

# PHASE I STREAM GEOMORPHIC ASSESSMENT

Conducted on the Mettowee River and Selected Tributaries  
by the POULTNEY METTOWEE WATERSHED PARTNERSHIP



## REPORT and DATA

Study Completed between October, 2004 and August, 2005  
Report Completed September, 2005

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SPECIAL THANKS to Mary Trombley, Jami Westerhold and Steve Schild, Rutland Regional Planning Commission; Fred Nicholson, Vermont DEC Stream Alterations Engineer; Kristen Underwood, South Mountain Research and Consulting and Shannon Hill, Vermont DEC River Management Section, for project technical support and quality assurance.

## INTRODUCTION

Fluvial geomorphology is the study of the interaction between streams and the landscape through which they travel. The phase 1 geomorphic assessment specifically looked at how changes on the landscape have translated to changes within the Mettowee Basin stream channels. The Poultney Mettowee Watershed Partnership (PMWP) used remote sensing tools such as maps, public records and files, aerial and orthophotos and digital mapping programs to survey the Mettowee River in Vermont and five of its tributaries. The tributaries surveyed included the Wells Brook, Flower Brook, Beaver Brook and Sykes Hollow Brook in Pawlet; Prentiss Brook in Dorset and one unnamed tributary in Rupert, VT.

This study was conducted using the Vermont Geomorphic Assessment Protocols, which were designed to standardize geomorphic assessments conducted by different organizations around the state. Steps 1-4 of this study looked at deterministic watershed characteristics such as valley width, stream channel slope and prevailing soil types. Steps 5 and 6 looked at changes that have occurred on the landscape through human activities such as development, berms and roads and rip-rap placed along the creeks. Step 7 included a field survey of the Mettowee and its tributaries from public access points. The purpose of the field survey was to verify the remote sensing information used in this assessment.

An additional and more in-depth field survey, or a phase 2 geomorphic survey, was conducted on selected reaches of the study area during the summer of 2005. For more information on the phase 2 field survey, please refer to *The Mettowee River Phase 2 Report*, September, 2005.

Results from both the phase 1 and phase 2 studies will provide much needed baseline data about the current conditions in the Mettowee watershed. The data will be used to provide recommendations for future restoration project locations, planning decisions, tree planting sites and the types of restoration projects that may be successful.

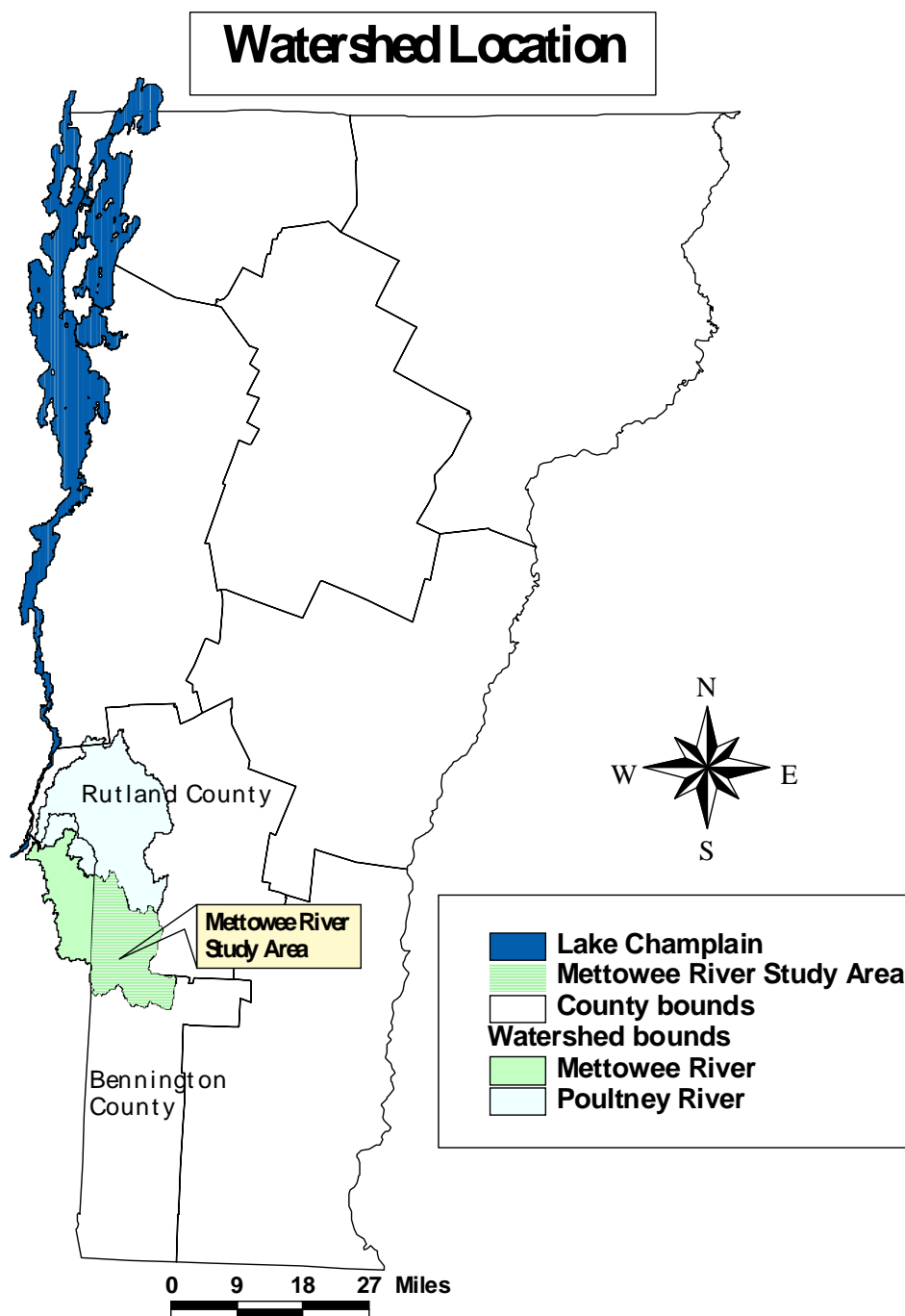
Funding for the Mettowee River Phase I geomorphic assessment was provided by Vermont's Clean and Clear Initiative (Corridor Management Grants from Vermont's Department of Environmental Conservation (DEC)) and a US Environmental Protection Agency (EPA) Clean Water Act section 319 grant.

The study was conducted by the Poultney Mettowee Watershed Partnership (PMWP) with support from the Poultney Mettowee Natural Resource Conservation District (NRCD), Vermont DEC and South Mountain Research and Consulting (SMRC).

Remote sensing data used in this study was obtained from the Vermont Center for Geographic Information (VCGI), Vermont DEC, the Rutland Natural Resource Conservation Service (NRCS) and the Rutland Regional Planning Commission (RRPC). Information was also provided by officials from the town of Pawlet, Ghostwriters Inc and SMRC.

The following map depicts the location of the study area.

Map 1: Watershed Location within the State of Vermont and Rutland and Bennington Counties



## **METTOWEE WATERSHED: STUDY AREA BACKGROUND**

The Mettowee Watershed (in Vermont, without the Indian watershed) is comprised of 113 mi<sup>2</sup>. The Mettowee River originates in Dorset and flows northeasterly into New York State, entering the barge canal and subsequently South Lake B (Lake Champlain) near Whitehall, NY. The Mettowee watershed includes the towns of Dorset, Rupert, East Rupert, Pawlet, East Pawlet, Wells and the outskirts of Danby and Tinmouth. Major tributaries include the Wells Brook, Mill Brook, Flower Brook, Sykes Hollow Brook, Prentiss Brook, Indian Brook and one unnamed tributary. All except Indian Brook and Mill Brook were included in this study (the assessment on the Indian is to take place later this year).

The Poultney Mettowee Watershed Partnership is a joint venture between the PMNRCD and NY's Washington County SWCD. The Partnership plans to collaborate to complete a study on the Indian River and the Lower Mettowee River in New York using the Vermont protocols.

The PMWP is currently also monitoring temperature, total phosphorus, E. coli and turbidity on the Mettowee River, Flower Brook and Beaver Brook. The temperature monitoring is the result of a study that showed high water temperatures in the Mettowee Basin were contributing to fish kills and loss of trout and other coldwater fish and macroinvertebrate species in the area. The other studies will provide background data and are the result of a grant provided by Vermont DEC's environmental laboratory, where water samples collected by our volunteers are taken for analysis.

More information about these studies can be found on our website: [www.poultneymettowee.org](http://www.poultneymettowee.org).

## **METHODOLOGY**

This assessment was completed using the methodologies outlined in the Vermont Geomorphic Assessment Phase I Handbook, dated April 2004 (plus subsequent updates). Computer mapping functions were completed through the automated GIS extension/tool, Stream Geomorphic Assessment Tool (SGAT), version 3. All data resulting from this study has been entered into Vermont DEC's online Data Management System (DMS) and checked for quality and reproducibility by qualified Vermont DEC staff.

## **DATA INPUTS/STUDY RESULTS**

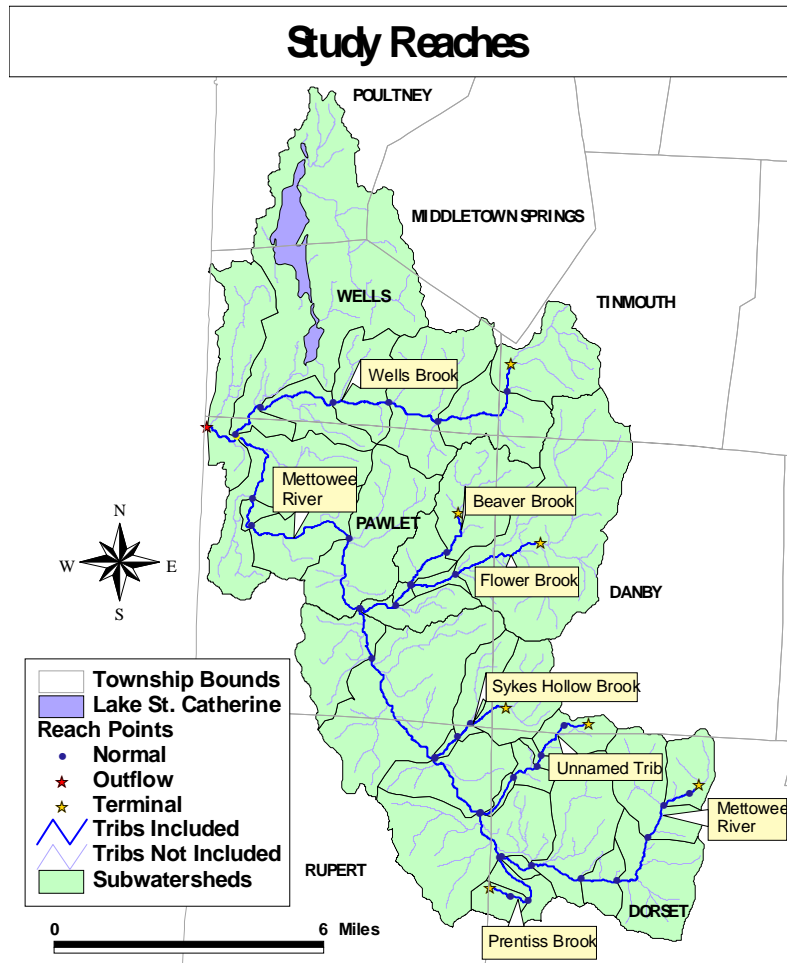
The results of this study are derived from the following data inputs: watershed location; valley and channel characteristics; soils data; land use and riparian buffer data; post-settlement changes to the channel, floodplain, stream corridor and watershed and a comparison of the expected stream channel characteristics to the measured characteristics. All of the phase 1 data (drawn upon in the following summaries) can be found in Appendix A or may be accessed through the Vermont DEC geomorphic assessment Data Management System (DMS).

