1.01-0. These reaches may have had upstream or downstream flow regulations, and in some cases, step 5 comments refer to them. Are you having problems saving step 4.6 in DMS? I'm not sure what happened here. I thought I had entered these in the DMS. The fact that the type of flow regulation is correctly stored there, gives me added confidence that I had. Maybe there was a DMS bug? I just re-entered the appropriate "upstream" or "downstream" values, and they seem to be storing OK.

Comments by reach:

M40-0

- Why is floodprone width (650') entered in step 2 of DMS greater than valley width (440') reported in step 1.5? All three cross sections suggest wider valleys. Please explain in step 5 notes. Valley width entered in step 1.5 represents an average for the segment. Cross section location had a locally higher valley width. Also, valley width is measured perpendicular to the long-valley axis. To be perpendicular to the channel, cross sections XS-3 and XS-2 were oriented at an angle to the long-valley axis. Regardless, all valley widths yielded ER greater than 2.2. Note added to DMS.
- Should step 2.11 riffle spacing be N/A if plane bed due to anthropogenic changes? Riffle pool was chosen as a subdominant, which suggests you might be able to measure riffle spacing, even if riffles are distant. Perhaps you meant to choose Not Evaluated? Added riffle spacing of 610 ft.
- In xs 2, did you consider RAF could be at feature (73.8, 5.1)? Looks lower than field RAF (150, 7.1) and would lower incision ratio. It is possible, and data are insufficient to know with certainty. This would

require more detailed surficial geologic investigations. In absence of that kind of detailed study, I erred on the conservative.

- How much of reach, if any, is affected by lake having "impounded" flows? Please comment in step 5. This is impossible to say with currently available data. The departure analysis of the Phase 2 report includes discussion of the upstream natural impoundment (Echo Lake) and the downstream regulated impoundment (Lake Rescue). Ordinarily, we might expect that upstream impoundment effects could lead to hungry water conditions and incision in M40. However, Patch Brook provides a significant source of sediments to M40. Fluctuations in water levels of the Lake Rescue impoundment over historic times may have alternately induced incision (from a drop in base levels) or aggradation (from a rise in base levels). Today, the net result of historic (and post-glacial) channel adjustments and historic channel modifications is a partially incised and entrenched channel in reach M40.

M40T5.01A

- Why is floodprone width (310') entered in step 2 of DMS greater than valley width (160') reported in step 1.5? XS suggests wider valley. Please check valley width. Valley width entered in step 1.5 represents an average for the segment where valley widths range from 80 to 240 ft. Also, the valley width for Patch Brook merges with the broader Black River main stem valley at this point of confluence. The Patch Brook valley wall shape file is artificially tapered down to close around the downstream reach break in this location. The floodprone width of 310 ft recorded for the cross section includes some area outside of this artificially-narrowed Patch Brook valley width and within the Black River valley.
- What evidence led you to choose channel evolution stage III? Have you considered stage II? It could make sense given the straightening, dredging, eroded steps, berms, incision, reduced channel width, and few depositional features. The fact that channel flows had recently breached the berms and splayed out onto the RB floodplain (sediment and remnant patterns of flood flows observed 8/7/2009). The landowner reportedly works on the RB berm periodically. Also, the "delta" of sediments from Patch Brook at the confluence in Black River main stem suggests a local sediment source (widening to erode the berms). It appears to be a channel in early stage III that is repeatedly managed back to II through berming (and possibly gravel extraction – though extraction not confirmed). The degree of channel incision may have been more pronounced in the past (e.g., following flood recovery efforts after the floods of the 1970s) and the channel has begun to fill in over time, reducing the degree of incision. This is speculation, however.
- Your reach narratives report indicates this segment is a subreach of Cb/riffle-pool (p.15). However, no subreach is entered in step 2.15. Which is correct? It appears you may wish to note a difference in reference bedform. I didn't realize that a difference in only reference bedform (not stream type) was sufficient to justify selecting subreach. I have selected subreach.
- I see you upgraded sensitivity because segment occupies alluvial fan. Protocol for sensitivity ratings does not yet systematically incorporate alluvial fans (other than indirectly, with known D streams), but we appreciate your effort to capture potentially heightened hazard risk. Please comment here further: In your opinion, could this "alluvial fan" reactivate? This segment (and upstream segment B) was classified as an "alluvial fan", in order to capture the marked reduction in valley gradient and confinement, although geologic investigations to confirm the origin and nature of sediments comprising the local landscape as a true alluvial fan, were beyond the scope of this study. If significantly higher sediment loading and/or hydrologic loading in the upstream watershed were to result from a future change in land use and/or hydrologic regime, it would be reasonable to expect that the incidence and rate of lateral migrations/braiding and the potential for avulsions would increase in this segment (and upstream segment B).Could it become a D stream, or is the stream too channelized? Flows have recently breached the RB berms and splayed out onto the floodplain (based on observations of the area on 8/7/2009). Based on this recent activity, it would be possible to see braided flows in this vicinity especially episodically during future flood events, or as a result of a change hydrologic loading or sediment transport from the upstream watershed. Do you think the stream has potential to avulse above Dublin Road bridge onto the north side of the road (ie, outside of the delineated ph.2 valley)? Yes, historic maps suggest that the channel may have once gone there. The Dublin Road bridge was washed out in

the 1973 flood according to the local landowner. Floodwaters and sediment were directed down Dublin Road to the Echo Lake Inn.

M40T5.01B

- Step 3.2. Please check dominant buffer type. FIT shows >58% 0-25 foot buffer on left and >83% on right, yet dominant types are 51-100 and >100. Dominant buffer types changed in the DMS.
  SP: Now, the FIT uploaded to DMS does not include any buffer less than 25' for this segment. Did you mean to remove indexing? If so, perhaps the dominant buffer type should be changed back?
  The latest FIT upload that I made (on 11/15/10), included data only for reach T6.01 (which was the only one for which edits to the FIT were made during the QA review process between 10/15 and 11/15). You, were correct that FIT data uploaded on 10/15/2010, contained 449 ft of LB buffers <25 ft wide for the segment (or >58%), and 639 ft of RB buffers < 25 ft (or >83%). So, the dominant buffer types now stored in the DMS are correct.

M40T5.01C

- Channel dimensions suggest Rosgen stream type B. Due to the very wide bankfull width. Did you mean to enter Cb in step 2.14? Yes. The cross section shows several features around 2x max depth, suggesting that floodprone width may be on the cusp of being smaller, and driving entrenchment more solidly into B territory. Please comment. Do you think there could be an STD from Cb to B? What about a subreach? Valley walls are approximately 85 feet apart here. Compared to a reference bankfull width (28 ft), that would yield an ER of 3+ which would be classified as a C stream (with a subclass slope of b for the estimated 3.8% gradient). Despite a degree of incision (estimated IRraf = 1.4), the channel appears to have access to its floodplain. The FPW elevation is 0.8 feet over the RB terrace. And I suspect that flood flows have access to much of the LB corridor via the LB flood chute and other areas upstream or downstream of local high points like those captured in the cross section (e.g., point -6, -1.5). The reason that the ER is in the range of a B stream type has to do with the wide bankfull width value that includes some area within the LB flood chute (the segment is actively widening and adjusting its planform). The value is on the cusp of a C classification if the +0.2 unit is considered (1.95 + 0.2 = 2.15).

M40T5.01D

- Would you update this sentence in step 5? "This "canal", as it is known locally, returns to the Patch Brook approximately xxx feet downstream in Segment B." 3000 feet; Step 5 in the DMS has been updated.

M40T5.02A

- Why is step 1.5 valley width so much narrower than valley width in cross section? What are you calling ph.2 valley width in xs? It looks like you have the ph.1 valley labeled. Are you choosing the base of a terrace, and if so, how does this support step 1.5? VW shapefile appears to be ~50' wide at xs location. However, xs plot could show 115'? This confusion stems from the uncertainty surrounding degree of incision and which amount of incision occurred historically (say, in the last 250 years) versus post-glacially. Further surficial geologic study would be required to know with greater certainty the composition, origin, and age of the terraces surrounding the Patch Brook in this segment. If we believe that RTER1 at elevation 7.4 represents a historic RAF, and the Patch Brook incised to its present depth below this RAF (IRraf = 2.67) within historic times, then the valley walls for this channel would be positioned at the base of the next terraces (distance -45 ft on the LB, and distance 70 ft on the RB, for a valley width of 115. However, if the RTER1 represents a terrace of post-glacial age and the channel has incised below this terrace over thousands of years, perhaps with incision rates renewed during historic times (as a result of deforestation/reforestation cycles, channelization, historic impoundment & subsequent dam breach, e.g.), then these post-glacial origin terraces may define the valley walls of the current channel – at distance -10 ft on the LB, and distance 43 ft on the RB, for a valley width of 53 ft at the cross section. Originally, I had mapped the ph2 valley wall shape file to depict the wider 115 foot valley width in this specific location – which represented a locally wider valley width as compared to the remainder of the segment (that is why the LVW and RVW are marked the way they are in the cross section spreadsheet). Later, due to the uncertainty regarding degree of historic incision, I changed the ph2 valley wall shape file to reflect the narrower 50-foot valley width near the downstream

end of the segment where this cross section is located. This valley width is much more consistent with valley widths measured elsewhere in the reach where the channel is closely confined by terraces at 3 to 4.6 times the Dmx. The uncertainty regarding degree of historic vs postglacial incision is discussed in Appendix E and in Step 5 of the DMS. If I revised the valley wall back to the wider position in this location, it would be consistent with the cross section notes, and it would offer a greater degree of protection in the event that the valley wall was utilized as a basis for development of fluvial erosion hazard corridors and hazard ratings. Please advise.
SP: Suggest going with more conservative valley width in light of FEH (the valley will be reducing the FEH corridor width somewhat in either case). It is okay to have multiple terrace sets within a phase 2 valley. You don't have to limit yourself to RAF and valley wall. Final phase 2 valley wall shape file includes more conservative (wider spacing) of valley walls.

M40T5.02B

- In xs spreadsheet, why is feature at (100, 8.1) labeled as RFPA? Looks well above 2x max depth. I was using the descriptor (RFPA = Right Flood Plane, as noted on the Cross section worksheet) to refer to the generalized floodplain-like feature there. I agree it would not be equivalent to the FPW identified by protocols as 2x Dmx to correspond to the Q10 to Q50 floodplain. This floodplain-like feature would not be active at most flood stages. I have removed the description.
- Please enter RAF to get IR_{RAF} in step 2.5 of DMS. Both incision ratios can be reported. Entered in the DMS.

M40T5.03

- Why is ph. 1 valley width less than ph. 2 valley width for both segments, especially when ph. 2 valley has human-caused change in width? Update phase 1 as needed. I changed the Phase 1 valley width to 40 ft.

M40T5.03A

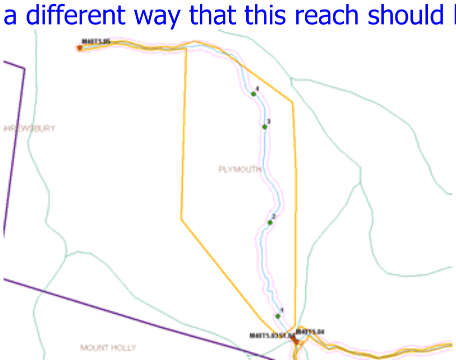
- Why didn't you evaluate step 2.11 step spacing? Although plane bed is dominant due to anthropogenic changes, step pool was chosen as a subdominant, which suggests you might be able to measure some step spacing. Perhaps you meant to choose Not Evaluated in the No Data box? Because the segment was predominantly plane bed. Upon reviewing my notes, there is insufficient data to calculate a step spacing, so I have chosen Not Evaluated.

M40T5.03B

No comments.

M40T5.04

- Do I have the correct valley wall verification data for this reach? It looks unnatural in shape, does not fit reported valley wall dimensions, and crosses the streamline mid-reach. Also, lower end does not even include downstream reach point. See screenshot below where gold line polygon is ph. 2 valley wall. Valley walls were not able to be delineated along most of the reach, because the VHD coverage defining the position of the Patch Brook main stem was considerably different than the actual channel position measured in the field with a GPS (see Figure 1 a on next page). Mapped valley wall positions would have crossed the channel in a number of locations, causing SGAT to generate errors when trying to delineate corridors using these valley walls. Should I delete this reach from the valley wall shape file? Or is there a different way that this reach should be treated?



SP: If possible, it would best to have the actual valley wall location portrayed in the shapefile. SGAT can be amended to account for the correct streamline if the corridor ever needs revision or setback/FEH options are explored. OK. Revised ph2 valley width shape file has been delivered via email attachment to this QA response, as well as stored on the updated Project CD #1. Please be aware that the actual channel position is an estimate only; it is more accurate than the channel position shown by the VHD, but it is not necessarily highly accurate. I would be uncomfortable with this approximate channel position (and the valley wall shape file developed from it) being used to depict fluvial erosion hazards. The GPS I used typically had an accuracy of +/- 17 to 20 ft on the assessment date. The channel width of the Patch Brook measured in this headwater setting ranged from 9 to 14.7 feet wide. Channel position was recorded every 50 or so feet along the traverse at meander cross-over points or prominent meanders (or other FIT features). Valley wall positions (generally high terraces on either side of the channel) were identified at a given distance from each channel waypoint, measured perpendicular to the channel. These segments are located within the Calvin Coolidge State Forest, suggesting that future development surrounding the channel is less likely than on non-state-forest lands. The upstream drainage area of the reach (1 sq mile) is smaller than would typically warrant mapping of FEH boundaries –instead this reach would likely be treated with a buffer of default width.

M40T5.04A

- Notes describe this segment as having "beaver activity". Should there be beaver dams mapped in FIT/step 4.9? None that we noticed in the segment on the assessment date. There is a much larger wetland complex that includes this segment and a tributary channel, extending to the west. There may be channel-spanning or bank beaver dens in that area.

M40T5.04B

- Bars present (mid, diagonal, side) and flood chutes on segment may suggest aggradation and planform adjustment. Step 7 describes "moderate aggradation." Have you considered channel evolution stage III, rather than II? You've indicated incision is historic (and probably limited by grade control), so maybe the channel evolution process has progressed? Depositional bars are present but less than ½ bankfull stage. W/D ratios are low, suggesting minimal active or historic widening. No signs of active widening such as trees leaning into the channel. There was a minor degree of undercut banks in the straightaways. It is possible that minor to moderate aggradation may be leading to a very minimal degree of widening (early stage III). However, lateral adjustments appear to be moderated by the cohesive nature of bank sediments and well forested buffers. Also, the degree of historic incision is relatively small (1.18 and 1.3 locally at XS-1), so bank heights relative to the thalweg are not excessively oversteepened to serve as a driver for widening. It is also possible that the degree of incision was greater in the past, the channel maintained reference widths due to boundary resistance, but has filled in with finer sediments over the years to result in the present minor net degree of incision.
- In both xsections, there is a flat floodplain feature around elevation 3 ft. Do you think this could be bankfull? While it is certainly possible that I underestimated the bankfull elevation, there was a subtle (and in the case of XS1, more pronounced) undercut profile of the left and right banks suggesting incision. And the floodplain feature at elevation 3 ft in each XS was well vegetated and showed no signs of recent, fine-sediment deposition. At both cross sections, the terrace at elevation 3 ft was occupied by mature trees with an organic soil layer. Also, in xs 2, the first terraces on both sides are fairly close to channel; is it possible RTER1 represents RAF, making for incision ratio of ~2 (still historic)? Or are you more comfortable calling them glacial terraces? What you've done fits with upstream segments, but thought to ask when I saw those close terraces. It is possible that RTER1 could represent a historic RAF. Further surficial geologic study, beyond the scope of a Phase 2 SGA, would be required to evaluate the composition, origin and age of these terraces. While the protocols suggest that terraces 3 times the height of Dmx should be considered to be older than historic (glacial or post-glacial), I believe it is possible, particularly in these smaller streams, that terraces less than 3 times the height of Dmx can be glacial or post-glacial in origin.

M40T5.04C

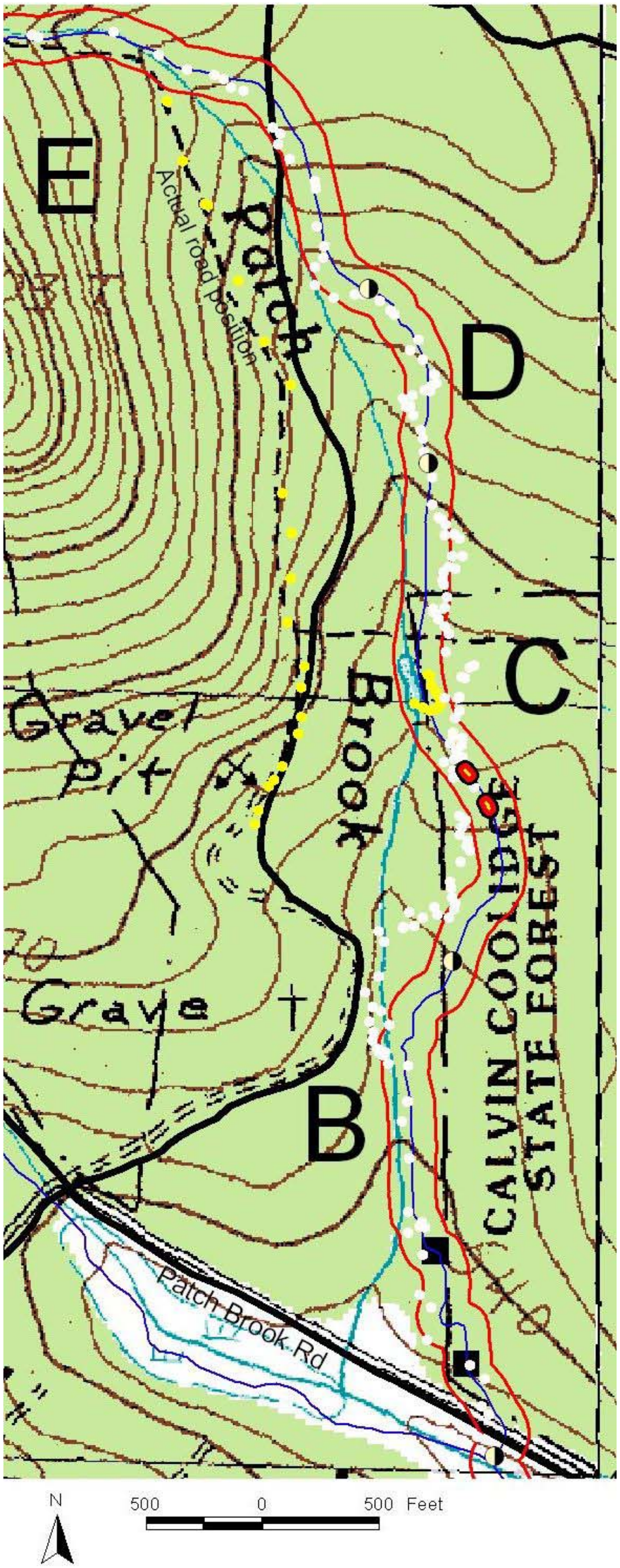
- You note VHD is inaccurate with respect to pond. Would you provide a sketch of current channel location? Can be shapefile or figure in report. (see Figure 1b, next page).
- Again, has segment moved on to stage III? We did not observe signs of active widening such as trees leaning into the channel. W/D ratios are low, suggesting minimal active or historic widening. Bed and bank materials contain large clasts (boulders) reflecting the glacial parent materials; these are likely not mobile except perhaps in extreme flow events. Erosion-resistance of boundary materials has probably limited lateral channel adjustments. Flood chutes are relatively frequent, but not uncommon in such a steep channel (estimated 3.9% gradient).
- If segment is semi-confined with no human-caused change in valley width, then please use Confined form in step 7. Fits slope/bedform better anyway. DMS updated with Confined RGA.

M40T5.04D

- You note VHD is inaccurate. Is actual channel located far enough away to make ph. 1 corridor inaccurate? Yes. Are you able to sketch channel? (see Figure 1a, next page).

M40T5.04E

- No comments.



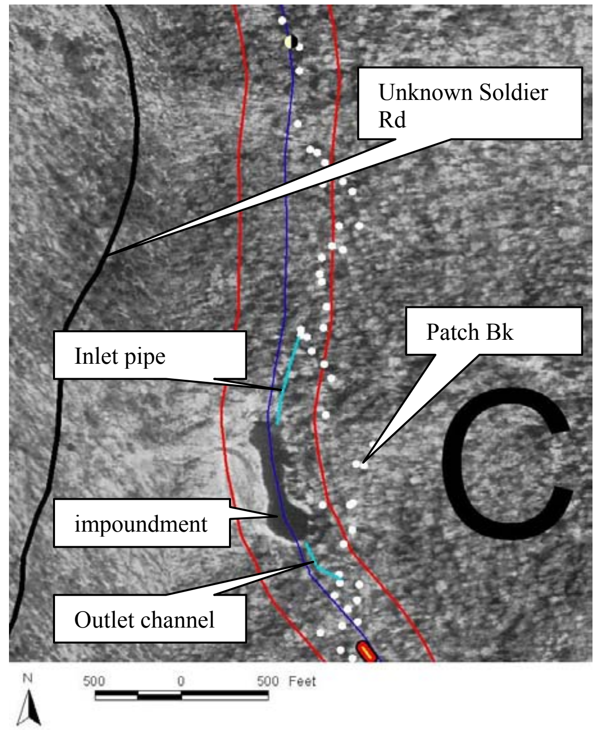


Figure 1b. Actual position of Patch Brook channel (indicated by white dots = waypoints from 2009 assessment) passes 50 to 100 ft east of impoundment.

Figure 1a. Actual position of Patch Brook channel (indicated by white dots = waypoints from 2009 assessment) vs VHD (blue line surrounded by red Phase 1 corridor) vs turquoise line on USGS topographic base map.

M40T5.03S1.01-0

- No additional comments.

M41T6.01A

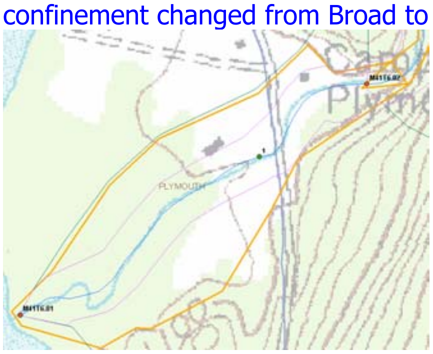
I revised the valley width somewhat (see next segment); still a Very Broad confinement.

- Step 2.13. Are largest particles reversed? Usually bed particle is larger than bar particle.
- I had mistakenly entered a value for a side bar located approx 790 feet upstream of the cross section site. Correct bar particle (170 mm) has been entered.

M41T6.01B

SP: I discovered a duplication in the FIT for buffers <25'. It appears the impact was indexed in phase 1 and again in phase 2, causing data to show an artificially high length of stream effected. Would you mind fixing this and re-uploading? We can fix it in our copy when it arrives by mail, assuming it's just a matter of removing the 2007 entries. Good catch. I have deleted the sections indexed during the Phase 1. FIT data for M41T6.01A and B re-uploaded to the DMS. Full FIT records included in the SGAT files on the revised Project CD #1 which has been sent via US Mail.

- Does valley wall shapefile need to be updated? When I measure segment B in GIS, I get more than 180' (reported in step 1.5). I'm not sure what happened here. I also get a larger value for valley width in Segment B. I took a closer look and revised the valley walls slightly (new valley wall shape file is stored on the Project CD). Average valley width for Segment B is 290. Revised valley width in Ph2 St 1.5; confinement changed from Broad to Very Broad.



- In xs, please label RBF. If there is a berm on right bank, please label it, too. RBF now labeled. Yes, there is a RB berm; I have now labeled it and uploaded revised cross section to DMS.
- Should this segment score good for RGA given change to plane bed, 96% straightening, gravel mining, erosion 11-16%, bank armoring, and severe bridge constriction? Please advise if I am mis-interpretting the protocols. 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. Rather, this susceptibility is captured in the sensitivity rating. The degradation adjustment process (probably enhanced by periodic post-flood windrowing/ channelization) which has resulted in the degree of incision (IRraf = 1.6) is inferred to be historic in nature. The enhanced degree of entrenchment caused by the berms on either side of the channel (IRhef = 1.8) is also inferred to be historic. The degree of channel incision and entrenchment (as well as the straightened planform, and noncohesive nature of bank and bed sediments) does make the channel susceptible to catastrophic adjustments in future high flows. Accordingly, the sensitivity would be noted as "Moderate", following protocols. Due to the location of this reach along the river network at a point of marked reduction in valley gradient and confinement, I have overridden the Sensitivity rating to "Extreme". The segment has been converted from a reference meandering Cb3-riffle pool status to a straightened, armored, partly bermed, undersized-width, transport-dominated, Cb3-plane bed status with moderate incision. Despite the channel 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 under flow conditions experienced since the last major flood.

SP: The RGA condition is *not just* a reflection of active adjustment; that is why historic adjustments are incorporated into the RGA questions. Yes, I agree, and I mis-stated the case in the second sentence. The

RGA does include Historic check boxes, and the metrics such as incision ratio and w/d ratio can reflect both active and/or historic processes. Yes, RGA indicates how much the stream has departed from reference condition. The signs I noted above (plane bed, etc.) are usually symptoms of both adjustment (active or historic) and departure. You seem to be okay with "good" because the stream, while altered, is now relatively inactive. I am not necessarily comfortable with an overall RGA score labeled "Good" for this segment. That's, in part, why I overrode the Sensitivity rating to Extreme (also due to the setting at a marked reduction in valley gradient and confinement). This seems to ignore the existing alteration. The existing alteration – historic incision leading to IRraf = 1.4 and berming enhancing the degree of entrenchment to an IRhef = 1.8 – is reflected in the 7.1.2 response and 7.1 score of 8. For example, a reach in stage II with historic incision may not have much active adjustment, but it would not have the same RGA score as a reach in stage I with no incision. I agree. However, it may not have an overall RGA score that drops below the range from 0.65 to 0.84 ("Good" category) if it has a regime w/d ratio with little signs of active widening, and very few signs of aggradation and planform adjustment (as is the case with this segment). In this case, to get an overall RGA score in the range of 0.35 to 0.64 ("Fair" category), I would have to artificially downgrade the scores of 7.2, 7.3 and/or 7.4, which I was not comfortable doing, since it would be a non-standard approach. While a reach "stuck" in stage II may not be actively adjusting, it is in a reduced geomorphic condition if it cannot progress into stage III; in other words, there is little hope for it to regain floodplain access because of its armored, straightened condition, which may even be maintained through gravel mining and further armoring. Unfortunately, these stage II reaches are common in Vermont, especially in areas of encroachment. I am concerned that a reach with an incision ratio of 1.8 (due to berming), plane bedform, and almost complete straightening is being rated "good." I wouldn't characterize it in good condition either, but I would characterize it to be in a minor to moderate present (and/or historic) state of adjustment and/or departure (as a result of historic modifications and encroachments) – which is what I had understood the second-from-the-left quadrant of the RGA labeled "Good" is designed to reflect. Clearly, this segment has departed geomorphically. Yes, the armoring and perhaps the bank trees have reduced the potential for widening; however, this is not necessarily favorable, since we know widening can be a positive step toward achieving equilibrium planform, profile, and channel dimension. That said, there are many stream conditions out there; if you can explain the "good" condition adequately in the DMS notes, perhaps we can come to an agreement about how such an unusual situation should be handled.

As for sensitivity, yes, it refers to likelihood the stream *will* adjust in response to watershed change. Sensitivity is usually assigned in phase 2 by following a specific categorization process as outlined on p.84 of the Phase 2 Handbook (May 2009), where the potential for channel adjustment is based on *both* RGA condition and existing stream type. In this segment, the sensitivity of High would come from Fair or Poor condition on a C3 stream. If you want to override the sensitivity you are getting because it does not seem to reflect the hazards associated with a channelized, bermed stream, then perhaps it is a sign that the RGA score should be lowered Based on feedback from past QA reviews, it seems that it has been more acceptable to override the sensitivity rating than to override the RGA score. Perhaps, I have been in error in the past to do so? As I re-read Step 7 of the protocols, it appears that it would be appropriate to keep the individual adjustment process scores and the overall RGA score as they are (reflecting the measured metrics and observed features) – however, override the RGA classification from "Good" to "Fair" despite the score of 0.68. I have added a note describing this to Step 5 of the DMS – let me know if that is not appropriate. Then, as you noted above, the specific categorization process outlined on p.84 of the Phase 2 handbook indicates that a C3b in "Fair" condition has a "High" sensitivity. I would still be inclined to override the sensitivity to an "Extreme" category, due to the notable decrease in valley gradient and confinement at this segment..

Adjusting sensitivity for alluvial fans is not typically done in phase 2. The phase 3 protocol does acknowledge that certain boundary conditions such as alluvial fans increase sensitivity. However, RMP has not fully developed a protocol for alluvial fans with respect to sensitivity, in part because phase 2 only goes as far as identifying the *setting,* or slope and valley conditions where a fan may have formed. For the purposes of this project, we are okay with you adjusting sensitivity in this way; however, please understand this is a part of the protocol RMP would like to review, and we may need to adjust the sensitivity for these or other alluvial fans in the future. While it is good to think about appropriate sensitivities, keep in mind that ph. 2 determination of an appropriate RGA condition is the key first step.

- Due to alluvial fan, you recommended extreme sensitivity but did not update sensitivity. This was an oversight on my part; I meant to change the Sensitivity rating in the DMS, and have now. As in M40T5.01A, do you think this fan is likely to reactivate/braid/avulse? This segment (and downstream segment A) are probably susceptible to catastrophic erosion or avulsion in the event of a future flood, due to their incised and entrenched status. This susceptibility is probably enhanced by their topographic position of notably-reduced valley gradient and confinement. This segment (and downstream segment A) were classified as "alluvial fan"s by protocol, in order to capture this marked reduction in gradient and confinement, although geologic investigations to confirm the origin and nature of sediments comprising the local landscape as a true alluvial fan, were beyond the scope of this study. Kame terrace deposits and lake sands are mapped in vicinity of this reach by Stewart (1955). If significantly higher sediment loading and/or hydrologic loading in the upstream watershed were to result from a future change in land use and/or hydrologic regime, it would be reasonable to expect that the incidence and rate of lateral migrations/braiding and the potential for avulsions would increase in this segment (and downstream segment A). Did you think it less likely than M40T5.01A since you did not update sensitivity? No, just an oversight.

M41T6.02A

- No comments.

M41T6.02B

- If segment is semi-confined with no human-caused change in valley width, then please use Confined form in step 7. Fits slope/reference bedform better anyway. Revised RGA accordingly. No change in score.

M41T6.03-0

- Again, am I looking at correct valley wall file? When I measure segment B in GIS, I get more than 80' (reported in step 1.5). The valley wall varies in width from 55 ft near the upstream end of the reach to 270 feet near the downstream end of the reach at the confluence of Reading Pond Brook. Taking an average of six evenly-spaced valley width measurements in GIS, I get 160 feet. I have replaced the valley width in Phase 1 St 2.9 and Phase 2 St 1.5 with 160 ft. Confinement type revised to Broad. Reference stream type unchanged. Cross section plot appears to show 240'. Yes, at that location along the reach, I would agree. Are you counting path/forest road as change in valley width? No.

- Step 2.10. Why is riffle type N/A? Data indicate change in bedform from step-pool to plane bed. If plane bed is not reference, then choose a riffle type that fits channel evolution processes. Step 2.10 changed to eroded.
- Please explain why you chose stream type Fb for step 2.14. Entrenchment ratio is 1.60, which is generally B. Although Rosgen's variation in entrenchment allows for F, the cross section suggests flood prone could be wider, if access occurs on right of RAF feature. I would agree, at this cross section

location in particular. Have you considered an STD of Cb to B? I did, but conditions in this very short reach are highly variable, and I wanted to err on the conservative. Meaning, the RB terrace is discontinuous along the length of the reach. Other locations upstream & downstream were more incised and entrenched relative to this cross section location. Some locations (near the upstream end of the reach were less incised and entrenched. Possibly, this historically (and post-glacially) incised reach is slowly evolving from a Cb to an Fb to a B channel. The surrounding sediments may represent coarser materials that were deposited in glacial and post-glacial times under a more intense hydrologic and sediment regime. And in mountain streams it can take more severe, less frequent events than a Q1.5 to do the work of shaping the channel (Phillips, Jonathan D., 2002; Faustini & Jone, 2003; Wohl, 2000). For all of these reasons, I classified the channel as an Fb. I believe this location is susceptible to future avulsions or possible catastrophic erosion in flood events, given it's incised and entrenched status, and its topographic position of notably lesser gradient and lesser valley confinement.

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M41T6.04-0

- Step 2.10. Why is riffle type N/A? Reserve N/A for reference plane bed or dune-ripple systems. If not evaluated, then check box for Not Evaluated. When I review the DMS in both data entry and data view modes, as well as generate the report output, all show "complete" under Step 2.10.
- XS. Is road functioning as an active flood chute? If so, then include flood chute area below 2x max depth in flood prone width to calculate entrenchment ratio. This approach results in C entrenchment. If road is not functioning as flood chute, then channel width would be 13.5' (rather than 14.3'), which is still B type entrenchment. In this particular location (which is generally representative of the segment), I don't believe the road is serving as an active flood chute at bankfull stage. I adjusted the cross section spreadsheet and added an explanatory note; reuploaded the XS to the DMS. Revised BFL width = 12.5, mean depth = 0.87ft, ER = 1.9, W/D = 14.4; updated the DMS record for Step 2. Stream type B3-S/P remained unchanged.

M41T6.05A

- Step 3.2. If right buffer has subdominant width of 0-25', shouldn't there be buffers <25' indexed on right side? Yes, I had missed a small (135 ft) section of RB buffer < 25'. Revised FIT file uploaded to the DMS.

M41T6.05B

- No comments.

M41T6.06-0

- No comments.

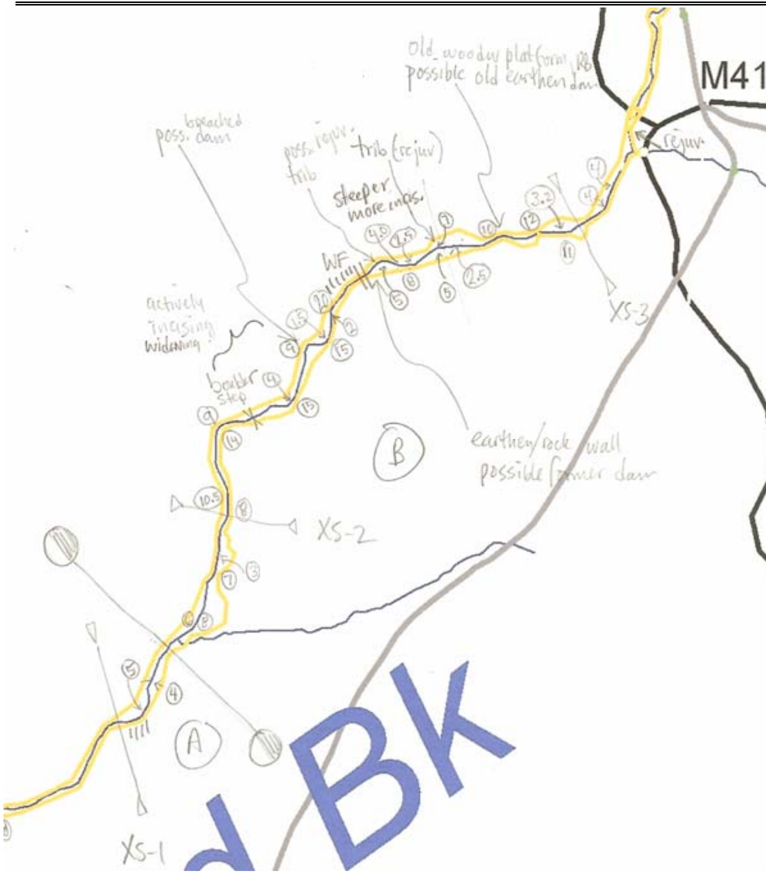
M41T6.02S1.01A

- Step 1.5. Did you mean SC for confinement type? Sorry, I meant Narrowly-confined. (DMS has been updated). Data suggest valley width/channel width=40/21=1.90 or Narrowly Confined. Or should valley width be >40'? Valley width varies between 25 to 60 feet, averaging 40 ft.
- Please label bankfull features, right valley wall, and flood prone in xs. Revised xs spreadsheet uploaded to the DMS.
- Looking at xs, reference stream type appears it could be C, rather than B, according to entrenchment if left floodplain area were accessible. Please consider assigning subreach stream type or explain. I could have picked a better cross section site for the Segment. The valley width at this spot is wider than is typical for the segment. Generally, the valley width is between 1.5 and 2 times the channel width (with just a few exceptions). A reference B stream type is really more representative of the reach as a whole.
- If a headcut is present, then why did you say degradation is historic? I was not certain that the nickpoint observed was in fact a head cut. There appeared to be a little recent incision in the vicinity with erosion evident along both banks in a somewhat straight section of channel. But this location at the head of the segment was not representative of the Segment A as a whole. In hind sight, I might have located the Segment break a little bit further downstream. In contrast to the upstream segment B, no rejuvenating tributaries were noted in Segment A; exposed tree roots along the banks were infrequent and weathered; LWD in the channel was weathered and stripped of small, leafed branches; trees leaning into the channel

were fairly rare. Because the headcut is at the top of the segment? Do you think the headcut is likely to continue working upstream? No.
SP: Would you please add these comments to the DMS, so those reviewing the data in the future will understand how the headcut relates to the overall adjustment noted? Sure, these comments have been added.

M41T6.02S1.01B

- Step 2.11. Did you forget to enter step spacing? If not evaluated, select "Not Evaluated" from no data dropdown menu. When distinct steps were present (rarely), the spacing was approximately 10 feet. (I have entered this value in the DMS). See discussion of cascade classification under next segment. (Because I classified the bedform as dominantly cascade, I had assumed step spacing was N/A).
- 2 xsections are included for this segment, one (XS-3) is Ba with 1.78 incision ratio (which I considered representative) and one (XS-2) is Fa with 1.00 incision ratio (which I considered non-representative, and classified as a B4, considering the +0.2 units for the ER=1.25 allowed by Rosgen). Why do you think such differences occurred? Conditions on this segment are pretty complex with adjustment processes overlapping in time and space. XS-2 is located near the downstream end of a short section of channel, Narrowly-confined by steep till-slopes that formed high terraces at thalweg heights ranging from 9 to 10.5 feet (5.6 to 6.6 times the Dmx) on the RB; and from 8 to 14 feet (5 to 8.8 times the Dmx) on the LB. Signs of recent incision in vicinity of XS-2 were not observed. XS-3 was located near the upstream end of the segment and represented conditions found along a majority of the segment. Valley walls were comprised of till terraces ranging in height from 9 to 30 feet high or more (see Figure 1 on next page). Confinement of the channel between these high terraces varied from Narrowly-confined to Semi-confined and even Narrow in a couple of places. A set of discontinuous lower terraces were present within these valley walls, generally 2 to 4 times the Dmx in height. Flood chutes on these lower terraces were relatively frequent but did not appear to be active at bankfull stage, unless forced at a DJ. Frequently, DJs and/or boulder-rafted LWD had blocked or partially blocked the channel (perhaps during the 2006 flood event) and large sediment slugs had been deposited in the channel behind the obstruction. Then it appeared that recent breaching of the obstruction had lead to localized incision through and beyond the sediment slug. Incision was somewhat localized and head cuts would wash out within a relatively short distance upstream, but might overlap with the next section of incision (see conceptual drawing, Figure 2 on next page). In other locations there might be a short section with little or no incision between sections of more pronounced incision. Tributary rejuvenation was apparent in many of the tributaries to this segment. Banks were undercut exposing fresh tree roots. Trees are actively leaning and collapsing into the channel from both banks. Did the non-incised xs (XS-2) have some localized vertical control? There was an apparent boulder grade control (control height to bed = 4.5 ft; control height to water surface = 3 ft) approximately 450 feet upstream of XS-2, and the transition from Semi-confined to Narrowly-confined occurred at about that point. If active incision in the remainder of the segment upstream from this location was a localized and discontinuous phenomenon related to localized aggradation at debris jams and LWD obstructions, it would make sense that this Narrowly-confined section of channel would have been spared the effects of recent flood-related deposition / local incision (i.e., a transport reach with little room for forced deposition). If the segment were characterized as an F, the sensitivity would be affected. Why did you decide xs #2 was not representative? Because it represented a short piece (less than 500 feet) of the 3,374-foot segment. Also, I classified it as a Ba stream, and felt that it was characterized by more stable conditions than the upstream majority of the segment.


M41
possible old earthen dam
poss. breached dam
trib (rejuv)
steeper
rejuv.
WF
actively incising widening
boulder step
earthen/rock wall
B
A
XS-3
XS-2
XS-1
Bk

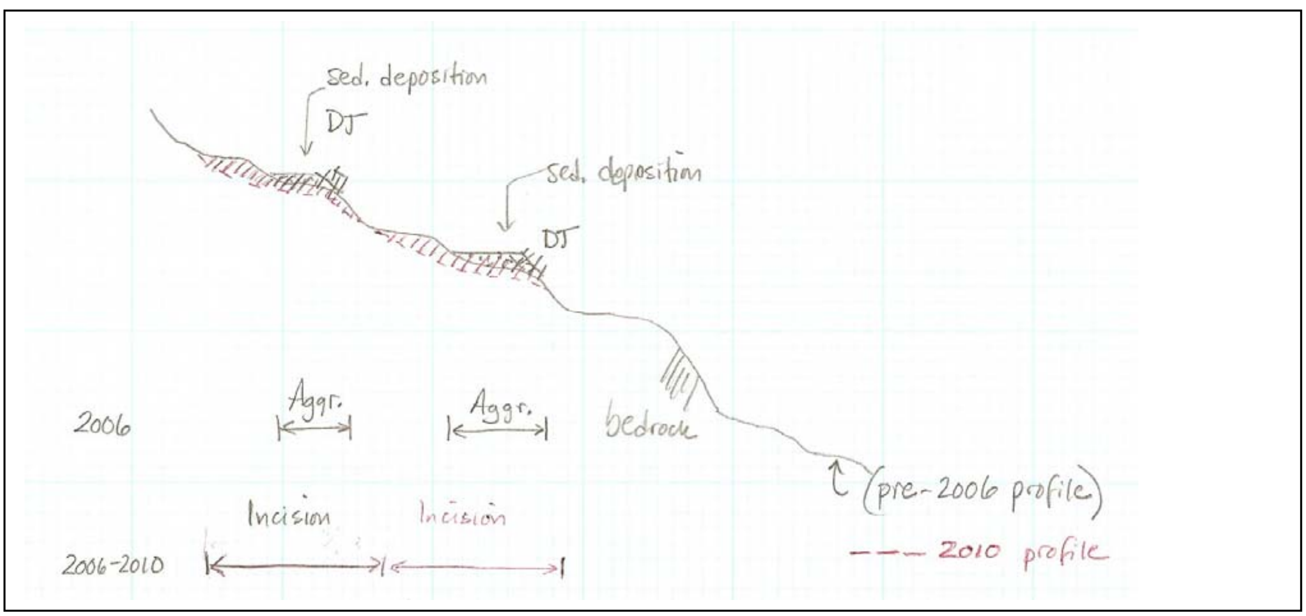

sed. deposition
DJ
sed. deposition
DJ
2006
Aggr.
Aggr.
bedrock
(pre-2006 profile)
Incision
Incision
2006-2010
--- 2010 profile

Figure 2.

M41T6.02S1.02A

- Step 2.10/2.11. Why N/A? Whether cascade or step-pool, "steps" should be measurable. Does not appear to be bedrock dominated. Please explain. When distinct steps were present (rarely), the spacing was approximately 10 feet (I have entered this value in the DMS). And correct, there was no channel-spanning bedrock indexed in the segment. By classifying the segment as cascade, I was following the descriptions for cascade bedform contained in Montgomery-Buffington, 1997 – "longitudinally and laterally disorganized bed material typically consisting of cobbles and boulders". I suspect that flood debris and colluvial processes including mass failures in this semiconfined channel (initiated by the recent flooding) have resulted in a disorganized, jumbled bed, without recognizable discrete steps. Perhaps, in the few years since that flood, the watershed has not been subjected to the magnitude of flows necessary to begin to sort the bed into a more organized step/pool structure that I speculate was the reference bedform.
- Did you mean to choose No for Historic in step 7.1 degradation? Yes, I chose "no" to reflect that I suspect incision is very recent (post-2006 flood) and is probably overprinted on a degree of historic (and/or post-glacial incision). While there were no distinct headcuts noted in the segment, I suspect that mass wasting and colluvial processes from the closely confining valley walls are contributing sediment and debris to the channel that may be blanketing or masking recent incision features. Is this because of recent flooding/ incision or do you think degradation is still ongoing /active?

M41T6.02S1.02B

- Please label bankfull features in xs spreadsheet. I have added the LBF label at point (4, 1.4). I entered a value of 2.0 in the bankfull elevation cell so that the spreadsheet would include the full width of this bankfull bench in the calculation of bankfull width. The right bank was a very steep eroding face, with no discernable bankfull feature at the location of the cross section.
- Did you mean to choose Yes for Historic in step 7.1 degradation? Yes. There is a head cut indexed, implying active incision in at least a portion of the segment, I assume related to recent flooding. I checked the original field notes which indicate two steep riffles, no head cuts. I suspect that I made an error selecting the subimpact during feature indexing. FIT file has been updated, and DMS corrected. Do you think the cut is likely to keep moving upstream? (Not applicable). Given the steep riffle, bars, and flood chutes, which process is more predominant on this segment—degradation or aggradation? Based on qualitative observations and limited metrics from one snap shot in time, I suspect that current adjustment processes are dominated by planform adjustment, driven in part by aggradation, overprinted on historic incision processes. There are only 2 steep riffles, bars are mostly point and side (only 1 MCB); flood chutes are not uncommon in a steep-gradient channel (estimate 2.2%).
  SP: I am still seeing a head cut in DMS for this segment. I don't have the corrected FIT file. Can you check in case there is an error with FIT/DMS transfer? FIT file corrected and uploaded to DMS.

M41T6.02S1.02C

- What is "other" channel constriction? Lower dam or stone mill foundation? Please enter description in step 5 notes. Yes, the lower breached dam near the upper extent of the reach (this is a second dam, not the breached dam that previously controlled the level of Reading Pond). Note entered in DMS.
- Why did you choose N/A for riffle spacing if reference stream type (and subdominant existing type) is riffle-pool? Riffle spacing was on average 220 ft; N/A replaced with this value in the DMS. Is change in bed form related to recent dam failure/flooding, or do you think it could be from historical channel evolution processes in general? It could be both; as I have data from only one snap-shot in time (post June 2006), it is not possible to state with certainty. Historic incision in downstream segment B suggests that historic incision could be present in segment C – overprinted by more recent incision resulting from dam breaching. If there are any riffles, measure the distance between them; if you forgot to evaluate riffle spacing, then enter Not Evaluated in DMS. Add notes to DMS as needed.

References:

Phillips, Jonathan D., 2002, Geomorphic impacts of flash flooding in a forested headwater basin. *Journal of Hydrology* 269: 236-250.

Faustini, John M. and Julia A. Jones, 2003), Influence of large woody debris on channel morphology and dynamics in steep, boulder-rich mountain streams, western Cascades, Oregon. *Geomorphology* 51: 187-205.

APPENDIX D

Reach Segmentation

Table D-1
Segmentation of Patch & Buffalo Brook reaches, 2009 Assessments

Reach	Segment	Feature	Point	Total Reach Length (ft)	Segment Lengths (ft)	Elevation (ft)	Segment Slopes	Reach Slope
M40T5.04		d/s end reach				1740		
	A	segment break	A/B		623	1742	0.3%	
	B	segment break	B/C		2,427	1791	2.0%	
	C	segment break	C/D		2,297	1880	3.9%	
	D	segment break	D/E		851	1919	4.6%	
	E	u/s end reach		10,776	4,578	2362	9.7%	5.8%
M40T5.03		d/s end reach				1265		
	A	segment break	A/B		1,856	1360	5.1%	
	B	u/s end reach		9,479	7,623	1740	5.0%	5.0%
M40T5.02		d/s end reach				1200		
	A	segment break	A/B		1,240	1240	3.2%	
	B	u/s end reach		2,111	871	1265	2.9%	3.1%
M40T5.01		d/s end reach				1060		
	A	segment break	A/B		397	1070	2.5%	
	B	segment break	B/C		764	1095	3.3%	
	C	segment break	C/D		1,449	1150	3.8%	
	D	u/s end reach		3,992	1,382	1200	3.6%	3.5%
M41T6.02S1.02		d/s end reach				1680		
	A	segment break	A/B		505	1700	4.0%	
	B	segment break	B/C		1,360	1730	2.2%	
	C	u/s end reach		2,630	765	1756	3.4%	2.9%
M41T6.02S1.01		d/s end reach				1260		
	A	segment break	A/B		5,564	1500	4.3%	
	B	u/s end reach		8,938	3,374	1680	5.3%	4.7%
M41T6.05		d/s end reach				1350		
	A	segment break	A/B		2,458	1460	4.5%	
	B	u/s end reach		3,964	1,506	1580	8.0%	5.8%
M41T6.02		d/s end reach				1095		
	A	segment break	A/B		1,556	1150	3.5%	
	B	u/s end reach		6,639	5,083	1260	2.2%	2.5%
M41T6.01		d/s end reach				1061		
	A	segment break	A/B		1,361	1080	1.4%	
	B	u/s end reach		2,010	649	1095	2.3%	1.7%

APPENDIX E

Reach Summaries

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E.1 Patch Brook watershed

M40T5.04

M40T5.04 is a 2.0-mile reach of Patch Brook extending through the Calvin Coolidge State Forest from the headwaters near Salt Ash Mountain downstream to the vicinity of Lake Ninevah. The area is generally covered by soils of glacial till origin. A few isolated deposits of glacio-fluvial sediments are also dispersed throughout the subwatershed, and have been historically excavated. Observed gravel pits were elevated above the Patch Brook channel along the valley walls. Hydric soils of alluvial origin are present in a locally wide valley south of Patch Brook Road near the downstream end of the reach. Wetlands are mapped by NWI associated with these alluvial sediments. Bedrock is exposed along the stream bed near the downstream end of the reach above the wetlands. A relatively large tributary drains the southwestern half of the M40T5.04 subwatershed, flows through the wetlands south of Patch Brook Road and joins the Patch Brook approximately 560 feet northwest of the downstream reach break.

Reach M40T5.04 was segmented to capture the natural variation in valley confinement, gradient, and bed substrates with distance downstream that defined distinct subreaches of alternate stream type (see also Figure x).

Segment	Length (ft)	Approx Gradient (%)	Stream Type	Notes
M40T5.04-E	4,578	9.7	B4a-casc	
M40T5.04-D	851	4.6	C4a-R/P	Subreach
M40T5.04-C	2,297	3.9	C4b-S/P	Subreach
M40T5.04-B	2,427	2.0	C4- R/P	Subreach
M40T5.04-A	623	0.3	N/A - Wetland	Not Assessed

Generally the river channel as depicted on the VHD does not match up well with the actual planform (as measured with the GPS on assessment dates 9/3/2009 and 9/11/2009). The channel is actually more sinuous than that depicted by the VHD. In addition, the roads depicted by Trans_RDS and Emergency_RDS shape file coverage obtained from VCGI diverge from the actual path of the gravel forest roads visible on the 1994 orthophotos and as measured with the GPS on the assessment dates.

The channel passes through soils of glacial till origin. There are a few pockets of glacio-fluvial sediments mapped along the west side of the channel, where historic sand and gravel extraction activities are evident. Near the downstream end of the reach the Patch Brook crosses Patch Brook Road to join a broad valley of alluvial sediments. In this location, south of Patch Road, the Patch Brook is dominated by wetland conditions: a multi-thread channel in hydric soils mapped as wetlands (NWI, VSWI).

History of forest clearing, and Class 4 roads cross the watershed draining to reach M40T5.01. The watershed is predominantly forested, with a few remaining gravel roads including the Unknown Soldier Road (TH-48) which crosses the channel mid-segment over a narrow timber bridge on stone abutments. Additional trails (former logging roads) cross the channel above this bridge (indexed as fords)

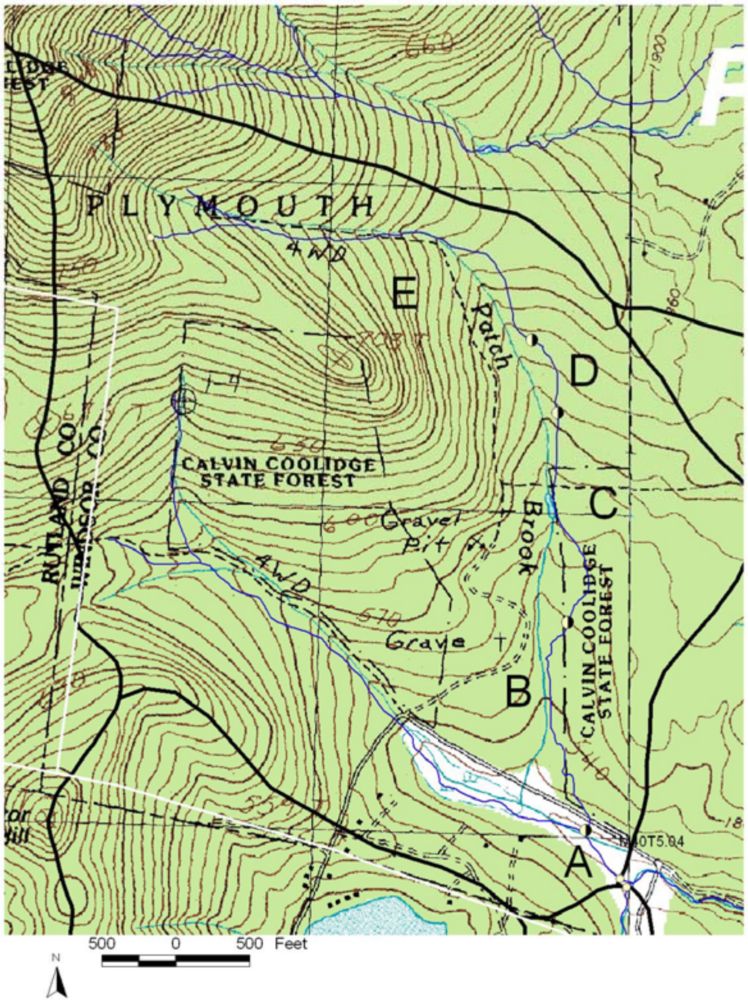

Figure 1. Segmentation of Reach M40T5.04, Patch Brook.

Segment E

Segment E at the upstream end of Patch Brook reach M40T5.04 is a steep-gradient boulder and cobble cascade channel with some sections of step/pool bedform – formed by a combination of colluvial and fluvial processes.

Generally, there are minimal current encroachments. The Unknown Soldier Road (TH-48) crosses the channel mid-segment over a narrow timber bridge on stone abutments. Stormwater inputs were indexed at this bridge location, due to overland runoff of road sediment to the channel. Additional trails (former logging roads) cross the channel above this bridge (indexed as fords)

The segment cross section confirmed the reference stream type of Ba-step/pool. Bed substrates are comprised of well-graded sediments ranging from silt (in the banks) to boulders. It is likely that the largest clasts are not mobile in most flows, and are of glacial rather than fluvial origin. Several glacial erratic boulders were observed along the channel margins. Evidence of recent blowdowns. Active recruitment of large woody debris; frequent debris jams. Occasional mid-channel bars, and flood chutes forced at debris jams. Few bifurcated sections of channel around tree covered islands. – not unusual for a steep, forested channel.

There is good channel connection to a semi-confined floodplain (IR_{RAF} = 1.0). Minor localized widening (mid-channel bars); minor planform adjustment (bifurcations, flood chutes). Lateral and vertical adjustments are probably moderated by the dense, young-growth forest cover, and erosion resistance of glacial till parent material in the bed and banks of the channel.

Figure 2. View upstream, M40T5.04 Segment E, Patch Brook; 3 September 2009.

Segment D

Segment D is a subreach of somewhat lesser gradient in an unconfined setting, with typical valley widths ranging from 100 feet to more than 200 feet. Good floodplain connection. Like the upstream segment E, bed substrates are dominated by very coarse gravels, but Segment D is characterized by fewer boulders and more cobbles. Minor aggradation and planform adjustment (mid-channel bars, point and side bars, one flood chute). A natural reduction in valley confinement and gradient (from approximately 10% in Segment E to 4.4% in Segment D) may be contributing to the minor degree of aggradation and planform adjustment. Lateral and vertical adjustments are probably moderated by the dense, young-growth forest cover, and erosion resistance of glacial till parent material in the bed and banks of the channel. Also, limited degree of sediment from upstream sources. Lots of LWD recruitment and a frequent spacing of channel-spanning debris jams. Woody material contributes to pool formation. Generally closed canopy – offering shading and ample organic material and detritus.

Figure 3. View downstream, M40T5.04 Segment D, Patch Brook; 3 September 2009

Segment C

Segment C is a subreach of slightly lesser gradient than upstream Segment D, but located in a Semi-confined to Narrow confinement setting. Valley walls are comprised of terraces ranging in height from 5 to 7 feet (or approximately 3 to 5 times the thalweg height). The valley defined by these terraces ranges in width from 15 to 80 feet. Low-bank heights along the channel ranged from approximately 1.2 to 1.7 times the thalweg height. Incision appeared historic in nature. The channel bed includes a range of substrate sizes from coarse sand to subangular boulders, but is dominated by very coarse gravels. It is likely that the largest cobbles and boulders are not mobile during bankfull flows, and reflect the glacial till parent material. Where the channel occasionally impinges on the adjacent terrace side slopes, erosion reveals a mix of substrate sizes.

Young-growth forest surrounds the channel. Generally closed canopy. Lots of LWD recruitment and a frequent spacing of channel-spanning debris jams. Large woody debris contributes to pool formation.

Within Segment C is a small flow diversion consisting of a 4-inch black flex hose leading from the channel to a nearby impoundment. The intake in the channel is a PVC pipe connected by a Fernco fitting to a flexible hose. The hose was traced through the woods to a narrow pond impounded by a horse-shoe shaped earthen dam approximately 8 feet high and 270 feet long. A culvert was located at the downstream end of the pond and apparently drains the pond. A concrete pad at the culvert inlet at the top side of the earthen dam is marked with the date "1979". Matted vegetation patterns indicated that the pond had overtopped the dam crest in a few locations east of the culvert outlet, in days prior to the assessment date. The exact outlet location of the culvert could not be located, although seepage was evident at the base of the dam along a majority of its length. A return channel joins the main Patch Brook channel approximately 650 feet downstream of the intake location.

Access to the pond is provided by the Catamount Trail which leads east from the Unknown Soldier Road located approximately 400 feet west of the pond. A small clearing surrounds the pond, which is approximately one-third of an acre in size. While the VHD indicates that Patch Brook flows through this pond, actual conditions on the ground indicate that the Patch Brook flows alongside the pond between 100 and 150 feet to the east (and 5 to 15 feet lower in elevation). This pond is visible on the 1994 orthophotograph of the region and the 1986 Wallingford, VT USGS topographic map, but was not specifically noted on the 1955 or 1893 Wallingford, VT USGS topographic maps.

Figure 4. Impoundment west of Patch Brook reach M40T5.04 Segment C, Patch Brook; 3 September 2009. (a) view upstream (north) from dam; (b) view south to culvert outlet.

Figure 5. View upstream, M40T5.04 Segment C, Patch Brook; 11 September 2009

Segment B

Segment B is a subreach of still lesser gradient (< 2%) than upstream Segment C, located in an unconfined, generally Narrow to Broad valley setting. Valley walls are comprised of terraces ranging in height from 4 to 10 feet (or approximately 2.5 to 6 times the thalweg height). The valley defined by these terraces ranges in width from 45 to more than 250 feet. Low-bank heights along the channel were generally less than in upstream Segment C, ranging from approximately 1.2 to 1.6 times the thalweg height. Incision appeared historic in nature. In contrast to upstream segments, the channel bed was dominated by fine to medium gravels, with the occasional cobble or boulder.

Near the downstream end of the segment was a short section of moderately-steep, narrowly-confined bedrock gorge. This section of B2-step/pool channel underlain by bedrock was indexed as a vertical grade control, but was not segmented due to its short overall length (less than 75 feet). A second occurrence of low-profile, channel-spanning bedrock was observed approximately 600 feet downstream from this gorge. Between the bedrock outcroppings was a short, linear section of channel confined between a left-bank terrace with a thalweg height of approximately 7 feet and a right-bank terrace approx 15 feet above the thalweg. The channel had access to a narrow floodplain approximately 20 to 30 feet wide between these two terraces. A cross section measured here (XS-1) indicated an incision ratio of 1.3 and an entrenchment ratio of 1.8. This gravel-dominated Bc-riffle/pool channel was not characteristic of the segment as a whole, but was not segmented due to its very short length. The linear nature of the channel and its unusual setting suggested historic channel modifications - possibly associated with the history of iron ore mining in the region. Proximity to the upstream bedrock gorge suggests possible mill dam operations. A black smith shop and saw mill were noted in the vicinity on the 1869 Beers Atlas of Windsor County (near the Patch Brook Road crossing). Today, a residence is located at the top of the right-bank terrace in vicinity of this short, linear section of channel.

Young-growth forest surrounds the channel in Segment B. Generally closed canopy. Lots of LWD recruitment and a frequent spacing of channel-spanning debris jams. Entrained woody material contributes to pool formation.

Figure 6. View downstream, M40T5.04 Segment B, Patch Brook; 11 September 2009

At the downstream end of the Segment, Patch Brook flows through a culvert under the Patch Brook Road. This instream culvert is a bankfull constrictor (approx. 24% of the measured bankfull width). The 1986 topographic map and 1955 topographic map seem to depict the crossing of Patch Brook Road at a location approximately 750 feet to the west of the current location, which would suggest a possible relocation of the channel.

Segment A

Segment A of Patch Brook reach M40T5.04 is the downstream-most 623 feet of the reach, located south of Patch Brook Road in an unconfined valley setting dominated by wetland conditions. Beaver activity was evident in the segment. There is a slight reduction in valley width due to the encroachment of Patch Brook Road along the left bank corridor. However, valley type (Very Broad) and confinement status (Unconfined) remain unchanged. Consistent with protocols, an RGA and RHA were not completed for this wetland-dominated segment.

M40T5.03s1.01 (Tributary to M40T5.03)

This is a short reach (1,221 feet) of river comprising the outlet from Lake Ninevah, a tributary to Patch Brook which joins reach M40T5.03 near the intersection of Patch Road and Townsend Barn Road in southwestern Plymouth. Lake Ninevah is described as a natural pond with an earthen dam that artificially increases the elevation and aerial extent of the lake (VTDEC, 2005). Historically, this pond was identified as "Patch Pond" on the 1893 Wallingford, VT USGS topographic map, and the Spaffic Iron Company ("S.I. Co") reservoir on the 1869 Beers Atlas of Windsor County (at the southern margins of the town of Plymouth). The current dam was reportedly installed in 1930 (VT Dam Inventory) on the approximate site of the former dam (perhaps breached in the 1927 flood).

This moderately-steep (2.2%) channel is Semi- to Narrowly-confined by moderately-sloping valley walls comprised of glacial till. Several large boulders are evident along the channel and on the forested slopes. The outlet joins Patch Brook a quarter of a mile north of Lake Ninevah dam at the downstream end of reach M40T5.04 which is dominated by wetland conditions. The downstream end (~125 feet) of the Lake Ninevah outlet channel is also characterized by wetland conditions and backwater effects from this wetland.

The Townsend Barn Road (which is named Sawyer Hill Rd south of the Plymouth town line in the town of Mount Holly) parallels the Lake Ninevah outlet channel beyond the RB valley wall. Loop Road, a private gravel road, crosses the channel near its mid-point via a timber frame bridge on laid-up-stone foundation. The span of this bridge is undersized with respect to the reference (42%) and measured (44%) bankfull width.

Cross section indicates a B3-step/pool channel surrounded by young growth forest. Pebble count suggests that a fraction of the bed material (the larger cobbles and boulders) are not mobile at bankfull flows. Typically, one might expect some degree of channel incision downstream of an impoundment due to "hungry water" effects (Kondolf, 1997). However, the channel appears to have access to a narrow floodplain ranging between 1 and 1.5 times the channel width. Since the Lake Ninevah was an existing natural impoundment that has been enhanced by the addition of an earthen dam, it is likely that the upstream elevation of this reach may not have changed much. The channel that developed naturally downstream of this post-glacial impoundment offered boundary resistance to the potential incision that might be imparted by enhanced pond elevations from the earthen dam. Just a marginal increase in scour energies downstream of the human-elevated impoundment.

M40T5.03

M40T5.03 is a 1.8-mile reach of Patch Brook that shares a narrow and steep valley with the Patch Brook Road. This reach extends from just upstream of the Townsend Barn Road bridge crossing to the vicinity of the Dublin Road bridge crossing located a quarter mile downstream of the Patch Brook Road intersection.

The natural valley setting is between 1.5 and 3 times the channel width, a Narrowly-Confined to Semi-confined setting. Underlying sediments are mapped as being derived from glacial till parent material (USDA), except for an area of glacio-fluvial sediments near the downstream end of the reach. A bedrock gorge approximately 200 feet in length with a vertical drop between 15 and 20 feet is located approximately 1900 feet upstream of the downstream reach break. Below this short bedrock gorge, the valley setting at this downstream end opens slightly (to a Narrow confinement; i.e., Unconfined) and the valley gradient decreases somewhat. The reach was segmented to capture the change in reference stream type inferred at this downstream end of the reach. Conditions in this downstream Segment A have also departed from reference due to a history of channel and floodplain modifications in response to past flood events.

Segment	Length (ft)	Approx Gradient (%)	Stream Type	Notes
M40T5.03-B	7,623	5.0	B3a-S/P	
M40T5.03-A	1,856	5.1	F3a-PB	Subreach of Ca-S/P w/ Vertical Stream Type Departure

Segment B

Segment B comprises the upstream 7,623 feet of reach M40T5.03. While the very upstream end of the segment has a somewhat wider valley width and lesser gradient (slightly less than 4%), the segment is generally a reference Ba-S/P channel. Over the years, Patch Brook Road has been maintained to encroach within this valley, and is elevated above the brook (cut into the left valley wall) at heights generally ranging from 6 to 15 feet (or 3 to nearly 8 times the bankfull depth of the channel). In one location mid-segment, where the height of the road is approximately 3.5 times the bankfull depth, presence of a short berm (between the road and the channel) and left-bank armoring suggests that the river may have avulsed in a past flood to wash out a section of the Patch Brook Road and temporarily occupy a small floodplain on the far side of the road. Encroachment by the road has resulted in human-modification of the valley width, such that the floodplain is now generally less than two channel widths (i.e., Narrowly-Confined). The natural valley width, prior to the road, was probably not much wider (between 1.5 to 2.5 times the channel width, or Narrowly-Confined to Semi-Confined valley type). No significant change in the reference stream type (Ba-S/P) is inferred as a result of the road encroachment.

Figure 7. View upstream, M40T5.03 Segment B, Patch Brook; 29 October 2009

The Beers Map (1869) shows that the Patch Brook Road once crossed the Patch Brook in two locations just upstream of the Dublin Road intersection. Specific evidence of former crossings or the previous road alignment was not able to be located in the field.

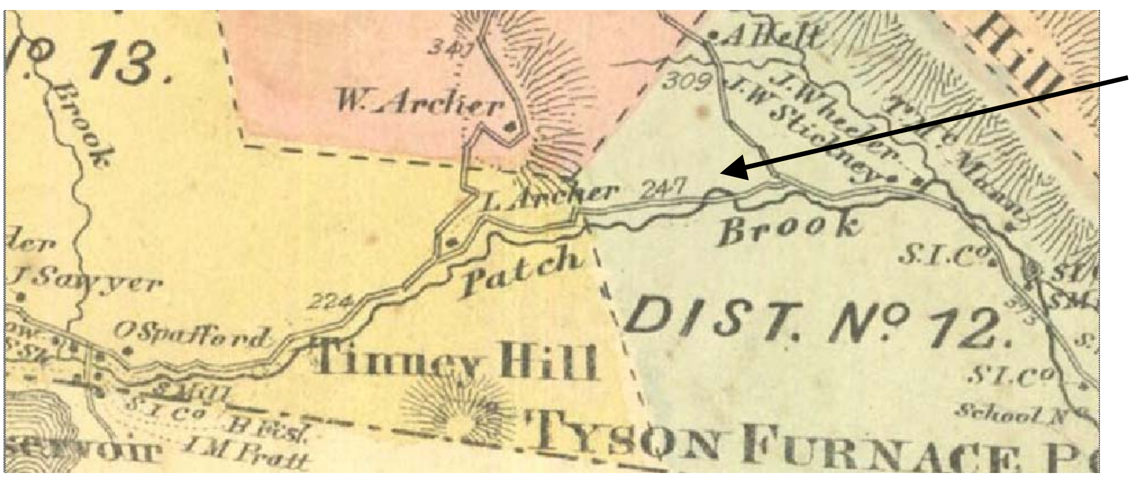

Figure 8. Beers Map (1869) indicates that Patch Brook Road once crossed the Patch Brook in two places.

The present map view of the road is more linear than depicted on this historic map also, suggesting that the road alignment has been somewhat straightened over the years. A few sections of rip-rap armoring were indexed along the reach where the road encroaches on the channel.

Several culverts receive road ditch drainage and small tributary inputs along the uphill (north) side of the road and convey stormwaters under Patch Brook Road directly to the channel. At least 21 cross culverts were indexed, most often 16 or 18 inches in diameter, but a few of 12- to 14-inch diameter and a few 2 feet in diameter. Often fine sand and gravels obstructed culvert inlets and culvert outlets were unstable (no headers). Road sediment was observed directly entering the channel at the outlet of several culverts. A few additional locations of direct sediment runoff by overland flow were indexed along the reach.

Figure 9. Stormwater inputs to Patch Brook, M40T5.03 Segment B, from Patch Brook Road; 29 October 2009. (a) cross culverts without headers are sites of road sediment runoff to the channel; (b) sections of the road are graded to drain directly to the channel.

In the 1980s and early 1990s, there is evidence to suggest that the Patch Brook received increased flows from Lake Ninevah in October of each year, as flashboards were removed at the Lake Ninevah dam to drop lake levels by approximately 3 to 4 feet (for weed management) (VTDEC, 2004). Increased flows would have been sustained in Patch Brook over a one to two-week period. See Section 4.1.1 for further details of the management of the Lake Ninevah dam and lake levels.

Remnants of a possible instream dam were noted near the upstream end of the reach in the vicinity of historic mills depicted on the Beers Atlas (1869). This dam appears to have been breached long ago (perhaps in the 1927 flood or prior events).

Figure 10. Remnants of breached dam at bifurcation in Patch Brook channel. View upstream, M40T5.03 Segment B, Patch Brook; 29 October 2009

Segment A

Segment A of reach M40T5.03 is comprised of the downstream 1,856 feet of the reach from a point just below the short bedrock gorge, along Dublin Road, to just below the Dublin Road bridge crossing. The natural valley width in Segment A is wider than upstream Segment B, suggesting an unconfined reference stream type of Ca-S/P. An alluvial fan was indexed in this segment to capture the marked reduction in natural valley confinement. Sediments of glaciofluvial origin are mapped at this transition point (USDA).

The channel is positioned close to the right valley wall along much of the segment length. Human encroachments along the left bank (Dublin Road and high gravel berms) have reduced the available valley width and led to a stream type departure. Channel straightening with windrowing in the downstream half is inferred due to the linear planform and presence of berms. A residence is located in the RB floodplain at the downstream end of the segment.

A cross section was completed near the mid-point of the segment in vicinity of left-bank berms. This cross section revealed a stream type departure due to encroachment of the berm. The berm was at a height of 8 feet above the thalweg, and constituted a "human-elevated floodplain" yielding an IR_{hef} = 4.2. Due to modifications of the floodplain and berm construction, the location and elevation of the "recently-abandoned floodplain" were not easily discerned. Between the berm and a terrace along Dublin Road there is a low spot at an elevation of 2 feet above the thalweg. It is very possible that this area was excavated in the past to produce gravel and cobble material for construction of the berm. This area may also have been occupied by floodwaters during an avulsion of the channel and may represent a historic flood chute. The terrace to the north of this flood chute along Dublin Road was likely graded at some time during flood recovery efforts and may not represent the natural, abandoned floodplain elevation. Therefore, the IR_{raf} value (of 3.7) may be overstated for this cross section location. Based on quick measurements, low bank heights (RAF) were approximately 2.9 times the measured bankfull depth in locations upstream of the cross section, closer to the short bedrock gorge.

Bed substrates are somewhat finer-grained than upstream Segment B – dominated by small cobbles on the cusp with coarse gravels.

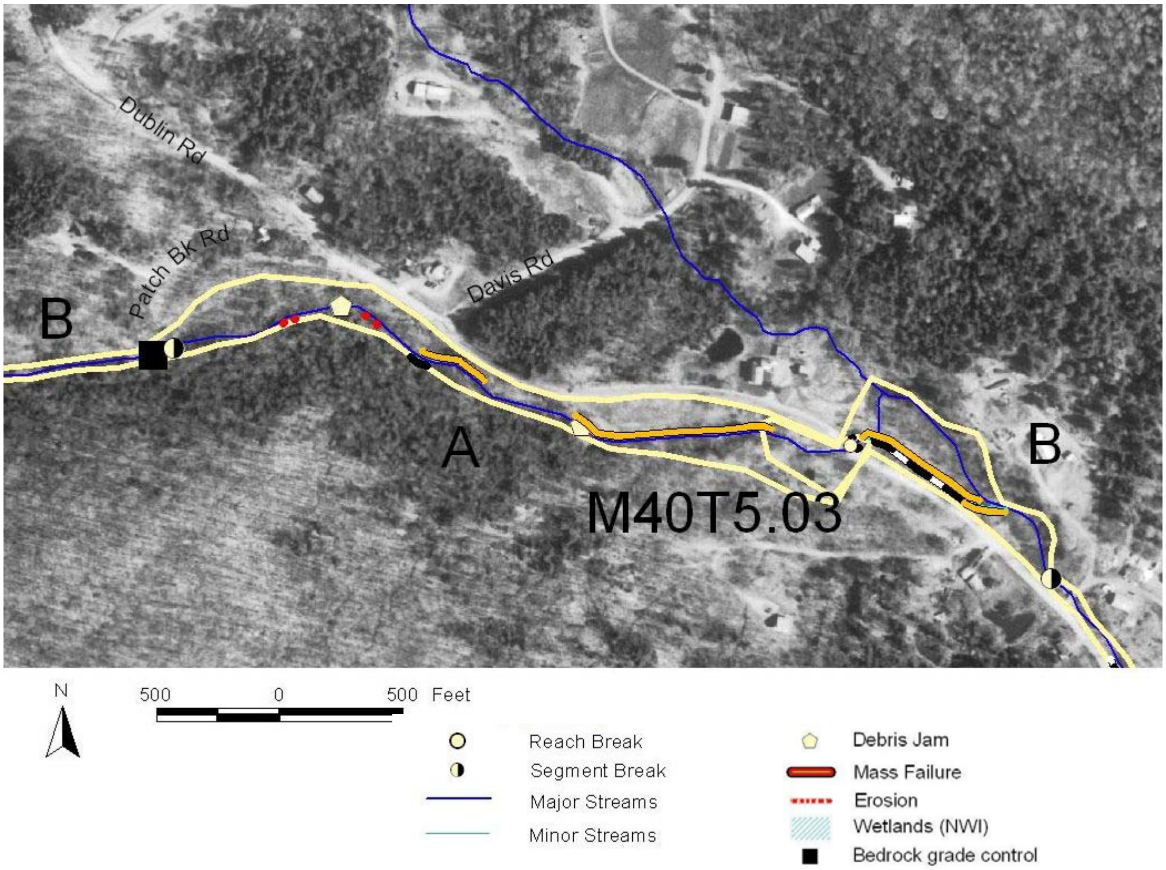

Figure 11. Features encountered along M40T5.03-A and upstream end of M40T5.02 (Segment B), 10 September 2009. (Yellow line indicates human-modified valley wall).

M40T5.02

This reach of Patch Brook extends just over 2,000 feet downstream from the upper Dublin Road bridge crossing, and was segmented to capture a difference in reference stream type in the upper 871 feet above the Tatro Road crossing.

Segment	Length (ft)	Approx Gradient (%)	Stream Type	Notes
M40T5.02-B	871	2.9	F3b-PB	Subreach of reference Cb-S/P that has departed to an Fb-PB
M40T5.02-A	1,240	3.2	B4-S/P	

Segment B

Segment B represents a short subreach of alternate reference stream in an unconfined valley setting. The natural valley width varies from 5 to greater than 10 times the channel width (Narrow to Very

Broad). Historic encroachment of Dublin Road within the RB corridor has reduced the valley width to a degree, to approximately 3 to 7 times the channel width, averaging a Narrow confinement. However, the valley type (Unconfined) has remained unchanged.

Actual channel position does not match VHD (Figure 12). Channel has been straightened along the Dublin Road; windrowing and berming are apparent. A 360-foot long cobble/gravel berm is present along the LB ranging from a thalweg height of 9.7 feet (near the Dublin Road bridge crossing) to 3 feet at its downstream end, where a 4-foot berm is also present along the RB for a short length of 110 feet. This LB berm effectively cuts off the river's access to the floodplain along the LB corridor, resulting in a Cb to F vertical stream type departure. A Human-elevated Floodplain incision ratio (IR_{HEF}) of 4.0 was estimated.

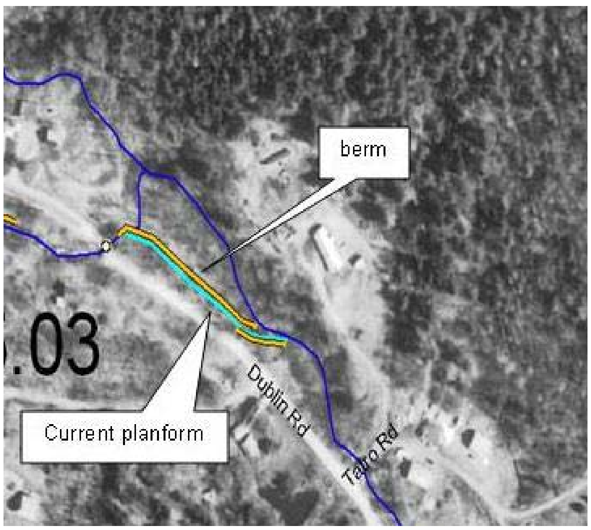

Figure 12. Section of Patch Brook (M40T5.02-B) has been channelized and bermed along Dublin Road.

Segment A

Due to the historic floodplain modifications to accommodate Dublin Road along the RB corridor of reach M40T5.02, the natural valley width of Segment A is somewhat difficult to discern, although it probably averaged between 1.5 and three times the channel width. The channel is confined between moderately-high terraces (mapped as glaciofluvial sediment [USDA]) that range in thalweg height from 7 to 11 feet (or 3 to 4.6 times the bankfull height above the thalweg) along the LB. Along the RB, the Dublin Road comprises the modified (or artificial) valley wall – at a thalweg height ranging between 7.5 and 10.4 feet. Between the road and the channel, there are a few isolated RB terraces, including two narrow terraces at a bankfull elevation near the upstream end of the reach (vegetated side bars), a terrace at a thalweg height of 4 to 5.5 feet at the mid-point of the segment, and a narrow, 6-foot terrace near the downstream end of the segment. These terraces are at approximate heights of 1.2, 2.3, and 2.5 times the bankfull depth, and may represent a more recently-abandoned terrace (resulting from channel incision within the last 250 years) – whereas the higher terraces along LB and RB (at greater than 3 times the bankfull height) likely represent former floodplains abandoned in postglacial times, up to thousands of years before present. Valley widths have been reduced somewhat by the encroachment of the Dublin Road, resulting in a modified valley width that varies between 30 and 75 feet, or 1.1 to 2.7 times the measured bankfull width.

The degree of historic incision versus postglacial incision is uncertain; thus, the reported degree of historic incision may be overstated. At least some degree of historic incision is indicated by the stepped footers on Tatro Road bridge crossing (and upstream Dublin Road crossing), and suggested by the history of straightening and berming. It is also possible that the degree of incision at cross section site for Segment A has been influenced locally by the presence and later breaching of a historic mill dam. In the field, remnants of an apparent stone wall / earthen dam were visible on both sides of the channel near the downstream end of Segment A. The Beers Atlas (1869) shows a small mill pond associated with an "S. I. & Co." saw mill in this approximate position. This former dam was associated with the Tyson Furnace and a diversion channel constructed to support the iron furnace operations and other industries in the hamlet of Tyson Furnace (see descriptions under M40T5.01). On the 1929 USGS topographic map, there is no evidence of a mill pond, suggesting that it was abandoned sometime between 1869 and 1929 (possibly washed out in the 1927 flood).

M40T5.01

Reach M40T5.01 is the downstream-most reach of Patch Brook extending 3,992 feet upstream from the confluence with the Black River. The reach is underlain by sediments of glaciofluvial origin. A decrease in gradient as well as valley confinement is evident near the confluence.

As visible on an 1859 map of the town of Plymouth, the Patch Brook confluence with the Black River was historically located approximately 50 yards south of its current position. The channel was reportedly diverted to its current position in 1929 following the 1927 flood (Jefferies, 2009).

Commercial and residential developments are evident near the downstream end of the reach, including the Echo Lake Inn, Tyson Library, and a church. These buildings are located in the historic hamlet of Tyson Furnace. An iron works was established in this vicinity circa 1837 by Isaac Tyson, Jr. This industrial center flourished for nearly 20 years, and produced a variety of products including farming implements, water pipes, and stoves (VT Historical Society, 2009; Thompson, 1842). The iron works were closed in 1855, but later re-opened during the Civil War and produced "iron for the building of the Monitor class gunboats" (Duffy et al, 2003). Following the war until 1872, the iron works were operated by Spathic Iron Company (Hartford, CT) for the production of steel cutlery (Duffy et al, 2003).

Evidence of a historic flow diversion site along Patch Brook was revealed from a review of the 1859 Map of the Town of Plymouth (Scott, Stickney, & Pollard, publishers), supported by field observations. Near the upper end of the reach (just downstream of the former mill dam in segment M40T5.02-A), a small bypass channel has been constructed historically to convey a portion of the flow from Patch Brook to a culvert under Dublin Road and into a constructed channel that flows somewhat parallel to Patch Brook, but on the far side of residential homes to the west of Dublin Road. This "canal", as it is known locally, returns to the Patch Brook approximately 3,000 feet downstream, below the Dublin Road bridge. This diversion channel was constructed historically to support operations at Tyson Furnace (Scott, Stickney, & Pollard, 1859). On the Beers Map (1869), this diversion channel originates at the downstream end of the small mill pond operated by the Spaffic Iron Company.

Near the downstream end of the reach, Patch Brook is crossed by Library Road and VT Route 100. Based on historic topographic maps, sometime between 1932 and 1983, the alignment of Route 100 was straightened, resulting in a shift in the bridge crossing site over Patch Brook. The bridge and culvert database maintained by VTrans suggests that this bridge was constructed in 1936.

Reach M40T5.01 was segmented to capture a difference in reference stream type at the lower end of the reach and to identify segments with differing dominant adjustment processes.

Segment	Length (ft)	Approx Gradient (%)	Stream Type	Notes
M40T5.01-D	1,382	3.6	F3b-PB	Vertical stream type departure from reference C3b-S/P
M40T5.01-C	1,449	3.8	C3b-PB	
M40T5.01-B	764	3.3	F3b-PB	Subreach of reference Cb-S/P that has departed to an Fb-PB
M40T5.01-A	397	2.5	C3b-PB	Subreach of reference Cb-R/P

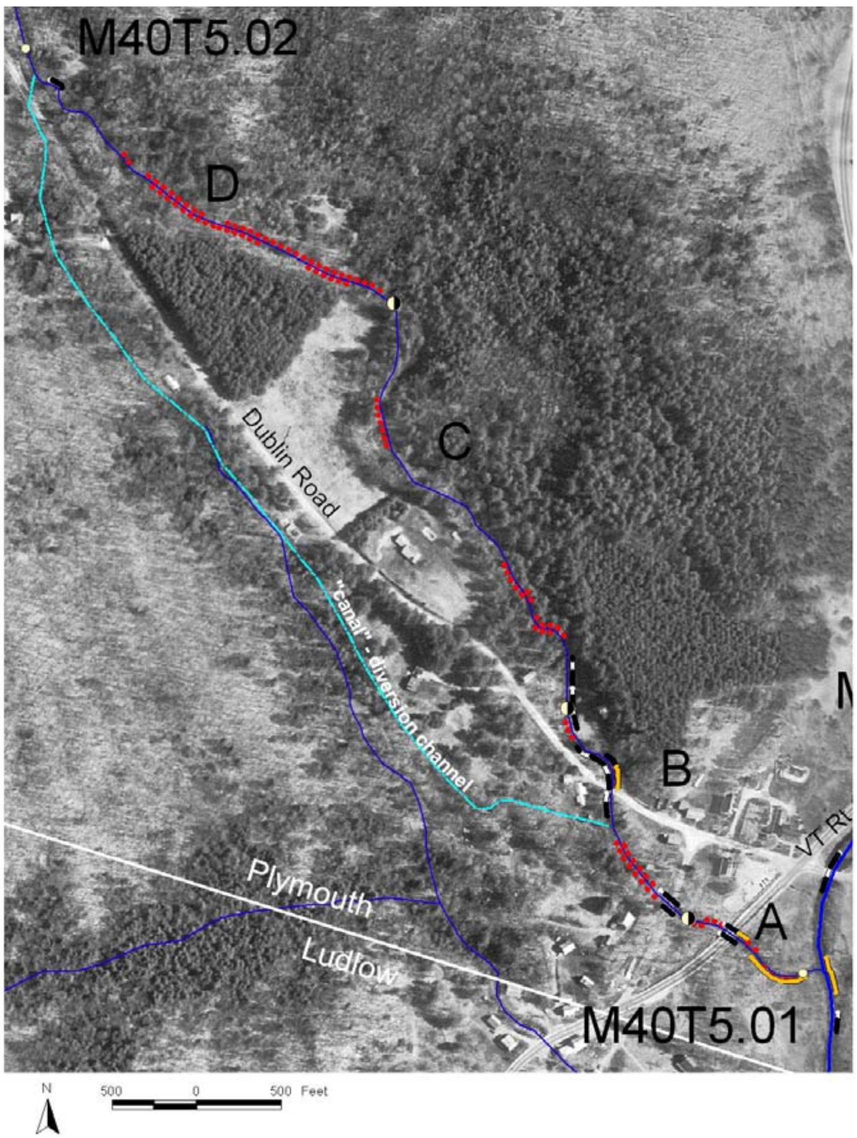

Figure 13. Diversion channel leading from the upstream end of reach M40T5.01 under Dublin Road, to the west of residential homes, and returning to the Patch Brook channel downstream of the DublinRoad bridge crossing.

Segment D

The uppermost 1,382 feet of the reach flows within a Semi-confined valley in a young-growth forested area, east of the Dublin Road. Generally, valley walls are comprised of coarse-grained glaciofluvial terraces between 2 and 4 times the channel width, and ranging in height from a thalweg height of 10 to 12 feet, or 5 to 6 times the thalweg depth of the channel.

Straightening of the channel is apparent from the linear planform with abandoned meanders on either side of the straightened channel. Given the nature of detritus and vegetation that has accumulated in these abandoned channel meanders, it is apparent that channelization is historic in nature. The straightened channel section appears to have undergone some historic incision, exposing tree roots along both banks, which have weathered to some degree.

Near the upper end of the segment, a small bypass channel has been constructed historically to convey a portion of the flow from Patch Brook to a culvert under Dublin Road and into a constructed channel that flows somewhat parallel to Patch Brook, but on the far side of residential homes to the west of Dublin Road. This "canal", as it is known locally, returns to the Patch Brook approximately 3,000 feet downstream in Segment B.

Historic incision and historic planform adjustment (straightening) are inferred. Hhistoric incision may have developed in response to historic channelization and/or channel management in response to the large flood events of 1927 or 1973. Historic incision may also have been associated with the historic mill dam operations, and/or water withdrawals to the canal. The channel is inferred to be persisting in early stage III of channel evolution, with widening moderated by the coarseness of the bed and bank material of glaciofluvial origin and the well-developed, though young-growth, forested buffers. Historic straightening of the channel has enhanced the natural transport function of this semi-confined channel with relatively steep valley gradient. There is little evidence of aggradation.

Figure 14. View upstream, M40T5.01 Segment D, Patch Brook; 10 September 2009

Segment C

Segment C of M40T5.01 is 1,449 feet long. The channel has a more natural planform and slightly more relaxed valley confinement in Segment C, as compared to upstream Segment D. Moderately high terraces (6 to 8 feet thalweg height) and a set of much higher terraces (15 to 25 feet high) along the RB comprised of glaciofluvial sediments define a natural valley width that ranges between 80 and 130 feet wide, or 2.9 to 4.6 times the channel width.

Presence of active flood chutes, and channel bifurcations around tree islands is more prevalent. Despite the steep gradient, a few signs of localized aggradation were noted, including a point bar and side bar. Evidence of breached debris jams and one intact debris jam was also noted, suggesting active recruitment of LWD. The channel has a degree of connection to a narrow floodplain in select locations.

The cross section for Segment C captured a flood chute and reflected the higher width/depth ratio and greater degree of floodplain connection that is characteristic of the segment. Bed and bank sediments are generally somewhat smaller in size than upstream segment D, but cobble is still the dominant grain size. Generally, a plane bed form, with weak step/pool form developing.

Figure 15. View upstream, M40T5.01 Segment C, Patch Brook; 10 September 2009

Segment B

Within the lower end of reach M40T5.01, Patch Brook transitions to a valley setting of more relaxed confinement and slightly lesser gradient on approach to the broader Black River valley and its confluence with the main stem of Black River between Echo Lake (upstream) and Round Pond of Lake Rescue (downstream). This segment was indexed as an "alluvial fan" in accordance with protocols to capture the change in valley setting, although surficial geologic studies to confirm the presence or absence of a true alluvial fan deposit are beyond the scope of this study.

Over the years, with development of the hamlet of Tyson, several encroachments occurred along the river. Dublin Road has been elevated above the floodplain and now forms a berm along the RB of the channel upstream of the crossing and in the LB corridor downstream of the crossing. This Dublin Road crossing reportedly was washed out in the 1973 flood (according to a nearby landowner), and a large cobble / earthen berm is now present along the LB of the channel at a thalweg height of 12.5 feet on the upstream approach to this Dublin Road bridge. Stepped footers of the LB abutment supporting this bridge are being scoured by the channel. The span of this bridge (29 ft) is undersized (87%) with respect to the measured bankfull width (33.3 ft).

Downstream of the Dublin Road crossing, the channel is entrenched and incised below high banks on both sides. The "canal" rejoins the Patch Brook approximately 85 feet downstream of the bridge, and a short distance further downstream, the river joins a high terrace along the RB. The LB corridor has a long history of development including the former Tyson Furnace. Fill material likely encroaches along the LB in vicinity of the present day Tyson Library building. A laid-up stone wall reinforces the LB on approach to Library Road bridge crossing. The 16-foot span between stone wall abutments of this bridge is undersized (48%, 57%, respectively) compared to the measured bankfull width (33.3 feet) and reference bankfull width (28 ft) of this channel.

A cross section was completed approximately 175 feet upstream of the Library Road bridge. If the terrace immediately adjacent to the channel on the LB is considered the Recently Abandoned Floodplain, an incision ratio of 3.7 is calculated. The degree of actual incision may be overstated (although there is a long history of extensive floodplain and channel modifications in this vicinity). It is likely that the current vertical displacement of the channel from the LB floodplain results from a combination of historic incision (associated with channelization, and possibly dredging) and historic encroachments involving fill, regrading of the floodplain, road building and berms. More recently, this area has probably been modified and regraded during flood response activities following the 1973 and 1927 floods, at a minimum.

Figure 16. View downstream to Library Road bridge, M40T5.01 Segment B, Patch Brook; 10 September 2009

Segment A

Segment A comprises the downstream 397 feet of the reach, from just below the Library Road bridge to the confluence with Black River. Like upstream Segment B, this segment of Patch Brook is located at a locally wider valley setting with slightly lesser gradient. It is a natural place for the channel to shift laterally and deposit sediment. Historic encroachments of the Dublin Road to the north have somewhat limited the valley width, and fill material for the VT Route 100 crossing has locally constricted the channel.

Today, although the channel appears moderately incised below the floodplain, the brook occasionally jumps its banks to flow out on the floodplain. The landowner downstream of VT Route 100 has managed the channel and floodplain over the years, placing berms along the RB to prevent the channel from flowing out onto a cleared area. The present channel appears a bit undersized for the given drainage area (narrower than expected width/depth ratio and smaller cross sectional area).

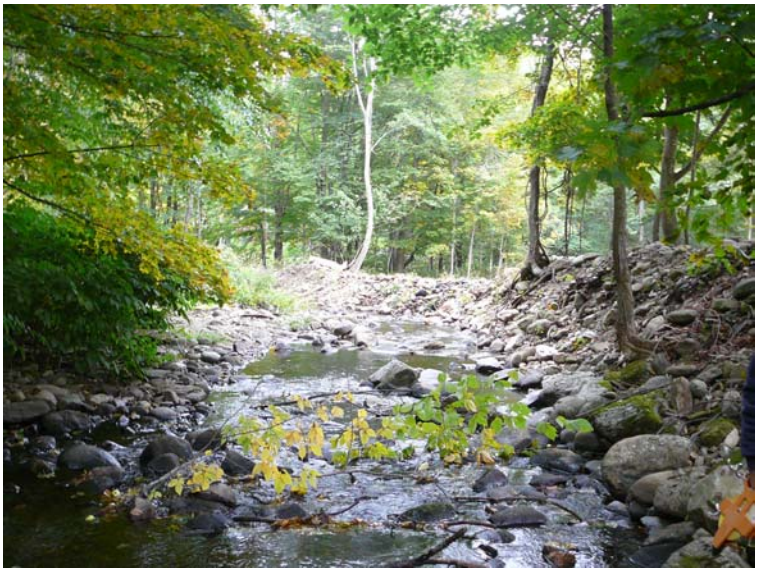

Figure 17.
View downstream from cross section site to right-bank berms, M40T5.01 Segment A, Patch Brook;
18 September 2009.

E.2 Black River main stem

M40

Slight reduction in valley width due to Vt Rt 100 along RB, driveway along LB corridor. Valley type (Broad confinement) and status (unconfined) remain unchanged. Reach receives Patch Brook as RB tributary. Position of confluence was reportedly altered over the years (see description under M40T5.01). Kingdom Road crosses the reach via a bankfull-constricting bridge. Former bridge in this position was washed out in the 1927 flood (Ward, 1983). Two discrete sections of berms along LB enhance the degree of channel entrenchment and cut off portions of the floodplain. One short section located near the Patch Brook confluence (Patch Bk itself is bermed just upstream of the confluence; sediment "delta" protrudes from Patch Brook). Second longer, higher berm is located spanning Tiny Brook confluence. Upstream flow regulation = run-of-river dam at Amherst Lake (reach M42, ~1 mile upstream). Downstream flow regulation = run-of-river dam at Lake Rescue (reach M39, ~1.1 mile downstream. Reach M40 flows into Round Pond, a small embayment at the north end of Lake Rescue where a large sediment delta has formed over recent decades. Historic straightening and dredging of M40 is inferred due to linear planform and presence of berms. Also anecdotal evidence indicates channel and floodplain management following flood events of 1973 and 1927.

E.3 Buffalo Brook

M41T6.06

Reach M41T6.06 is 2,415 feet long and represents the upstream–most reach of this tributary to Echo Lake. It drains downslope to the southeast from a gravel forest road beginning at a point approximately 0.44 mile west of the terminus of Reading Pond Road.

The channel is confined between extremely-steep (>25%) bedrock-controlled valley walls. Generally, the valley is between 2 and 4 times the channel width, although occasionally a bit wider, and marked by two main occurrences of steeper-gradient Narrowly-confined bedrock cascade channel. The reach as a whole was classified as a bedrock gorge according to protocols; thus, exempted from the Rapid Geomorphic Assessment. A provisional stream type of B1a-cascade was assigned, although there are short sections of A or Ca stream type, and sections of step/pool rather than cascading bedform with a boulder/cobble veneer over bedrock.

The area surrounding reach M41T6.06 is forested with relatively new-growth deciduous forest. Available historic documents indicate that the area was deforested during the mid-1800s for support of the lumber industry, and possibly to provide charcoal for the nearby Tyson Furnace. There is also a history of gold placer mining in the area.

A forest road (and VAST trail) leads west from the terminus of Reading Pond Road and crosses the reach near the upstream end, approximately 0.4 mile west from the junction. This culvert (3.9 ft wide) is 49% of the reference bankfull width (8 ft) for the channel. The structure invert is perched approximately 2 feet above the channel bed (Figure 18).

Figure 18. View upstream through culvert under forest road at upstream end of reach M41T6.06, Buffalo Brook, 22 October 2009

Three fords were noted in the reach associated with minimally used former logging roads or skidder trails. At one location near the downstream end of the reach, an apparent breached earthen dam was noted – possibly associated with former gold placer mining. Recreational-scale gold mining equipment (bucket, tubing) was noted near a bedrock falls at the upper end of the reach.

M41T6.05

Reach M41T6.05 is a 3,964 feet long. It has been segmented to capture an upstream subreach of steep, narrowly-confined bedrock channel (i..e., “bedrock gorge”).

Segment B

The segment has a short section (250 feet long) of C4b-riffle/pool channel at very upstream end in vicinity of tributary confluence, which was too short to segment. Channel quickly transitions from the confluence area to the bedrock gorge.

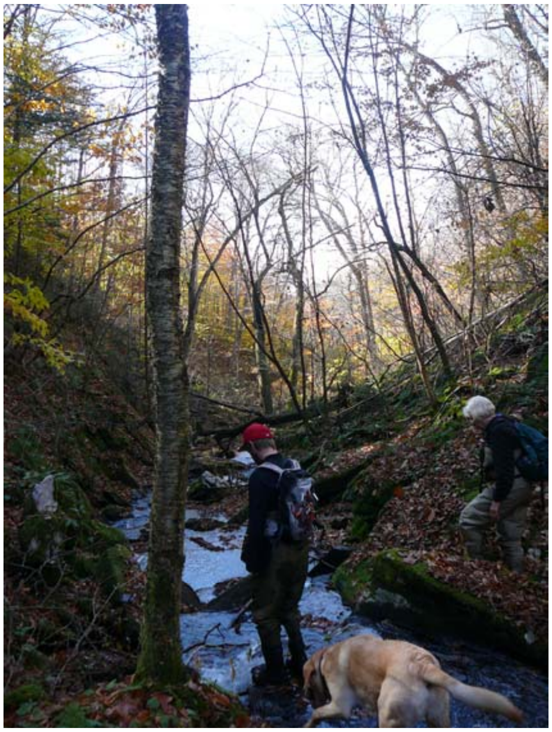

Figure 19. View downstream Segment B, reach M41T6.05, Buffalo Brook, 22 October 2009

Segment A

Slightly lesser gradient and wider valley confinement (2 to 4 times channel width) in Segment A has allowed for an occasional terrace along either side of the channel. Stream bed material is comprised of a wide range of sediment sizes from gravel to boulder, dominated by coarse gravels. Sediments are generally deposited in a shallow veneer over bedrock. Bedrock was observed exposed in the channel in several locations, including three channel-spanning ledges or waterfalls. Bedrock was occasionally exposed along the valley walls. Channel appears partly incised (historically, or post-glacially) below the occasional stream terrace.

In the lower 1300 ft of the segment, an old forest road (gravel) joins the stream valley. The road appears to have been installed at grade on occasional terraces and along the base of the valley wall to either side of the channel. The road height above the channel varies but averages 2.5 feet above the thalweg. No evidence of bridge or culvert crossings was observed, and the road is inferred to have originally crossed the river channel via fords. At least three current ford crossings were located. Over the years, the river appears to have avulsed to flow in the path of the road. In some locations evidence of the road has been eroded away. In other locations the former road grade has been eroded to form a flood chute (Figure 20). Where the road bed is elevated to a position along the right- or left-valley wall, the road segments are intact.

Figure 20. View downstream, river crossing old road bed, which now functions as a flood chute during higher-flow conditions upstream of the crossing, Segment A, reach M41T6.05, Buffalo Brook, 22 October 2009

M41T6.04

Reach M41T6.04 has a slightly lesser gradient (3.4%), but similar valley confinement (predominantly Semi-Confined) to upstream segment M41T6.05-A. As with upstream reach, a gravel road follows the channel in this reach. Often, the road has been cut into the valley wall. In other cases, it follows a discontinuous terrace at grade; occasionally, the road appears to have been excavated below the terrace level (for example, at cross section location). Three road crossings were indexed within the reach. There was evidence of concentrated runoff eroding sections of the road on approach to a crossing. Some sections of the old road serve as flood chutes during high flows. The former road grade serves to concentrate stormwater runoff and convey it to the river channel at locations of flood chute returns or channel crossings.

At the downstream end of the reach, the road segment has been eroded to function as an active part of a bifurcated channel that extends into the next downstream reach. Several tributaries join the channel in this reach. Roads were observed along the banks of two of the larger tributaries. These road networks may be associated with previous logging activity and /or gold placer mining.

In contrast to the upstream segment, reach M41T6.04 appears to have good floodplain connection. A B3-step/pool channel was assigned, consistent with reference stream type.

Figure 21. View downstream, old road bed follows the channel, crossing three times within the reach, with most traces eroded in a bifurcation of the channel near the downstream end of the reach, M41T6.04, Buffalo Brook, 22 October 2009

M41T6.03

This 807-foot reach was separately delineated due to the change in valley setting in the vicinity of the confluence with Reading Pond Brook. At the downstream end of reach T6.03, the Buffalo Brook has a drainage area of 1.9 square miles, and it receives the Reading Pond Brook with an upstream drainage area of 2.9 square miles. It is a short reach exhibiting a significant decrease in valley gradient – transitioning from 5.8% in T6.05 and 3.4% in T6.04 to 2.5% in reach T6.03. A change in valley confinement is also notable within this reach, as the valley transitions from Semi-Confined to Broad in vicinity of the confluence of Reading Pond Brook, whereupon the valley quickly becomes Semi-confined once again in downstream reach M41T6.02. This general location was indexed as an "alluvial fan" following protocols to capture the marked decrease in valley gradient and valley confinement – although geologic investigations to confirm the origin and nature of sediments comprising this feature as a true alluvial fan, were beyond the scope of this study. Soils in the corridor surrounding T6.03 have a glacio-fluvial parent material in contrast to upstream and downstream reaches which pass through soils of glacial till origin (USDA).

The channel follows the right valley wall, where bedrock is occasionally exposed. The channel appears historically (or post-glacially) incised below a discontinuous RB terrace which ranges in height from 1.4 to 2.5 times the maximum depth of the channel. And the channel is entrenched below a higher LB terrace approximately 4 to 5 times the max depth. This LB terrace represents a relatively broad level surface between two steep, bedrock-controlled valley walls. These valley walls range in width from 55 ft near the upstream end to 270 feet near the downstream end, with an average of 160 ft. Forested vegetation is sparse on this surface. Old road networks appear to cross the surface, which may have served as a historic logging landing, or staging area for gold mining operations in the late 1800s.

It is possible that historic incision in this reach has been induced by incision occurring in Reading Pond Brook (upstream of the confluence) and the remainder of Buffalo Brook downstream of reach T6.03. Given the history of gold mining in the area, it is possible that dredging occurred in this reach in the late 1800s, leading to possible incision. Headward migration of incision was likely arrested at the channel-spanning exposure of bedrock located mid-reach and 350 ft upstream in reach M41T6.04. Also, the relatively close confinement of bedrock-controlled valley walls at the upstream end of the reach may have moderated the potential for further upstream migration of incision and widening in the Buffalo Brook due to colluvial processes and the steep gradient.

The degree of historic incision is less pronounced in the upstream third of reach M41T6.03, possibly due to moderating effects of bedrock exposures. This trend may also reflect overprinting of aggradational processes from upstream sediment sources at this local decrease in gradient (and decrease in sediment transport capacity).

M41T6.02

Within reach M41T6.02, the Buffalo Brook drainage area increases by a factor of three with the introduction of flows from Reading Pond Brook. This reach is underlain by sediments of glacial till origin (USDA).

The reach was segmented to capture a subreach of bedrock gorge near the downstream end, which had a somewhat steeper gradient (estimated 3.5%) and closer confinement (Semi-confined) than the remainder of the reach (Segment B).

Segment B

Valley width varies between 50 and 110, but averages 90, or approximately 3.75 times the measured bankfull width (Semi-confined). Bedrock is exposed in a few locations in the banks and bed, with three channel-spanning occurrences of ledge indexed in the segment. A reference C3b-step/pool channel is inferred.

Road follows channel and crosses the channel in at least six locations throughout Segment B. Generally, the road follows the grade of a terrace on either side of the channel, or is occasionally notched into the valley wall. In a few locations where bedrock creates a valley pinch point, the road climbs the valley wall up and over the bedrock control.

In most locations, the historically incised and entrenched channel contains nearly the full volume of a bankfull or low to moderate flood and demonstrates a degree of historic widening (somewhat elevated W/D ratio, leaning curvilinear trees, low-level scour along both banks, including sometimes undercut banks, and exposed tree roots). Overall, widening has been moderated by erosion-resistance of the bed and bank materials and tree buffers. Cross section #1 is representative of this condition. These sections of the channel might be characterized as persisting in channel evolution stage II [F].

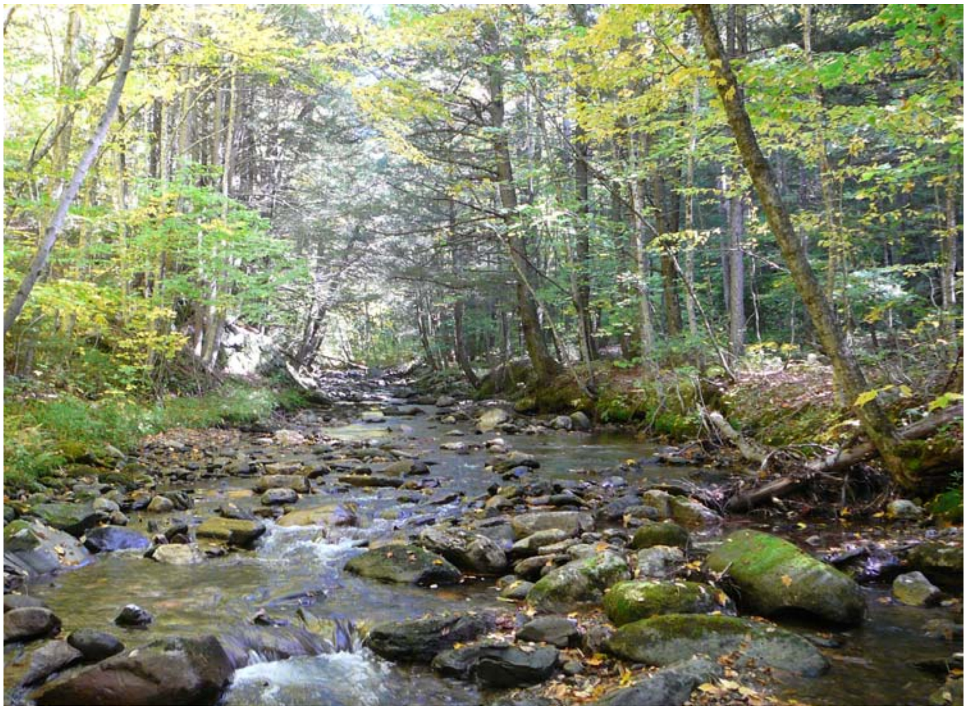

Figure 22. View upstream, forest road is located on LB terrace (picture right) beyond the tree buffer, valley wall is coincident with RB (picture left); plane bed channel form; historically incised, historic widening indicated by curvilinear trees, Segment B, M41T6.02, Buffalo Brook, 24 September 2009

In at least three locations, evidence of the road has been entirely eroded away by avulsions of the channel, occurring in recent years to decades. There are a few locations where the channel has avulsed recently, to occupy the road bed and form a flood chute that is now active at bankfull flows (as evidenced by relative elevation of this flood chute compared to the main channel, imbricated gravels in the bed of the flood chute, and absence of vegetation (Figure 23)).

Elsewhere, the river occasionally occupies flood chutes at a higher-than-bankfull flow stage, which helps to dissipate the flood energy of these higher flows, and minimize the degree of active widening of the incised and entrenched channel. This condition is demonstrated by cross section #2 for the reach. These sections of the channel might be characterized as channel evolution stage II [F] or early III [F]. Incision status may be overstated; there may be a degree of historic incision (related to gold mining, logging history) that is overprinted on a degree of post-glacial incision.

Generally, there were more frequent occurrences of flood chutes and channel avulsions in this segment, as compared to upstream reaches T6.03, T6.04, and T6.05. In part, this is probably related to the somewhat more relaxed valley confinement (Semi-confined to Narrow) and lesser channel gradient (2.5%). The increased incidence of planform adjustment features is likely also related to the recent flooding in upstream reaches of Reading Pond Brook (June 2006, sudden breaching of Reading Pond dam).

Also, there were more frequent occurrences of depositional bars (point bars, mid-channel bars, side bars) in this segment, as compared to upstream reaches T6.03, T6.04, and T6.05 - generally related to locally wider valleys, debris jams, locations of road crossings, and avulsion sites. Still, there is relatively limited floodplain available for deposition of sediments, and this segment is functioning largely as a Transport – dominated channel.

Figure 23. View downstream, recent avulsion along the former path of the forest road in LB corridor, Segment B, M41T6.02, Buffalo Brook, 24 September 2009

Segment A

Bedrock gorge. Tall bedrock walls, Semi-confined.
(As the bedrock walls become steeper and more closely confine the channel in this downstream Segment A, the roads on either side of the channel climb the valley wall and remain somewhat distant from the channel).

Figure 24. View upstream at base of bedrock gorge which comprises Segment A of reach M41T6.02, Buffalo Brook, 18 September 2009

M41T6.01

Underlain by glaciofluvial sediments and alluvial sediments at the downstream end. Identified as an "alluvial fan" following protocols to capture the marked decrease in valley gradient and valley confinement – although geologic investigations to confirm the origin and nature of sediments comprising this feature as a true alluvial fan, were beyond the scope of this study. Kame terrace deposits and lake sands are mapped in vicinity of this reach by Stewart (1955).

Camp Plymouth State Park occupies a majority of the grounds surrounding Buffalo Brook in this reach. This land has been owned by the State of Vermont since 1984. Prior to that time, the Boy Scouts of America operated a camp on these lands from 1927 (VT Division of Historic Preservation sign).

Historic map indicates gold placer mining occurred in the 1800s on this section of the Buffalo Brook (see main report).

Reach segmented to capture an upstream subreach of alternate reference stream type (that has also undergone a stream type departure).

Segment B

Park cabins along the right bank (which have increased in number from two in 1994 to four by 2003). Berms are present along both banks of the channel for a majority of the segment. As the channel pulls away from the right valley wall at the top of the segment, a gravel / cobble / earthen berm is present along the top of the right bank at a thalweg height ranging from 5.5 to 7.5 feet. This berm is reinforced along the toe of the bank by rip-rap armoring. A similar berm is present along the left bank at a height ranging from 4 feet near the upstream end to 2.5 feet near the downstream end of the segment on approach to the Scout Camp Road bridge. Rip-rap reinforces the left bank from a position approximately 40 feet upstream of the bridge. Presence of berms along both banks suggests possible historic windrowing of the channel along with straightening – perhaps in response to the 1973 or 1927 floods, or both.

Figure 25. View downstream, berms along right bank (to protect Camp Plymouth State Park cabins) and left bank, Segment B, M41T6.01, Buffalo Brook, 18 September 2009

The bridge has a span of 15 feet, or approximately 46% of the measured bankfull width (32.6 ft) at a downstream cross section site. Issues: approach angle, sediment upstream, scour pool under the bridge at the downstream end leading to undermining of the abutments (stepped footer on LB abutment). RB abutment has spalling, cracking.

Figure 26. Scout Camp Road bridge, Segment B, M41T6.01, Buffalo Brook, 18 September 2009. (a) View downstream, to sharp approach angle, sediment accumulation at the inlet, armored banks, stepped footers on LB abutment. (b) spalling, cracking and apparent dislodging of right bank abutment.

Some flood scour depressions were observed on the floodplain along the LB corridor beyond the low berm, suggesting that at times in the past, flood waters have been able to breach the berm and overtop the banks to spread out across the floodplain. However, continued channel management following floods has likely been carried out to revert the channel to a more transport-dominated function.

Where this segment / reach might ordinarily serve as a location for sediment attenuation, historic incision (channelization) and construction of berms and armoring of the channel have served to convert the reach to a transport-dominated role. Sediments are conveyed through the reach to downstream areas. However, segment still remains susceptible to catastrophic erosion in future flood events due to partially incised/ entrenched condition. Sensitivity is futher enhanced by its topographic position of notably reduced gradient and lesser valley confinement. For these reasons, sensitivity classification was overridden to "Extreme".

Segment A

General fining downstream sequence of bed material from cobbles and coarse gravels below the Scout Camp Road to medium and fine gravels near the confluence with Echo Lake. Accompanies a gradual decrease in channel gradient. Losing conditions – flow decreases as a component of streamflow recharges the shallow groundwater below the bed of the channel.

Developments of the Camp Plymouth State Park occupy the corridors on either side of the channel in the upstream half of Segment A. Gravel access roads are present at grade along both sides of the channel near the upstream end, providing access to camp pavilions, cabins, and parking areas. A road continues to follow along the RB corridor nearly to the mid-point of the segment. Vegetation then reverts to scrub/shrub and young-growth forest downstream to the confluence of Buffalo Brook with Echo Lake.

Decreased sediment transport capacity due to decreasing gradient on approach to the relatively fixed base level of Echo Lake. Also, losing conditions reduce the flow (and sediment transport capacity) considerably during low-flow to base-flow times of the years. Thus, the lower extent of Segment A has some large accumulations of gravel and sand sediments. In a few cases these have diverted flow to a bifurcated channel, leading to erosion along the banks.

A breached debris jam positioned approx 150 feet upstream of the lake has contributed to local overwidening and forced deposition in a series of side bars and one large mid-channel bar. These features are leading to localized deposition and a series of steep aggradational riffles as the channel incises a path up through these slugs (splays) of sediment.

Figure 27. View downstream, berms along right bank (to protect Camp Plymouth State Park cabins) and left bank, Segment B, M41T6.01, Buffalo Brook, 18 September 2009

A delta of sediment has built out into Echo Lake at the downstream end of Buffalo Brook. Anecdotal accounts (Salerno, 2009; Poirier, 2009) indicate that this delta has grown significantly in area and thickness since the 2006 flooding event that impacted the watershed.

Figure 28. View downstream to delta of fine gravels which extends out into Echo Lake from the mouth of Buffalo Brook, reach M41T6.01, Segment A, 7 August 2009. Kayak paddles mark approximate lateral extent of deposits.

E.4 Reading Pond Brook (Tributary to Buffalo Brook)

M41T6.02S1.02

Mapped as glaciofluvial outwash in a narrow valley between till-mantled bedrock slopes (USDA).

Segmented to capture downstream subreach of alternate stream type below the Reading Pond Road culvert crossing, and to delineate a change in incision status, adjustment processes, and stream type in the remainder of the reach upstream of this crossing.

Segment C

2nd dam 350 feet downstream of main dam. Upper feet of segment appear to have historically been impounded behind a stone / earthen dam which is now breached. Based on field observations, it is likely that this dam was breached prior to the 2006 flood event that breached the upper dam. For example, there was no recently exposed sediments devoid of vegetation in the short channel section between the two dams. Lush vegetation including saplings were present and the channel between the two dams showed a reasonably well-developed fluvial form, rather than an early fluvial form in a recently impounded setting.

Old stone foundation along the left valley wall adjacent to the lower breached dam – possible former mill site.

Segment B

Planform view (199x) – shows pond, two possibly straightened sections that may represent diversions of the channel possibly in support of historic gold mining activities and/or logging operations. Recently, possibly during the 2006 flood event, the channel avulsed to abandon its former (in one case, straightened) path to occupy a new channel.

The Reading Pond Road crossing is a corrugated steel culvert that is a bankfull constrictor. Its span measures 9 feet, or 58% of the measured bankfull width. Sediment has accumulated upstream of the culvert, and a large scour pool has developed downstream of the culvert.

Figure 29. View upstream, to bankfull constricting culvert crossing under Reading Pond Road, Segment B, M41T6.02S1.02, Reading Pond Brook, 4 September 2009.

Segment A

Comprised of the lower 505 feet of the reach downstream of the Reading Pond Road culvert. This is a subreach of alternate reference stream type (B3-S/P), which has undergone recent incision (IRraf = 2.0) resulting in a vertical stream type departure to F3b-S/P.

M41T6.02S1.01

Segmented

Segment B

Valley walls are defined by high terraces ranging from 7 to 20 feet high (or 3.5 to 10 times bankfull depth). Set of discontinuous lower terraces from 1.5 to 4 feet high (or 1 to 2 times bankfull depth - may represent RAF. One waterfall grade control indexed mid-reach. Couple other exposures of lateral bedrock grade controls. Several mass failures in glacial till are exposed where channel impinges upon the higher terraces. Reference B3a-S/P which is undergoing considerable vertical and lateral adjustments, presumably as a response to the 2006 flood event and sudden breaching of the Reading Pond. Frequent MFs, and eroding bank sections that have led to bedform departure from step/pool to cascade flows around LWD and boulders and large cobbles. Frequent side and point bars forced at debris jams, LWD and detritus; frequent flood chutes and bifurcated channel sections around these obstacles. Width / depth ratio (26) is quite large for a semi-confined, steep-gradient channel, suggesting active widening. This observation is supported by the presence of numerous trees leaning into the channel from both banks. Often trees have fallen across the narrow stream valley to perch above the bankfull elevation.

These LWD were not counted in the talley of LWD. Nevertheless, they will continue to be an ongoing source of woody debris to the channel in years to come as they weather and break down to a size that can become entrained within the bankfull channel. Groundwater seeps are evident on the lower terraces.

Conditions on this segment are complex, with adjustment processes overlapping in time and space. XS-2 is located near the downstream end of a short section of channel, Narrowly-confined by steep till-slopes that formed high terraces at thalweg heights ranging from 9 to 10.5 feet (5.6 to 6.6 times the Dmx) on the RB; and from 8 to 14 feet (5 to 8.8 times the Dmx) on the LB. Signs of recent incision in vicinity of XS-2 were not observed. XS-3 was located near the upstream end of the segment and represented conditions found along a majority of the segment. Valley walls were comprised of till terraces ranging in height from 9 to 30 feet high or more. Confinement of the channel between these high terraces varied from Narrowly-confined to Semi-confined and even Narrow in a couple of places. A set of discontinuous lower terraces were present within these valley walls, generally 2 to 4 times the Dmx in height. Flood chutes on these lower terraces were relatively frequent but did not appear to be active at bankfull stage, unless forced at a DJ. Frequently, DJs and/or boulder-rafted LWD had blocked or partially blocked the channel (perhaps during the 2006 flood event) and large sediment slugs had been deposited in the channel behind the obstruction. Then it appeared that recent breaching of the obstruction had lead to localized incision through and beyond the sediment slug. Incision was somewhat localized and head cuts would wash out within a relatively short distance upstream, but might overlap with the next section of incision. In other locations there might be a short section with little or no incision between sections of more pronounced incision. Tributary rejuvenation was apparent in many of the tributaries to this segment. Banks were undercut exposing fresh tree roots. Trees are actively leaning and collapsing into the channel from both banks.

Segment A

Valley width somewhat narrower in this segment as compared to upstream Segment B. Channel confined by higher terraces ranging in thalweg height from 8 to 18 feet and higher. Fewer discontinuous lower terraces than Segment B - at thalweg heights of 4 to 5 feet, or 2 to 2.5 times the bankfull height. Fewer occurrences of mass failures and bank erosion generally. Four occurrences of bedrock grade controls (waterfalls); few exposures of bedrock along the valley walls. Often fine to medium gravels have accumulated upstream of large boulder steps or entrained LWD in forced bars. A few leaning trees or saplings, suggesting ongoing planform adjustments or localized widening. But overall less actively adjusting than upstream Segment B. Abandoned forest road joins the stream valley from the LB corridor near the downstream end of the segment and crosses at one location to the RB.

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 – Patch Brook and Black River main stem

Reach / Segment	Reach-Scale Stressors: Stream Power			Boundary Resistance		
M40T5.04-E	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	D	Slope	Unknown Soldier Rd bridge is bankfull constrictor with negligible upstream aggradation.			
M40T5.04-D	I	Slope	Historic deforestation, more recent logging.	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	D	Slope	Boulder grade control (likely) and valley pinch point near the downstream segment break.			
M40T5.04-C	I	Slope	Historic deforestation; more recent logging.	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	D	Slope	Diversion of water to nearby impoundment in upstream end of segment, may have led to decreased stream power in 650 feet of channel.			
	D	Slope	Catamount Trail bridge is bankfull constrictor with some upstream aggradation.			
M40T5.04-B	I	Slope	Historic deforestation; more recent logging.	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	D	Slope	Natural reduction in sediment transport capacity on approach to wetland segment (T5.04-A).	I	Bed, Banks	Localized bedrock exposures in bed and banks.
	D	Slope	Patch Brook Road culvert is bankfull constrictor (minor upstream aggradation).	I	Bed, Banks	Cohesive sediments
M40T5.03S1.01	I	Depth	Historic localized reduction in sediment supply below dam at upstream end of reach (Lake Ninevah - natural impoundment enhanced by earthern dam).	I	Bank	Armoring (some, RB)
	I	Depth	Recent marginal increase in sustained flows during Fall months as Lake Ninevah was drained prior to Winter - (mid-1980s to late 1990s).			
	I	Slope	Local flow increase downstream of Loop Rd bridge which is a bankfull constrictor (minor to negligible scour).	I	Bank	Maintenance of tree buffers, limited encroachments.
	D	Slope	Loop Rd bridge is bankfull constrictor with minor upstream aggradation (localized).			
M40T5.03-B	I	Depth	Recent marginal increase in sustained flows during Fall months as Lake Ninevah was drained prior to Winter - (mid-1980s to late 1990s).	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Slope	Localized channelization (historic) along Patch Brook Rd.	I	Bed, Banks	Localized bedrock exposures in bed and banks.
	I	Depth	Stormwater: localized flow increases from stormwater outfalls (overland flow and road ditch outfalls)	I	Bank	Armoring (short lengths, both banks)
M40T5.03-A	I	Slope	Historic channelization w/ windrowing	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	D	Slope	Natural reduction in sediment transport capacity as valley transitions from Semi-confined to Narrow / Broad confinement.	D	Bank	Localized removal of woody vegetation related to residential use and road encroachments (RB).
	I	Depth	Recent marginal increase in sustained flows during Fall months as Lake Ninevah was drained prior to Winter - (mid-1980s to late 1990s).	I	Bank	Armoring (short length, RB)
	I	Slope	Encroachment: Dublin Rd			
	I	Slope	Encroachment: berms, LB			
	D	Slope	Dublin Rd bridge is bankfull constrictor with significant upstream aggradation (localized).			

Table F-1. Stressor Tables, Reach-Scale – Patch Brook and Black River main stem (CONTINUED)

Reach / Segment	Reach-Scale Stressors: Stream Power			Boundary Resistance		
M40T5.02-B	I	Slope	Historic channelization w/ possible windrowing	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Slope	Encroachment: Dublin Rd	I	Bank	Armoring (short lengths, both banks)
	I	Slope	Encroachment: berms, LB, RB			
	D	Slope	Natural reduction in sediment transport capacity at reduced valley gradient and confinement.			
M40T5.02-B	I	Slope	Historic channelization w/ possible windrowing	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Slope	Encroachment: Dublin Rd	I	Bank	Armoring (short lengths, both banks)
	I	Slope	Encroachment: berms, LB, RB	D	Bed	Reported historic dredging
	D	Slope	Natural reduction in sediment transport capacity at reduced valley gradient and confinement.			
M40T5.02-A	I	Slope	Historic channelization possible	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Slope	Encroachment: Dublin Rd, private road	I	Bank	Armoring (short lengths, both banks)
	I	Slope	Encroachment: berms, LB	D	Bed	Reported historic dredging
	D	Slope	Tatro Rd bridge is bankfull constrictor with upstream aggradation (localized).			
	I	Slope	Local flow increase downstream of Tatro Rd bridge which is a bankfull constrictor (moderate scour).			
	I	Slope	Possible incision due to breaching of historic mill dam at downstream end of segment.			
M40T5.01-D	I	Slope	Historic channelization	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Slope	Possible incision due to "hungry water" effects during historic operation of mill dam at upstream end of segment.	I	Bank	Armoring (short lengths, LB)
	D	Depth	Possible historic aggradation due to partial diversion of flows to "canal" on west side of Dublin Road.	D	Bed	Reported historic dredging
M40T5.01-C	D	Depth	Diversion of water to "canal" on west side Dublin Rd, may have led to decreased stream power within the segment.	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Slope	Historic channelization	I	Bank	Armoring (short length, LB)
M40T5.01-B	I	Slope	Historic channelization			
	I	Slope	Encroachment: Dublin Rd	I	Bank	Armoring (short lengths, both banks)
	I	Slope	Encroachment: berm, LB			
	D	Depth	Diversion of water to "canal" on west side Dublin Rd, may have led to decreased stream power within the segment.	D	Bank	Localized removal of woody vegetation related to residential use and road encroachments (RB).
	D	Slope	Dublin Rd bridge is bankfull constrictor with upstream aggradation (localized).			
	I	Slope	Local flow increase downstream of Dublin Rd bridge which is a bankfull constrictor (moderate scour).			
	D	Slope	Library Rd bridge is bankfull constrictor with upstream aggradation (localized).			
	D	Slope	Natural reduction in sediment transport capacity at reduced valley gradient and confinement.			
M40T5.01-A	I	Slope	Historic channelization			
	I	Slope	Encroachment: berms, LB, RB	I	Bank	Armoring (short lengths, both banks)
	D	Slope	Dublin Rd bridge is bankfull constrictor - negligible aggradation	D	Bed	Reported historic dredging
	D	Slope	Natural reduction in sediment transport capacity at reduced valley gradient and confinement.	D	Bank	Localized removal of woody vegetation related to residential use and road encroachments (RB).
M40	I	Slope	Historic channelization			
	I	Slope	Encroachment: berms, LB	I	Bank	Armoring (short lengths, both banks)
	I	Slope	Encroachment: VT Route 100, RB	D	Bed	Reported historic dredging
	D	Slope	Natural reduction in sediment transport capacity at reduced valley gradient on approach to Round Pond at the downstream end of the reach.			

Table F-2. Stressor Tables, Reach-Scale – Buffalo Brook tributary reaches

Reach / Segment	Reach-Scale Stressors					
	Stream Power			Boundary Resistance		
M41T6.06	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	D	Slope	Forest road culvert is bankfull constrictor with minor upstream aggradation.	I	Bed, Banks	Frequent bedrock exposures in bed and banks.
				D	Bed, Banks	Reported historic gravel mining associated with gold placer mining; probably moderated by shallow bedrock controls.
M41T6.05-B	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
				I	Bed, Banks	Frequent bedrock exposures in bed and banks.
M41T6.05-A	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Depth	Stormwater: localized flow increases from concentrated flow along forest road network.	I	Bed, Banks	Frequent bedrock exposures in bed and banks.
				D	Bed, Banks	Removal of trees to construct close forest road with frequent fords, provides opportunity for localized avulsion, channel widening, and sediment erosion.
M41T6.04	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Depth	Stormwater: localized flow increases from concentrated flow along forest road network.	I	Bed, Banks	Occasional bedrock exposures in bed and banks.
				D	Bed, Banks	Removal of trees to construct close forest road with frequent fords, provides opportunity for localized avulsion, channel widening, and sediment erosion.
M41T6.03	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Depth	Stormwater: localized flow increases from concentrated flow along forest road network.	I	Bed, Banks	Occasional bedrock exposures in bed and banks.
				D	Bed, Banks	Reported historic gravel mining associated with gold placer mining;
				D	Bed, Banks	Removal of trees to construct close forest road with frequent fords, provides opportunity for localized avulsion, channel widening, and sediment erosion.
M41T6.02-B	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Depth	Stormwater: localized flow increases from concentrated flow along forest road network.	I	Bed, Banks	Occasional bedrock exposures in bed and banks.
	D	Slope	Moderate constriction at downstream end of segment as channel transitions to steeper-gradient bedrock gorge.	D	Bed, Banks	Reported historic gravel mining associated with gold placer mining;
				D	Bed, Banks	Removal of trees to construct close forest road with frequent fords, provides opportunity for localized avulsion, channel widening, and sediment erosion.
M41T6.02-A	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
				I	Bed, Banks	Frequent bedrock exposures in bed and banks.

Table F-2. Stressor Tables, Reach-Scale – Buffalo Brook tributary reaches (CONTINUED)

Reach / Segment	Reach-Scale Stressors					
	Stream Power			Boundary Resistance		
M41T6.01-B	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Slope	Encroachment: berm, each bank	I	Bank	Armoring (some, both banks)
	I	Slope	Apparent channelization (historic)	D	Bed, Banks	Reported historic gravel mining associated with gold placer mining;
	D	Slope	Natural reduction in sediment transport capacity downstream of bedrock gorge due to reduction in valley confinement and gradient - appears moderated by channel modification to transport-dominated condition.			
	D	Slope	Scout Camp Road bridge is bankfull constrictor with upstream aggradation at sharp approach angle.			
	I	Slope	Local flow increase downstream of Scout Camp Rd bridge which is a bankfull constrictor.			
M41T6.01-A	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Slope	Apparent channelization (historic)	I	Bank	Armoring (some, RB)
	D	Slope	Natural reduction in sediment transport capacity downstream of bedrock gorge due to reduction in valley confinement and gradient	D	Bed, Banks	Reported historic gravel mining associated with gold placer mining;
	D	Slope	Natural reduction in sediment transport capacity on approach to relatively stable base level of Echo Lake.			

Table F-3. Stressor Tables, Reach-Scale – Reading Pond Brook tributary reaches

	Reach-Scale Stressors					
Reach / Segment		**Stream Power**				**Boundary Resistance**
M41T6.02S1.02-C	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Depth	Episodically, by sudden breaching of Reading Pond Brook dam in June 2006	D	Bed, Banks	Reported historic gravel mining associated with gold placer mining
M41T6.02S1.02-B	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Slope	Apparent channelization and possible flow diversion in limited sections (historic)	D	Bed, Banks	Reported historic gravel mining associated with gold placer mining
	D	Slope	Reading Pond Road culvert is bankfull constrictor with upstream aggradation.			
	I	Slope	Local flow increase downstream of Reading Pond Rd culvert which is a bankfull constrictor.			
	I	Depth	Episodically, by sudden breaching of Reading Pond Brook dam in June 2006			
M41T6.02S1.02-A	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Depth	Episodically, by sudden breaching of Reading Pond Brook dam in June 2006	D	Bed, Banks	Reported historic gravel mining associated with gold placer mining
M41T6.02S1.01-B	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
	I	Depth	Episodically, by sudden breaching of Reading Pond Brook dam in June 2006	D	Bed, Banks	Reported historic gravel mining associated with gold placer mining
				I	Bed, Banks	Occasional bedrock exposures in bed and banks.
M41T6.02S1.01-A	I	Slope	Historic deforestation	I	Bank	Regeneration of tree buffers and forest cover in the surrounding watershed in recent decades, limited encroachments.
				D	Bed, Banks	Reported historic gravel mining associated with gold placer mining
				D	Bed, Banks	Removal of trees to construct close forest road with frequent fords, provides opportunity for localized avulsion, channel widening, and sediment erosion.
				I	Bed, Banks	Frequent bedrock exposures in bed and banks.

APPENDIX G

Departure Analysis Tables

Abbreviations used in the following tables:

BFL	Bankfull
FPW	Flood Prone Width
RB	Right Bank
LB	Left Bank
H	Human-constructed Constraint
N	Natural Constraint
X	Significant
(X)	Somewhat Significant

Table G-1. Departure Analysis Tables, Patch Brook and Black River main stem reach M40

	Constraints		Transport		Attenuation (storage)			
Reach / Segment	Vertical	Lateral	Natural	Converted	Natural	Decreased	Increased	Asset
M40T5.04-E			**X**					
M40T5.04-D			(X)		(x) due to localized reduction in valley confinement & gradient			
M40T5.04-C				(x)		(x) Somewhat, due to historic incision (moderate degree)		
M40T5.04-B	channel-spanning bedrock (2 locations)				(x) due to localized reduction in valley gradient above wetlands	(x) Somewhat, due to historic incision (minor to moderate degree)		**X**
M40T5.03S1.01 **(Lake Ninevah outlet)**	Earthen impound-ment on bedrock in immediate upstream reach (Lake Ninevah)	H: Loop Road bridge (	**X**					
M40T5.03-B		H: Patch Brook Rd (gravel) H: Townsend Barn Rd bridge (BFL)	**X**					
M40T5.03-A		H: Dublin Road (LB) H: Dublin Road bridge (BFL) H: residence (RB)			(x) due to localized reduction in valley confinement	**X** due to historic incision (moderate degree) and entrenchment by berms, resulting in STD		(x)

Table G-1. Departure Analysis Tables, Patch Brook and Black River main stem reach M40 (CONTINUED)

	Constraints		Transport		Attenuation (storage)			
Reach / Segment	Vertical	Lateral	Natural	Converted	Natural	Decreased	Increased	Asset
M40T5.02-B		H: Dublin Road (RB)			(x) due to localized reduction in valley gradient and confinement	**X** due to historic incision (moderate degree) and entrenchment by berms, resulting in STD		(x)
M40T5.02-A		H: Dublin Road (RB) H: Tatro Road bridge (BFL) H: Old abutments (breached dam, FPW)	(x)			**X** due to historic incision resulting in STD		
M40T5.01-D			(x)			**X** due to historic incision resulting in STD		
M40T5.01-C			(x)			(x) Somewhat, due to historic incision (moderate degree)		
M40T5.01-B		H: Dublin Road (RB) H: Dublin Road bridge (BFL) H: Library Road bridge (BFL) H: residential, commercial buildings			**X** due to localized reduction in valley gradient and confinement	**X** due to historic incision and floodplain encroachments, resulting in STD		
M40T5.01-A		H: VT Route 100 bridge (FPW)			**X** due to localized reduction in valley gradient and confinement	**X** due to historic incision and berms		**X**
M40		H: Kingdom Road bridge (FPW) H: residential, commercial buildings H: VT Route 100 (upstream end, RB)			**(x)** At downstream end, due to localized reduction in gradient at Round Pond	**X** due to historic incision and berms		

Table G-2. Departure Analysis Tables, Buffalo Brook

	Constraints		Transport		Attenuation (storage)			
Reach / Segment	Vertical	Lateral	Natural	Converted	Natural	Decreased	Increased	Asset
M41T6.06	Channel-spanning bedrock	N: Extensive lateral bedrock controls H: Culvert - forest road (BFL)	**X**					
M41T6.05-B		N: Extensive lateral bedrock controls	**X**					
M41T6.05-A		N: some lateral bedrock controls	**X**					
M41T6.04		N: some lateral bedrock controls	**X**					
M41T6.03		N: some lateral bedrock controls		(x)	(x) due to localized reduction in valley gradient and confinement	(x) Somewhat, due to historic (or post-glacial) incision leading to stream type departure		
M41T6.02-B		N: some lateral bedrock controls		(x)	(x) due to localized reduction in valley gradient and confinement	(x) Somewhat, due to historic (or post-glacial) incision leading to stream type departure		
M41T6.02-A		N: Extensive lateral bedrock controls	**X**					
M41T6.01-B		H: berms, both banks H: camp buildings, RB H: Scout Camp Road bridge (BFL)		**X**	(x) due to localized reduction in valley gradient	(x) Somewhat, due to historic incision (minor to moderate degree) and entrenchment by berms		(X)
M41T6.01-A				**X**	(x) due to localized reduction in valley gradient above Echo Lake	X Somewhat, due to historic (or post-glacial) incision leading to stream type departure		**X**

Table G-3. Departure Analysis Tables, Reading Pond Brook

	Constraints		Transport		Attenuation (storage)			
Reach / Segment	Vertical	Lateral	Natural	Converted	Natural	Decreased	Increased	Asset
M41T6.02S1.02-C		H: abutments of breached dam		**X**		X due to recent and historic incision leading to stream type departure		
M41T6.02S1.02-B		H: Reading Pond Road culvert (BFL)		**X**	(x) due to localized reduction in valley gradient and confinement upstream of valley pinch point	(x) Somewhat, due to historic and recent incision		**X**
M41T6.02S1.02-A			**X**			(x) Somewhat, due to historic and recent incision	(x) Somewhat, due to debris jams and LWD	
M41T6.02S1.01-B	Channel-spanning bedrock	N: some lateral bedrock controls	**X**			(x) Somewhat, due to historic and recent incision	(x) Somewhat, due to debris jams and LWD	
M41T6.02S1.01-A	Channel-spanning bedrock	N: some lateral bedrock controls	**X**			(x) Somewhat, due to historic (& post-glacial) incision	(x) Somewhat, due to debris jams and LWD	

APPENDIX H

Valley Wall Updates

South Mountain Research & Consulting (SMRC) has 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 Patch Brook or Buffalo Brook watersheds, SMRC is aware that this updated Phase 2 valley wall shape file 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 2 valley wall shapefile prepared by SMRC does not necessarily represent lateral extents of fluvial erosion hazard along these Black River tributary channels.

It is possible that a future migration or avulsion of the channel could occur beyond the valley wall. Often the 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 often 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 modified Phase 2 valley wall - this human infrastructure (e.g., roads, railroads, engineered levees) may still be susceptible to erosion hazards.

<u>Deliverables:</u>
"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.

<u>Notes:</u>
Patch Brook reach M40T5.04:
Valley wall positions along this reach should be considered very approximate. The VHD coverage defining the position of the Patch Brook main stem was considerably different than the actual channel position measured in the field with a GPS. Further details and limitations of the valley wall delineation in this reach are contained in the QA Documentation in Appendix C.

Mount Holly, VT

DEC Stormwater Infrastructure Mapping Project

This map shows the connectedness of the stormwater infrastructure and was compiled from various sources including Town plans, WWMD plans, Stormwater permit plans, municipal member knowledge, field data, and a mapping grade GPS.

This map is for illustrative purposes only. The accuracy of the data layers shown on this map are limited by the accuracy of the source materials and field data collection. No warranty as to the accuracy or the usefulness of the data is expressed or implied. It is meant to be used as a planning level tool only.

Legend

Line Symbols

- Storm line
- Storm line (old Sanitary line)
- Tunnel (storm)
- Combined sewer
- Sanitary line
- Swale
- Footing drain
- Under drain
- Roof drain
- Infiltration pipe
- French drain
- Trench drain
- Emergency spillway
- Stream
- Overland flow

Point Symbols

- Catchbasin
- Dry Well
- Drop Inlet
- Grate/Curb Inlet
- Yard drain
- CB tied to sanitary sewer
- Junction Box
- Stormwater Manhole
- Outfall
- Pipe Cross (not connected)
- Combined sewer MH
- Sanitary Manhole
- Culvert inlet
- Culvert outlet
- Pond outlet structure
- Treatment feature
- Retrofit
- Unknown Point
- Information Point
- Known CSO outfalls

Stormwater Areas

- Existing Area
- Proposed Area

Proposed Point and Line Symbols

- Proposed Catchbasin
- Proposed Dry well
- Proposed Drop inlet
- Proposed Yard drain
- Proposed Stormwater manhole
- Proposed Pond outlet structure
- Proposed Outfall
- Proposed Culvert inlet
- Proposed Culvert outlet
- Proposed Storm line
- Proposed Swale
- Proposed Footing drain
- Proposed Roof drain
- Proposed Under drain
- Infiltration pipe
- Proposed French drain
- Proposed Emergency spillway
- Tunnel (storm)

0 0.05 0.1

Miles

Creator: David Ainley, Jim Pease
DEC - WMD - Ecosystem Restoration Program
Print Date: 2/22/2017
Data Sources: VTRANS Roads Data, VT Hydrography Data Set, DEC Stormwater Database
Imagery Source: VCGI Best Available

N

VERMONT

Mill River
River Corridor Management Plan
Rutland County, Vermont

FINAL REPORT

FEBRUARY 17, 2009

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Mill River
River Corridor Management Plan

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1.0 EXECUTIVE SUMMARY

The Mill River watershed extends from its headwaters in Mount Holly downstream through the surrounding landscape eventually entering the Otter Creek in Clarendon. The Mill River defines a significant valley shared by the towns of Mount Holly, Wallingford, Shrewsbury, and Clarendon and the many landowners that live along its banks. Historically a multitude of resources, at the cost of private landowners and state taxpayers, have been spent on protecting property adjacent to the river by methods such as channel straightening, dredging, berming, and streambank armoring. These practices are predictably temporary and often detrimental to the health of the river ecosystem as well as having negative flood and water quality impacts downstream all the way to Lake Champlain. In order to reduce the need for maintenance of traditional channel management applications along the Mill River and to shift the focus of management projects from short term control (2 year planning) to long term equilibrium and stability (50 to 100 year planning) the Rutland Natural Resource Conservation District (RNRCD) retained Round River Design (RRD) to complete a River Corridor Management Plan.

The Corridor Plan follows up on a Phase 1 and Phase 2 Stream Geomorphic Assessment conducted by the Rutland Regional Planning Commission (RRPC) and RRD respectively on the main stem of the Mill River Watershed during the autumn of 2007. Stream geomorphic assessments provide information about the physical condition of streams and examine the factors that influence their stability. The studies followed the assessment protocol (version 2007) developed by the Vermont River Management Program, Agency of Natural Resources (VTANR) as well as the "Vermont Agency of Natural Resources River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects" (developed by the VTANR in 2007). Because the geomorphic assessments studied the historic and current condition of the river, they are able to make predictions about how the Mill River will continue to adjust in the future. The results provided by the assessments were used to develop management strategies in this Plan.

This River Corridor Plan is meant to summarize information about the physical condition of the Mill River watershed; identify the factors that are influencing the stability of this system; and synthesize this information to identify restoration and management priorities. The Clarendon, Shrewsbury, Wallingford, and Mount Holly communities have the opportunity to provide long-term protection to the river corridor and encourage the reestablishment of functioning floodplain and healthy in-stream habitat through river corridor management, protection, and restoration.

Among the more significant findings of this plan:

- The majority of Mill River reaches are incised. The reduced floodplain access means increased stream energy is contained within the channel. Rather than providing storage during times of excess, these reaches now function to transport flow, sediment, and nutrients downstream (except for in areas where over-widening or channel constrictions (such as undersized bridges) reduce stream power sufficiently to cause deposition). In addition to the problems created by lack of sediment and nutrient storage, the lack of flood water storage means the Mill River is much more likely to see flood damage as a result of channel avulsions and catastrophic erosion rather than high water inundation. While floodplain ordinances (based primarily on flood inundation levels) may be incorporated in zoning regulations, fluvial erosion hazard mapping is recommended as a means to further reduce conflicts and protect valuable assets (see Appendix E).
- Channel incision and subsequent widening has been exacerbated by pervasive straightening, dredging, berming, armoring, and floodplain encroachment. Except for in

areas where intense community investment (such as in East Wallingford and Cuttingsville Village) may require active management, these activities have provided the false temporary appearance of stability while causing long-term significant detriment to the Mill River.

- Certain reaches of the Mill River are able to provide flow, sediment, and nutrient storage during flood events. Protecting these areas from channelization and floodplain development in order to perpetuate the functionality of these reaches would benefit the long-term health of the Mill River.
- Vegetation along streambanks provides an important long-term benefit to the river and landowners are encouraged to move ahead with revegetation efforts independent of other restoration efforts.
- Stormwater reduction is an important watershed-wide effort that should be considered with all new and existing development.
- The majority of Mill River reaches are classified as having high to extreme sensitivity indicating the possibility of rapid channel adjustment. The best approach to restoring these unpredictable reaches is through passive restoration efforts that focus on protecting the river corridor in order to reduce conflicts with land development. This approach would reduce costs for project implementation in comparison with approaches such as continued channelization or armoring, but will require time and patience on behalf of the community for stream channel processes to play out and for a more stable, ecologically healthy channel to develop.

2.0 PROJECT AND PROGRAM OVERVIEW

2.1 State of Vermont River Management Goals

The Vermont Agency of Natural Resources' (VTANR) goal is to, "manage toward, protect, and restore the equilibrium conditions of Vermont's rivers by resolving conflicts between human investments and river dynamics in the most economically and ecologically sustainable manner." The objectives of the Program include fluvial erosion hazard mitigation, sediment and nutrient load reduction, and aquatic and riparian habitat protection and restoration. The Program seeks to conduct river corridor planning, such as this Mill River project, in an effort to remediate the geomorphic instability that is largely responsible for flood damage and nutrient loading (to the Otter Creek and Lake Champlain), as well as loss of habitat and recreational opportunities. Additionally, the Vermont River Management Program has set out to provide funding and technical assistance to facilitate an understanding of river instability and the establishment of well-developed and appropriately-scaled strategies to protect and restore river equilibrium (Vermont River Management Program, personnel communication, 2006). Ultimately it is their strategy that sound research will lead to sound planning and meaningful and long-lasting restoration and management efforts.

The VTANR River Management Program uses the "river corridor" as a primary tool in its avoidance strategy to restore and protect the natural values of rivers and to minimize flood damage. River corridors consist of lands adjacent to and including the present channel of a river. The adjacent lands included in a "corridor" are those that are capable and perhaps likely to be occupied by the channel itself as the river meanders within a valley bottom over time (For a technical description of how they are delineated see "River Corridor Protection

Guide: Fluvial Geomorphic-Based Methodology to Reduce Flood Hazards and Protect Water Quality": VTANR 2008). River corridor planning is conducted in Vermont to remediate the river instability that is largely responsible for excessive erosion and flooding, increased sediment and nutrient loading to surface waters, and a reduction in habitat (VTANR 2007a). Reducing current and future near-stream investment in infrastructure and achieving natural stream stability promotes a sustainable relationship between humans and rivers over time, minimizing the costs associated with floods ($14 Million annually average in Vermont) and maximizing the benefits of clean water and healthy ecosystems (VTANR 2008).

2.2 Local Initiatives in the Mill River Watershed

Local restoration initiatives have been largely driven by the Rutland Natural Resource Conservation District (RNRCD) conservation interests, VTANR basin planning efforts, and the Rutland Regional Planning Commission (RRPC). The Upper Otter Creek Watershed Council (UOCWC), for example, is a project initiated by the RNRCD and VTANR. The group formed in May of 2003, after a series of public forums, at which many issues and concerns were identified. Since then, the UOCWC, the RNRCD, and/or RRPC have received funding to assess riparian buffers and geomorphic conditions along the Otter Creek and many of its significant tributaries including the Mill River (Rutland Regional Planning Commission 2005).

The Mill River Corridor Plan is derived predominately from data collected during a stream geomorphic assessment. Stream geomorphic assessments provide information about the physical condition of streams and the factors that influence their stability. The Vermont Agency of Natural Resources River Management Program has developed a series of protocols (Phase 1, Phase 2, and Phase 3) for the statewide assessment of rivers and streams. A Phase 1 Stream Geomorphic Assessment looks at broad scale landscape data, historical data, and limited field reconnaissance to begin to understand watershed characteristics and potential stressors. A Phase 1 Geomorphic Assessment of the Mill River was completed in 2007 by the Rutland Regional Planning Commission (RRPC). The Phase 1 project report summarized the results of this work (Rutland County Planning Commission, 2007). A Phase 2 Geomorphic Assessment of select reaches (predominately mainstem) of the Mill River was recommended by the RRPC to gather more detailed information about the stream channel and riparian corridor in order to inform current and future planning and restoration efforts. The RRPC retained Round River Design to perform a Phase 2 Stream Geomorphic Assessment of the main stem of the Mill River and a short segment of a tributary in the Towns of Clarendon, Shrewsbury, Wallingford, and Mount Holly during the autumn of 2007. In 2008, these same reaches were targeted for the development of this River Corridor Management Plan.

2.3 The River Corridor Planning Team

This River Corridor Plan has been developed following guidance provided by the VTANR document, "Vermont Agency of Natural Resources River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects" (VTANR 2007a) as well as guidance provided by VTANR watershed staff scientists. Funding has been provided by the Vermont Agency of Natural Resources. Support, review, and project development guidance were provided by Nanci McGuire (RNRCD – District Manager), Shannon Pytlik (VTANR – River Resource Scientist), and Ethan Swift (VTANR – Watershed Planner).

3.0 MILL RIVER STUDY AREA: BACKGROUND WATERSHED INFORMATION

3.1 Geographic Setting

3.1.1 Watershed Description

Located in Rutland County (with a very small portion in Windsor County), Vermont, the Mill River watershed area is 71.26 square miles (Figure 1). The Mill River drains from its forested headwaters in the Green Mountains southeast of Rutland predominately in the towns of Clarendon, Shrewsbury, Wallingford, and Mount Holly with very minor portions in Mendon, Killington, Mount Tabor, and Weston. The Mill River flows north westerly and joins the Otter Creek at approximately 550 feet above sea level in the town of Clarendon. The Otter Creek drains north into Lake Champlain carrying with it the waters, sediments, and nutrients of the Mill River. The combined length of the Mill River reaches targeted through this River Corridor Plan is approximately 15 miles (Figure 2).

3.1.2 Political Jurisdictions

The Mill River mainstem reaches are located in Rutland County in the Towns of Clarendon, Shrewsbury, Wallingford, and Mount Holly. All towns are members of the Rutland Regional Planning Commission. The State of Vermont Water Resources Board classifies and regulates the use of all public waters. The Vermont Agency of Natural Resources issues permits regarding water and stream use. The U.S. Army Corps of Engineers also issues permits and enforces water law in the state.

3.1.3 Land Use History

The Mill River, like many waterways, has been vitally important to the inhabitants of this land. Before the colonists arrived in Vermont, rivers, streams, and lakes were a major avenue of transportation for the Algonquin and Iroquois people. Colonial settlements were established in Vermont in the late 1700's on the back of forestry and agriculture. Settlements typically arose around gristmills and sawmills at suitable sites along rivers and streams. At least a dozen mills dotted the Mill River during the 18th & 19th century. The mills used water from the river and its tributaries to power saws, grists, and fulling and carding machines for preparing wool. The exact location of many of these old mills is difficult to discern in the field as many years have passed. Several known mill locations include the Kingsley's Grist Mill, which served some of Vermont's grain production needs from 1882 until 1935 which was located at reach M03-B near the Shrewsbury and Clarendon town line. Also on the Mill River near the same town line was Smith's Sawmill which operated well into the 1820's. In Cuttingsville, several mills were in harnessing energy from the river from 1820 until 1927 when the great flood washed out the low (~5 foot high) dam spanning the river (at the bedrock grade control on reach M06 upstream from the Route 103 bridge). According to Klyza (1999), mill sizes were typically kept small in order to accommodate the needs of farmers upstream and downstream of the dams. Upstream farmers wanted to ensure that their croplands would not be severely inundated and downstream farmers demanded that they receive enough water yearlong.

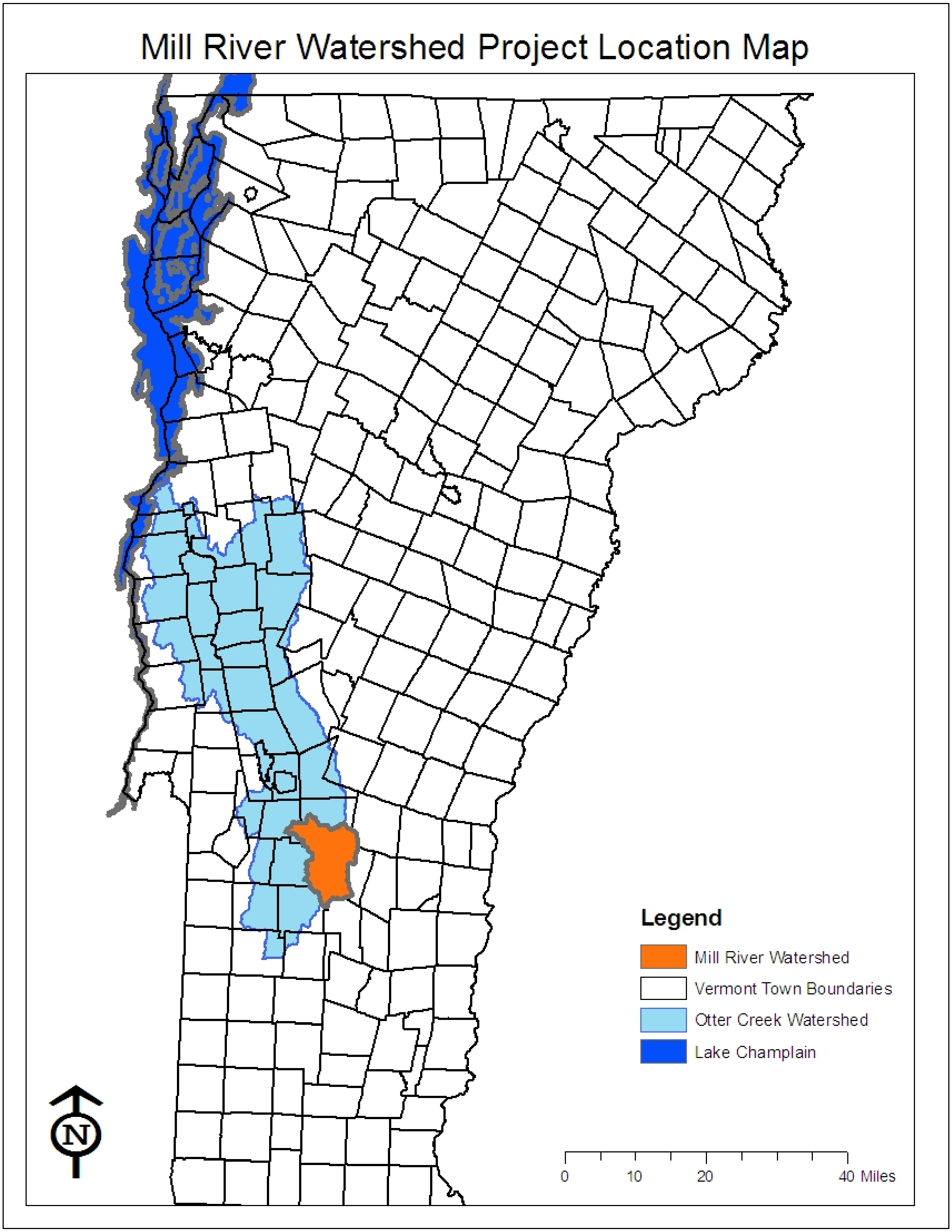


Figure 1: Project Location Map

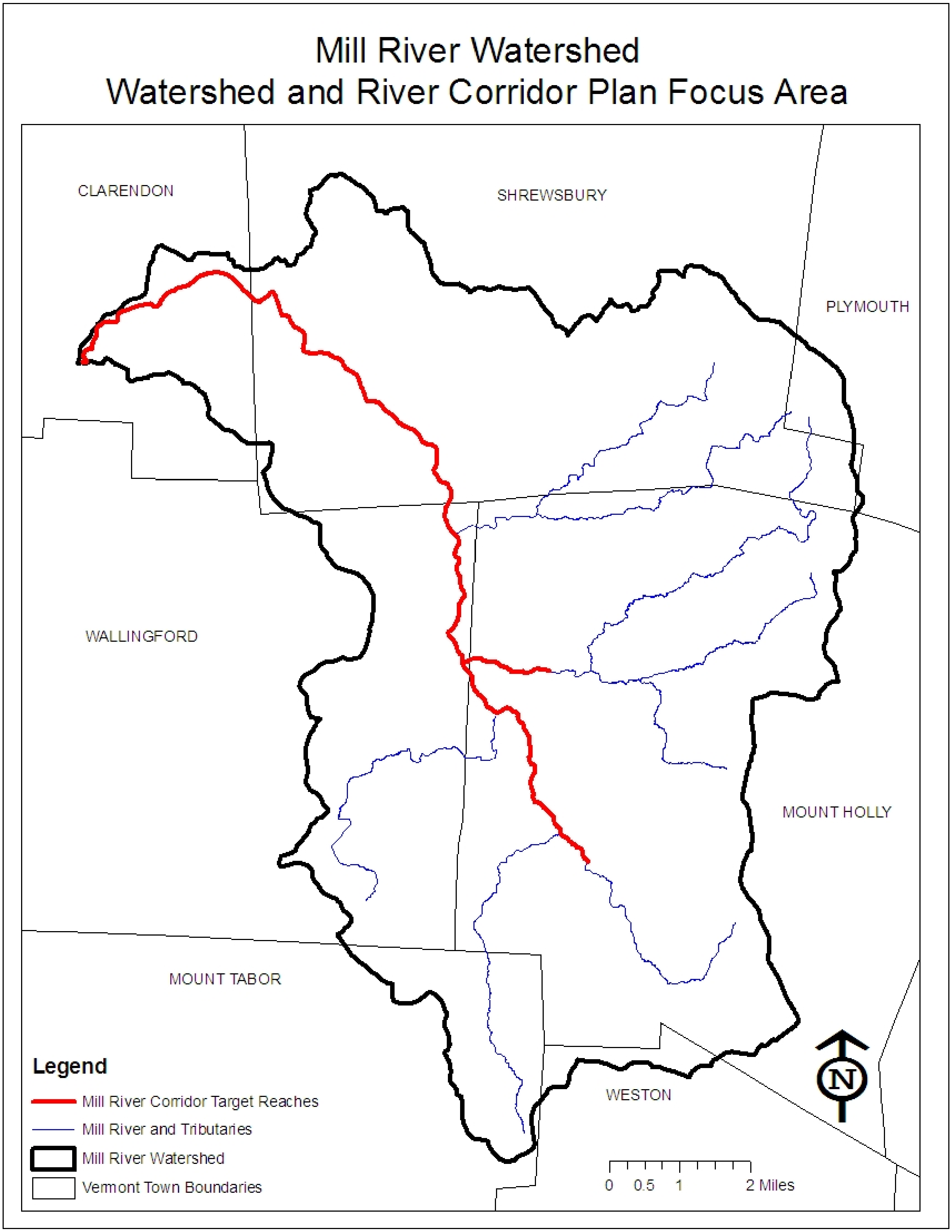


Figure 2: Target Area for the Mill River Corridor Plan.

Agriculture tended to be largely subsistence farming during the early years of settlement and then shifted to primarily growing wheat as a cash crop as demand from non-farming populations (especially southern New England) increased and transportation costs decreased. Competition with mid-western farmers, nutrient-depleted soils, demand from the growing textile mills of southern New England, and a greater need for cash income, among other reasons, caused a shift to sheep farming in the 1820's. Sheep farming enabled Vermonters to put to use the vast areas of deforested land and it became so widespread that, in 1840, during its peak, sheep out-numbered humans 6 to 1 statewide (Klyza, 1999). In the mid- to late- eighteen hundreds, falling wool prices and the availability of horse drawn mechanical farm equipment enabled farmers to develop larger tracts of land to grow feed for dairy cows and another shift in agriculture ensued (Albers, 1999).

While mills were at work utilizing the water within the river, transportation routes were being established in the valley carved by the Mill River and its tributaries. Upon completion of the Bellows Falls to Rutland railroad in 1849, East Wallingford grew up around a station on that line as a lumbering and manufacturing center (Wallingford Town Plan, 2004). The construction of the railway had enormous impacts on the riparian corridors that it passed through as rivers were straightened to facilitate its passage.
The great flood of 1927 led to major changes in land use in the Mill River Watershed and throughout the state. The flood caused massive damage to the state's railroad infrastructure (as well as bridges, homes, farms and businesses) and although much was rebuilt, the growing affordability and popularity of the automobile spurred the construction of improved roads. Commercial and residential development expanded along these transportation corridors (again, following the rivers for the most part) and the percentage of impervious surfaces in the river corridor enlarged. Roads also increased tourism, and with the construction of the highway systems in the 1960's the number of ski resorts and second homes rose sharply. The Civilian Conservation Corps also launched a huge flood control initiative following the 1927 disaster that included erosion prevention, reforestation, habitat protection, reclamation of abandoned farmlands, and the construction of recreational trail networks (the extent of these efforts on the Mill River was not determined).

Today the Mill River is dominated by forested hill tops with residential, commercial, and agricultural lands concentrated near the river valley bottom and along select tributaries (Figure 3).

3.2 Geologic Setting

Streams are transport systems that carry *water* AND *sediment* from highlands to lowlands. The geology of a watershed determines: the source material that water will transport; the conditions that cause the material to be carried; the rate of channel adjustments in response to the energy of flowing water; and also influences the chemistry and ecology of stream systems.

3.2.1 Mountain Building and Bedrock Geology

In a broad geological context the Mill River spans two larger physioregions. The “Vermont Valley” – a continuation of the Champlain Valley that lies to the west of the Green Mountains and north of the Taconic Mountains where hills thrust up from bedrock dominate the lower river. The upper reaches of the Mill River are considered part of the “Green Mountain”

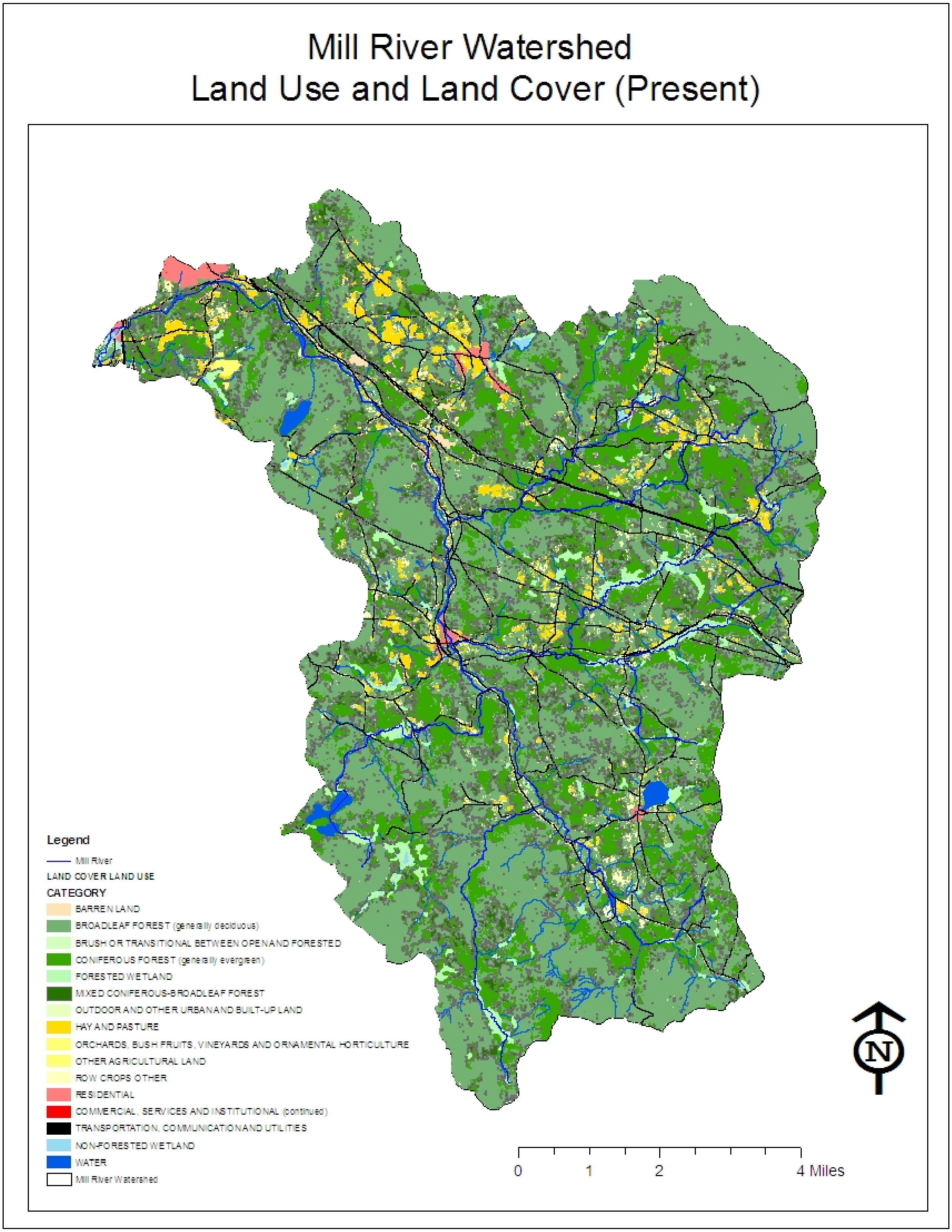


Figure 3: Present day land use and land cover of the Mill River Watershed.

physioregion a huge anticlinorium comprised of three anticlines that have been compressed and uplifted and trend in a north-south direction (Stewart 1972).

The upper reaches of the Mill River flow over bedrock of the Green Mountain Physioregion. According to Stewart (1972), Precambrian basement rock (Mount Holly Complex) forms the core of the Green Mountains and the bedrock geology of the upper Mill River watershed. These rocks were created about 1,200 million years ago during the Grenville Orogeny. During this period, lasting approximately 80 million years, the proto-North American plate collided with another continent approaching from the east, creating a massive mountain chain which was later completely eroded away (Klyza, 1999). As a result of the mountain building events, the Mount Holly Complex is the most highly metamorphosed rock of the whole region. The rock is a complex mixture of schists and gneisses with large areas of quartzite and small concentrations of calcite and dolomite marble.

As the Mill River descends out of the Green Mountains it enters the Vermont Valley physioregion; a series of mostly Cambrian carbonate rock composed both of dolomitic and limestone marbles with occasional quartzite members. As indicated on a map titled, "Areal Geology of the Rutland Area" (Vermont Geological Survey 1952), the Mendon Formation (a Lower Cambrian quartzite formation) is found near reach M04. The Danby Quartzite formation (Upper Cambrian) forms the beginning of the Lower Clarendon Gorge with Winooski Dolomite and Monkton Quartzite forming the lower gorge. From here the Mill River spills out to the valley floor of the Otter Creek and into an area dominated by glacial drift and surficial deposits.

In the areas where bedrock does directly underlie the river channel; the stability of a river channel is typically improved. Exposed bedrock along the stream bottom and/or channel walls typically prevents rapid incision and planform adjustments. In the Mill River, channel spanning bedrock is found in reaches M11-B, M06, M04, M03-C, M03-B and M02. This bedrock provides a more stable stream channel in these reaches and in most cases has limited incision directly upstream and downstream as well. These channel spanning bedrock formations are known as "grade controls" since they set the grade (i.e. the slope) of the river to a certain set elevation.

3.2.2 Glacial History and Surficial Geology

According to Wright and Larsen (2004) almost all of the surficial materials [in Vermont] owe their origin, either directly or indirectly, to the Laurentide ice sheet. The Laurentide ice sheet was the last big continental-scale glacier that covered all of New England. It first formed in the Hudson's Bay region of Canada sometime between 80–100,000 years ago. As the climate slowly cooled the ice sheet grew and advanced slowly towards New England, flowing south and east, up the Mill River valley. As the ice sheet advanced and thickened it eventually overwhelmed and completely buried the Green Mountains (as well as the Adirondacks and White Mountains) and, by approximately 23,000 years ago, extended as far south as Long Island. As the climate rapidly warmed the ice sheet responded by thinning and retreating to the north leaving most of Vermont ice-free by approximately 14,000 years ago, but having a very significant impact on the surficial geology of the landscape.

The surficial materials in the Mill River region are composed of sediments transported by glaciers or by melt water from streams or deposits made in small lakes associated with glaciation. The exception is the recent alluvium from postglacial floodwaters that forms a thin veneer on land adjacent the river (i.e. floodplain). Till (unsorted glacial debris deposited directly from melting ice) contains a wide variety of particles sizes. According to Stewart (1972), till covers the uplands of the Rutland region as a thin veneer generally less than 10 feet thick and much thicker in the valleys. At the base of the Green Mountains, near the Vermont Valley, kame terraces, kames, and valley train deposits (outwash from glacial streams) can be found.

The Phase 1 Stream Geomorphic Assessment (Rutland Regional Planning Commission 2007) used soil maps (provided by the Natural Resource Conservation Service) to determine that ice-contact, glacial till, and alluvial deposits are the dominant surficial geologic materials in the Mill River watershed. Alluvium soils are frequently flooded and have high erodibility potential. Ice contact soils are infrequently flooded; however have high to severe erodibility. Glacial till deposits are infrequently flooded and have high erodibility.

3.3 Geomorphic Setting

3.3.1 Description and Mapped Location of Study Reaches

The Phase 1 Assessment of the Mill River Watershed (Rutland Regional Planning Commission, 2007) delineated geomorphic reaches (sections of river that are expected to exhibit similar characteristics). Reaches were defined according to VTANR Phase 1 protocol based on variations in valley confinement, slope, sinuosity, and soils. Based on the channel and watershed stressors identified during the Phase 1 Assessment, fifteen mainstem reaches and one tributary reach of the Mill River were prioritized for Phase 2 Stream Geomorphic Assessments in 2007. These targeted reaches were expected to demonstrate higher degrees of channel adjustment and sensitivity. As depicted in Figure 5, several of these fifteen reaches were further subdivided into “segments” due to localized variations in stream type, channel and floodplain encroachment, incision, and/or other significant differences observed during the Phase 2 field assessment. In total 22 unique sections of river were investigated for the Phase 2 assessment.

3.3.2 Longitudinal Profile, Alluvial Fans, and Natural Grade Controls

The Mill River drops at an average slope of 1.4% from reach M15 to the confluence with the Otter Creek (a valley distance of almost 13 miles) (Figure 4). Soil profiles at significant slope changes located at reaches M11-B and M01 indicate the possible presence of alluvial fans. Natural bedrock grade controls (where bedrock spans the river channel and prevents rapid incision) were located at reaches M02, M03, M04, M06, and M11.

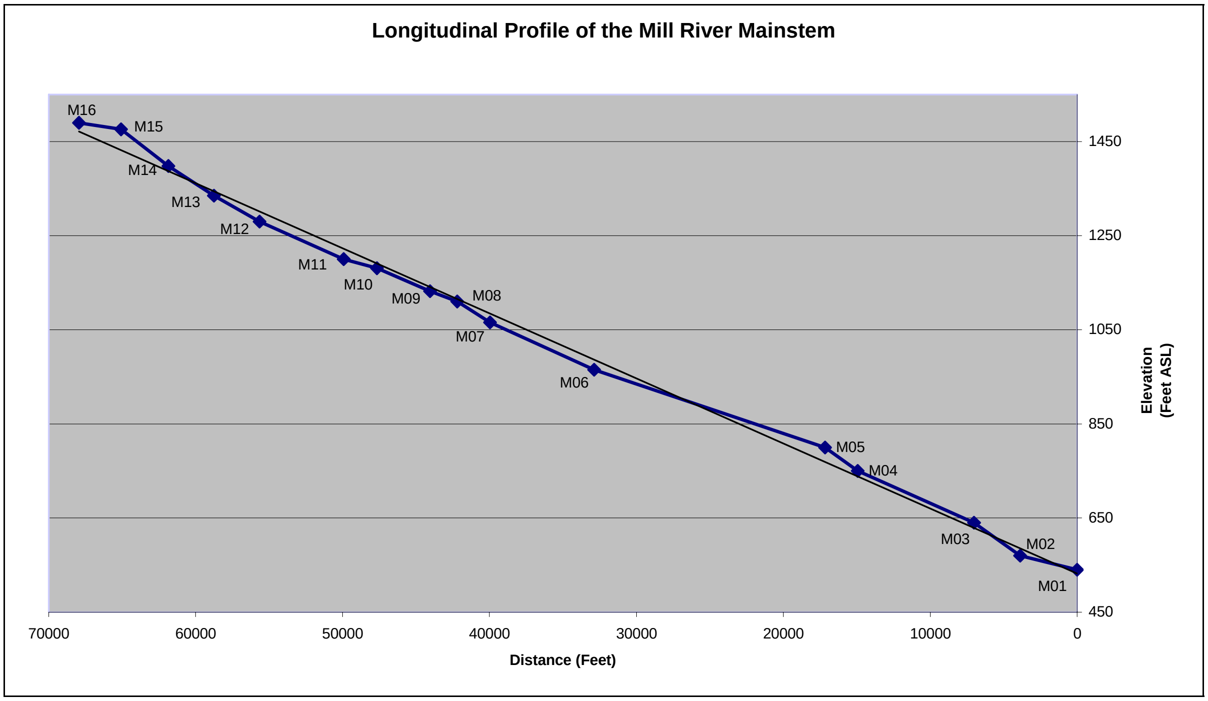


Figure 4: Longitudinal Profile of the Mill River.

3.3.3 Valley and Reference Stream Types

Reference stream and valley types are designated to describe stream channel forms and processes that would exist in the absence of human-related changes to the channel, floodplain, and/or watershed. Reference stream types are based largely on characteristics of the valley, geology, and climate and are identified using data from both the Phase 1 and Phase 2 Assessments (VTANR 2007b). Reference stream types are based in the science of fluvial geomorphology which informs us that given consistent inputs (average annual precipitation and sediment input), every river has a single most probable form toward which it is constantly working (Leopold 1994). Given the long history of stream channelization and human-related changes to the Vermont landscape it is common to observe that existing stream and valley conditions are significantly different than what one would expect to find in a pristine watershed. Recognizing differences between current on-the-ground conditions and a streams "most probable form" may be useful for determining restoration and management approaches (as outlined in section 5.0).

Table 1 describes the reference stream and valley types for the Mill River study reaches. The majority of the mainstem of the Mill River is by reference a "C" type channel dominated by gravel substrates, an unconfined floodplain, and a riffle-pool bedform (see Rosgen 1996 for stream type definitions). Several of the mainstem reaches are reference "B" type channels that have steeper slopes, a naturally confined floodplain, and in this case, dominated by bedrock on the stream channel bottom.