### Reach Location

The Vermont portion of the Mettowee River Basin was divided into 40 reaches for the purposes of this study. Each reach is a like area studied as one geologic unit. The Mettowee River was divided into 16 reaches, the Wells Brook was divided into 6 reaches, Flower Brook (below Lilly Hill Road) was divided into 4 reaches, Beaver Brook was divided into two reaches, Sykes Hollow Brook was divided into 3 reaches, the unnamed tributary in Rupert was divided into 5 reaches and Prentiss Brook was

divided into 3 reaches. Please refer to Appendix A, report 1, for a complete list of the reaches and their locations within the basin. The following map details the location of each reach and a representation of its subwatershed area.

Map 2: Mettowee Basin Subwatersheds by Reach



### Stream Types

All stream reaches in this study were classified as Rosgen (1996) and Montgomery Buffington (1996) stream types A, B or C.

Stream type “A”- steep, cascading, headwater reaches

Stream type “B”- include moderately steep, step-pool streams

Stream type “C”- the most common stream type in the Mettowee Basin, “C” streams include less-steep, pool-riffle streams with floodplain access.

The “C” stream type predominated, especially in the valleys.

## Basin Characteristics: Geology and Soils

As stated in the Vermont DEC protocols, “A stream carries not only water but also sediment. Geology determines the source material that the river is carrying, the way that material is carried and the rate of channel adjustments.” For an in-depth study of the geologic character of the Mettowee Valley, please refer to the phase 2 assessment report.

Based on the phase 1 results, the dominant geological materials in the Mettowee Valley are ice-contact, alluvial and glacial till. The characteristics of the dominant soil types in the watershed show infrequent flooding, but variable erosion rates across the basin, with some reaches having soil types throughout that show potential for very severe erosion.

## Land Cover and Reach Hydrology

Landuse in the watershed is mainly forested, with forest cover in each subwatershed ranging from 52.6 percent on one reach on Beaver Brook to 95.7 percent in the Sykes Hollow Brook headwaters. Historically, a much higher percent of the watershed was cleared for pasture and croplands.

Landuse in the stream corridor is a mix of forested land, crops and fields and occasionally, urban areas. Urban areas make up as much as 48.2 percent of the landuse along one reach of Flower Brook.

Woody vegetative buffers of greater than 100 feet in width dominate much of the watershed, though eight reaches show at least one bank with less than 25 feet of buffer dominating. Many of the reaches had long stretches of minimal vegetation along fields, roads or developed areas.

Groundwater and wetland inputs vary greatly by reach.

## Instream Channel Modifications

Instream channel modifications include the impact or frequency of bridges and culverts, bank armoring, channel straightening and dredging on the river.

Because the exact location of stream alteration permits was not usually available and most of this basin will undergo a phase 2 field survey, information on bank armoring was not collected during the phase 1 survey. Information for the seven reaches that have already undergone phase 2 assessment has been added to the phase 1 data tables. As discovered during the phase 2 assessment, one reach, M07, had rip-rap along 32% of the left bank and 41% of the right bank. Often the areas with rip-rap were narrow with steep banks and little floodplain access. These areas act as transport flumes with large-sized sediment carried from these areas to depositional, often unstable areas, downstream.

Reaches showing high impacts from channel straightening include two on the Wells Brook, seven on the Mettowee, and one reach each on Flower, Beaver and Prentiss Brooks. Only one reach M07, had repeated (reported) dredging in a depositional area downstream of a long stretch of rip-rap.

## Floodplain Modifications and Planform Change

Floodplain modifications include roads, berms and development within the floodplain that alter the ability of the river to migrate in response to changes within the system. Planform changes include

depositional features, meander migration and a deviation (usually a decrease) in the sinuosity of a river from the predicted or reference condition.

Eleven reaches had roads or berms in the floodplain for over 20% of the length of the creek. The highest of these, M0503.01, had a road or berm (sometimes both) along 81% of the length of the reach.

Except in four reaches (M04, M05T03.01, M07, and M10), development impacts were listed as low or not significant.

The planform changes, which include in-stream depositional features, meander migration and a deviation from expected sinuosity, show adjustments within the system that appear to be in response to historic land clearing, channelization and bank armoring.

### Windsheild Survey

The windshield survey provided a means of limited field verification of the phase 1 data. Brief observations were taken at points of vehicular and/or public access along the creeks in the study. The windshield survey was in no way a comprehensive field verification and the results of the phase 1 study should be considered preliminary.

## **DATA ANALYSIS**

### Impact Ratings

The following table lists impact ratings by reach. These impact scores combined with local knowledge of the area were used to determine which reaches received a phase 2 field assessment. Due to limited funds, only seven reaches were selected for the phase 2 assessment during the 2005 field season. Additional reaches (see priority rating) are being targeted for phase 2 field assessments during the 2006 field season.

Note that the impact ratings for reaches that have undergone the rigorous phase 2 field assessment are substantially higher than the other reaches. This indicates that while these reaches were originally chosen due to their high scores, the phase 2 assessment finds additional impacts or stressors to those found in the phase 1 assessment.

Table 1: Stream and Watershed Provisional Impact and Priority Rankings

Reach ID	Stream Name	Impact Score	Priority Ranking*	Comments:
M01	Mettowee River	8	2	
M01T02.01	Wells Brook	7	2	
M01T02.02	Wells Brook	12	2	
M01T02.03	Wells Brook	9	2	
M01T02.04	Wells Brook	14	2	
M01T02.05	Wells Brook	14	2	
M01T02.06	Wells Brook	4	2	
M02	Mettowee River	12	2	
M03	Mettowee River	4	3	

M04	Mettowee River	22	1	Phase 2 complete
M05	Mettowee River	17	1	Phase 2 complete
M05T03.01	Flower Brook	26	1	Phase 2 complete
M05T03.02	Flower Brook	13	1	Phase 2 complete
M05T03.02S01.01	Beaver Brook	9	2	
M05T03.02S01.02	Beaver Brook	11	2	
M05T03.03	Flower Brook	14	1	Phase 2 complete
M05T03.04	Flower Brook	5	1	
M06	Mettowee River	23	1	Phase 2 complete
M07	Mettowee River	22	1	Phase 2 complete
M07T04.01	Sykes Hollow Brook	7	2	
M07T04.02	Sykes Hollow Brook	6	3	
M07T04.03	Sykes Hollow Brook	1	3	
M08	Mettowee River	13	2	
M08T05.01	Unnamed Trib	3	3	
M08T05.02	Unnamed Trib	3	3	
M08T05.03	Unnamed Trib	1	3	
M08T05.04	Unnamed Trib	9	3	
M08T05.05	Unnamed Trib	2	3	
M09	Mettowee River	9	2	
M09T06.01	Prentiss Brook	10	2	
M09T06.02	Prentiss Brook	10	2	
M09T06.03	Prentiss Brook	2	3	
M10	Mettowee River	11	2	
M11	Mettowee River	8	2	
M12	Mettowee River	8	2	
M13	Mettowee River	7	2	
M14	Mettowee River	7	2	
M15	Mettowee River	0	3	
M16	Mettowee River	1	3	

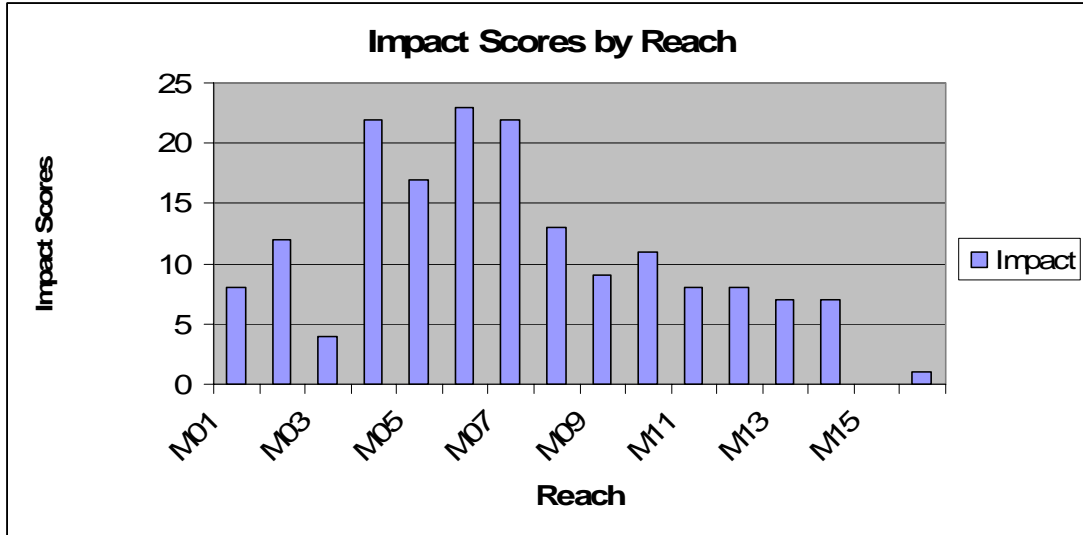
\*1 = very high priority; based on high impact scores and our knowledge of the area, we elected to complete phase 2 work along these reaches and will apply for a project scoping grant this year to help us implement projects along these reaches.

2 = high priority; we applied for funding to complete phase 2 assessments on a subset of these reaches and will continue to seek funding to gather field data in hope of eventually implementing projects along these reaches.