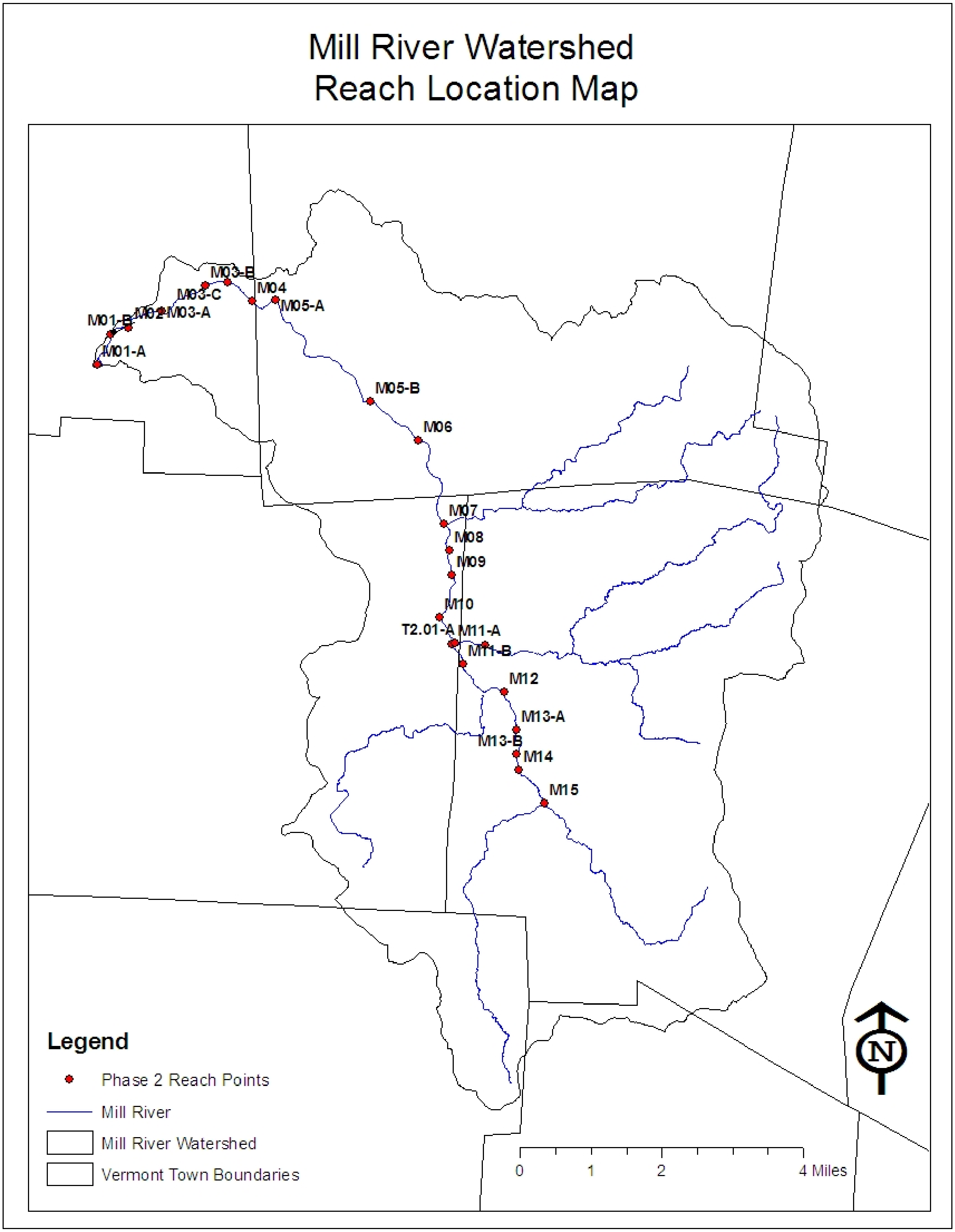


Figure 5: Reach location map for the Mill River Phase 2 Stream Geomorphic Assessment

Table 1: Reference Valley and Stream Types for the Mill River

Segment Number	Valley Type	Expected Channel Width (ft.)	Channel Slope (%)	Sinuosity	Reference Stream Type	Reference Bedform
M15	Very Broad	35.9	0.45	1.08	C4	Riffle-Pool
M14	Very Broad	45.4	2.29	1.06	C3b	Riffle-Pool
M13-B	Broad	45.9	1.85	1.10	B3	Riffle-Pool
M13-A	Broad	45.9	1.85	1.10	C4	Riffle-Pool
M12	Very Broad	46.5	1.74	1.02	C4	Riffle-Pool
M11-B	Very Broad	55.1	1.29	1.09	C4	Riffle-Pool
M11-A	Very Broad	55.1	1.29	1.09	C4	Riffle-Pool
M10	Broad	66.4	0.80	1.04	C4	Riffle-Pool
M09	Narrow	67.5	1.36	1.00	C4	Riffle-Pool
M08	Narrow	67.9	1.16	1.03	C3	Plane Bed
M07	Broad	75.8	1.85	1.06	C4	Riffle-Pool
M06	Broad	77.2	1.33	1.07	C4	Riffle-Pool
M05-B	Broad	83.6	0.99	1.06	C4	Riffle-Pool
M05-A	Broad	83.6	0.99	1.06	C4	Riffle-Pool
M04	Confined	83.7	2.25	1.00	B1	Bedrock Gorge
M03-C	Semi-Confined	84.5	1.33	1.04	B4	Plane Bed
M03-B	Confined	84.5	1.33	1.04	B1	Bedrock Gorge
M03-A	Broad	84.5	1.33	1.04	C3	Riffle-Pool
M02	Confined	84.7	2.22	1.01	B1	Bedrock Gorge
M01-B	Very Broad	85.6	0.62	1.25	C4	Riffle-Pool
M01-A	Very Broad	85.6	0.62	1.25	C4	Riffle-Pool
T2.01-B	Very Broad	41.1	1.46	1.07	C4	Riffle-Pool
T2.01-A	Very Broad	41.1	1.46	1.07	C4	Riffle-Pool

3.4 Hydrology

As reported in the Phase 1 Assessment Report (Rutland Regional Planning Commission 2007), most of the Mill River watershed is currently forested. Some subwatersheds were reported to have as much as 9% in urban land use and 6% in cropland/pasture based on an analysis of data obtained from the Vermont Center for Geographic Information. Within the stream corridor urban land use development rose to as much as 60% of the corridor of one reach (M10).

These numbers are important because development in the watershed, both current and historic, may have a large impact on fluvial erosion, water quality, and habitat quality. For instance, according to a study conducted at the University of Maryland (Barnes et al, 2007), declines in biological integrity and habitat quality are observable in watersheds with impervious cover as low as 10%. The alteration of first-order, and in some cases, second-order channels (the small feeder streams that join to become the major tributaries to the Mill River) is problematic since runoff and sediments formerly distributed among many small channels become concentrated to fewer channels. The outcomes of this are more rapid flow velocities and flood peaks downstream leading to erosion and enlargement of stream channels; the washing-out of culverts and crossing structures not previously sized to handle such flows; as well as other detrimental affects.

Channel and bank instability, which leads to the physical degradation of streams, is aggravated by the increased flooding and increased flow concentration that follows increased imperviousness as a result of poor development. The signs of instability, however, may not become evident for several years following development. Signs of instability include channel widening by bank erosion or a deepening of the channel through down-cutting. With the former, channel beds may become covered in sediment; with the latter, beds are subject to frequent scours.
The Maryland study continues to describe that, "When development occurs on floodplains not previously developed, natural flooding will inevitably threaten the people and property inhabiting those floodplains. What's more, areas that did not commonly flood before urbanization may suffer more frequent inundations due to the greater volumes of runoff and increased flood heights associated with imperviousness. Properties and structures may be threatened by bank erosion from streams' whose channels have been destabilized by upstream development (Barnes et al, 2001)."

In the context of the Mill River the conditions for this instability exist and the human reaction to instability such as channel dredging, berming, stoning, ditching of small runoff channels, and straightening appears to be a pattern that is widespread and persistent.

3.4.1 Stream Gage Information and Flood History

According to the Vermont Agency of Natural Resources document "Municipal Guide to Fluvial Erosion Hazard Mitigation" (2006), "Of all the natural hazards experienced in Vermont, flooding is the most frequent, damaging, and costly." The guide documents that over the last 50 years, flood recovery has cost the state an average of $14 million a year and that during the period of 1995-1998 alone, flood losses in Vermont totaled almost $57 million. Of particular concern for towns and properties near streams, it notes that, "While some flood losses are caused by inundation (i.e. waters rise, fill, and damage low-lying structures), most flood losses in Vermont are caused by "fluvial erosion". Fluvial erosion is erosion caused by moving water and can range from gradual streambank erosion to catastrophic changes in river channel location and dimension during flood events (Figure 6)."

Figure 6: These images show damage from the 1927 flood. Left image is looking towards the intersection of Route 140 and Route 155 (Reach M10) in East Wallingford. Right image is of route 103 washout in Cuttingsville near reach M06/M07.

The Municipal Guide further documents that, "Closer study of our rivers and streams reveals that Vermont's erosion hazard problems are largely due to pervasive, human-caused alteration during the past 150 to 200 years of our waterways and landscapes they drain. By the end of the 19th century, forests had been cleared from many watersheds, resulting in major changes in watershed hydrology and sediment production. Towns and villages, the centers of commerce, grew on the banks of rivers, whose role in power generation and transportation at first outweighed flood risks. In addition, many watersheds were changed by development, agriculture, log drives, roads and railways." The legacy of this landscape manipulation is rivers and streams, such as the Mill River, which are unstable and prone to sudden and significant fluvial erosion (Vermont Agency of Natural Resources 2006).
To further concern streamside landowners, precipitation trend analysis suggests that intense, localized storms, which can cause flash flooding, are occurring with greater frequency (Vermont Department of Public Safety, 2006). In order to better understand the flood history of the Mill River, long term data from the U.S. Department of the Interior, U.S. Geological Survey (USGS) gauge on the Otter Creek in Rutland, VT (Figure 7) and data from a smaller nearby stream, the Ottauquechee River near West Bridgewater, VT (Figure 8), were obtained (United States Geological Survey 2007). Seventy-eight years of record are available for the Otter Creek gauge at Rutland, VT which provides a continuous record of flow from 1929 through the present. Only the last twenty-two (1985-2007) years of records are available on the Ottauquechee River.

The Otter Creek generally has good access to its floodplain and floods at least once each year at spring runoff. The long term record at the Otter Creek gauge shows a 25 year flow was recorded in 1973 and 10 year flows have been recorded in 1947, 1949, 1976, 1977 and 1987. In 1938, during the New England Hurricane, the Otter Creek reached a peak of 13,700 cfs, the only flow greater than the 50 year flood stage measured on this gauge (which was not operational during Vermont's largest flood, 1927) (Vermont Agency of Natural Resources, 2007b). In the near term record of the Ottauquechee River gauge (from 1985 to 2006) major events occurred in 1996, 1998, 2000, and 2002.

It is safe to presume that future flooding and flood damage are a certainty. Preparation for and response to flood situations may have significant and long-lasting influence on whether flooding continues to be a cause of significant financial harm or whether it becomes a natural phenomenon that is ultimately a long-term expression of river stability and dynamism. It may possibly even become something to be appreciated for, under the right conditions, flooding can replenish nutrients in agricultural fields and, where wetlands are adjacent to streams, create temporary habitat for the reproduction of many aquatic and riparian species.

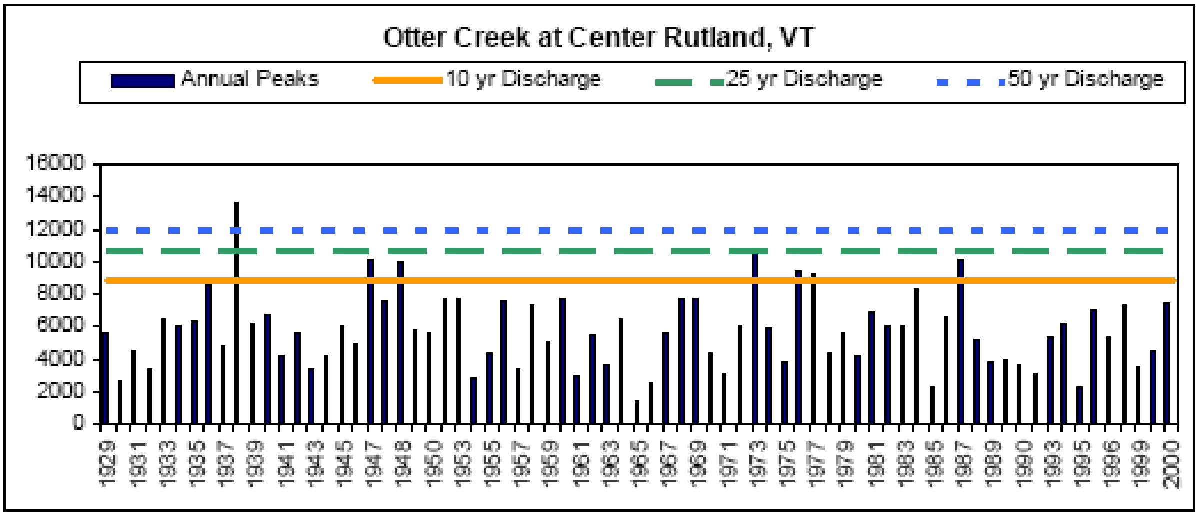


Figure 7: Flood frequency analysis for Otter Creek, Rutland, VT.

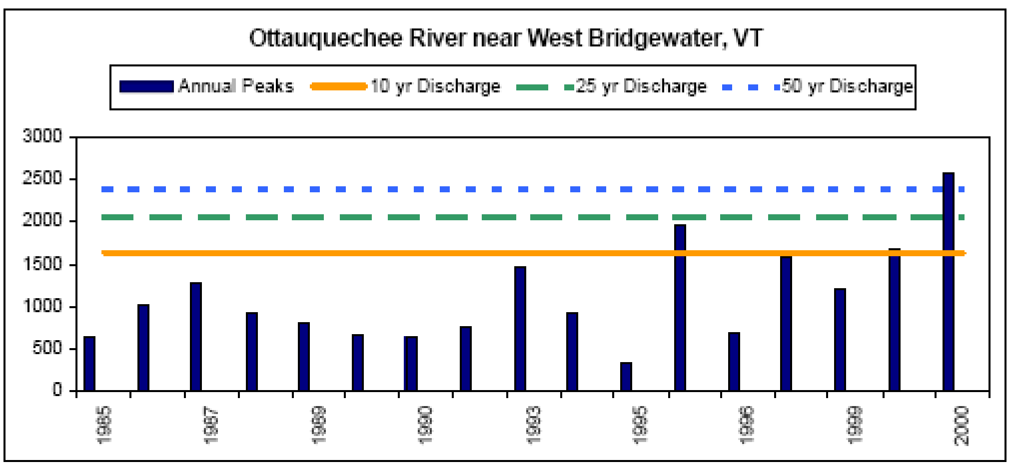


Figure 8: Flood frequency analysis for Ottauquechee River at West Bridgewater, VT.

3.5 Ecological Setting

3.5.1 Distribution of In-stream, Riparian, and Wetland Habitats

During the Phase 2 Assessment a rapid habitat evaluation was conducted for twenty assessed segments. The habitat observations found that in-stream shelter within many of the upstream reaches consisted only of small pocket pools behind large boulders. In-stream habitat has suffered due to channel straightening and dredging which have reduced the quality and depth of pools and where large woody debris (such as logs and tree stumps) has been removed from the channel. Additionally, fine sediments from bank erosion and surface water runoff from roads and other clearings have caused some loss of habitat as cobbles and gravels on the stream bottom become filled in.

Shading from the riparian corridor varied between very good to poor with much of the stream lacking adequate buffer or simply being over-wide (high width/depth ratio) and therefore being susceptible to thermal pollution (see Figure 9). Many reaches, especially near the villages had major intrusion into their river corridor from roads and many had inadequate riparian buffers due to historic and /or recent land clearing. In addition, where roads and railroads border the stream, vegetation tends to be disturbed and not as robust as if the stream were meeting an unaltered floodplain. The benefits of wider riparian corridors are numerous. From a wildlife perspective, riparian buffers offer corridors for habitat and migration, while large woody debris provides habitat pools for aquatic life (Magillian et al., 2008). From a geomorphic perspective, forested riparian buffers improve bank stability and help control erosion (McBride et al., 2008). Also, large woody debris in streams helps maintain natural flow by providing high flow mitigation and acting as sediment traps. Finally, from a water quality perspective, riparian buffers help control nutrient cycles and shading helps control water temperatures needed to sustain healthy ecosystems.

Overall, the habitat assessment results were similar to the geomorphic assessment results (indicating major declines in stream stability) implying that the ecological health of the Mill River is closely related to the geomorphic condition of the stream.

Figure 9: Despite a well forested riparian buffer, over-wide reaches such as M03-A may suffer from thermal pollution due to lack of shading.

3.5.2 Unique Plant and Animal Communities

The VTANR Biomonitoring Section monitors the Mill River on a regular basis. None of the species that have been collected from the Mill River watershed are considered unique or rare in Vermont. The Vermont Fish and Wildife Department, Nongame and Natural Heritage Program's GIS data layer "Rare, Threatened and Endangered Species & Significant

Communities" does, however, indicate the presence of noteworthy biota in the Mill River watershed, particularly in some of the tributaries (the information describes several plants, a mammal, and a bird that are known to exist). Despite there being no indication of these species on the main stem, care should be given by residents and developers within the Mill River to protect local ecosystems and species, recognized or not.

4.0 METHODS AND RESULTS OF GEOMORPHIC ASSESSMENT WORK

4.1 Fluvial Geomorphic and Bridge Assessments

The following sections summarize the stream stability assessments that were carried out on the Mill River in support of this River Corridor Management Plan.

4.1.1 Phase 1 Stream Geomorphic Assessment

A Phase 1 Stream Geomorphic Assessment looks at broad scale landscape data, historical data, and limited field reconnaissance to begin to understand watershed characteristics and potential stressors. A Phase 1 Geomorphic Assessment of the Mill River was completed in 2007 by the RRPC. The Phase 1 project report summarized the results of this work (Rutland County Planning Commission, 2007). The Phase 1 Assessment collected data from 59 subwatersheds. The study concluded that on these 59 reaches, floodplain modifications and land use changes were likely to have the greatest impact on stream stability (Figure 10).

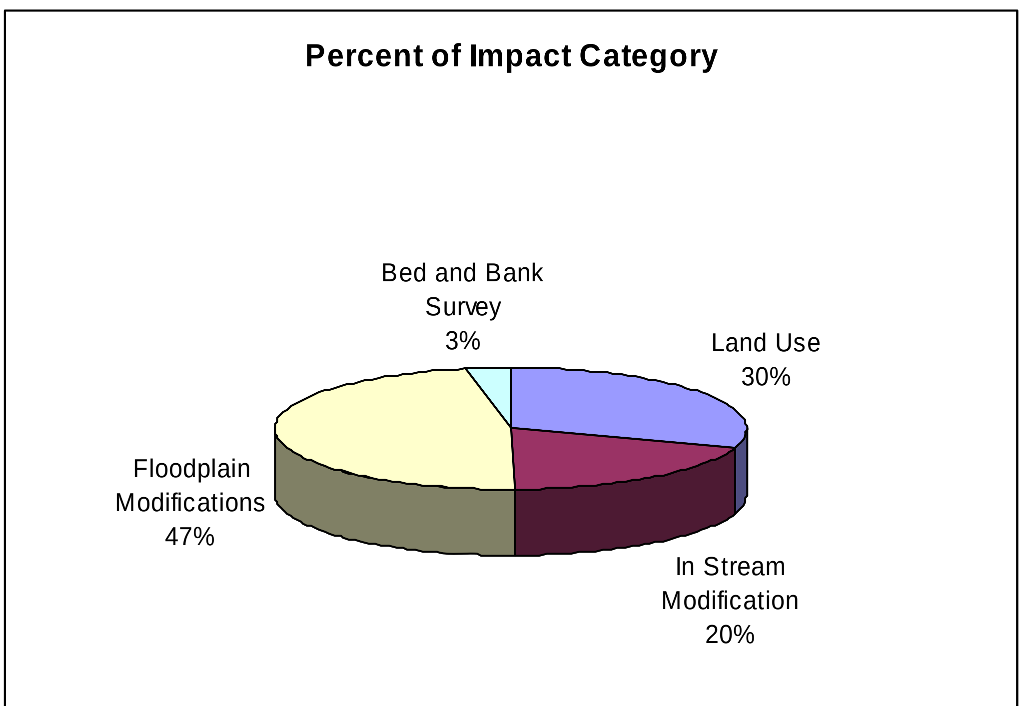


Figure 10: Mill River Phase 1 Impact Score results.

4.1.2 Phase 2 Stream Geomorphic Assessment

The Phase 2 Fluvial Geomorphic Assessment, conducted by RRD, followed procedures specified in the Vermont Stream Geomorphic Assessment Phase 2 Handbook (Vermont Agency of Natural Resources 2007b). The Phase 2 Assessment focused on the mainstem reaches starting above East Wallingford Village (M15) downstream to the mouth of the river. All assessment data were recorded on the Agency of Natural Resources Phase 2 field data sheets, and were entered in to the VTANR Stream Geomorphic Assessment online data management system (DMS) (https://anrnode.anr.state.vt.us/ssl/sga/index.cfm). The Phase 1 database was updated when necessary based on the field data collected during the Phase 2 assessment.

The Phase 2 study observed that the upper section of the Mill River in Mount Holly and East Wallingford has seen high amounts of historic channel straightening, floodplain encroachment, berming, and removal of riparian vegetation. There has been a collective loss of floodplain access due to berming, incision of the streambed, and floodplain encroachment. The result has been a loss of water and sediment storage in the upper watershed which has created an increase in river power during flood events resulting in instability and fluvial erosion hazards in these reaches. From the Upper Clarendon Gorge to the Lower Clarendon Gorge in the town of Shrewsbury the Mill River regains a sense of general stability aided by bedrock dominated channels. From the Lower Clarendon Gorge to the confluence with the Otter Creek in Clarendon the Mill River is a predictably dynamic stream in a natural area of sediment deposition (steeper narrow valley widens and flattens in a broader river valley). A recent study indicated that, "excessive sediment contributions and an apparent reduction in sediment transport capacity" were found in the Otter Creek at the Mill River confluence (Underwood 2006).

The most common adjustment processes observed in the Mill River during the Phase 2 Assessment were widening and planform migration as a result of degradation within the channel. A reach by reach summary of the Phase 2 data may be found in Appendix B.

4.1.3 Bridge and Culvert Analysis

The need to cross the Mill River via bridge is imperative. The act of placing a bridge over the river has historically involved constructing stone footers onto which rest timbers and later iron and steel. The footers (or abutments) were placed close enough together so that a single large timber could span from one side to the other. In a large stream such as the Mill River, these abutments were often narrower than the natural channel. Today, even with new materials, bridge crossings tend to be constructed narrower than the river channel. This narrowing of the river becomes problematic when, during high flows, floodwaters back up due to the constriction. This causes flooding upstream of the bridge. This is worsened by debris that can accumulate at a constricted area including sediment which can accumulate upstream at unnatural locations further exacerbating instability. During flood conditions, pressure is increased on the downstream side of the bridge (similar to placing one's thumb on the end of a garden hose). The extra energy causes erosion and leaves a wide scoured area downstream of the bridge. Furthermore, physical changes to the river channel such as straightening and stone armoring leading up to and through a bridge, even in newer wider bridges, may prevent a river from migrating naturally across the valley bottom and may create fluvial erosion hazards.

In order to assess the impact of these crossings, bridge and culvert assessments were completed for all permanent structures located on Phase 2 reaches in accordance with Appendix G of the Phase 2 Geomorphic Assessment (2007b). Complete bridge and culvert assessment results can be found in Appendix C of this report. In total, fifteen structures were assessed according to VTANR protocols for such characteristics as specific height and width, geomorphic and fish passage data, nearby vegetation, and evidence of wildlife.

During the Phase 2 Assessment a number of bridge and culverts were observed to be considerably narrower than the existing bankfull width subsequently causing instability in the river (Table 2). Narrow crossings reduce sediment transport capacity and disconnect floodplains from the river channel. In particular need of replacement based on the problems observed and their percent bankfull width are the Route 155 Bridge in East Wallingford and the Barlow Road Bridge in Mount Holly. Also the two structures located on T2.01were found to be undersized. From a technical measurement (from footing to footing) the railroad bridge on M11-A does not appear to be a problem, however, the channel width of the river from bridge abutment to the Route 155 embankment was only 39 feet (70% reference channel width) and should also be considered a problem structure (Figure 11).

Figure 11: The railroad bridge span on M11-A is adequate for the Mill River (red line), however, location of Route 155 in relation to the bridge and the river creates a channel constriction between the bridge abutment and the road (yellow line).

TABLE 2: MILL RIVER BRIDGES: PROBLEMS AND POTENTIAL FAILURE MODES

Reach	Road	Type	F1	F2	F3	F4	F5	F6	P1	P2	P3	P4	P5	P6	P7	Width
M15	Private road	Bridge	-	-	-	X	-	X	X	X	X	X	-	-	X	111 %
M14	BARLOW RD	Bridge	-	-	-	-	-	-	-	-	-	-	-	-	X	77 %
M11-B	ROUTE 155	Bridge	-	X	X	X	X	X	-	X	X	-	-	-	X	54 %
M11-A	Railroad	Bridge	X	-	-	X	-	X	X	-	-	-	-	-	-	190 %
M10	ROUTE 140-EAST	Bridge	-	-	-	X	-	X	X	-	X	X	-	-	X	172 %
M10	VILLAGE ST	Bridge	-	-	X	X	-	X	-	-	X	-	-	-	X	253 %
M08	Railroad	Bridge	-	-	X	-	-	X	X	X	X	-	-	-	X	163 %
M06	VT RTE 103	Bridge	-	-	-	-	-	X	-	-	-	-	X	-	X	171 %
M05	VT RTE 103	Bridge	-	-	-	X	-	X	X	-	X	X	-	-	X	237 %
M03-B	EAST ST	Bridge	-	-	X	-	-	-	-	X	-	-	-	-	X	85 %
M01-B	ROUTE 7	Bridge	-	-	-	X	-	X	X	-	-	X	-	-	X	364 %
M01-B	ROUTE 7	Bridge	-	-	-	X	-	X	X	-	-	X	-	-	X	364 %
M01-B	Railroad	Bridge	-	-	-	X	-	X	X	-	-	X	-	-	X	154 %
T2.01-B	BOWLSVILLE RD	Bridge	-	X	X	X	X	-	-	X	X	-	-	-	X	50 %
T2.01-A	ROUTE 140-EAST	Bridge	-	X	X	X	X	X	X	X	-	X	X	-	X	61 %

	Failure Modes
F1	Concern for structure due to fluvial condition or process
F2	Potential failure due to out-flanking
F3	Potential failure due to scour
F4	Potential failure due to ice or debris jam
F5	Structure related damage due to flooding of adjacent property
F6	Structure related damage due to erosion of adjacent property
	Existing Problems
P1	Upstream sediment deposit
P2	Upstream Scour and/or erosion present
P3	Downstream Scour and/or erosion present
P4	Inlet obstruction present
P5	Poor location or alignment
P6	Beaver activity
P7	Floodplain filled entirely or partially by roadway approaches
Width	Structure width divided by channel width as a percent (% bankfull width)

4.2 Quality Assurance (QA) Review

The Phase 1 and 2 Geomorphic Assessment and Bridge and Culvert Survey were carried out in compliance with the VTANR Programmatic QAPP (VTANR, 2003). Round River Design performed a thorough in-house quality assurance (QA) review of the Phase 2 data in November of 2007. The DMS and the ArcView Shapefiles for the Mill River Phase 2 study were submitted to Shannon Pytlik of the VTANR for a QA review in November of 2007. Shannon Pytlik completed the QA review during the first week of December, 2007. Mapping of existing valley walls was conducted in support of fluvial erosion hazard zone development by the VTANR River Management Program.

5.0 FURTHER ANALYSIS: STRESSORS, CHANNEL RESPONSE, SENSITIVITY

The science of fluvial geomorphology informs us that given consistent inputs (average annual precipitation and sediment input), every stream has a single most probable form (width, depth, planform, slope) toward which it is constantly working (Leopold 1994). We also know that natural and anthropogenic impacts to a river channel or watershed may alter the equilibrium between sediment transport and water flow and may set in motion a series of morphological responses (aggradation, degradation, and widening and/or planform adjustment) as the river works to reestablish a self-maintaining stable channel (as depicted in Figure 12). It is important to recognize that all streams are consistently undergoing dynamic in-channel adjustments. Over time the bed level, location, and width of a channel may vary around a certain consistent "probable form". Under the right conditions, however, these equilibrium altering impacts (which may be small to moderate changes in slope, discharge, and/or sediment supply or large-scale changes) can exceed the threshold limit of a channel thereby causing a major shift in the form and equilibrium balance of the stream (Figure 13). These significant threshold exceedences may transform channel and floodplain interactions through entire reaches (up to several miles in length) (Ryan 2001).

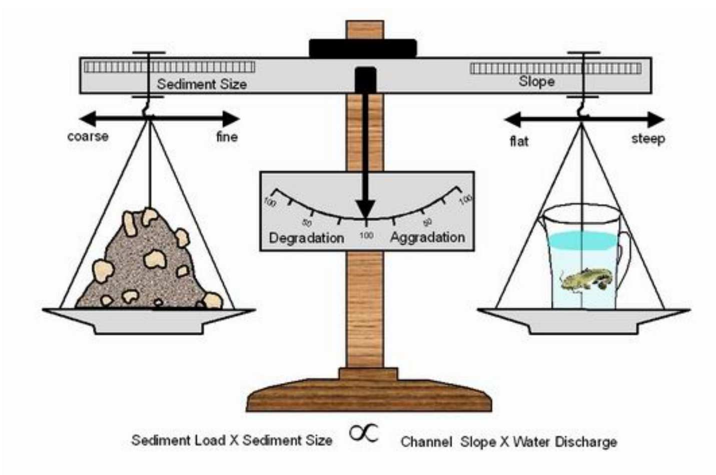


Figure 12: Lane's Balance (1955) *depicts how a change in sediment load, sediment size, channel slope, and/or the amount of water discharged may lead to channel degradation or aggradation.*

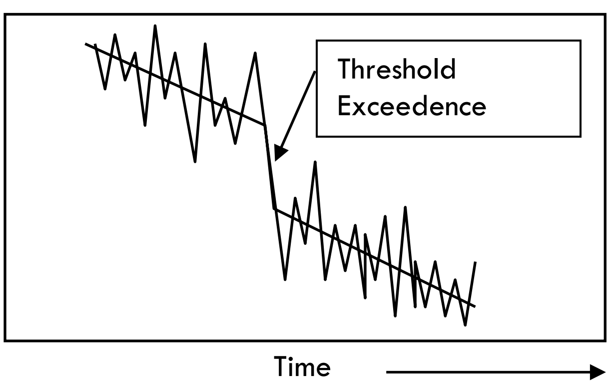


Figure 13: Threshold exceedences in dynamic stream channels. (Jaquith 2008)

Typically, channel adjustments fall into four major categories: degradation, aggradation, planform, and widening. Degradation (sometimes referred to as 'incision') is the term used to describe the process whereby the stream bed lowers in elevation through erosion, or scour, of bed material. Aggradation is a term used to describe the raising of the bed elevation through an accumulation of sediment in the channel. The planform is the channel configuration as seen from above. Planform change may be a reaction to channel straightening (Figure 14), or a channel response to other adjustments such as aggradation and widening. Channel widening occurs when stream flows are contained in a channel as a result of degradation or floodplain encroachment or when sediments overwhelm the stream channel and the erosive energy is concentrated into both banks.

Analysis of the impacts that have led to changes in the sediment regime, hydrology, and channel configuration and dimensions of the Mill River, and therefore caused morphological adjustments such as those described above, is useful for informing restoration and planning efforts and is the focus of Section 5.1. Predicting how unstable river channels will react is the focus of Sections 5.2 and 5.3.

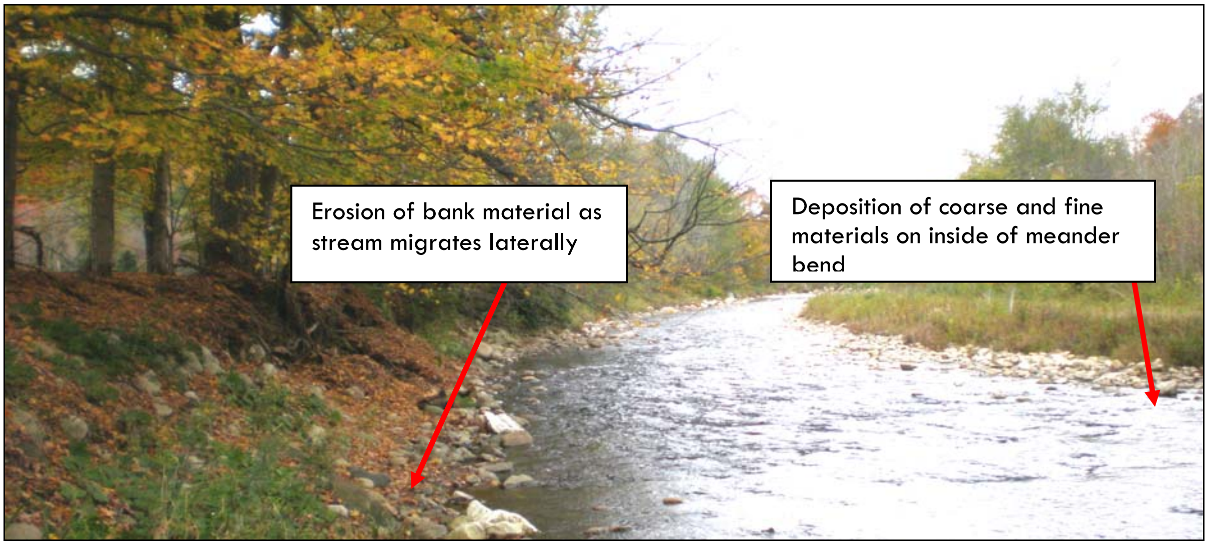


Figure 14: Planform migration associated with historic channel straightening of the Mill River.

5.1 Factors Influencing the Stability and Health of the Mill River

Appendix C is comprised of maps depicting some of the factors influencing the stability of the Mill River. Analysis of the map topics is provided below.

5.1.1 Alterations to the Hydrologic Regime of the Mill River

The hydrologic regime of a watershed refers to the timing, volume, and duration of runoff events that have, over time, influenced the shape and physical form of a river channel. Hydrology is influenced by climate, soils, geology, groundwater inputs, vegetation, riparian areas, and valley and stream shape. When the hydrologic regime of a watershed is significantly altered a river channel will adjust (e.g., increased stormwater flows result in consistently higher volumes of water passing through a channel and lead to channel degradation and incision).

While the significant deforestation that occurred in Vermont watersheds in the 19th century may still be influencing the Watershed, a number of more easily discernable hydrologic stressors are impacting the Mill River today. As depicted in Appendix A Figure 1, stormwater inputs from roads, field and road drainage ditches, and impervious surfaces are numerous in some reaches of the Mill River, particularly around the Villages of East Wallingford and Cuttingsville. These stormwater inputs hasten the timing and amount of water entering the channel during a runoff event and may contribute to localized channel enlargement and flooding (as described in section 3.4).

Another significant impact to the hydrologic regime of the Mill River watershed may be alterations to the land use and land cover of the watershed. Specifically, the transition of land from forest to cropland and development, as well as the loss of wetlands causes a decrease in soil and floodplain storage and an increase in surface water runoff (Appendix A Figure 2). According to the VTANR River Corridor Planning Manual (VTANR 2007a), recent studies in Burlington and Saint Albans show that major channel adjustment and biological impacts are associated with watersheds that have over 5% impervious cover. The Phase 1 geomorphic assessment of the Mill River indicated numerous subwatersheds near or exceeding 5% urban and cropland cover indicating the possibility for major channel adjustment and biological impacts.

5.1.2 Alterations in the Sediment Regime of the Mill River

Understanding sediment transport and its role in stream stability and habitat is critical for successful river corridor planning and restoration. During high flows, small sediments are easily transported and deposited where low velocities are found (typically the inside of a bend or the floodplain). When floodplains do not exist or are inaccessible and where bends have been removed through straightening, fine sediments may be transported long distances until low velocities are met (such as the Otter Creek). As fine materials have the highest concentration of nutrients and organic material, the absence or overabundance of fine sediment in a stream system can have great impacts on the aquatic biology (VTANR 2007a).

Along the bottom of a stream the larger cobbles and gravels of a stream slide and tumble along during high water events. In a stable stream these larger particles are transported and sorted according to variations in stream power associated with slope, depth, and width. Disruptions in the transport of these larger particles either through increasing stream power (e.g. channel straightening, berming) or decreasing stream power (e.g. channel constricting bridges, gravel extraction) can have a significant affect on the stability and habitat of a stream and at worse may cause undesirable erosion and flood hazard issues.

Where excessive erosion, mass bank failures, rejuvenating tributaries, channel widening, and/or planform adjustments are occurring, sediment deposits are often formed as a river works to transport and redistribute these excessive sediment additions. Appendix A Figure 3 is a map depicting the number of sediment deposition features found in each reach of the study area. In the Mill River, higher rates of depositional features (e.g. gravel bars) are found in reaches with wide floodplains and some degree of unconstrained (i.e. not straightened, armored, and bermed) channel movement. Reaches locked into bedrock gorges or which have been artificially straightened tend to pass sediment through the channel rather than store it.

5.1.3 Modification of Channel Depth and Slope of the Mill River

Historic alterations of stream channels in post-flood cleanup efforts and for land use purposes have had great impacts on most Vermont Rivers. The Mill River is no exception. Impacts from channel straightening effect 15 reaches, six of which are over 75% straightened (Appendix A

Figure 4). Channel straightening increases the slope and therefore the power of a stream – this increase in stream power is typically followed by channel incision and eventually widening. Encroaching development onto the floodplain of the Mill River as well as berming to protect this development is also problematic. Berming and floodplain fill (for roads, railroads, and development) effectively raises the bank height, which increases channel depth, and thereby increases the erosive power of the stream. Increased erosive power creates a detriment locally as well as increases the potential for catastrophic fluvial erosion downstream (see Appendix E). Floodplain encroachment is a common phenomenon along the Mill River as depicted in Appendix A Figure 5.

5.1.4 Modification of Streambank and Riparian Conditions along the Mill River

The material (cohesiveness) of the banks as well as the naturally occurring vegetation that binds soils has a tempering affect to resist the erosive energy of a stream. Changes in the condition of a streambank from such activities as riparian vegetation removal and rock armoring may increase stream power resulting in channel adjustments such as widening and planform adjustment. Riparian forests that have been reduced to less than 25 feet in width are depicted in Appendix A Figure 6.

5.1.5 Constraints to Sediment Transport and Attenuation

The analysis of sediment transport regimes is based on methodology outlined in the VTANR River Corridor Planning Guide (2007a) which assists in the identification of the reference and altered sediment regimes of reaches based on the Phase 2 Assessment data. The sediment regime types used in this analysis are summarized in Table 3. Figures 15 and 16 have been provided to assist in understanding where sediment transport areas have been increased and attenuation areas have been lost in the Mill River Watershed. Table 4 has also been provided to summarize all of the stream and watershed stressors and to assist in understanding why these changes in sediment transport capacity have occurred.

Figure 15 indicates that nearly the entire main stem of the Mill River had (in its pre-settlement state) the capacity to store fine sediments in the floodplain and to transport the normal balance of gravels, cobbles, and the occasional boulder downstream at a rate that was in balance with the inputs coming from the highest sources in the watershed thus leading to long-term channel and habitat stability. Analysis of Figure 16, the current sediment regime map, indicates that *nearly all reaches in the Mill River watershed are now* ***sources*** *of both fine and coarse materials and that storage of fine materials in the floodplain* ***has been significantly reduced***. In areas where deposition of coarse materials is occurring in the upper watershed this deposition may be occurring at a high rate (leading to numerous mid-channel bars and channel migration and subsequently a local response of dredging this accumulating material) such as was observed in reaches M11-B and M06. The cumulative effect of this sediment storage loss has been an overloading of sediment in the receiving body, the Otter Creek. As indicated in a Phase 2 assessment of the Otter Creek, "Excessive sediment contributions and an apparent reduction in sediment transport capacity are noted in the vicinity of the Mill River confluence with the Otter Creek." It is a concern that this sediment may "tip the balance" of stable conditions in the Otter Creek if left unchecked (Underwood 2006).

The excessive degree of departure in the upper watershed presents two situations downstream. First, the downstream reaches may be moving towards excessive aggradation of material (such as in reach M05-A) and therefore may be expected to have a high degree of lateral channel adjustment and bar building. Second, the storage capacity of these downstream reaches is a key asset to the watershed and the receiving watershed, the Otter Creek (and eventually Lake Champlain). Analysis of these maps reveals that restoration of attenuation capacity in the upper reaches of the watershed, especially above the village locations of East Wallingford and Cuttingsville, may be helpful in restoring some of the overall equilibrium of the Mill River Watershed and reducing pressure on those areas where significant human investment has been concentrated (such as the village settings).

TABLE 3: Sediment Regime Definitions

Transport	Steep bedrock and boulder cascade type streams; confining valley walls, comprised of bedrock, till, and large glacial erratics, do not supply appreciable quantities of sediments to downstream reaches on an annual basis; little or no mass wasting; storage of fine sediment is negligible due to high transport capacity derived from both the high gradient and/or entrenchment of the channel.
Confined Source and Transport	Cobble step pool and steep plane bed type streams; confining valley walls, comprised of erodible tills, glacial lacustrine, glacial fluvial, or alluvial materials; mass wasting and landslides common and may be triggered by valley rejuvenation processes; storage of coarse or fine sediment is limited due to high transport capacity derived from both the gradient and entrenchment of the channel. Look for streams in narrow valleys where dams, culverts, encroachment (roads, houses, etc.), and subsequent channel management may trigger incision, rejuvenation, and mass wasting processes.
Unconfined Source and Transport	Sand, gravel, or cobble plane bed type streams; at least one side of the channel is unconfined by valley walls; may represent a stream type departure due to entrenchment or incision and associated bed form changes; these streams are not a supply of sediments due to boundary resistance such as bank armoring, but may begin to experience erosion and supply both coarse and fine sediment when bank failure leads to channel widening; storage of coarse or fine sediment is negligible due to high transport capacity derived from the deep incision and little or no floodplain access for the channel. Look for straightened, incised or entrenched streams in unconfined valleys which may have been bermed and extensively armored and are in Stage II or early Stage III of channel evolution.
Fine Source and Transport **Coarse Deposition**	Sand, gravel, or cobble streams with variable bed forms; at least one side of the channel is unconfined by valley walls; may represent a stream type departure due to vertical profile and associated bed form changes; these streams supply both coarse and fine sediments due to little or no boundary resistance; storage of fine sediment is lost or severely limited as a result of deep channel incision and little or no floodplain access; an increase in coarse sediment storage occurs due to a high coarse sediment load coupled with the lower transport capacity that results from a lower gradient and/or channel depth. Look for historically straightened, incised or entrenched streams in unconfined valleys, having little or no boundary resistance, increased bank erosion, and large unvegetated bars. These streams are late Stage III and Stage IV of channel evolution.
Coarse Equilibrium (in = out) **Fine Deposition**	Sand, gravel, or cobble streams with equilibrium bed forms; at least one side of the channel is unconfined by valley walls; these streams transport and deposit coarse sediment in equilibrium (stream power—produce as a result of channel gradient and hydraulic radius—is balanced by the sediment load, sediment size, and channel boundary resistance); storage of fine sediment as a result of floodplain access for high frequency (annual) floods. Look for unconfined streams which are not incised or entrenched, have boundary resistance (woody buffers), minimal bank erosion, and vegetated bars. These streams are Stage I, late Stage IV, and Stage V of channel evolution.

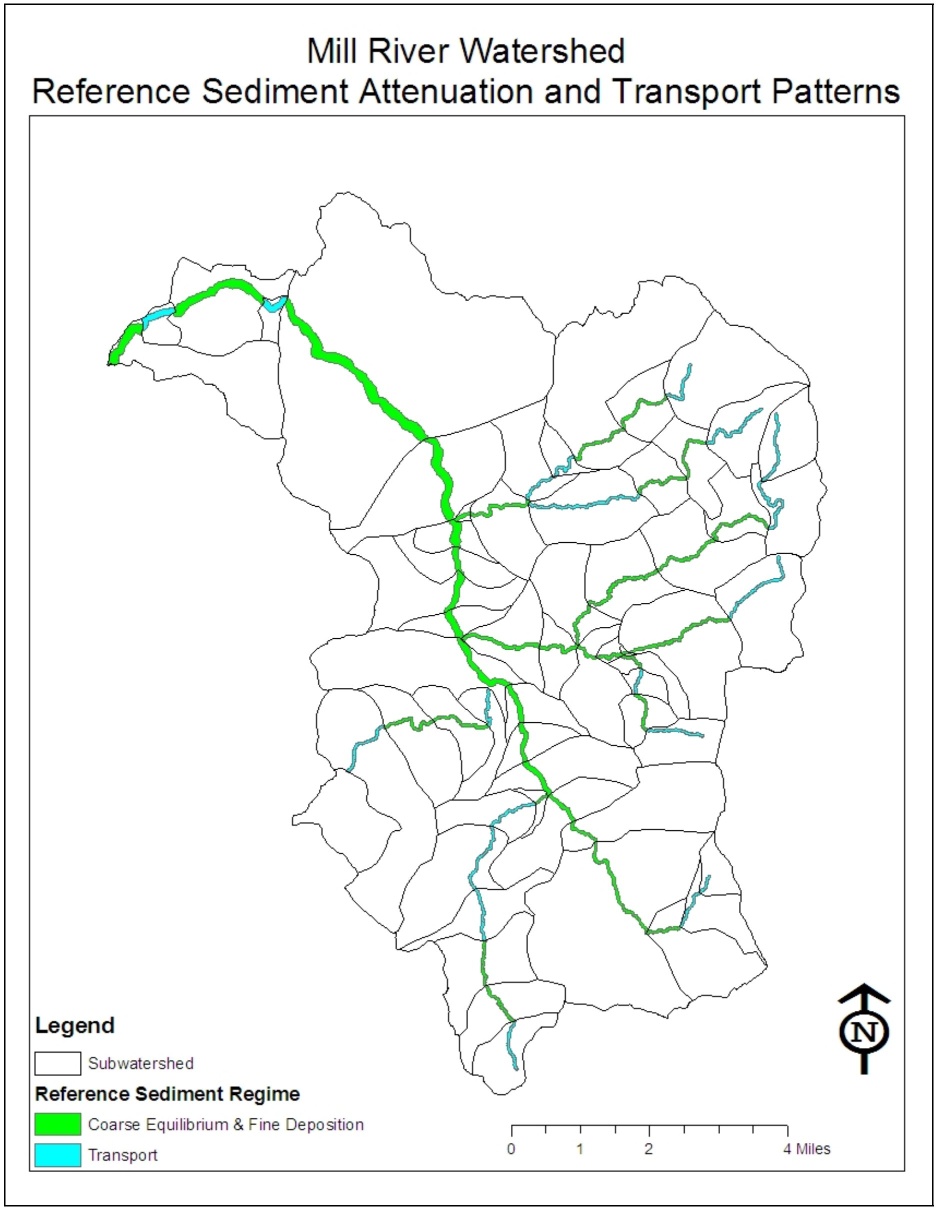


Figure 15. Sediment Transport and Attenuation under reference conditions.

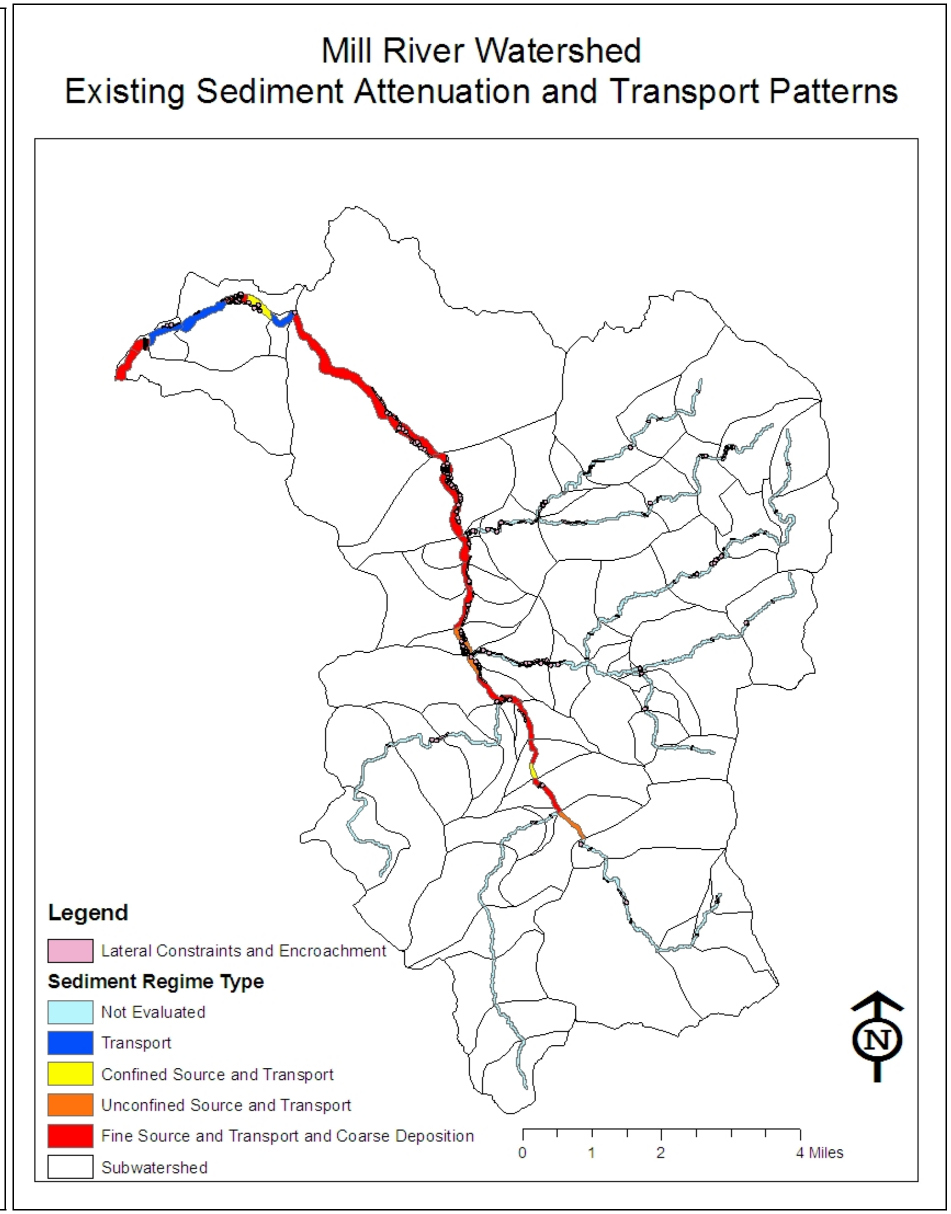


Figure 16. Sediment Transport and Attenuation, existing Mill River conditions.

Table 4: Watershed, Floodplain, and Channel Stressors													
	Watershed Stressors			Floodplain and Channel Stressors									
Segment Number	Deforestation in the 1800's	Increased Road Networks (1800-1900's)	Historic Flood Events	Channelization/Straightening	Dredging	Berming	Bank Armoring	Floodplain Development	Loss of Forested Buffers	Impoundment (Historic)	Gravel Extraction	Undersized Bridge/Culvert	Stormwater Inputs
M15	↓	↓	↓	√		√			√				√
M14	↓	↓	↓	√			√		√			√	√
M13-B	↓	↓	↓										√
M13-A	↓	↓	↓										
M12	↓	↓	↓										√
M11-B	↓	↓	↓	√	√		√		√		√		√
M11-A	↓	↓	↓	√	√	√	√	√	√			√	√
M10	↓	↓	↓	√	√	√	√	√	√			√	√
M09	↓	↓	↓	√	√	√	√	√					
M08	↓	↓	↓	√			√	√					√
M07	↓	↓	↓	√	√	√		√	√				
M06	↓	↓	↓	√	√	√	√	√	√	√			√
M05-B	↓	↓	↓	√	√	√	√	√	√				√
M05-A	↓	↓	↓	√	√		√						√
M04	↓	↓	↓										
M03-C	↓	↓	↓						√				
M03-B	↓	↓	↓						√	√			√
M03-A	↓	↓	↓										
M02	↓	↓	↓										
M01-B	↓	↓	↓	√	√	√	√	√	√		√		
M01-A	↓	↓	↓	√	√				√				
T2.01-B	↓	↓	↓				√	√				√	
T2.01-A	↓	↓	↓	√	√	√	√	√	√			√	

5.2 Understanding Channel Response to Disturbance

The information presented in section 5.1 indicates that a large number of watershed and channel stressors are potentially affecting the Mill River. Because the stability of a stream channel is based on maintaining a certain flow of water and sediment and shape and slope of the channel, when any of these change significantly, the river channel must change, typically resulting in erosion of the stream bed or banks, or a filling of the channel with sediment.

As a result of channel straightening, berming, gravel mining, stormwater runoff, and similar watershed and reach alterations, we may conclude that stream power has increased within the Mill River channel. One of the most common channel responses to an increase in stream power is degradation. Once a stream begins to incise, it will typically erode its way through a predictable evolution process until it has created a new floodplain at a lower elevation in the landscape. The common stages of channel evolution (as shown below in Figure 17 and reported in more detail in Appendix D), include:

- A pre-disturbance period (I)
- Incision – Channel degradation (cutting of stream into the channel bed) (II)
- Aggradation (sediment build up in the bed) and channel widening (III-IV)
- The gradual formation of a stable channel with access to its floodplain at a lower elevation. (V)

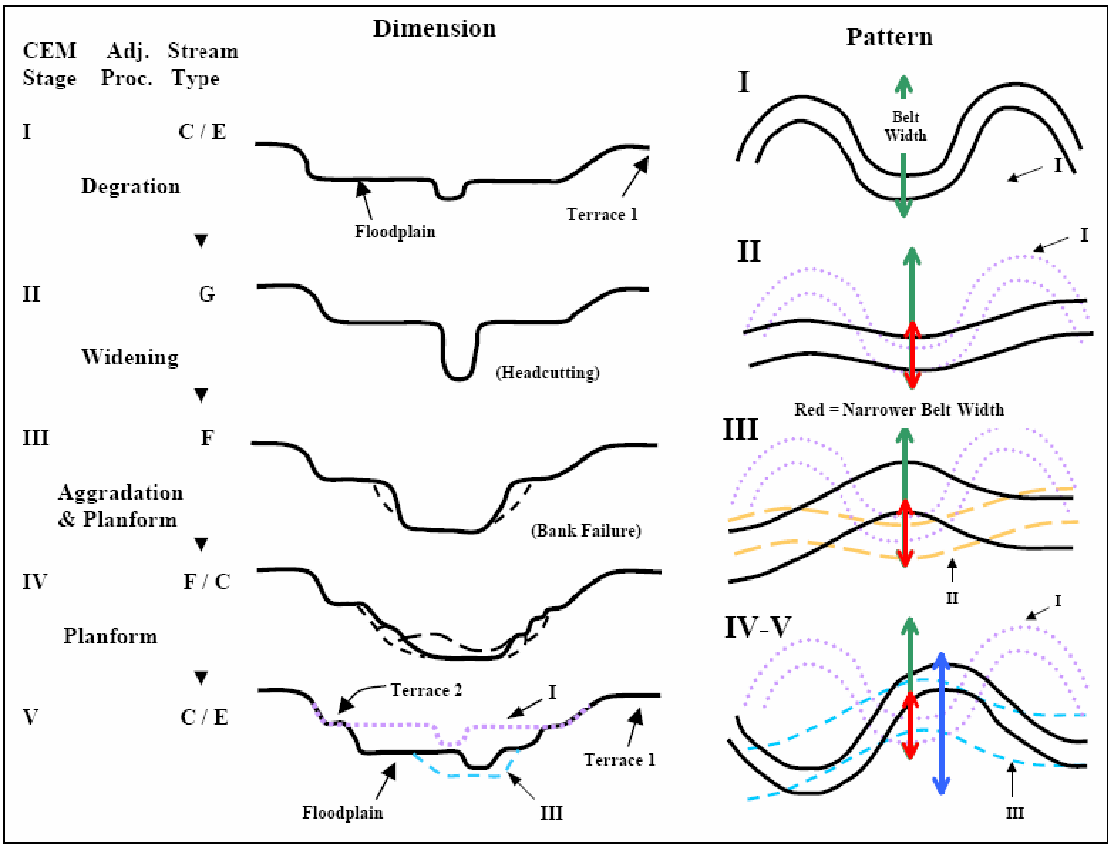


Figure 17. F-stage Channel Evolution Process (from Vermont Agency of Natural Resources, 2006)

The bed erosion that occurs when a meandering river is straightened in its valley is a problem that often extends to other sections of the stream. Incision points will travel upstream and into tributaries eroding sediments from otherwise stable streambeds. These bed sediments will move into and clog reaches downstream leading to planform adjustments, widening, and erosion of the streambanks. Channel evolution processes may take decades to play out and may not only affect areas immediately adjacent to evolving channels. Even landowners that have maintained forests along their stream and riverbanks may experience eroding banks, sedimentation, and migrating channels, as the river responds to alterations up or downstream (such as the case with reaches M13-A, M12, and M05-A). Furthermore, consistent changes in the location of a river channel are expected as rivers have always and will always continue to migrate laterally across valleys; this migration is often unperceivable to the human eye, however, is sometimes catastrophically rapid (see Figure 18).

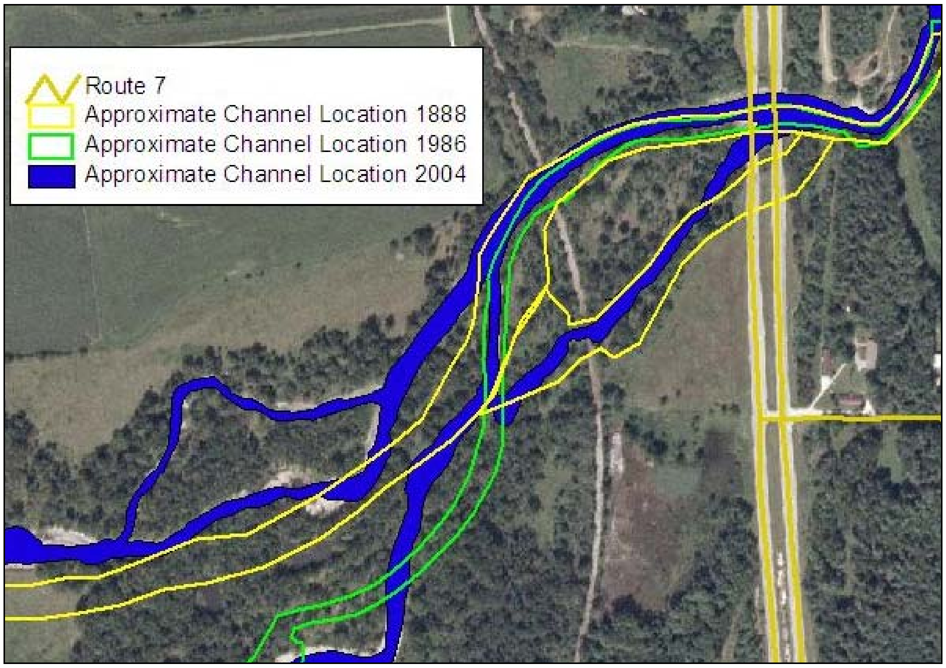


Figure 18: Meander patterns in the lower Mill River in Clarendon.

After a channel incision process it may be difficult for streams to attain equilibrium where the placement of roads and other infrastructure has resulted in little or no valley space for the stream to access or to create a floodplain as is the case with many of the Mill River's reaches (e.g. M09, M11-A). Making matters worse, landowners and government agencies have repeatedly armored and bermed many of Vermont's rivers to contain floodwaters in channels. These efforts have proven to be temporary fixes at best, and in some cases have lead to disastrous property losses and natural resource degradation.

Field research conducted during the Phase 2 assessment indicated that several of the reaches are actively, or have historically, undergone a process of minor or major geomorphic adjustment. In many reaches the channel has undergone historic degradation as evidenced by abandoned terraces, juvenile floodplain benches, and rejuvenating tributaries. Many of the cross sections on study reaches were found to be incised. The incision ratio ranged from 1.5 to 3.1. Along many of the main stem reaches and near the mouths of the tributaries, the system is currently actively adjusting to this lower bed elevation by moving laterally (planform) and widening in order to create a new floodplain at a lower elevation (phase II, III, and IV of the channel evolution model depicted in Figure 17). This widening and planform adjustment is leading to another adjustment process, aggradation. Aggradation in the Mill River study area is likely a combination of endogenous sediment that is created as the stream widens and erodes its banks in response to channel adjustments as well as from exogenous sources such as gravel roads and land clearing. Table 5 below summarizes the channel evolution of each study reach and the primary adjustment processes that are believed to be occurring.

Table 5. Stream Type, Active Adjustment Processes*, and Channel Evolution Stage

Segment Number	Incision Ratio	Entrench-ment Ratio	Width to Depth Ratio	Reference Stream Type	Existing Stream Type	Channel Evolution Stage	Active Adjustment Process
M15	2.08	2.18	17.09	C4	B3c	III	None
M14	3.16	2.0	20.51	C3b	B3	III	**Widening**
M13-B	1.97	1.75	27.83	B3	B3	III	None
M13-A	1.85	5.83	28.17	C4	C4	IV	**Planform**
M12	1.89	4.88	30.48	C4	C4	IV	**Widening Planform**
M11-B	2.33	1.54	29.74	C4	B3c	III	**Aggradation Widening Planform**
M11-A	3.19	1.37	36.00	C4	F3c	II	**Widening**
M10	1.80	2.14	22.11	C4	B3c	III	None
M09	1.84	1.28	39.55	C4	B3c	III	**Widening**
M08	1.90	3.47	25.35	C3	C3	III	None
M07	1.65	1.29	45.79	C4	F4	III	**Widening**
M06	1.84	6.10	32.06	C4	C3	III	**Widening Planform**
M05-B	1.74	1.79	35.33	C4	B3	III	**Widening**
M05-A	1.57	4.76	26.84	C4	C4	IV	**Planform**
M04	Not Assessed: Bedrock Controlled Gorge						
M03-C	1.61	1.74	33.74	B4	B4	III	**Widening**
M03-B	Not Assessed: Bedrock Controlled Gorge						
M03-A	1.55	5.24	38.89	C3	C3	IV	**Widening**
M02	Not Assessed: Bedrock Controlled Gorge						
M01-B	1.83	5.00	36.02	C4	C3	III	**Widening Planform**
M01-A	1.95	10.8	54.44	C4	C4	IV	**Aggradation Widening Planform**
T2.01-B	1.93	1.93	26.98	C4	B4c	IV	**Planform**
T2.01-A	2.29	1.3	25.6	C4	F3c	II	**Widening**

Bold Red lettering - denotes extreme adjustment process
Bold Black lettering – denotes major adjustment process
*NOTE: All reaches except M01-A, M03-A, M03-C, and M13-B had major or extreme historic degradation

5.3 Stream Sensitivity

As Section 5.1 described, there are numerous watershed and reach-level stressors that have affected the Mill River. In response, the Mill River has undergone and continues to undergo reasonably predictable channel adjustments as described in section 5.2. As we move towards managing restoration and future development in the Mill River watershed it is important to understand that certain areas of the river may be more or less sensitive to management and development activities in the channel and floodplain. "Stream sensitivity" refers to the likelihood that a stream will morphologically respond to a watershed level or reach level stress, such as; floodplain encroachment, channel straightening, berming, armoring, changes in sediment or flow inputs, disturbance of riparian vegetation, and even in-channel restoration efforts meant to stabilize the channel. A stream's inherent sensitivity is based on a host of factors including the relative magnitude of channel adjustments occurring together with the topographic, geologic, and vegetative context that surrounds the reach. The existing sensitivity of a given reach may be increased when human activities alter the characteristics that influence a stream's natural adjustment rate including changes to the: boundary conditions; sediment and flow regimes; and the degree of confinement within the valley. Streams that are currently in adjustment, especially those undergoing degradation or aggradation, may become acutely sensitive to stress (Vermont Agency of Natural Resources 2007a).

In Vermont, it can be generalized that steeper mountain streams with large bottom substrates (boulders and cobbles) are less sensitive to rapid channel adjustment than those gravel and sand dominated stream channels that have low slopes (<3%) and therefore less ability to transport sediments received from upstream. These more sensitive channels often have highly-erodible soils and are more sensitive to increases and decreases in stream power that may occur from channel and floodplain alterations and/or changes in sediment supply (increase or decrease) (Underwood 2006).

The stream sensitivity of the Mill River, categorized by segment according to ANR protocols, is depicted in Table 6 and in Figure 19. Predominately, the Phase 2 Geomorphic Assessment purposefully studied reaches that would be expected to exhibit a higher sensitivity and be undergoing active adjustments. It is not surprising therefore that all of the study area reaches were defined as having high, very high, or extreme sensitivity. The exception being the bedrock controlled reaches M04, M03-B, and M02 which have a greater resistance to rapid adjustment due to the bedrock bed and banks (and therefore a low sensitivity).

Incorporating stream sensitivity data into management and restoration activities is critical. In general, highly sensitive stream types should be approached with great caution before engaging in direct in-channel restoration activities. Often these highly sensitive reaches may be better protected by reducing upstream, in-channel, and corridor stressors. Less sensitive channels may be better candidates for in-stream channel restoration activities and floodplain restoration projects as these channels tend to have a high tolerance for change.

Table 6. Stream Sensitivity for Phase 2 Reaches					
Segment Number	**Reference Stream Type**	**Existing Stream Type**	**Stream Type Departure**	**Geomorphic Condition**	**Sensitivity**
M15	C4	B3c	C to B	Fair	High
M14	C3b	B3	C to B	Fair	High
M13-B	B3	B3	None	Good	High
M13-A	C4	C4	None	Fair	**Very High**
M12	C4	C4	None	Fair	**Very High**
M11-B	C4	B3c	C to B	Fair	High
M11-A	C4	F3c	C to F	Fair	**Extreme**
M10	C4	B3c	C to B	Fair	High
M09	C4	B3c	C to B	Fair	High
M08	C3	C3	None	Fair	High
M07	C4	F4	C to F	Fair	**Extreme**
M06	C4	C3	None	Fair	High
M05-B	C4	B3	C to B	Fair	High
M05-A	C4	C4	None	Fair	**Very High**
M04*	B1	B1	None	Good	Very Low*
M03-C	B4	B4	None	Fair	High
M03-B*	B1	B1	None	Good	Very Low*
M03-A	C3	C3	None	Fair	High
M02*	B1	B1	None	Good	Very Low*
M01-B	C4	C3	None	Fair	**Very High**
M01-A	C4	C4	None	Fair	**Very High**
T2.01-B	C4	B4c	C to B	Fair	**Very High**
T2.01-A	C4	F3c	C to F	Fair	**Extreme**
*Partial Assessment – Administrative judgment made regarding geomorphic condition and sensitivity					

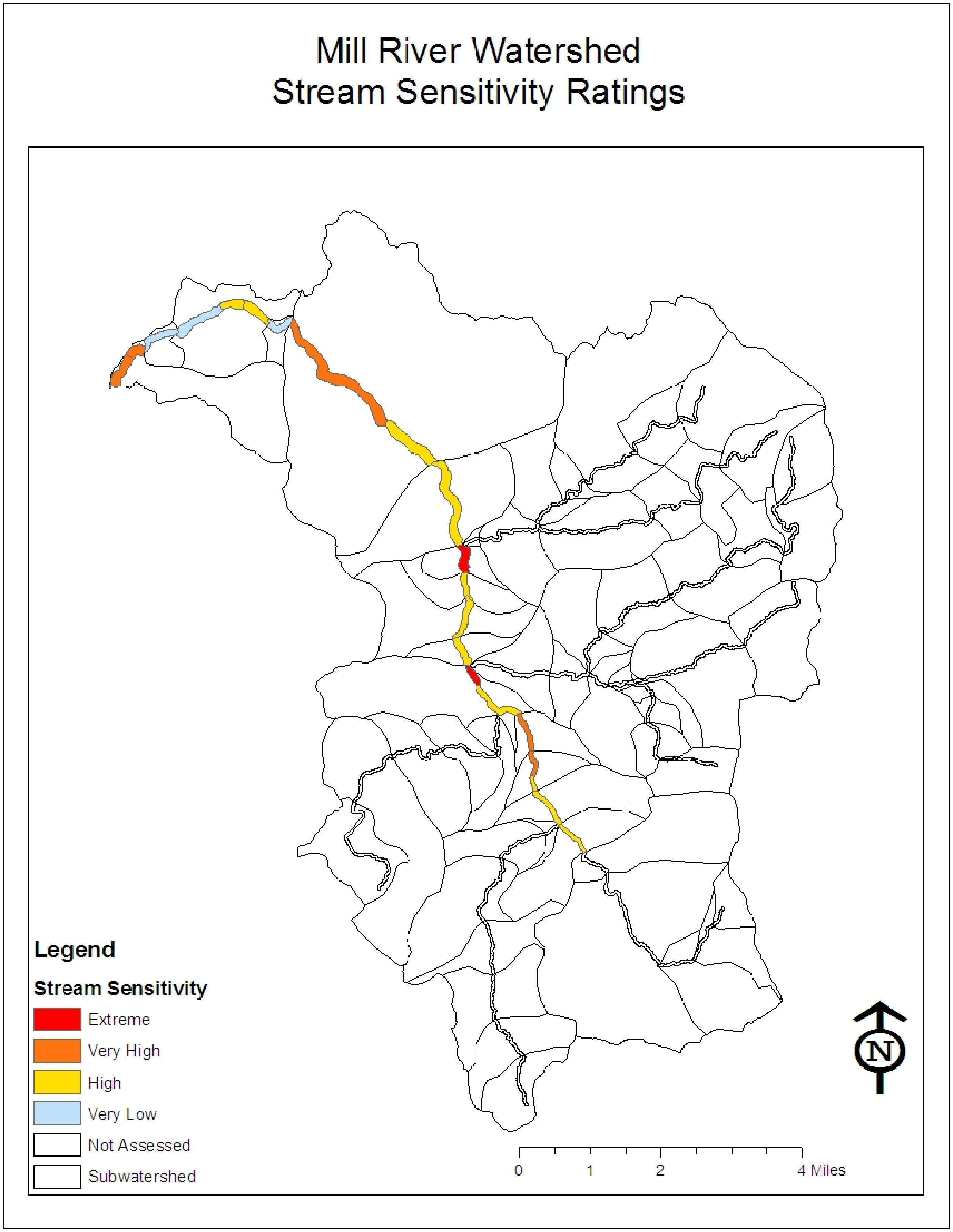


Figure 19: Mill River Stream Sensitivity Map

6.0 PROJECT IDENTIFICATION

As outlined in the preceding sections, riparian landowners, community members, town planners, and agency personnel from State and Federal resource groups would all benefit from having a holistic perspective of watershed processes and the stressors that lead to instability in these systems. Concurrently, knowledge and awareness of factors hat lend to stream stability is also desired. The objective of this management plan is to consider these complex interactions with an eye toward implementing various restoration, conservation, and planning activities for the long term benefit of the community.

Recommended corridor restoration and protection initiatives have been identified based on the synthesis of: the project and program goals (Section 2.0); wealth of current and historic watershed information (Section 3.0); field based observations (Section 4.0 and summarized for each reach in Appendix B); and on the remotely-sensed observations of channel and floodplain stressors (Section 5.1). This data was processed to determine stream types, adjustment processes, and channel evolution stages (Section 5.2). From this information, the sensitivity of each reach and segment was derived (Section 5.3). And here finally a step-wise procedure for identifying projects which would be consistent with the goal of managing a stream toward equilibrium condition (VTANR 2007a) was enacted.

It should be noted that, while the focus of this report has been on developing management decisions based on geomorphic information, social and fiscal opportunities must be taken into account as should be landowner interests. Adding this information to the equation may present possibilities for collaborative and synergistic projects not envisioned within this document. Recommended initiatives have been prioritized according to urgency. Many of the recommendations (e.g., buffer plantings) can be considered for immediate implementation, independent of other watershed projects.

6.1 Watershed Level Opportunities

Often many reach level problems may be best addressed through watershed-level, community-initiated strategies that seek to address the 'source' of a problem and consider that in watersheds, top-down problem-solving is often the only long-term solution. These large-scale watershed efforts may be initiated through local governments and/or community organizations, such as the Upper Otter Creek Watershed Council. They may also be embraced and driven by local residents that are inspired through demonstration projects or other outreach efforts.

<u>Watershed scale strategies that would benefit the Mill River include:</u>

- The establishment and protection of riparian buffers along the entire river corridor.
- On-site stormwater management retrofitting for all existing residential and commercial building sites and implementation of low-impact design (LID) techniques for all future development.
- Sound municipal dirt road management and ditch remediation for minimizing stormwater and sediment contamination of the Mill River.
- Replacing and/or retrofitting undersized bridges and culverts and ensuring all new structures are sized for geomorphic stability.
- Practicing soil conservation and erosion control practices (AMP's and BMP's) on all agricultural land, logging operations, construction and other sites where soil is disturbed.

- Floodplain and river corridor planning and protection (such as adoption of Fluvial Erosion Hazard zones, stream setbacks, wetland regulations, etc.) to reduce further floodplain encroachment.
- Wetland restoration projects that reduce stormwater volumes and increase groundwater and subsurface recharge rates.

6.2 Reach Level Projects

Reach level projects are based on conditions specific to the given reach, though they are also considered in the context of upstream and downstream impacts. These projects are especially appropriate where the disturbance extends along the entire reach and/or where land ownership is dominated by a few key stakeholders that are able to easily enact large-scale land management decisions. This River Corridor Management Plan includes detailed descriptions of individual reaches (Appendix B) as well as the identification of reach-specific projects (Table 7).

6.3 Site Specific Project Priorities

Site specific projects were distinguished from reach level opportunities utilizing guidance from the VTANR River Corridor Planning Guide (2007a). Compiling information from a step-wise analysis of each reach along with field observations collected during the Phase 2 Assessment, Round River Design, Bear Creek Environmental, and representatives from the RNRCD and VTANR identified 13 site specific priority projects (Table 8). These projects have been briefly evaluated for technical, social, and financial feasibility. Further analysis of these sites was conducted by Bear Creek Environmental and may be available through the local office of the VTANR River Management Program.

The selected projects include: river corridor protection projects in strategic locations; berm removal projects; and feasibility studies for the removal of undersized structures. It is important to note that these projects affect private landowners. The RNRCD and the VTANR are looking for landowners to partner with in order to implement these important projects.

7.0 NEXT STEPS AND IMPLEMENTATION

7.1 Single and Multiple Landowner Project Implementation

In October of 2008, Bear Creek Environmental, the Rutland Natural Resource Conservation District and other project partners began to meet with Mill River landowners to discuss the results of this plan. While historic stream protection efforts have focused on addressing individual landowner concerns, it is the hope of the watershed planning team that this document will help landowners see their land in a watershed context. Certain restoration and protection measures may be highly influenced by upstream challenges as well as may be highly important in reducing problems transferred to downstream landowners. The key to developing a mutually beneficial relationship with the Mill River is implementing future restoration and protection efforts with a watershed system in mind. The goal is that the Mill River will be managed to achieve a dynamic, geomorphically-stable stream channel in the future that is able to attenuate and transport its sediments in balance; access floodplains adequately without causing significant damage to property or life; and maintain a healthy ecology and acceptable water quality for future generations to enjoy.

7.2 Watershed Resident Participation

Despite the efforts that may be made towards site specific river restoration projects, the long-term health and vitality of the Mill River is also intimately linked to the residents of the Watershed and whether they choose to collectively engage in land use practices that care for the river. Strategies that provide incentives for landowners and residents to engage in land stewardship may be effective since in the Mill River every resident has a neighbor downstream that may be affected by their actions. Community-based watershed associations have a long history of successfully implementing grassroots initiatives that bolster local watershed stewardship. Such an organization may prove highly beneficial to the long-term management of the Mill River. Additionally, town projects that ensure public access to the river may be important in developing connections between the river and the community. At the same time, educational efforts that create connections with the community youth and the watershed have also been found to be valuable in developing a long-term watershed stewardship ethic and sense of place.

7.3 Town and State Implementation

Implementation of the Mill River Corridor Management Plan will greatly rely on the inherent ability of Towns and the State to garner expertise and funding. It will be important for Towns and the State to develop strong collaborative relationships with streamside landowners.
<u>At the town level, priority opportunities include:</u>

- Management of town roads, culverts, crossings, and ditches in ways that protect water quality, prevent excess sediment from entering the Mill River, and allow the river and streams that feed it to pass under roads without creating instability in the streams.
- Adoption of town land use policies that prevent wetland loss, floodplain encroachment, and the further restriction of the Mill River (see Appendix E).

<u>At the state level, priority opportunities include:</u>

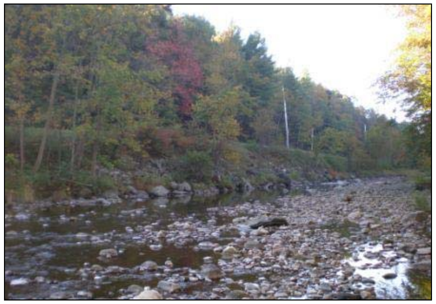
- Provision of scientifically informed data and management recommendations.
- Support of landowner initiatives through program recommendation and/or permitting that encourages beneficial restoration and protection efforts to move forward.

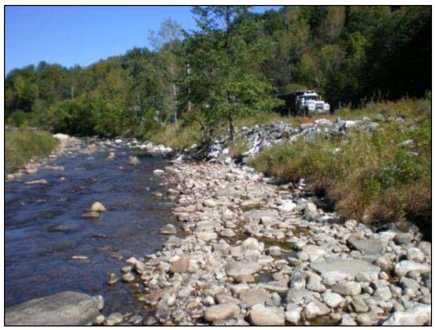
TABLE 7: Reach Level Projects

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVER-SION	PARTNERS
M15 	Protect River Corridor	Upstream of Constrained/ Altered Reach	Reach M15 lies upstream of the constrained and channelized reach M14 as well as those near East Wallingford Village	No major structures along river	Unk.	Open land and forest remains structure free	Town, RRPC, VTANR
	Restore Riparian Buffer	Long term stability	Buffer removal on the left bank has made this reach vulnerable in the long-term.	No major structures along river. River may remain stable for years to come and allow trees to grow.	Low	Agriculture and Residential Land to Forest	UOCWC, RNRCD, FWS
	Restore Incised Reach	Reduce flooding downstream, store sediment in the floodplain	Possible site for restoring floodplain access to improve flood and sediment load attenuation and take pressure off of downstream reaches.	Depends on method of restoration. No major structures along stream.	High	Agricultural land to floodplain	VTANR
M14 	Protect River Corridor	Upstream of Constrained/ Altered Reach	Reach M14 lies upstream of the constrained and altered reaches near East Wallingford Village	Only one house along river. Out of floodway and FEH zone.	Unk.	Open space with one residence is not developed further	Town, RRPC, VTANR
	Restore Riparian Buffer	Long term stability	Buffer removal on the left bank has made this reach vulnerable in the long-term.	No major structures along river. River may remain stable for years to come and allow trees to grow.	Low	Open Land to Forest	UOCWC, RNRCD, FWS
	Restore Incised Reach	Reduce flooding downstream, store sediment in the floodplain	Possible site for restoring floodplain access to improve flood and sediment load attenuation and take pressure off of downstream reaches.	Depends on method of restoration. No major structures along stream.	High	Open land to floodplain	VTANR

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVER-SION	PARTNERS
M13-A 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance)	This fairly undeveloped reach is already attenuating floodwaters and sediment. Long term river corridor protection would reduce future conflict and ensure these functions are served for future generations.	No structures near the river.	Unk.	None, remains forest	Town, RRPC, VTANR
M12 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance)	This fairly undeveloped reach has capacity for attenuating floodwaters and sediment. Long term river corridor protection would reduce future conflict and ensure these functions are served for future generations.	No structures near the river.	Unk.	None, remains forest	Town, RRPC, VTANR
M11-B 	Protect River Corridor	Upstream of Constrained/ Altered Reach	Reach M11-B lies upstream of the constrained and altered reaches of those near East Wallingford Village	Agricultural land, but no significant structures along river corridor.	Unk.	None, remains agricultural land.	Town, RRPC, VTANR, NRCS

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVER-SION	PARTNERS
M11-B (cont.)	Restore Riparian Buffer	Long term stability	Buffer removal on the right bank has made this reach vulnerable in the long-term.	No major structures along river. Channel is incised and will likely widen over time.	Low	Agricultural Land to Forest	UOCWC, RNRCD, FWS
	Restore Incised Reach	Reduce flooding downstream, store sediment in the floodplain	Possible site for restoring floodplain access to improve flood and sediment load attenuation and take pressure off of E. Wallingford Village reach.	Depends on method of restoration. No major structures along stream.	High	Open land to floodplain	VTANR
M11-A 	Protect River Corridor	Inform Residents of FEH Hazards and Reduce FEH Hazards	This is an already highly settled area and residents should be made aware of Fluvial Erosion Hazards. The reach is highly sensitive and has a major departure from equilibrium conditions.	Numerous existing structures	Unk.	Remains residential	Town, RRPC, VTANR
	Restore Incised Reach	Reduce flood hazard in East Wallingford Village	Possible site for restoring floodplain access to improve flood and sediment load attenuation and take pressure off of downstream reaches.	May only be possible in small zone on left bank.	High	Forest to floodplain.	VTANR
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Buffer has been removed along a good portion of right bank due to armoring along the road.	Very little room for reforestation	Low	Barren to forest	VTANR, RNRCD
M10 	Protect River Corridor	Reduce FEH Hazards	This is a highly sensitive reach with a major departure from equilibrium conditions near a residential area.	Numerous existing structures	Unk.	Remains residential	Town, RRPC, VTANR
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Buffer has been removed along a good portion of right bank due to armoring along the road.	Very little room for reforestation	Low	Barren to forest	VTANR, RNRCD

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVER-SION	PARTNERS
M09 	Protect River Corridor	Upstream of Constrained/ Altered Reach	Reach M09 lies upstream of the constrained and altered reaches of Cuttingsville Village	Some existing structures.	Unk.	Prevention of further development in the corridor.	Town, RRPC, VTANR
	Berm Removal Site	Improve floodplain access by removing bermed material.	Large berm on the lower end of the reach (right bank) may be removed or relocated.	Road along right corridor needs to be protected.	Med.	Remains forested land.	VTANR
M07 	Protect River Corridor	Upstream of Constrained/ Altered Reach with existing FEH Hazards.	Reach M07 lies upstream of the constrained and altered reaches of Cuttingsville Village. This is a highly sensitive reach with a major departure from equilibrium conditions near a residential area.	A few structures near corridor.	Unk.	Potential restriction on landuse depending on agreement.	Town, RRPC, VTANR
	Berm Removal Site	Removing berms would open a large section of floodplain back up.	Possible berm removal project, land conservation to public land.	A few structures near corridor need to be protected.	Mod.	Opening up the floodplain.	VTANR

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVER-SION	PARTNERS
M06 	Protect River Corridor	Upstream of Constrained/ Altered Reach with existing FEH Hazards.	Reach M06 lies upstream of the constrained and altered reaches of Cuttingsville Village	Adoption of an FEH Zone will need to go through town planning.	Low	Potential restriction on land-use depending on easement language.	Town, RRPC, VTANR
	Berm Removal Site	Flood and sediment attenuation asset	Remove and/or relocate berm to allow some floodplain access and restore flow to a flood chute.	Cost of berm relocation and reforestation.	Med.	No additional structures in corridor	Landowners, RNRCD, ANR
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Buffer has been removed along a good portion of right bank due to armoring along the road.	Very little room for reforestation	Low	Barren to forest	VTANR, RNRCD
M05-B 	Protect River Corridor	Inform Residents of FEH Hazards	This is an already highly settled area and residents should be made aware of Fluvial Erosion Hazards.	Adoption of an FEH Zone will need to go through town planning.	Low	Potential restriction on land-use depending on easement language.	Town, RRPC, VTANR
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Buffer has been removed along a good portion reach.	Low	Bare to forest	VTANR, RNRCD	Improve shade, stability of river, habitat

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVER-SION	PARTNERS
M05-A 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance)	This fairly undeveloped reach is already attenuating floodwaters and sediment. Long term river corridor protection would reduce future conflict and ensure these functions are served for future generations.	Railroad has R.O.W. in corridor. Otherwise no obvious restrictions.	Unk.	Remain forested undeveloped area.	Town, RRPC, VTANR
M01-B 	Protect River Corridor	Reduce FEH at Alluvial Fan	Due to the significant slope change, this area is especially susceptible to sediment aggradation and planform adjustment.	Adoption of an FEH Zone will need to go through town planning.	Unk.	Potential restriction on land-use depending on easement language.	Town, RRPC, VTANR
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Short corner of field is lacking adequate buffer.	None.	Low	Bare to forest	VTANR, RNRCD, CREP
	Berm Removal Site	Improve floodplain access by removing bermed material.	Large berm on right bank may be removed or relocated.	Berm looks to be protecting farmland. Removing berm may affect crops.	Med.	Remains forested and agricultural land.	VTANR

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVER-SION	PARTNERS
M01-A 	Protect River Corridor	Reduce FEH at Alluvial Fan	Due to the significant slope change, this area is especially susceptible to sediment aggradation and planform adjustment.	Landowner is interested in buffer protection.	Unk.	Remains forested and agricultural land.	VTANR, CREP, RNRCD
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Buffer in area to protect stream as well as crops.	None.	Low	Bare to forest	VTANR, RNRCD, CREP
T2.01-B 	Protect River Corridor	Upstream of Constrained/ Altered Reach with existing FEH Hazards	Reach T2.01-B lies upstream of the constrained and altered reaches of Cuttingsville Village. This is an already highly settled area and residents should be made aware of Fluvial Erosion Hazards.	Adoption of an FEH Zone will need to go through town planning.	Low	Potential restriction on land-use depending on easement language.	Town, RRPC, VTANR

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVER-SION	PARTNERS
T2.01-A 	Protect River Corridor	Reduce FEH Hazards	This is a highly sensitive reach with a major departure from equilibrium conditions.	Adoption of an FEH Zone will need to go through town planning.	Low	Potential restriction on land-use depending on easement language.	Town, RRPC, VTANR
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Buffer in area to protect stream as well as crops.	None.	Low	Bare to forest	VTANR, RNRCD, CREP

Table 8: Mill River High Priority Sites for Restoration and Protection - Updated 12/13/09 (BCE and RRD)

Reach	Condition and Channel Evolution Stage	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners
M01-A	Fair, Stage IV	Confluence with Otter Creek, active Agriculture on right bank and pasture in between channels.	Conserve and Protect River Corridor and existing buffer, manage braided channel.	High priority	Flood and sediment attenuation asset for Otter Creek and Lake Champlain	Cost of river corridor easements and possible Phase 3 assessment.	Potential to keep agricultural use with BMPs	Landowners, RNRCD, ANR, VRC, CREP, WHIP
M06	Fair, Stage III	Agricultural field	Protect River Corridor to provide attenuation area	High priority (important location in watershed)	Flood and sediment attenuation asset	Cost of river corridor easement acquisition, WHIP	Land use conversion may be minimal	ANR, VRC, RNRCD, WHIP
M11-B	Fair, STD C to B, Stage III	Few lateral constraints in reach; upstream of E. Wallingford Village and long stretch that has been significantly altered by floodplain encroachment Soils maps show alluvial soils so maybe historic deposition area. Some gravel mining currently occurring indicated current deposition.	Protect River Corridor, Examine restore incised reach. Restore riparian buffer.	High priority –above reach that is significantly altered by floodplain encroachment. Land use is currently agricultural.	Floodwater and sediment attenuation area upstream of reach with significant floodplain encroachment	Cost of river corridor easements; possible cost of geomorphic project; cost of trees and shrubs, CREP, WHIP	Loss of agricultural land.	Landowners, CREP, RNRCD, ANR, VRC
T2.01-A	Fair, STD C to F, Stage II	Located in the Village of East Wallingford and constrained by a road on one side, but only agricultural land on the other.	Enroll in CREP or WHIP, possible floodplain redevelopment.	High priority	Improved sediment and floodwater attenuation above the Village.	Would be a large cost to redevelop floodplain.	Agricultural land to forest.	Landowners, RNRCD, ANR, CREP, WHIP

Reach	Condition and Channel Evolution Stage	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners
M07	Fair, STD C to F, Stage III	Existing houses in River Corridor, one currently for sale.	Possible berm removal project, land conservation to public land.	High priority	Improve sediment transport and floodplain access upstream of Cuttingsville.	Cost of property acquisition and berm removal.	Private to public.	Landowners, ANR, RNRCD, FEMA, WHIP
M11-A	Fair, STD C to F, Stage II	Located in the Village of East Wallingford and constrained by buildings and roads and berm (keeping it in stage II)	Replace degraded bridge and pier that is causing sediment transport disruption and relocate berm on right bank	High priority (Bridge scheduled for replacement?)	Increase sediment transport through Village, reduce flood hazard in village, remove split flow in channel, create some floodplain in vital area upstream of bridge.	Large cost to replace bridge	Trees that have grown on berm would have to be removed.	Landowners, RNRCD, ANR, VTRANS
M14	Fair, STD C to B, Stage III	Located upstream of the Village of East Wallingford. Some limitation by the Valley wall and a road on the right side, agricultural land and limited development on the left bank.	Enroll in CREP or WHIP, possible floodplain redevelopment.	Med priority	Improved sediment and floodwater attenuation above the Village.	Would be a large cost to redevelop floodplain.	Agricultural land to forest.	Landowners, RNRCD, ANR, CREP, WHIP
M15	Fair, STD C to B, Stage III	Located upstream of the Village of East Wallingford. Forest on one right bank, agricultural land on the left bank.	Enroll in CREP or WHIP, possible floodplain redevelopment.	Med priority	Improved sediment and floodwater attenuation above the Village.	Would be a large cost to redevelop floodplain.	Agricultural land to forest.	Landowners, RNRCD, ANR, CREP, WHIP
M09	Fair, STD C to B, Stage III	Riparian banks influenced by agricultural practices; historically straightened	Relocate berm back from stream so that road is still protected but that stream has some floodplain access.	Low priority	Flood and sediment attenuation asset; habitat improvement	Cost of river corridor easement acquisition, engineering design and construction.	Young forest would have to be replanted. Possible conversion to public or conserved land.	CREP, ANR, VRC, RNRCD

Reach	Condition and Channel Evolution Stage	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners
M11-A	Fair, Stage II	Railroad bridge with road and river underneath causing channel constriction.	Alternatives Analysis for solving sediment transport and scour issues caused by constriction.	Low priority	Reduce sediment deposition and erosion caused by channel constriction.	Alternatives Analysis, sediment and hydraulic analysis, meetings with landowners	Dependent upon alternative selected	Landowners, RNRCD, ANR, Railroad
M06	Fair, Stage III	Private residences	Remove and/or relocate berm to allow some floodplain access and restore flow to a flood chute.	Low priority	Flood and sediment attenuation asset	Cost of berm relocation and reforestation.	No additional structures in corridor	Landowners, RNRCD, ANR, VRC
M06	Fair, Stage III	Public buildings and a parking lot.	Remove and/or relocate berm to allow some floodplain access.	Low priority – would allow some flood relief above Cuttingsville Village.	Improved sediment transport and geomorphic stability	Cost of design, relocation of berm, reforestation.	No additional structures in corridor	Town of Shrewsbury, ANR, Rutland NRCD
M10	Fair, STD C to B, Stage III	Private landowners property	Relocate berm back away from top of bank in order to allow some flood access, yet still protect structures. Stabilize mass failure.	Low Priority	Possibly reduce mass failure landslide on opposite bank.	Cost of berm relocation and trees and shrubs	None. Remains private property.	Property owner, ANR, RNRCD

7.4 Resources and Contacts for River Restoration and Management

Stream Alteration Permits, River Corridor Easements:
Vermont Department of Environmental Conservation
450 Asa Bloomer State Office Building
88 Merchants Row
Rutland, Vermont 05701-5903
Phone: 802-786-2501
Fax: 802.786.5915

Tree planting, Land conservation Assistance:
Rutland Natural Resources Conservation District
Nanci McGuire, District Manager
170 South Main Street
Rutland, VT 05701
phone: 802-775-7192 ext. 17
fax: 802-773-4177
email: nanci.mcguire@vt.nacdnet.net

Wetland restoration:
Sally Eugair, Soil Conservation Tech, USDA NRCS
170 South Main Street
Rutland,Vermont 05701
Phone: 1-802-775-7192 Ext.16
Fax: 1-802-773-4177

Assistance with Planning and Zoning:
Rutland Regional Planning Commission
P.O. Box 965
67 Merchants Row
Rutland, Vermont 05702
Phone: 802.775.0871
Fax: 802.775.1766

For information on Basin Planning and Water Quality Monitoring Projects in the Otter Creek Watershed visit:
http://www.vacd.org/rcd/district_maps.html

8.0 REFERENCES

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9.0 GLOSSARY

Adapted from:
Glossary of Stream Restoration Terms
by Craig Fischenich.. February 2000
USAE Research and Development Center,
Environmental Laboratory, 3909 Halls Ferry
Rd., Vicksburg, MS 39180

TERMS

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

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

Alluvial -- Deposited by running water.