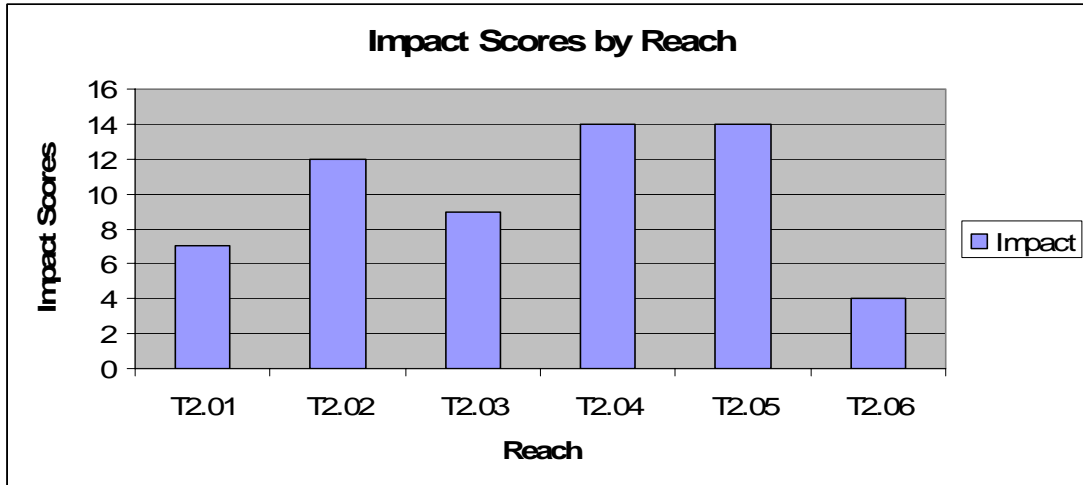
3 = lower priority; we have little reason to believe that projects are necessary in these reaches.

The following graphics depict the reach impact scores from upstream (right) to downstream (left) along the Mettowee Mainstem (M01-M16), Wells Brook (T2.01-06) and Flower and Beaver Brooks (T3.01-04 and T3.02S01.01-02). These graphics can be used to visualize where along the reach the impacts are higher. Additional information can be gained by comparing the reach impact scores to the locations of the reaches on topographic maps.

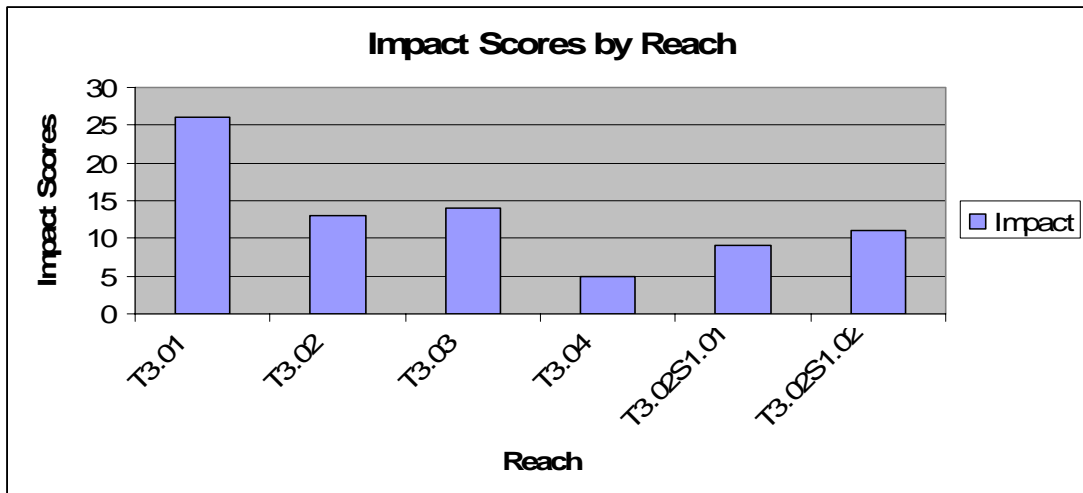
Graph 1: Impact scores along the Mettowee River



Graph 2: Impact scores along Wells Brook



Graph 3: Impact scores along Flower and Beaver Brooks



## Adjustment processes

Please refer to Table 2, located at the end of this report (or as a separate file, “table 2 step 9”, on the report CD).

Overall the Mettowie Basin system appears to be degrading, or becoming more incised in its channel. Of the four adjustment categories, degradation received the highest scores overall. This indicates that as the Mettowie River scours out its channel, it may contribute to sediment and nutrient loads in Lake Champlain.

Some aggradation, or sediment storage, is noted in selected reaches (M05T03.02 scored higher aggradation than degradation scores). In many cases aggradation and degradation scores are similar within a reach indicating that to some degree both processes are occurring simultaneously at different points along the reach.

Based on the phase 1 provisional adjustment scores, the Mettowie River and its tributaries don't appear overly widened, though these scores may change after completion of the phase 2 field assessment.

Several reaches are exhibiting planform change, or a change in their path. Planform changes often include a slow increase in sinuosity after historic channelization (M5T3.03, M04, M06 and M07). M06 and M07 have a high percentage of rip-rap along the banks, though where rip-rap is not present the river is actively recreating sinuosity and depositing sediment.

Nine reaches scored “fair” or “poor” for reach condition as compared to others within the project area (M01T02.04, M01T02.05, M04, M05T03.01, M05T03.02S01.01, M05T03.03, M06, M07 and M09T06.01).

Twelve reaches showed high sensitivity to change (M01T02.05, M04, M05, M05T03.02, M05T03.02S01.01, M05T03.02S01.02, M05T03.03, M06, M07T04.03, M08T05.04 and M08T05.05).

## **CONCLUSIONS**

Overall, the Mettowie River and its tributaries are degrading or becoming incised in their channels. This is often accompanied by increased sediment transport as the bed and banks are scoured and the sediment carried away. This sediment most likely contributes to the sediment and associated nutrient enrichment problems in Lake Champlain. Projects that address the source of this sediment or help to permanently deposit sediment within the channel should be considered.

Though most historic state permit records do not record the location or length of rip-rap installed along the channel, the reaches surveyed during the phase 2 assessment showed that the occurrence of rip-rap along the Mettowie mainstem is common. Alternative forms of bank stabilization or system stabilization may prove effective in decreasing erosion and sediment transport, while maintaining the width of the channel and floodplain access.

Many of the reaches in the river valleys showed long stretches with minimal buffers, which contributes to the increased temperatures measured within the Mettowie Basin. Tree planting projects in these areas is recommended.

While the effect of berms and roads on the channel morphology appears to be high, the pressures from development are not yet significant in many reaches. Implementing planning measures along the river corridors can help preserve the functionality of the stream system in the basin.

Based on the results of the phase 1 geomorphic assessment, the PMWP in concert with our phase 2 contractor, Kristen Underwood, SMRC, decided to conduct phase 2 assessments on seven reaches of the Mettowee and Flower Brook. These reaches included M04-M07, or two reaches on the Mettowee upstream of Pawlet and another two downstream of Pawlet. We also surveyed Flower Brook from its confluence upstream three reaches, or M05T03.01-03. The results of this study are available upon request.

In addition to the reaches surveyed in 2005, the partnership wishes to survey an additional 20 reaches in the Mettowee Basin (see table 1). We have currently applied for and been awarded funding to at least partially complete this work. While many of these reaches were selected based on the impact scores from the phase 1 study, many were also selected based on results of the phase 2 field assessment, which showed high rates of instability, degradation and deposition in the system.

## Appendices

Appendix A- Phase 1 Data Reports

Appendix B- Quality Assurance (QA) form

Appendix C- US EPA approved Quality Assurance Project Plan (QAPP)

# Appendix A

# Appendix B

## QUALITY ASSURANCE WORKSHEET

**QA Project Leader:** Hilary Solomon

**ANR Project Leader:** Shannon Hill

**Training:**

Phase 1: Completed under the direction of Shannon Hill  
 SGAT: Completed under the direction of Shannon Hill  
 Quality Assurance (QA): Training received at RTI, OEPA and US EPA

**Watershed Orientation Completed:** With assistance from Ethan Swift, DEC, Marli Rupe, PMNRCD, and Joel Flewelling, Ghostwriters, Inc. (former watershed coordinator).

**Reach Break Review:** Completed by Shannon Hill

**Protocols and Database:** Vermont ANR protocols were used exclusively

**Tools Used to Collect Data:** Also refer to DMS metadata. *The following data tools were used for the phase 1 assessment. Reaches M04-M07 and M05T03.01-03 have been verified by a phase 2 assessment and the phase 1 data for those reaches was updated on September 12, 2005 to reflect the results of the detailed field survey.*

Phase 1 Step Number	Tools to Collect Data	Date Completed	Date Updated	Date of Local Review	Date of State Review
Step 1	1:24K Topos, 1:5K Orthos (1994), Vermont Gazetteer	1/18/05		1/18/05	2/22/05
Step 2	1:24K Topos, SGAT, preliminary estimates based on protocols	1/18/05		1/18/05	2/22/05
Step 3	1:24K Topos, soil slope data and field observations	6/24/05	9/12/05	8/2/05, 9/12/05	8/3/05
Step 4	1:24K Topos, 1:5K Orthos (1994, 1968, 1942), old aerials, 1:5K NHD, NWI maps	6/24/05		8/2/05, 9/12/05	8/3/05
Step 5	1:24K Topos, 1:5K Orthos (1994), 1:5K NHD, files, interviews with DEC and NRCS staff	6/24/05	8/2/05, 9/8/05	8/2/05, 9/12/05	8/3/05
Step 6	1:24K Topos, 1:5K Orthos (1994, 1968), 1:5K NHD, other aerial photos	6/24/05	8/2/05, 9/8/05	8/2/05, 9/12/05	8/3/05
Step 7	1:24K Topos, field observations at points along reach	6/24/05	9/12/05	8/2/05, 9/12/05	8/3/05

**Confidence Level:** Overall confidence level Moderate to Moderate-High

Phase 1 Step Number	Confidence	Comments
Step 1	High	Standard information
Step 2	Moderate-High	Valley widths may be biased wide
Step 3	Moderate	Soils info difficult to use for slope; many reaches should have had “some” groundwater inputs, but this was not an option (minimal or abundant only)
Step 4	Moderate-High	Many buffer conditions have been field verified
Step 5	Moderate	Revetments and straightening difficult to verify
Step 6	Moderate-High	Protocols fairly straightforward
Step 7	Moderate	Not all reaches were accessible

**Data Updated:** Final data update September 12, 2005 (especially for phase 2 reaches)

**Date of Local QA Project Review:** Ongoing with final review on September 12, 2005

**Date of State QA Project Review:** Ongoing with GIS review on 1/11/05, SGAT review on 1/28/05, Steps 1-2 review on 2/22/05, Steps 3-7 review on 8/3/05, and rough draft report review on 9/9/05.

**Comments:** Confidence level Moderate/Moderate-High chosen due to overall adherence to the state protocols, with a fair amount of field verification in most parts of the watershed. There was no field verification along Prentiss Brook. There was also no information entered for revetments or dredging along reaches that did not receive phase 2 assessments. Information for many of these reaches will be updated after next summer’s phase 2 assessments, which will address most of the remaining reaches along the Mettowee River and Wells Brook.

# Appendix C

**Quality Assurance Project Plan  
for the Mettowee River  
Phase I and II- Stream Geomorphic Assessment**

Version 1: November 2004

Prepared by:  
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For submittal to:  
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Marli Rupe, Project Coordinator, PMNRCD Date

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Hilary Solomon, Project Manager, PMWP Date

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Shannon Hill, Project QA Officer, Vermont DEC RMS Date

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Eric Perkins, US EPA Date

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Steve DiMattei, US EPA New England QA Chemist Date

Quality Assurance Project Plan  
Mettowee Geomorphic Assessment – Phase I and partial Phase II  
November 2004

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Quality Assurance Project Plan

Mettowie Geomorphic Assessment – Phase I and partial Phase II

November 2004

### **3.0 Distribution List**

Names, addresses and telephone numbers of those receiving a copy of this distribution QAPP.

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Quality Assurance Project Plan

Mettowee Geomorphic Assessment – Phase I and partial Phase II  
November 2004

## 4.0 Project Task Organization

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*Project Manager: Responsible for project planning and coordination, Data collection, entry and analysis, Daily activities and project reports*

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*Provides technical assistance,  
Assists in data gathering, Assists coordination  
between New York and Vermont entities.*

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*Project QA Officer: Provides technical assistance, assessment protocol training, Responsible for design and implementation of quality assurance quality control plans Responsible for data QA check and verification and adherence to the QAPP*

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*Provides technical assistance for GIS work & mapping, helps with data management*

## 5.0 Problem Definition/Background

### Existing Rationale

Excessive sedimentation, loss of riparian buffers, degradation of water quality and deterioration of aquatic resources and riparian habitats associated with stream channel instability represents, is by far, the greatest threat to the ecological quality and the recreational and aesthetic values of Vermont rivers. Sedimentation resulting from instability of stream channels and the resulting channel adjustment processes can generally be traced to anthropogenic sources, such as development within active floodplains (including dwellings, roads, and bridges), channel management activities (including gravel mining, bank armoring, dredging and channelization), removal or suppression of vegetation in the riparian zone, and changes in watershed hydrology, such as increased stormwater runoff or water diversions. The interactions of these various land uses and their effects on a watershed or river system can be complex, and require thorough evaluation of the many factors through a watershed-wide assessment, in order to achieve effective solutions to water quality impairments.

The need to address the Mettowee River thermal impairment was first identified in the early 1970's. The cold-water fishery in the Mettowee continues to be impacted from the loss of riparian vegetation, streambank instability, over-widening and decreasing water depth. An earlier assessment conducted by researchers from Green Mountain College demonstrated a direct correlation between the lack of riparian buffer and areas of erosion (Field, 2002). The significant findings of this assessment for the Vermont portion of the Mettowee River and Flower Brook indicate more than 40 percent of the Mettowee River in Vermont is classified as eroding, moderately eroding, or protected by riprap.

In the summer of 2001, the environmental firm ENSR was contracted through the VT Department of Environmental Conservation to model conditions in the Mettowee River watershed to quantify the nature and extent of the elevated temperature problem through continuous recording of water temperatures throughout the study area for a 72-day period (ENSR, 2002). A set of 4 model scenarios representing alternative management actions predicted reductions in the temperature-area load range acceptable for remediating the (water) temperature impairment. The most effective (and reasonably attainable) management actions would most likely involve a combination of increased shading and (river) channel modification along certain reaches of the Mettowee River and Flower Brook (tributary to the Mettowee) to achieve the desired outcome(s).

In addition, the Poultney Mettowee Natural Resource Conservation District (PMNRCD) and Poultney Mettowee Watershed Partnership (PMWP) have coordinated or participated in several other assessments of the Mettowee River in the past five years that support these recommendations and address other similar issues. These projects include:

- A streambank assessment study conducted by PMNRCD and NRCS in 1999, which visually evaluated conditions of the Mettowee streambanks. Several sites were flagged as priority areas for possible future restoration based on high erosion conditions and potential for severe sedimentation increase to the river. In addition, areas without buffers were noted.
- A summer temperature monitoring project done by the Partnership and NY Department Environmental Conservation and Washington County Soil & Water Conservation District.
- VT Fish & Wildlife research, including fish population surveys, and a
- VT Department of Environmental Conservation water quality and aquatic habitat assessment

In 2003, the PMNRCD received a grant through the EPA 319 funding to do additional assessment and implementation work on the Mettowee River and its tributaries. This grant involves streambank stabilization projects, temperature monitoring, buffer installation, and public education. It also includes some funding to begin a Phase 1 geomorphic assessment of these water bodies. However, funding is not adequate to complete the Phase 1 assessment, or to begin the Phase 2 assessment on the critical areas outlined in the ENSR report mentioned previously. As part of the Vermont Corridors grant, PMNRCD and the PMWP plan to conduct a phase II assessment on areas of the Mettowee near Pawlet village and the downstream reaches of Flower Brook. These areas were cited in the ENSR report as especially critical in addressing the thermal impairment issues.

Our current project includes both Phase 1 and Phase 2 assessments.

The proposed project will ultimately address the following documented project needs:

#### Lake Champlain Phosphorus TMDL

DEC's Lake Champlain Phosphorus TMDL recommends reductions in phosphorus loads from non-point sources from agricultural, forest and urban uses. Preliminary target allocations reduce phosphorus loads in South Lake B by x.xx% for non-point sources. Most of the non-point source reduction will occur from the implementation of agricultural BMPs, transportation infrastructure upgrades (bridges, culverts, roadside ditching), and storm water management controls.

#### State of Vermont's Year 2002 List of Impaired Waters

The Mettowee River in Vermont is listed on the 2002 Vermont state 303(d) list of impaired waters as being threatened by thermal pollution. The Phase I on the Mettowee and selected tributaries (Wells, Flower Brook, Beaver Brook, unnamed, unnamed and Prentiss Brook) will complement ongoing temperature monitoring and proposed chemical monitoring on the Mettowee.

#### VT DEC's Watershed Planning Initiative

DEC has initiated watershed planning in the Poultney-Mettowee watershed as required by *Vermont Water Quality Standard 2000*. The Poultney-Mettowee Basin Plan is currently in draft form, due for final publication in December 2004. The plan establishes strategies to address stakeholder concerns about water quality issues in the watershed. The DEC watershed coordinator has been working closely with the watershed partners in bringing together all of the parties necessary to work collaboratively on identifying and developing a remediation plan for the watershed.

#### Opportunities for Action

This project will address phosphorus loading to Lake Champlain as described in the *Opportunities for Action*, 1996. Streambank restoration, the installation of buffer strips, stormwater management measures, nutrient management, implementation of BMPs for road construction and maintenance, new development, and streambank restoration and protection have been identified as strategies to reduce phosphorus.

### **6.0 Project Description (Abstract)**

Using funding from both a 319-Act grant and the Vermont Corridors grant (through the Lake Champlain Clean and Clear Initiative), the PMNRCD and PMWP are conducting a Phase I stream geomorphic assessment on the Vermont portion of the Mettowee and its tributaries and the Vermont

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portion of the Indian River. At this time, it is our goal to use other funds to assess the New York sections of the Indian and Mettowee Rivers in conjunction with the Vermont study. As part of the Vermont Corridors grant, PMNRCD and the PMWP plan to conduct a phase II stream geomorphic assessment on areas of the Mettowee River near Pawlet village and the downstream reaches of Flower Brook. These areas were cited in the ENSR report as especially critical in addressing the thermal impairment issues.

The Agency of Natural Resources' (ANR) stream geomorphology assessment protocols will be used to prioritize stream segments for watershed restoration efforts. Results of the Phase I assessment will identify sources of significant erosion, inventory anthropogenic disturbances, delineate sub-watershed boundaries, develop stream reaches, calculate stream and valley conditions, and assess bridges and culverts in the watershed. The second phase of assessment will field verify data collected at the remote sensing level using in-stream evaluation criteria.

The study will lead to project recommendations with the goal of reducing existing erosion, increasing riparian vegetation, thereby contributing to a decrease in temperature and a reduction in erosion-related phosphorus loading to the Mettowee River and ultimately Lake Champlain. The assessment will generate a database that will include rapid geomorphic and rapid habitat assessment results. The database can be built upon and queried for various attributes that will prioritize future protection and restoration projects. Outreach to the local community will consist of a watershed assessment results summary that will be available to watershed groups and landowners. Volunteers will be invited to participate in the field assessments with hope that knowledge about the past and present conditions of the Mettowee will be exchanged.

## 7.0 Project Schedule & Timeline

Table 7-1: Phase I Assessment tasks and timeline

Objective	Task	Product	Responsible party	Schedule
Getting started	Reach break, numbering, subwatershed delineation	ArcView themes	Hilary Solomon with oversight by Marli Rupe	September, 2004
Generate ArcView themes for SGAT	W/S, meander centerline, valley walls	ArcView themes	Hilary Solomon	September, 2004
SGAT and database creation	1.3, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 3.3, 3.5, 4.1, 4.2	SGAT database	Hilary Solomon	October-December, 2004
Parameters clipped in SGAT w/ Ap. E corridor	3.3, 3.5, 4.1, 4.2, data transfer	Land use and soils corridor themes	Hilary Solomon	October-December, 2004
Steps done w/ Ap. E and orthos	6.1, 6.2	Bridge and culvert assessments	Hilary Solomon	October-December, 2004
Steps w/out SGAT and associated data entry	1.1, 1.2, 2.11, 3.1, 3.2, 3.4, 4.3, 4.4, 5.1, 5.2, 5.3, 5.4, 5.5, 6.3, 6.4, 6.5, 6.6, 7.1, 7.2, 7.3, 8.1, 8.2, 9.1, 9.2, 9.3, 10	Map steps	Hilary Solomon	January-July, 2005
Data entry, bridge and culvert survey		Database	Hilary Solomon	Jan – July 05
QA/QC review		Quality Assurance	Shannon Hill, Ethan Swift, Marli Rupe	September, 2004 - October, 2005
Public Outreach		Meetings and publications	Marli Rupe, Ethan Swift and Hilary Solomon	January 2005 - October, 2005
Administrative oversight			Marli Rupe	Sept 2004 – October 2005

Table 7-2: Phase II Assessment Tasks and Timeline

<b>Objective</b>	<b>Tasks</b>	<b>Product</b>	<b>Responsible Party</b>	<b>Schedule</b>
Phase II Field Assessment	In-stream data collection Compile field data Analyze results & create database	Database, rapid geomorphic & habitat assessment scores, site sketches & photo logs, inventory of flood plain and final report	Hilary Solomon and Professional Contractor	May – September 2005
Project Coordination and Administration	Communication among partners, project scheduling, administration, and mid-grant reports	Work plan and invoice submittal and overall project coordination, requested progress reports to Vermont DEC	Marli Rupe	April – October 2005
Community Education and Outreach	Hold 3 public meetings and send out 3 press releases	Informational meeting presenting the Phase II Geomorphic and Habitat Assessment results	Professional Contractor, PM NRCD, PMWP, VT DEC, NRCS, RRPC	April – October 2005
Community Education and Outreach, Results Documentation	Summarize findings and provide recommendations, Distribute assessment summary	A summary of the geomorphic and habitat assessment, Final report	Professional contractor, Marli Rupe, Hilary Solomon, VT DEC, VT F&W, NRCS	October 2005