Alluvium -- A general term for detrital deposits make by streams on riverbeds, floodplains, and alluvial fans; esp. a deposit of silt or silty clay laid down during time of flood. The term applies to stream deposits of recent time. It does not include subaqueous sediments of seas or lakes.

Aquatic ecosystem -- Any body of water, such as a stream, lake, or estuary, and all organisms and nonliving components within it, functioning as a natural system.

Armoring -- A natural process where an erosion-resistant layer of relatively large particles is established on the surface of the streambed through removal of finer particles by stream flow. A properly armored streambed generally resists movement of bed material at discharges up to approximately 3/4 bank-full depth.

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

Bank stability -- The ability of a streambank to counteract erosion or gravity forces.

Bankfull channel depth -- The maximum depth of a channel within a riffle segment when flowing at a bank-full discharge.

Bankfull channel width -- The top surface width of a stream channel when flowing at a bank-full discharge.

Bankfull discharge -- The stream discharge corresponding to the water stage that first overtops the natural banks. This flow occurs, on average, about once every 1 to 2 years.
Bankfull width -- The width of a river or stream channel between the highest banks on either side of a stream.
Bar -- An accumulation of alluvium (usually gravel or sand) caused by a decrease in sediment transport capacity on the inside of meander bends or in the center of an overwide channel.
Bed load -- Sediment moving on or near the streambed and transported by jumping, rolling, or sliding on the bed layer of a stream. See also suspended load.
Bed material -- The sediment mixture that a streambed is composed of.
Bed slope -- The inclination of the channel bottom, measured as the elevation drop per unit length of channel.
Berms -- mounds of dirt, earth, gravel, or other fill built parallel to the stream banks designed to keep flood flows from entering the adjacent floodplain.
Biota -- All living organisms of a region, as in a stream or other body of water.
Boulder -- A large substrate particle that is larger than cobble, 256 mm in diameter.
Braided channel -- A stream characterized by flow within several channels, which successively meet and divide. Braiding often occurs when sediment loading is too large to be carried by a single channel.
Buffer strip -- A barrier of permanent vegetation, either forest or other vegetation, between waterways and land uses such as agriculture or urban development, designed to intercept and filter out pollution before it reaches the surface water resource.
Canopy -- A layer of foliage in a forest stand. This most often refers to the uppermost layer of foliage, but it can be used to describe lower layers in a multistoried stand. Leaves, branches and vegetation that are above ground and/or water that provide shade and cover for fish and wildlife.
Channel -- An area that contains continuously or periodically flowing water that is confined by banks and a streambed.
Channelization -- The process of changing (usually straightening) the natural path of a waterway.
Clay -- Substrate particles that are smaller than silt and generally less than 0.003 mm in diameter.
Cobble -- Substrate particles that are smaller than boulders and larger than gravels, and are generally 64-256 mm in diameter. Can be further classified as small and large cobble.
Confluence -- (1) The act of flowing together; the meeting or junction of two or more streams; also, the place where these streams meet. (2) The stream or body of water formed by the junction of two or more streams; a combined flood.
Cover – "cover" is the general term used to describe any structure that provides refugia for fish, reptiles or amphibians. These animals seek cover to hide from predators, to avoid warm water temperatures, and to rest, by avoiding higher velocity water. These animals come in all sizes, so even cobbles on the stream bottom that are not sedimented in with fine sands and silt can serve as cover for small fish and salamanders. Larger fish and reptiles often use large boulders, undercut banks, submerged logs, and snags for cover.
Culvert -- A buried pipe that allows flows to pass under a road.
Degradation -- (1) A progressive lowering of the channel bed due to scour. Degradation is an indicator that the stream's discharge and/or sediment load is changing. The opposite of aggradation. (2) A decrease in value for a designated use.
Ditch -- A long narrow trench or furrow dug in the ground, as for irrigation, drainage, or a boundary line.
Drainage area -- The total surface area upstream of a point on a stream that drains toward that point. Not to be confused with watershed. The drainage area may include one or more watersheds.
Ecology -- The study of the interrelationships of living organisms to one another and to their surroundings.
Ecosystem -- Recognizable, relatively homogeneous units, including the organisms they contain, their environment, and all the interactions among them.
Embankment -- An artificial deposit of material that is raised above the natural surface of the land and used to contain, divert, or store water, support roads or railways, or for other similar purposes.
Embeddedness – is a measure of the amount of surface area of cobbles, boulders, snags and other stream bottom structures that is covered with sand and silt. An embedded streambed may be packed hard with sand and silt such that rocks in the stream bottom are difficult or impossible to pick up. The spaces between the rocks are filled with fine sediments, leaving little room for fish, amphibians, and bugs to use

the structures for cover, resting, spawning, and feeding. A streambed that is **not** embedded has loose rocks that are easily removed from the stream bottom, and may even "roll" on one another when you walk on them.
Entrenchment ratio --The width of the floodprone area divided by the bankfull width.
Erosion -- Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.
Floodplain -- Land built of sediment that is regularly covered with water as a result of the flooding of a nearby stream.
Floodplain Function – Flood water access of floodplain which effects the velocity, depth, and slope (stream power) of the flood flow thereby influencing the sediment transport characteristics of the flood (i.e., loss of floodplain access and function may lead to higher stream power and erosion during flood).
Flow -- The amount of water passing a particular point in a stream or river, usually expressed in cubic feet per second (cfs).
Fluvial -- Migrating between main rivers and tributaries. Of or pertaining to streams or rivers.
Ford -- A shallow place in a body of water, such as a river, where one can cross by walking or riding on an animal or in a vehicle.
Geographic information system (GIS) – A computer system capable of storing and manipulating spatial data.
Geomorphology -- A branch of both physiography and geology that deals with the form of the earth, the general configuration of its surface, and the changes that take place due to erosion of the primary elements and the buildup of erosional debris.
Gradient -- Vertical drop per unit of horizontal distance.
Gravel -- An unconsolidated natural accumulation of rounded rock fragments, mostly of particles larger than sand (diameter greater than 2 mm), such as boulders, cobbles, pebbles, granules, or any combination of these.
Habitat -- The local environment in which organisms normally live and grow.
Headwater -- Referring to the source of a stream or river.
Hydrologic balance -- An accounting of all water inflow to, water outflow from, and changes in water storage within a hydrologic unit over a specified period of time.
Hydrology -- The scientific study of the water of the earth, its occurrence, circulation and distribution, its chemical and physical properties, and its interaction with its environment, including its relationship to living things.
Incised river -- A river that erodes its channel by the process of degradation to a lower base level than existed previously or is consistent with the current hydrology.
Incision ratio -- The low bank height divided by the bankfull maximum depth.
Infiltration (soil) -- The movement of water through the soil surface into the soil.
Instream cover -- The layers of vegetation, like trees, shrubs, and overhanging vegetation, that are in the stream or immediately adjacent to the wetted channel.
Islands – mid-channel bars that are above the average water level and have established woody vegetation.
Large woody debris (LWD) -- Pieces of wood at least 6 ft. long and 1 ft. in diameter (at the large end) contained, at least partially, within the bankfull channel.
Mainstem -- The principal channel of a drainage system into which other smaller streams or rivers flow.
Meander -- The winding of a stream channel, usually in an erodible alluvial valley. A series of sine-generated curves characterized by curved flow and alternating banks and shoals.
Mid-channel Bars – bars located in the channel away from the banks, generally found in areas where the channel runs straight. Mid-channel bars are caused by recent channel instability and are unvegetated.
Outfall -- The mouth or outlet of a river, stream, lake, drain or sewer.
Point bar -- The convex side of a meander bend that is built up due to sediment deposition.
Pool -- A reach of stream that is characterized by deep, low-velocity water and a smooth surface.
Reach -- A section of stream having relatively uniform physical attributes, such as valley confinement, valley slope, sinuosity, dominant bed material, and bed form, as determined in the Phase 1 Assessment.
Restoration -- The return of an ecosystem to a close approximation of its condition prior to disturbance.

Riffle -- A reach of stream that is characterized by shallow, fast-moving water broken by the presence of rocks and boulders.
Riffle/step frequency -- ratio of the distance between riffles to the stream width.
Riparian area -- An area of land and vegetation adjacent to a stream (or any other freshwater aquatic ecosystem) that has a direct effect on the stream. This includes woodlands, vegetation, and floodplains.
Riparian buffer is the width of naturally vegetated land adjacent to the stream between the top of the bank (or top of slope, depending on site characteristics) and the edge of other land uses. A buffer is largely undisturbed and consists of the trees, shrubs, groundcover plants, duff layer, and naturally uneven ground surface. The buffer serves to protect the water body from the impacts of adjacent land uses.
Riparian corridor includes lands defined by the lateral extent of a stream's meanders necessary to maintain a stable stream dimension, pattern, profile, and sediment regime. For instance, in stable pool-riffle streams, riparian corridors may be as wide as 10-12 times the channel's bankfull width. In addition the riparian corridor typically corresponds to the land area surrounding and including the stream that supports (or could support if unimpacted) a distinct ecosystem, generally with abundant and diverse plant and animal communities (as compared with upland communities).
Riparian habitat -- The aquatic and terrestrial habitat adjacent to streams, lakes, and other freshwater aquatic ecosystems.
Riparian -- Located on the banks of a stream or other body of freshwater.
Riparian vegetation -- The plants that grow adjacent to a wetland area such as a river, stream, reservoir, pond, spring, marsh, bog, meadow, etc., and that rely upon the hydrology of the associated water body.
Riprap -- Rock or other material with a specific mixture of sizes referred to as a "gradation," used to stabilize streambanks or riverbanks from erosion or to create habitat features in a stream.
River channels -- Large natural or artificial open streams that continuously or periodically contain moving water, or which form a connection between two bodies of water.
River reach -- Any defined length of a river.
Roads - Transportation infrastructure. Includes private, town, state roads, and roads that are dirt, gravel, or paved.
Runoff -- Water that flows over the ground and reaches a stream as a result of rainfall or snowmelt.
Scour -- The erosive action of running water in streams, which excavates and carries away material from the bed and banks. Scour may occur in both earth and solid rock material and can be classed as general, contraction, or local scour.
Sediment -- Soil or mineral material transported by water or wind and deposited in streams or other bodies of water.
Sedimentation -- (1) The combined processes of soil erosion, entrainment, transport, deposition, and consolidation. (2) Deposition of sediment.
Segment: A relatively homogenous section of stream contained within a reach that has the same reference stream characteristics but is distinct from other segments in the reach in one or more of the following parameters: degree of floodplain encroachment, presence/absence of grade controls, bankfull channel dimensions (W/D ratio, entrenchment), channel sinuosity and slope, riparian buffer and corridor conditions, abundance of springs/seeps/adjacent wetlands/stormwater inputs, and degree of channel alterations.
Sensitivity --of the valley, floodplain, and/or channel condition to change due to natural causes and/or anticipated human activity.
Silt -- Substrate particles smaller than sand and larger than clay (3 to 60 mm).
Sinuosity -- The ratio of channel length to direct down-valley distance. Also may be expressed as the ratio of down-valley slope to channel slope.
Slope -- The ratio of the change in elevation over distance.
Stable channel -- A stream channel with the right balance of slope, planform, and cross section to transport both the water and sediment load without net long-term bed or bank sediment deposition or erosion throughout the stream segment.
Straightening -- the removal of meander bends, often done in towns and along roadways, railroads, and agricultural fields.

Stream banks are features that define the channel sides and contain stream flow within the channel; this is the portion of the channel bank that is between the toe of the bank slope and the bankfull elevation. The banks are distinct from the streambed, which is normally wetted and provides a substrate that supports aquatic organisms. The top of bank is the point where an abrupt change in slope is evident, and where the stream is generally able to overflow the banks and enter the adjacent floodplain during flows at or exceeding the average annual high water.
Stream channel -- A long narrow depression shaped by the concentrated flow of a stream and covered continuously or periodically by water.
Stream condition -- Given the land use, channel and floodplain modifications documented at the assessment sites, the current degree of change in the channel and floodplain from the reference condition for parameters such as dimension, pattern, profile, sediment regime, and vegetation.
Stream morphology -- The form and structure of streams.
Stream reach -- An individual segment of stream that has beginning and ending points defined by identifiable features such as where a tributary confluence changes the channel character or order.
Stream type -- Gives the overall physical characteristics of the channel and helps predict the reference or stable condition of the reach.
Streambank armoring – The installation of concrete walls, gabions, stone riprap, and other large erosion resistant material along stream banks.
Streambank erosion -- The removal of soil from streambanks by flowing water.
Streambank stabilization -- The lining of streambanks with riprap, matting, etc., or other measures intended to control erosion.
Streambed -- (1) The unvegetated portion of a channel boundary below the baseflow level. (2) The channel through which a natural stream of water runs or used to run, as a dry streambed.
Substrate -- (1) The composition of a streambed, including either mineral or organic materials. (2) Material that forms an attachment medium for organisms.
Suspended sediment -- Sediment suspended in a fluid by the upward components of turbulent currents, moving ice, or wind.
Tributary -- A stream that flows into another stream, river, or lake.
Urban runoff -- Storm water from city streets and gutters that usually carries a great deal of litter and organic and bacterial wastes into the sewer systems and receiving waters.
Water quality -- A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Watershed -- An area of land whose total surface drainage flows to a single point in a stream.
Watershed management -- The analysis, protection, development, operation, or maintenance of the land, vegetation, and water resources of a drainage basin for the conservation of all its resources for the benefit of its residents.
Watershed restoration -- Improving current conditions of watersheds to restore degraded habitat and provide long-term protection to aquatic and riparian resources.

APPENDIX A

STRESSOR IDENTIFICATION MAPS

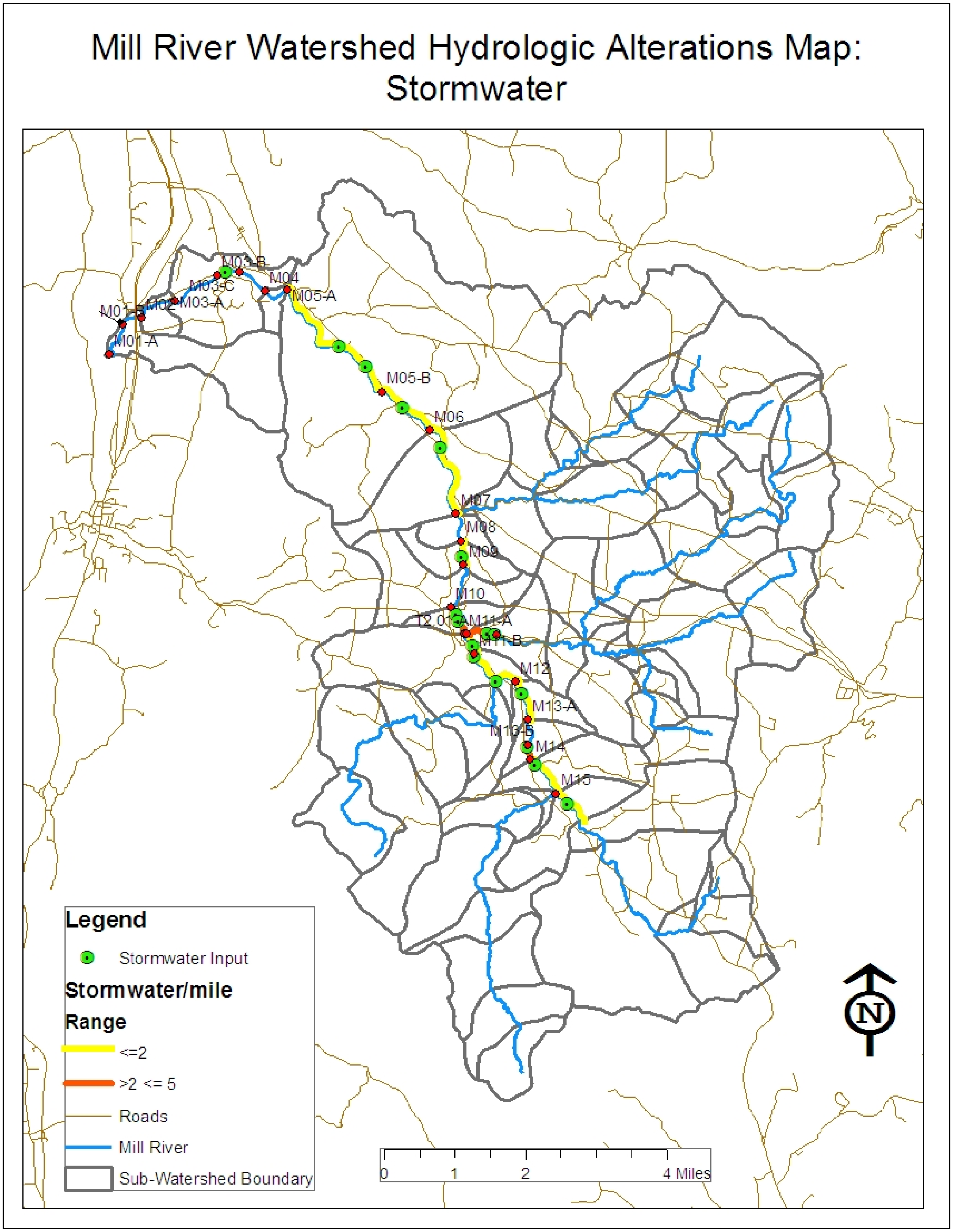

Figure 1. Hydrologic Alterations Map of the Mill River Watershed depicting Stormwater Inputs.

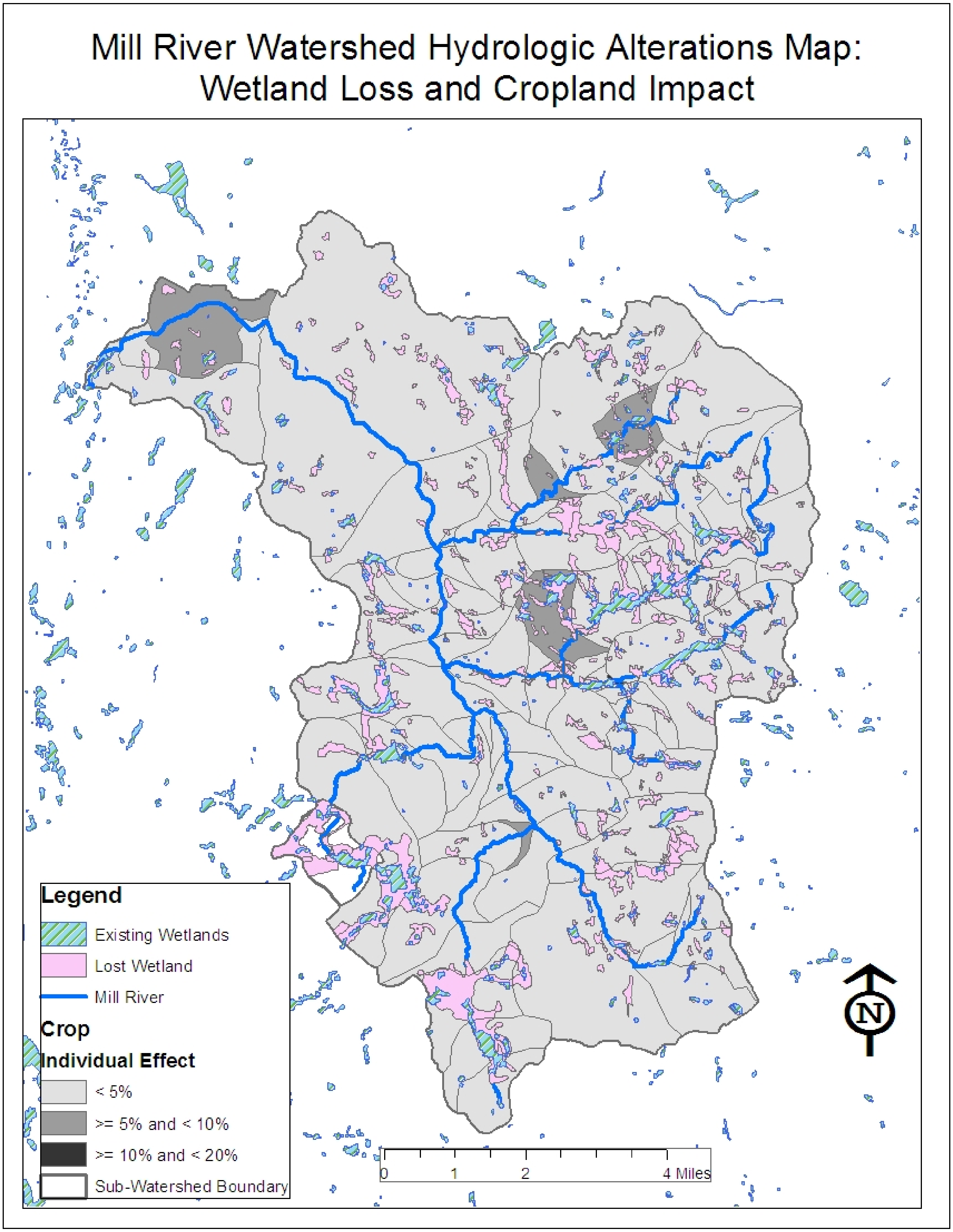

Figure 2: Wetland loss and the effect of cropland on the Mill River and its tributaries.

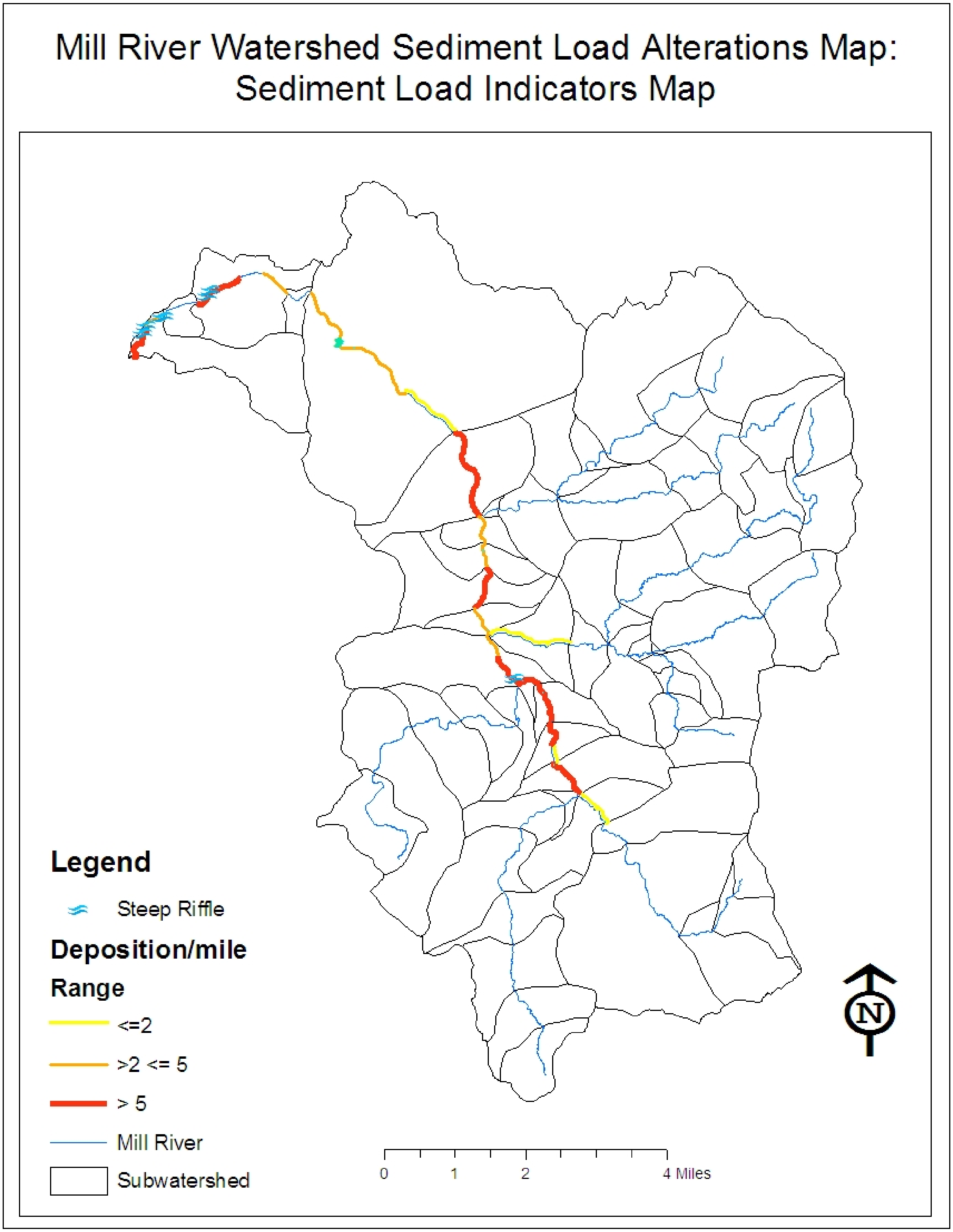

Figure 3: Indicators of excessive sediment loading in the Mill River.

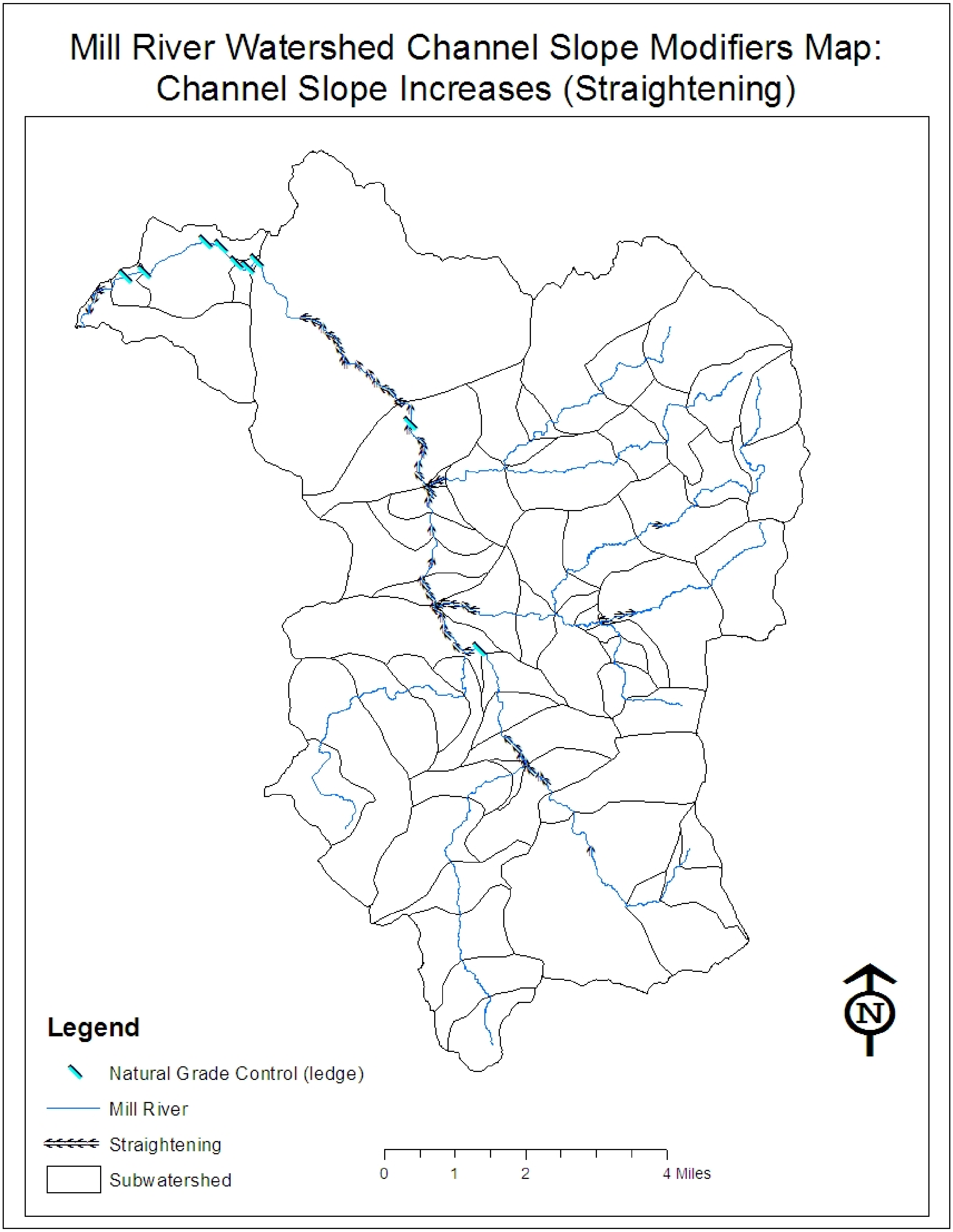

Figure 4: Channel straightening and grade control locations on the Mill River and its tributaries.

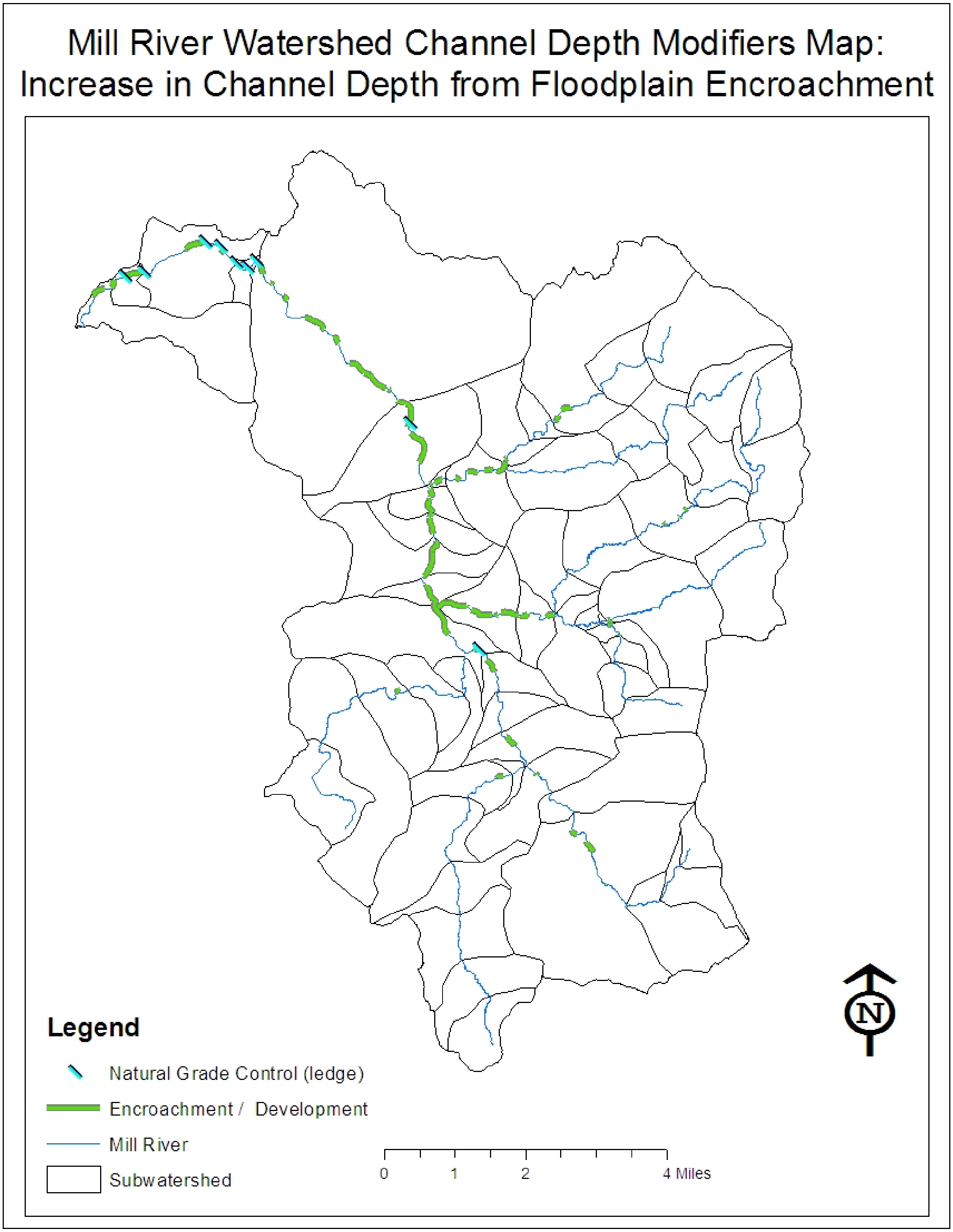

Figure 5: Increase in channel depth as a result of floodplain encroachment on the Mill River and its tributaries.

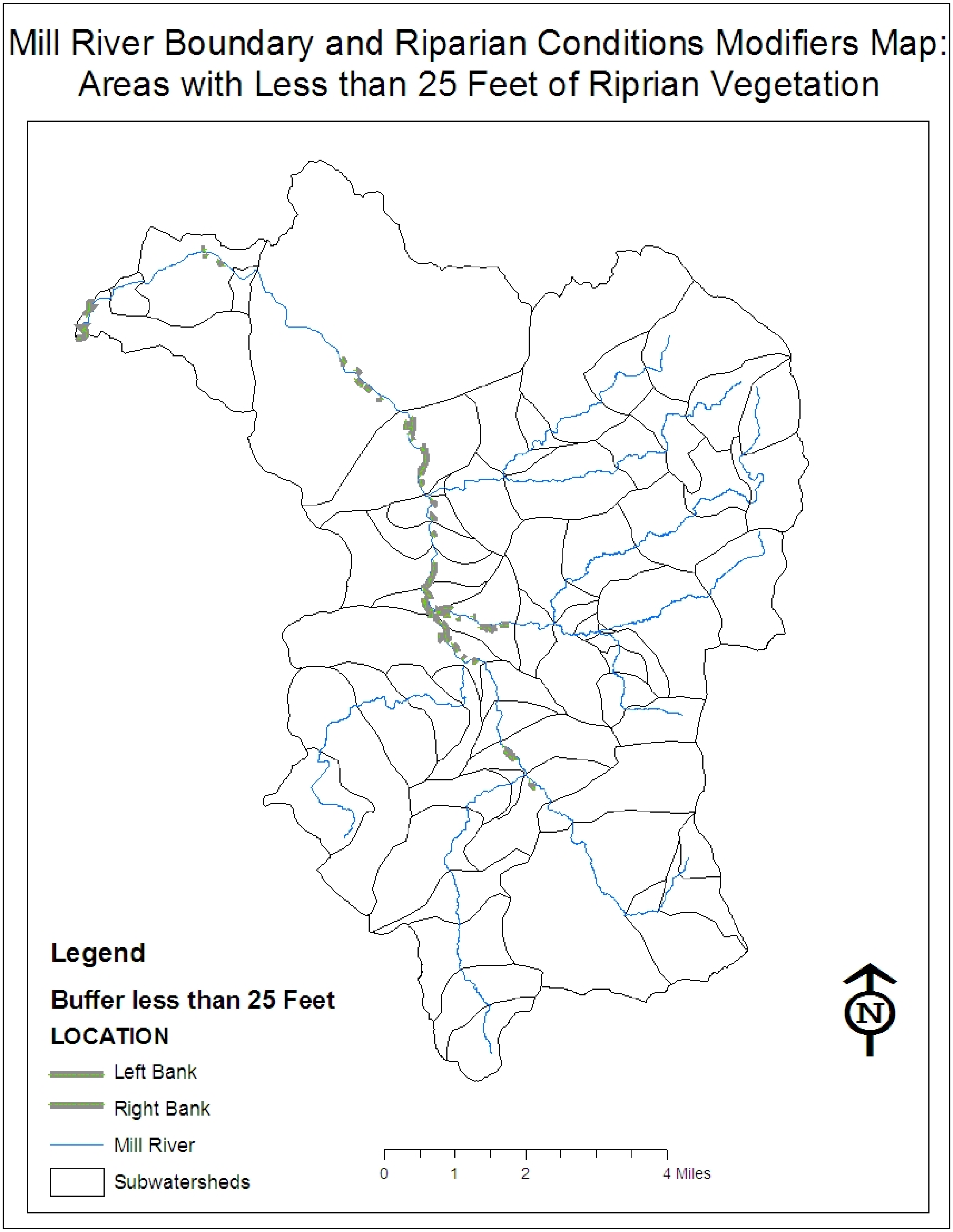

Figure 6: Loss of Riparian Buffer along the Mill River.

APPENDIX B

PHASE 2 REACH SUMMARIES

PHASE 2 RESULTS

The results of the Phase 2 study are discussed below by reach number. In addition, four overview maps (Figures 1, 11, 16, and 21) have been included to provide a reference for location as well as to display channel modifications such as straightening and berming, both of which have greatly affected the condition of the Mill River.

The most common adjustment processes observed in the Mill River are widening and planform migration as a result of historic degradation within the channel. Degradation is the term used to describe the process whereby the stream bed lowers in elevation through erosion, or scour, of bed material. Aggradation is a term used to describe the raising of the bed elevation through an accumulation of sediment. The planform is the channel shape as seen from the air. Planform change can be the result of a straightened course imposed on the river through different channel management activities, or a channel response to other adjustment processes such as aggradation and widening. Channel widening occurs when stream flows are contained in a channel as a result of degradation or floodplain encroachment or when sediments overwhelm the stream channel and the erosive energy is concentrated into both banks.

RIVER SECTION 1: MOUNT HOLLY TO EAST WALLINGFORD VILLAGE

The first section of river (illustrated in Figure 1) begins in Mount Holly and flows northerly towards East Wallingford Village. The valley alternates between very broad and narrow and land use changes from predominately agricultural and forested to commercial and residential in East Wallingford. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, dredging, berming, channel armoring, and floodplain encroachment.

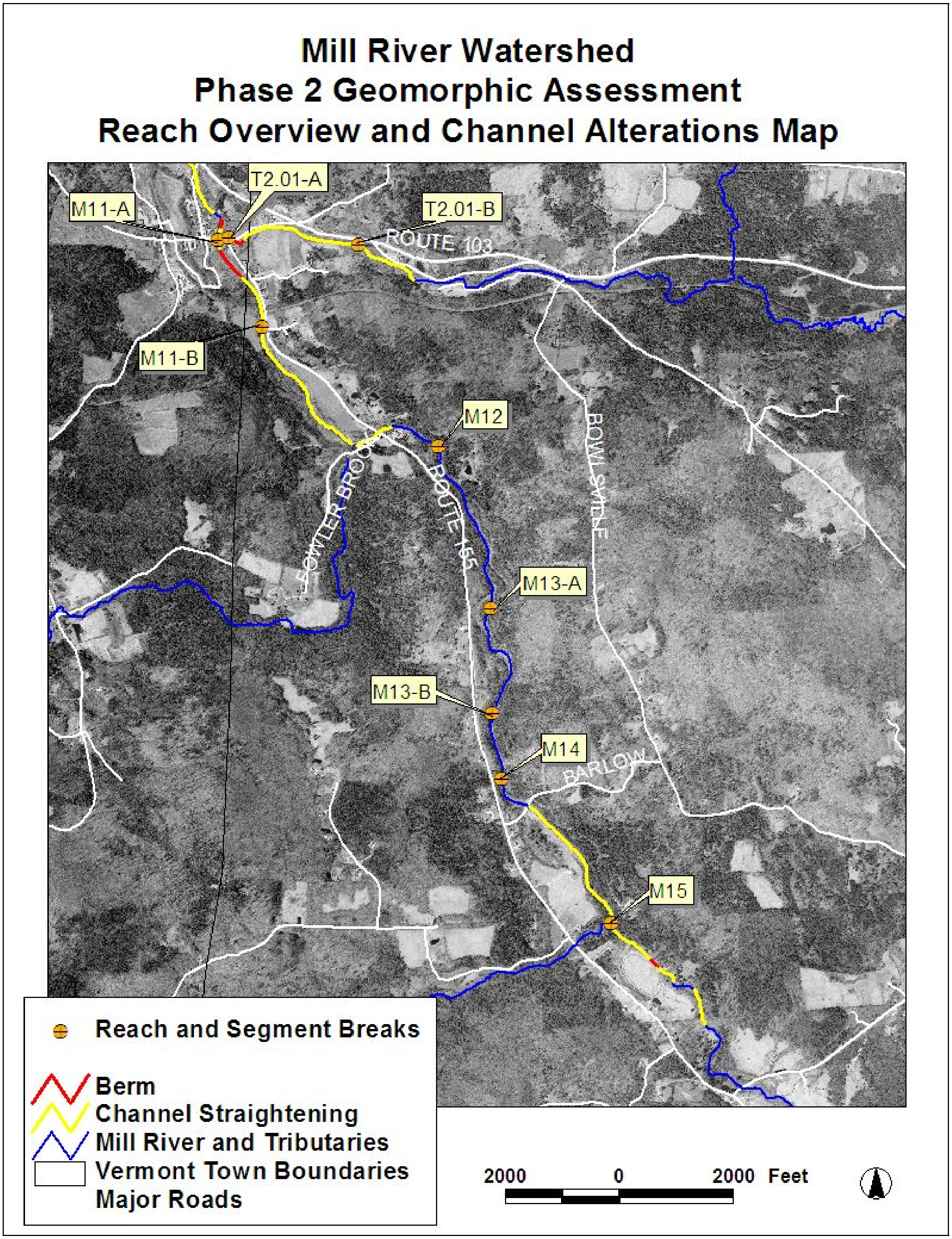

Figure 1: Overview of reaches M11 through M15 (including T2.01), and channel straightening and berming.

4.1 Reach M15

The most upstream reach of this Phase 2 study, M15 of the Mill River is located at approximately 1490 feet above sea level in a very broad valley in the town of Mount Holly. The land on the southwestern border of the stream is pasture land and it appears that the river through this reach has been straightened and pushed up against the right valley wall in order to make more room for agricultural activities. Deep down-cutting into the streambed material has occurred (incision ratio of 2) likely as a result of this straightening. A stream type departure from a reference C riffle-pool channel to a B type plane bed was recorded (Figure 2). This departure has significantly reduced the capacity of this reach to attenuate floodwater and sediment. Currently the reach is exhibiting only minor widening and planform adjustment. This is likely due to the large substrates in the channel. Continued lateral adjustment is expected to occur as the river works to redevelop floodplain in this reach.

Construction of a new bridge was observed. With the exception of this structure, the rest of the reach was undeveloped although as stated the left corridor is currently being used for pasture and hay. By reference this reach should be an area where floodwaters and sediment are able to be stored in the Mill River system. Drainage work in the fields indicates that much of the land may be class III wetland. A riparian buffer restoration project on the left bank may be appropriate as only a very narrow row of trees currently exists.

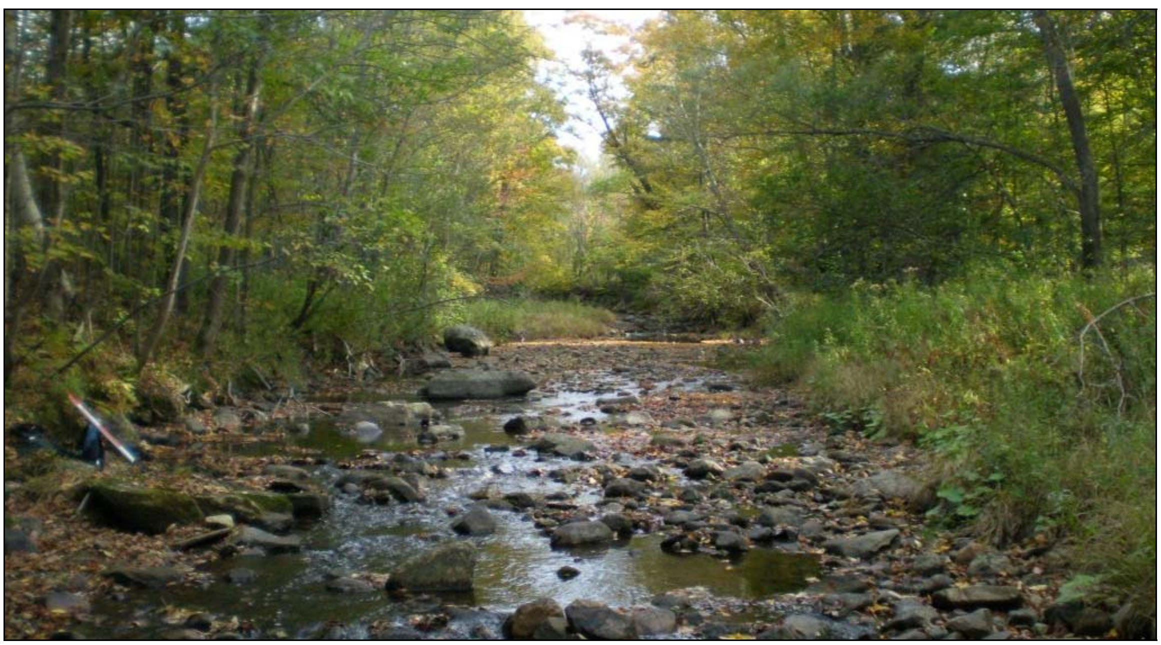

Figure 2. Reach M15 has been historically straightened. It is an incised channel with a planebed form that is currently undergoing minor channel widening and planform adjustment.

4.2 Reach M14

Reach M14 begins where Meadow Brook enters the Mill River in the town of Mount Holly. Similar to M15, this reach borders recently agricultural (some no longer in production) land. The river through this reach appears to have been straightened (Figure 3) and pushed up against the right (northeast) valley wall. An old meander scar is visible on aerial photographs just upstream from the Barlow Road Bridge indicating a level of historic sinuosity has been lost. Deep incision was observed (measured ratio of 3). A stream type departure has ensued from a C-type channel to a B-type plane bed with a significantly reduced capacity to attenuate water and sediment due to the disconnection with the floodplain. Extensive widening and minor planform adjustments are occurring in the reach as the channel works to recover from the high level of incision.

Also of note in this reach, a large delta exists at the Meadow Brook confluence. The brook appears to be contributing course and fine sediment to the system as a result of tributary rejuvenation and possible other adjustments upstream. In regards to land use in the M14 corridor a single residence exists on the left bank. With much of the corridor still void of trees and undeveloped this reach may be suitable for an active geomorphic restoration project and/or buffer restoration efforts on the left bank.

Figure 3. M14 has been historically straightened and is now has a plane bed form. Widening and planform adjustment are actively occurring.

4.3 Reach M13

Mill River reach M13 begins below the Barlow Road Bridge in Mount Holly (off of Vermont Route 155) and continues downstream for 3399 feet. The reach was split into two segments by RRD due to a natural change in channel confinement related to the valley width. This change in channel confinement resulted in a change in reference stream type within the reach.

Segment B:

Reach M13-B is a short segment located where the valley wall of the Mill River narrows thereby creating a semi-confined channel that is a B3 planebed by reference (Figure 4). Some development has occurred along the top of the left valley wall, however, the development is well above the floodplain and is only mentioned as the landowners in this reach are in close proximity to the stream and may have an impact on its water quality. These houses are also located on top of a steep valley wall and may have some erosion hazard risks. Landowner education in this area to ensure that the forested buffer remains intact and stormwater and garbage is minimized from entering the channel would be beneficial in this segment.

In regards to the observed stream condition, the channel was found to be slightly incised. Some minor widening has occurred. Extreme adjustments are unlikely in this reach due to the stable tendencies of B3 planebed streams.

Figure 4. M13-B is a B3 planebed segment by reference.

Segment A:

Mill River segment M13-A is a short segment located in a broad valley. Historic channel incision has led to minor channel widening and major channel planform adjustments. Despite a high degree of incision the stream has remained a C-type channel dominated by gravel substrates (Figure 5). The river is adjusting laterally through several flood chutes and has stored a significant amount of gravel in a large point bar. The well forested buffer in this corridor is an asset for the river as are the floodchutes and wetlands that will store some water and sediment during a large runoff event.

Figure 5. M13-A is a C type channel that is undergoing planform adjustment and minor widening.

4.4 Reach M12

Mill River reach M12 begins upstream from Fowler Brook Road in the town of Mount Holly. This is a C channel that flows through a well forested corridor in a broad valley (Figure 6). Historic incision has led to a great degree of instability in the channel. There were numerous active flood chutes documented as well as new gravel bars indicating both planform adjustment and aggradation as the channel works to redevelop floodplain. Channel widening was also considered a major active adjustment process. This reach may be both a source and sink of sediment and flood waters and will become more of a resource for the watershed as the channel evolution processes continue to improve floodplain access.

Figure 6. M12 has incised historically. Major planform adjustment, widening, and minor aggradation were observed.

4.5 Reach M11

Mill River reach M11 begins just upstream from where Fowler Brook enters the mainstem and continues downstream to East Wallingford Village where another tributary (T2.01) enters from the east. M11 was divided into two segments for the Phase 2 assessment due to an observed change in the degree of corridor encroachment, bank armoring, buffer quality, and corridor land use. The segment break was near a railroad bridge crossing from which point downstream the channel is heavily impacted by straightening, streambank armoring, floodplain development, and fill.

Segment B:

Mill River segment M11-B captures an area where the valley walls open up and a tributary enters the Mill River from the west. In this segment, soils maps indicate that the parent material is alluvial suggesting the possibility that this area is an alluvial fan. There appears to have been a high degree of historic channel straightening that occurred in this reach, likely in order to increase the amount of agricultural land which dominates the right corridor. In addition active gravel extraction was observed to have recently occurred in the reach.

A high degree of channel incision has caused a departure from a C-type channel to a B plane bed (Figure 7). These channel alterations have caused a significant loss of sediment and floodwater attenuation in an important area upstream of East Wallingford and Cuttingsville Villages.

Figure 7. M11-B has been historically straightened. Currently undergoing major planform, widening, and aggradation adjustments.

Segment A:

Mill River segment M11-A is one of two reaches that run through the Village of East Wallingford. Due to the relative location of the village to the river, extensive channel straightening, armoring, and dredging have altered this channel, likely in response to past flood events. These alterations have transformed riffle-pool system in a broad valley into a F-type stream with a plane bed form lacking in habitat as well as floodwater and sediment storage capabilities. Vermont Route 155 and commercial and residential development have significantly encroached on the channel (Figure 8). The bridge at the downstream end of the reach appears to be a debris/ice jam potential hazard - it already has held enough sediment behind the middle pier for a fully vegetated mid -channel bar to form. In addition a railroad bridge crossing which funnels both a road and the river underneath appears to be limiting sediment transport. The upstream aggradation the bridge is causing may be increasing an erosion issue on pasture land on the left bank of M11-B. Opportunities to increase conveyance of water and sediment underneath these bridges may be appropriate projects to reduce fluvial erosion hazard in East Wallingford Village.

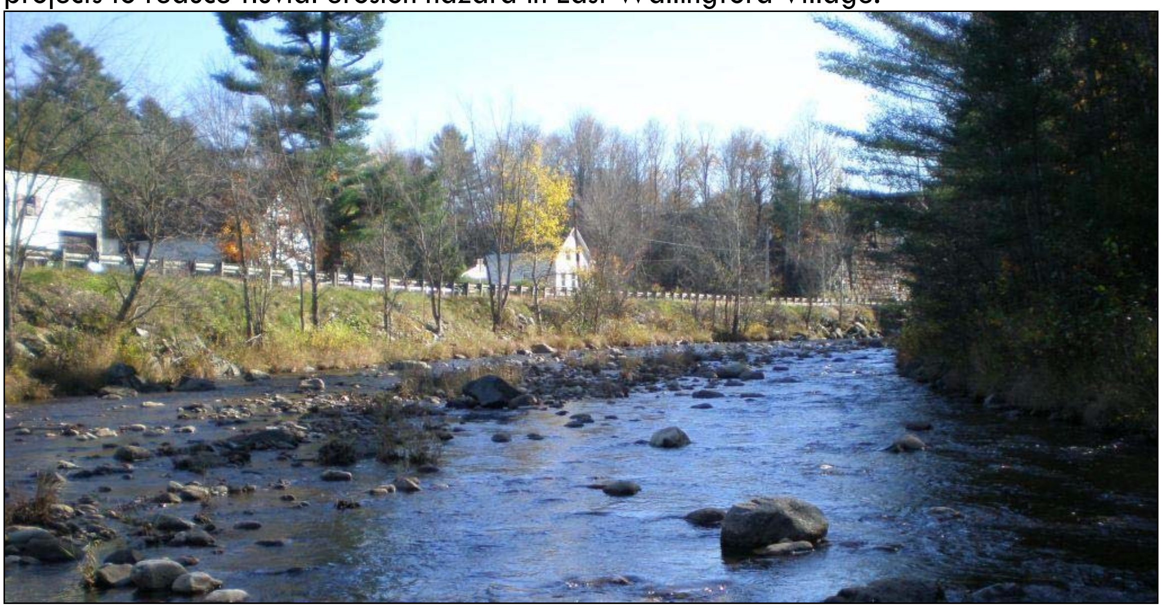

Figure 8. M11-A flows through East Wallingford Village and has a high degree of incision due to channel straightening and dredging.

4.5 Reach T2.01

Mill River watershed reach T2.01 is the downstream end of a large tributary to the Mill River. This tributary is unnamed on the 1984 USGS topography map. The reach studied for the Phase 2 Assessment begins at the Bowlsville Road Bridge and continues 6515 feet downstream to the confluence with the Mill River in East Wallingford Village. The reach was divided into two segments by RRD due to an extreme amount of channel straightening and bank armoring that was observed near the lower end of the reach.

Segment B:

Tributary T2.01-B begins at the Bowlsville Road Bridge and ends downstream near the west entrance to Millbrook Lane. The upper portion of this segment is in fair geomorphic condition. It has undergone major historic incision, however, is actively working to redevelop floodplain and has a fairly well developed riffle-pool bedform that looks to be providing good habitat with several deep pools. Active planform adjustment has led to the development of small gravel bars and a juvenile floodplain in some areas (Figure 9). Continued planform, widening, and aggradation adjustments are expected. Preventing further development of the floodplain of this reach will be an important step to ensure that floodwaters and sediment storage capacity is retained in this reach.

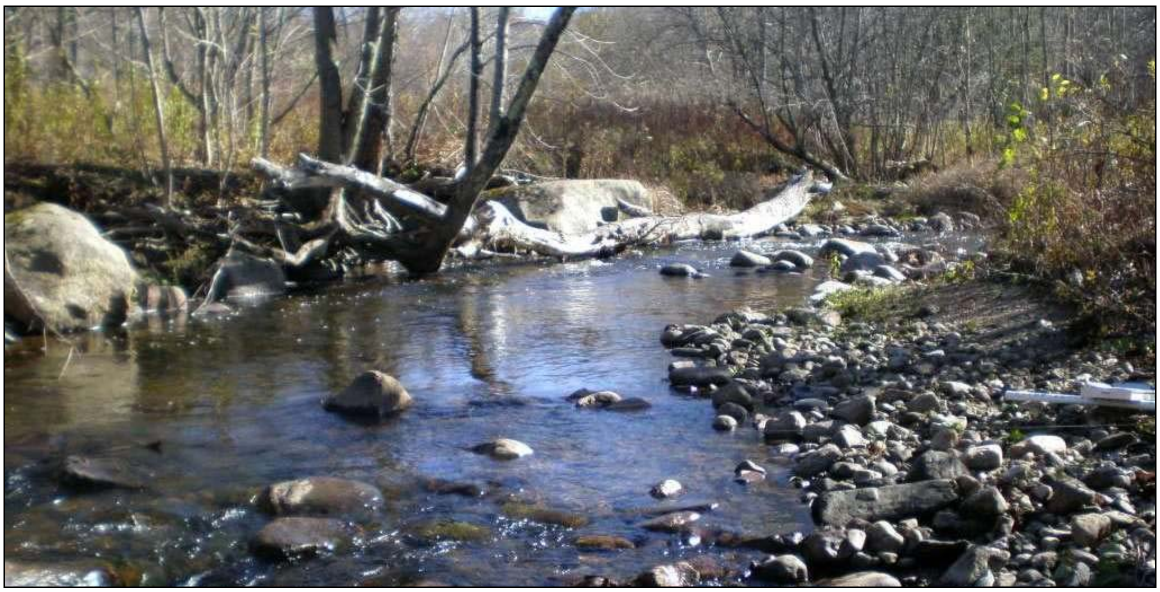

Figure 9. T2.01-B has historically incised, however is undergoing major planform adjustment as a new floodplain bench is developed.

Segment A

Tributary segment T2.01-A has seen extensive historic channel straightening and armoring (Figure 10). There is also evidence of dredging and windrowing just above the Route 140-East Bridge. The right side of the floodplain has been filled almost entirely by Routes 140 and 103 which create the top of the right bank. On the left side of the channel the riparian buffer has been cleared down to a thin strip of vegetation along the top of the bank. Agricultural land use dominates the left corridor while commercial and residential land use dominates the right corridor. Cross section analysis indicates that a stream type departure has occurred from a C-type channel to an F-type stream due to a high grade of incision.

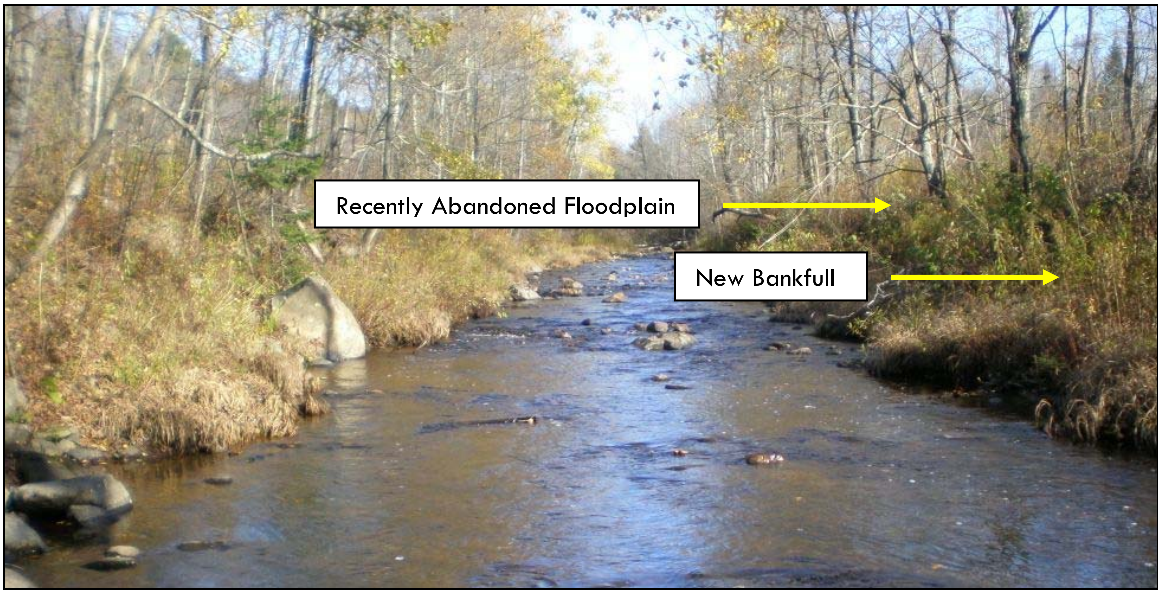

Figure 10. T2.01-A has been historically straightened and is now has a plane bed system that is disconnected from its floodplain.

RIVER SECTION 2: EAST WALLINGFORD VILLAGE TO CUTTINGSVILLE

The second section of river (illustrated in Figure 11) begins below East Wallingford Village and continues downstream to Cuttingsville. The valley alternates between very broad and narrow and the land use changes from commercial and residential in East Wallingford to agricultural and then back to development in Cuttingsville. Major significant impacts in this section include removal of riparian vegetation, channel straightening and dredging, berming, channel armoring, and floodplain encroachment.

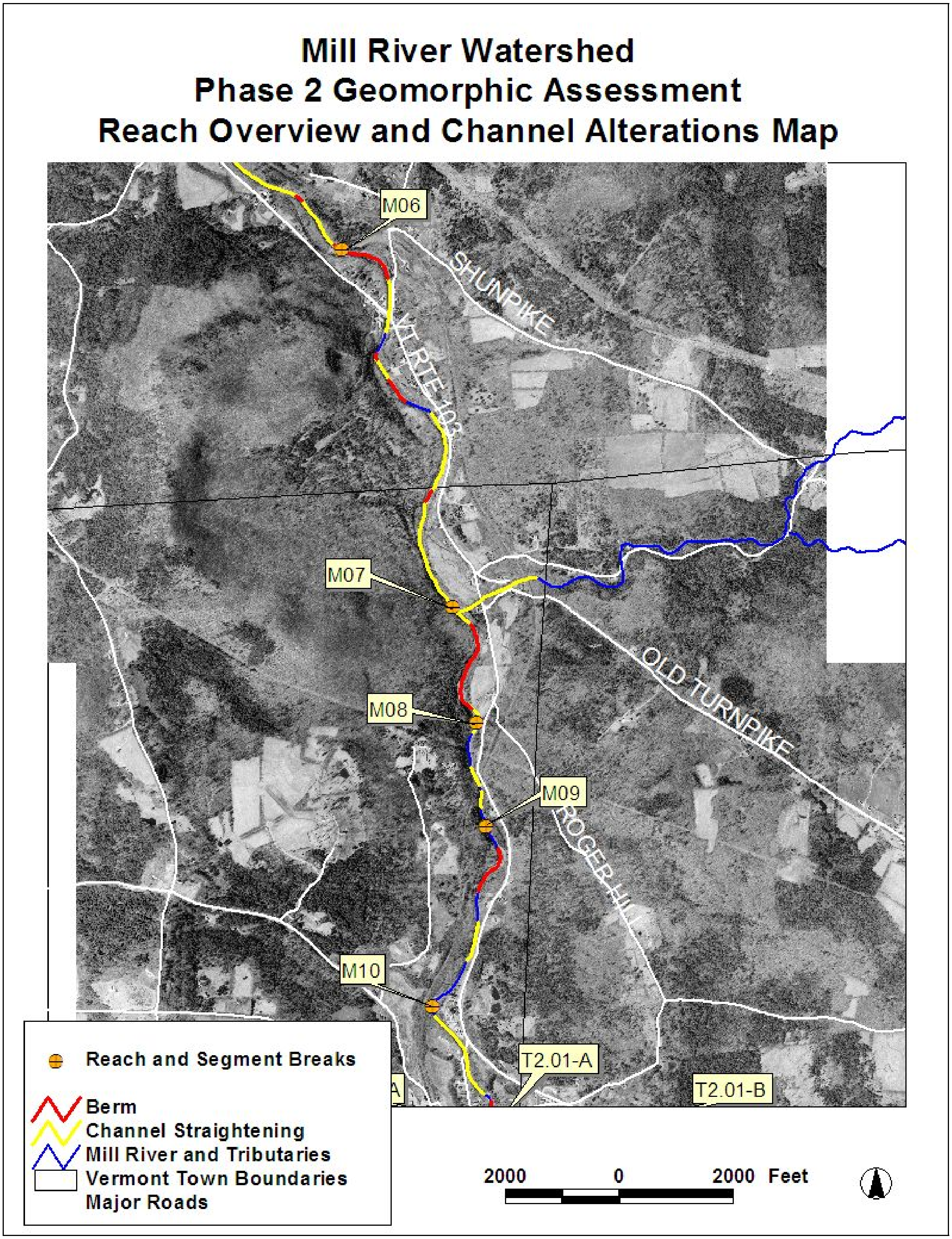

Figure 11: Overview of reaches M06 through M10 and channel straightening and berming.

4.6 Reach M10

Mill River reach M10 flows through East Wallingford Village. The reach begins just below the Route 140 Bridge at the confluence with tributary T2.01 and continues downstream for 2369 feet. This short reach has been highly managed in order to maintain its location and minimize flooding in the Village. RRD observed evidence of channel straightening and armoring (Figure 12). The high incision ratio has caused a stream type departure from a C-type channel which historically flowed through a forested broad valley to a B-type plane bed system that has a high degree of floodplain development. Due to the significant investment in infrastructure within this reach the Mill River is likely to be maintained near its current configuration. Deteriorating bridge conditions on Village Street may provide an opportunity for redesigning access to the Village and or at least allowing better sediment and water transport under the bridge (which is currently holding sediment in its mid-pier and may create debris jam and flooding under the right conditions).

Figure 12. M10 has been historically straightened. There is a high degree of bank armoring within the reach.

4.7 Reach M09

Although development pressure is not as significant as in the reach upstream, Mill River reach M09 has been impacted predominately by VT Route 103 which has changed the valley width from broad to narrow. In order to protect the roadway and a few structures located within the river corridor, extensive berming and channel armoring has occurred (Figure 13). Berming and straightening has increased the erosive forces in the channel leading to a high degree of incision (ratio of 1.8) and a stream type departure from a C riffle-pool channel to a B plane bed system. Adjusting to this incision, the stream has undergone extreme channel widening. Extensive channel management (riprap, dredging, straightening) has prevented the channel from developing new floodplain and storing sediment.

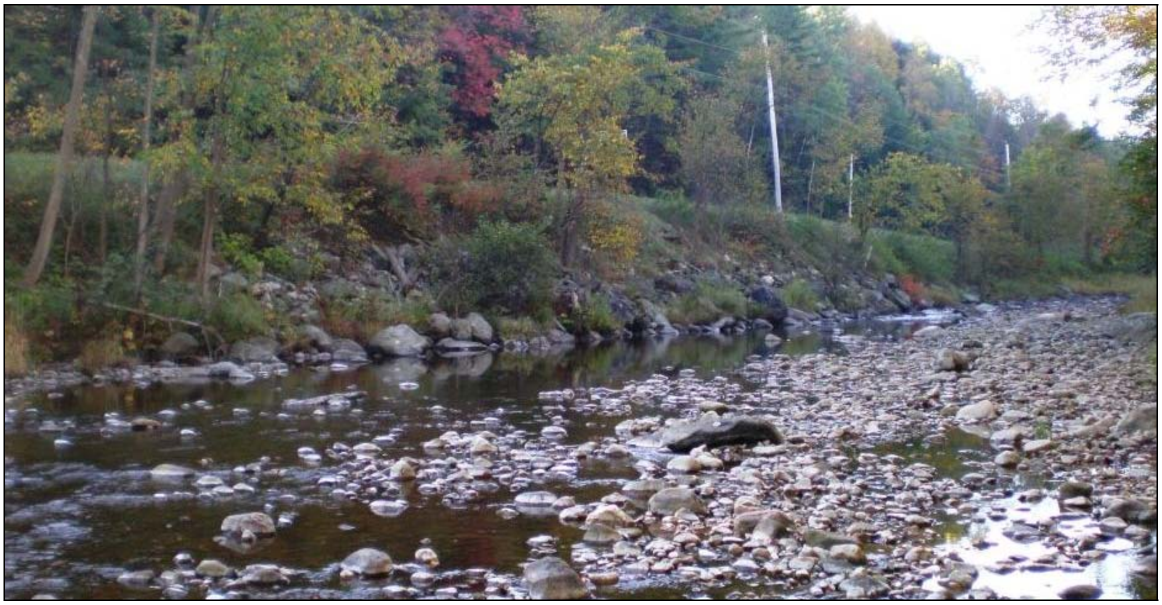

Figure 13. The valley width of M09 has been decreased due to encroachment from VT Route 103. The channel has undergone extreme widening.

4.8 Reach M08

Mill River reach M08 is a short reach in a semi-confined valley that has been further confined by Vermont Route 103. Despite a high degree of historic channel incision (Figure 14) the stream remains a C-type channel with access to floodplain during only the largest events. Although there is no stream type departure or bedform change (planebed by reference) the stream is nearly an F-type channel due to the high degree of incision. As a result of the incision the current sediment and floodwater storage capability of this reach has been significantly reduced.

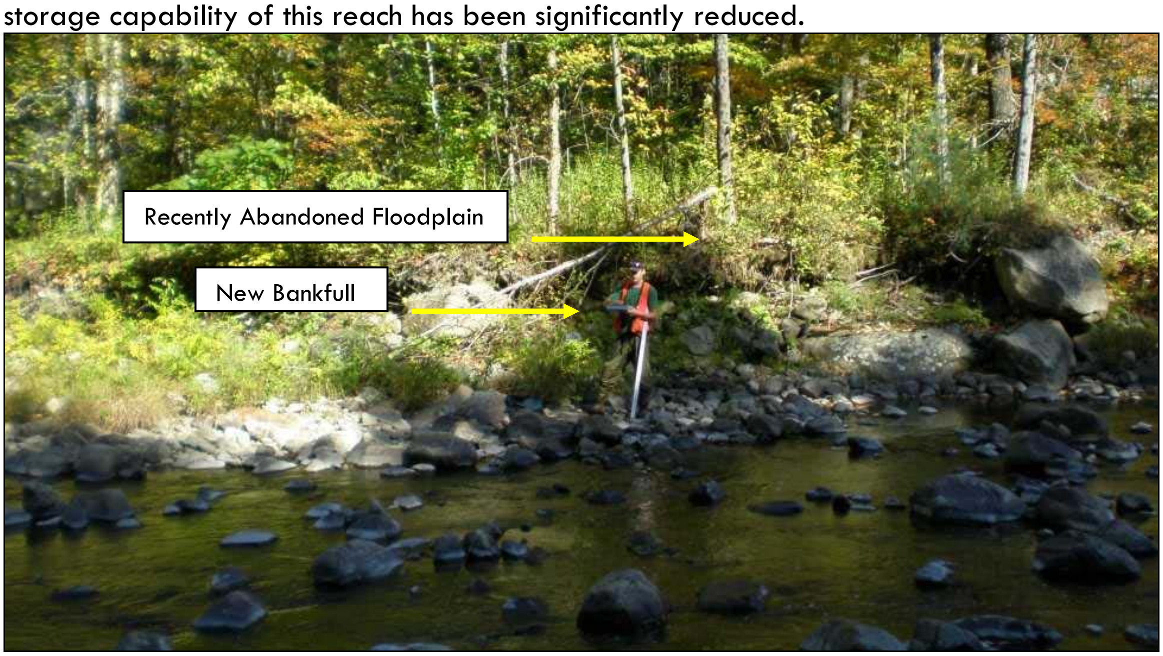

Figure 14. M08 is a short reach that has limited floodplain access due to streambed degradation.

4.9 Reach M07

Mill River reach M07 is a very short reach that appears to have been straightened up against the left valley wall in order to increase cultivatable land. Significant berming has occurred on the right bank in order to prevent flooding (Figure 15). Incision and channel widening in response to these channel management activities have led to a stream type departure from a C channel to a F-type channel and loss of bedform from riffle-pool to plane bed system.

Figure 15. M07 has seen significant berming on the right bank causing a significant loss of floodplain access.

4.10 Reach M06

Mill River reach M06 runs directly through Cuttingsville Village with a great deal of human alteration, both historic and recent. Channel straightening, berming, dredging, armoring, and windrowing were all observed. Additionally much of the floodplain has been filled by development and roads (Figure 16) increasing stormwater inputs into the system. It appears that the stream may have been straightened and relocated up against the left valley wall through much of the reach. A high degree of incision (1.8 ratio) was observed with major channel widening and planform adjustments currently occurring. Although there was some evidence of juvenile floodplain creation most of the reach still lacks significant floodplain benches. Some opportunities for channel adjustment and floodplain reconnection still exist in this reach.

Figure 16. M06 flows through Cuttingsville and has been significantly impacted by channel straightening, armoring, berming, and floodplain development.

RIVER SECTION 3: CUTTINGSVILLE TO THE UPPER CLARENDON GORGE

The third major section of river (illustrated in Figure 17) begins just downstream of Cuttingsville Village. From here down to the upper Clarendon Gorge, the Mill River flows through a broad valley. Major significant impacts in this section include removal of riparian vegetation, channel straightening and dredging, corridor encroachment and an undersized bridge.

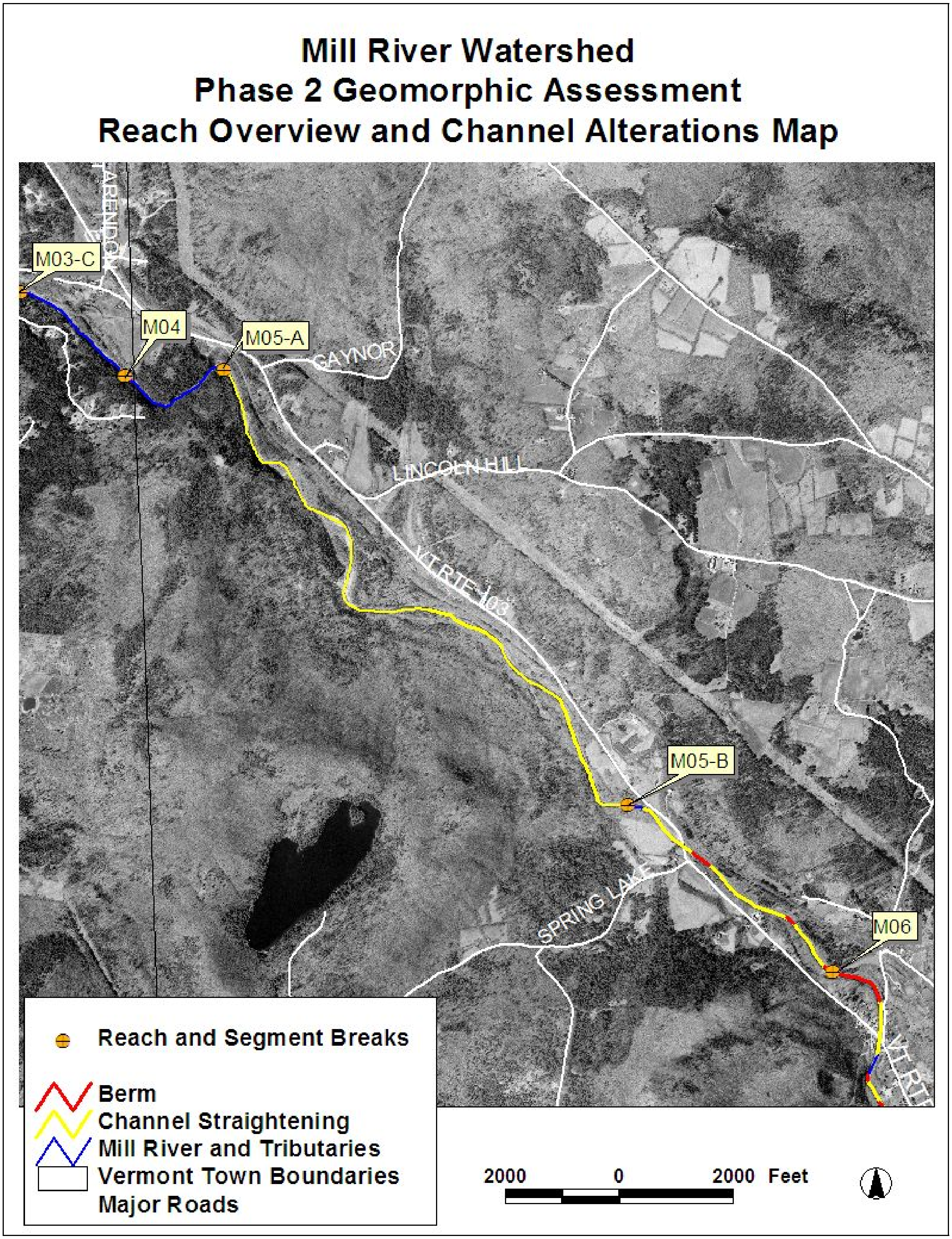

Figure 17: Overview of reaches M03-C through M06 and channel straightening and berming.

4.11 Reach M05

Mill River reach M05 is a long reach (16699 feet) that begins just below Cuttingsville Village and flows downstream to the beginning of the Upper Clarendon Gorge near the Long Trail suspension bridge. RRD divided the reach into two segments based on major shifts in corridor encroachment and channel dimensions as the stream transitions from the residential, commercial, and agricultural development near Cuttingsville and enters a forested corridor.

Segment B:

M05-B, as with many segments upstream, is heavily influenced by recent and historic channel management activities including berming, armoring, dredging and windrowing. Floodplain encroachment from VT 103 and residences and commercial development along with significant channel straightening have led to an incised stream that has departed from a reference C riffle-pool system (Figure 18). The B-type channel that now exists has less capacity to attenuate floodwaters and sediment and is a plane bed system with low quality habitat. A berm at the upstream end of the reach has prevented access to a major flood chute. Active major widening is occurring in response to channel incision. The planform and widening adjustments are limited by the valley wall, armoring, and dredging. Although there are significant corridor encroachments, some limited floodplain connectivity may be able to be restored in this reach in areas where structures are not currently located.

Figure 18. M05-B has been significantly altered through channel straightening, berming, armoring, and floodplain encroachment.

Segment A:

Mill River segment M05-A flows through a well forested corridor. Limited encroachment by the railroad track has impacted the right corridor. The channel has incised enough to abandon an old floodplain and begin to develop a juvenile floodplain. The degree of channel incision is low enough so that the stream remains unentrenched and able to store flood waters during the largest events. A large mass failure within this reach is a source of fine sediment and gravels to the downstream system (Figure 19). This sediment appears to be assisting the stream in rebuilding bars and floodplain downstream. Several large flood chutes exist in the stream corridor indicating planform adjustment.

Figure 19. A large mass failure on the left bank is providing some sediment recruitment to help rebuild bars in the incised Mill River reach M05-A.

4.12 Reach M04

Mill River reach M04 encompasses the Upper Clarendon Gorge (Figure 20). The gorge begins at a sharp southwestward bend in the river where a Long Trail suspension bridge hangs from the bedrock cliffs on each side. The Mill River cuts through the Dalton Formation (a cambrian dolomite/conglomerate), the Mount Holly Gneiss, and the Cheshire Quartzite on its way through the gorge. Due to the bedrock this reach received only a partial Phase 2.

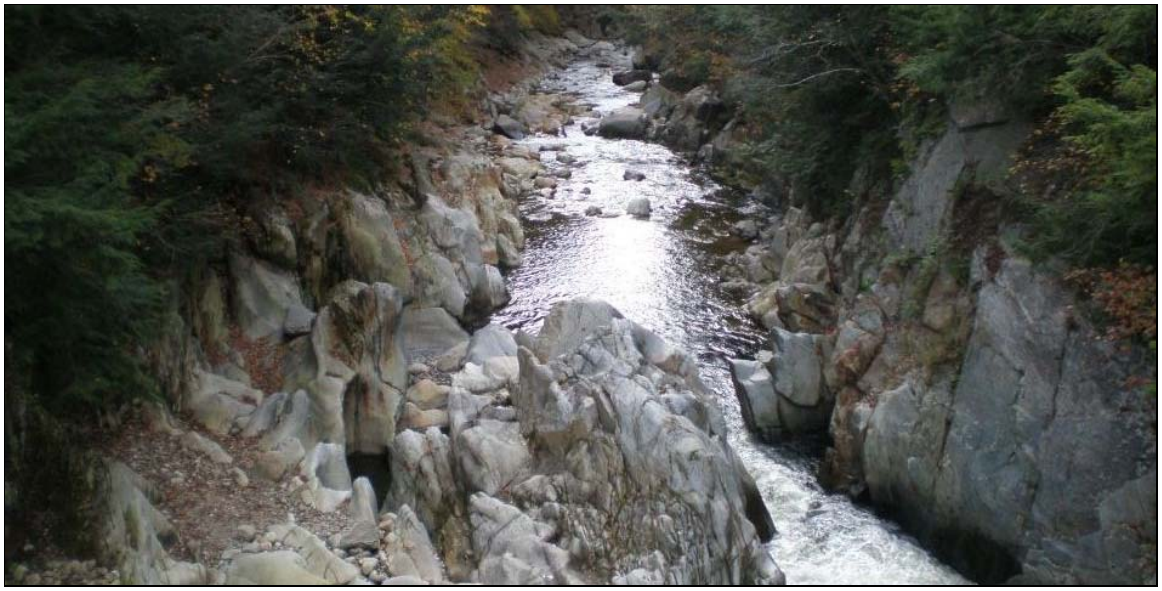

Figure 20. M04 consists of the Upper Clarendon Gorge.

RIVER SECTION 4: UPPER CLARENDON GORGE TO CONFLUENCE WITH THE OTTER CREEK

The final section of river (illustrated in Figure 21) begins below the Upper Clarendon Gorge (near the Kingsley Covered Bridge) in the town of Clarendon. From here down to the confluence with the Otter Creek, the Mill River flows through a few bedrock dominated reaches bordered by state and federally owned wooded landscapes before spilling onto the much broader Otter Creek valley bottom. Major significant impacts in this section include removal of riparian vegetation, channel straightening, dredging, and several undersized bridges.

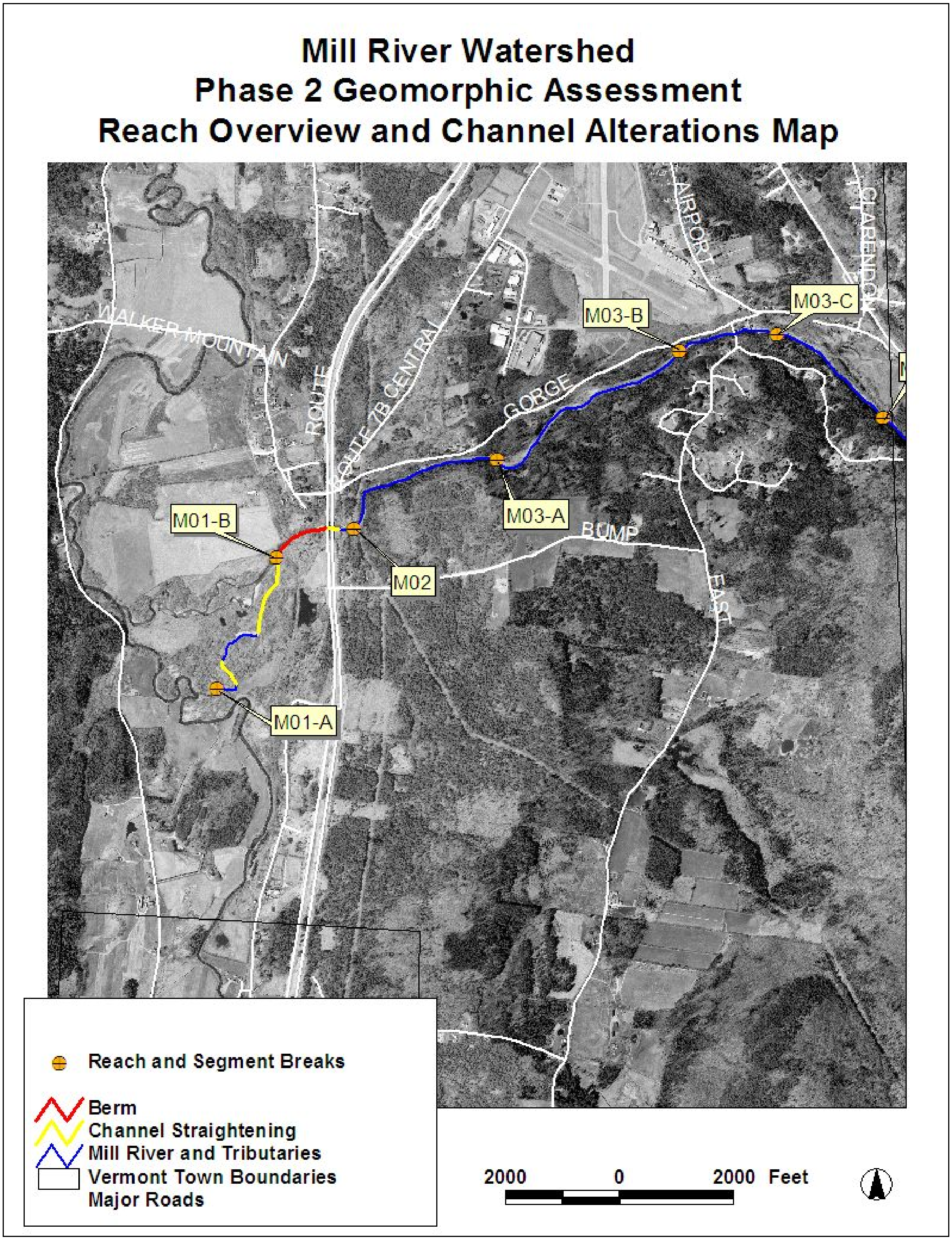

Figure 21: Overview of reaches M01 through M03 and channel straightening and berming.

4.13 Reach M03

Mill River reach M03 flows through residential and forested land in the town of Clarendon. The reach begins near the Clarendon/Shrewsbury town line at the end of the Upper Clarendon Gorge. RRD divided this reach into three segments due to significant changes in channel dimensions, entrenchment, and grade controls that occur throughout this reach.

Segment C:

This segment is located between the Upper Clarendon Gorge (a bedrock controlled section) and the bedrock controlled segment at the former Kingsley Mill site. Channel incision observed here may be a result of the river working back through sediments that were stored when there was a mill dam, or due to a sediment imbalance upstream. The Mill was in operation from 1882 until 1935. There are residences encroaching on the river corridor on the left bank, and land was cleared for agriculture on the right of the corridor. This reach was observed to be a B-type channel with a planebed form dominated by gravel substrates (Figure 21). This is expected to be the reference stream type despite major channel widening.