## 8.0 Budget Table and Justification

Table 8-1: Budget table (match funds for administrative oversight and phase I are from 319 grant)

Expense	Proposal request	Match	Total Cost
Admin oversight – 60 hours @ \$25/hr	\$750	\$750	\$1,500
<b>Phase I</b> 200 hrs @ \$25/hr	\$2,000	\$4,000	\$5,000
<b>Phase II</b> H.S. 50 hrs @ \$30/hr Contractor – 50 hrs @ \$50/hr RRPC assistance	\$1,500 \$2,500	\$500	\$4,500
Equipment Costs	\$500		\$500
Public Outreach 40 hrs @ \$25/hr	\$1,000		\$1,000
<b>Brochure publication/printing</b>	\$300		\$300
Total	\$8,550	\$5,250	\$13,800

## 9.0 Project Quality Objectives and Measurement Performance Criteria

The stream geomorphic data management system (DMS) will provide the baseline against which to assess the existing geomorphic condition of the Mettowee in relation to the reference physical condition. Maps, substrate, and riparian vegetation data will be used to describe the geomorphic condition of the Mettowee (see Appendix E: *Map, Sketch & Photo Documentation, Data Sheets and Field Forms* for a comprehensive listing of the data that will be generated). Quantification of the reference condition will support and enable the development of channel adjustment indicators, provide greater understanding of the causes of those adjustments and allow for the identification of solutions to stream instability problems. The DMS will provide river managers with the high quality data necessary for effective allocation of resources to address sediment loading and other erosion-related stream morphology problems.

Hilary Solomon, under direction of the project quality assurance manager (Shannon Hill), will collect the data for the phase I assessment. A professional contractor will be hired to complete the phase II assessment. Hilary Solomon will assist and Shannon Hill will perform quality assurance reviews. Strict adherence to methodologies that have been outlined in the Phase I and II Stream Geomorphic Assessment Handbooks will ensure a high degree of comparability and representativeness of data collected. VT DEC has compiled these methodologies in a well-organized protocol that is strengthened by comprehensive data collection forms, spreadsheets and databases. The data collection forms will organize and ensure completeness of data. Correct use of field equipment will allow for collection of precise and accurate data that far exceeds the level of sensitivity necessary to quantify geomorphic characteristics of concern.

## **10.0 Training Requirements**

The Phase I Project Manager has a background in water resources and experience with GIS. She will be adequately trained in VT DEC protocols and will work closely with the quality assurance manager through all steps of the phase I assessment.

The Phase II Project Manager will be fluent in VT DEC geomorphic assessment protocols. The science of fluvial morphology utilizes sampling protocols of several disciplines including soil sampling, sedimentologic and hydrologic measurement, and vegetation survey. The field crew will be adequately trained by VT DEC personnel on specific sampling techniques and will have total competence to perform any of the various data collection protocols undertaken in this study. Volunteer training sessions, coordinated by the Phase II contractor in conjunction with VT DEC, will also be available for interested citizens. Volunteers will become familiar with the VT ANR Stream Geomorphic Assessment protocols before entering in any fieldwork sessions.

## **11.0 Documents and Deliverables**

The following deliverables will be provided as a result of this project:

- Quarterly reports on the progress of the project submitted by the Project Coordinator to VT DEC
- Press releases and notices of public meetings will be sent to area newspapers to increase public awareness of the project
- Public meetings will be held to share the results with the community
- A final report will be submitted to Vermont DEC and US EPA
- Submittal of the project database to Vermont DEC and, if requested, US EPA upon project completion

Equipment Calibration and Maintenance Schedule and Records (Appendix B), QA/QC Checklist for Data Entry Reduction and Analysis (Appendix C), Internal Q/A Audit Form (Appendix D), and Map, Sketch & Photo Documentation, Data Sheets, Field Forms (Appendix E) will be kept on file in the Poultney-Mettowee Natural Resources Conservation District office in Poultney, VT.

## **12.0 Assessment Process Design**

Geomorphically stable and unstable (in adjustment) stream reaches will be identified and targeted for study during the Phase 1 Assessment. The Project Manager will determine geomorphic condition through analysis of historic aerial photos, survey data, topographic maps and ortho-photos. The assessment will focus on lateral adjustment, watershed land use / land cover, river corridor land uses, instream management activities, floodplain modifications, in-field qualitative assessment of stability indicators and cursory quantitative assessment of morphology. The Phase 1 assessment will result in a list of reaches designated for Phase II evaluation to further assess potential reference and impacted sections of the watershed.

Phase II assessments will be conducted on selected reaches of the Mettowee upstream and downstream of Pawlett and the lower reaches of Flower Brook (see attached map). The Phase II rapid assessment

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involves collection of data and field observations to verify Phase 1 stream geomorphic data on a reach specific basis. Stream geomorphic condition, physical habitat condition, adjustment processes, reach sensitivity and the stage of channel evolution are identified by data gathered from erosion and depositional characteristics, changes in channel and floodplain configuration, and fluctuating riparian land use/land cover. The Rapid Stream Assessment will result in each reach having field maps and photos demonstrating stream type, the geomorphic condition evaluation, and a stream habitat evaluation.

### **13.0 Assessment Methods**

Standard map and field survey work will be conducted to measure the parameters that define watershed and stream geomorphology for purposes of classification and assessment of channel condition, adjustment, and sensitivity. The work will be conducted by the Poultney-Mettowee NRC and Watershed Partnership staff, a professional contractor and trained volunteers under the supervision of VT River Management Program staff. The Project Manager and/or professional contractor will consult with the QA Officer and compile monitoring data into a database file for each reach assessed. A comprehensive list of the parameters and methods of assessment and survey are described in detail in the Stream Geomorphic Assessment Protocol Handbooks. Some reaches may require less detailed assessment, to be determined on a site or project-specific basis by the Project Manager.

### **14.0 Sample Handling and Custody Requirements**

There will be no samples to handle in this project; data forms will be completed on site and remain in custody of the Project Manager.

### **15.0 Analytical Methods**

GIS data entry and remote sensing analysis for the Phase I assessment will be conducted by the Project Manager in accordance with VT DEC protocols. Work will be conducted under guidance of the Project QA Officer. Standardized data entry QA sheets will be used when appropriate.

Data entry and analysis for the Phase II assessment will be performed following the completion of each reach survey by field personnel or the Project Manager following guidance of a standardized data entry QA/QC checklist (see Appendix C). Any errors or omissions will be corrected by the Project Manager in consultation with the leader of the survey team as needed, and noted on the checklist form. Any further problems will be reconciled with a field visit to verify the accuracy of the data.

Data analysis, calculations and analytical methods will be conducted as described in Assessment Handbooks (Phase 2, Steps 6 and 7; and Bridge and Culvert Assessments) and consist of database reporting of reach impact ratings, stream conditions, adjustment processes, stage of channel evolution and reach sensitivity. All prepared data presentation forms and graphs will be collated into a data file for each project or stream basin.

### **16.0 Quality Control Requirements**

Review of the worksheet and computer data entry will be conducted to ensure that:

1. Field data forms are being completely and correctly filled out,

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2. The precision requirements for all data is enforced,
3. The minimum number of observations for particle analyses is being met,
4. All office procedures are up-to-date and data is being entered into the database as specified,
5. All field equipment is checked and calibrated according to the specified procedures,
6. A logbook is maintained on problems encountered and corrective measures taken.

### **17.0 Instrument/Equipment Testing, Inspection and Maintenance**

Regular maintenance procedures will be conducted in accordance with assessment protocols listed above. For the Phase II analysis, regular maintenance procedures will be conducted in accordance with standard procedures provided by the instrument manufacturer and a log of regular maintenance will be kept. Spare parts for mechanical equipment will be kept readily available so there will be no interference with data collection in case of a mechanical breakdown. Electronic equipment will be serviced on a schedule recommended by the manufacturer. See Appendix B for calibration, maintenance and servicing logs.

### **18.0 Instrument Calibration and Frequency**

All survey equipment will be calibrated before each use following the calibration instructions provided by the manufacturer. A calibration log book will track calibration results and note when re-calibration is required.

### **19.0 Inspection and Acceptance Requirements for Supplies**

Data collection supplies are purchased from various manufacturers and distributors. Calibration and testing of equipment will be conducted by project field crews prior use.

### **20.0 Non-direct Measurements**

USGS topographic maps, Vermont aerial photographs, Vermont ortho-photographs, and historic survey data will be used as mentioned in Section 12.

### **21.0 Data Management**

Phase I and Phase II data will be entered into a data management system (DMS) designed to facilitate organization, reduction and efficient analysis of remote sensing and field data. For each study watershed, reach and site electronic and paper files containing raw data and documentation of reduction and analyses procedures will be retained. Other data will include digital photos and hard copies of original field data sheets.

## **22.0 Assessment and Response Action**

If the audit review outlined in Section 16 indicates that any of the QA/QC requirements are violated, corrective measures will be taken. The Project Manager, will then notify field and office personnel of any corrective action and changes in procedures and will document problems and corrective actions in the field logbook.

## **23.0 Report to Management**

Annual reports will be submitted from the Project Manager to the EPA Project Officer. During preparation of the project reports the following items will be given consideration and reported on:

1. Results from watershed and stream reach data collection,
2. Performance evaluation and system audit results,
3. Evaluation of data quality measurement trends, and
4. Identification of problems, needs, and recommendations for solutions.

## **24.0 Verification and Validation Requirements**

Data will be validated through completion of the data entry checklist (Appendix C). This process will provide data of known and documented quality. Complete data packets collected on VT DEC data sheets and field forms following VT DEC protocols will be accepted. Data packets that are incomplete or developed without strict adherence to the protocol will have a limited usability and will be qualified on the Quality Assurance Sheets (Appendix E) so as to describe the limitations.

## **25.0 Verification and Validation Procedures**

The Project QA Officer will be notified when collection of preliminary field data begins and invited to join team members in the field. Data will be entered into the DMS following the completion of each reach assessment by field personnel or the Project Manager and reviewed by the QA Officer following guidance of a standardized data entry QA/QC checklist (see Appendix D). Any errors will be corrected by the Project Manager in consultation with the leader of the survey team as needed, and noted on the checklist form. Any further problems will be reconciled with a field visit to verify the accuracy of the data.

## **26.0 Reconciliation with Data Quality Objectives.**

Complete data packets collected using VT DEC data sheets and field forms, following VT DEC protocols will meet performance criteria. Data packets qualified as incomplete or generated without adherence to the stream geomorphic assessment protocol will be qualified so as to describe their deficiency and used accordingly (see Quality Assurance Sheets in Appendix E).

# Appendices

**Appendix A:** Mettowee River Phase I and Phase II extent maps and reach break delineations

**Appendix B:** VT River Management Program Field Sampling Equipment Calibration and Maintenance Schedule and Records

**Appendix C:** QA/QC Stream Geomorphic Assessment; Data Entry, Reduction and Analysis Checklist

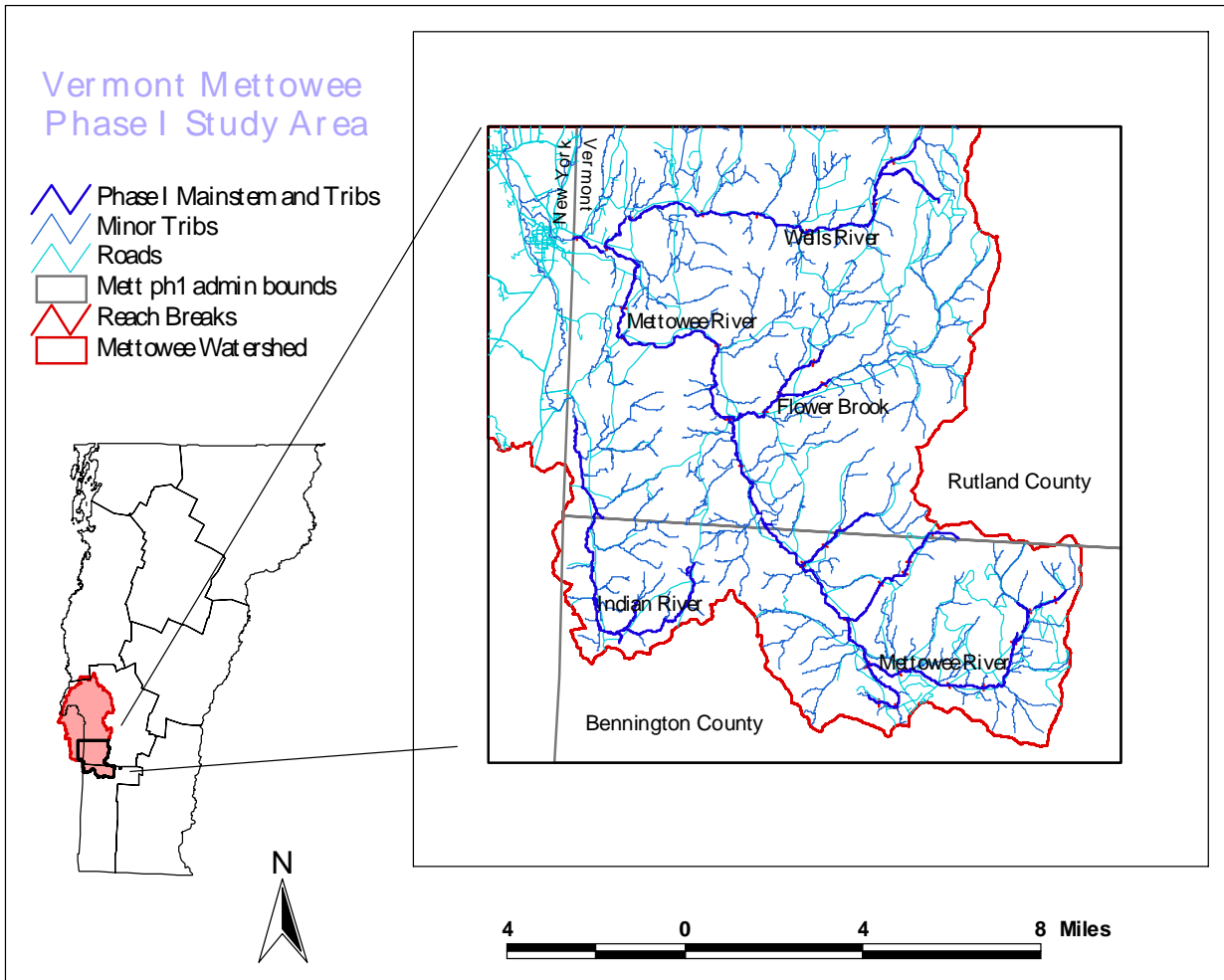
**Appendix D:** VT River Management Program Internal Q/A Audit Form for Stream Geomorphic Assessment

**Appendix E:** Maps, Sketch & Photo Documentation, Data Sheets, Field Forms, and Quality Assurance Sheets

**Appendix F:** Data Management System Instructions (*Email Attachment*)

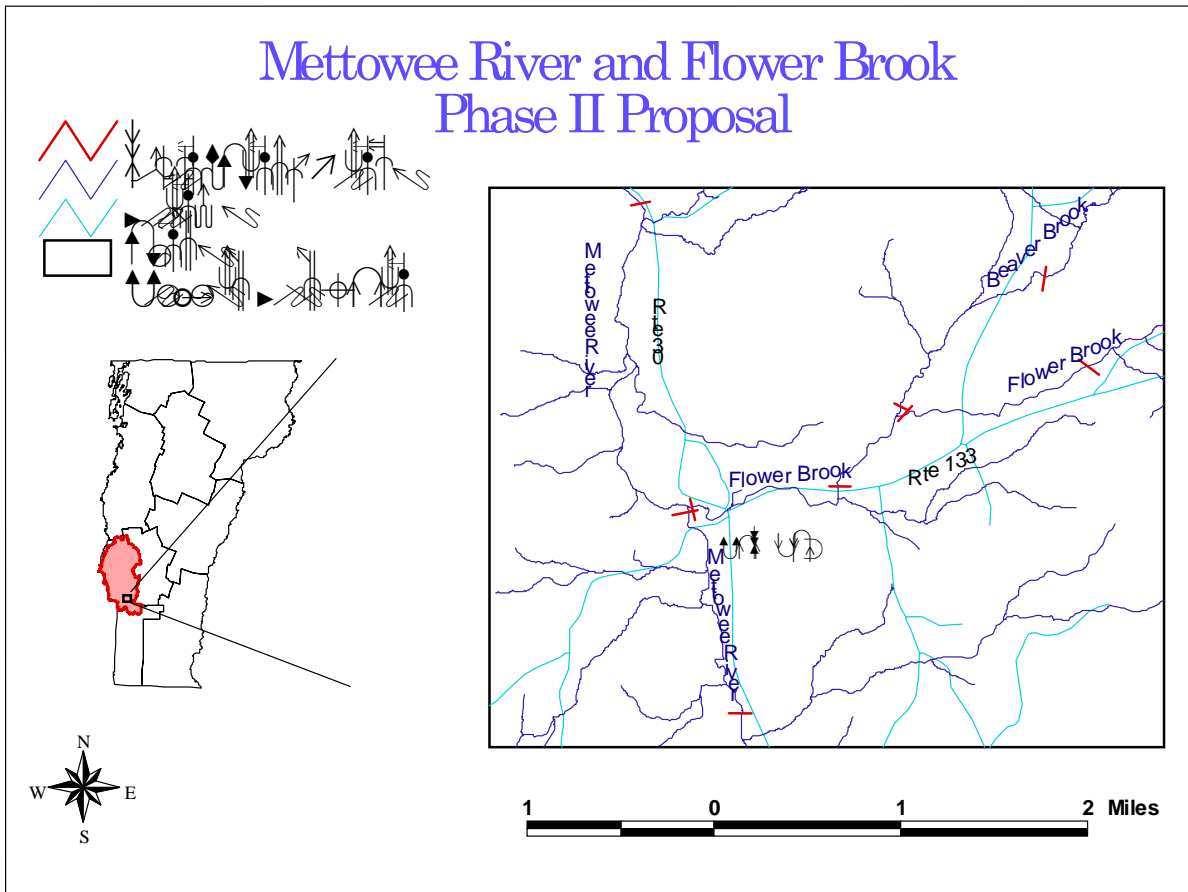
# Appendix A

Map A-1: Vermont Mettowee Phase I Study Area



Created by Hilary Solomon November, 2004

Map A-2: Mettowie Phase II Study Area

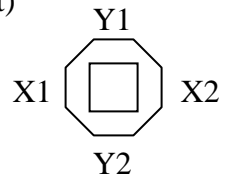


**Appendix B**  
**VT River Management Program**  
**Field Sampling Equipment**  
**Calibration and Maintenance Schedule and Records**

**Table 1. Laser Level Calibration**

Date	Operator Name	(X1)+(X2) <sup>1</sup>	(Y1)+(Y2)	Allowable <sup>2</sup> Horizontal Error	Recalibration (Y / N)

1. The difference in elevations shot at 100 ft with the laser level facing the laser eye receiver from either side of the X and Y-axes. Diagram (to the right) is looking at the laser level from the top.
2. If the X1-X2 or Y1-Y2 is greater than 0.1 inch then instrument recalibration is necessary. (Reference: Operator's Manual for the Laserplane Leveling System, Spectra Precision Company, Dayton Ohio)



**Table 2. Regular Maintenance**

		Maintenance Activity				
Date	Name	Laser cleaned (list serial #)	Laser Receiver cleaned (list serial #)	General tripod maintenance	Lenker rod cleaned (list rod #)	Lenker rod part replacement (list rod and part #)

**Table 3. Electronic Equipment Servicing Record**

Date	Equipment Name and Serial #	Servicing Company	Invoice no. and date

**Appendix C**  
**QA/QC**  
**Stream Geomorphic Assessment**  
**Data Entry Reduction and Analysis Checklist**

Name of Data Manager: \_\_\_\_\_ Site ID: \_\_\_\_\_  
Date of Data Collection: \_\_\_\_\_ Stream Name: \_\_\_\_\_  
Date of Entry into Database: \_\_\_\_\_ Type of Data: \_\_\_\_\_

1. Review calibration and maintenance logs equipment for problems encountered during the survey. Verify that corrective action was taken and that any data that may have been affected by the problem was validated.

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Review calculations for allowable survey error. Record allowable survey error and measured error from the survey closeout. If measured error is greater than allowable error the data cannot be accepted. Reference provided below.

allowable error: \_\_\_\_\_  
measured error: \_\_\_\_\_

Equation to estimate allowable error in survey closure: $0.007 (\text{total distance}/100)^{0.5}$
--

2. Circle any particle count transects that do not meet the minimum number of observation criteria in red ink.
3. Circle any omissions on field data forms in red ink, if the omitted values can be determined enter the values in green ink.
4. Circle any illegible field data with green ink. Once data in question has been verified enter data.
5. Highlight data that is not recorded to the required precision.

**Survey Closure Error Reference:** Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An illustrated Guide to Field Technique. General Technical Report RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

**Appendix D**  
**VT River Management Program**  
**Internal Q/A Audit Form for**  
**Stream Geomorphic Assessment**

Name of Auditor(s): \_\_\_\_\_ Date of Audit: \_\_\_\_\_

Stream Name: \_\_\_\_\_

Date of Data Collection: \_\_\_\_\_

Date of Entry into Database: \_\_\_\_\_

1. Identify and describe any omissions on the field forms that were not identified during the data entry process.

\_\_\_\_\_  
\_\_\_\_\_

2. Identify any failures to meet degree of precision required that were not identified during the data entry process.

\_\_\_\_\_  
\_\_\_\_\_

3. Identify any legibility issues that could have resulted in misreading of data during data entry prohibit recovery of field data in the event of lost electronic files.