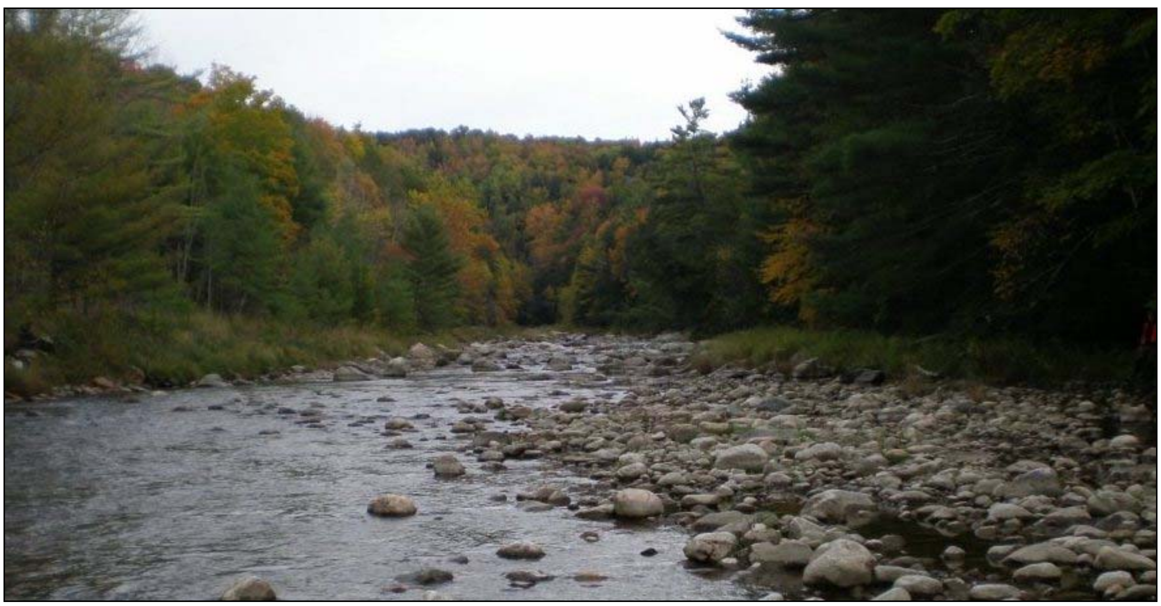

Figure 21. M03-C is a short plane bed segment between two bedrock grade controls.

Segment B:

Segment M03-B is a short bedrock controlled segment that includes the former Kingsley Mill dam site (Figure 22). Bedrock grade control and bedrock on most of the banks limited this segment to receiving only a partial Phase 2 assessment. Although some residential development has affected the riparian buffer, in general the bedrock has created a stable geomorphic condition in this segment.

Figure 22. M03-B is a bedrock controlled segment at the site of the former Kingsley Mill.

Segment A:

Mill River segment M03-A is also located between two bedrock grade controlled segments. Although this segment is slightly incised, it seems to be an area of sediment and floodwater attenuation, having large gravel bars, accessible floodplains and a forested buffer greater than 100 feet on both sides (Figure 22). As a result of the incision there is evidence of widening that has occurred in this segment. Minor planform and aggradation were observed as the stream rebuilds floodplain on both the left and right banks. This area will likely continue to be an important area in the lower Mill River watershed for sediment and floodwater attenuation.

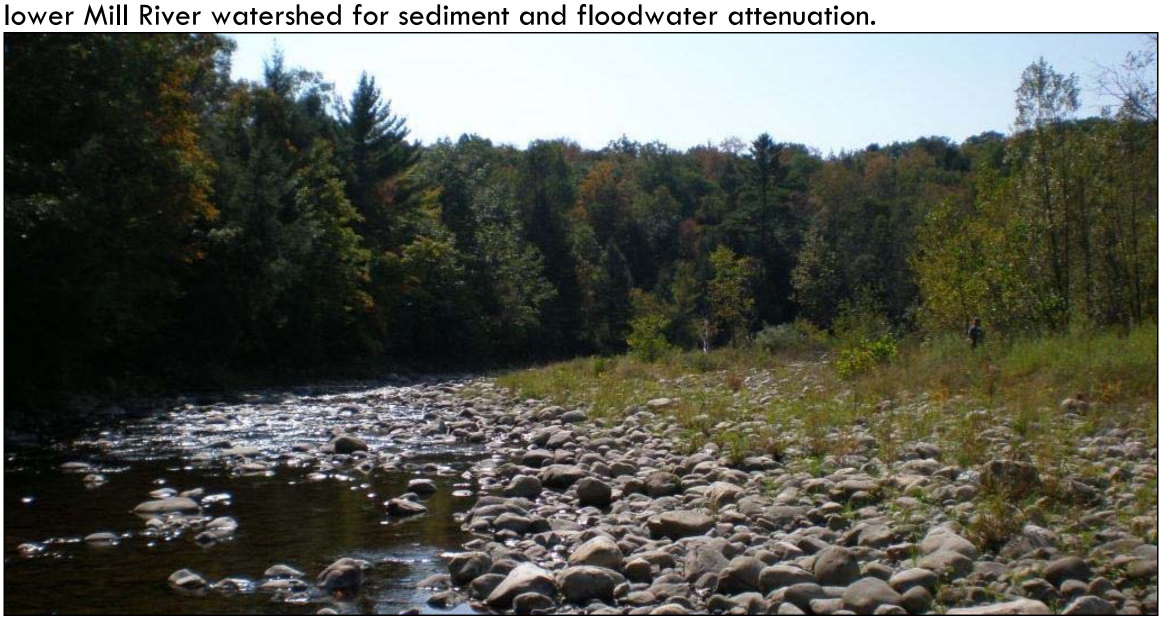

Figure 22. M03-A is bordered by a forested buffer. Large bars of unvegetated sediment indicate recent adjustments in the channel.

4.14 Reach M02

Mill River reach M02 consists of the Lower Clarendon Gorge (Figure 23). The gorge is carved through the Cambrian Dalton formation and Cheshire Quartzite (Van Diver 1987). The Dalton formation lies on Precambrian rocks of the Green Mountain core at the upstream end of the gorge. Only a partial assessment was conducted for this reach due to the bedrock controlled channel.

Figure 23. M02 is the Lower Clarendon Gorge in Clarendon.

4.15 Reach M01

Reach M01 is a highly dynamic reach located at the foothills of the Green Mountains where the Mill River spills out onto the valley floor of the Otter Creek. Here the bedrock dominated channel of the Lower Clarendon Gorge gives way to the alluvial soils of the Otter Creek Valley. This area is a natural alluvial fan area for the Mill River. Channel migration, sediment deposition, and seasonal flooding were likely frequent occurrences in the predevelopment watershed. RRD divided this reach into two segments due to a significant amount of recent channel alteration that has occurred in the area just downstream from the Clarendon Gorge.

Segment B:

Mill River segment M01-B is a C-type channel by reference in a very broad valley. Significant channel management in the form of straightening, dredging, berming, and armoring has significantly altered the channel dimensions and entrenchment of this segment. The current incision ratio was observed to be 1.8 indicating that both berming and bed degradation have affected the nature of the channel. A landowner whose family has managed much of the surrounding land recounts the 1973 flood that washed out the railroad bridge. He noted that there was significant dredging of the stream channel after the 1973 flood between the railroad bridge and Route 7. He also noted that in the 1950's the area below the railroad bridge was dredged for gravel to help build Route 103. Field observers from RRD and VTANR recorded that the channel has become a plane bed cobble dominated channel as a result of increased stream power (Figure 24).

Figure 24. M01-B has been significantly impacted by channel straightening, berming, dredging, and armoring.

Segment A:

M01-A is the lowest reach of the Mill River. This segment is located at a highly dynamic zone where floodwaters and sediment coming down from the relatively steep Green Mountain hillsides are released in the flat valley bottom of the Otter Creek. Scientists from RRD and VTANR observed a high degree of bank erosion and channel adjustment in this segment (Figure 25). The steambank material are composed of silts and clay near the confluence with the Otter Creek and the bank height increases significantly which is likely due to the influence of the Otter Creek. There is plenty of woody debris recruitment in this reach as the river migrates laterally pulling in trees. Although some areas are in need of a healthier riparian buffer, the habitat in this reach overall looks to provide good depth cover and structure. It is certain that continued investment in channel management will be necessary in order to keep the channel in its relative location, however this area is highly dynamic and should be expected to always be undergoing extreme adjustment, especially during flood events as the river reacts to changes in sediment transport and hydrology in the watershed upstream.

Figure 25. M01-A is a gravel dominated reach near the confluence with the Otter Creek. Agricultural land use dominates the corridor. The river is undergoing extreme planform adjustment and major widening and aggradation.

APPENDIX C

BRIDGE AND CULVERT REPORT

Mill River

Rutland County, Vermont

Bridge and Culvert Report

February 17, 2009

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Mill River
Rutland County, Vermont
Bridge and Culvert Report

EXECUTIVE SUMMARY

- Round River Design was retained by the Rutland Regional Planning Commission (RRPC) to conduct a Bridge and Culvert Assessment of the Mill River Watershed limited to the Phase 2 assessed reaches (M01-M15 and T2.01).
- The Vermont Agency of Natural Resources (ANR) Bridge and Culvert Assessment and Survey Protocols (dated July 2007) were used to conduct a rapid assessment of stream crossings. The assessment results were entered into the ANR bridge and culvert database. A photo log of the structures was created.
- The objective of the analysis is to identify structures whose replacement would lend to geomorphic stability at a reach or segment scale, as well as structures that may be at risk of failure.
- A total of 15 bridges within the towns of Clarendon, Shrewsbury, Wallingford, and Mount Holly were surveyed during August and September of 2007. The stream crossings included 10 structures on state roads, 3 bridges on town roads, and 2 privately owned crossings.
- All of the structures surveyed were red flagged by the ANR's database for having an attribute that may lend to them being geomorphically incompatible and potentially increasing flood and fluvial erosion hazards and/or stream instability.

1.0 INTRODUCTION

The need to cross the Mill River via bridge is imperative. The act of placing a bridge over the river has historically involved constructing stone footers onto which rest timbers and later iron and steel. The footers (or abutments) were placed close enough together so that a single large timber could span from one side to the other. In a large stream such as the Mill River, these abutments were often narrower than the natural channel. Today, even with new materials, bridge crossings tend to be constructed narrower than the river channel. This narrowing of the river becomes problematic when, during high flows, floodwaters back up due to the constriction. This causes flooding upstream of the bridge. This is worsened by debris that can accumulate at a constricted area including sediment which can accumulate upstream at unnatural locations further exacerbating instability. During flood conditions, pressure is increased on the downstream side of the bridge (similar to placing one's thumb on the end of a garden hose). The extra energy causes erosion and leaves a wide scoured area downstream of the bridge. Furthermore, physical changes to the river channel such as straightening and stone armoring leading up to and through a bridge, even in newer wider bridges, may prevent a river from migrating naturally across the valley bottom and may create fluvial erosion hazards.

Round River Design was retained by the Rutland Regional Planning Commission (RRPC) to conduct a Bridge and Culvert Assessment of the Mill River Watershed limited to the reaches that received a Phase 2 assessment (M01-M15 and T2.01). In total 15 structures were assessed according to

VTANR protocols for such characteristics as specific height and width, geomorphic and fish passage data, nearby vegetation, and evidence of wildlife. The assessment results were entered into the ANR bridge and culvert database. The objective of this analysis is to identify structures that are potential barriers to fish and wildlife movement and/or are flood or erosions hazards.

2.0 METHODOLOGY

The Bridge and Culvert Assessment and Survey Protocols specified in Appendix G of the Vermont Stream Geomorphic Assessment Handbook (Vermont Agency of Natural Resources 2007) were followed. All assessment data were recorded on the Agency of Natural Resources (ANR) "Bridge and Culvert Assessment – Geomorphic & Habitat Parameters" data sheet, and were entered into the Bridge and Culvert database. ArcView shapefiles of stream crossings for the State of Vermont " TRANS_TRANSTRUC_POINT" were downloaded from the Vermont Center for Geographic Information. This shapefile includes stream crossings on state and town roads. With the exception of a private road in Mount Holly and two railroad bridges, all other structures were the maintenance responsibility of the town or state.

The bankfull channel width was measured in areas close to, but uninfluenced by, each of the structures. This measurement was compared to the Vermont Regional Hydraulic Geometry Curves as a QA check. The channel measurements were then compared with structure widths to determine whether the structures created a constriction in the channel and/or floodplain of the Mill River. Latitude and longitude at each of the structures was determined using orthophotographs and ArcView GIS. The assessment included photo documentation of the inlet, outlet, upstream, and downstream of each of the structures.

3.0 RESULTS

Fifteen bridges were included in the bridge and culvert assessment (see Figure 2). As shown on in Table 1 and 2, all 15 structures were flagged on the ANR's bridge failure mode report for some geomorphic incompatibility. In particular a number of bridge and culverts were observed to be considerably narrower than the existing bankfull width subsequently causing instability in the river. Narrow crossings reduce sediment transport capacity and disconnect floodplains from the river channel. In particular need of replacement based on the problems observed and their percent bankfull width are the Route 155 Bridge in East Wallingford and the Barlow Road Bridge in Mount Holly. Also the two structures located on T2.01were found to be undersized. From a technical measurement (from footing to footing) the railroad bridge on M11-A does not appear to be a problem, however, the channel width of the river from bridge abutment to the Route 155 embankment was only 39 feet (70% reference channel width) and should also be considered a problem structure (Figure 1).

Figure 1: The railroad bridge span on M11-A is adequate for the Mill River (red line), however, location of Route 155 in relation to the bridge and the river creates a channel constriction between the bridge abutment and the road (yellow line).

TABLE 1: MILL RIVER BRIDGES: PROBLEMS AND POTENTIAL FAILURE MODES

Reach	Road	Type	F1	F2	F3	F4	F5	F6	P1	P2	P3	P4	P5	P6	P7	Width
M15	Private road	Bridge	-	-	-	X	-	X	X	X	X	X	-	-	X	111 %
M14	BARLOW RD	Bridge	-	-	-	-	-	-	-	-	-	-	-	-	X	77 %
M11-B	ROUTE 155	Bridge	-	X	X	X	X	X	-	X	X	-	-	-	X	54 %
M11-A	Railroad	Bridge	X	-	-	X	-	X	X	-	-	-	-	-	-	190 %
M10	ROUTE 140-EAST	Bridge	-	-	-	X	-	X	X	-	X	X	-	-	X	172 %
M10	VILLAGE ST	Bridge	-	-	X	X	-	X	-	-	X	-	-	-	X	253 %
M08	Railroad	Bridge	-	-	X	-	-	X	X	X	X	-	-	-	X	163 %
M06	VT RTE 103	Bridge	-	-	-	-	-	X	-	-	-	-	X	-	X	171 %
M05	VT RTE 103	Bridge	-	-	-	X	-	X	X	-	X	X	-	-	X	237 %
M03-B	EAST ST	Bridge	-	-	X	-	-	-	-	X	-	-	-	-	X	85 %
M01-B	ROUTE 7	Bridge	-	-	-	X	-	X	X	-	-	X	-	-	X	364 %
M01-B	ROUTE 7	Bridge	-	-	-	X	-	X	X	-	-	X	-	-	X	364 %
M01-B	Railroad	Bridge	-	-	-	X	-	X	X	-	-	X	-	-	X	154 %
T2.01-B	BOWLSVILLE RD	Bridge	-	X	X	X	X	-	-	X	X	-	-	-	X	50 %
T2.01-A	ROUTE 140-EAST	Bridge	-	X	X	X	X	X	X	X	-	X	X	-	X	61 %

Failure Modes

F1 Concern for structure due to fluvial condition or process

F2 Potential failure due to out-flanking

F3 Potential failure due to scour

F4 Potential failure due to ice or debris jam

F5 Structure related damage due to flooding of adjacent property

F6	Structure related damage due to erosion of adjacent property
	Existing Problems
P1	Upstream sediment deposit
P2	Upstream Scour and/or erosion present
P3	Downstream Scour and/or erosion present
P4	Inlet obstruction present
P5	Poor location or alignment
P6	Beaver activity
P7	Floodplain filled entirely or partially by roadway approaches
Width	Structure width divided by channel width as a percent (% bankfull width)

TABLE 2: MILL RIVER BRIDGES: Failure Modes Report – Problem Causes

			Upstream Sediment Deposition			Upstream Scour and Erosion			Downstream Scour and Erosion				Poor Location and Alignment		
Reach	**Road**	**Bankfull Width %**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C12**	**C13**	**C14**
M15	Private road	154 %	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
M14	BARLOW RD	85 %	No	No	No	No	No	Yes	No	No	No	No	No	No	No
M11-B	ROUTE 155	364 %	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
M11-A	Railroad	364 %	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
M10	ROUTE 140-EAST	111 %	Yes	No	No	No	Yes	No	No	Yes	No	No	No	No	No
M10	VILLAGE ST	77 %	No	No	No	No	No	No	No	No	No	No	No	No	No
M08	Railroad	50 %	No	No	No	No	No	Yes	No	No	Yes	No	No	No	No
M06	VT RTE 103	54 %	No	No	No	Yes	Yes	Yes	No	No	No	No	No	No	No
M05	VT RTE 103	171 %	No	No	No	No	No	No	No	No	No	No	No	No	Yes
M03-B	EAST ST	237 %	Yes	No	No	No	No	No	No	Yes	No	No	No	No	No
M01-B	ROUTE 7	190 %	No	No	Yes	No	No	No	No	No	No	No	No	No	No
M01-B	ROUTE 7	163 %	No	No	Yes	No	No	Yes	Yes	No	Yes	No	No	No	No
M01-B	Railroad	172 %	Yes	No	No	No	No	No	No	Yes	No	No	No	No	No
T2.01-B	BOWLSVILLE RD	61 %	Yes	Yes	No	Yes	Yes	No	No	No	No	No	Yes	No	No
T2.01-A	ROUTE 140-EAST	253 %	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No
		154 %	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No

Explanation of codes used in table header

Upstream Sediment Deposition

- **C1** Opening obstructed by sediment
- **C2** Sediment deposits >= half bankfull
- **C3** steep riffle upstream

Upstream Scour and Erosion

- **C4** Bank armoring failing
- **C5** Bank erosion high
- **C6** Scour under structure

Downstream Scour and Erosion

- **C7** Bank armoring failing
- **C8** Bank erosion high
- **C9** Scour under structure
- **C10** Banks higher downstream than upstream
- **C11** Culvert outlet is cascade or freefall

Poor Location or Alignment

- **C12** Stream approach angle is sharp bend
- **C13** Located at significant valley break
- **C14** Avulsion follow road

In order to assist the towns with priorities for replacement of these structures, priority lists were generated using the information and photographs taken during the assessment. The bridge span and the culvert diameter as a percentage of the channel width were used as a first cut in prioritizing the structures for replacement. Bridges and culverts with channel widths of approximately 70 percent of the bankfull width or less, which were significantly impeding natural sediment transport were placed in Category 1.

Category 2 structures included the remaining structures with percent bankfull widths less than 100%, which were not selected for Category 1. The priority 2 category is of lower priority for replacement, but still contains structures that may be incompatible in terms of sediment transport. Category 3 structures have a percent bankfull width which is greater than or equal to 100 percent.

3.1 Priority One Structures

The category 1 structures are summarized below in Table 1, and are identified on the map in Figure 3.

Table 3: Priority 1 Structures for Replacement

Town	Location	% BF Width	Problems Noted By RRD
Mount Holly	Bowlsville Road North	50	Scour downstream of structure, riprap around outlet failing
Mount Holly	VT Route 155	54	Channel constriction
Wallingford	Rte 140 East	61	Downstream undermining, high debris jam potential

3.2 Priority Two Structures

Based on the results of the ANR Bridge and Culvert Assessment, the structures with percent bankfull widths of less than 100% (but greater than 70%) were placed in the list of priority two structures because they did not appear to be a high priority in terms of sediment transport. One additional structure was added due to concerns raised during field observations. A brief explanation of these structures is provided below.

Table 4: Priority 2 Structures for Replacement

Town	Location	% BF Width	Problems Noted By RRD
Mount Holly	Barlow Road	77	Scour downstream of structure, riprap around outlet failing
Clarendon	East Street	85	Channel constriction

3.3 Priority Three Structures

All of the remaining structures with culvert diameters or spans of greater than 100 percent bankfull width were placed in category three. At this time, the priority 3 structures are a lower priority for replacement. In the future, replacement of these structures should include consultation with the Vermont State River Management Program in order to ensure geomorphic compatibility.

4.0 RECOMMENDATIONS

Due to the significant impact that undersized structures can have on the stability, habitat, and flood hazard of the Mill River, the towns, state, and federal government should work together to replace and/or retrofit undersized bridges and culverts and ensure all new structures are sized for geomorphic compatibility.

REFERENCES

Vermont Agency of Natural Resources. 2007. Vermont Stream Geomorphic Assessment, Appendix G: Bridge and Culvert Assessment and Survey Protocols. Waterbury, Vermont

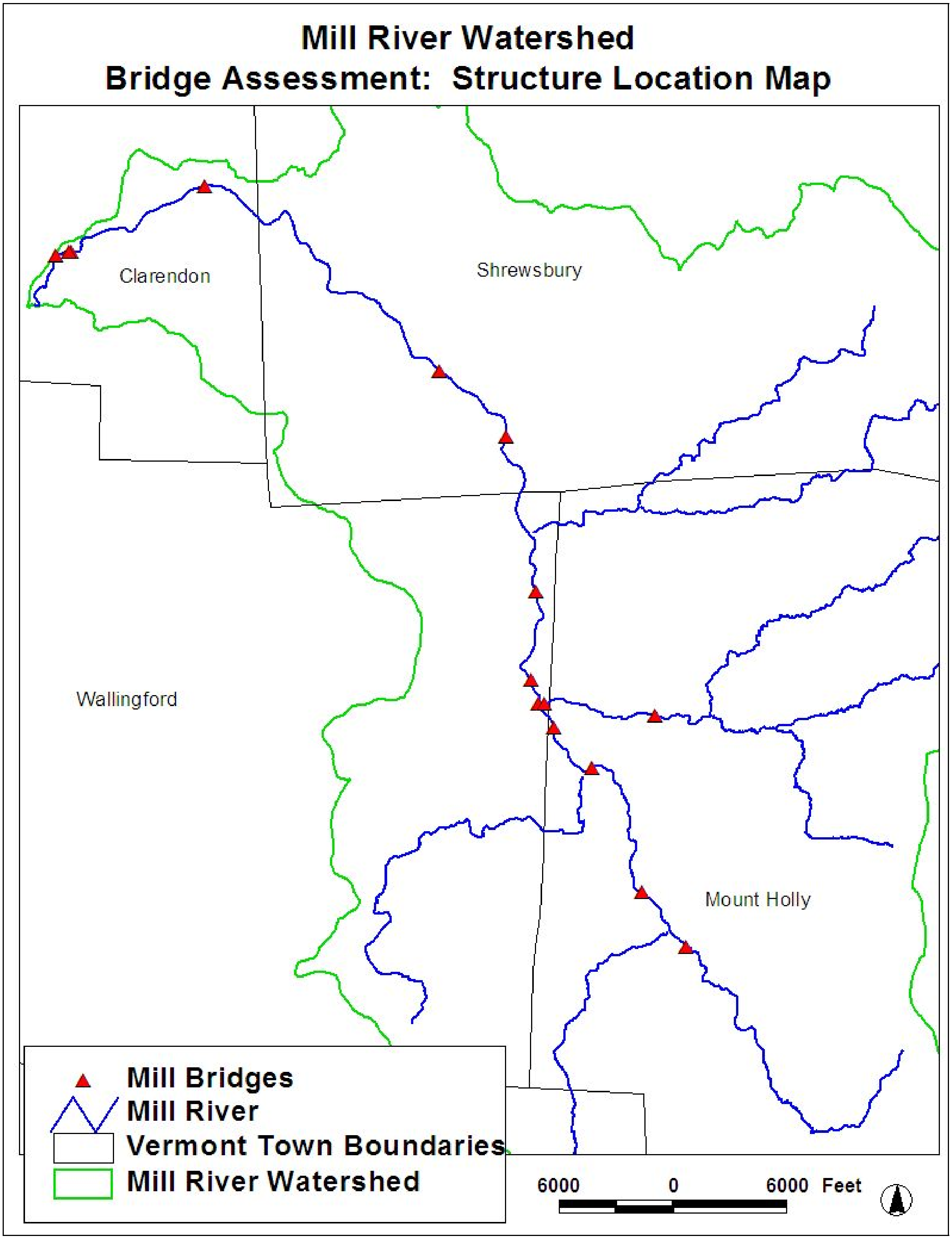


Figure 2. Bridges and culverts assessed during fall 2007 by Round River Design using the ANR protocol.

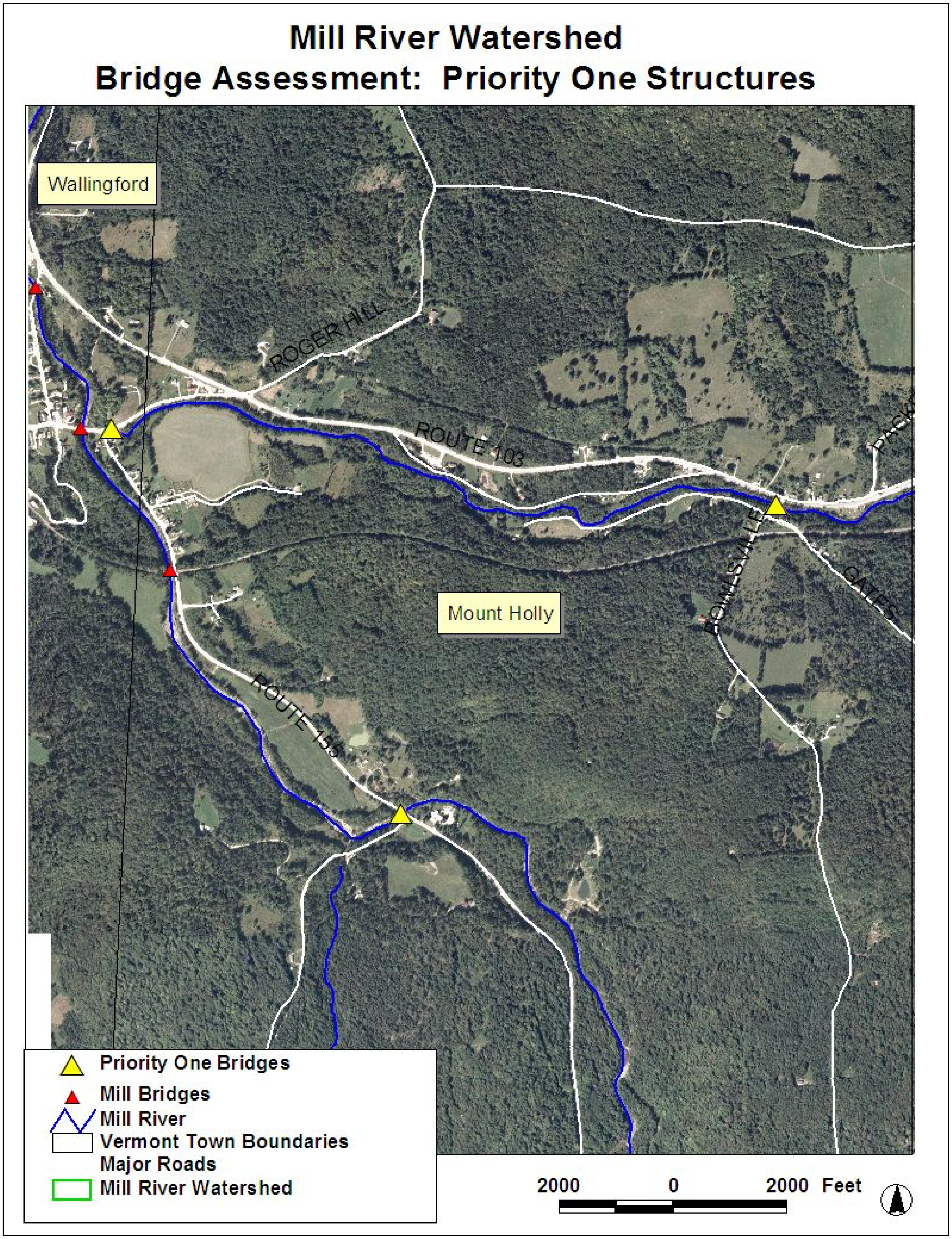


Figure 3. Stream crossings in the Mill River watershed considered to be high priority for replacement due to geomorphic incompatibility.

APPENDIX D

Channel Evolution Models

(Vermont Agency of Natural Resources, Appendix C, May 2007)

Channel Evolution Models

F-stage Channel Evolution Process

The capital letters used throughout the following discussions refer to the stream types (Rosgen, 1996) typically encountered as the channel form passes through the different stages of channel evolution. The F-stage adjustment process begins where the streams are not entrenched and have access to a floodplain at the 1-2 year flood stage. Moderately entrenched, semi-confined “B” streams may also go through an F-stage channel evolution. This channel evolution model (CEM) is based on the assumption that the stream has a bed and banks that are sufficiently erodible so that they can be shaped by the stream over the course of years or decades. Streams beginning this process are typically flowing in alluvium or other materials that may be eroded by an increase in stream power. As the incision process continues, they may degrade to bedrock or glacial till materials. When a stream with a low width to depth ratio (“E” stream types) goes through this process, the sequence of stream types may be **E-C-F-C-E** (other forms may include **E-C-G-F-C-E** or **C-G-F-C** or **C-F-C** or **C-B-F-B-C** or **B-G-F-B** or **B-G-F** or **C-B-C**).

Stage I - Channel in regime with access to floodplain or flood prone area at discharges at and above the average annual high flow. Planform is moderate to highly sinuous; supportive of energy dissipating bed features (steps, riffles, runs, pools) essential to channel stability (B, C and E Stream Types). Channel slope (vertical drop in relation to length) generates flow velocities and stream power in balance with the resistance of stream bed and bank materials. Sediment transport capacity in equilibrium with sediment load.

Stage II - Channel has lost access to its floodplain or flood prone area, at its historic bankfull discharge, through a bed degradation process or floodplain build up. Stream has become more entrenched as discharges in excess of the annual high flow are now contained in the channel (B or G or F Stream Type). Channel slope is increased with commensurate increase in velocity and power to erode the stream bed and banks (boundary materials). The result of preventing access to the floodplain and containing greater flows in the channel is to increase the stream’s power that must be resisted by the channel boundary materials; i.e., the rocks, soil, vegetation or man-made structures that make up the bed and banks of the river. Plane bed may begin to form as head cuts move upstream and step/riffle materials are eroded.

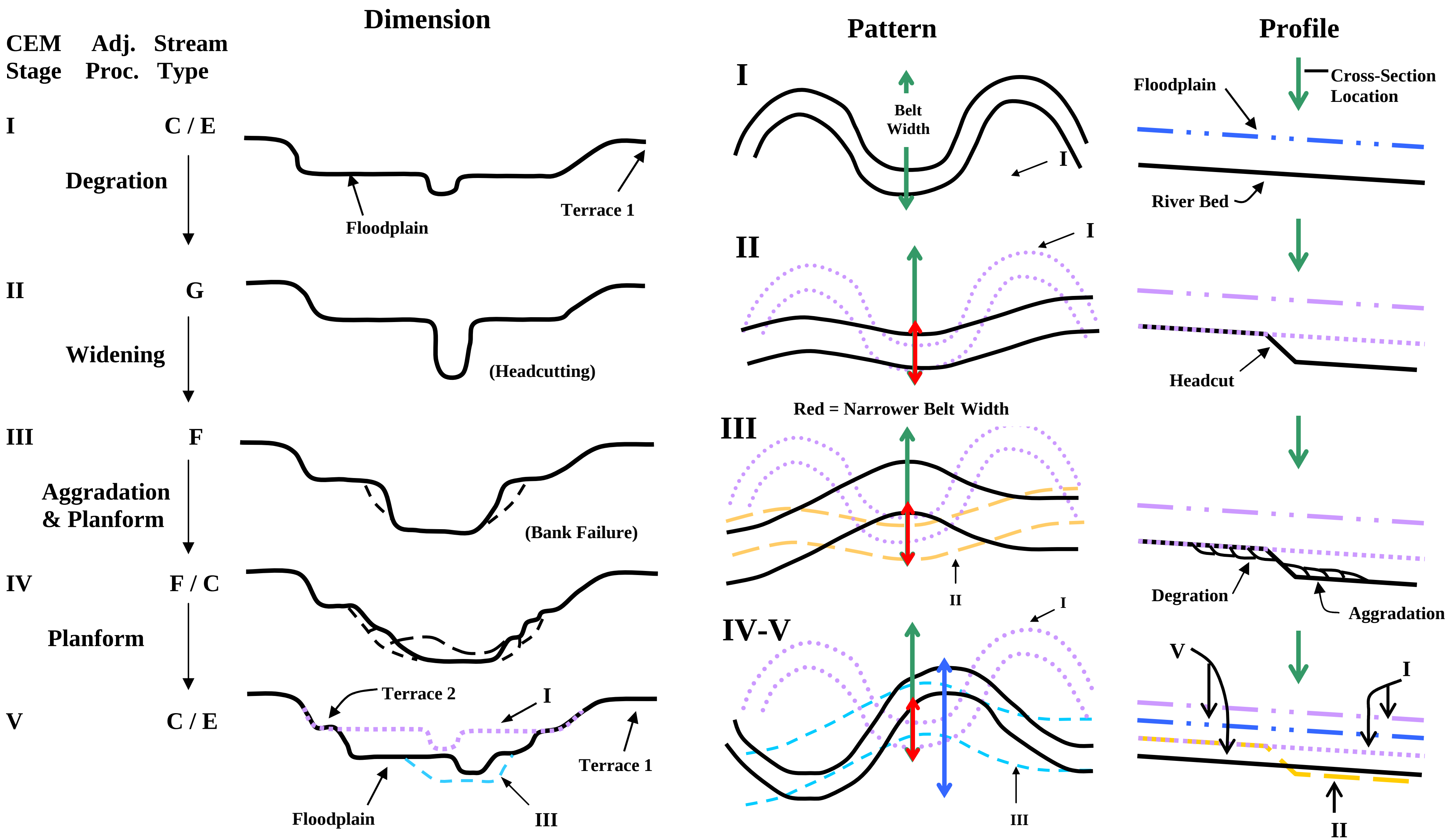
Stage III - Channel is still entrenched, widening and migrating laterally through bank erosion caused by the increased stream power (B or G or F Stream Type). The system regains balance between the power produced and the boundary materials as sinuosity increases and slope decreases. There are profound physical adjustments that occur upstream and downstream from the site of alteration as bed degradation (head cuts) migrates up through the system and aggradation in the form of sedimentation occurs downstream. Stream bed largely becomes a featureless plane bed.

Stage IV - Channel dimension and plan form adjustment process continues. Channel width begins to narrow through aggradation and the development of bar features. The main channel may shift back and forth through different flood chutes, continuing to erode terrace side slopes as a juvenile floodplain widens and forms. Weak step/riffle-pool bed features forming. Transverse bars may be common as planform continues to adjust. At Stage IV, erosion may be severe. Historically, channels have been dredged, bermed, and/or armored at this Stage pushing the process back to Stage II or III.

Stage V - Channel adjustment process is complete. Channel dimension, pattern, and profile are similar to the pre-adjustment form but at a lower elevation in the landscape (B, C and E Stream Types). Planform geometry, longitudinal profile, channel depth, and bed features produce an energy grade that is in balance with the sediment regime produced by the stream’s watershed.

Higher gradient, more entrenched streams (“A” or “B” stream types) with erodible beds also go through channel evolution processes that involves bed degradation. In these cases, the floodplain forming stages may be comparatively minor. A lowering of the bed elevation is more quickly followed by a re-sloping of the banks until the appropriate energy grade is achieved.

F-stage Channel Evolution Process (VTDEC-Modified from Schumm, 1977 & 1984 and Thorne et al, 1997)



D-stage Channel Evolution Process

Only use the D stage CEM where the stream has no opportunity to incise. If the stream has incised and has now hit bedrock or clay and is currently widening, you would still use the F stage CEM.

The capital letters used throughout the following discussions refer to the stream types (Rosgen, 1996) typically encountered as the channel form in the different stages of channel evolution. The difference between F and D-stage channel evolution processes is the degree of channel incision. In D-stage channel evolution, the dominant, active adjustment processes is **aggradation**, widening, and plan form change. In some situations, the stream may not experience any degradation because its bed is significantly more resistant to erosion than its banks. The process may start with limited vertical adjustment and goes right into aggradation and a lateral adjustment processes. Stream with low width to depth ratios ("E" Stream Types) may also go through this process.

Stage I - Channel in regime with access to floodplain or flood prone area at discharges at and above the average annual high flow (B, C and E Stream Types). Plan form is moderate to highly sinuous; supportive of energy dissipating bed features (steps, riffles, runs, pools) essential to channel stability. Channel slope (vertical drop in relation to length) generates flow velocities and stream power in balance with the resistance of stream bed and bank materials. **Then either of the following Stage II scenarios may occur:**

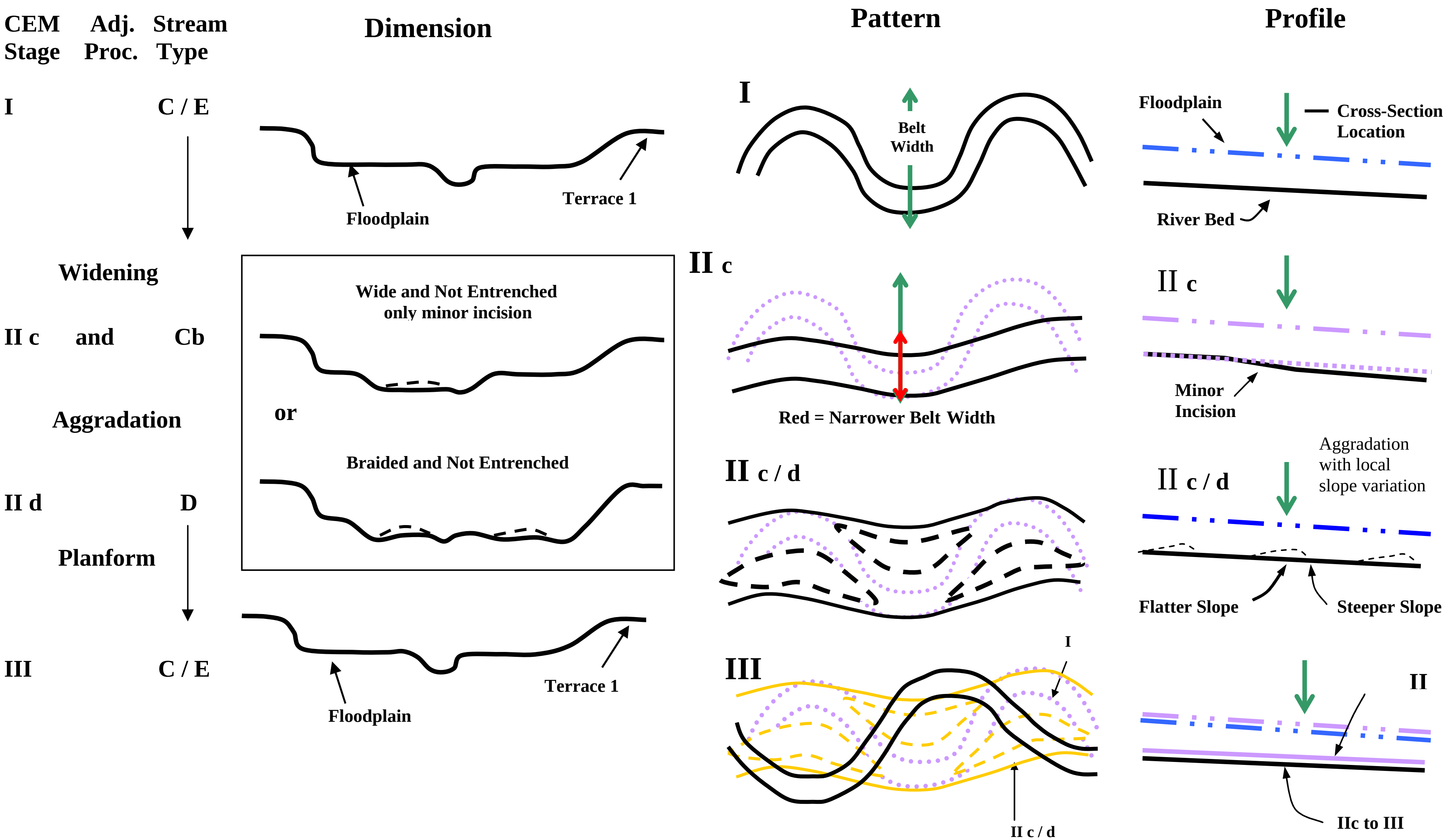
Stage IIc Steeper gradient may be imposed through activities such as channelization, but due to the resistance of the bed material, the stream has not incised significantly or lost access to its floodplain (remaining a "C" Stream Type). Channel is widening and migrating laterally through bank erosion caused by the increased stream power. The balance between stream power and boundary materials is re-established when the slope flattens after a process of channel lengthening and increased sinuosity. Stream bed may be a combination of poorly defined riffle-pool and plane bed features.

Stage IId Channel becomes extremely depositional and becomes braided with water flowing in multiple channels at low flow stage ("D" stream type). Dimension and plan form adjustment processes continue. Channel width begins to narrows through aggradation and the development of bar features. The main channel may shift back and forth through different channels and chute cut-offs, continuing to erode banks or terrace side slopes. Riffle-pool bed features develop as single thread channel begins forming. Transverse bars may be common as planform continues to adjust.

Stage III Channel adjustment process is complete (back to a B, C or E stream type). Channel dimension, pattern, and profile are similar to the pre-adjustment form. May or may not be at a lower elevation in the landscape. Planform geometry, longitudinal profile, channel depth, and bed features produce an energy grade (sediment transport capacity) that is in balance with the sediment regime produced by the stream watershed.

Important Notes: 1) The imposition of new constraints or changes at watershed, reach, or local scales, especially those related to large floods that energize the stream system with high flows of water, sediment, and debris, will affect the time scales associated with each stage of channel evolution. They may also have dramatic effects on the direction of a channel evolution process. The overlapping pulses of channel adjustment moving upstream and downstream in a watershed often makes the pinpointing of a specific channel evolution stage complicated. 2) Bedrock-controlled reaches in Vermont are presumed to be relatively fixed for the purposes of these protocols as little bed or back erosion can be expected even over a century. Such reaches may, however, dramatically change or evolve due to rapid or catastrophic avulsions of the flow onto more erodible sediments nearby, leaving the bedrock channel wholly or partially abandoned.

C-D-C Channel Evolution Process (VTDEC-Modified from Schumm, 1977 & 1984 and Thorne et al, 1997)



APPENDIX E

FLUVIAL EROSION HAZARD ANALYSIS

Mill River

Clarendon, Shrewsbury, Wallingford, and Mount Holly
Rutland County, Vermont

Fluvial Erosion Hazard (FEH) Analysis

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Mill River

Clarendon, Shrewsbury, Wallingford, and Mount Holly
Rutland County, Vermont

Fluvial Erosion Hazard (FEH) Analysis

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Mill River
Rutland County, Vermont
Fluvial Erosion Hazard (FEH) Analysis

1.0 EXECUTIVE SUMMARY

- Round River Design was retained by the Rutland Natural Resource Conservation District to analyze a draft Fluvial Erosion Hazard (FEH) Zone developed for the Mill River Phase 2 study area by the Vermont Agency of Natural Resources.

- The Vermont Agency of Natural Resources FEH Zone Analysis utilized Phase 2 data collected during the autumn of 2007 by Round River Design and a valley wall verification performed by VTANR staff scientists.

- The objective of the analysis is to compare the proposed FEH zone to the existing zoning, structures, and conserved lands in order to determine the effect of the FEH zoning on property along the Mill River.

- The greatest concentration of existing structures lie in the village centers of East Wallingford and Cuttingsville. Here FEH zoning would affect the greatest number of landowners.

- Many reaches have little or no existing structures in the FEH corridor. Designation of an FEH corridor in reaches with little or no existing structures would be a proactive approach that may assist in long term channel stability.

- The Towns of Clarendon, Shrewsbury, Wallingford, and Mount Holly should work with the VTANR and the Rutland Regional Planning Commission to consider the adoption of a FEH Overlay District into their Town Regulations.

- Education about the FEH corridor and erosion hazard risks would be a valuable service for landowners.

2.0 INTRODUCTION

Round River Design was retained by the Rutland Natural Resource Conservation District (RNRCD) to develop a River Corridor Plan for the Mill River. The Vermont Agency of Natural Resources (VTANR) uses the “river corridor” as a primary tool in its avoidance strategy to restore and protect the natural values of rivers and to minimize flood damage. River corridors consist of lands adjacent to and including the present channel of a river. The adjacent lands included in a "corridor" are those that are capable and perhaps likely to be occupied by the channel itself as the river meanders within a valley bottom over time (For a technical description of how they are delineated see "River Corridor Protection Guide: Fluvial Geomorphic-Based Methodology to Reduce Flood Hazards and Protect Water Quality" (VTANR 2008)). River corridor planning is conducted in Vermont to remediate the river instability that is largely responsible for erosion and flooding conflicts, increased sediment and nutrient loading to surface waters, and a reduction in river habitat (VTANR 2007). Reducing current and future near-stream investment and achieving natural stream stability promotes a sustainable relationship with rivers over time, minimizing the costs associated with floods ($14 Million annually average in Vermont) and maximizing the benefits of clean water and healthy ecosystems (VTANR 2008). The Mill River Corridor Plan is derived significantly from data collected from a stream geomorphic assessment project. Stream geomorphic assessments provide information about the physical condition of streams and the factors that influence their stability.

As a component of the River Corridor Plan, Round River Design was retained by the Rutland Natural Resource Conservation District (RNRCD) to analyze the draft Fluvial Erosion Hazard (FEH) Zone of the Mill River (limited to the reaches that received a Phase 2 assessment (M01-M15 and T2.01) (see Figure 1). The draft FEH Zone was created by the Vermont Agency of Natural Resources following the Phase 2 Geomorphic Assessment (Blazewicz, 2007). The objective of this analysis is to compare the draft FEH zone to the existing zoning, structures, and conservation lands within the Mill River corridor to determine the effect of adoption of FEH Zoning on these properties.

Kari Dolan of the VTDEC developed the FEH overlay zone using the Stream Geomorphic Assessment Tool (SGAT) and the VTANR FEH approach (Vermont Agency of Natural Resources 2005a and 2008). Data regarding the current condition of the stream channel was provided by Round River Design and formed the backbone of the FEH zone development.

2.1 Fluvial Erosion Hazard Zones

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

The purpose of defining Fluvial Erosion Hazard Zones is to prevent increases in fluvial erosion resulting from uncontrolled development in identified fluvial erosion hazard areas; minimize property loss and damage due to fluvial erosion; prohibit land uses and development in fluvial erosion hazards areas that pose a danger to health and safety; and discourage the acquisition of property that is unsuited for the intended purposes due to fluvial erosion hazards (VTANR 2005b).

The basis of a Fluvial Erosion Hazard Zone is a defined river corridor which includes lands adjacent to and including the course of a river. The width of the corridor is defined by the lateral extent of the river meanders, called the meander belt width, which is governed by valley landforms, surficial geology, and the length and slope requirements of the river channel. The width of the corridor is also governed by the stream type and sensitivity of the stream. River corridors, further defined through VTDEC Geomorphic Assessments (VTANR 2007), are intended to provide landowners, land use planners, and river managers with the area of land which would accommodate the meanders and slope of a balanced or equilibrium channel, which when achieved, would serve to maximize channel stability and minimize fluvial erosion hazards.

NOTE: It should be noted that the glacial history of the Mill River may have created soils along valley side slopes and river terraces that are extremely erodable. Although a Fluvial Erosion Hazard Zone may protect against hazards in the beltwidth of the river, where the Mill River runs up against its valley walls, there may be danger of landslide hazard. A discussion of landslide hazard should be included with any discussion of adoption of Fluvial Erosion Hazard Zones.

2.2 Riparian Protection

It is also important to note that depending on a landowner's goals the area deserving consideration for conservation, restoration, or protection from encroachment may extend beyond delineated FEH zones. For example, vegetated buffers measuring back from the top of an existing stream bank may extend beyond an FEH zone in order to capture some of the other ecological and water quality benefits such as habitat for wildlife, water quality improvements, and landslide hazard protection. Riparian landowners are encouraged to work on a voluntary basis with the Rutland Natural Resource Conservation District (RNRCD) to protect and enhance riparian buffers along the Mill River. Some federal and state programs may assist landowners in funding streamside reforestation projects.

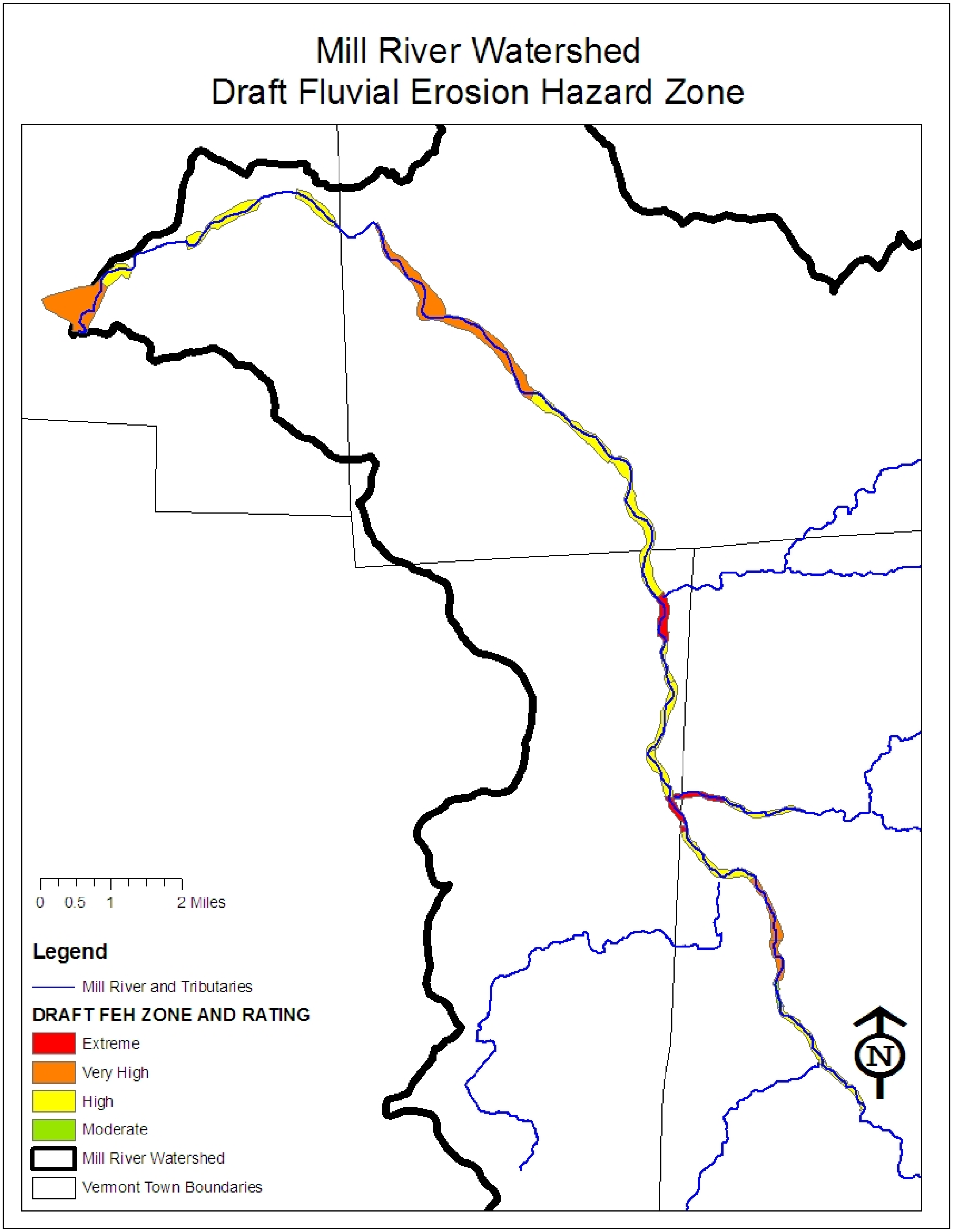

Figure 1: Draft FEH Zone developed by the VTANR.

3.0 METHODOLOGY

Utilizing the FEH Zone drafted by the VTDEC, Round River Design conducted a reach by reach review to investigate how adoption of an FEH zone would interact with existing zoning, as well as to investigate how adoption may affect landowners. In order to conduct this analysis, an Emergency 911 dataset of existing structures was obtained from the Vermont Center for Geographic Information website. Additionally, zoning maps were obtained from the Rutland Regional Planning Commission.

FEH Sensitivity Rating	FEH Corridor Width (related to reference channel width)	Typical Mill River Setting
Very Low	Equal to reference channel width	Bedrock controlled channels (gorges)
Low	Equal to reference channel width	None in this study
Moderate	Four channels widths	Semi-confined channels with good geomorphic stability
High	Six channel widths *(8+ channel widths on "E" type streams)*	Moderate sloped channels, may be somewhat confined, that have some but limited human impact
Very High	Six channel widths *(8+ channel widths on "E" type streams)*	Unconfined channels that have been significantly impacted by humans
Extreme	Six channel widths *(8+ channel widths on "E" type streams)*	Channels that have been significantly impacted and have undergone a stream type departure to a highly unstable channel

Below is reach-based summary of the current channel conditions and the opportunities and challenges for property protection as implicated by an FEH district overlay. Following the narrative summaries are recommendations for further actions that the Towns, VTDEC, and RNRCD may wish to pursue.

4.0 RESULTS

M15: Mount Holly

<u>*Current Condition*</u>

The most upstream reach, M15 is located at in a very broad valley in the town of Mount Holly. The land on the southwestern border of the stream is pasture land and it appears that the river through this reach had been straightened and pushed up against the right valley wall in order to make more room for agricultural activities. Deep down-cutting into the streambed material has occurred (incision ratio of 2) likely as a result of this straightening. This incision has significantly reduced the capacity of this reach to attenuate floodwater and sediment. Future lateral adjustment is expected to occur as the river works to redevelop floodplain in this reach.

FEH Opportunities and Challenges

Existing Zoning	Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	Construction of a new bridge was observed near the midway point of the reach.
Assets and Liabilities	The left corridor of the reach is currently being used for pasture and hay. Drainage work in the fields (observable in aerial photographs) indicates that much of the land may be wetland and therefore may have some protection from further development.

M14: Mount Holly

Current Condition

Reach M14 begins where Meadow Brook enters the Mill River in the town of Mount Holly. Similar to M15, this reach borders recently agricultural (some no longer in production) land. The river through this reach appears to have been straightened and pushed up against the right (northeast) valley wall. An old meander scar is visible on aerial photographs just upstream from the Barlow Road Bridge indicating a level of historic sinuosity has been lost. Deep incision was observed (measured ratio of 3). Extensive widening and minor planform adjustments are occurring in the reach as the channel works to recover from the high level of incision.

FEH Opportunities and Challenges

Existing Zoning	Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	A single residence exists on the left bank. The structure itself, which sits atop a large terrace which is effectively the valley wall, lies just on the outside of the FEH delineated corridor. Although this house may be protected from fluvial erosion hazard due to the high embankment, there may be landslide potential at this site (which would require further geologic study). There is also a bridge crossing, Barlow Road, within this reach the width of which (77% that of reference bankfull width) may lead to sudden stream migration due to sedimentation during high flow events.
Assets and Liabilities	Much of the land is currently undeveloped. Several landowners own the properties along this reach.

M13: Mount Holly

Current Condition

Reach M13-B is a short segment located where the valley wall of the Mill River narrows thereby creating a semi-confined channel by reference. The channel was found to be slightly incised. Some minor widening has occurred. Extreme adjustments are unlikely in this reach due to the stable tendencies of B3 planebed streams, however, the potential for landslide hazard exists where the river runs along the toe of the valley wall on the left bank. Downstream, Mill River segment M13-A is a short segment located in a broad valley. The river is adjusting laterally through several flood chutes in this segment.

FEH Opportunities and Challenges

Existing Zoning	Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	Some development has occurred along the top of the left valley wall, however, the development is well above the floodplain and is only mentioned as the landowners in this reach are in close proximity to the stream and may have an impact on its water quality. These houses are also located on top of a steep valley wall and may have some erosion hazard risks. Currently most of the FEH Corridor is forested and owned by several landowners.
Assets and Liabilities	The well forested buffer in this corridor is an asset for the river as are the flood chutes and wetlands that will store some water and sediment during a large runoff event.

M12: Mount Holly

Current Condition

Mill River reach M12 begins upstream from Fowler Brook Road in the town of Mount Holly. The river flows through a well forested corridor in a broad valley. There is a great degree of instability in the channel. There were numerous active flood chutes documented as well as new gravel bars indicating both planform adjustment, widening, and aggradation as the channel works to redevelop new floodplain and tend to instability upstream.

FEH Opportunities and Challenges

Existing Zoning	Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	None
Assets and Liabilities	Currently forested.

M11-B: Mount Holly

Current Condition

Mill River segment M11-B captures an area where the valley walls open up and a tributary enters the Mill River from the west. In this segment, soils maps indicate that the parent material is alluvial suggesting the possibility that this area is an alluvial fan. There appears to have been a high degree of historic channel straightening that occurred in this reach, likely in order to increase the amount of agricultural land which dominates the right corridor.

FEH Opportunities and Challenges

Existing Zoning	Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	A major commercial lodging facility (and outbuildings) exists within the FEH corridor on the left bank upstream of the Route 155 bridge. In addition to the hazard posed by the stream itself, the Vermont Route 155 bridge at this location is also significantly undersized (54% of reference bankfull width) and increases the hazard posed to land upstream.
Assets and Liabilities	Land on the right bank is field.

M11-A: Mount Holly/East Wallingford

Current Condition

Mill River segment M11-A is one of two mainstem reaches that run through the Village of East Wallingford. Due to the relative location of the village to the river, extensive channel straightening, armoring, and dredging have altered this channel, likely in response to past flood events.

FEH Opportunities and Challenges

Existing Zoning	• Village B District • Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	Vermont Route 155 and commercial and residential development have significantly encroached on the channel. The bridge at the downstream end of the reach appears to be a debris/ice jam potential hazard - it already has held enough sediment behind the middle pier for a fully vegetated mid -channel bar to form. In addition a railroad bridge crossing which funnels both a road and the river underneath appears to be limiting sediment transport. The upstream aggradation the bridge is likely increasing an erosion issue on pasture land on the left bank of M11-B. Surprisingly, despite the high level of development, the draft FEH corridor affects only two single-family residences located just upstream of the Route 140E bridge (Figure 2). This is largely due to Vermont Route 155 acting as a new valley wall through this reach and protecting the development on its eastern flank. Berming to protect the residence on the right bank is already significant.
Assets and Liabilities	Continued development in the Village setting may be expected.

Figure 2: FEH Zone (red), berms (green) and structures at end of reaches M11-A and T2.01-A.

M10: East Wallingford

Current Condition

Mill River reach M10 flows through East Wallingford Village. This short reach has been highly managed in order to maintain its location and minimize flooding in the Village. RRD observed evidence of extensive channel straightening and armoring and a high incision ratio. Due to the significant investment in infrastructure within this reach the Mill River is likely to be maintained near its current configuration.

FEH Opportunities and Challenges

Existing Zoning	• Village B District • Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	Deteriorating bridge conditions on Village Street may provide an opportunity for redesigning access to the Village and or at least allowing better sediment and water transport under the bridge (which is currently holding sediment in its mid-pier and may create debris jam and flooding under the right conditions). Numerous houses exist within the FEH corridor (Figure 3).
Assets and Liabilities	Continued development pressure in the village may be expected.

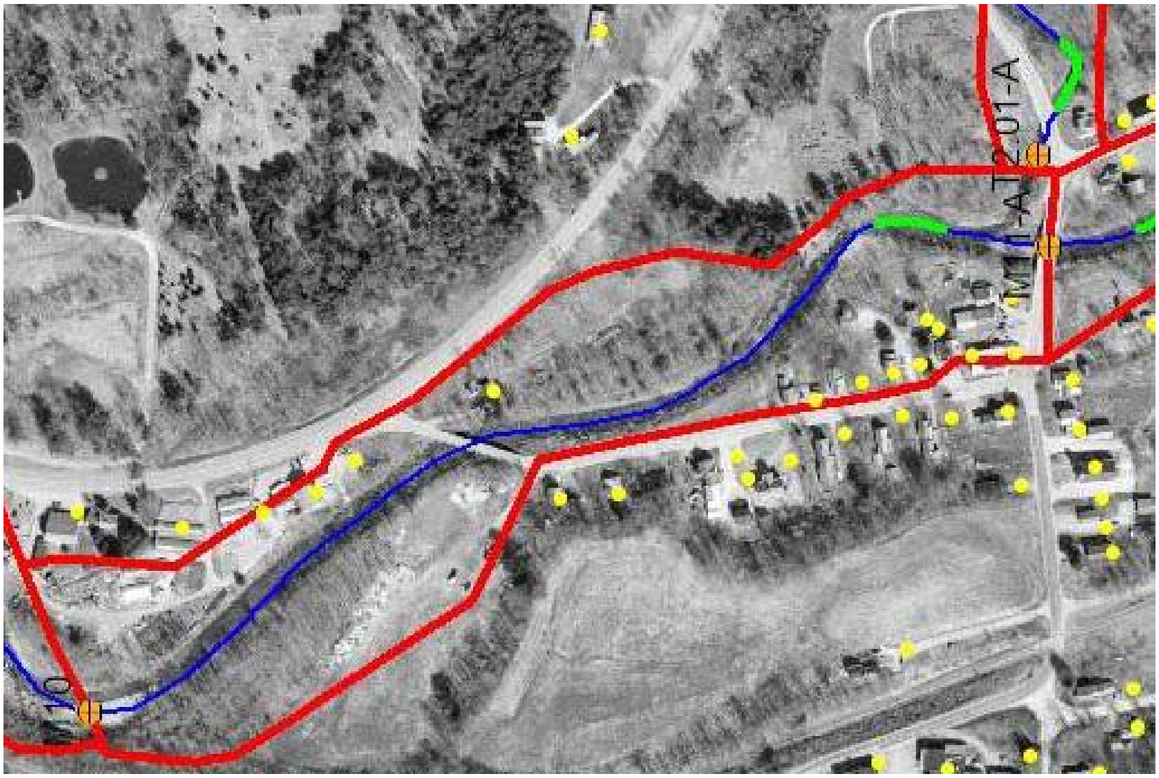

Figure 3: Structures (yellow) located in the FEH Corridor (red) in E. Wallingford Village

M09: East Wallingford

Current Condition

Although development pressure is not as significant as in the reach upstream, Mill River reach M09 has been impacted predominately by VT Route 103 which has changed the valley width from broad to narrow. In order to protect the roadway and a few structures located within the river corridor, extensive berming and channel armoring has occurred. Berming and straightening has increased the erosive forces in the channel leading to a high degree of incision (ratio of 1.8). Adjusting to this incision, the stream has undergone extreme channel widening. Extensive channel management (riprap, dredging, straightening) has prevented the channel from developing new floodplain and storing sediment.

FEH Opportunities and Challenges

Existing Zoning	• Rural District • Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	Despite a high level of floodplain encroachment only one structure (a residence) currently exists in the proposed FEH overlay zone.
Assets and Liabilities	None identified.

M08: East Wallingford

Current Condition

Mill River reach M08 is a short reach in a semi-confined valley that has been further confined by Vermont Route 103. Despite a high degree of historic channel incision the stream retains access to floodplain during only the largest events. As a result of the incision the current sediment and floodwater storage capability of this reach has been significantly reduced.

FEH Opportunities and Challenges

Existing Zoning	• Rural District • Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	Two houses are located on the edge of the proposed FEH Zone on the right bank (Figure 4).
Assets and Liabilities	None identified.

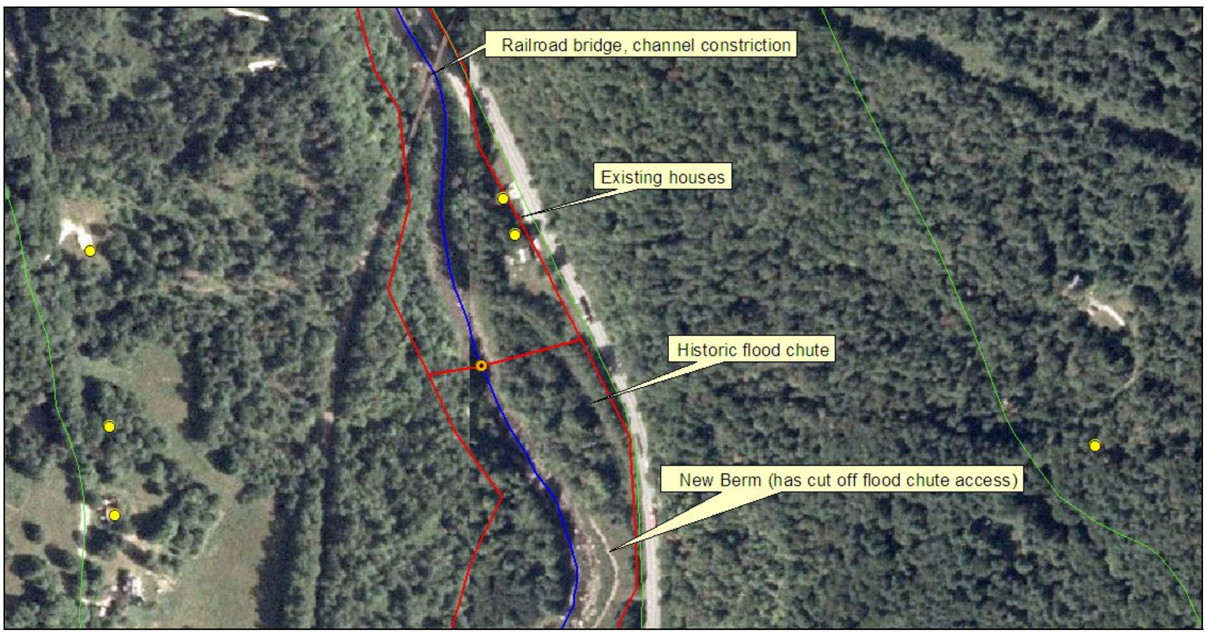

Figure 4: Structures located in the FEH zone in reach M08.

M07: East Wallingford

Current Condition

Mill River reach M07 is a very short reach that appears to have been straightened up against the left valley wall in order to increase cultivatable land. Significant berming has occurred on the right bank in order to prevent flooding. Incision and channel widening have occurred.

FEH Opportunities and Challenges

Existing Zoning	• Rural District • Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	Two houses are located on the edge of the proposed FEH Zone on the right bank, one of which is significantly protected by an existing berm (Figure 5).
Assets and Liabilities	None identified.

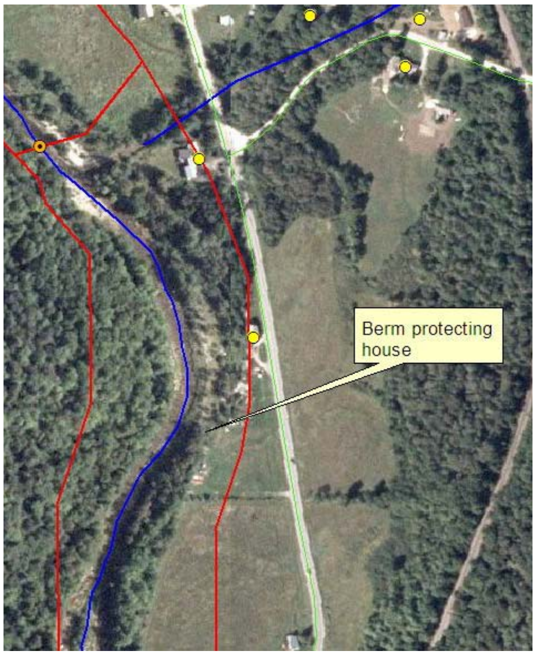

Figure 5: Structures in the draft FEH reach M07.

M06: East Wallingford/Shrewsbury

Current Condition

Mill River reach M06 runs directly through Cuttingsville Village (Figure 6) with a great deal of human alteration, both historic and recent. Channel straightening, berming, dredging, armoring, and windrowing were all observed. Additionally much of the floodplain has been filled by development and roads increasing stormwater inputs into the system. It appears that the stream may have been straightened and relocated up against the left valley wall through much of the reach. A high degree of incision (1.8 ratio) was observed with major channel widening and planform adjustments currently occurring.

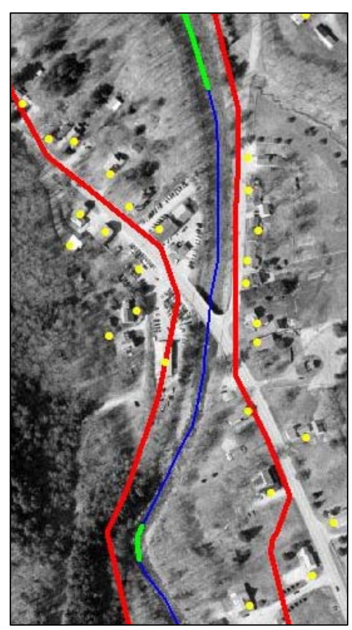

Figure 6: Structures (yellow) existing in the draft FEH overlay zone (red) through Cuttingsville Village (reach M06).

FEH Opportunities and Challenges

Existing Zoning	• Upstream portion is in the Wallingford Rural District • Wallingford Flood Hazard Areas Zoning defined by FIRM Maps • Predominately in the Shrewsbury Cuttingsville District • Small portion in the Rural Residential (Min lot size 4 acres on north side – right bank) and Limited Residential (Min lot size 10 acres on south side – left bank)
Existing Structures	As with many typical Vermont village settings, the Village of Cuttingsville has significant amounts of existing residential and commercial development within the proposed FEH overlay zone.
Assets and Liabilities	Village growth may put more development pressure in this reach.

M05-B: Shrewsbury

Current Condition

M05-B, as with many segments upstream, is heavily influenced by recent and historic channel management activities including berming, armoring, dredging, and windrowing. Floodplain encroachment from VT 103 and residences and commercial development along with significant channel straightening have led to an incised stream with less capacity to attenuate floodwaters and sediment. A berm at the upstream end of the reach has prevented access to a major flood chute. Active major widening is occurring in response to channel incision. The planform and widening adjustments are limited by the valley wall, armoring, and dredging.

FEH Opportunities and Challenges

Existing Zoning	Rural Residential (Min lot size 4 acres)
Existing Structures	Six existing residential and commercial structures are located in the proposed FEH Zone.
Assets and Liabilities	None identified.

M05-A: Shrewsbury

Current Condition

Mill River segment M05-A flows through a well forested corridor. Limited encroachment by the railroad track has impacted the right corridor. The channel has incised enough to abandon an old floodplain and begin to develop a juvenile floodplain. The degree of channel incision is low enough so that the stream remains able to store flood waters during the largest events. A large mass failure within this reach is a source of fine sediment and gravels to the downstream system. Several large flood chutes exist in the stream corridor indicating planform adjustment.

FEH Opportunities and Challenges

Existing Zoning	Rural Residential (Min lot size 4 acres on north side – right bank) Limited Residential (Min lot size 10 acres on south side – left bank)
Existing Structures	None
Assets and Liabilities	The land within the FEH corridor is predominately forested. A good portion of the lower reach is public land. Some land on the right bank is protected from development due to the railroad and the railroad r.o.w. The FIRM Map does not cover the area of land that is needed for the river to maintain long term stability (Figure 7).

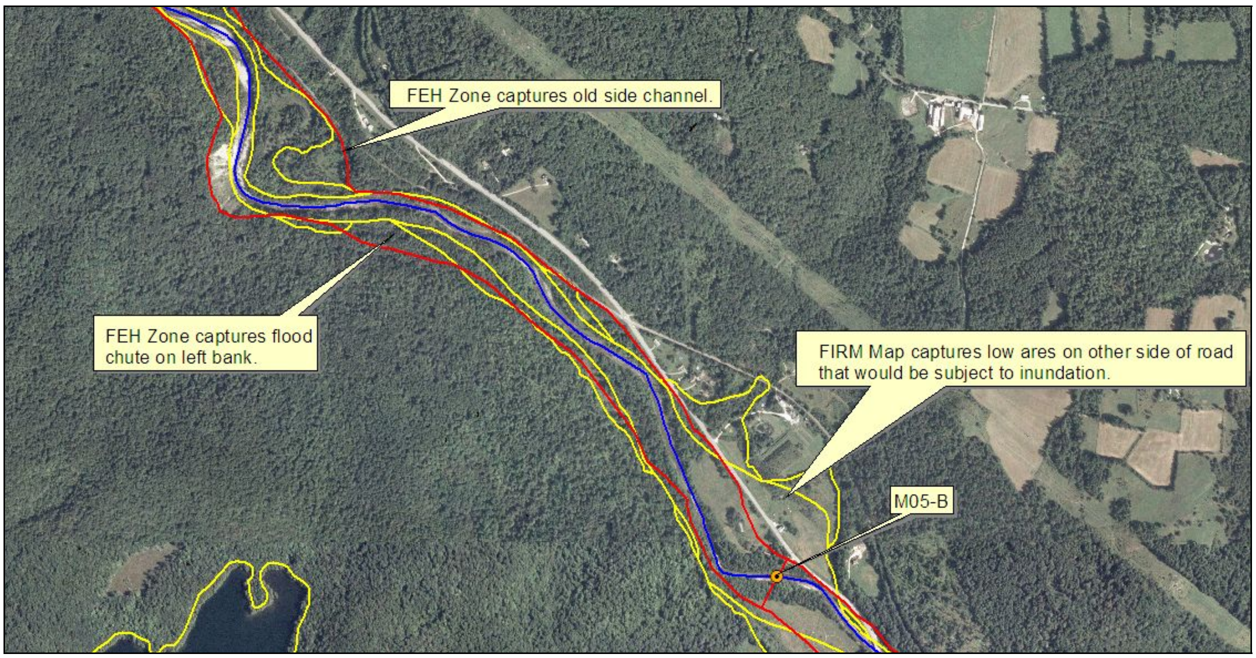

Figure 7: Variations in the FIRM boundaries and FEH zone on reach M05-A.

M04: Shrewsbury/Clarendon

<u>*Current Condition*</u>

Mill River reach M04 encompasses the Upper Clarendon Gorge. The bedrock gorge begins at a sharp southwestward bend in the river where a Long Trail suspension bridge hangs from the bedrock cliffs on each side.

FEH Opportunities and Challenges

Existing Zoning	• Limited residential (10 acre lots size) in Shrewsbury • Conservation land with residential development on the fringes • Zoned Residential in Clarendon • In Clarendon Flood Hazard Zoning Permit required in FIRM area
Existing Structures	None.
Assets and Liabilities	Due to the highly stable nature of the bedrock gorge, the FEH zone for this reach is the existing bankfull width and does not affect the adjacent land which is currently forested. Almost all of the land in this reach is publicly owned.

M03-C: Clarendon

Current Condition

This segment is located between the Upper Clarendon Gorge (a bedrock controlled section) and the bedrock controlled segment at the former Kingsley Mill site. Channel incision observed here may be a result of the river working back through sediments that were stored when there was a mill dam, or due to a sediment imbalance upstream.

FEH Opportunities and Challenges

Existing Zoning	• Zoned Conservation (some residential at outer perimeter of FEH) • Flood Hazard Zoning Permit required in FIRM area
Existing Structures	There are several residences encroaching on the river corridor on the left bank as part of development happening on Knipes Drive.
Assets and Liabilities	Most of the land is zoned for Conservation, however, development may still occur (Figure 8). Also The riparian buffer has suffered in this area due to development in the FEH zone.

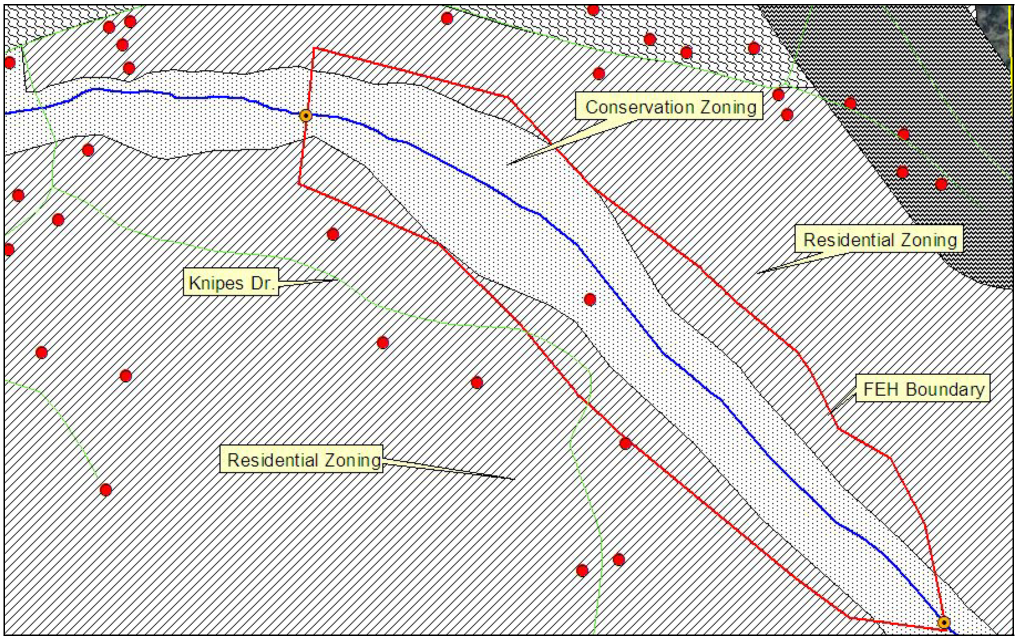

Figure 8: Areas where residential zoning and the FEH zone overlap in reach M03-C.

M03-B: Clarendon

Current Condition

Segment M03-B is a short bedrock controlled segment that includes the former Kingsley Mill dam site. Bedrock in the stream channel bottom and bedrock on most of the banks provide long-term stability to this reach.

FEH Opportunities and Challenges

Existing Zoning	• Zoned Conservation (some residential at outer perimeter of FEH) • Flood Hazard Zoning Permit required in FIRM area
Existing Structures	Although some residential development has affected the riparian buffer, in general the bedrock has created a stable geomorphic condition in this segment. Adoption of an FEH overlay may only affect the Kingsly Mill House as it may exist within the bankfull width – which is the extent of the FEH Zone here.
Assets and Liabilities	Bedrock walls and steep banks will limit development in the river corridor.

M03-A: Clarendon

Current Condition

Mill River segment M03-A is also located between two bedrock grade controlled segments. Although this segment is slightly incised, it seems to be an area of sediment and floodwater attenuation, having large gravel bars, accessible floodplains and a forested buffer greater than 100 feet on both sides. As a result of the incision there is evidence of widening that has occurred in this segment. Minor planform and aggradation were observed as the stream rebuilds floodplain on both the left and right banks. This area will likely continue to be an important area in the lower Mill River watershed for sediment and floodwater attenuation.

FEH Opportunities and Challenges

Existing Zoning	• Zoned Conservation (some residential at outer perimeter of FEH) • Flood Hazard Zoning Permit required in FIRM area
Existing Structures	None
Assets and Liabilities	Adoption of an FEH overlay zone would not affect this reach which is already land that is conserved by the VT Dept of Forest Parks and Recreation and the Vermont Housing and Conservation Board and therefore is not under significant risk of future development.

M02: Clarendon

Current Condition

Mill River reach M02 consists of the Lower Clarendon Gorge. The gorge is carved through bedrock which provides long-term stability to this reach.

FEH Opportunities and Challenges

Existing Zoning	• Zoned Conservation • Flood Hazard Zoning Permit required in FIRM area
Existing Structures	None
Assets and Liabilities	Due to the highly stable nature of the bedrock gorge, the FEH zone for this reach is the existing bankfull width and does not affect the adjacent land which is currently forested. Also, most of land is publicly owned.

M01-B: Clarendon

Current Condition

Mill River segment M01-B is a C-type channel by reference in a very broad valley. Significant channel management in the form of straightening, dredging, berming, and armoring has significantly altered the channel dimensions and entrenchment of this segment. The current incision ratio was observed to be 1.8 indicating that both berming and bed degradation have affected the nature of the channel. A landowner whose family has managed much of the surrounding land recounts the 1973 flood that washed out the railroad bridge. He noted that there was significant dredging of the stream channel after the 1973 flood between the railroad bridge and Route 7. He also noted that in the 1950's the area below the railroad bridge was dredged for gravel to help build Route 103.

FEH Opportunities and Challenges

Existing Zoning	• Zoned Residential • Flood Hazard Zoning Permit required in FIRM area
Existing Structures	Railroad bridge is a channel constriction.
Assets and Liabilities	Short segment with a large portion in the Route 7 and railroad right-of-way's which will limit development potential.

M01-A: Clarendon

Current Condition

M01-A is the lowest reach of the Mill River. This segment is located at a highly dynamic zone where floodwaters and sediment coming down from the relatively steep Green Mountain hillsides are released in the flat valley bottom of the Otter Creek. Scientists from RRD and VTANR observed a high degree of bank erosion and channel adjustment in this segment. The steambank material is composed of silts and clay near the confluence with the Otter Creek and the bank height increases significantly which is likely due to the influence of the Otter Creek.

FEH Opportunities and Challenges

Existing Zoning	• Zoned Residential • Flood Hazard Zoning Permit required in FIRM area
Existing Structures	None
Assets and Liabilities	Much of the land in this reach is under agreement with the CREP program.

T2.01-B: Mount Holly

Current Condition

Tributary T2.01-B begins at the Bowlsville Road Bridge and ends downstream near the west entrance to Millbrook Lane. The upper portion of this segment is in fair geomorphic condition. It has undergone major historic incision, however, is actively working to redevelop floodplain. Active planform adjustment has led to the development of small gravel bars and a juvenile floodplain in some areas. Continued planform, widening, and aggradation adjustments are expected.

FEH Opportunities and Challenges

Existing Zoning	Flood Hazard Areas Zoning defined by FIRM Maps
Existing Structures	Adoption of an FEH overlay will affect numerous private landowners, six of which have homes located within or directly bordering the draft FEH corridor (Figure 9).
Assets and Liabilities	Stream is in fairly stable condition.

Figure 9: Houses crowd the FEH zone in reach T2.01-B.

T2.01-A: Mount Holly

Current Condition

Tributary segment T2.01-A has seen extensive historic channel straightening and armoring. There is also evidence of dredging and windrowing just above the Route 140-East Bridge. The right side of the floodplain has been filled almost entirely by Routes 140 and 103 which create the top of the right bank. On the left side of the channel the riparian buffer has been cleared down to a thin strip of vegetation along the top of the bank. Agricultural land use dominates the left corridor while commercial and residential land use dominates the right corridor

FEH Opportunities and Challenges

Existing Zoning	Flood Hazard Zoning Permit required in FIRM area
Existing Structures	With an extreme sensitivity rating, the two structures located within the FEH Zone of this reach are at risk (Figure 10).
Assets and Liabilities	Stream has been significantly altered. Much of the land is undeveloped on the left bank.

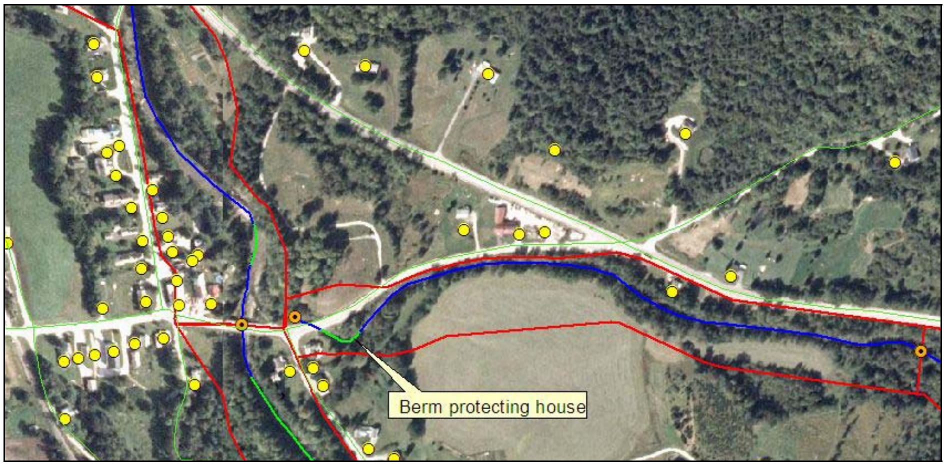

Figure 10: Encroachments and opportunities along reach T2.01-A in Mount Holly and E. Wallingford.

5.0 CONCLUSION AND RECOMMENDATIONS

Based on the results of this limited FEH Analysis the following broad conclusions and recommendations can be made:

Conclusions:

- The greatest concentration of structures lies in the village centers of East Wallingford and Cuttingsville. Here FEH zoning would affect the greatest number of landowners.

- Many reaches have little or no existing structures in the FEH corridor. Although land use restrictions would affect many landowners, proactively addressing the issue of development in the FEH corridor through proper zoning is important considering the ongoing losses that occur in Vermont due to fluvial erosion and the current and expected channel adjustment processes ongoing in many reaches. Designation of an FEH corridor in the reaches with little or no existing structures would be a proactive approach that may assist in long term channel stability.

Recommendations:

- The Towns of Clarendon, Shrewsbury, Wallingford, and Mount Holly should work with the VTANR and the Rutland Regional Planning Commission to consider the implementation of a FEH Overlay District into their Zoning Bylaws. FEH overlay districts would help reduce the risk of future property damage through the prevention of further development in the FEH corridor.

- Even if an overlay zoning district is not adopted, identification of an FEH corridor may deter some detrimental construction from occurring. Education about the FEH corridor and erosion hazard risks would be a valuable service for landowners and may lead to voluntary restrictions on development in the river corridor.

6.0 REFERENCES

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Mount Holly, Vermont
Local Hazard Mitigation Plan

Debris Jam at Bridge (B1-2) on VT Route 155 – Tropical Storm Irene

FEMA Approval Pending Adoption Date: January 27, 2021
Municipal Adoption Date: February 9, 2021
FEMA Formal Approval Date: February 12, 2021

Prepared by the Mount Holly Hazard Mitigation Planning Team
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Western Vermont Floodplain Manager

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1 INTRODUCTION

The impact of expected, but unpredictable natural events can be reduced through community planning and action. The goal of this Plan is to provide a natural hazards local mitigation strategy that makes Mount Holly (the Town) more disaster resistant and more resilient after disaster has struck.

Hazard Mitigation is any sustained policy or action that reduces or eliminates long-term risk to people and property from natural hazards and their effects. FEMA and state agencies have come to recognize that it is less expensive to prevent disasters than to repeatedly repair damage after a disaster has struck. This Plan recognizes that communities have opportunities to identify mitigation strategies and measures during all the other phases of Emergency Management – Preparedness, Response and Recovery. Hazards cannot be eliminated, but it is possible to determine what the hazards are, where the hazards are most severe, and identify local actions and policies that can be implemented to reduce the severity of the hazard.

2 PURPOSE

The purpose of this Plan is to assist the Town in identifying all natural hazards facing the community, ranking them according to local vulnerabilities, and developing strategies to reduce risks from those hazards. Once adopted, this Plan is not legally binding; instead, it outlines goals and actions to reduce the degree of injury and inconvenience to the townspeople and their private and municipal property.

The benefits of mitigation planning include:

- Identifying actions for risk reduction that are agreed upon by stakeholders and the public.
- Focusing resources on the greatest risks and vulnerabilities.
- Increasing education and awareness of threats and hazards, as well as their risks.
- Communicating priorities to State and Federal officials.
- Aligning risk reduction with other community objectives.

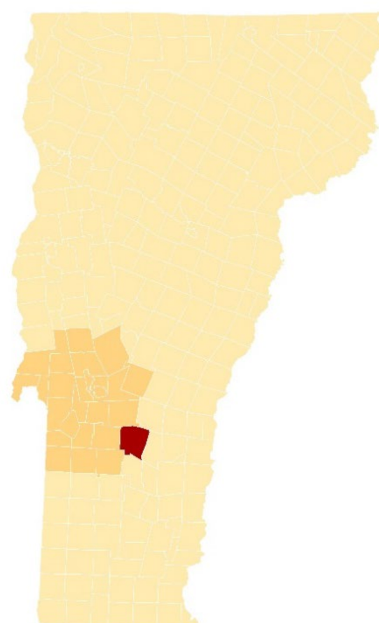
Furthermore, the Town seeks to be in accordance with the 2018 State Hazard Mitigation Plan.

3 COMMUNITY PROFILE

Land Use and Development Patterns

Mount Holly is largely rural with scattered residential development, active agricultural uses, and some areas of concentrated commercial development primarily in the village of Belmont and to a lesser degree in Healdville.

This includes the Crowley Cheese Factory, which is still in operation and is also on the National Register of Historic Places. A portion of the Okemo ski area is also located within Mount Holly's borders.



Land Features

Mount Holly is located on a hilly plateau on the central ridge of the Green Mountains. The Town of Mount Holly is composed of a series of hills and low mountains which are separated by mountain streams and brooks. Its elevation ranges from about 1,200 feet above sea level to 3,343 feet at the summit of Okemo Mountain.

In total land area, Mount Holly is one of the larger towns in Rutland County with 29,338 acres. About one-fifth of the town consists of publicly owned land within Okemo State Forest on the Town's eastern border, Green Mountain National Forest on the southwestern border, and about 92 acres on the northeast side of Star Lake that is owned by the State of Vermont.