\_\_\_\_\_  
\_\_\_\_\_

4. Identify any unclosed surveys or surveys that did not meet allowable survey error criteria.

\_\_\_\_\_  
\_\_\_\_\_

5. According to Equipment calibration and maintenance logbook, has field equipment been checked and calibrated according to the specified procedures and maintenance schedules?

\_\_\_\_\_  
\_\_\_\_\_

6. Is there documented corrective action for any problems encountered during equipment checks? \_\_\_\_\_

\_\_\_\_\_

7. Record any other omissions in the reviewed data entry QA/QC checklists.

\_\_\_\_\_  
\_\_\_\_\_

## **Appendix E: Map, Sketch & Photo Documentation, Data Sheets and Field Forms**

Sketch Form for Sites – Segments – Reaches

Photo Logs

Field Notes Form for Steps 1 - 5

Cross-Section Worksheet

Field Quick Refer Tables

Rapid Habitat Assessment (RHA)

Rapid Geomorphic Assessment (RGA)

Quality Assurance Data Sheet

## Sketch Form for Sites – Segments – Reaches

Stream Name: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 \_\_\_\_\_  
 Observers: \_\_\_\_\_  
 Organization /Agency: \_\_\_\_\_

Segment or Site ID: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Town: \_\_\_\_\_  
 Elevation: \_\_\_\_\_ Ft.

**Site Sketch** - see reverse side for sketch codes and tally columns for left and right bank erosion, revetments, and corridor developments and calculating the total length of the segment affected by beaver flowages.

Scale: \_\_\_\_\_

**Height of bankfull features above water surface (Ft.)**

\_\_\_\_\_

\_\_\_\_\_

••   ••   ••••••••   •   •   •   •

Selected BKF Height

•   •   •

**LWD tally** \_\_\_\_\_  
**Debris Jams** \_\_\_\_\_  
**Stormwater** \_\_\_\_\_  
**Constrictions** \_\_\_\_\_  
 •• culverts, bridges, old footings, bedrock •





# Rapid Stream Assessment Field Notes

Stream Name: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 Observers: \_\_\_\_\_  
 Organization /Agency: \_\_\_\_\_  
 USGS Map Name(s): \_\_\_\_\_  
 Weather: \_\_\_\_\_  
 Rain Storm within past 7 days: Y / N     Flood history known

Segment I.D.: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Town: \_\_\_\_\_  
 Elevation: \_\_\_\_\_ ft.  
 Latitude (N/S): \_\_\_\_\_  
 Longitude (E/W): \_\_\_\_\_  
 Drainage Area: \_\_\_\_\_ sq. mi.  
 Segment Length: \_\_\_\_\_ ft.

## 1. Valley and River Corridor

**1.1 Watershed Zone:** Source / Transfer / Response

**1.2 Alluvial Fan:** Yes / No

1.3 River Corridor Encroachments	Corridor Length		1.4 Adjacent Side Slopes				Total Height (0.0 ft)	Height Above Water Surface (0.0 ft)	Photos taken? Y/N	GPS Y/N
	Left	Right	Left Corridor		Right Corridor					
Berms			x-steep	steep	x-steep	steep				
Roads			moderate	gentle	moderate	gentle				
Railroads			Continuous w/bank	A / S / N	Continuous w/bank	A / S / N				
Improved Paths			Within 1x Wbkf	A / S / N	Within 1x Wbkf	A / S / N				
Development			<u>Texture of Exposed Slope</u>		<u>Texture of Exposed Slope</u>					
			till	boulder/cobble	gravel	sand				
			silt	clay	bedrock	other	NE			

1.5 Confinement <i>Valley width / Channel width</i>	1.6 Grade Controls (circle one)					Fill out height fields for grade control with greatest total height →	Total Height (0.0 ft)	Height Above Water Surface (0.0 ft)	Photos taken? Y/N	GPS Y/N
Valley Width: <input type="checkbox"/> Gorge	Location in Reach (record locations on field map)									
Narrowly Confined (1-2)	<b>Waterfall</b>	upstream	downstream	both	none					
Semi-confined (>2-4)	<b>Ledge</b>	upstream	downstream	both	none					
Narrow (>4-6)	<b>Dam</b>	upstream	downstream	both	none					
Broad (>6-10)	<b>Weir</b>	upstream	downstream	both	none					
Very Broad (>10)	<b>Culverts</b>	upstream	downstream	both	none					

## 2. Stream Channel

**2.1 Bankfull Width:** \_\_\_\_\_ ft.    **2.2 Max. Bankfull Depth:** \_\_\_\_\_ ft.    **2.3 Mean Bankfull Depth:** \_\_\_\_\_ ft.

**2.4 Floodprone Width:** \_\_\_\_\_ ft.    **2.5 Low Bank Height:** \_\_\_\_\_ ft.    **2.6 Ratio W/d<sub>mean</sub>:** \_\_\_\_\_

**2.7 Entrenchment:** \_\_\_\_\_    **2.8 Incision Ratio:** \_\_\_\_\_    **2.9 Sinuosity:** \_\_\_\_\_

**2.10 Riffles/Steps:** complete / partial / diagonal / continuous / NA    **2.11 Riffle/Step Spacing:** \_\_\_\_\_ ft.

**2.12 Bed Substrate Composition (percent):**

1 Bedrock	2 Boulder >10 in >256 mm	3 Cobble 2.5 - 10 in 64 - 256 mm	4 Gravel Fine 0.1-0.6in 2-16 mm    Coarse 0.6-2.5in 16-64 mm		5 Sand < 0.1 in < 2 mm	% Detritus	Large Woody Debris (# pieces)	Silt or Clay (present)	2.13 Avg. Size of Largest Particles on:  Bed:            Bar: circle: inches or millimeters

**2.14 Stream Type:** A G F B E C D 1 2 3 4 5 a b c  
 Cascade    Step-Pool    Plane Bed    Riffle-Pool    Ripple-Dune    Braided

Stream Type

### 3. Riparian Banks, Buffers and Corridors

3.1	<b>Typical Bank Slope</b>	shallow   moderate   steep   undercut <b>(evaluate on the higher of the two banks)</b>						
<b>Bank Texture</b>	<b>Lower</b>	bedrock	boulder/cobble	gravel	sand	silt/clay	mix	cohesive / non-cohesive
	<b>Upper</b>	bedrock	boulder/cobble	gravel	sand	silt/clay	mix	cohesive / non-cohesive
<b>Bank Erosion</b>	<b>Left</b>	<b>Length:</b>	ft.	<b>Height:</b>	ft.	<b>Bank Revetment Type:</b>		<b>Length:</b> ft.
	<b>Right</b>	<b>Length:</b>	ft.	<b>Height:</b>	ft.	<b>Bank Revetment Type:</b>		<b>Length:</b> ft.
<b>Near Bank Veg. Type</b>	<b>Left</b>	coniferous / deciduous / shrubs-sapling / herbaceous / lawn / pasture / bare / invasives						
	<b>Right</b>	coniferous / deciduous / shrubs-sapling / herbaceous / lawn / pasture / bare / invasives						
<b>Bank Canopy</b>	<b>Left</b>	76 - 100%	51 - 75%	26 - 50%	1 - 25%	0%	<b>Channel Canopy</b> Open   Closed	
	<b>Right</b>	76 - 100%	51 - 75%	26 - 50%	1 - 25%	0%		
3.2	<b>Buffer Width</b>	<b>Left</b>	< 5 ft.	5 – 25 ft.	26 – 50 ft.	51 – 100 ft.	> 100 ft.	
	<b>Right</b>	< 5 ft.	5 – 25 ft.	26 – 50 ft.	51 – 100 ft.	> 100 ft.		
<b>Buffer Veg. Type</b>	<b>Left</b>	coniferous	deciduous	mixed trees	shrubs-sapling	herbaceous	invasives	
	<b>Right</b>	coniferous	deciduous	mixed trees	shrubs-sapling	herbaceous	invasives	
3.3	<b>Riparian Corridor</b>	<b>Left</b>	forest	shrub-sapling	crop / pasture / hay	commercial / industrial	residential	bare
	<b>Right</b>	forest	shrub-sapling	crop / pasture / hay	commercial / industrial	residential	bare	
								<b>Mass Failures:</b> _____ (ft) avg. height One / Multiple / None

### 4. Flow & Flow Modifiers

- 4.1 Springs or Seeps: abund. / some / none    4.2 Adjacent Wetlands: abund. / some / none    4.3 Flow status: low / mod / high
- 4.4 Current Debris Jams: # \_\_\_\_\_    4.5 Impoundments: small / large / none / unknown     in reach  upstream
- 4.6 Stormwater Inputs: # \_\_\_\_\_    4.7 Flow Regulation: r-o-r dam / store-release dam / diversion / none / unknown
- 4.8 Channel Constrictions: # \_\_\_\_\_    instream culverts / bridges / old abutments / bedrock outcrops / other / none
- Problems: dep. above / dep. below / scour below / alignment / none    **Floodprone Constriction:** Yes / No
- 4.9 Beaver Dams: # \_\_\_\_\_    \_\_\_\_\_ ft. of the segment affected.     Bridge & Culvert Assessments

### 5. Channel Bed and Planform Changes

- 5.1 Bed Sediment Storage - Bar Types (circle all that apply): mid   point   side   diagonal   delta   island   none
- 5.2 Flood Chutes: Yes / No    Neck Cut-offs: Yes / No    Channel Avulsions: Yes / No    Braiding: Yes / No
- 5.3 Steep Riffles: Yes / No    Head Cuts: Yes / No    5.4 Stream Ford or Animal Crossing: Yes / No
- 5.5 Channel Alterations (circle all that apply): dredging   straightening   bar scalping   gravel mining   none

Comments:



## Step 1: Valley and Floodplain Corridor – Quick Refer Menus and Tables

### 1.1 WATERSHED ZONE

<b>Source</b>	Confined headwater streams with steep slopes, large bed materials, and no storage of alluvium (high transport streams).
<b>Transfer</b>	Transition area between transport and depositional process streams.
<b>Response</b>	Unconfined valley streams with shallow slopes, small bed materials, and depositional with large quantities of stored alluvium.
<b>Unknown</b>	Unknown which watershed zone would best describe the reach.

### 1.2 ALLUVIAL FAN

<b>Yes</b>	Segment or reach on alluvial fan.
<b>No</b>	Segment or reach not on alluvial fan.
<b>Unknown</b>	Unknown whether the segment is located on an alluvial fan.

### 1.3 CORRIDOR ENCROACHMENTS

<b>Yes</b>	Encroachment within a distance of 2 times bankfull channel width or 100', whichever is greater, measured from top of bank out into floodplain.
<b>No</b>	Encroachment <u>not</u> within a distance of 2 times bankfull channel width or 100', whichever is greater, measured from top of bank out into floodplain.