The Town's woodlands are an important resource for aquifer recharge, plant and wildlife habitat, and recreation, as well as timber production, maple sugaring operations, and carbon sequestration.

Demographics and Growth Potential

The 2018 American Community Survey Five-Year Estimates prepared by the U.S. Census Bureau shows an estimated population of 1,168, and 988 housing units. Between 2010 and 2018, the population has held relatively steady. The median age of Mount Holly residents is 52.2 years old, which is 22% higher than the Vermont median age of 42.8. The portion of the population over 60 is 34%, compared to 25% in Vermont and 20.9% in the country.

Due to the influence of the Okemo ski area, a large percentage (41.7%) of the housing units in Mount Holly are seasonal. Therefore, the total population may be close to double during certain times of year.

Currently, the Town has limited regulations in place to control development and growth. A rise in population may cause development that is not aligned with the stated goals of the Mount Holly Town Plan – to "preserve the town's rural lifestyle and appearance" and maintain a "compact village center within a rural setting, surrounded by undeveloped areas".

Precipitation and Water Features

Average annual precipitation is 48 inches of rain; with October being the wettest month. Average annual snowfall is 96 inches making Mount Holly snowier than most places in Vermont, with January being the snowiest month.

There are three lakes in the Town: Star Lake in Belmont; Lake Ninevah in the north near the Town's boundary with Plymouth; and Tiny Pond, which the Town shares with Ludlow in the northeastern corner. There are several rivers and streams that flow through Mount Holly, Mill River being the largest, and three important watershed sub-basins: Otter Creek, Black-Ottauquechee, and West.

Another important water feature is the Winslows' Flats Wetlands. This extensive area of wetlands, marsh and alder swamp extends along the south side of Vermont Route 103. Vermont Department of Fish and Wildlife has identified this as a significant natural community.

Drinking Water and Sanitary Sewer

Aside from a spring fed water system that supplies some buildings in Belmont, the rest of the Town depends on drilled wells or natural springs.

A significant aquifer recharge area exists on the summit of Hedgehog Hill. A seasonal pond and permanent wetland mark the location covering approximately one acre. This area provides water to numerous springs on the flanks of the hill in addition to providing the water to spring systems feeding the village of Belmont.

Sewer service in Mount Holly is provided entirely by individual, on-site septic systems.

Transportation

The present network of ±69 miles of roads in Mount Holly serves the needs of current residents. Vermont State Routes 103, 140, and 155 provide primary access into and out of Mount Holly. In addition to these State Routes, there are several other roads that have been identified as locally important for use as through-ways, detours, short-cuts, and access to critical facilities such as the fire stations, town garage, town office, and school. These routes are shown in orange on the map in **Figure 1**.

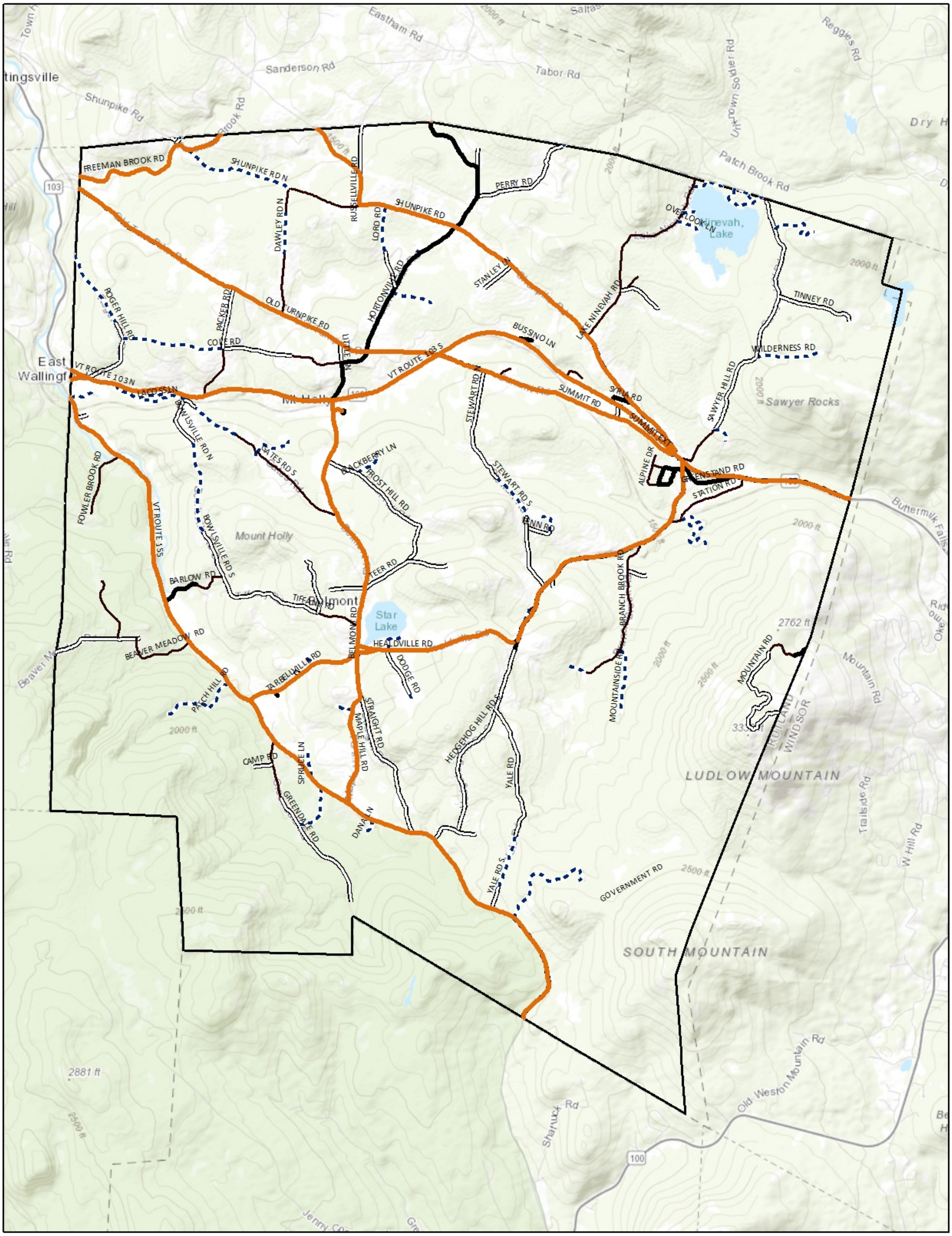


Figure 1: Locally Important Routes for Through-Ways, Detours, Short-Cuts, and Access to Critical Facilities

Shown in orange on Figure 1

According to the Town's Road Erosion Inventory Report, nearly 87% of the Town's road mileage is hydrologically connected - meaning it is within 100-feet of a water resource (i.e., perennial/intermittent stream, wetland, lake, or pond). Proximity to water resources can make these sections more vulnerable to flooding and fluvial erosion.

Mount Holly has a total of 9 town-owned bridges and ±460 culverts. Seven of the bridges have a span of over 20 feet. The local transportation network is maintained by the Town Highway Maintenance crew, whose garage is located on School Street.

A rail line runs through Mount Holly, crossing several roads including Healdville Road and Belmont Road. In addition, there is a rail siding off Summit Road with freight storage and a significant rock cut at the height of land.

Electric Utility Distribution System

Electric service to approximately 1,170 customers is provided by Green Mountain Power via one circuit. Average annual outage statistics between 2015 and 2019 are summarized in **Table 1**.

Table 1: Power Outage Summary

5-Year Average (2015-2019)	
Avg # of times a customer was without power	3.77
Avg length of an outage in hours	5.47
# of hours the typical customer was without power	20.63
2019 only	
Avg # of times a customer was without power	2.43
Avg length of an outage in hours	5.09
# of hours the typical customer was without power	12.34

The longest power outage affecting the greatest number of customers between 2015 and 2019 was 84.61 hours long and impacted 14 customers.

Public Safety

Mount Holly has a volunteer fire department, with two stations – the main station on School Street and a substation in Belmont Village. Both stations are operated by a 21-member, volunteer department.

Law Enforcement in Mount Holly is provided by the one part-time Town Constable, who is certified as a full-time Vermont law enforcement officer, with assistance from the Rutland County Sheriff's Department and Vermont State Police as needed.

Mount Holly has a Volunteer Rescue Squad that provides treatment to residents and visitors on an emergency call basis. The nearest hospital is the Rutland Regional Medical Center, but Springfield Hospital is also within a reasonable distance and there is a medical clinic in Ludlow that is staffed and operated by Springfield Hospital. Ambulance service is provided by the Rescue Squad.

Emergency Management

The Town has an appointed Emergency Management Director (EMD) and Emergency Management Coordinator (EMC) who work with others in town to keep the Local Emergency Plan up-to-date as well as to coordinate with nearby towns and regional emergency planning efforts.

4 PLANNING PROCESS

Plan Developers

Steffanie Bourque, an Emergency Management Planner at the Rutland Regional Planning Commission (RRPC), assisted the Town with updating its Local Hazard Mitigation Plan. Hazard Mitigation Grant Program funds from FEMA supported this process.

The Hazard Mitigation Planning Team members who assisted with the update include the EMD / Selectboard member, EMC, Planning Commission member, and Road Foreman.

Plan Development Process

The 2020 Mount Holly Local Hazard Mitigation Plan is the first single jurisdiction mitigation plan drafted for the Town. Previously, the Town had a town-specific Annex in the 2009 Rutland County, VT Hazard Mitigation Plan.

This Plan has been reconstructed as a single jurisdiction, stand-alone Mount Holly Local Hazard Mitigation Plan that will be submitted for individual approval to FEMA. As such, several sections have been added or updated to include all necessary information. A summary of the process taken to develop this Plan is provided in **Table 2**.

Table 2: Plan Development Process

June 23, 2020: Hazard Mitigation Planning Team kick-off meeting. Planning Team members were confirmed. Discussed what a LHMP is; the benefits of hazard mitigation planning; current plan status; the planning process; outreach strategy; and plan sections. Planning Team meetings were not open to the public.

June 25 – June 29, 2020: Public notice posted on RRPC and Town social media (website, Facebook page, and email newsletter) that the Town is engaged in hazard mitigation planning and updating their LHMP. Notice also posted at the Town Post Office and submitted for inclusion in the August edition of the monthly town newsletter, the *Mount Holly Chit Chat* – see Appendix D. No public comments received. Emailed notice to officials in neighboring towns of Shrewsbury, Wallingford, and Mount Tabor. Name and contact information provided in notices for more information. No comments received from neighboring towns.

July 13, 2020: Planning Team meeting – confirmed the plan purpose and completed work on the community profile and hazard risk assessment. Began work on storm history and identifying assets vulnerable to the highest risk natural hazards.

August 12, 2020: Planning Team meeting – completed work on the storm history and assets vulnerable to the highest risk natural hazards. Completion of the hazard identification and risk assessment is a critical milestone in the plan update process. Draft readied for public meeting on September 8.

September 2020: Article in the *Mount Holly Chit Chat* regarding LHMP update on plan development process and September 8 public meeting – see Appendix D.

September 8, 2020: Working draft LHMP shared with Vermont Hazard Mitigation Officer and Rutland Natural Resource Conservation District for review and comment. No comments received. Working draft LHMP presented at joint public meeting of the Mount Holly Selectboard and Planning Commission to encourage input from local government and the public that could affect the plan's conclusions and better integrate with Town initiatives. Members of the public were present at this meeting. No comments received. Plan posted on RRPC and Town websites. Comments on the draft plan were accepted until September 22. Minor comments on the High Wind Hazard Profile received from the Selectboard.

September 23, 2020: Planning Team meeting - incorporated comments received on the High Wind Hazard Profile into the working draft; completed work on hazard identification and risk assessment. Began work on hazard mitigation strategy – confirmed mitigation goals, identified community capabilities; and began to evaluate a range of mitigation actions.

October 21, 2020: Planning Team meeting – completed work on community capabilities and continued work evaluating, prioritizing, and selecting mitigation actions for implementation.

November 30, 2020: Planning Team completed work on the mitigation strategy; plan maintenance; and changes since the 2009 annex. Draft LHMP finalized for presentation to local officials and the public at the December 8, 2020 Selectboard meeting.

November 2020: LHMP update on plan development process and December 8, 2020 public meeting articles in the *Mount Holly Chit Chat* – see Appendix D.

December 8, 2020: Final draft LHMP emailed to local officials in neighboring towns and Rutland Natural Resource Conservation District for review and comment. Also posted on RRPC and Town websites. Final draft LHMP presented at joint public meeting of the Mount Holly Selectboard and Planning Commission for review and comment. Members of the public were present at this meeting. Public notice of the comment period included in the community email listserv – "Newsflash". Notice included instructions to email comments on the draft plan to Jeff Chase. Comments on the draft plan were accepted until December 22, 2020. No comments were received.

January 6, 2021: Final draft LHMP submitted to VEM for Approval Pending Adoption.

In addition to the local knowledge of Planning Team members and other relevant parties, several existing plans, studies, reports, and technical information were utilized in the preparation of this Plan. A summary of these is provided in **Table 3.**

Table 3: Existing Plans, Studies, Reports & Technical Information
2020 Local Emergency Management Plan
2020 FEMA NFIP Insurance Reports
2019 Transportation Resiliency Planning Tool
2019 *Falling Dominoes:* A Planner's Guide to Drought and Cascading Impacts
2019-2015 Green Mountain Power Outage Data
2018 Mount Holly Town Plan
2018 Road Erosion Inventory and Report
2018 State of Vermont Hazard Mitigation Plan
2018 American Community Survey Five-Year Estimate
2017 Stormwater Infrastructure Mapping Project
2009 Mill River Corridor Management Plan
2008 Flood Hazard Area Regulations
RRPC Local Liaison Reports of Storm Damage
National Oceanic and Atmospheric (NOAA) National Climatic Data Center's Storm Events Database
FEMA Disaster Declarations for Vermont
OpenFEMA Dataset: Public Assistance Funded Project Summaries for Vermont
United States Drought Monitor
U.S. Geological Survey National Water Information System- Stream Gage Data
FEMA Flood Insurance Rate Maps

Changes Since the 2009 Annex

Mount Holly's 2018 Town Plan aims to preserve the town's rural lifestyle and appearance, while providing community services, as well as recreational and cultural opportunities.

Several of the Town Plan objectives also help make the community more resilient to the impacts of natural hazards. For example, consider the objective – "To assure that any project for increasing the capacity of any existing highway or any new highways will be consistent with the general character of the town, and to require that, where possible, public utilities and transmission facilities share the use of corridors to minimize the impact on the environment and to foster desired development patterns." This objective helps mitigate against power outages by encouraging the co-location of power lines within the road right-of-way as opposed to cross-country runs.

In addition, the Flood Resilience section of the Town Plan contains two goals:

1) Avoid new development in flood hazard, fluvial erosion, and river protection areas. Any new development in such areas should not exacerbate flooding and fluvial erosion.

2) Encourage the protection and restoration of floodplains and upland forested areas that constrict and reduce flooding and fluvial erosion.

As described in the Community Profile section of this Plan, the Town's population has held relatively steady since 2010. However, a high percentage of homes are seasonal so the total population may be close to double during certain times of year.

Although Mount Holly does not have local zoning to regulate development in the community, they have adopted Special Flood Hazard Area regulations to regulate development in flood-prone areas. Between 2010 and 2020, there were 118 new E911 sites added in Mount Holly, which equates to an approximate 1% growth rate.

Development in Mount Holly since 2009 has not made the community more vulnerable to natural hazards.

The Town's mitigation priorities shifted a bit. In 2009, the Mount Holly Annex in the Rutland County, VT Hazard Mitigation Plan addressed all-hazards (natural, manmade, and technological). Winds, floods, and power outages were the most likely and costly hazards for Mount Holly.

The 2020 Local Hazard Mitigation Plan update focused exclusively on natural hazards. Severe thunderstorms (with associated flooding, fluvial erosion, high winds); severe winter storms (with associated extreme cold, snow, ice); and drought (with associated water shortage) were ranked as the community's highest risk natural hazards.

In 2020, the Town did not formally assess the risk associated with invasive species; however, they did discuss the potential hazards and risks associated with the Emerald Ash Borer (EAB) given the confirmed detection in Rutland County in October 2020. Invasive species were not included in the 2009 Annex.

Spurred by new legislation passed in October 2020 to modernize Vermont's tree warden statutes, the role of the local Tree Warden as a partner in hazard mitigation is also a change reflected in the 2020 update.

Mount Holly has made some progress in completing the mitigation projects identified in the 2009 Annex – see **Appendix C**. A significant accomplishment was repair to the Star Lake dam. These repairs are instrumental to protecting the village of Belmont, located downstream of Star Lake, during a flood event. In addition, the Town continues to make significant progress bringing their roadside ditches up to current Road Standards with work completed in 2020 on Roger Hill, Cole Road, Packer Road, and Bowlsville Road North.

Actions taken by Mount Holly since 2009 and following Tropical Storm Irene have made the community more prepared and less vulnerable to future natural hazard impacts.

Nonetheless, due to an increase in the frequency and intensity of weather events, the Town remains vulnerable to flash flooding, fluvial erosion, high winds, severe winter storms, drought, as well as invasive species (particularly the Emerald Ash Borer).

As a result, the Town has identified three new mitigation actions to address severe winter storm and high wind impacts; three new actions to address drought impacts; one new action to address invasive species, and several actions to address remaining flood hazards – see **Table 6**.

5 HAZARD IDENTIFICATION AND RISK ASSESSMENT

Local Vulnerabilities and Risk Assessment

One of the most significant changes from the 2009 Annex is the way hazards are assessed. To be consistent with the approach to hazard assessment in the 2018 State Hazard Mitigation Plan, the Hazard Mitigation Planning Team conducted an initial analysis of known natural hazard events[1] to determine their probability of occurring in the future.

The Planning Team then ranked the hazard impacts associated with the known natural hazard events based on the probability of occurrence and potential impact to life, the economy, infrastructure, and the environment. The ranking results are presented in **Table 4**.

After engaging in discussions, the Town identified the following "highest risk hazards" that they believe their community is most vulnerable to:

- *Thunder and Tropical Storms with associated flash flooding, fluvial erosion, and high winds – and to a lesser extent inundation flooding and hail.*
- *Winter Storms with associated extreme cold, snow, ice, and high winds.*
- *Drought with associated water shortage, high winds – and to a lesser extent extreme heat.*

Each of these "highest risk hazards" (**orange** in **Table 4**) are further discussed in this section and depicted in the Local Natural Hazards and Vulnerabilities Map in **Appendix B**.

The "lower risk hazards" that are considered to have a low probability of occurrence and low potential impact are not discussed. For information on these hazards, consult the State Hazard Mitigation Plan.

Table 4: Community Hazard Risk Assessment

Hazard Event	Hazard Impacts	Probability	Potential Impact					Score
			Life	Economy	Infrastructure	Environment	Average	
Thunderstorm **Tropical Storm/Hurricane**	**Flash Flooding/ Fluvial Erosion**	**4**	**2**	**2**	**4**	**4**	**3.00**	**12.00**
Landslide	Inundation Flooding	3	2	1	1	1	1.50	4.50
Ice Jam	**High Winds**	**4**	**2**	**2**	**2**	**1**	**2.00**	**8.00**
Tornado	Hail	4	1	1	2	1	1.25	5.00
Winter Storm	**Cold/Snow /Ice/Wind**	**4**	**3**	**3**	**3**	**3**	**3.00**	**12.00**
Drought	Heat	3	2	1	1	3	1.75	5.25
	Drought	**3**	**1**	**2**	**2**	**3**	**2.00**	**6.00**
Wildfire	Wildfire	2	2	1	2	1	1.5	3.00
Earthquake	Earthquake	2	1	1	1	1	1.00	2.00

*Score = Probability x Average Potential Impact

	Frequency of Occurrence: Probability of a plausibly significant event	Potential Impact: Severity and extent of damage and disruption to population, property, environment, and the economy
1	**Unlikely:** <1% probability of occurrence per year	**Negligible:** isolated occurrences of minor property and environmental damage, potential for minor injuries, no to minimal economic disruption
2	**Occasionally:** 1–10% probability of occurrence per year, or at least one chance in next 100 years	**Minor:** isolated occurrences of moderate to severe property and environmental damage, potential for injuries, minor economic disruption
3	**Likely:** >10% but <75% probability per year, at least 1 chance in next 10 years	**Moderate:** severe property and environmental damage on a community scale, injuries or fatalities, short-term economic impact
4	**Highly Likely:** >75% probability in a year	**Major:** severe property and environmental damage on a community or regional scale, -multiple injuries or fatalities, significant economic impact

[1] This Plan defines natural hazards as atmospheric, hydrologic, geologic, and wildfire phenomena. Hazards not necessarily related to the physical environment, such as infectious disease, were excluded from consideration by the Planning Team.

Invasive Species

The Planning Team did not formally assess the risk associated with invasive species; however, they did discuss the potential hazards and risks associated with the Emerald Ash Borer (EAB) specifically. Vermont's EAB infestation was first detected in 2018 in northern Orange County. In October 2020, a new detection of EAB in West Rutland was confirmed. This is the first confirmed detection in Rutland County. The Town will work with the Vermont Urban & Community Forestry Program to develop a *Rural Road Resilient Right-of-Way Vegetation Assessment*, which will include recommendations regard EAB management and roadsides with plentiful or prominent Ash trees. The Wilderness Community members around Lake Ninevah have begun to treat hundreds of their Ash trees.

Highest Risk Hazard Profiles

Inundation/Flash Flooding/Fluvial Erosion

Floods can damage or destroy public and private property, disable utilities, make roads and bridges impassable, destroy crops and agricultural lands, cause disruption to emergency services, and result in fatalities. People may be stranded in their homes for a time without power or heat or they may be unable to reach their homes. Long-term collateral dangers include the outbreak of disease, loss of livestock, broken sewer lines or wash out of septic systems causing water supply pollution, downed power lines, loss of fuel storage tanks, fires and release of hazardous materials.

As noted in the State Hazard Mitigation Plan, "Flooding is the most common recurring hazard event in Vermont" (2018: 55). There are two types of flooding that impact communities in Vermont: inundation and flash flooding. Inundation is when water rises onto low lying land. Flash flooding is a sudden, violent flood which often entails fluvial erosion.

Inundation flooding of land adjoining the normal course of a stream or river is a natural occurrence. If these floodplain areas were left in their natural state, floods likely would not cause significant damage.

While inundation-related flood loss is a significant component of flood disasters, the more common mode of damage in Vermont is associated with fluvial erosion, often associated with physical adjustment of stream channel dimensions and location during flood events. These dynamic and oftentimes catastrophic adjustments are due to bed and bank erosion, debris and ice jams, or structural failure of or flow diversion by human-made structures. An ice jam occurs when the ice layer on top of a river breaks into large chunks which float downstream and cause obstructions (State HMP 2018). The Town does not have a high incidence or probability of ice jams.

Several major flooding events have affected the state in recent years, resulting in multiple Presidential Disaster Declarations. From 2003 to 2010, Rutland County experienced roughly $1.4 million in property damages due to flood events.

The worst flooding event in recent years came in August of 2011 from Tropical Storm Irene (DR4022), which dropped up to 10-11 inches of rain in some areas of Rutland County. Irene caused 2 deaths and $55,000,000 in reported property damages and $2.5 million in crop damages in Rutland County. Although the storm was technically a tropical storm, the effects of the storms are profiled in this flooding section, since the storm brought only large rainfall and flooding to the Town, not the high winds typically associated with tropical storms. This caused most streams and rivers to flood in addition to severe fluvial erosion.

From 2012 to 2019, Rutland County experienced approximately $3.5 million in property damages; with $1.9 million due to a flash flood event in July 2017 (DR4330) and $1 million due to a flash flood event in April 2019 (DR4445).

In Mount Holly, flooding is a risk. Damages from Tropical Storm Irene were significant, resulting in approximately $500,000 in impacts ($46,834 in Individual Assistance; $443,275 in Public Assistance; $9,917 in National Flood Insurance). In Mount Holly, damage due to flooding usually consists of impacts to roads, culverts, and bridges.

As shown on the Local Natural Hazards and Vulnerabilities Map in **Appendix B**, Mount Holly is not particularly vulnerable to inundation flooding, except for the following locations:

- Perry Road (in the vicinity of bridges B54 and B50 - historic flooding has not overtopped the road) along a tributary to Cold Brook.
- Belmont Road (near the VT Route 103 intersection at bridge B14) along Mill Brook.
- Fowler Brook Road (near the VT Route 155 intersection at bridge B60) along Mill River.
- VT Route 155 (near the intersection with Beaver Meadow Road) along Mill River.
- Belmont Road/Lake Street intersection (at the spillway for Star Lake – tributary to Mill River)

Star Lake Spillway Breach – Tropical Storm Irene

26 structures are in the Special Flood Hazard Area (2% of community structures); including residential, commercial, and governmental properties. According to FEMA, 9% of these properties have flood insurance. In total, these 8 policies cover $2,068,600 in value.

There are <u>no</u> repetitive loss properties.

Flash flooding can impact areas in Town that are located outside of designated floodplains, including along streams confined by narrow valleys. Gravel roads with steep slopes, such as Packer, Roger Hill, Sawyer Hill, are especially vulnerable to wash outs due to flash flooding.

Flash Flooding Impacts on Belmont Road

In 2018, the Town completed an inventory of hydrologically-connected roads for the Municipal Roads General Permit. This inventory identified areas vulnerable to flash flooding and recommended corrective actions to make these areas more resilient.

Flash Flooding Impacts on Station Road

In 2009, a river corridor plan was prepared for the Mill River watershed. Of the approximate 45,610 acre watershed that drains through Mount Holly, 19,167 acres (42%) is in Mount Holly. That plan summarized information about the physical condition of the Mill River watershed; identified factors that are influencing the stability of the system; and synthesized the information to identify restoration and management priorities.

The Mill River corridor plan includes six locations in Mount Holly with projects to protect the river corridor, restore incised reaches, and restore riparian buffers.

Additional locations vulnerable to fluvial erosion include: Freeman Brook Road, including bridge B65; Old Turnpike Road; and Beaver Meadow Road.

Effects of Fluvial Erosion on Freeman Brook Road

Effects of Fluvial Erosion on Lushas Acres Lane and Bridge B65 along Freeman Brook

High Wind

Severe thunderstorms can produce high winds, lightning, flooding, rains, large hail, and even tornadoes. Thunderstorm winds are generally short in duration, involving straight-line winds and/or gusts more than 50 mph. Thunderstorm winds can cause power outages, transportation and economic disruptions, significant property damage, and pose a high risk of injuries and loss of life.

From 2004 to 2010, for thunderstorms that caused more than $200,000 in damage, Rutland County experienced nearly $2 million in property damage.

From 2011 to 2019, thunderstorms resulted in just under $2.2 million in property damage in Rutland County, with $525,000 due to a high wind event in May 2017.

Hail is a form of precipitation composed of spherical lumps of ice. Known as hailstones, these ice balls typically range from ¼ - 2" diameter on average, with much larger hailstones forming in severe thunderstorms. The size of hailstones is a direct function of the severity and size of the thunderstorm that produces it.

Much of the hail activity in Rutland County is scattered and varies in intensity, and the resulting damage usually takes form in uprooted trees, downed power lines, damage to automobiles and crops.

Violent windstorms are possible here; Mount Holly is susceptible to high directional winds, particularly north of VT Route 103. Many storms with high winds result in downed trees, damaged phone and power lines, buildings, and other property. Mount Holly is vulnerable to power outages and they present a potentially significant risk to many residents.

Much of the Town is served by a land line phone service that has converted from copper wire to fiber service. When the power goes out, an in-home battery provides the electricity necessary to make a call. The battery life is about eight hours, whether the phone is used or not.

Due to the natural terrain in Mount Holly, most areas cannot receive cell phone service. In the event of an emergency during a power outage many cannot contact the fire department, police, or ambulance service. This is of concern given Mount Holly's aging demographics and many remote and isolated homes.

To mitigate the impacts of power outages, the following public buildings/critical facilities have been equipped with backup power: Church Street Fire Station (alternate local emergency operations center and shelter), School Street Fire Station, and Town Garage.

The Elementary School (primary local shelter) and Town Office (primary local emergency operations center) do not have backup power. If a power outage coincided with a large scale sheltering event, the Town could be faced with a serious situation.

Extreme Cold/Snow/Ice/Wind

In the Rutland Region, most winter weather events occur between the months of December and March. Throughout the season, winter weather events can include snowstorms, mixed precipitation events of sleet and freezing rain, blizzards, glaze, extreme cold, the occasional ice storm, or a combination of any of the above. Events can also be associated with high winds or flooding, increasing the potential hazard.

The costs of these storms come in the form of power outages, damaged trees, school closings and traffic accidents.

From 2002 to 2010, Rutland County experienced $1.1 million in property and crop damages from winter storms. From 2011 to 2019, Rutland County experienced $1.5 million in property damage, with $300,000 due to a 10"-20" heavy, wet snowfall across the county on December 9, 2014.

There have been four winter storm-related federally declared disasters in the county (the ice storm of January 1998 – DR 1201; severe winter storms in December 2000 and 2014 – DR 1358 and DR 4207, respectively; and severe storm and flooding in April 2007 – DR 1698).

Typically, towns' vulnerability to snow and ice storms are power outages and loss of road accessibility. As previously described, the Town is somewhat prepared for a power outage. However, if the outage coincided with a large scale sheltering event, the Town could be faced with a serious situation.

In general, snow accumulation has not made the Town vulnerable to loss of road accessibility. The Town's fleet of snowplows has ensured that roads are accessible, even in major snow accumulation events. Areas prone to drifting (Lake Ninevah Rd, Sawyer Hill Rd, Healdville Rd) are maintained accordingly.

Drought

Drought, in the most general sense, is a period of lower-than-average precipitation that results in a water shortage.

It is typically a slow-onset natural hazard that can last for months or years. Drought is a natural part of the climate cycle. Higher temperatures, water demands that exceed availability, low winter snowpack and lack of rainfall are all causes that can lead to a significant drought.

The USDA rates droughts from D0-D4, depending on the severity of the drought, the amount of time it will take for vegetation to return to normal levels, and the possible effects of the drought on vegetation and water supply:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

Drought is a natural phenomenon that has unique characteristics that make it different from other hazards. Reference the 2018 State Hazard Mitigation Plan for a full discussion of how drought differs from other natural hazards.

In addition to the obvious effects on the quantity and quality of drinking water, drought can compromise food and nutrition; increase incidents of illness and disease; and diminish the ability of water ecosystems to properly function.

Municipal water supply and delivery, municipal wastewater, transportation systems, and parks and recreational facilities can all be adversely impacted by drought.

There may be situations where water-intensive industries and agricultural production shift to different locations due to lack of water. Other industries directly affected include energy, tourism, and fisheries. The wide-ranging impacts of drought can include job losses, business failures, and lost investments.

When different natural hazards overlap, such as drought and flood, it can lead to cascading hazards, with one event compounding the other. Drought is particularly likely to be part of a cascading hazard because it can cover a large area and go on for a long time.

In the Rutland region, there have been several instances of moderate drought (D1) and one instance in the last 20 years of severe drought (D2). The region is in a moderate drought at the time of this writing.

Drought impacts of concern in Mount Holly include the following:

- Loss of snow cover with moderate to severe impacts on ski and snowmobile recreation, tourism, and the local economy.
- Reduced fall foliage with moderate impacts on the local tourism economy.
- Increased occurrences of wildland fires with minor to moderate impacts on human life, built infrastructure, and the natural environment (particularly for spruce/fir forests and deer wintering areas).
- Interruption of water supply with minor to moderate impacts on drinking water supplies and surface waters for fire suppression.
- Crop and agricultural losses with minor to moderate impacts on maple syrup production and minor impacts on hay production, perennial fruit and orchards, and livestock.
- Low water level and poor water quality in local water bodies – Lake Ninevah, Star Lake, and Buttermilk Falls – with minor impacts on water recreation.
- Increases in human/wildlife conflict with minor impacts due to shift from natural food systems (mast crops, etc.) to human food sources and habituation.

Highest Risk Hazard History

Note: These are the most up to date significant events impacting Mount Holly. Federal declarations are depicted in **bold**.

Inundation/Flash Flooding/Fluvial Erosion

6/20/2019: ±6" rain: no reported damage
4/15/2019: DR4445 1-2" rain with significant snow melt: **$59,800 local damage**
7/1/2017: DR4330 3-4" rain the previous 3-4 days with flash flooding on 7/1/17: **$39,110 local damage**
6/25-7/11/2013: DR4140 heavy rain over multiple days: **$20,300 local damage**
8/28/2011: DR4022 Tropical Storm Irene +/-5" rain: **$500,026 local damage** ($46,834 Individual / $443,275 Public / $9,917 NFIP)
7/16/2000: DR1336 heavy rainfall: **$8,875 local damage**

High Wind

2/24/2019: 48 mph winds: $25,000 regional damage
4/1/2018: 55 mph winds: $50,000 regional damage
10/30/2017: 40 mph wind: $100,000 regional damage
5/5/2017: 40 mph winds: $25,000 regional damage
6/2/2013: 50 mph winds: $5,000 local damage
12/9/2009: 55 mph winds: $25,000 regional damage
3/5/2008: 43 mph winds: $25,000 regional damage
12/16/2007: 50 mph wind: $25,000 regional damage
2/17/2006: 37 mph winds: $50,000 regional damage
9/29/2005: 35 mph winds: $50,000 regional damage

Extreme Cold/Snow/Ice/Wind

2/1/2015: Record cold month with 15 to 20+ days below zero: no reported impact
1/7/2015: 0 to 10 degrees with winds of 15-30 mph creating wind chills colder than 20 to 30 below zero: no reported impact
12/9/2014: DR4207 24-36" snow: **$27,150 local damage**
11/26/2014: 8-12" snow: $25,000 regional damage
2/13/2014: 30" snow: $10,000 regional damage
12/29/2012: 12" snow: $10,000 regional damage
2/23/2010: 6-30" snow: $200,000 regional damage
4/15-16/2007: DR1698 Nor'icane with 3" snow and rain with winds of 60 to 80 mph: **$25,885 local damage**
2/14/2007: 20-35" snow with wind chills of 10 below zero or colder: $75,000 regional damage
3/5/2001: EM3167 26" snow: **$2,895 local damage**

Drought

11/11/2020: USDA Disaster S4869 2020 Crop Year
Jun – Aug 2020: D1 drought in 50-100% of county
Jun – Sept 2018: D1 drought in 50-100% of county
Sept 2016 – Feb 17: D1 drought in 50-100% of county
Oct – Nov 2016: D2 drought in 60% of county
Sept 2001 – Mar 02: D1 drought in 50-100% of county

Vulnerability Summary

Inundation/Flash Flooding/Fluvial Erosion

Location[1]: *Inundation Flooding* – Perry Rd along tributary to Cold Brook; Belmont Rd along Mill Brook; Fowler Brook Rd and VT Route 155 along Mill River
Flash Flooding – gravel roads with steep slopes including Packer, Roger Hill, Sawyer Hill, Tarbelville Rd, Barlow Rd, Tiffany Rd, Healdville Rd, Greendale Rd
Fluvial Erosion – Freeman Brook Rd and Lushas Acres Ln, including bridge B65; Old Turnpike Rd; Beaver Meadow Rd

Vulnerable Assets[1]: Roads, culverts, bridges

Extent: 5-6" rain; fluvial erosion extent data is unavailable

Impact: $500,026 local damage

Probability: Flash flooding/fluvial erosion: >75% chance per year; Inundation flooding: >10% but <75% chance per year

High Wind

Location[1]: Town-wide, especially north of VT Route 103

Vulnerable Assets[1]: Phone and power lines; buildings; other property; trees

Extent: 55 mph winds

Impact: $100,000 regional / $5,000 local damage

Probability: >75% chance per year

Extreme Cold/Snow/Ice/Wind

Location[1]: Town-wide; Drifting on Lake Ninevah Rd, Sawyer Hill Rd, Healdville Rd

Vulnerable Assets[1]: Roads, culverts, bridges, trees, power and phone lines

Extent: Up to 36" of snow; 80 mph winds; 15-20+ days below zero

Impact: $200,000 regional / $27,150 local damage

Probability: >75% chance per year

Drought

Location[1]: Town-wide

Vulnerable Assets[1]: Water supplies, natural ecosystems, agriculture

Extent: D2 drought in 60% of county for 2 months

Impact: Data on financial impacts is unavailable

Probability: >10% but <75% chance per year

[1] See **Appendix B:** Local Natural Hazards and Vulnerabilities Map

6 HAZARD MITIGATION STRATEGY

The highest risk natural hazards and vulnerabilities identified in the previous section of this Plan directly inform the hazard mitigation strategy outlined below, which the community will strive to accomplish over the coming years. The mitigation strategy chosen by the Town includes the most appropriate activities to lessen vulnerabilities from potential hazards.

Mitigation Goals

The Hazard Mitigation Planning Team discussed mitigation goals and identified the following as the community's main mitigation goals:

- Reduce or avoid long-term vulnerabilities to identified hazards.
- Reduce the loss of life and injury resulting from these hazards.
- Mitigate financial losses incurred by municipal, residential, industrial, agricultural, and commercial establishments due to disasters.
- Reduce the damage to public infrastructure resulting from these hazards.
- Encourage hazard mitigation planning as a part of the municipal planning process.
- Encourage the adoption and implementation of existing mitigation resources, such as River Corridor Plans and Fluvial Erosion Hazard Maps, if available.
- Recognize the connections between land use, stormwater, road design, maintenance, and the effects from disasters.
- Ensure that mitigation measures are sympathetic to the natural features of community rivers, streams, and other surface waters; historic resources; character of neighborhoods; and the capacity of the community to implement them.

Community Capabilities

Each community has a unique set of capabilities, including authorities, programs, staff, funding, and other resources available to accomplish mitigation and reduce long-term vulnerability. Mount Holly's mitigation capabilities that reduce hazard impacts or that could be used to implement hazard mitigation activities are listed below.

Administrative and Technical

In addition to the Emergency Management staff described in Section 3, municipal staff that can be used for mitigation planning and to implement specific mitigation actions include: Town Clerk, Town Treasurer, Road Foreman, and Land Use Regulations Administrative Officer.

In addition to paid staff, there is a 3-member Selectboard, 5-member Planning Commission, 9-member Conservation Commission, and Town Health Officer.

To augment local resources, the Town has formal mutual aid agreements for emergency response - fire, EMS, and public works. Technical support is available through the RRPC in the areas of land use planning, emergency management, transportation, GIS mapping, and grant writing. Technical support is also available through the State ANR for floodplain administration and VTrans Districts for hydraulic analyses.

Strengths: Very competent and responsive Fire and Highway Departments – they are well trained and capable ● local participation – volunteers tend to be knowledgeable with significant experience ● coordination between departments is effective ● past success securing and administering grants for public infrastructure projects

Areas for Improvement: greater emphasis on record retention and what documentation is needed right from the start, regardless of an Emergency Declaration ● maintenance programs to reduce risk could be more robust, particularly that for cleaning culverts, roadside ditches, and tree trimming within the road right-of-way ● develop an emergency communications plan because cell coverage is poor and fiber optic land line batteries last only 8-hours ● periodic tabletop and field exercises to test and strengthen operational coordination ● few staff perform multiple functions – lack of redundancy makes town's administrative and technical capabilities vulnerable

Planning and Regulatory

Planning and regulatory capabilities are the plans, policies, codes, and ordinances that prevent and reduce the impacts of hazards. Examples of planning capabilities that can either enable or inhibit mitigation include land use plans, capital improvement programs, transportation plans, stormwater management plans, disaster recovery and reconstruction plans, and emergency preparedness and response plans. Examples of regulatory capabilities include the enforcement of zoning ordinances, subdivision regulations, and building codes that regulate how and where land is developed, and structures are built.

Strengths: Road and bridge standards are adequately administered and enforced ● elements of hazard mitigation are included in other local plans

Areas for Improvement: Existing land use ordinances should be updated to be more effective at reducing hazard impacts ● protect river corridors from new encroachment through River Corridor Bylaws ● capital planning ● continuity of operations planning ● stormwater master planning

Flood Hazard Area (FHA) Regulations: Adopted June 24, 2008
Description: Apply to all areas in the Town identified as existing lots defined in the Mount Holly land records.
Relationship to Natural Hazard Mitigation Planning: Promote orderly growth in Mount Holly in conjunction with the Town Plan.

Subdivision Regulations: Adopted March 3, 1998
Description: Apply to all areas in the Town identified as areas of special flood hazard.
Relationship to Natural Hazard Mitigation Planning: Ensures the design and construction of development in flood and other hazard areas are accomplished in a manner that minimizes or eliminates the potential for flood loss or damage to life and property.

Road and Bridge Standards: Adopted on July 9, 2019
Description: Provide minimum codes and standards for the construction, repair, and maintenance of all town roads and bridges.
Relationship to Natural Hazard Mitigation Planning: Standards include management practices and are designed to ensure the safety of the traveling public, minimize damage to road infrastructure during flood events, and enhance water quality protections.

Fire Department ISO Rating: Issued in 2020
Description: The Mount Holly Fire Department's ISO rating is 9/10. This rating is a score from 1 to 10 that indicates how well-protected the community is by the local fire department.
Relationship to Natural Hazard Mitigation Planning: Everyone wants to keep family, home, and business safe from fires. The ISO rating is a measure of the effectiveness of a community's fire services.

Municipal Plan: Adopted October 9, 2018
Description: A framework for defining and attaining community aspirations through public investments, land use regulations, and other implementation programs.
Relationship to Natural Hazard Mitigation Planning: The Flood Resilience sections of the Town Plan include specific goals and policies related to natural hazards.

Local Emergency Management Plan: Last adopted on April 22, 2020
Description: Establishes lines of responsibility and procedures to be implemented during a disaster and identifies high risk populations, hazard sites, and available resources.
Relationship to Natural Hazard Mitigation Planning: The LEMP includes actions for tracking events and response actions including damage reports to facilitate funding requests during recovery. This type of information can be essential to preparing hazard mitigation project applications for FEMA funding.

Road Erosion Inventory Report: December 2018
Description: Prioritizes those infrastructure projects necessary to improve transportation network resiliency and water quality.
Relationship to Natural Hazard Mitigation Planning: Improvements are designed to minimize or eliminate flood impacts on hydrologically-connected road segments regulated under the Municipal Roads General Permit.

Stormwater Infrastructure Mapping Study: February 2017
Description: Developed up to date municipal drainage system maps and established locations for BMP stormwater retrofit sites.
Relationship to Natural Hazard Mitigation Planning: Assist with emergency preparedness for large rainfall and spring snowmelt runoff events and identified several structural projects to improve stormwater drainage system capacity.

Financial

Financial capabilities are the resources that a community has access to or is eligible to use to fund mitigation actions.

Mount Holly's current annual budget is approximately $1,366,895, with $469,900 to fund the Highway Department. Although the Town has not done so in the past, it is eligible to incur debt through general obligation bonds to fund mitigation actions.

Strengths: Dedicated reserve funds (e.g., bridge and equipment) that can be used to fund mitigation actions

- maximize grant opportunities

Areas for Improvement: Increase budget amounts going into culvert and bridge reserve funds annually

Education and Outreach

Mount Holly has several education and outreach opportunities that could be used to implement mitigation activities and communicate hazard-related information:

- Okemo Valley Television
- Mount Holly Chit Chat (monthly newsletter)
- Newsflash (community email distribution list)
- Bone Builders
- Community Guild
- Mount Holly Library
- Mount Holly Community Association
- Historical Museum
- Odd Fellows
- Friends of Star Lake
- Ninevah Foundation
- Mount Holly Conservation Trust
- Mount Holly SnoFlyers
- Mount Holly Land Trust
- Mount Holly PTSA
- Village Baptist Church

Strengths: Multiple programs/organizations are already in place in the community

- monthly community newsletter

Areas for Improvement: Better coordination with existing programs/organizations would be needed to help implement future mitigation actions

National Flood Insurance Program Compliance

The Town joined the National Flood Insurance Program (NFIP) in 1985. An Administrative Officer enforces NFIP compliance through permit review requirements in its Flood Hazard Area regulations. Mount Holly's regulations outline detailed minimum standards for development in flood hazard areas defined as FEMA Special Flood Hazard Areas and Floodway Areas.

The Town discussed the following as possible actions to continue NFIP compliance:

1) Provide information to residents on safe building initiatives and the availability of flood insurance.
2) Adopt river corridor protection language in the flood hazard regulations bylaw.
3) Work with the RRPC to ensure that floodplain and river corridor maps are kept up to date.

State Incentives for Flood Mitigation

Vermont's Emergency Relief Assistance Funding (ERAF) provides state funding to match FEMA Public Assistance after federally-declared disasters. Eligible public costs are generally reimbursed by FEMA at 75% with the State matching 7.5%. The State will increase its match to 12.5% or 17.5% of the total cost if communities take steps to reduce flood risk as described below.

12.5% funding for eligible communities that have adopted four (4) mitigation measures:

1) NFIP participation
2) Town Road and Bridge Standards
3) Local Emergency Management Plan (LEMP)
4) Local Hazard Mitigation Plan (LHMP)

17.5% funding for eligible communities that also participate in FEMA's Community Rating System OR adopt Fluvial Erosion Hazard or other river corridor protection bylaw that meets or exceeds the Vermont ANR model regulations.

Mount Holly's current ERAF rate is 7.5% because they 1) participate in the NFIP; 2) have adopted Town Road and Bridge Standards; and 3) have a current LEMP. Mount Holly's ERAF rate will increase to 12.5% with adoption of a FEMA-approved LHMP.

Mitigation Action Identification

The Hazard Mitigation Planning Team discussed the mitigation strategy, reviewed projects from the 2009 Annex, and identified possible new actions from the following categories for each of the highest risk natural hazards identified in Section 5:

1) **Local Plans and Regulations:** These actions include government authorities, policies, or codes that influence the way land and buildings are developed and built.
2) **Structure and Infrastructure Projects:** These actions involve modifying existing structures and infrastructure to protect them from a hazard or remove them from a hazard area. This applies to public or private structures as well as critical facilities and infrastructure. Many of these types of actions are projects eligible for funding through the FEMA Hazard Mitigation Assistance Program.
3) **Natural Systems Protection:** These are actions that minimize damage and losses and preserve or restore the functions of natural systems.
4) **Education and Awareness Programs:** These are actions to inform and educate the public about hazards and potential ways to mitigate them. Although this type of mitigation reduces risk less directly than structural projects or regulation, it is an important foundation. A greater understanding and awareness of hazards and risk is more likely to lead to community support for direct actions.

Local Plans and Regulations

Integrate Mitigation into Capital Improvement Programs: Hazard mitigation can be included in capital improvement programs by incorporating risk assessment and hazard mitigation principles into the capital planning efforts.

Manage Development in Erosion Hazard Areas: The intent of River Corridor Bylaws is to 1) allow for wise use of property within river corridors that minimizes potential damage to existing structures and development from flood-related erosion, 2) discourage encroachments in undeveloped river corridors and 3) reasonably promote and encourage infill and redevelopment of designated centers that are within river corridors.

Improve Stormwater Management Planning: Rainwater and snowmelt can cause flooding and erosion in developed areas. A community-wide stormwater management plan can address stormwater runoff.

Reduce Impacts to Roadways: The leading cause of death and injury during winter storms is from automobile or other transportation accidents, so it is important to plan for and maintain adequate road and debris clearing capabilities.

Develop a Drought Contingency Plan: A strategy or combination of strategies for monitoring the progression of a drought and preparing a response to potential water supply shortages resulting from severe droughts or other water supply emergencies.

Structure and Infrastructure Projects

Remove Existing Structures from Flood Hazard Areas: FEMA policy encourages and may provide funding for the removal of structures from flood-prone areas to minimize future flood losses and preserve lands subject to repetitive flooding.

Improve Stormwater Drainage Capacity: Improving the stormwater drainage capacity can help to minimize inundation flooding and fluvial erosion by: 1) increasing drainage/absorption capacities with green stormwater management practices; 2) increasing dimensions of undersized drainage culverts in flood-prone areas; 3) stabilizing outfalls with riprap and other slope stabilization techniques; and 4) re-establishing roadside ditches.

Conduct Regular Maintenance for Drainage Systems: Regular maintenance will help drainage systems and flood control structures continue to function properly. Techniques include: 1) routinely cleaning and repairing stormwater infrastructure – culverts, catch basins, and drain lines; 2) routinely cleaning debris from support bracing underneath low-lying bridges; and 3) inspecting bridges and identifying if any repairs or retrofits are needed to maintain integrity or prevent scour.

Protect Infrastructure and Critical Facilities: Mitigation techniques can be implemented to help minimize losses to infrastructure and protect critical facilities from flood events by:

1) elevating roads above the base flood elevation to maintain dry access; 2) armoring the banks of streams near roadways to prevent washouts or 3) rerouting a stream away from a vulnerable roadway; and 4) floodproofing critical facilities.

Protect Power Lines: Power lines can be protected from the impacts of natural hazards by: 1) incorporating inspection and maintenance of hazardous trees within the road right-of-way into the drainage system maintenance process and 2) burying power lines.

Retrofit Critical Facilities: Critical facilities can be protected from the impacts of high winds and winter storms. Techniques include: 1) retrofitting critical facilities to strengthen structural frames to withstand wind and snow loads; 2) anchoring roof-mounted mechanical equipment; and 3) installing back-up generators or quick connect wiring for a portable generator.

Invest in Infrastructure to Expand Water Supplies: Improve water supply and delivery systems to ensure adequate supply for fire suppression during times of drought.

Natural Systems Protection

Protect and Restore Natural Flood Mitigation Features: Natural conditions often provide floodplain protection, riparian buffers, groundwater infiltration, and other ecosystem services that mitigate flooding. It is important to preserve such functionality. Possible projects include: 1) establishing vegetative buffers in riparian areas; 2) stabilizing stream banks; 3) removing berms; 4) minimizing impervious area development; and 5) restore incision areas.

Education and Awareness Programs

Educate Property Owners About Freezing Pipes: Extreme cold may cause water pipes to freeze and burst, which can cause flooding inside a building. Consider: 1) educating building owners on how to protect their pipes and 2) informing homeowners that keeping water within the pipes moving by letting a faucet drip during extreme cold weather may prevent freezing and the buildup of excessive pressure in the pipeline, avoiding bursting.

Assist Vulnerable Populations: Ensure vulnerable populations are adequately protected from the impacts of natural hazards, such as: 1) organize outreach and 2) establish and promote accessible heating or cooling centers in the community.

Educate Residents on Drought-related Hazards and Water Saving Techniques: Increase awareness of drought-related hazards - brush fire, diminished water quality and quantity. Encourage residents to take water-saving measures, such as 1) install low-flow water saving showerheads and toilets; 2) check for leaks in plumbing or dripping faucets; and 3) install rain-capturing devices for irrigation.

Mitigation Action Evaluation and Prioritization

For each mitigation action identified, the Hazard Mitigation Planning Team evaluated its potential benefits and/or likelihood of successful implementation. Each action was evaluated against a broad range of criteria, including a planning level assessment of whether the costs are reasonable compared to the probable benefits. Results of this evaluation are presented in **Table 5**.

Mitigation Action Implementation

After careful evaluation and prioritization, the Planning Team agreed on a list of acceptable and practical actions for the community to implement.

Those actions without overall public support/political will were not selected for implementation. Those actions whose costs were not reasonable compared to the probable benefits were also not selected.

For the selected actions, the Planning Team then 1) assigned a responsible party to lead the implementation of each action; 2) identified potential funding mechanisms; and 3) developed a timeframe for implementing each action. This action plan is presented in **Table 6**.

Note that the Town will make every effort to maximize use of future Public Assistance Section 406 Mitigation opportunities when available during federally declared disasters.

Table 5: Mitigation Action Evaluation and Prioritization

Mitigation Action	Life Safety	Prop Protect	Tech	Political	Admin	Other Obj	Benefit Score	Est Cost	C/B
Local Plans and Regulations									
Integrate Mitigation into Capital Improvement Programs	1	1	1	1	1	1	6	1	Yes
Improve Stormwater Management Planning by Completing a Stormwater Management Plan	1	1	1	1	1	1	6	1	Yes
Develop a Drought Contingency Plan	1	1	1	1	1	1	6	1	Yes
Plan for and Maintain Adequate Road and Debris Clearing Capabilities	1	1	1	1	1	1	6	2	Yes
Update Road Erosion and Culvert Inventories	1	1	1	1	0	1	5	1	Yes
Manage Development in Erosion Hazard Areas by Adopting River Corridor Bylaws	1	1	1	0	1	1	5	1	Yes
Review VTrans Bridge Inspection Reports[1] and Plan for Identified Repairs to Prevent Scour	1	1	1	1	0	1	5	1	Yes
Structure and Infrastructure Projects									
Install/Re-establish Roadside Ditches	1	1	1	1	1	1	6	1	Yes
Protect Power Lines and Roadway by Inspecting and Removing Hazardous Trees in Road ROW	1	1	1	1	1	1	6	1	Yes
Install Back-up Generators or Quick Connect Wiring at Critical Facilities	1	1	1	1	1	1	6	1	Yes
Invest in Infrastructure to Expand Water Supplies for Fire Suppression	1	1	1	1	1	1	6	1	Yes
Increase Dimension of Drainage Culverts in Flood-Prone Areas	1	1	1	1	1	1	6	2	Yes
Routinely Clean and Repair Stormwater Infrastructure	1	1	1	1	0	1	5	1	Yes
Stabilize Outfalls	1	1	1	1	1	1	6	1	Yes
	There are currently no identified outfalls requiring stabilization, so the Planning Team did not recommend this action for implementation. Outfalls will be monitored and stabilized as needed to comply with current Road Standards and the MRGP.								
Increase Drainage/Absorption Capacities with Green Stormwater Management Practices	1	1	1	1	1	1	6	1	Yes
	There are currently no identified project locations for this practice, so the Planning Team did not recommend this action for implementation.								
Floodproof Critical Facilities	1	1	1	1	1	1	6	1	Yes
	There are no critical facilities that need floodproofing, so the Planning Team did not recommend this action for implementation.								
Elevate Roads Above Base Flood Elevation to Maintain Dry Access	1	1	1	1	1	1	6	3	No
Retrofit Critical Facilities to Strengthen Structural Frames to Withstand Wind and Snow Loads	1	1	1	0	0	0	3	1	No
Bury Power Lines	1	0	1	-1	1	1	3	3	No
Remove Existing Structures from Flood-Prone Areas	1	1	1	-1	0	1	3	3	No
Anchor Roof-Mounted Mechanical Equipment on Critical Facilities	0	0	1	0	0	0	1	1	No
Routinely Clear Debris from Support Bracing Underneath Low-Lying Bridges	0	0	1	0	-1	0	0	1	No

[1] VTrans inspects all town-owned bridges in the State's Town Highway Bridge Program every two years. Bridge inspection reports are available on the VTrans website.

Mitigation Action	Life Safety	Prop Protect	Tech	Political	Admin	Other Obj	Benefit Score	Est Cost	C/B
Natural Systems Protection									
Establish Vegetative Buffers in Riparian Areas	1	1	1	0	1	1	5	1	Yes
Stabilize Stream Banks	0	1	1	0	0	1	3	1	Yes
	The banks on Freeman Brook have been stabilized in the past to mitigate fluvial erosion. There are currently no known areas requiring stabilization.								
Restore Incision Areas	0	0	1	0	0	0	1	1	No
Remove Berms	0	0	0	0	0	0	0	1	No
Education and Awareness Programs									
Increase Awareness about Drought-related Hazards and Water Saving Techniques	1	1	1	1	1	1	6	1	Yes
Keep the Ditches Clean Campaign	1	1	1	1	1	1	6	1	Yes
Assist Vulnerable Populations	Mount Holly already has a system in place to assist vulnerable populations – se 2020 Local Emergency Management Plan.								
Educate Property Owners about Freezing Pipes	Mount Holly already has an awareness program in place to educate property owners about freezing pipes – information is published in the *Chit Chat*.								

Table 5 Evaluation Criteria:

Life Safety – How effective will the action be at protecting lives and preventing injuries?
Property Protection – How effective will the action be at eliminating or reducing damage to structures and infrastructure?
Technical – Is the mitigation action a long-term, technically feasible solution?
Political – Is there overall public support/political will for the action?
Administrative – Does the community have the administrative capacity to implement the action?
Other Community Objectives – Does the action advance other community objectives, such as capital improvements, economic development, environmental quality, or open space preservation?

Rank each of the above criteria in Table 5 with a -1, 0, or 1 using the following table:
1= Highly effective or feasible
0 = Neutral
-1 = Ineffective or not feasible

Estimated Cost – 1 = less than $50,000; 2 = $50,000 to $100,000; 3 = more than $100,000
C/B – Are the costs reasonable compared to the probable benefits? Yes or No

Table 6 Community Lifelines Description: A Community Lifeline enables the continuous operation of critical government and business functions and is essential to human health and safety or economic security. The primary objective of lifelines is to ensure the delivery of critical services that alleviate immediate threats to life and property when communities are impacted by disasters. These critical services are organized into one of seven lifelines:

Safety and Security:
1. Law Enforcement
2. Fire Service
3. Search & Rescue
4. Government Service
5. Community Safety

Food, Water, Shelter:
1. Food
2. Water
3. Shelter
4. Agriculture

Health and Medical:
1. Medical Care
2. Public Health
3. Patient Movement
4. Medical Supply Chain
5. Fatality Management

Energy (Power & Fuel):
1. Power Grid
2. Fuel

Communications:
1. Infrastructure
2. Responder Communications
3. Alerts, Warnings, & Messages
4. Finance
5. 911 & Dispatch

Transportation:
1. Highway/Road/ Motor Vehicle
2. Mass Transit
3. Railway
4. Aviation
5. Maritime

Hazardous Materials:
1. Facilities HAZMAT, Pollutants, Contaminants

Table 6: Mitigation Action Implementation

Develop a Stormwater Management Plan: A Stormwater Management Plan can guide the town in planning, funding, and implementing a comprehensive program for addressing current and future requirements for managing stormwater runoff, flooding problems, and the Town's natural resources. Mount Holly will explore the feasibility of developing this Plan.

ADDRESSED HAZARDS

Flooding

Lead Party
Selectboard

Type of Project
Local Plans and Regulations

COMMUNITY LIFELINES

Safety & Security

Transportation
Primary Lifeline

Area of Impact
Town-wide; Star Lake, Lake Ninevah, Tiny Pond; Mill River; Winslows' Flats Wetland

FUNDING SOURCES
- Local funding

PARTNERSHIPS
- Rutland NRCD
- Conservation Commission
- Planning Commission

BENEFIT SCORE = 6

PROJECT TIMELINE
Outreach to Rutland NRCD to explore funding and technical assistance in Jun 2021

Develop a Drought Contingency Plan: A Drought Contingency Plan is a strategy or combination of strategies for monitoring the progression of a drought and preparing a response to potential water supply shortages resulting from severe droughts or other water supply emergencies. Mount Holly will explore the feasibility of developing this Plan.

ADDRESSED HAZARDS

Drought

Lead Party
Selectboard

Type of Project
Local Plans and Regulations

COMMUNITY LIFELINES

Safety & Security

Food, Water, Shelter
Primary Lifeline

Area of Impact
Town-wide; Star Lake, Lake Ninevah, Tiny Pond; Mill River; Winslows' Flats Wetland

FUNDING SOURCES
- Local funding

PARTNERSHIPS
- Rutland NRCD
- Conservation Commission
- Planning Commission
- Volunteer Fire Department

BENEFIT SCORE = 6

PROJECT TIMELINE
Outreach to Rutland NRCD to explore funding and technical assistance Jun 2021

Plan for and Maintain Adequate Road and Debris Clearing Capabilities: This includes capital planning and funding to support the appropriate number of staff and equipment needed to maintain the transportation network in Mount Holly.

ADDRESSED HAZARDS

Winter Storm
Primary Hazard

High Winds

Lead Party
Selectboard

Type of Project
Local Plans and Regulations

COMMUNITY LIFELINES TARGETED

Safety & Security

Transportation
Primary Lifeline

Area of Impact
Town-wide; ±69 mile road network

FUNDING SOURCES
- Local funding

PARTNERSHIPS
- Road Foreman

BENEFIT SCORE = 6

PROJECT TIMELINE
To coincide with preparing the annual Town budget each fall

Update Road Erosion and Culvert Inventories: These inventories were completed in 2017 and serve as the basis for asset management and should be kept up-to-date annually, with a full re-assessment every 5 years. Driveway culverts should be included in the 2022 culvert inventory re-assessment.

ADDRESSED HAZARDS

Flooding

Lead Party

Road Foreman

Type of Project

Local Plans and Regulations

COMMUNITY LIFELINES TARGETED

Safety & Security

Transportation
Primary Lifeline

Area of Impact

Town-wide; ±60 miles of hydrologically-connected roads and ±460 culverts

FUNDING SOURCES

- Local funding
- VTrans Better Roads

PARTNERSHIPS

- Rutland Regional Planning Commission

BENEFIT SCORE = 5

PROJECT TIMELINE

Re-assessment summer 2022

Manage Development in Erosion Hazard Areas with River Corridor Bylaws: River Corridor Bylaws can be used in conjunction with Flood Hazard Area Regulations to manage development in areas prone to flood impacts. Mount Holly will explore the feasibility of adopting River Corridor Bylaws.

ADDRESSED HAZARDS

Flooding

Lead Party

Planning Commission

Type of Project

Local Plans and Regulations

COMMUNITY LIFELINES TARGETED

Safety & Security

Transportation
Primary Lifeline

Area of Impact

Town-wide

FUNDING SOURCES

- Local funding

PARTNERSHIPS

- Selectboard
- Rutland Regional Planning Commission

BENEFIT SCORE = 5

PROJECT TIMELINE

Gauge the public support/political will starting in Jul 2021
Submit recommendations to Selectboard by Dec 2021

Plan for Bridge Repairs: Every two years, VTrans inspects all town-owned bridges that are in the State's Town Highway Bridge Program. These inspection reports will be reviewed and used to plan for any identified flood-related bridge repairs.

ADDRESSED HAZARDS

Flooding

Lead Party

Road Foreman

Type of Project

Local Plans and Regulations

COMMUNITY LIFELINES TARGETED

Safety & Security

Transportation
Primary Lifeline

Area of Impact

Seven (7) town-owned bridges: B61, B63, B64, B65, B67, B68, B69

FUNDING SOURCES

- Local funding

PARTNERSHIPS

- Selectboard
- VTrans

BENEFIT SCORE = 5

PROJECT TIMELINE

Review reports in Nov 2020
Develop plan for bridge repairs, if needed, by Jun 2021
Follow-up with VTrans on the schedule for replacing bridge B64 through the VTrans Capital Program in Jun 2021

Re-work Roadside Ditches: Properly installed and stabilized roadside ditches are critical to protect the integrity of the road. Although Mount Holly has an extensive network of ditches, the areas noted below either need new ditches or have ditches that need to be re-worked to bring them up to current municipal Road Standards.

Addressed Hazards

Flooding

Lead Party

Road Foreman

Type of Project

Infrastructure

Community Lifelines Targeted

Safety & Security

Transportation
Primary Lifeline

Area of Impact

1) Old Turnpike
2) Sawyer Hill

Funding Sources

- Local funding
- VTrans Better Roads
- Grants-In-Aid

Partnerships

- Selectboard

Benefit Score = 6

Project Timeline

1) 2021 construction season
2) 2022 construction season

Remove Hazardous Trees in Road Right-of-Way: Hazardous trees in the road right-of-way can contribute to power and communication outages as well as debris in the roadway during winter storms and high wind events. Mount Holly will remove hazardous trees within their road right-of-way as they are identified and/or request removal by Green Mountain Power if also within the power line right-of-way. This work will be done in accordance with the Rural Road Resilient Right-of-Ways Vegetation Assessment, when completed.

Addressed Hazards

Winter Storm

High Winds

Lead Party

Road Foreman

Type of Project

Infrastructure

Community Lifelines Targeted

Energy
Primary Lifeline

Transportation

Communications

Area of Impact

Town-wide

Funding Sources

- Local funding

Partnerships

- Tree Warden
- Green Mountain Power
- Selectboard

Benefit Score = 6

Project Timeline

As needed
See Rural Road Resilient Right-of-Ways Vegetation Assessment

Install Back-up Power at Critical Facilities: Generators are emergency equipment that provide a secondary source of power to a facility. Mount Holly has identified two critical facilities in need of back-up power.

Addressed Hazards

All Hazards

Lead Party

Selectboard – Town Office
Schoolboard – Elementary School

Type of Project

Infrastructure

Community Lifelines Targeted

Energy
Primary Lifeline

Food, Water, Shelter

Area of Impact

1) Town Office (local emergency operations center)
2) Elementary School (local shelter)

Funding Sources

- Local funding
- FEMA HMGP

Partnerships

- None

Benefit Score = 6

Project Timeline

1) 2026 construction season
2) 2026 construction season

Expand Water Supplies for Fire Suppression: Lacking municipal drinking water infrastructure, Mount Holly relies exclusively on a system of dry hydrants for fire suppression. During times of drought, surface water sources relied upon could become compromised. To improve fire suppression for village residents as well as more rural areas, Mount Holly will install additional dry hydrants in the following locations.

ADDRESSED HAZARDS

Drought

Lead Party

Volunteer Fire Department

Type of Project

Infrastructure

COMMUNITY LIFELINES

Safety & Security

Area of Impact

1) Around Lake Ninevah
2) Along VT Route 155

FUNDING SOURCES

- Local funding
- Vermont Rural Fire Protection Task Force

PARTNERSHIPS

- Ninevah Foundation
- Private Landowners

BENEFIT SCORE = 6

PROJECT TIMELINE

1) 2023 construction season
2) 2025 construction season

Adequately Size Drainage and Perennial Stream Culverts in Flood-Prone Areas: Undersized culverts can lead to road washouts and flooding. Mount Holly has identified several locations where upsized culverts are needed.

ADDRESSED HAZARDS

Flooding

Lead Party

Road Foreman

Type of Project

Infrastructure

COMMUNITY LIFELINES

Safety & Security

Transportation
Primary Lifeline

Area of Impact

1) Summit Road (B49): 5' to 15'x7' box – this temporary culvert was permitted as temporary work by ANR.
2) Sawyer Hill: 3' squashed to 14'x7' box
3) Others, including driveway culverts, as required by MRGP

FUNDING SOURCES

- Local funding
- VTrans Better Roads
- VTrans Structures Grant
- Grants-In-Aid
- FEMA HMGP

PARTNERSHIPS

- Selectboard
- ANR Stream Engineer
- US Army Corps of Engineers

BENEFIT SCORE = 6

PROJECT TIMELINE

1) 2023 construction season
2) 2023 construction season
3) See MRGP

Routinely Clean and Repair Stormwater Infrastructure: Regular maintenance is one of the most effective ways to mitigate the impacts of flooding. Routine cleaning and repairs of ditches, culverts, and catch basins will be done according to the Highway Department's maintenance schedule and the Municipal Roads General Permit (MRGP).

ADDRESSED HAZARDS

Flooding

Lead Party

Road Foreman

Type of Project

Infrastructure

COMMUNITY LIFELINES

Safety & Security

Transportation
Primary Lifeline

Area of Impact

Town-wide; ±69 mile road network and ±460 culverts

FUNDING SOURCES

- Local funding
- VTrans Better Roads
- Grants-In-Aid

PARTNERSHIPS

- Selectboard

BENEFIT SCORE = 5

PROJECT TIMELINE

See Highway Department's Maintenance Schedule and MRGP

Establish Vegetative Buffers in Riparian Areas and Stabilize Stream Banks: Mount Holly will work with the Rutland Natural Resources Conservation District to identify areas for collaboration to pursue these actions, especially those listed in the 2009 Mill River Corridor Management Plan.

ADDRESSED HAZARDS

Flooding

Lead Party

Selectboard

Type of Project

Natural System Protection

COMMUNITY LIFELINES

Safety & Security

Transportation
Primary Lifeline

Area of Impact

1) Mill River Watershed, particularly along Mill River and Freeman Brook
2) Branch Brook Watershed

FUNDING SOURCES

- Local funding
- VTrans Better Roads
- VANR Water Quality Grants

PARTNERSHIPS

- Road Foreman
- Rutland Natural Resources Conservation District
- ANR Stream Engineer
- US Army Corps of Engineers

BENEFIT SCORE = 3-5

PROJECT TIMELINE

Meet with Rutland NRCD to review status of 2009 Mill River Corridor Plan recommended projects and begin discussing opportunities for collaboration in Jul 2021

Educate Property Owners about Drought-related Hazards; Emerald Ash Borer; and Keep the Ditches Clean Campaign: Mount Holly will undertake education and awareness efforts on 1) drought-related hazards (e.g., brush fires, diminished water quality, water conservation); 2) the Emerald Ash Borer and the impacts of infestation; and 3) the importance of keeping the municipal ditches free of yard waste and other debris.

ADDRESSED HAZARDS

Drought

Invasive Species

Flooding

Lead Party

Selectboard

Type of Project

Education and Awareness

COMMUNITY LIFELINES

Safety & Security
Primary Lifeline

Transportation

Food, Water, Shelter

Area of Impact

Town-wide

FUNDING SOURCES

- Local funding

PARTNERSHIPS

- Tree Warden
- *Chit Chat* staff

BENEFIT SCORE = 6

PROJECT TIMELINE

Spring 2021 – Emerald Ash Borer educational outreach in *Mount Holly Chit Chat*
Summer 2021 – Drought educational outreach in *Mount Holly Chit Chat*
Fall 2021 – Keep the Ditches Clean educational outreach in *Mount Holly Chit Chat*

Process for Incorporating Plan Requirements into Other Planning Mechanisms

For Mount Holly to succeed in reducing long-term risks, the information and recommendations of this Plan should be integrated throughout government operations.

The following are specific examples of how the Town will incorporate this Plan into other plans, programs, and procedures:

- The Selectboard will work with the Road Foreman to incorporate risk assessment and hazard mitigation goals into capital planning efforts and improvement programs.

- The Planning Commission will integrate the hazard mitigation goals for disaster resiliency into the goals and objectives of the next updates to the Town Plan and Flood Hazard Area Regulations.

- The Road Foreman will implement several mitigation infrastructure projects (e.g., upsize perennial and drainage culverts in flood-prone areas, re-work roadside ditches) through existing plans (2018 Road Erosion Inventory and Report for hydrologically-connected road segments).

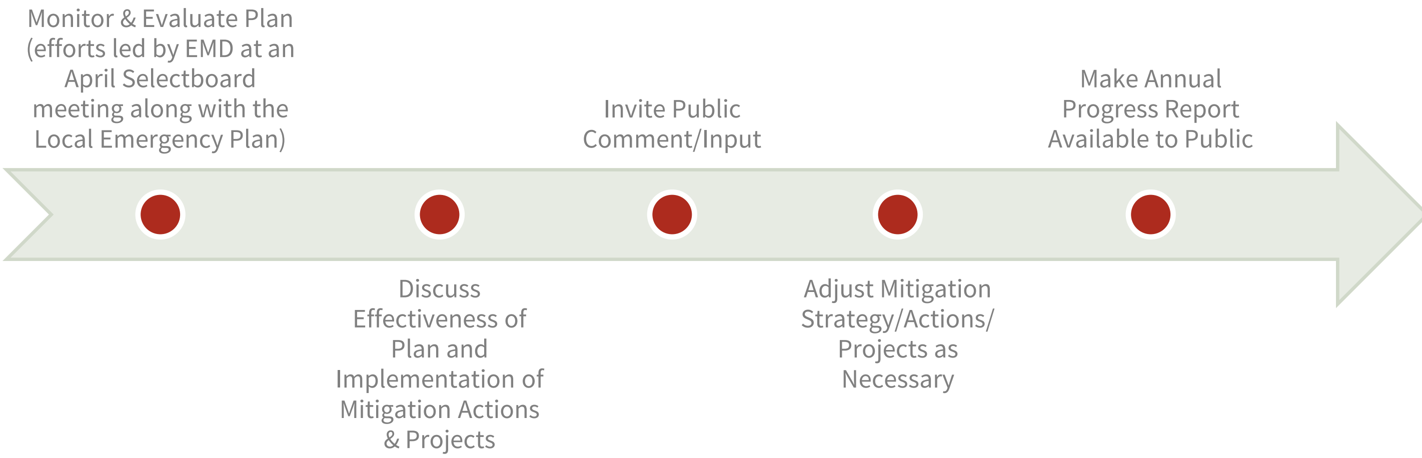
- The Selectboard (or an appointed committee) will work with the Rutland Natural Resources Conservation District to identify opportunities to collaborate on addressing the hazard mitigation projects identified in the 2009 River Corridor Plan for the Mill River Watershed.

7 PLAN MAINTENANCE

This Plan is dynamic. To ensure the Plan remains current and relevant, it is important it be monitored, evaluated, and updated periodically.

Monitoring and Evaluation

This Plan will be monitored and evaluated annually starting in 2022 in accordance with the following process:



The status (e.g., in progress, complete) of each mitigation action should be recorded in **Table 7**. If the status is "in progress" note whether the action is on schedule. If not, describe any problems, delays, or adverse conditions that will impair the ability to complete the action.

Updating

This Plan will be updated at a minimum every five (5) years in accordance with the following process:

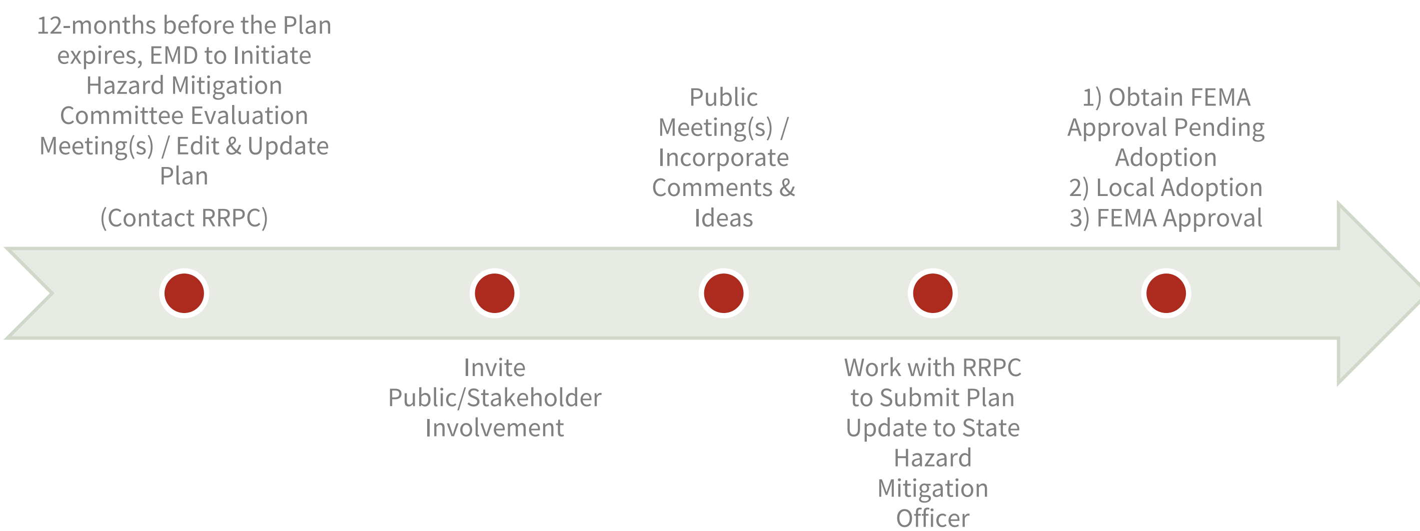


Table 7: Mitigation Action Status

Mitigation Action	2022	2023	2024	2025	2026
Local Plans and Regulations					
Develop a Stormwater Management Plan					
Develop a Drought Contingency Plan					
Plan for and Maintain Adequate Road and Debris Clearing Capabilities					
Update Road Erosion and Culvert Inventories					
Manage Development in Erosion Hazard Areas with River Corridor Bylaws					
Plan for Bridge Repairs					
Structure and Infrastructure Projects					
Re-work Roadside Ditches					
Remove Hazardous Trees in Road ROW					
Install Back-up Power at Critical Facilities					
Expand Water Supplies for Fire Suppression					
Adequately Size Drainage and Perennial Stream Culverts in Flood-Prone Areas					
Routinely Clean and Repair Stormwater Infrastructure					
Natural Systems Protection					
Stabilize Stream Banks					
Establish Vegetative Buffers in Riparian Areas					
Education and Awareness Programs					
Drought-related Hazards Educational Outreach					
Emerald Ash Borer Educational Outreach					
Keep the Ditches Clean Campaign					

CERTIFICATE OF ADOPTION
TOWN OF Mount Holly, Vermont Selectboard
A RESOLUTION ADOPTING THE Mount Holly, Vermont 2021 Local Hazard Mitigation Plan

WHEREAS, the Town of Mount Holly has historically experienced severe damage from natural hazards and it continues to be vulnerable to the effects of the hazards profiled in the **2021 Mount Holly, Vermont Local Hazard Mitigation Plan,** which result in loss of property and life, economic hardship, and threats to public health and safety; and

WHEREAS, the Town of Mount Holly has developed and received conditional approval from the Federal Emergency Management Agency (FEMA) for its **2021 Mount Holly, Vermont Local Hazard Mitigation Plan (Plan)** under the requirements of 44 CFR 201.6; and

WHEREAS, the **Plan** specifically addresses hazard mitigation strategies, and Plan maintenance procedures for the Town of Mount Holly; and

WHEREAS, the **Plan** recommends several hazard mitigation actions (projects) that will provide mitigation for specific natural hazards that impact the Town of Mount Holly with the effect of protecting people and property from loss associated with those hazards; and

WHEREAS, adoption of this **Plan** will make the Town of Mount Holly eligible for funding to alleviate the impacts of future hazards; now therefore be it

RESOLVED by Town of Mount Holly Selectboard:

1. The **2021 Mount Holly, Vermont Local Hazard Mitigation Plan** is hereby adopted as an official plan of the Town of Mount Holly;

2. The respective officials identified in the mitigation action plan of the **Plan** are hereby directed to pursue implementation of the recommended actions assigned to them;

3. Future revisions and **Plan** maintenance required by 44 CFR 201.6 and FEMA are hereby adopted as part of this resolution for a period of five (5) years from the date of this resolution; and

4. An annual report on the process of the implementation elements of the Plan will be presented to the Selectboard by the Emergency Management Director or Coordinator.

IN WITNESS WHEREOF, the undersigned have affixed their signature and the corporate seal of the Town of Mount Holly this 9 day of Feb. 2021.

ATTEST

Susan C Covalla

Town Clerk

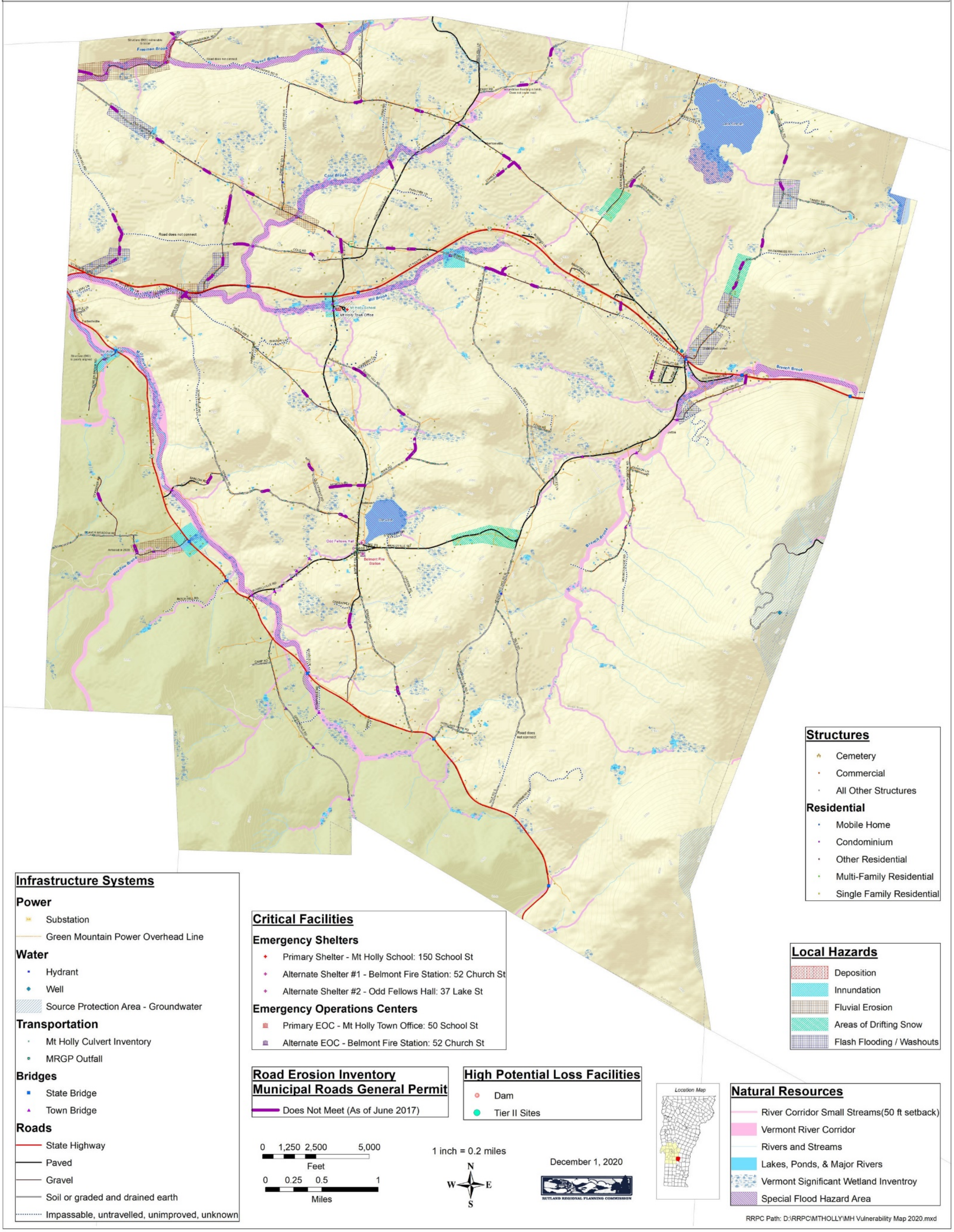
Selectboard Chair

Jeff Chase

Selectboard Member

Selectboard Member

Mount Holly, Vermont: Local Natural Hazards and Vulnerabilities Map



PRIORITY SCORE	MITIGATION ACTION	Who is Responsible	**Approx. Time Frame & Potential Funding Sources**	Initial Implementation Steps	Status	2020 Status
35	Install back-up generators (or necessary wiring for portable generator) at the school.	Fire Department	• Med-term • HSU funds	Apply for funding from HSU or other equipment grants	Will occur as state/Federal funding is available.	Incomplete – remains a priority
35	Continue adding dry hydrants to more rural areas of town. Install hydrants connecting Star Lake to points in Belmont to improve fire protection for village residents.	Fire Department and local property owners	• Med Term • Dry Hydrant Grant	Apply for dry hydrant funding through George Aiken Resource Conservation and Development Council	Ongoing as funding allows.	Incomplete – remains a priority to add dry hydrants to more rural areas and in Belmont. No longer a priority to install hydrants connecting Star Lake to points in Belmont.
34	Incorporate proposed strategies into Annual Budget and/or Capital Improvement Plan	Selectboard	• Short-Term • Local Resources	Incorporated in next Budget Cycle	Ongoing annually.	Remains an ongoing priority
33	Continue upgrade, replacement and clean-out of culverts. Continue road resurfacing.	Selectboard, Town Manager and Road Crew.	On-going; local resources.		Ongoing as funding allows.	Remains an ongoing priority
33	Repair bridges designated in 1992 State survey as needing work (bridges #61, 64, 66)	State of Vermont AOT	• Med-term • State and Local Funding	Incorporate into future capital budgets	Will occur as funding allows.	Repairs to Bridge #61 complete; repairs to Bridge #64 remain a priority; Bridge #66 was closed to vehicle traffic
33	Examine Town Plan, bylaws and development regulations to ensure identified hazard areas are addressed	Planning Commission/ Selectboard	• Med-term • Municipal Planning Grant	Incorporated in next Town Plan update	Ongoing as Plan and regulations are reviewed regularly.	Was completed in 2018; remains an ongoing priority
32	Repair dam on Star Lake.	Selectboard	• Long Term • State and Federal Resources	Pursue potential funding sources for repairs.	Will occur as funding allows.	Complete
29	Seek ways of increasing cell tower coverage in town as a backup communication network during a power outage.	Selectboard with support from Planning Commission	• Short Term • Local Resources		State efforts are active on Route 103 corridor.	Incomplete – remains a priority
29	Follow recommendations in Mill River Corridor Plan and SGAs to address fluvial erosion hazards. Create Fluvial Erosion Hazard Zones.	Selectboard/ Agency of Natural Resources	• On-going • Long Term	Incorporate Fluvial Erosion Hazard zones into Town Plan and Zoning Regulations.	New in 2009.	Incomplete – remains a priority

requirements needed for re-opening businesses. Discussion ensued on those requirements: social distancing, number of people allowed per square foot, face coverings, contact tracing logs, disinfecting procedures, and others. Mr. Turco will pull together the health and safety requirements to be followed for the town office to reopen, and he will review these with the town office staff. Mr. Turco made a motion to reopen the town office on Monday, July 20th with adherence to all health and safety guidelines, seconded by Ms. Matthews, unanimously approved. Brigid Sullivan stated that additional masks were available through Rotary, if needed.

d. **Swap Shed Reopening?** – No, will revisit the issue in August.

e. **Other** – There was no additional Old & Ongoing Business.

9. **Announcements/Other Business**
   a. **VT Route 155 Closure for Bridge #7 Replacement: July 21st – August 18th**
   b. **VT Statewide Primary – Tuesday, August 11th – Polls Open 10:00 am – 7:00 pm**

10. **Review & Sign Orders** – to be signed one Select Board member at a time at the town office.
11. **Executive Session: Title 1 V.S.A. S 313(a)(3) – personnel** – Not needed this evening.
12. **Adjourn** - Ms. Matthews made a motion to adjourn the meeting at 8:33 pm, seconded by Mr. Turco, unanimously approved, and the meeting was adjourned. Respectfully submitted: Jennifer Matthews

Planning Commission Virtual Meeting Minutes - June 22, 2020

Present: Jon McCann, Nicole Lewis, Clinton Woolley, Jim Seward, Gabrielle Macklin-Bickford, Ed Bove, Mark Turco, Jeff Chase, Jennifer Matthews, David Johnson, Brigid Sullivan, Okemo Valley TV

Jim called the meeting to order at 7:02 PM.

Discussion with Ed Bove, Executive Director of the Rutland Regional Planning Commission. Town Plans carry weight with regard to Act 250, particularly when it comes to identifying specific natural features that a town wishes to protect. Town Plans have the ability to be more regulatory than they were 15 years ago (ie/ views from specific right-of-ways can be protected through the Town Plan). Jennifer Matthews raised the concern about the possible impact by Vail with regard to any potential future development of the Mount Holly side of Okemo Mountain. Other towns restrict this sort of development through zoning regulations, which Mount Holly does not have. Options instead might include changing land use regulations, to safeguard that area. Also, much of the backside of Okemo is currently conserved land. In the Town Plan, providing a more specific definition of "Conserved Land" in the Future Land use section as well as including more specificity within the Rural Residential areas of Mount Holly would add additional protection against future unwanted development. A re-adoption of the Town Plan would "re-start" the 8-year clock of how long a Town Plan is good for. Other helpful resources could include a Viewshed Study and/or Community Value Mapping (ecological concerns) to gather more data, as well as looking at the Town Plans of towns similar in composition to Mount Holly (all Town Plans are linked on the RRPC website). At the next Planning Commission meeting on July 20th, a work plan for amending the Mount Holly Town Plan will be developed.

The meeting adjourned at 8:08 PM by motion, second and vote (5-0). Respectfully Submitted, Nicole Lewis, Planning Commission Secretary

Mount Holly Updating Hazard Mitigation Plan

The Town of Mount Holly is currently engaged in hazard mitigation planning and is updating the Mount Holly, Vermont Local Hazard Mitigation Plan. For more information on the planning process or to find out about upcoming opportunities for public input, contact Steffanie Bourque at the RRPC – sbourque@rutlandrpc.org or 802-775-0871 x206.

Thanks, Jeff Chase

Mount Holly Administrative Officer and Planning Commission Clerk Needed

The Mount Holly Planning Commission is looking for a strong candidate to serve as our Planning Commission Clerk and to nominate for the position of Administrative Officer for the Town of Mount Holly.

This position will serve the community by helping to administer permits for our land-use bylaws, manage administrative tasks, and work with the Planning Commission to provide customer service to the public. This position will perform work requiring clerical skills, public relations, email and word processing, records management, and should be able to work with minimum supervision.

The position is up to 10 hours per month (hours are flexible and can vary weekly), with the opportunity for the position to be done partially remote (a portion of the work will need to be done on location at the town office). Attendance at regularly scheduled meetings is required, which are held every third Monday of the month at7 pm. Pay is competitive.

Do you have great organizational skills and have a desire to help your community?

Email a letter of interest and your resume to the Planning Commission at planningcomm@mounthollyvt.org

Local Hazard Mitigation Plan (LHMP) Update

A team of four Mount Holly Residents are currently working with the Rutland Regional Planning Commission to create a Local Hazard Mitigation Plan (LHMP). This plan is required by the State of Vermont for all communities. Its purpose is to assist the Town to understand the natural hazards facing the community, rank them according to level of risk, and develop strategies to mitigate those hazards.

The first five sections of the plan; the Introduction, Community Profile, Hazard Identification, and Risk Assessment, will be ready for public review and comment on September 2, 2020 for a 14 day period. The draft plan will be posted to the town website at http://www.mounthollyvt.org/announcements-bulletin-board/ and at the Town Office.

The remaining sections address analysis of specific hazards and development of mitigation strategies and will be created later in September. A second public review and comment period will be provided once the plan is complete.

Public review and comment are critical to the development of the plan. Your past experiences in Mount Holly and your perspective on natural disasters and hazards will be important to this plan. We request your assistance and input.

A brief overview of the draft plan will be presented at the September 8th regular Select Board meeting. This meeting will be held remotely via Zoom, at 6:30 pm. For the meeting link and/or call-in telephone number please visit http://www.mounthollyvt.org/150047-2/. Time for public comments will be provided after the overview. Comments can also be communicated in writing to Jeff Chase at jeff@chasevermont.com or dropped off at the Town Office or mailed to Jeff Chase, PO Box 248, Mount Holly, VT.

Straight from the horses mouth . . . .

Stay Safe . . . . . Stay Spaced

from Reinbow Riding Center

September, where did the summer go? The current situation has definitely curtailed some of our usual summer activities, especially our therapeutic riding program, but also allowed us to work on things we rarely have time for. We are making Activity Bags for riders, recharging our engines, working on program ideas and chomping at the bit to get started again, although it looks like that won't happen until this coming Spring. Meanwhile the horses are fat and sassy and definitely enjoying the summer off.

We are also working on some fundraising ideas to help us replace some of the funding we lost due to Covid like this year's cancelled annual Summer Palooza event. We will be rolling those out soon. We would like to thank the Mt. Holly community for all the returnable can and bottle donations left in our shed at the dump. Please double-check your donations to make sure they are returnables. Don't forget to check out our website: reinbowridingcenter.org, and follow us on Facebook, Twitter @ReinbowRiding and Instagram @reinbow_riding_center.

Everyone stay well and remember to social distance at least a horse length apart.

The Nite' Fore Deer Season

T'was the nite before Deer Season;
And cold in the shack.
The guns had been polished, and lay in the rack.
The Hunter were nestle, all snug in their beds.
With visions of "8 pointer", dancing in their heads.
I in my overcoat, gloves, boots and cap
Had just settled to a four-hour nap.
When out from the woods there arose such a clatter.
I sprang from my bedroll to see what was the matter.
Out of the door I flew like a flash;
Stumbled and fell; tripped over some trash.
The moon on the crest of the new-fallen snow
Gave the luster of mid-day to objects below.
When what to my wondering eyes should appear
But a little old man out jacking deer.
The flurries of snow made it fairly hard to see;
But he lay out a salt lick; and perched in a tree!
To the top of the tree, to the top of the limb
He seemed quite assured no deer could see him.
Back at the shack, I was turning around
When he fell from the tree, and sprawled on the ground.
He was dressed all in wool; from his head to his toe
And his clothes were all "soggy" with the water of snow.
A stock of a rifle he held in his hand.
It was then I whistled and shouted, "Get off my land!"
He said not a word, he went straight to his work.
Brushed off his clothing and turned with a jerk.
He ran like the wind right past our shack
And then he sped off in a new Cadillac.
But I heard him exclaim with a voice full of cheer
"What a miserable night to be out jacking deer!!!"
The moral is this: If you're going to jack a deer,
do it on your own land!!!

Submitted by Bob Buswell for the B.R.V. Senior Center November Newsletter.

I received this from Gus Muguira from California in December 2007 and have kept it just for the November publication of the Chit Chat.

The Confederate Flag

In July of this year the Chairman of the Joint Chiefs of Staff, General Mark Milley, called confederate leaders traitors. Both my husband Andy and I agree since our ancestors fought in the Civil War. On July 3, 1863 Andy's Mennonite great grandfather described the roar of the cannons at the Battle of Gettysburg and on August 14 of that year he traveled to Lancaster, Pennsylvania to receive a blanket and $17 for service to his country. He was following the tradition of his family since earlier generations of Andy's family had furnished the American revolutionary soldiers with supplies.

My great grandfather arrived in New York State and immediately enlisted to fight the confederate soldiers. Over 4,000 Vermonters also battled the confederacy at Gettysburg and many died, yet today people fly the confederate flag in Vermont—the flag that represents traitors and their values, the willingness to enslave others. Instead of supporting the confederacy, they should be proud of the Vermonters who were crucial in turning around the battle of Gettysburg and assisted in the Union forces success.

General George Mead, commander of the Army of the Potomac said "there was no individual body of men who rendered greater service at a critical moment than the comparatively raw troops commanded by General Stannard"— the Lieutenant Colonel of the 2nd Vermont Volunteer Infantry. Major General Abner Doubleday cried out "See the Vermonters go it!" Later he wrote, "I can only say that they performed perhaps the most brilliant feat during the war for they broke the desperate charge of Pickett, saved the day and with it, the whole North from invasion and devastation." It is so important to know the history of our state and our country. Marcy Tanger

OLD SAYINGS BY VETERANS

43rd Div. Winged Victory Division Newsletter put out by the Brown family for years.

Coffin Quotes

You have a rapport that you'll never have again there's no competitiveness no money values. You trust the man on the left and your right with your life. Audie Murphy, CMB most decorated soldier of World War II.

Resistance to tyrants is obedience to God. President Thomas Jefferson

An Irish Blessing

May your pockets be heavy, your heart be light and may Good Luck pursue you each morning and night.

An Army Of One

We no longer differentiate in an ultimate sense between the Army, National Guard, Reserve forces. Every energy – is bent – to the development of the Army of the United States. Our purpose is to think only of the American Citizen who is to be a soldier in that Army and to prepare in time of peace for duties in war. General John J. Blackjack Pershing – Mexican War – WWI

The elder General Wing, Commander of the 43rd Div. said he knew General Pershing, sitting in the mess hall of Co. B Ludlow 172nd talking to Capt. Billado and Lieutenant Harold Arthur, later to be our Governor of VT and all good friends of myself – Which is a long story back to 1923-1927.

Patriotism is easy to understand in America; it means looking out for yourself by looking out for your country. President Calvin Coolidge of VT 1872-1933 30th President of the United States (1923-1929)

Local Hazard Mitigation Plan Update

The purpose of the plan is assist the town in identifying all natural hazards facing the community, ranking them according to local vulnerabilities. Having this plan puts the town in accordance with the 2018 State Hazard Mitigation Plan. A team of 4 town members are working with Steffanie Bourque, Emergency Planner at the Rutland Regional Planning Commission, to draft the plan.

In the month of November we will be working on the final section, which is Mitigation Actions. These actions mainly will revolve around improvements to road infrastructure, such as ditches and culverts. The final draft of the plan will be available for public review and comment in early December and an overview will be provided at the December Regular Selectboard Meeting. More information will be in December's Chit Chat. If you have any questions please contact Jeff Chase at jeff@chasevermont.com.

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

Prepared by | *Prepared under contract to*

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Regional Planning Commission
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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.

o 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.

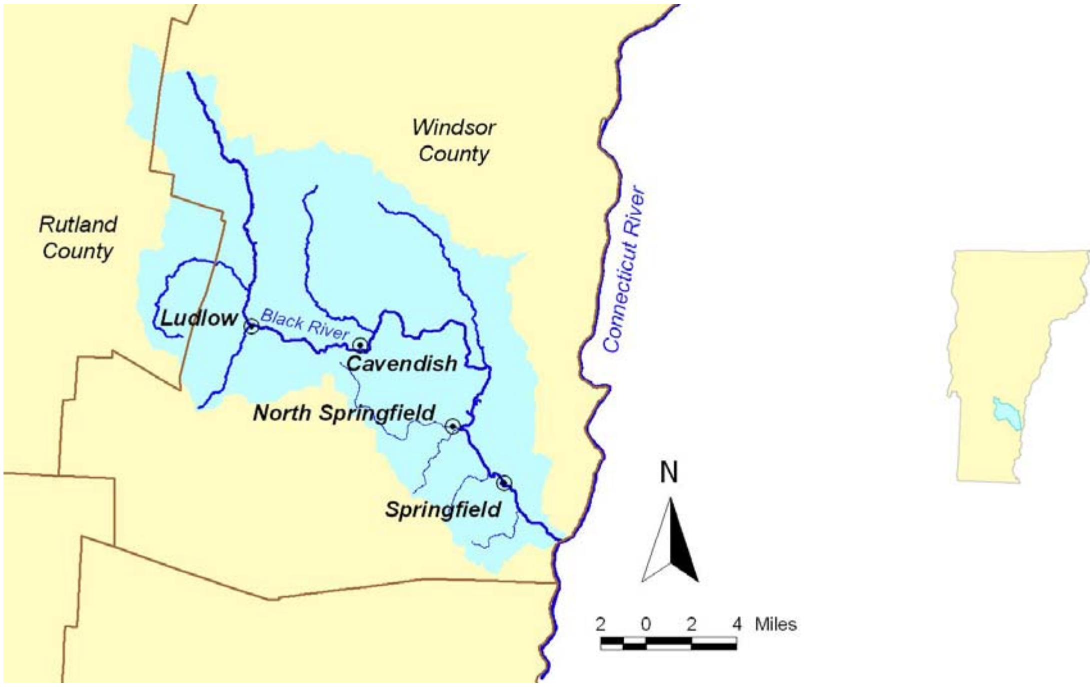

Figure 1. Black River Watershed Location within Windsor & Rutland Counties, Vermont.

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.

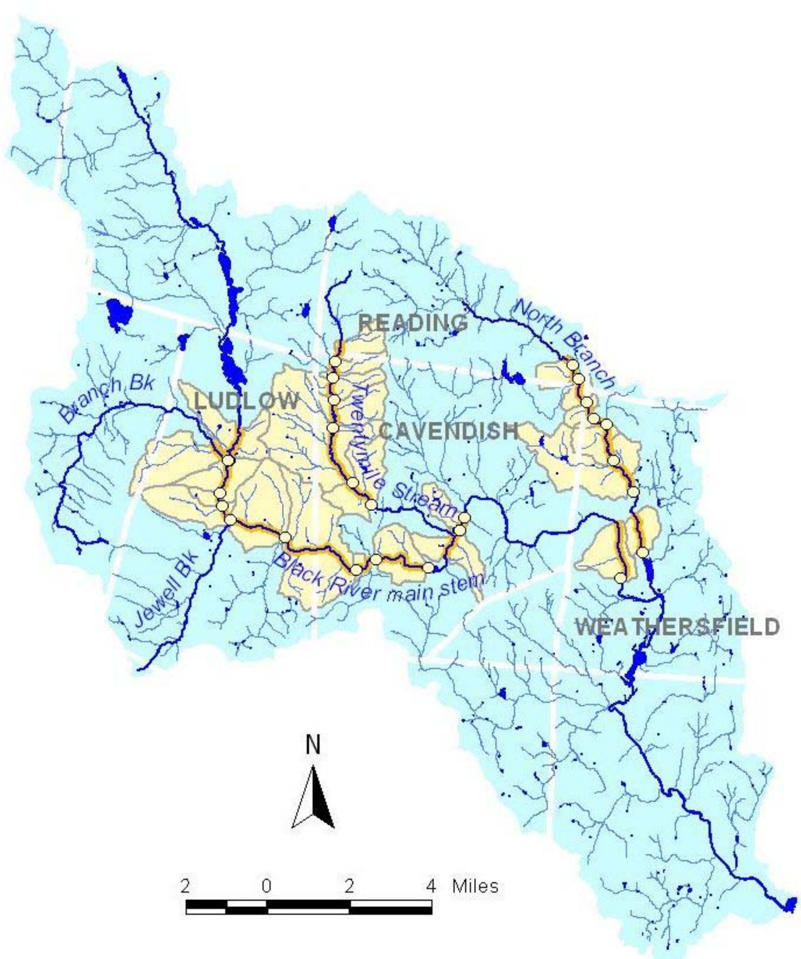

Figure 3. Location of reaches assessed in 2007 and 2008, Black River watershed.

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).

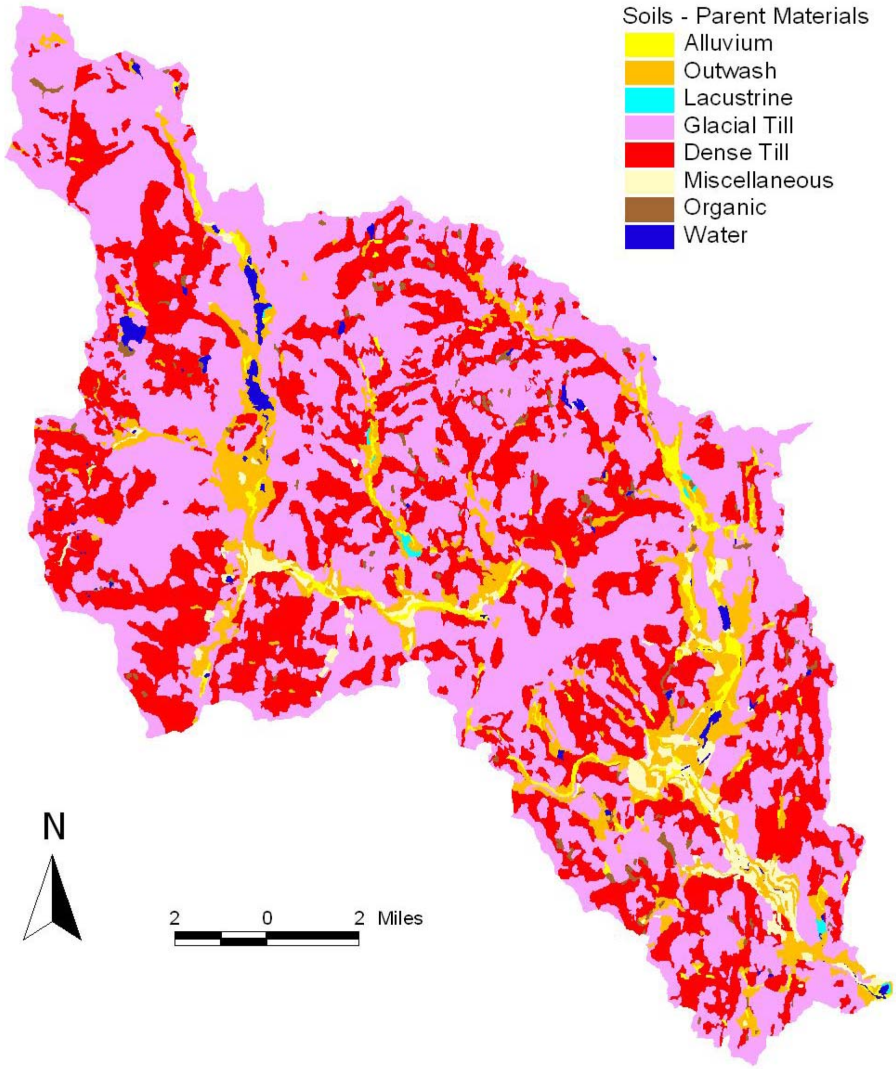

Figure 4. Generalized map of soil parent material in the Black River watershed (NRCS Soil Survey mapping).

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.

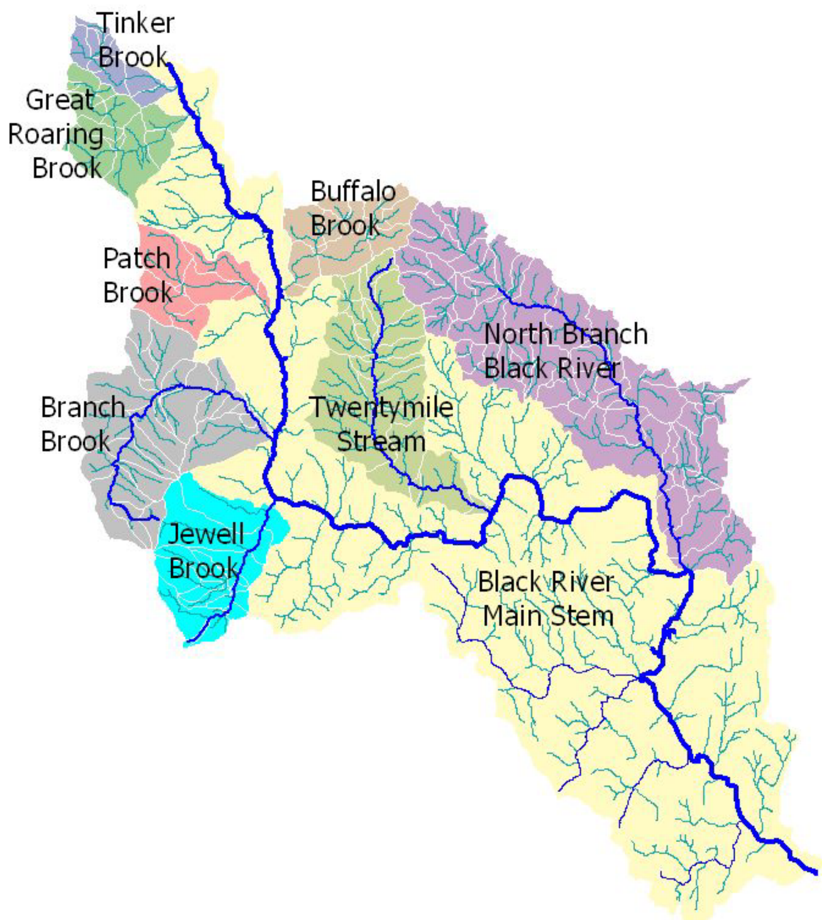

Figure 5. Major Sub-watersheds Delineated in the Black River Watershed

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 Main Stem	Ludlow	**M37**	5,311	1.0	2008
	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**	

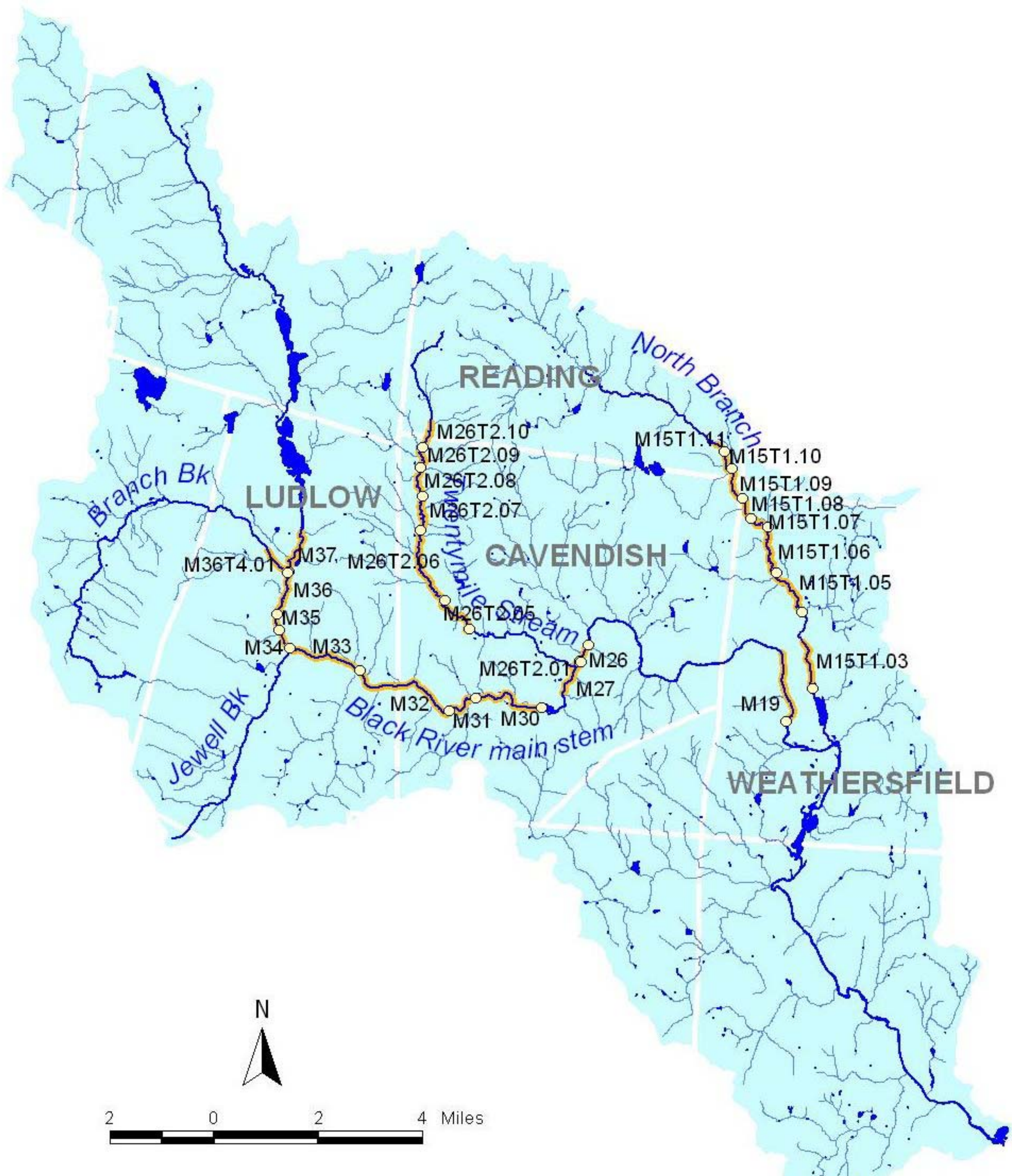

Figure 6. Location of reaches assessed in 2007 – 2008.

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].

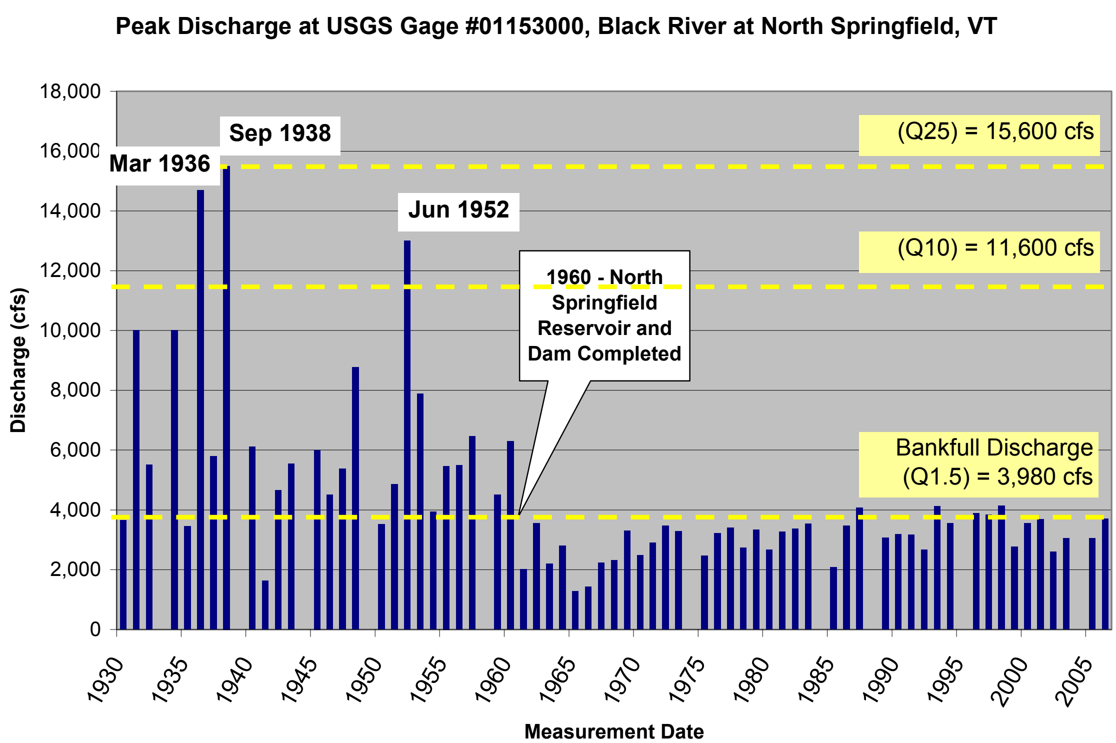

Figure 7. Peak Discharges for USGS Gage Station #01153000, Black River at North Springfield, VT. *(Data obtained from USGS on-line surface water data, <http://waterdata.usgs.gov/vt/nwis> annotated with estimated bankfull discharge after VTDEC WQD, 2001, and pre-regulated flood peaks after Olson, 2002).*

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; Cavendish WWTF destroyed; 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 VTDEC WQD, 1976 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. Significant damages in Ludlow. 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 Harris, 1949 Minsinger, W. E., 2002; Perkins Landscape Change Program images, 2008;
1913	Springfield flood damages	Perkins Landscape Change Program images, 2008
1869, October	Tropical storm; Springfield flood damages: washouts of the Springfield Railroad, Gould's Mill dam.	USGS, 1990; Perkins Landscape Change Program images, 2008; 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.

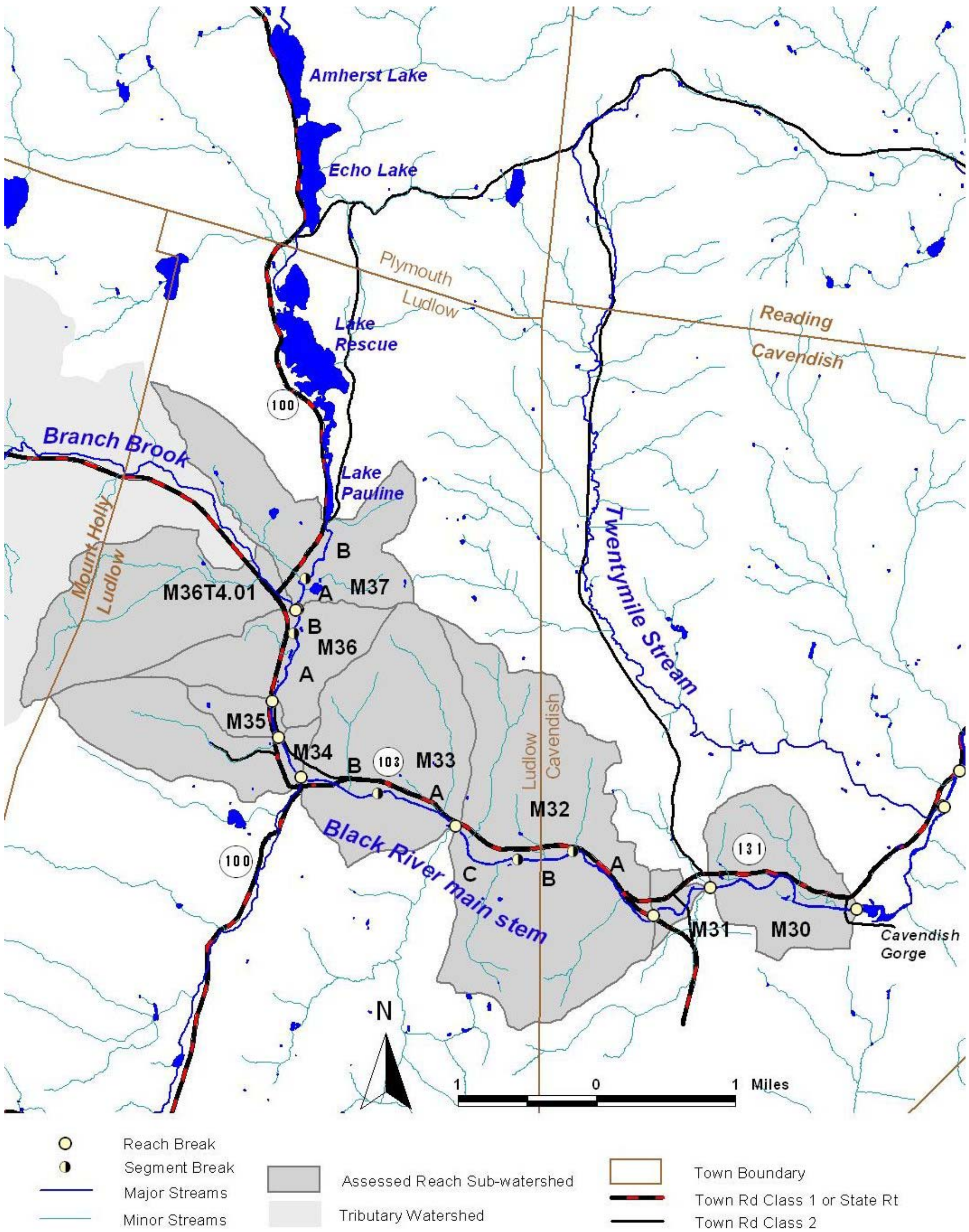

Figure 9. Location of Black River main stem reaches upstream of Cavendish Gorge, assessed in 2007 – 2008.

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.

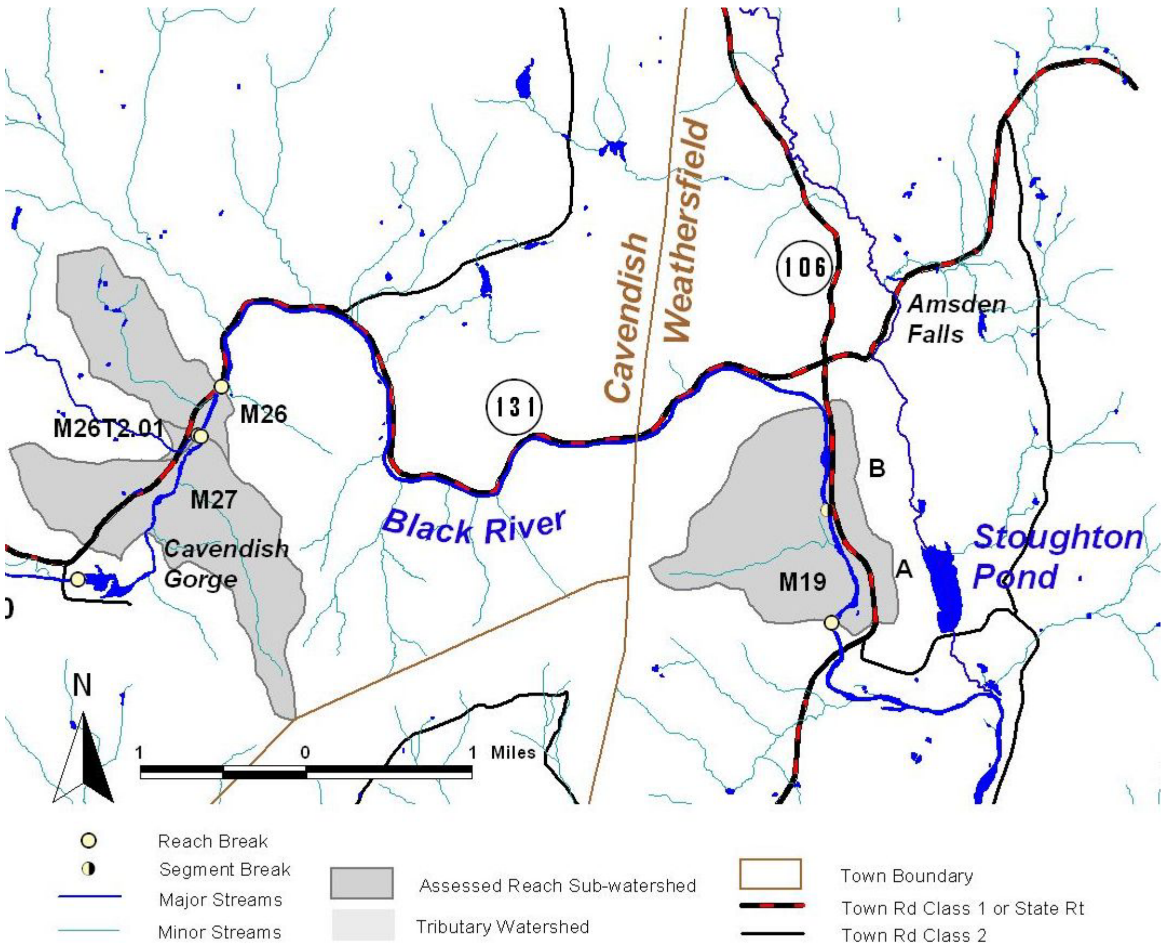

Figure 10. Location of Black River main stem reaches downstream of Cavendish Gorge, assessed in 2007 – 2008.

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).

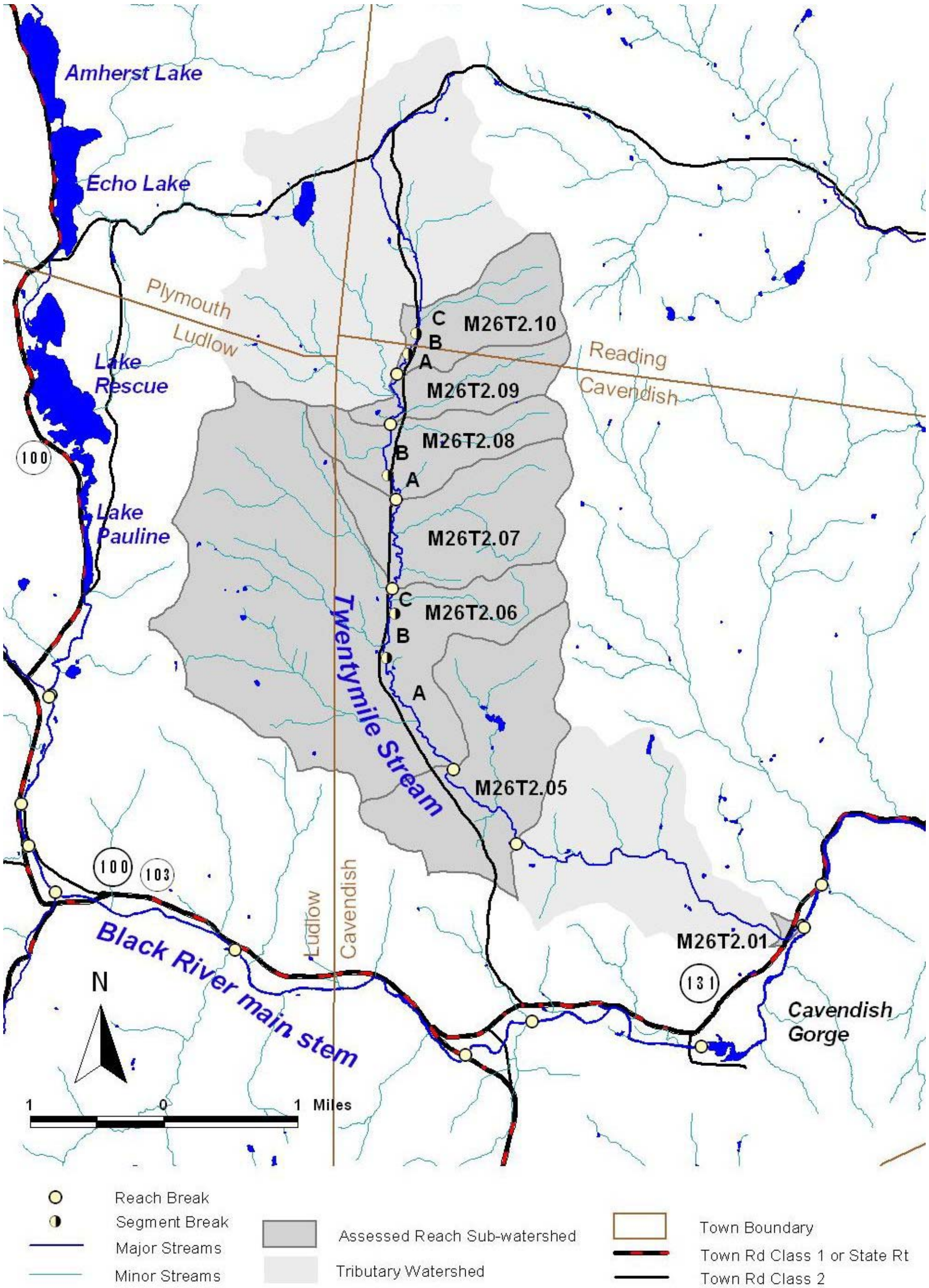

Figure 11. Location of Twentymile Stream reaches assessed in 2007 – 2008.

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.

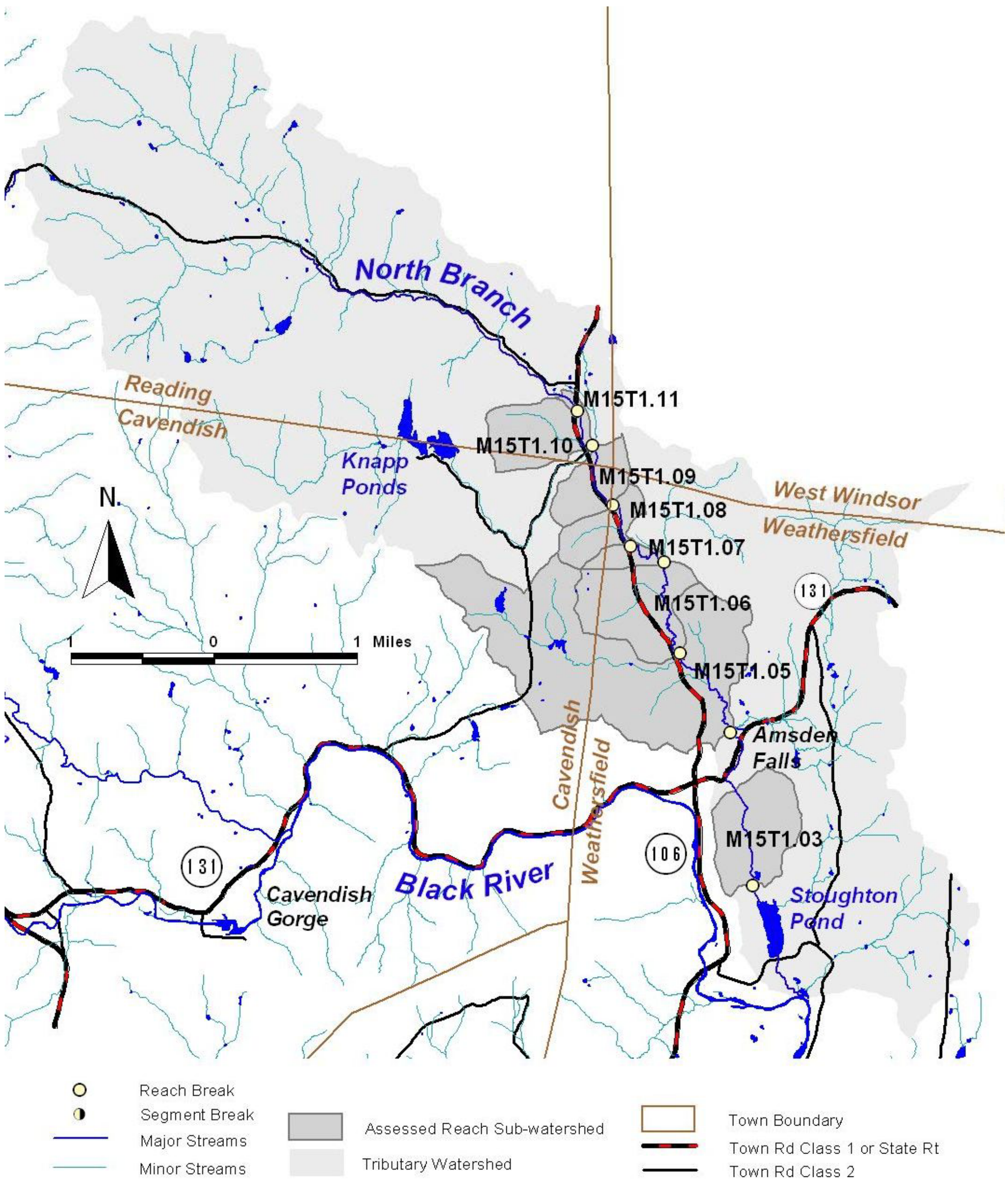

Figure 12. Location of North Branch tributary reaches assessed in 2007 – 2008.

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

Reach	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
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 19th 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).

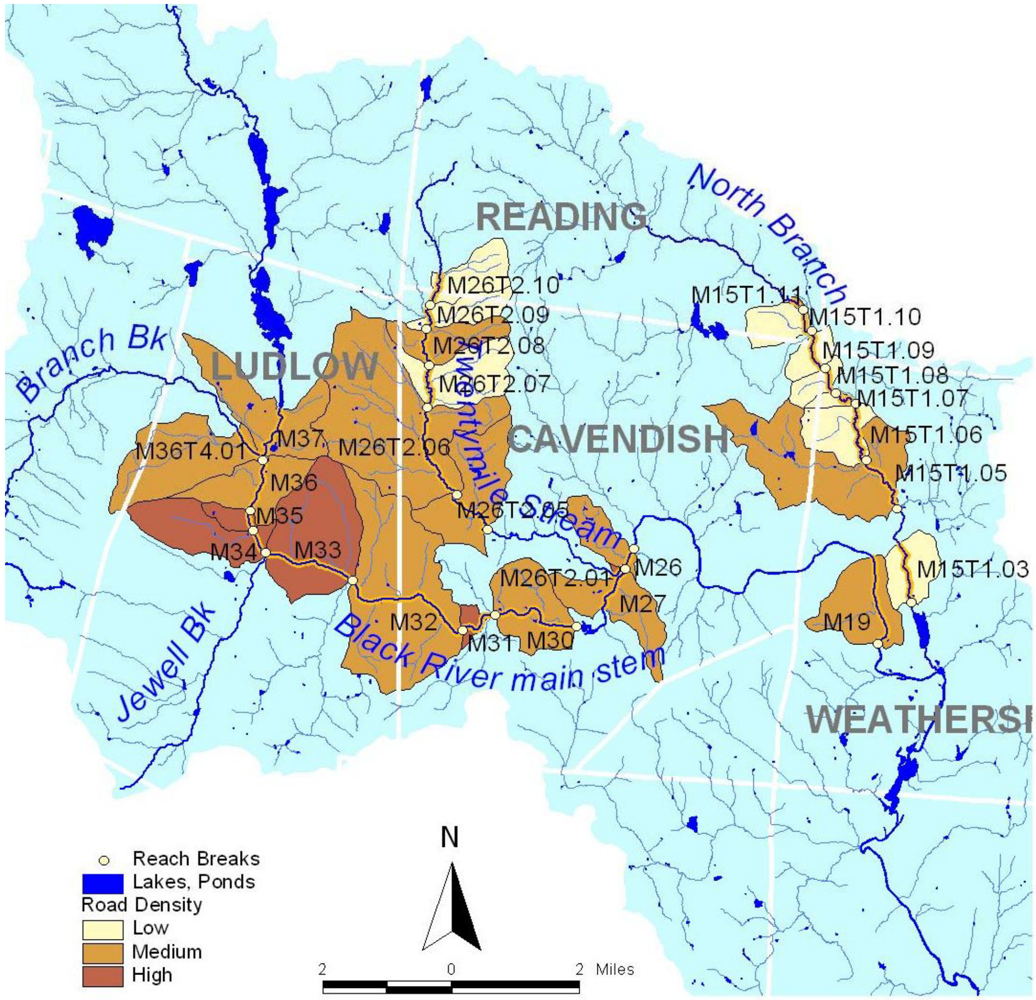

Figure 13. Relative road density in reach-based subwatersheds for the 27 reaches of the Black River watershed assessed in 2007 – 2008.

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.

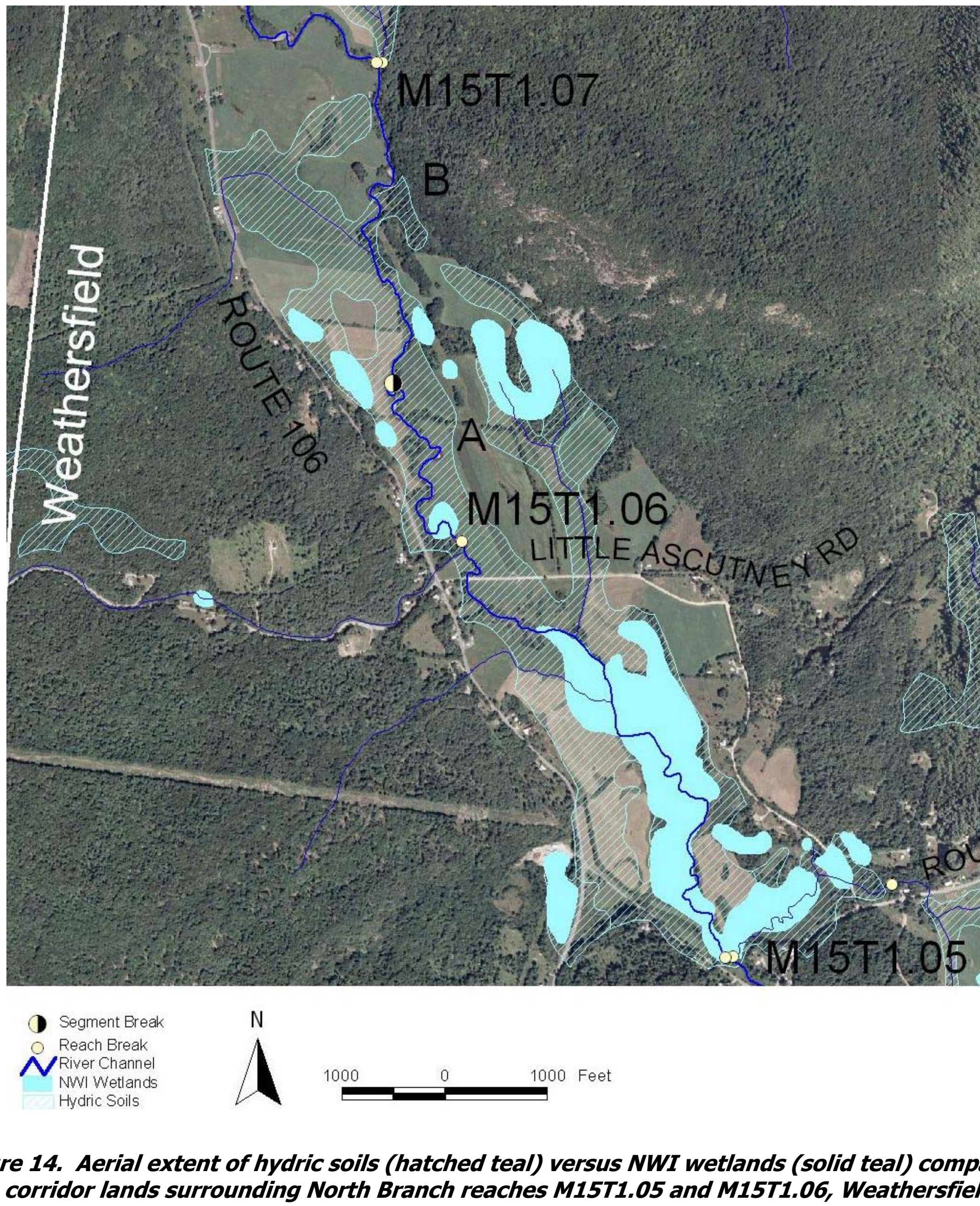

Figure 14. Aerial extent of hydric soils (hatched teal) versus NWI wetlands (solid teal) compared in corridor lands surrounding North Branch reaches M15T1.05 and M15T1.06, Weathersfield.

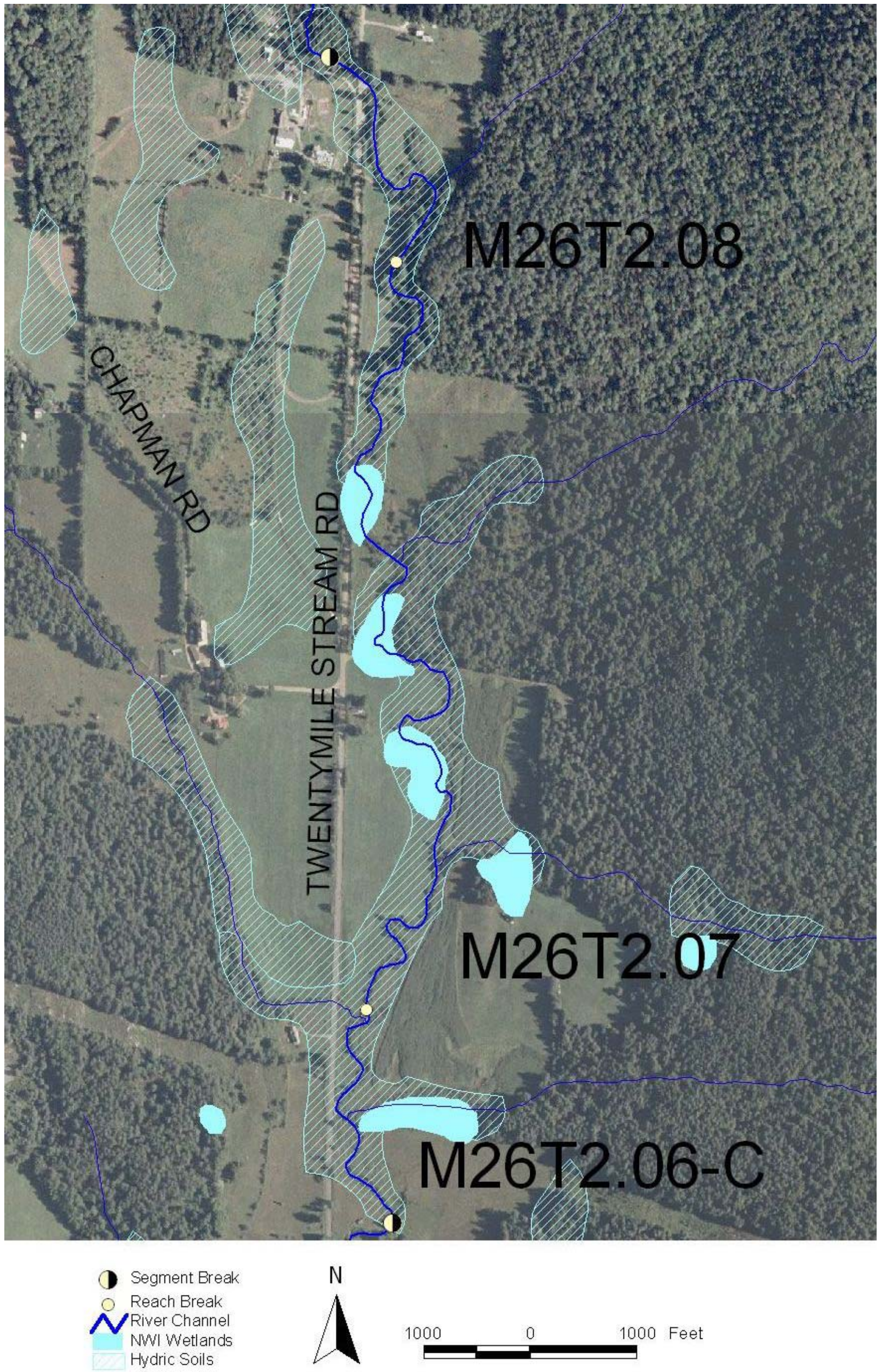

Figure 15. Aerial extent of hydric soils (hatched teal) versus NWI wetlands (solid teal) compared in corridor lands in Twentymile Stream reaches M26T2.08, M26T2.07, and M26T2.06-C, Cavendish.

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

<u>Channel Slope</u>

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.

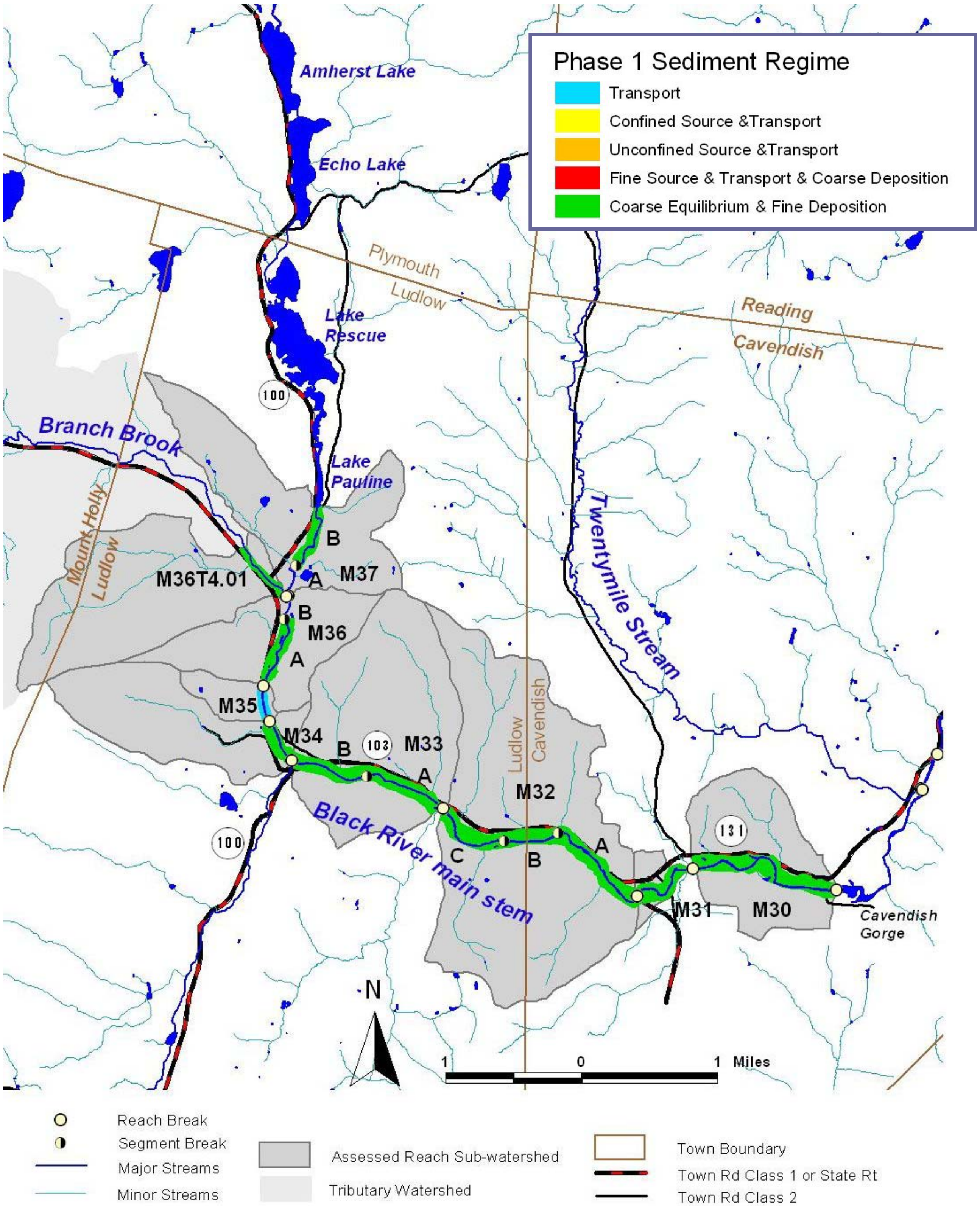

Figure 18-a. Phase 1 (Reference) Sediment Regime Map
Assessed Reaches of the Black River main stem, Upstream of Cavendish Gorge.

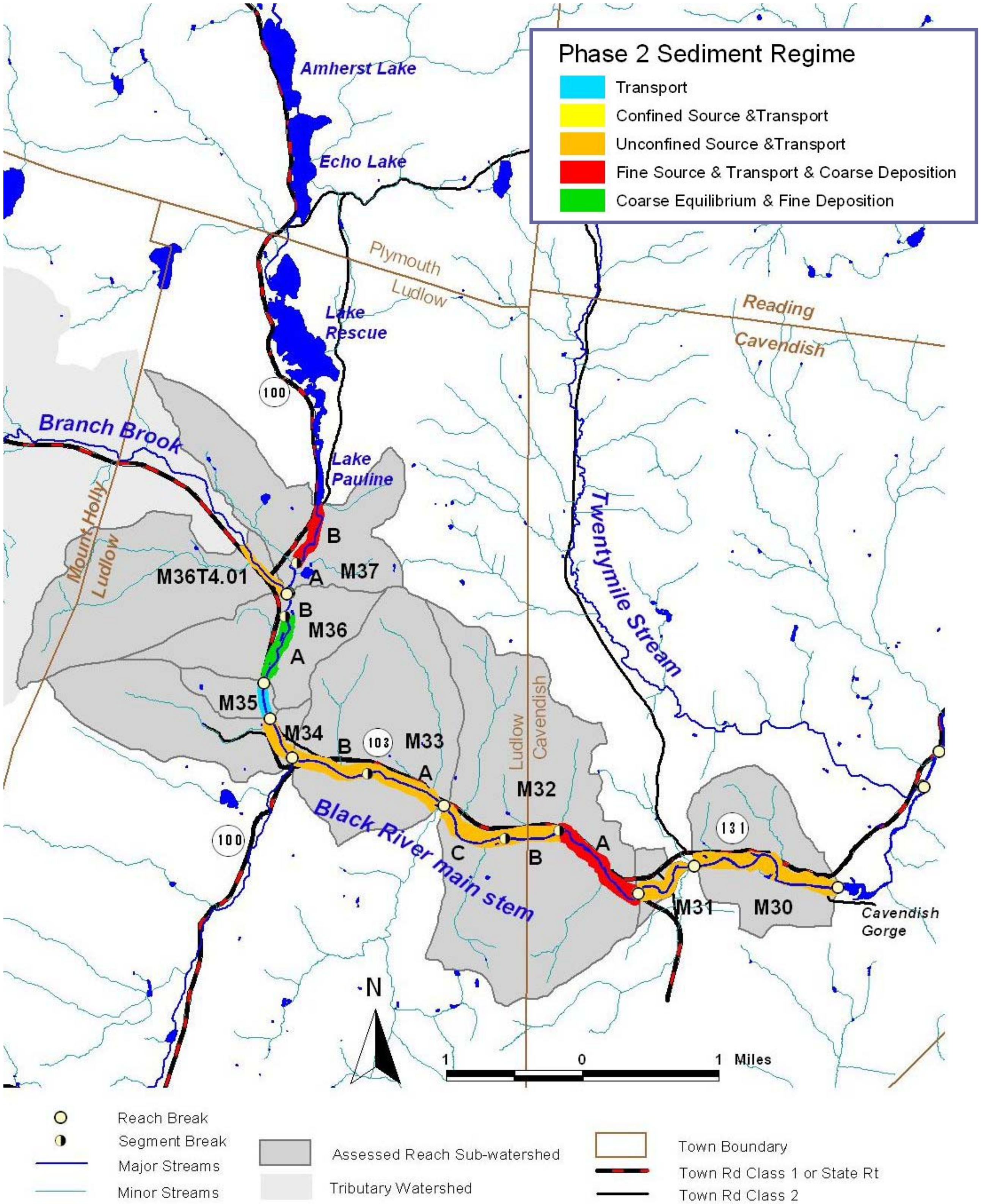

Figure 18-b. Phase 2 (Existing) Sediment Regime Map
Assessed Reaches of the Black River main stem, Upstream of Cavendish Gorge.

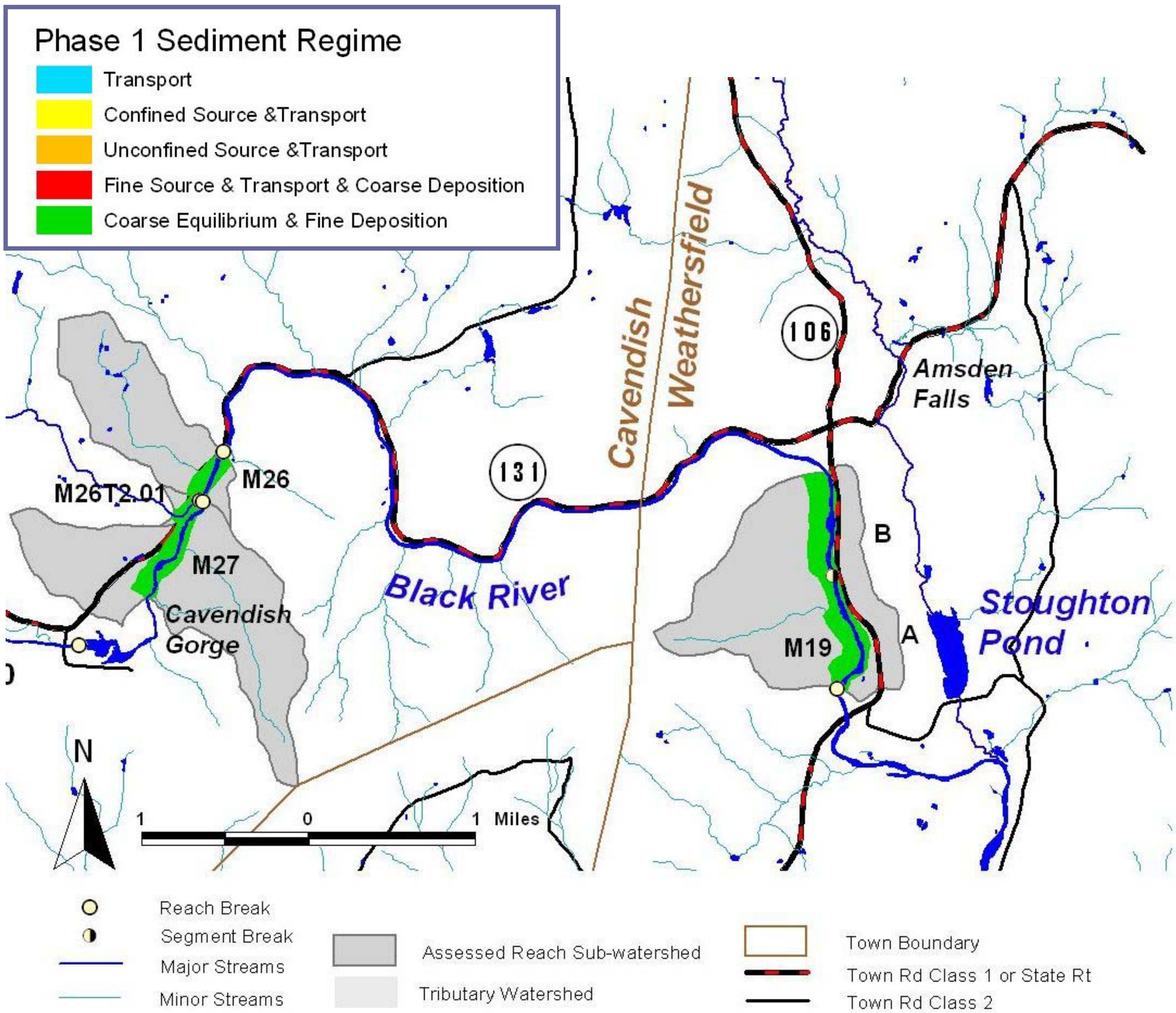

Figure 19-a. Phase 1 (Reference) Sediment Regime Map
Assessed Reaches of the Black River main stem, Downstream of Cavendish Gorge

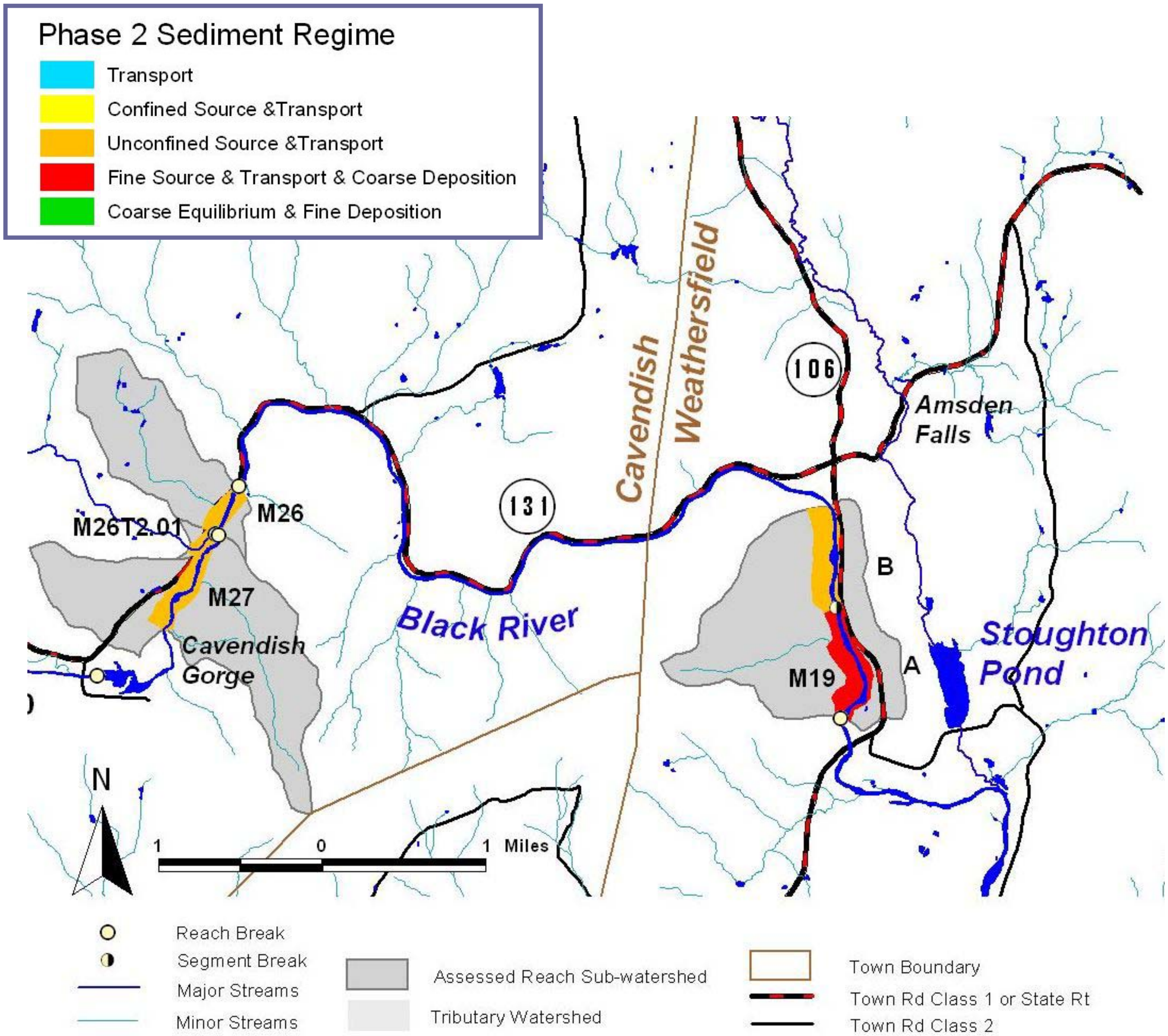

Figure 19-b. Phase 2 (Existing) Sediment Regime Map
Assessed Reaches of the Black River main stem, Downstream of Cavendish Gorge

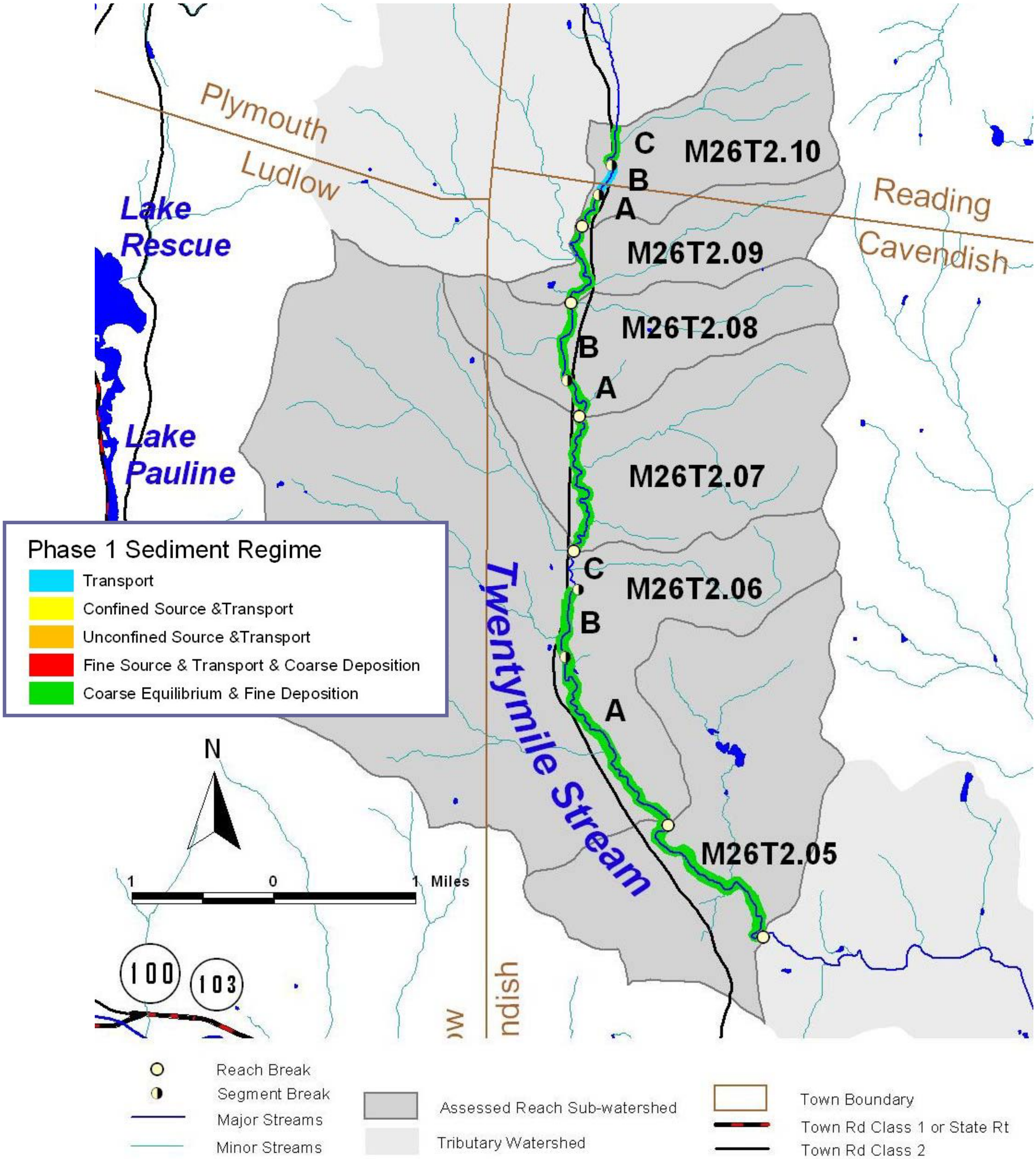

Figure 20-a. Phase 1 (Reference) Sediment Regime Map, Assessed Reaches of Twentymile Stream tributary.

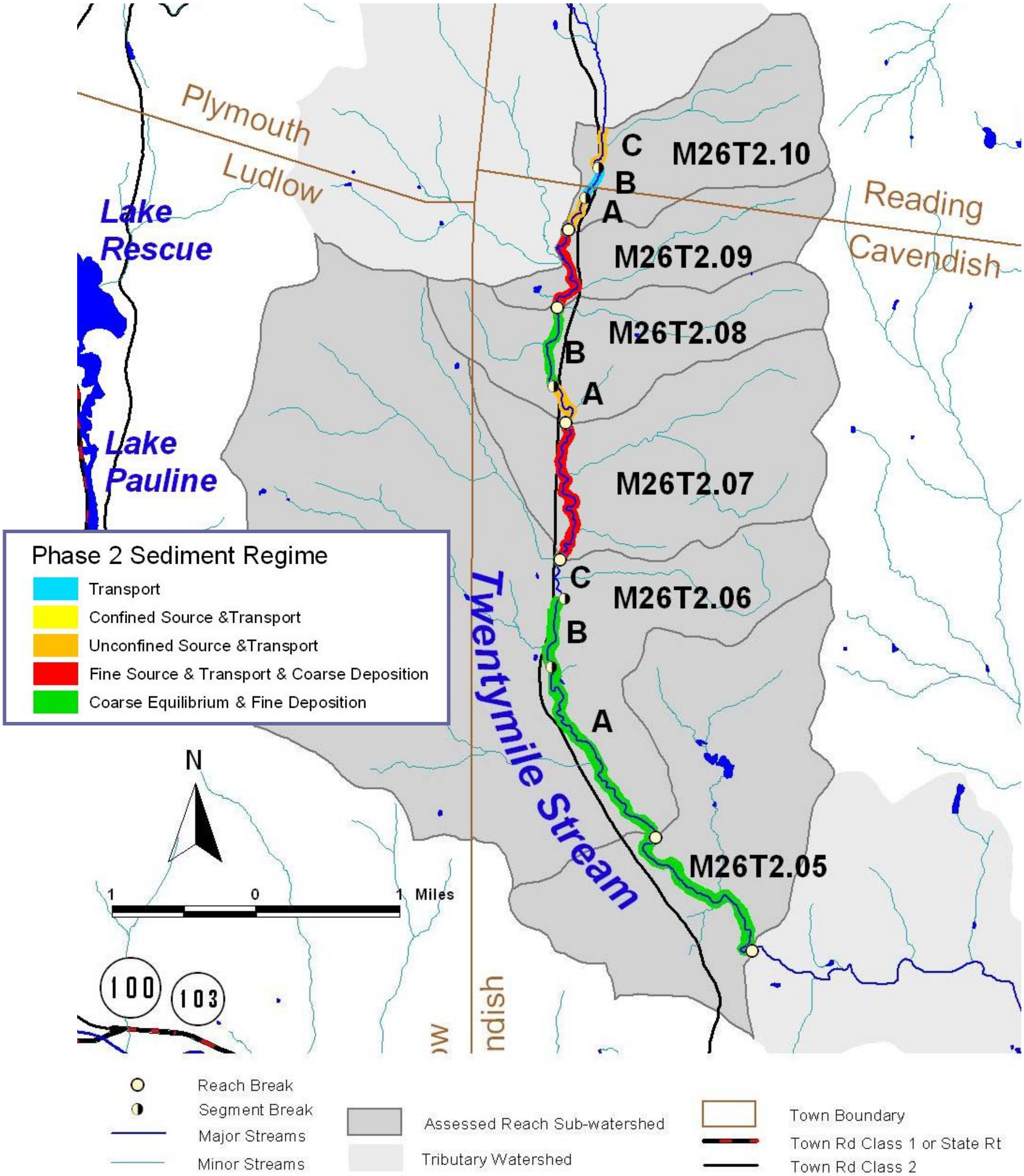

Figure 20-b. Phase 2 (Existing) Sediment Regime Map, Assessed Reaches of Twentymile Stream tributary.

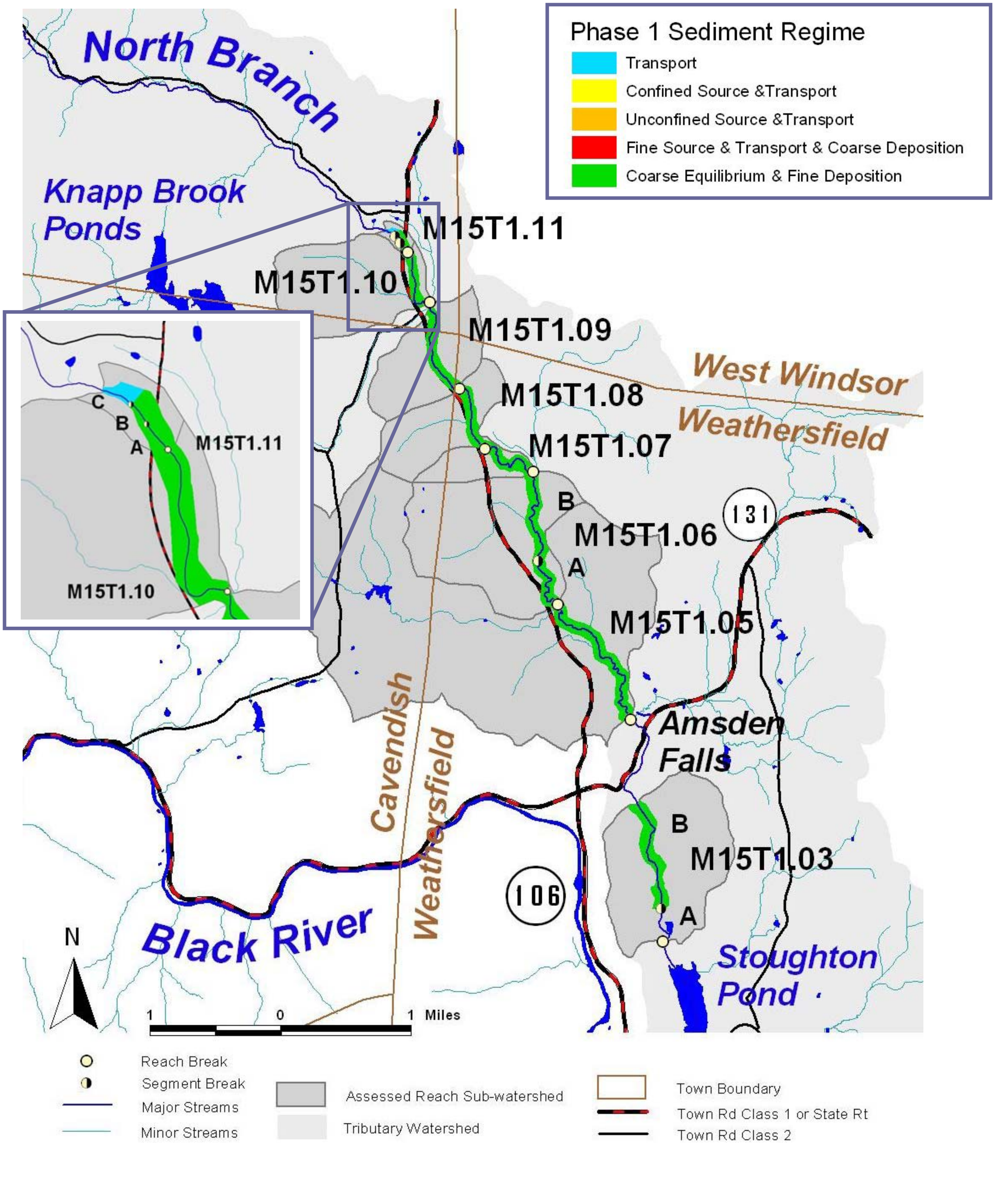

Figure 21-a. Phase 1 (Reference) Sediment Regime Map, Assessed Reaches of the North Branch tributary

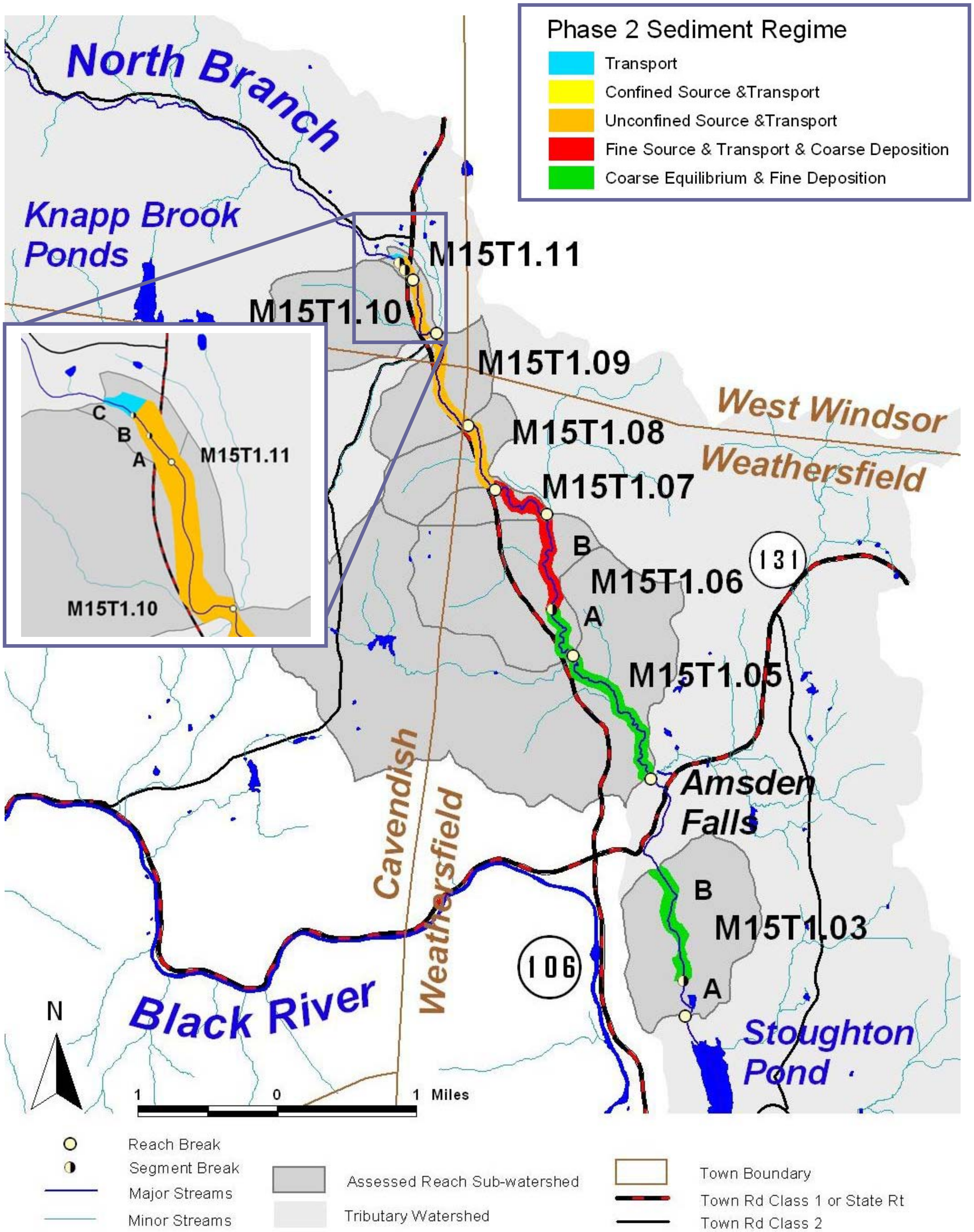

Figure 21-b. Phase 2 (Existing) Sediment Regime Map, Assessed Reaches of the North Branch tributary

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).

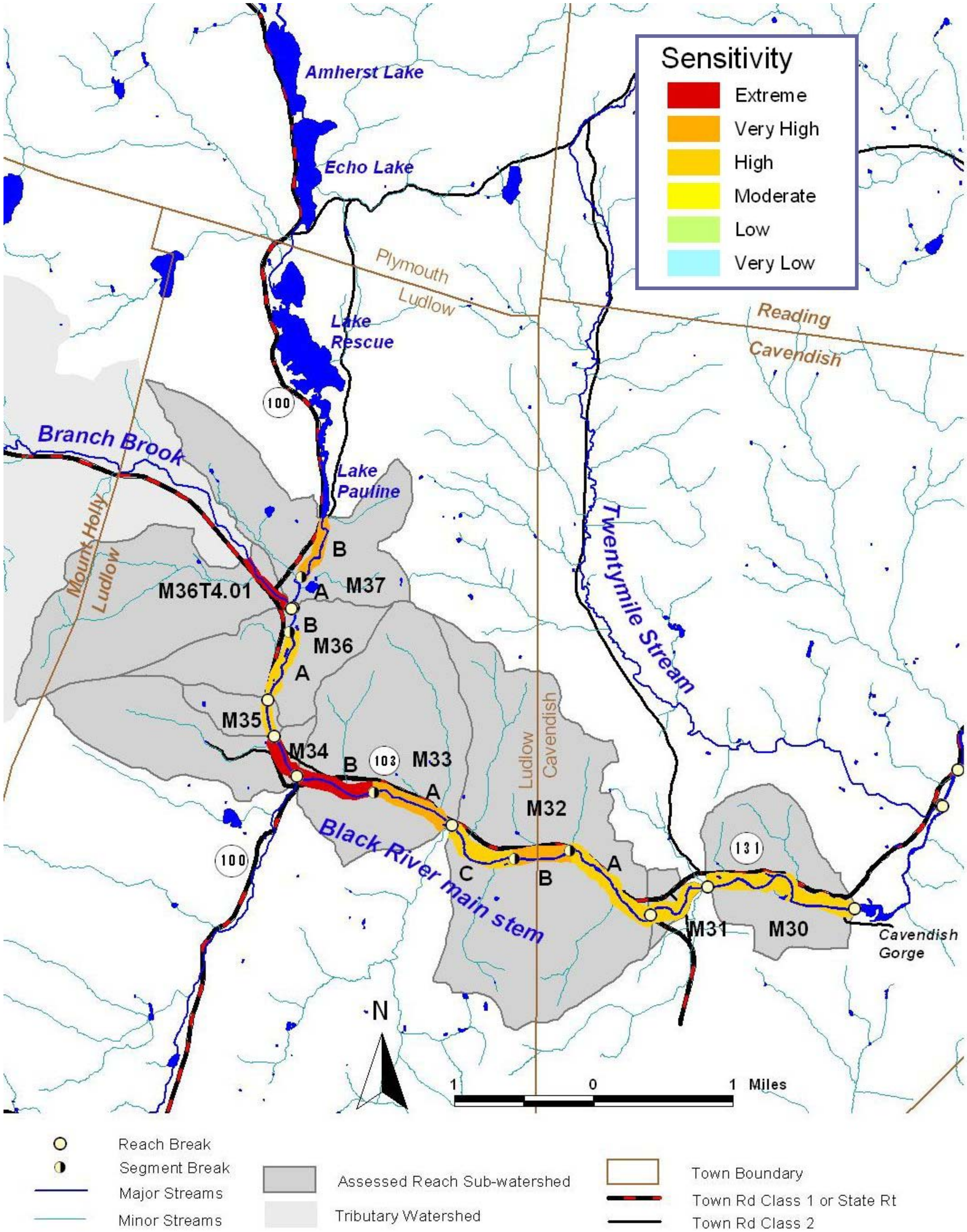

Figure 22. Stream Sensitivity Map
Assessed Reaches of the Black River Main Stem, Upstream of Cavendish Gorge.

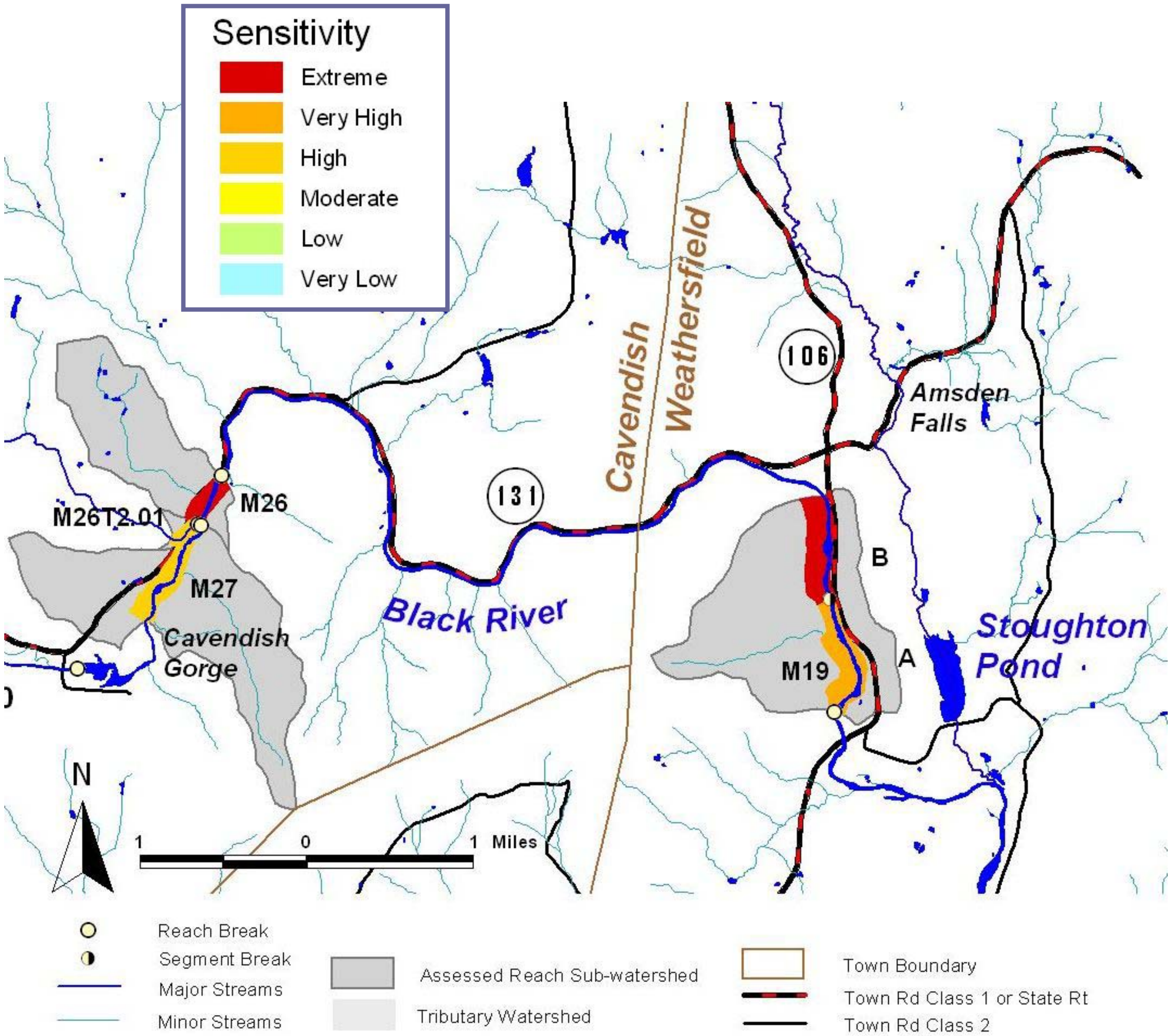

Figure 23. Stream Sensitivity Map
Assessed Reaches of the Black River Main Stem, Downstream of Cavendish Gorge.

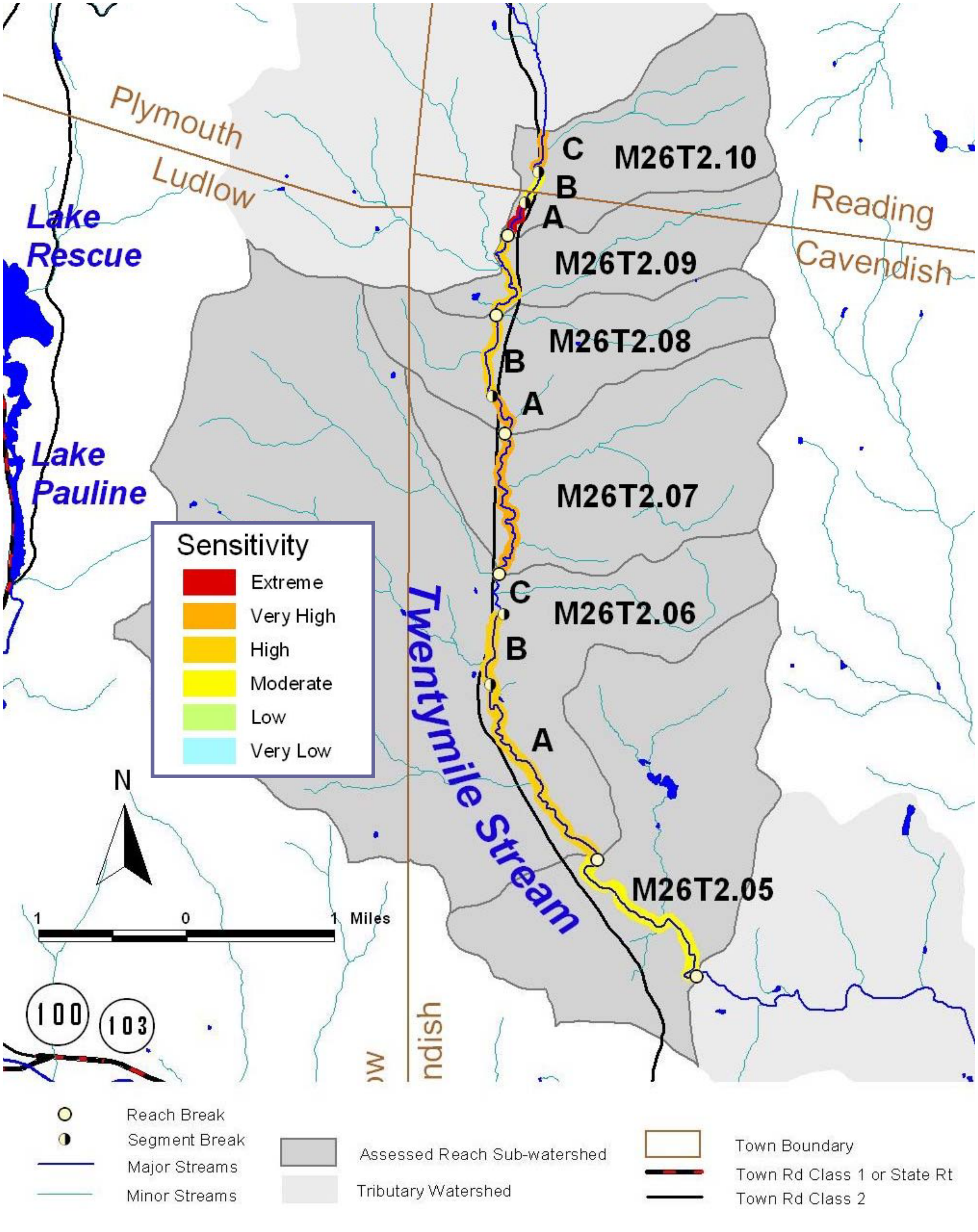

Figure 24. Stream Sensitivity Map, Assessed Reaches of the Twentymile Stream tributary.

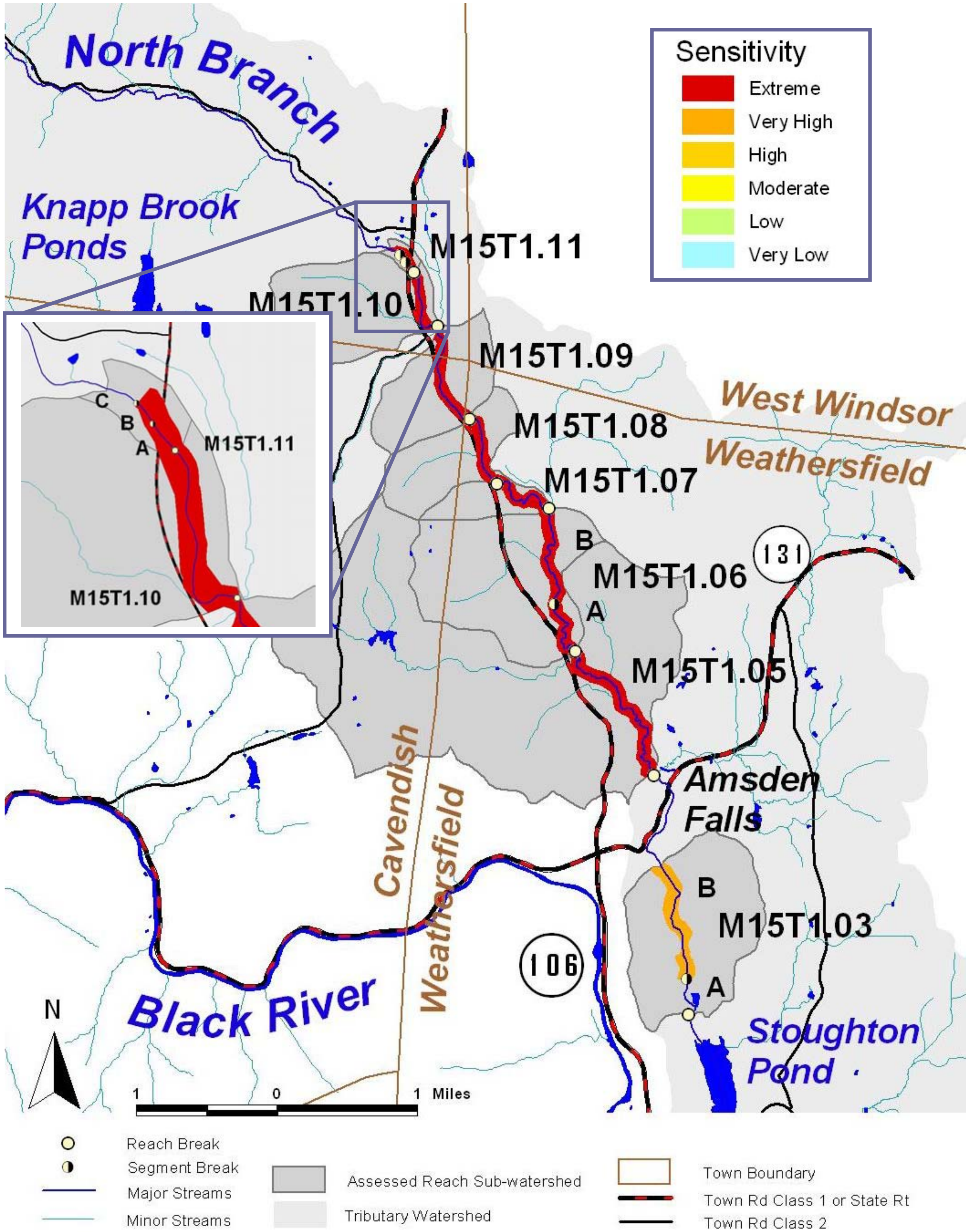

Figure 25. Stream Sensitivity Map, Assessed Reaches of the North Branch tributary.

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:

> <u>Active Geomorphic:</u> 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.
>
> <u>Passive Geomorphic</u>: 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.
>
> <u>Active-Passive Combination</u>: 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).

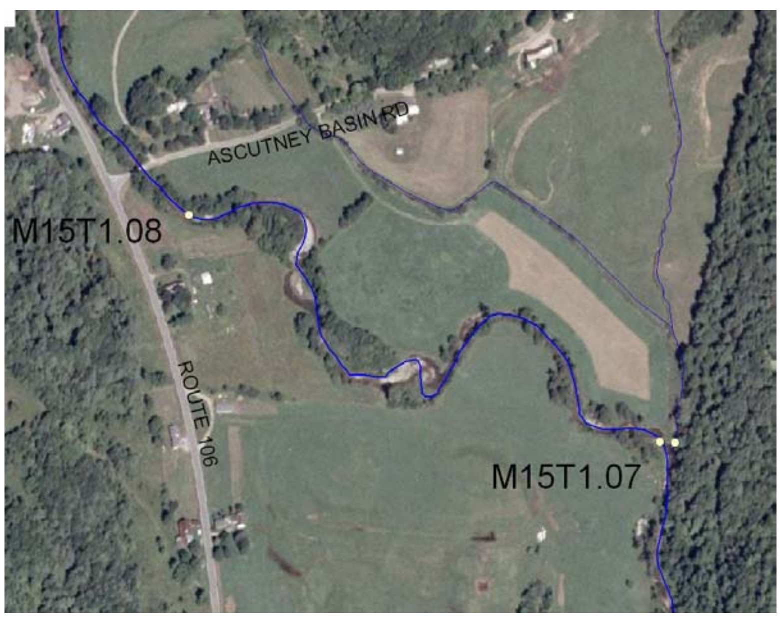

Figure 31. Aggradational reach M15T1.07 of North Branch tributary.
Base image dated 2003. Blue line represents 1994 channel position.

(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.

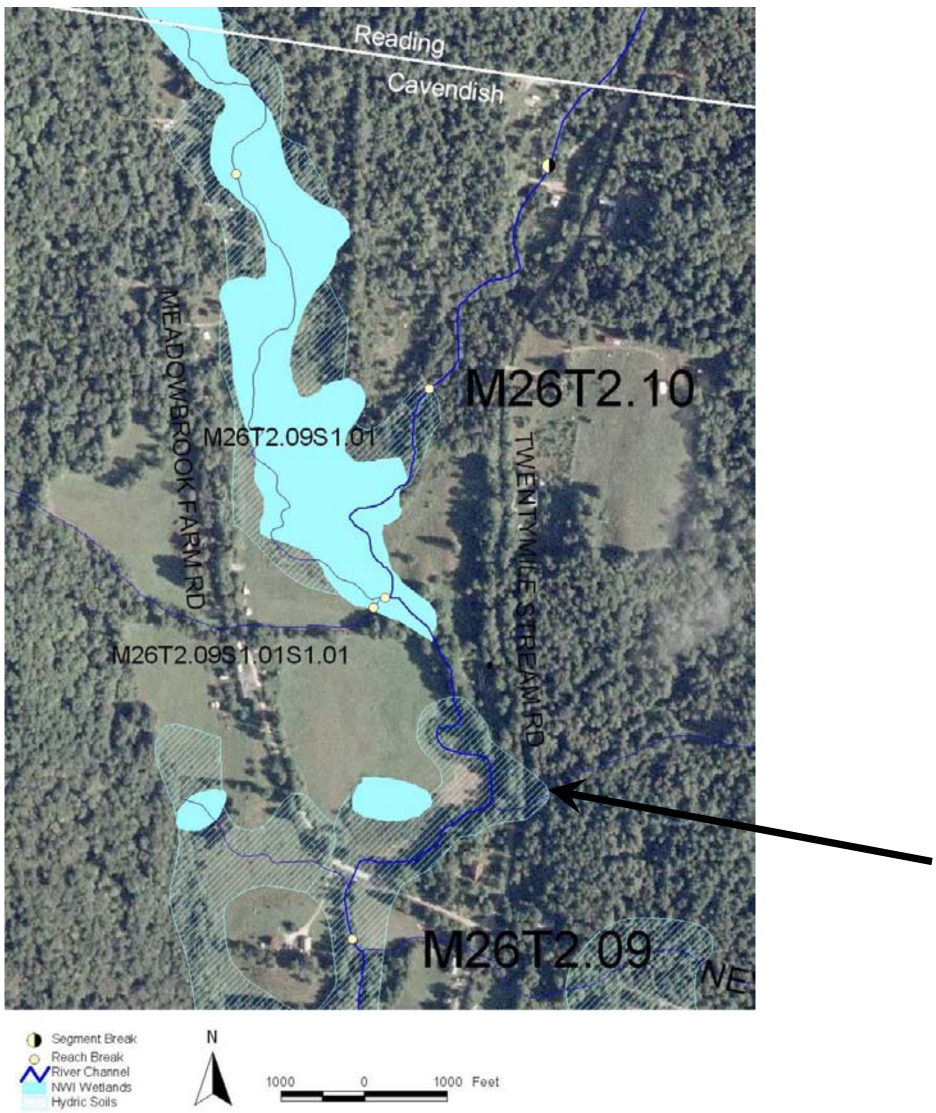

Figure 32. Potential channel-contiguous wetland restoration site along Twentymile Stream reach M26T2.09 in Cavendish. *(Moderate Priority) (See arrow).*

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 Eight (8) channel widths for E stream types
Very High	Six (6) channel widths Eight (8) channel widths for E stream types
Extreme	Six (6) channel widths Eight (8) channel widths for D & E stream types

<u>Reference:</u> 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 M15T1.06-A Extreme	49.9 49.9	399 399	41.4 41.3	331 330
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.

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APPENDIX A

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

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

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

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** %

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

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**

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

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

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

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** %

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

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**

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

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

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** %

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

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**

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.	0 N.S.	0 N/A	0 N/A	1 Low	2 High	19

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

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

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 Cavendish**
1.2 Towns:
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

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 Low	2 High	2 High	0 N.S.	0 N.S.	2 High	2 High	0 N.S.	2 High	0 N.S.	1 Low	1 Low	1 Low	0 N.S.	0 N.S.	1 Low	15

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

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** %

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

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**

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	1 Low	0 N/A	0 N/A	0 N.S.	1 Low	12

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 Low	2 High	2 High	0 N.S.	0 N.S.	0 N.S.	2 High	0 N.S.	1 Low	1 Low	1 Low	2 High	2 High	2 High	0 N.S.	1 Low	17

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 Low	2 High	2 High	0 N.S.	0 N.S.	1 Low	2 High	0 N.S.	2 High	1 Low	1 Low	1 Low	0 N/A	0 N/A	0 N.S.	1 Low	14

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** %

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

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**

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

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** %

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

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**

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	2 High	2 High	2 High	1 Low	1 Low	2 High	2 High	0 N.S.	2 High	24

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

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

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

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** %

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

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**

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

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 Low	2 High	2 High	0 N.S.	1 Low	2 High	0 N.S.	0 N.S.	2 High	2 High	0 N.S.	1 Low	0 N/A	0 N/A	1 Low	1 Low	15

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

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

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

Project: Black River | Phase 2 Segment Summary | | May 19, 2009 SGAT Version: 4.56

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 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	1,384	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

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.

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.

Project: Black River | Phase 2 Segment Summary | | May 19, 2009 | SGAT Version: 4.56

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.

Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Project: **Black River**
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.

Project: Black River

Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

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.

Project: Black River | **Phase 2 Segment Summary** May 19, 2009 SGAT Version: 4.56

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.

Project: Black River

Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

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.

Project: **Black River**
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.

Project: **Black River** | **Phase 2 Segment Summary** | May 19, 2009 SGAT Version: 4.56

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 Passed

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.

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.

Project: Black River

Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

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 confinement 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.

Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Project: **Black River**
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 confinement 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** | page 1 of 2 | 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.

Project: Black River

Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

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.

Project: Black River

Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

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** | page 1 of 2 | 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.

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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**	page 1 of 2	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.

May 19, 2009 SGAT Version: 4.56

Project: Black River
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.

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.

Project: Black River | **Phase 2 Segment Summary** | | May 19, 2009 SGAT Version: 4.56

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.

Project: Black River

Phase 2 Segment Summary May 19, 2009 SGAT Version: 4.56

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.

Project: **Black River** | **Phase 2 Segment Summary** May 19, 2009 SGAT Version: 4.56

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	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.

Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Project: **Black River**
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 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	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.

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.

Phase 2 Segment Summary

May 19, 2009 SGAT Version: 4.56

Project: Black River
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.

Project: **Black River** | **Phase 2 Reach Summary** | | May 19, 2009

Stream: **North Branch Black River** Reach # **M15T1.03** Segment: **A** Completion Date: **September 5,**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **1,428** Segment Location: **Downstream 1/3 of reach at upstream end of Stoughton Pond.**

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

Project: **Black River** — **Phase 2 Reach Summary** — May 19, 2009

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.

Project:	**Black River**	**Phase 2 Reach Summary**	page 2 of 2		May 19, 2009
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.

Project:	Black River		Phase 2 Reach Summary		
Stream:	North Branch Black River	Reach #	M15T1.06	Segment: B	Completion Date: June 11, 2008
Organization:	South Windsor County Regional	Observers:	KLU, BOS - SMRC		Rain: Yes
Segment Length (ft):	3,718	Segment Location:	Upstream 2/3 of the 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	**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).

Project: **Black River** | **Phase 2 Reach Summary** | May 19, 2009

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.

Stream: **North Branch Black River** Reach # **M15T1.11** Segment: **C** Completion Date: **August 29, 2008**

Organization: **South Windsor County Regional** Observers: **KLU, BOS - SMRC** Rain: **No**

Segment Length (ft): **409** Segment Location: **From upstream end of reach near ball park to downstream end of waterfall at Niagara**

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

Project:	**Black River**	**Phase 2 Reach Summary**	page 2 of 2		May 19, 2009
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 Take	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.

Project: **Black River** | **Phase 2 Reach Summary** | | May 19, 2009

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.

Project: **Black River** | **Phase 2 Reach Summary** | May 19, 2009

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 Take	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).

Project: **Black River**	**Phase 2 Reach Summary**		May 19, 2009
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.

Project: **Black River**	**Phase 2 Reach Summary**		May 19, 2009
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**			

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**

Narrative:

Minor aggradation.

Project: **Black River** | **Phase 2 Reach Summary** | May 19, 2009

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?

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

Narrative:

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 Take	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**

Project: **Black River** | **Phase 2 Reach Summary** | May 19, 2009

Stream: **Black River** | Reach # **M31** | Segment: **0** | Completion Date: **October 2, 2007**

Organization: **South Windsor County Regional** | Observers: **KLU, BOS - SMRC; SP - BRAT** | Rain: **No**

Segment Length (ft): **3,741** | Segment Location: **Reach through Proctorsville.**

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**				

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**

Narrative:

Minor aggradation, widening, planform adjustment. Historic incision.

Project:	**Black River**	**Phase 2 Reach Summary**	May 19, 2009
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?

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**

Narrative:
Minor to moderate widening (localized).

Project:	**Black River**	**Phase 2 Reach Summary**			May 19, 2009
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

Project: **Black River**	**Phase 2 Reach Summary**		May 19, 2009
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).

Project: **Black River** | **Phase 2 Reach Summary** | | May 19, 2009

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

Project:	**Black River**		**Phase 2 Reach Summary**		May 19, 2009
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.		

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).		

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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).		

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).		

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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.		

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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?

	Upstream	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	---		

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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"		

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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	---		

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.		

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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.		

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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	---		

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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	---		

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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?

	Upstream	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.		

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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	---		

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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.		

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	---		

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) .		

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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.		

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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.		

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	---		

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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		

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"		

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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	---		

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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		

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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		

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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.		

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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"		

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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?

	Upstream	Downstream	In Structure
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.		

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	---		

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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	---		

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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.		

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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.		

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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?

	Upstream	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.		

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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?

	Upstream	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).		

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.

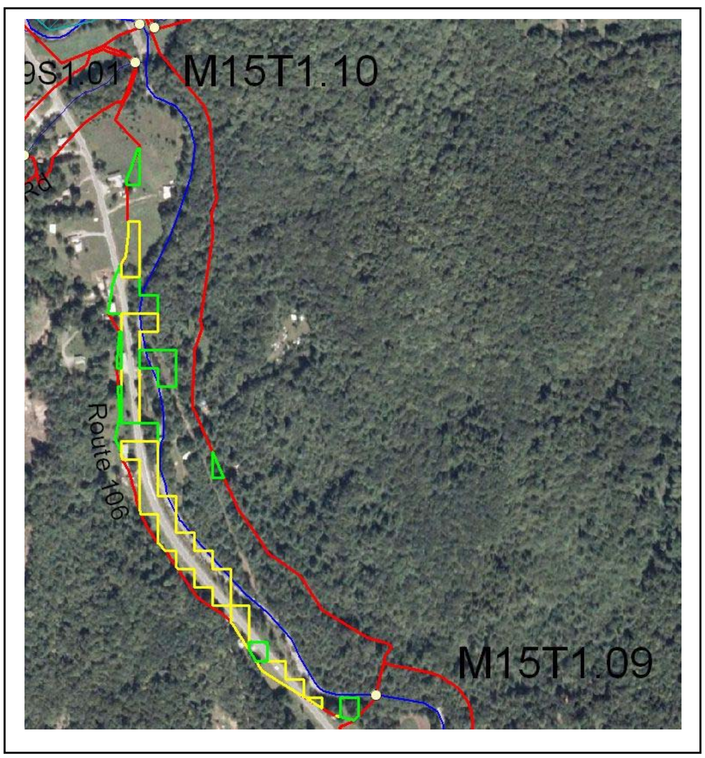
  You may be noting the Corridor-Area percent urbanization of 22% for M15T1.09 (calculated in Phase 1) and suggesting that this amount of Urbanization exceeds thresholds outlined in the River Corridor guidance (page 19). However, I would offer that a Corridor-Area percent urbanization is not a valid predictor 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.

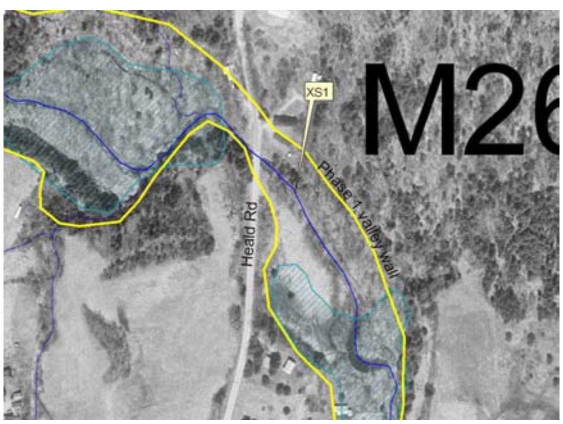
Thank you for your comments. Again, you've delineated the phase 2 valley wall (in the shapefile submitted 4/30/09) based on the phase 2 constraints to confinement and channel hydraulics (i.e., the valley is restricted to the area below floodprone elevation or 2X max depth), calling Whitesville Road the 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.

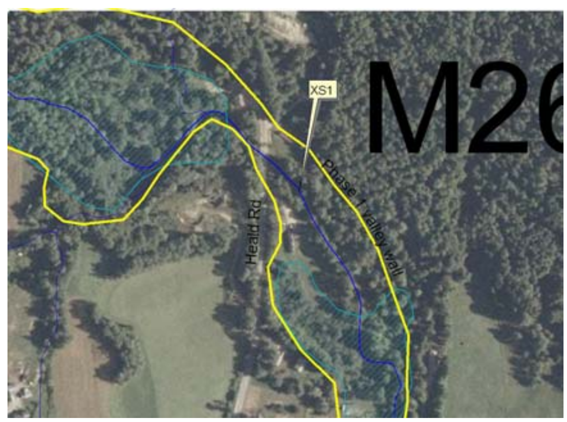
- If this reach is in stage II, then why do you say riffles are "sedimented" in step 2.10? Should they be "eroded"? Incision is historic, and the current active adjustment processes appear to be minor aggradation and widening. I probably chose sedimented to capture the two steep riffles noted in the 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 <u>Encroachment</u> 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.

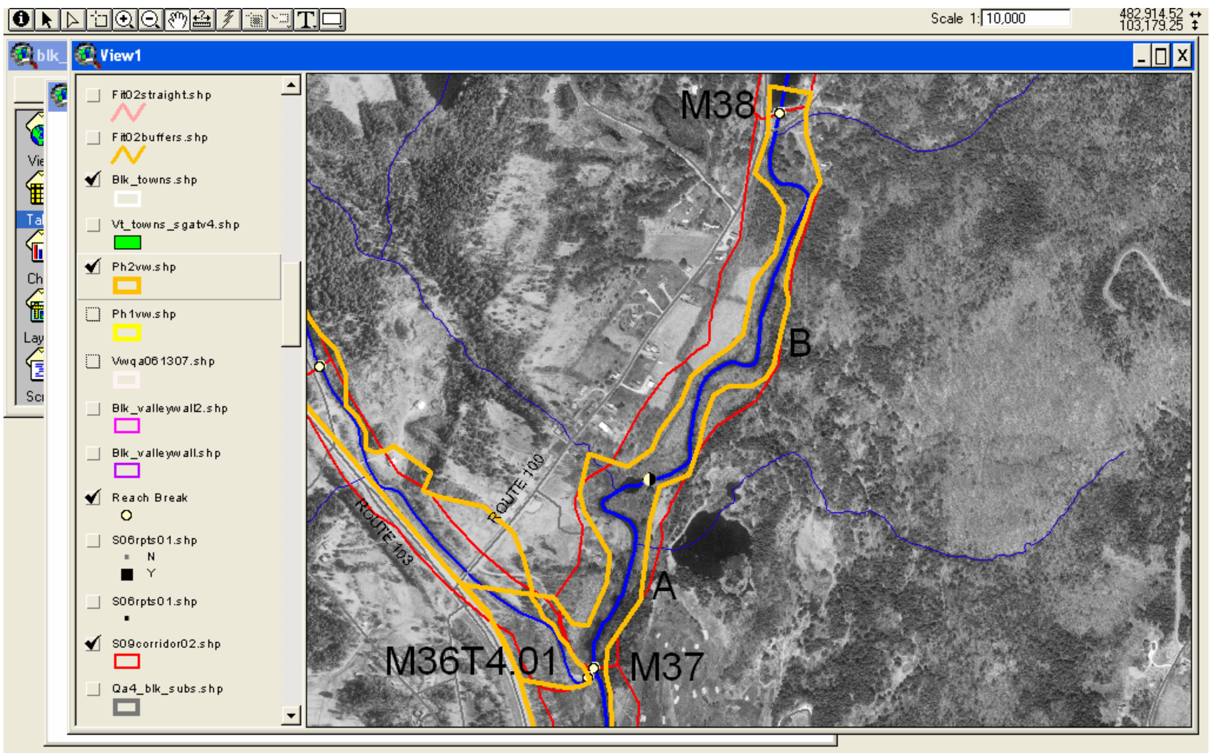
M36T4.01

- 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

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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).

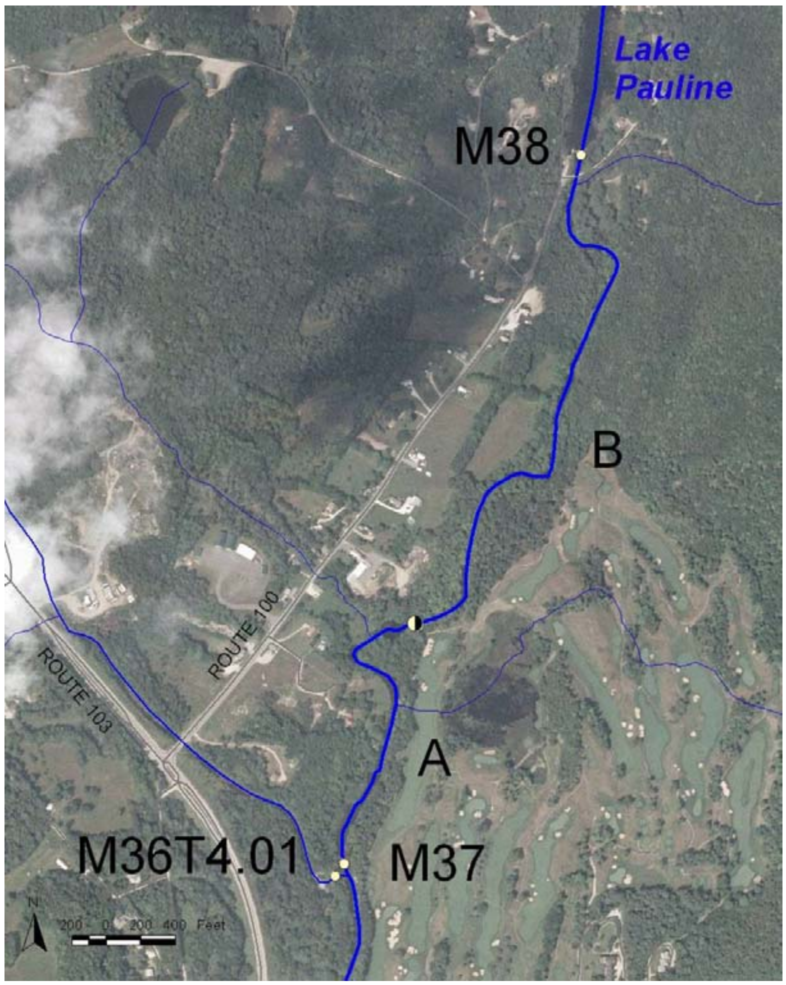


Figure 1. Segmentation of reach M37, Black River main stem, Ludlow.

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.

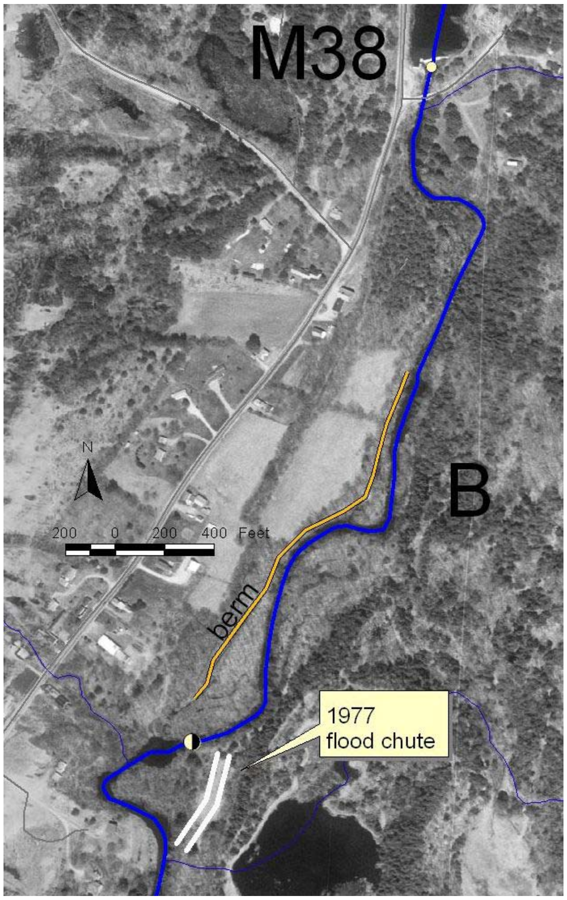


Figure 3.
Approximate position of cobble/ boulder/ earthen berm within RB corridor of Black River (M37-B), possibly created during the flood recovery efforts following the 1936/1938 or 1973 floods, or both.
A 1977 aerial photograph shows a major flood chute at the downstream end of the segment which 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.

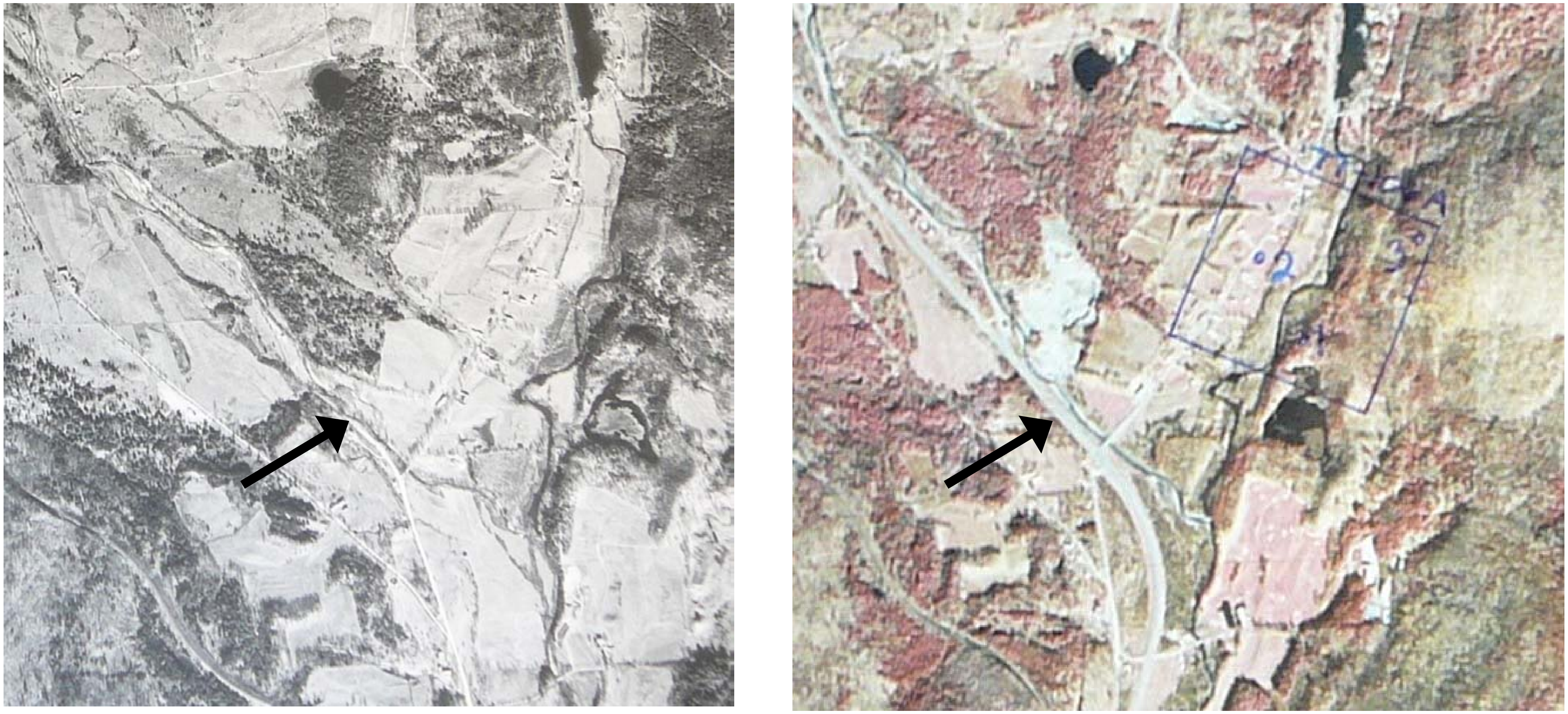
Two bridge crossings constrict the flood prone width of the Branch Brook channel at points along the reach:

- 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.

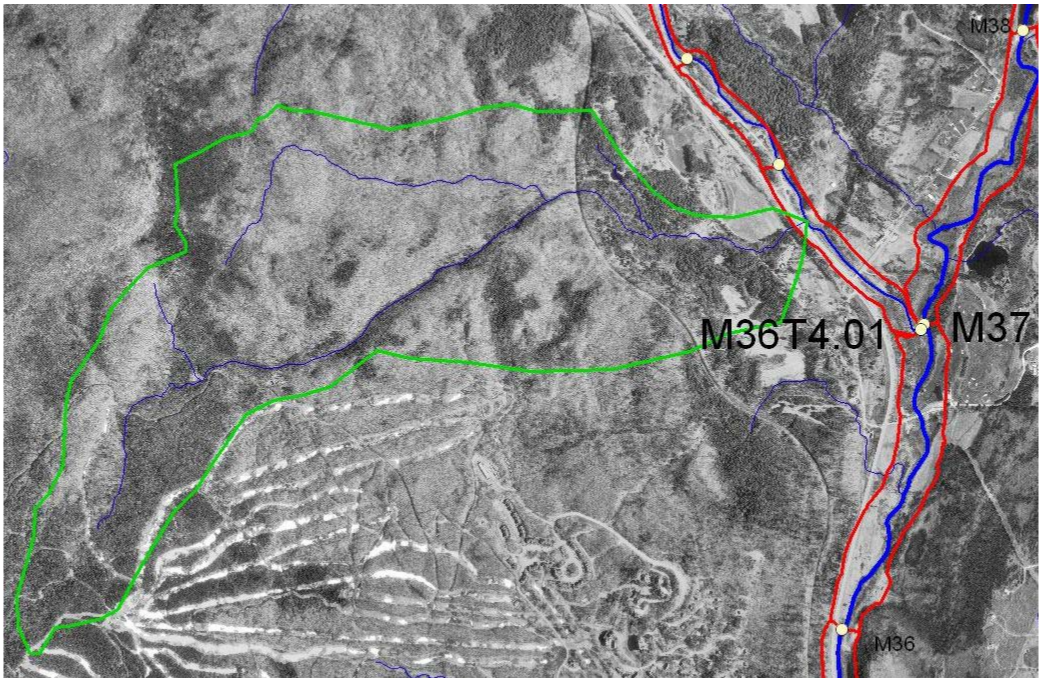
Field reconnaissance on 8 November 2007 (and during the August 2008 assessment of this reach) revealed that approximately one third of the flow from the Black River main stem has been “captured” by the Branch Brook, and the confluence has shifted to a point approximately 600 feet downstream of the position 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.

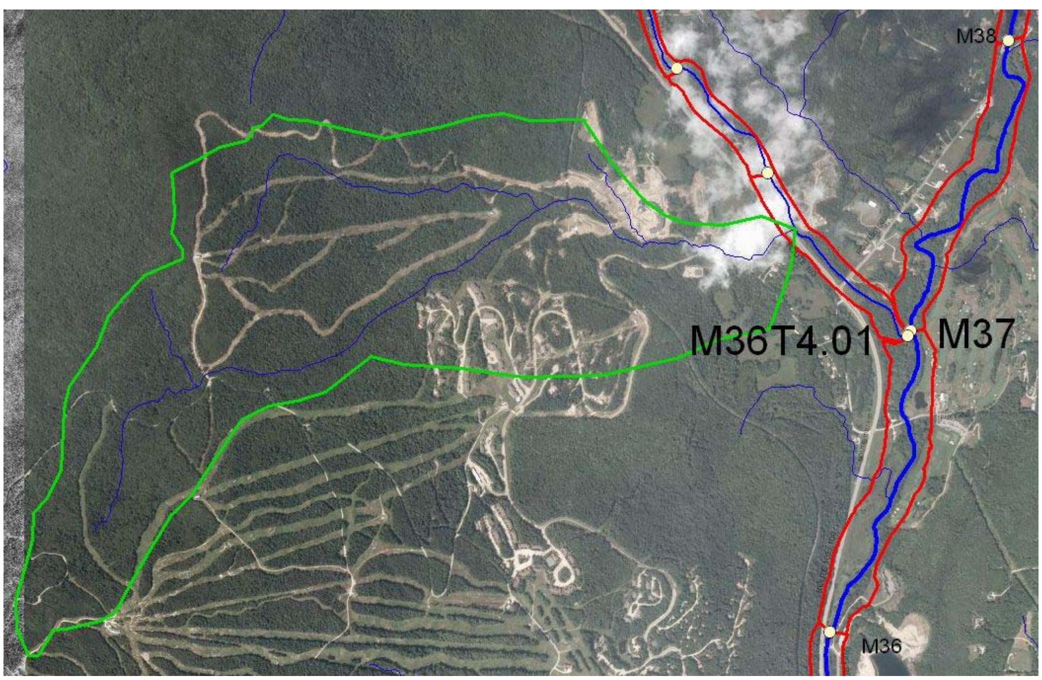


(a) (b)

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.

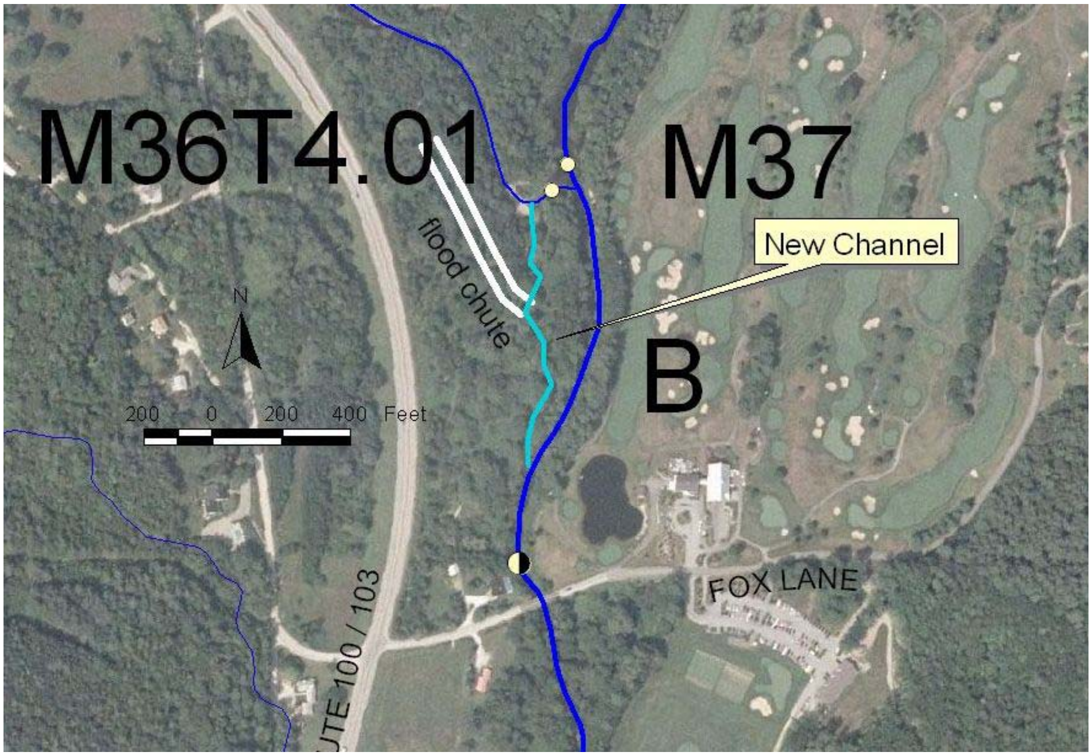


Figure 7. (Segment M36-B). A pre-1994 avulsion has resulted in a shift of the Branch Brook confluence to a position approximately 600 ft downstream of the confluence noted on the VHD. Approximately one-third of the Black River main stem flow has been "pirated" from the former confluence position to flow 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).

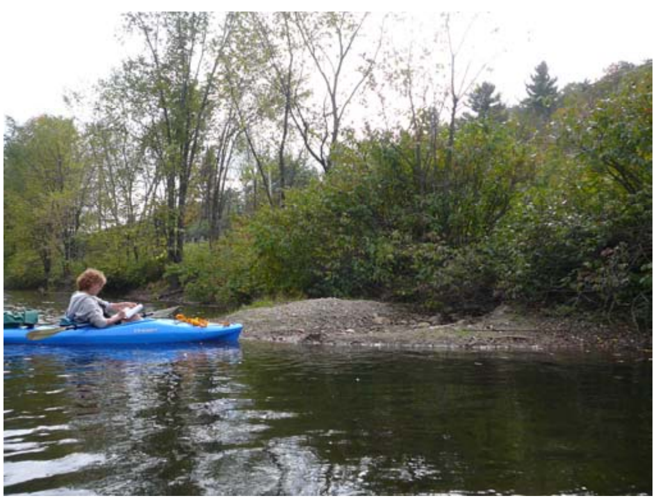


Figure 10. Deposition of fine to medium gravel sediments at RB confluence of stormwater channel directed through a culvert under Route 103. 1 October 2007.

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)

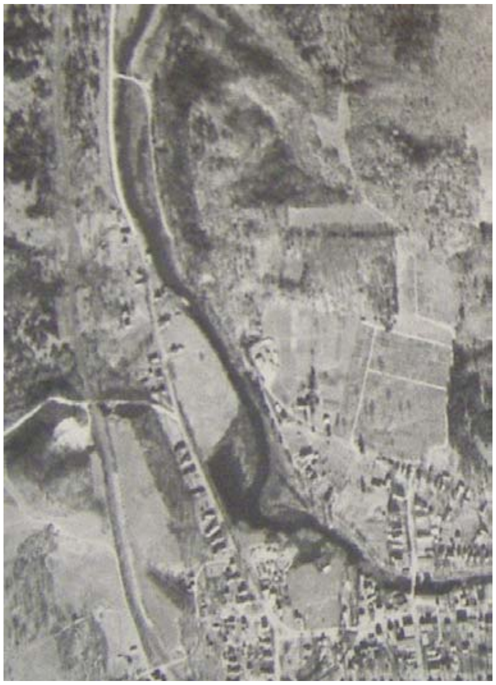
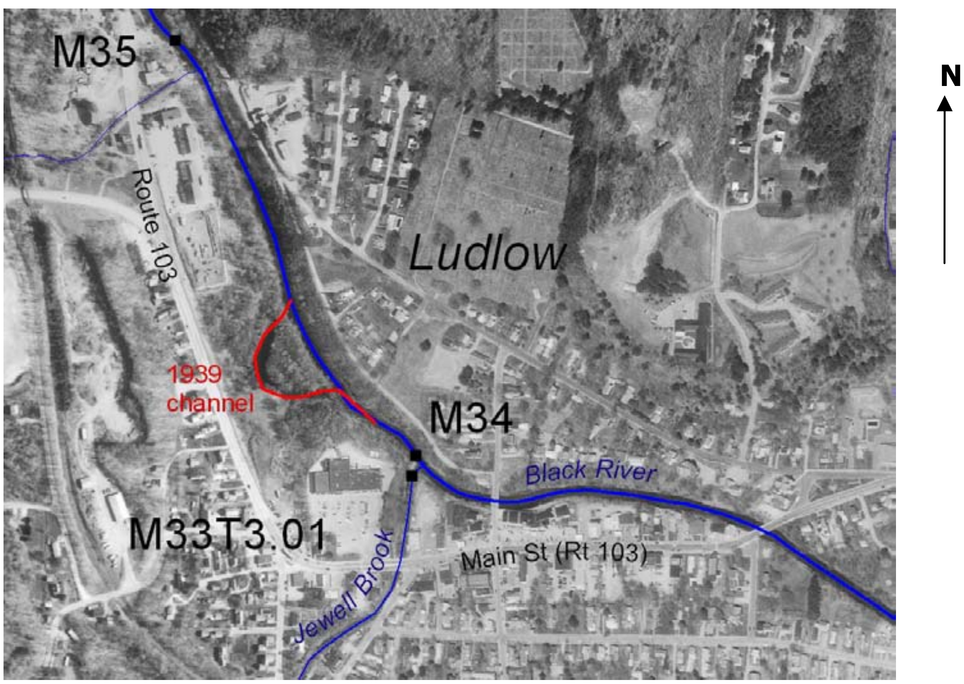


Figure 12. (a) (left) Black River planform through Ludlow, reach M34, 1939.

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.

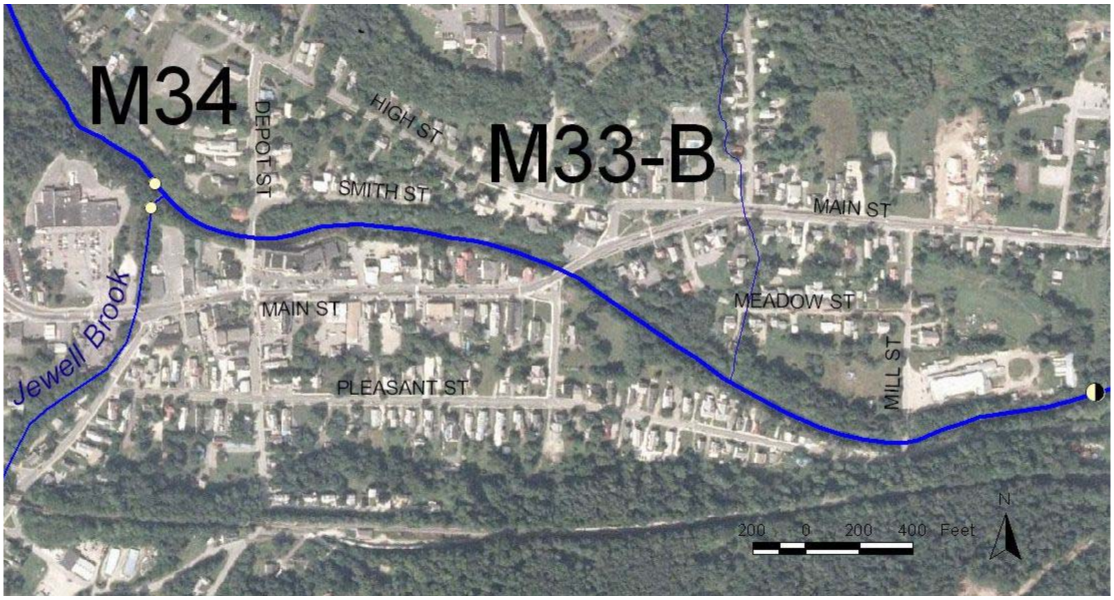


Figure 16. Segment M33-B of the Black River main stem through Ludlow village.

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.

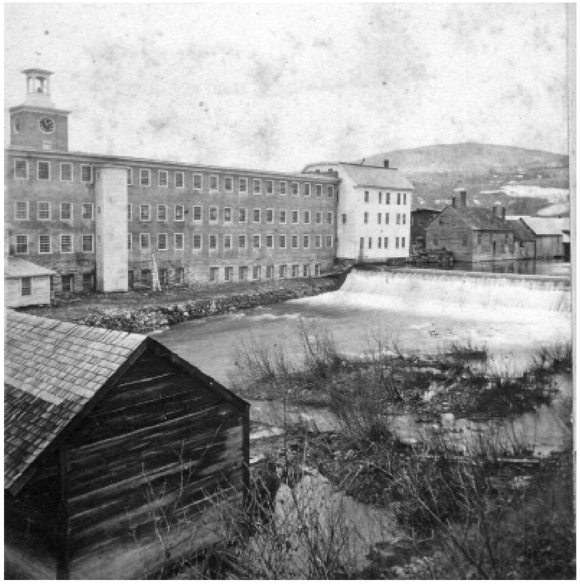


Figure 17. Historic dam at Ludlow Mill just downstream of Depot Street bridge crossing.

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.

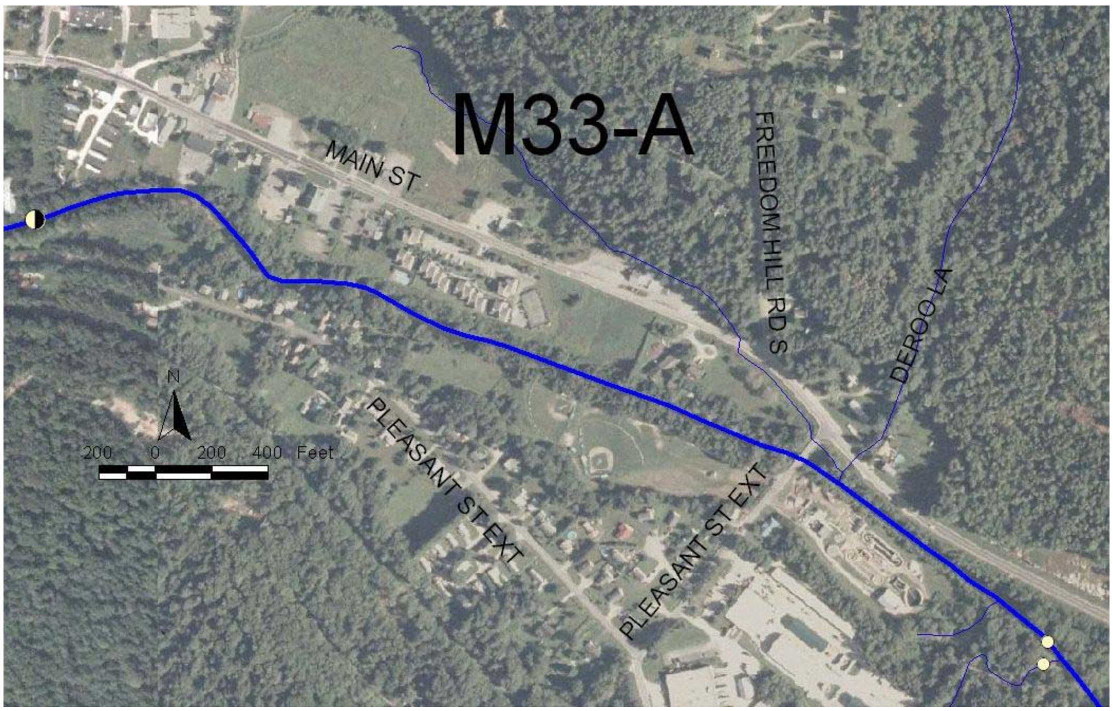


Figure 18. Segment M33-A of the Black River main stem downstream of Ludlow village.

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.

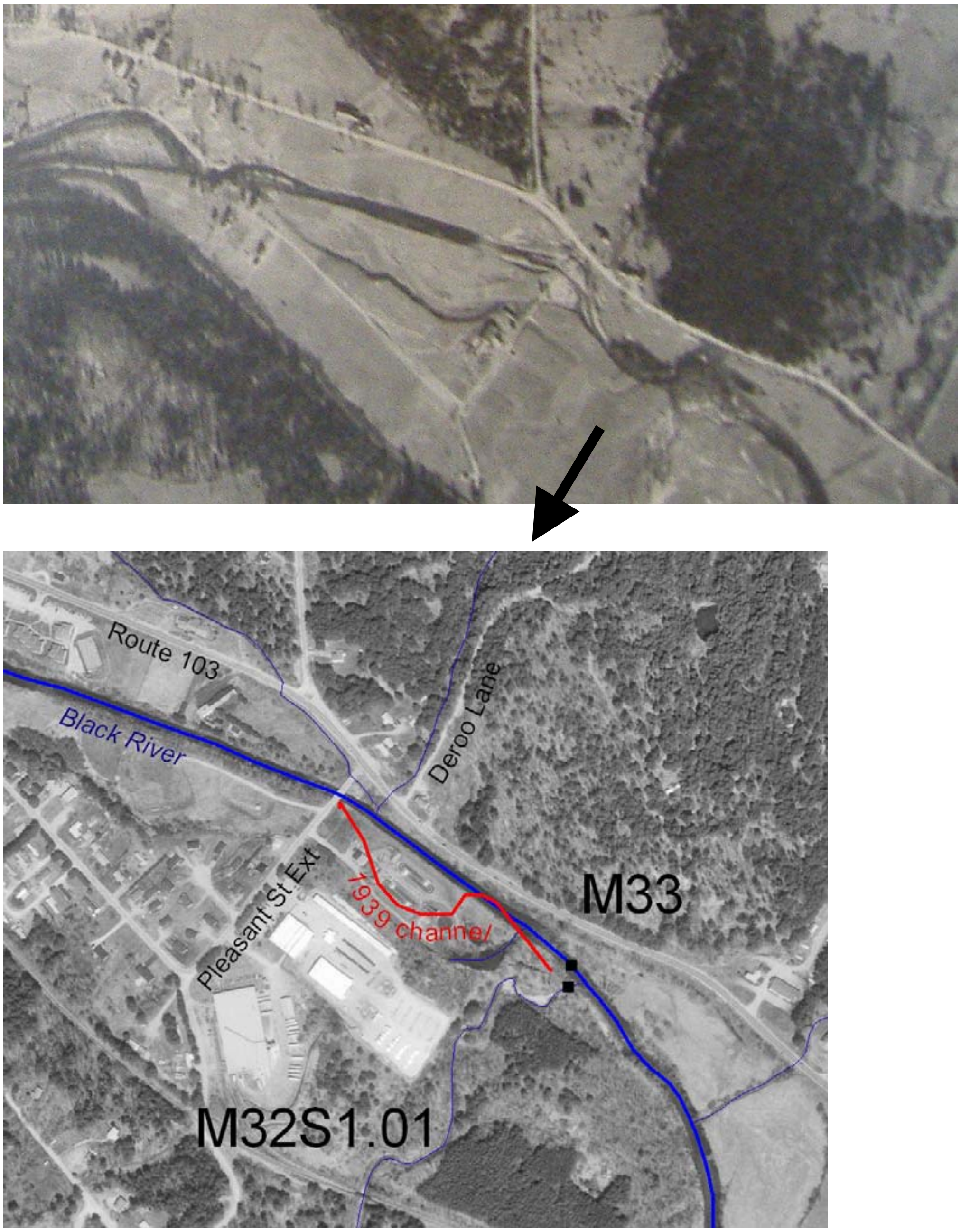


Figure 19. Post-1939 channelization of the Black River (Segment M33-A) along Route 103 in the area of the present-day wastewater treatment plant, Ludlow, Vermont. (a) (top) is Segment M33-A in 1939; (b) (bottom) is same location in 1994. Review of the 1939 aerial photograph also highlights the considerable 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.

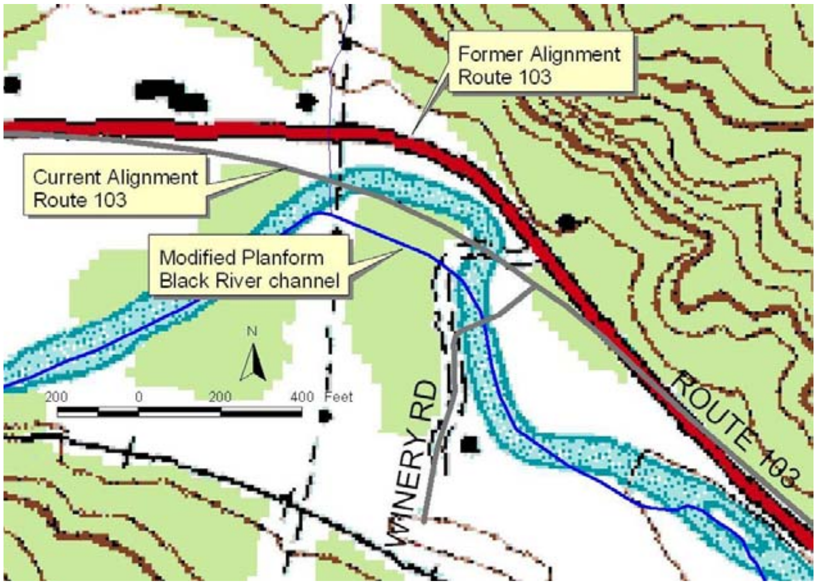


Figure 20. Pre-1994, post-1980 modification of Black River channel to accommodate realignment of Rt 103. Flow is from picture left to picture right.

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.

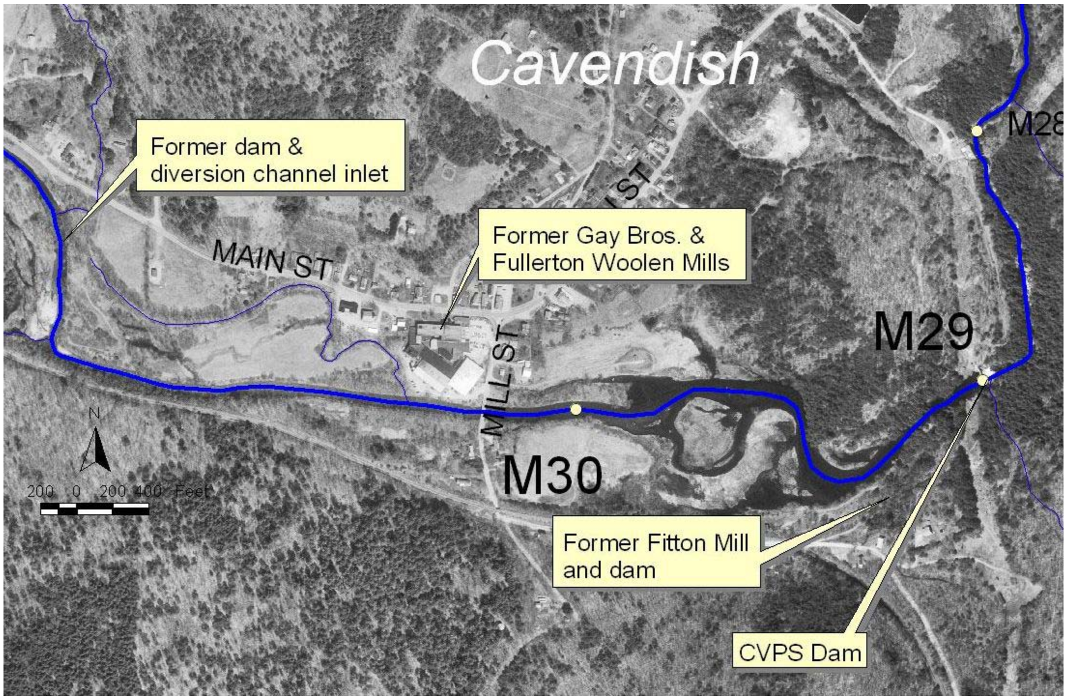
Historically, a dam was present approximately one-half mile upstream of the Fullerton Woolen Mills at Cavendish. (This facility later operated as the Gay Brothers Woolen Mill until the late 1930s, when ownership transferred to Mack Molding). Waters impounded at this dam were diverted through a constructed 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.

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.

(a) *(b)*

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).

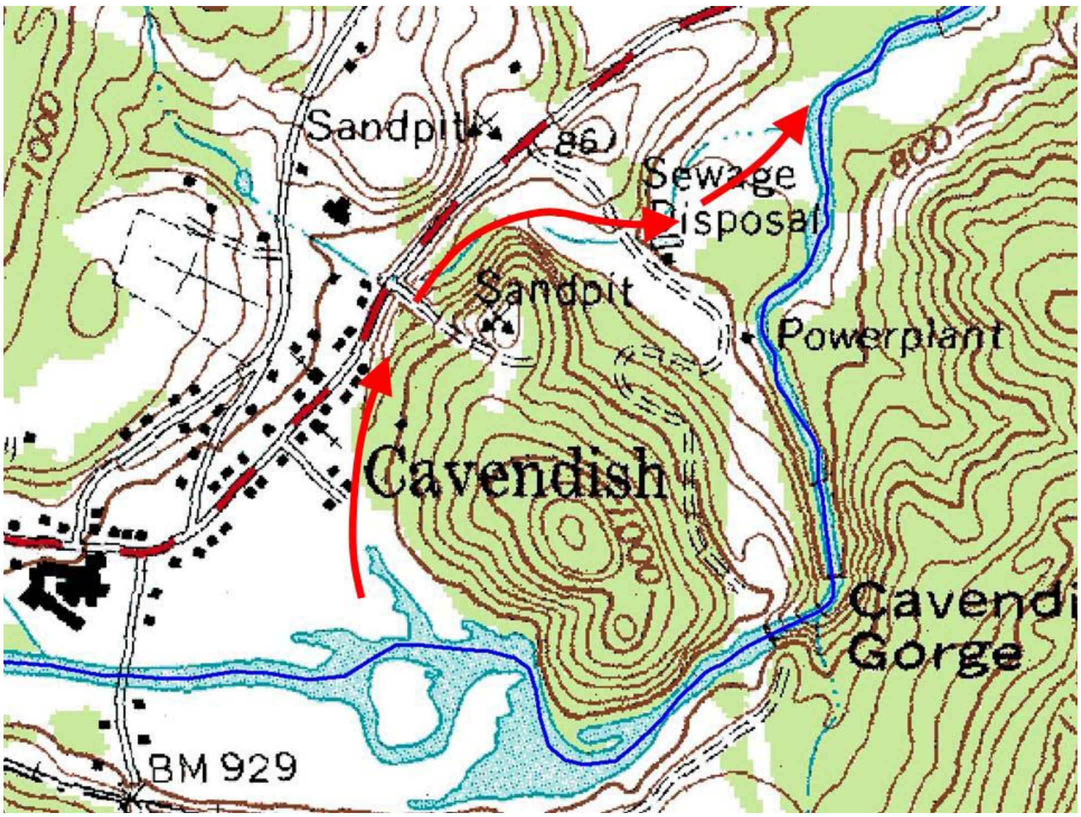


Figure 27. Approximate path of channel avulsion on the Black River main stem during the 1927 flood (from Reach M29 to M27), Cavendish, VT.

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:

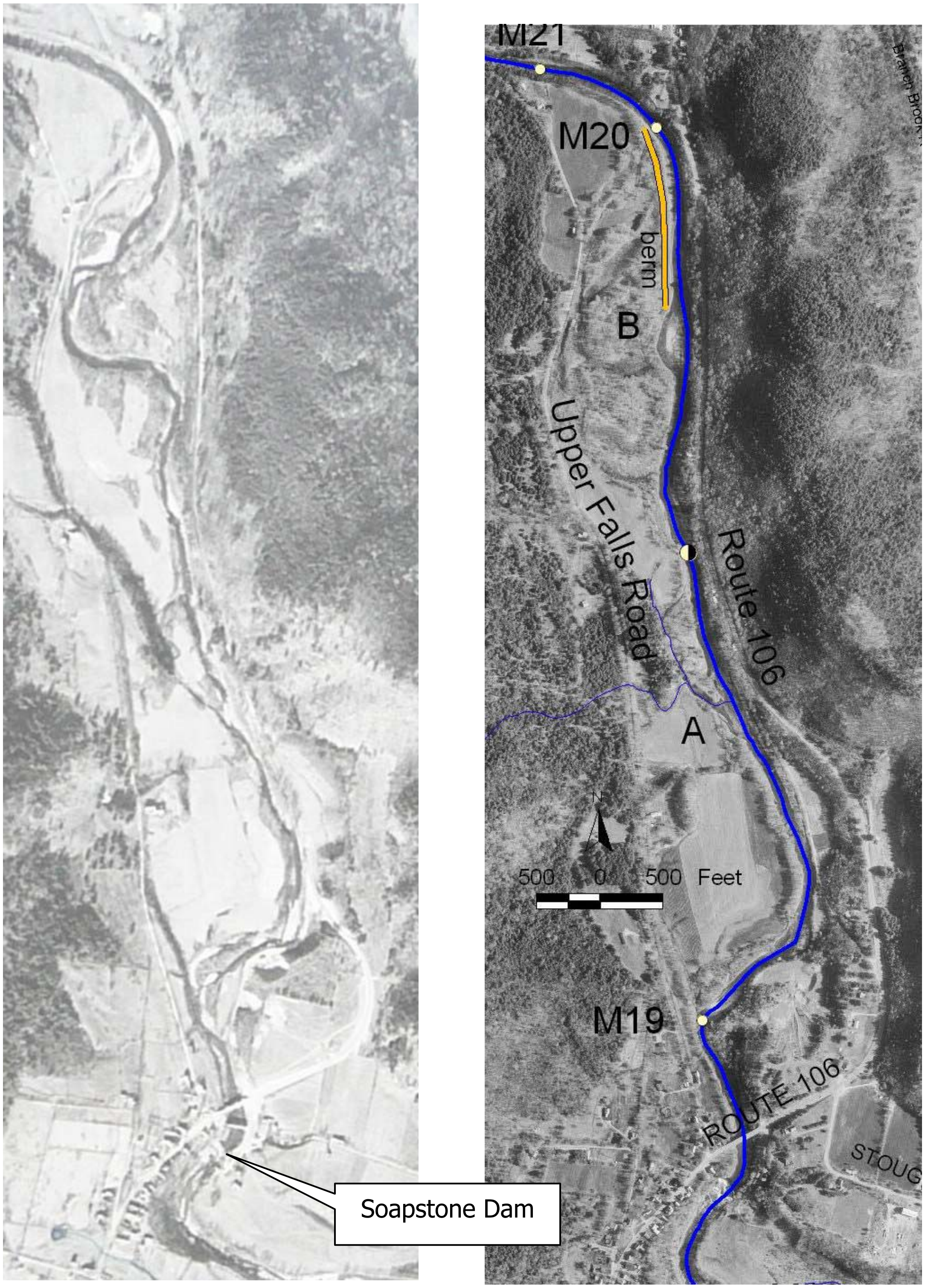
- Segment B – 3454 ft, 0.6% gradient, C to F stream type departure, IR_{RAF} = 2.2;
- Segment A – 4243 ft, 0.2% gradient, C4 stream type, IR_{RAF} = 1.7.

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].



(a) (b)

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.

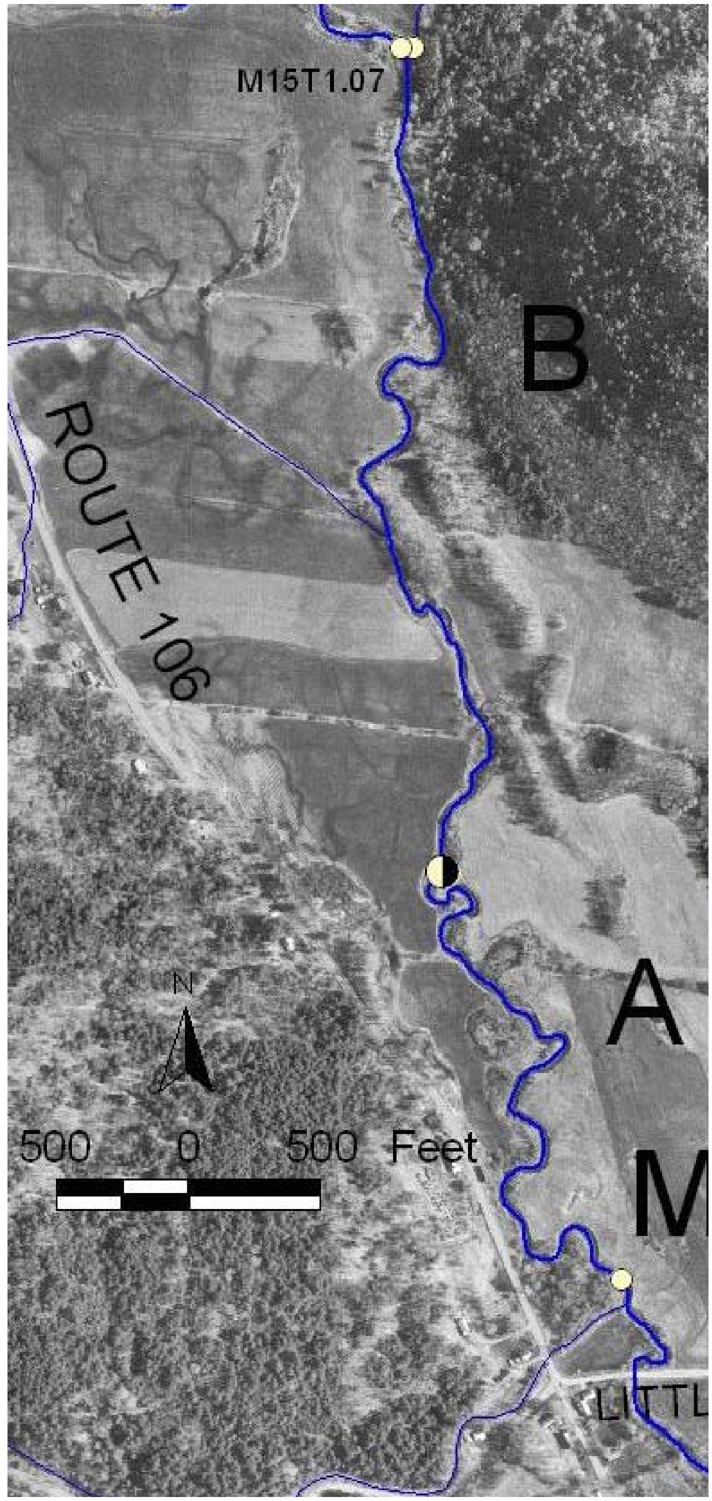
Substantial planform adjustments and widening are ongoing, combined with a moderate degree of aggradation. A reduction in sediment transport capacity would be expected in this reach, governed by the decrease in valley gradient and confinement. Historic removal (or narrowing) of tree buffers to support 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.

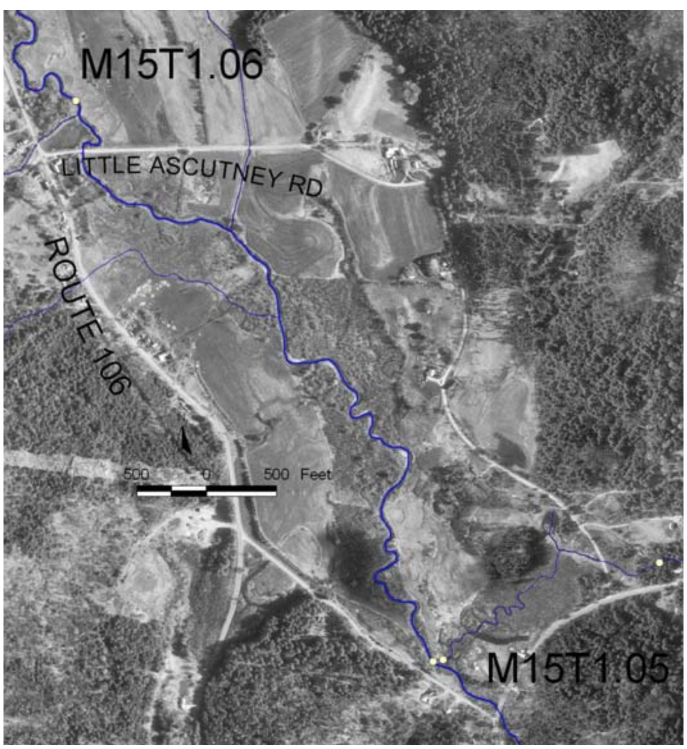
Slight encroachment by roads along the left and right valley walls; however, this encroachment is not sufficient to result in a significant change to the valley type (Very Broad) or confinement status (unconfined). Sparse residential development is present along these roads at the valley edge. Floodplain 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.

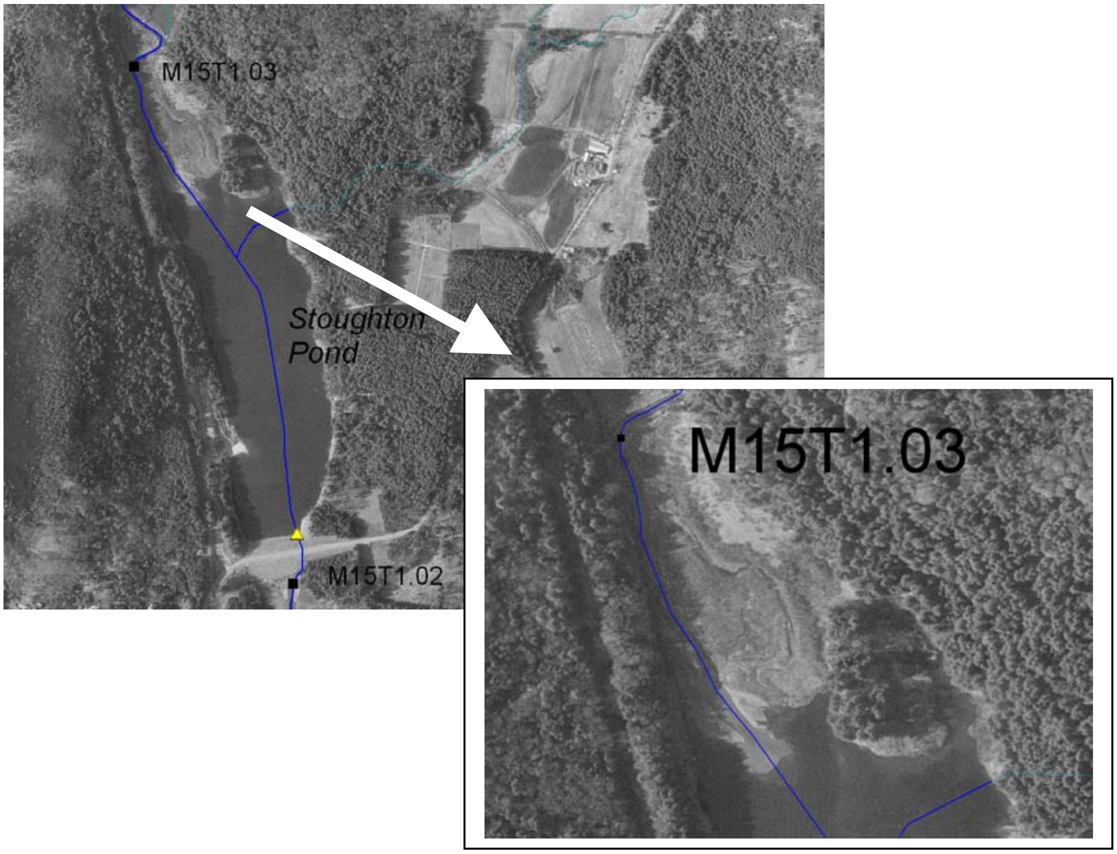


Figure 33. Delta of fine sediments extending into upstream end of Stoughton Pond from the North Branch of the Black River (base map: 1994 orthophoto).

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 / Segment	Reach-Scale Stressors					
	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 / Segment	Reach-Scale Stressors					
	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 / Segment	Reach-Scale Stressors					
			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 / Segment	Reach-Scale Stressors					
	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 / Segment	Reach-Scale Stressors					
	Stream Power			Boundary Resistance		
M15T1.11-C (Not Assessed)	I	Slope	Steep bedrock falls	I	Bank	Maintenance of tree buffers, limited encroachments.
				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 / Segment	Reach-Scale Stressors					
	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) H: Berm - RB H: Bridge - East Lake Rd (BFL) H: Old Abuts - historic bridge site (BFL) N: Bedrock lateral control, RB (localized)		**X**		(X) Due to upstream impoundment of sediments in lakes, reservoirs; historic channelization.		
M37-A (Not Assessed)							(X) 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) H: Berms - one or both banks, 62% of reach H: Residential Development (minor) H: Commercial Development (minor) H: Bridge - Commercial driveway (FPW) H: Bridge - Route 100 (FPW)		**X**		X Due to straightening, berms.		
M36-B (Not Assessed)		H: Road - Route 103 (RB)						**X**
M36-A		H: Road - Route 103 (RB) H: Bridge - Fox Lane (BFL)			Locally, above natural valley pinch point.	(X) Locally, due to limited inferred channelization. Good floodplain access overall.		**X**
M35		H: Road - Route 103 (RB); Dug Rd (LB) H: Residential Development (minor, RB) H: Bridge - Dug Road (BFL)	**X**			(X) 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 H: Commercial Development, RB N: High glaciofluvial terrace, LB		**X**		**X** 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) H: Berms - LB, downstream of Rt 103 bridge H: Residential/ Comm. Development (RB,LB) H: Bridge - Depot St (FPW) H: Bridge - Main Street (Route 103) (BFL) H: Bridge - Mill Street (BFL) N: High glaciofluvial terrace, LB		**X**		**X** Due to channel dredging, berming, commercial & residential encroachments (fill).		
M33-A		H: Roads- Main St (LB), Pleasant St (RB) H: Berms - LB, discontinuous H: Residential/ Comm. Development (RB,LB) H: Bridge - Pleasant St Ext (FPW) H: Constriction, armored channel at WWTF		**X**		**X** Due to channel dredging, berming, commercial & residential encroachments (fill).		
M32-C	Remant, low-head dam, Smith-ville	H: Roads- Main St (Route 103) (LB) H: Residential/ Comm. Development (RB,LB) H: Remnant mill foundations (LB, localized) H: Bridge - East Hill Road (BFL)		**X**		**X** Due to channelization, historic incision.		
M32-B		H: Roads- Main St (Route 103) (LB) (minor) H: Berms - LB, discontinuous, low elevation H: Railroad - RB, minor (usually elevated above floodprone width on valley side slope) H: Recreational Fields, LB N: Bedrock lateral control, RB (localized)		**X**		**X** 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) H: Railroad - RB upstream end of segment; LB downstream end of segment. H: Residential Development (RB) H: Commercial Development (LB, RB) H: Sand & Gravel Quarry (RB) H: armored, undersized channel at Route 103 encroachment just upstream of Winery Rd H: Bridge - Winery Rd (BFL) H: Old Bridge Abutments - (BFL) H: Bridge - Railroad (FPW) H: Old Abutments (dam? and historic diversion channel inlet - (BFL) H: Bridge - Route 103 (FPW)		**X**		**X** Due to channelization, historic incision, encroachments.		**X**
M31		H: Railroad - LB, RB H: Residential/ Comm. Development (RB,LB) H: Recreational Fields, RB H: Bridge - Depot St. (Proctorsville) (FPW) H: Bridge - Railroad (FPW)		**(X)**		**(X)** Due to channelization, historic incision, encroachments.		
M30		H: Roads- Rt 131 (LB) (minor) H: Railroad - RB (minor - often elevated above FPW on valley side slope. H: Residential/ Comm. Development (LB) H: Abutments - former (breached) dam (BFL) H: Bridge - Mill Street (Cavendish) (FPW)		**(X)**		**(X)** 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) H: Bridge - Carlton Rd (FPW) N: Bedrock lateral control, both banks.		**X**		**(X)** Due to channelization, historic incision		
M26T2.01 (Twentymile Stream)		H: Roads- Rt 131 (LB); Whitesville Rd (RB) H: Berms (LB, minor) H: Residential Development (LB) H: Commercial Development (RB) H: Bridge - Route 131 (FPW) N: Bedrock lateral control (RB, localized)		**X**		**(X)** Due to channelization, historic incision		
M26		H: Road- Rt 131 (LB) H: Berms (LB, low elevation)		**X**		**(X)** Due to channelization, historic incision		
M19 - B		H: Road- Upper Falls Rd (RB) H: Berms (RB) H: Residential Development (sparse, RB) N: Bedrock lateral control, LB (localized)		**X**		**(X)** Due to channelization, historic incision		
M19 - A		H: Road- Upper Falls Rd (RB) H: Driveway - LB (localized) H: Residential Development (sparse, RB; localized, LB) N: Bedrock lateral control, LB (localized)		**(X)**		**(X)** 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) H: Berms (LB) H: Residential Development (LB, RB) H: Culvert - Twentymile Stream Rd (BFL) N: Bedrock lateral control, LB (localized)		**X**		**(X)** Due to channelization, historic incision		
M26T2.10-B	Two bedrock ledge	H: Road- Twentymile Stream Rd (LB) H: remant mill foundations (potential) N: Bedrock lateral control, LB, RB (localized)	**X**					
M26T2.10-A		H: Residential Development (LB, RB, sparse) H: remant mill foundations (potential) H: Culvert - driveway (BFL)		**X**		**(X)** Due to historic incision		
M26T2.09		H: Road- Twentymile Stream Rd (LB) (minor) H: Residential Development (LB, minor) H: Culvert - Meadowbrook Farm Rd (BFL)		**X**	Locally, above natural valley narrowing.	(x) Due to historic channelization, incision	(x) Increased somewhat by constriction of channel due to fill / culvert crossing for Meadowbrook Farm Rd; increased locally by beaver dams. (Could be enhanced with wetland restoration.)	**X**
M26T2.08-B	None						(x) 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) H: driveway (RB) H: berms (RB) H: Culvert - Twentymile Stream Rd (BFL)		**(X)**		**(X)** 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) H: berms (RB, minor) H: Bridge - VAST Trail (BFL)		**(X)**		**(X)** Due to historic incision, limited channelization		
M26T2.06-B	Channel-spanning bedrock mid-segment	H: Road - Twentymile Rd (RB) H: Residential Development (RB) H: Bridge - farm road (BFL) 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) H: Residential Development (minor, LB, RB) H: Bridge - Heald Rd (BFL) H: Bridge - Davis Rd (BFL) N: Bedrock lateral control, RB (localized)			Locally, above natural valley pinch point.		(x) 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) H: Berms (LB, minor) H: Residential Development (LB) H: Commercial Development (RB) H: Bridge - Route 131 (FPW) N: Bedrock lateral control (RB, localized)		**X**		**(X)** 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) H: berm - RB H: Residential development (each bank) H: Constriction (BFL) - LB armored road, RB berm		**X**		**X** Due to historic encroachments, channelization, incision		
M15T1.11-A		H: Road - Route 106 (RB, minor) H: berms - both banks H: Residential development (each bank) H: Bridge - Rt 106 - (BFL)		**X**		**X** Due to historic encroachments, channelization, incision		
M15T1.10		H: Road - Route 106 (RB, minor) H: berms - extensive, both banks		**X**		**X** Due to historic encroachments (berms), channelization, incision		
M15T1.09	60 ft long waterfall mid-reach	H: Road - Route 106 (RB) H: berm - RB, short section H: Residential development (sparse, ea.bank) H: old abut pair (BFL) - #1 H: old abut pair (BFL) - #2 H: Bridge - Rt 106 - (BFL)		**X**		**X** Due to historic encroachments (road), channelization, incision		
M15T1.08	Channel- spanning bedrock upstream end	H: Road - Route 106 H: Berms - both banks, downstream end H: Residential Development (minor, LB, RB) H: Bridge - farm/ VAST trail (BFL) H: Old Abutments (BFL) H: Bridge - Ascutney Basin Rd (BFL) N: Bedrock lateral control, LB (upstream end)		**(X)**		**(X)** 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) H: Road - Ascutney Basin Rd, LB (minor) H: Berms - both banks, upstream end		**(X)**		**(X)** Somewhat, due to inferred historic incision.		
M15T1.06-B		H: Road - Route 106, RB (minor) H: historic cemetery, RB (localized)		**(X)**		**(X)** Somewhat, due to inferred historic incision.		
M15T1.06-A		H: Road - Route 106, RB		**(X)**		**(X)** Somewhat, due to channelization locally, but good floodplain connection overall.	(Could be enhanced with wetland restoration.)	**X**
M15T1.05		H: Road - Route 106, RB H: Residential Development (minor, RB) H: Bridge - Little Ascutney Basin Rd (BFL) H: Bridge - VAST trail (FPW)			Locally, above natural valley pinch point at Amsden Falls.		(Could be enhanced with wetland restoration.)	**X**
M15T1.04 (Not Assessed)	Amsden Falls (bedrock)	N: Bedrock lateral controls, LB, RB						
M15T1.03-B		H: Road - Branch Brook, RB, minor N: Bedrock lateral controls, LB				(X) Sightly, due to local channelization or avulsion, but good floodplain connection overall.	**(X)** Increased by impoundment effects extending from downstream Stoughton Pond dam.	**X**
M15T1.03-A (Not Assessed)		H: Road - Branch Brook, RB					**X** 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.