### 1.4 ADJACENT SIDE SLOPE

<b>X-Steep</b>	<b>Steep</b>	<b>Moderate</b>	<b>Shallow</b>
<b>Continuous</b>	<b>Within 1 Bankfull Width</b>		

**Slope Texture**

<b>Bedrock</b>	<b>Boulder</b>	<b>Cobble</b>	<b>Gravel</b>	<b>Sand</b>
<b>Silt /Clay</b>	<b>Mixed Texture</b>		<b>Other</b>	<b>Not Evaluated (NE)</b>

### 1.5 CONFINEMENT

Valley Description	Valley Width / Channel Width Ratio
<b>Narrowly Confined</b>	• 1 and < 2
<b>Semi Confined</b>	• 2 and < 4
<b>Narrow</b>	• 4 and < 6
<b>Broad</b>	• 6 and < 10
<b>Very Broad</b>	• 10 with abandoned terraces on one or both sides

### 1.6 GRADE CONTROLS

<b>Waterfalls</b>	Bedrock that extends across the channel and forms a vertical, or near vertical, drop in the channel bed, usually $\geq$ 2 feet high.
<b>Ledge</b>	Bedrock that extends across the channel and forms no noticeable drop in the channel bed, or only a gradual drop in the channel bed, usually < 2' high.
<b>Dams</b>	High cross-channel structures.
<b>Weirs</b>	Low cross-channel structures.
<b>Culverts</b>	Instream culverts (see discussion on culverts below).

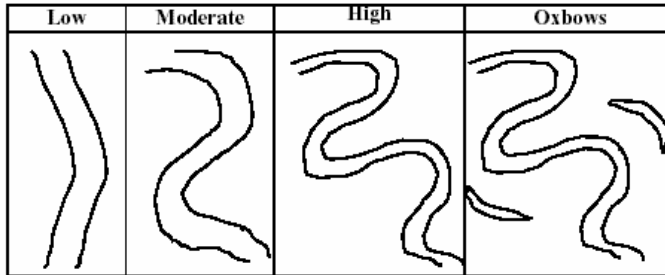
### 1.6 Grade Control Locations

<b>Upstream</b>	Grade control of this type located at/near upstream end of segment/reach
<b>Downstream</b>	Grade control of this type located at/near downstream end of segment/reach
<b>Both</b>	Grade controls of this type located at/near both ends of segment/reach
<b>None</b>	No grade controls of this type present in reach

## Step 2: Stream Channel – Quick Refer Menus and Tables

- 2.6 WIDTH / DEPTH RATIO:** Divide the bankfull width (2.1) by the mean depth (2.3)  
**2.7 ENTRENCHMENT RATIO:** Divide flood-prone width (2.4) by the bankfull width (2.1)  
**2.8 INCISION RATIO:** Divide the low bank height (2.5) by the bankfull maximum depth (2.2)

### 2.9 SINUOSITY



### 2.10 RIFFLES/STEPS

<b>Complete</b>	Riffles or steps completely cross the channel and are perpendicular, or nearly so, to the channel banks
<b>Partial</b>	Riffles/steps do not completely cross the channel
<b>Diagonal</b>	Riffles/steps cross the channel at a sharp (transverse) angle in relation to the channel banks
<b>Continuous</b>	Riffles/steps are continuous
<b>None</b>	Runs only, riffles/steps washed out or not present (applicable to ripple dune and plane bed streambed types)

### 2.11 Riffle / Step Spacing

Stream Type	Spacing
Cascade / Step-pool	A 1-3 times $W_{bkf}$
Step / Riffle-pool	B 3-5 times $W_{bkf}$
Riffle-pool	C & E 5-7 times $W_{bkf}$
Plane bed / Ripple-dune	any Riffles and steps are not present

### 2.12 BED SUBSTRATE COMPOSITION

Size Class	Millimeters	Inches	Relative Size
<b>1-Bedrock</b>	> 4096	> 160	Bigger than a Volkswagen Bug
<b>2-Boulder</b>	256 – 4096	10.1 - 160	Basketball to Volkswagen Bug
<b>3-Cobble</b>	64 – 256	2.5 - 10.1	Tennis ball to basketball
<b>4-Gravel</b>	2 – 64	0.1 – 2.5	Pepper corn to tennis ball
<b>5-Sand</b>	0.062 – 2.00	0.002 -0.1	Smaller than a pepper corn

### 2.14 STREAM TYPE

Stream Type	(1) Entrenchment (+ or - 0.2)	(2) Width/depth (+ or - 2)	(3) Sinuosity (+ or - 0.2)	(4) Slope % (See Note)
<b>A – Single Thread</b>	<1.4 - Entrenched	<12 - Low	<1.2 - Low	<b>4-10</b>
<b>G – Single Thread</b>	<1.4 - Entrenched	<12 - Low	>1.2 - Low to Mod.	<b>2-4</b>
<b>F – Single Thread</b>	<1.4 - Entrenched	>12 - Mod. to High	>1.2 - Low to Mod.	<b>&lt;4</b>
<b>B – Single Thread</b>	1.4 -2.2 - Moderately Entrenched	>12 - Moderate	>1.2 - Low to Mod.	<b>2-4</b>
<b>E – Single Thread</b>	>2.2 - Slightly Entrenched	<12 - Very Low	>1.5 - Very High	<b>&lt;2</b>
<b>C – Single Thread</b>	>2.2 - Slightly Entrenched	>12 - Mod. to High	>1.2 - Moderate	<b>&lt;2</b>
<b>D – Multiple Thread</b>		>40 - Very high	<1.2 - Low	<b>&lt;4</b>

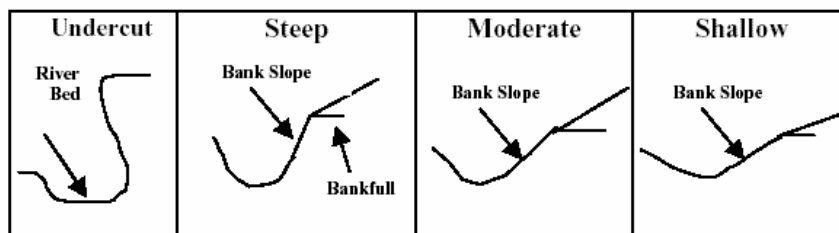
Slope Subscript	Slope %
a	4-10
b	2-4
c	<2

<b>Cascade</b>	Generally occur in very steep channels, narrowly confined by valley walls. Characterized by longitudinally and laterally disorganized bed materials, typically bedrock, boulders, and cobbles. Small, partial channel-spanning pools spaced < 1 channel width apart common.
<b>Step-Pool</b>	Often associated with steep channels, low width/depth ratios and confining valleys. Characterized by longitudinal steps formed by large particles (boulder/cobbles) organized into discrete channel-spanning accumulations that separate pools, which contain smaller sized materials. Step-pool systems exhibit pool spacing of 1 to 4 channel widths.
<b>Plane Bed</b>	Occur in moderate to high gradient and relatively straight channels, have low width/depth ratios, and may be either unconfined or confined by valley walls. Composed of sand to small boulder-sized particles, but dominated by gravel and cobble substrates. Channel lacks discrete bed features (such as pools, riffles, and point bars) and may have long stretches of featureless bed.
<b>Riffle-Pool</b>	Occur in moderate to low gradient and moderately sinuous channels, generally in unconfined valleys, and has well-established floodplain. Channel has undulating bed that defines a sequence of bars, pools, and riffles. Pools spaced every 5 to 7 channel widths in a self-formed (alluvial) riffle-pool channel.
<b>Dune-Ripple</b>	Usually associated with low gradient and highly sinuous channels. Dominated by sand-sized substrates. Channel may exhibit point bars or other bedforms forced by channel geometry. Typically undulating bed does not establish distinct pools and riffles.
<b>Bedrock</b>	Lack a continuous alluvial bed. Some alluvial material may be temporarily stored in scour holes, or behind obstructions. Often confined by valley walls.
<b>Braided</b>	Multiple channel system found on steep depositional fans and deltas. Channel gradient is generally the same as the valley slope. Ongoing deposition leads to high bank erosion rates. Bed features result from the convergence/divergence process of local bed scour and sediment deposition. Unvegetated islands may shift position frequently during runoff events. High bankfull widths and very low meander (belt) widths.

### Step 3: Riparian Banks, Buffers and Corridors – Quick Refer Menus and Tables

#### 3.1 TYPICAL BANK SLOPE

<b>Undercut</b>	upper bank overhanging the streambed
<b>Shallow</b>	bank slope (<30%)
<b>Moderate</b>	bank slope (31-50%)
<b>Steep</b>	bank slope (>51%)



#### 3.1 BANK REVETMENTS

<b>Rip-rap</b>	Blanket of rock covering the bank, usually large angular boulders
<b>Walls</b>	Walls of large rocks, concrete blocks or rectangular gabion wire baskets (filled with stone) lining banks e.g.: tree revetments or vanes intended to stop the lateral erosion of the stream channel
<b>Other</b>	
<b>None</b>	No bank revetments observed

#### 3.1 LOWER & UPPER BANK TEXTURE

<b>Bedrock</b>	Very resistant to erosion
<b>Boulder/Cobble</b>	(boulders > 10 inches / cobbles 2.5 to 10 inches) Moderately resistant to erosion
<b>Gravel</b>	(0.1 to 2.5 inches) Moderate to high bank erodibility when present as dominant component or as part of the bank materials
<b>Sand</b>	High bank erodibility when present as dominant component or as part of the bank materials
<b>Silt/Clay</b>	Non-cohesive silt has very high / extreme bank erodibility; while cohesive clays are relatively resistant to erosion
<b>Mix</b>	Variety of particle sizes present from very small to very large. Glacial till may be an example of mixed bank materials (Figure 3.3)

#### 3.2 BUFFER WIDTH

< 5 ft
5 – 25 ft.
26 – 50 ft.
51 – 100 ft
> 100 ft

#### 3.1 BANK VEGETATION TYPE

<b>Coniferous</b>	Trees that keep their leaves year round i.e. pine, cedar, hemlock
<b>Deciduous</b>	Trees that lose their leaves seasonally i.e. elm, butternut, maple, oak
<b>Shrubs-saplings</b>	Small trees, saplings, and brush species, such as alder, willows, sumac, and dogwood
<b>Herbaceous</b>	Native grasses, rushes and sedges, & plants such as asters, goldenrod
<b>Lawn</b>	Mowed lawn
<b>Pasture</b>	Land managed for grazing livestock
<b>Bare</b>	Bare soil, no or very sparse vegetation. This does not pertain to unvegetated features such as point-bars, mid-channel bars or shoals.
<b>Invasives</b>	Non-native invasive plant species: Phragmites, Japanese knotweed, Purple loosestrife, Honeysuckle (note there are native honeysuckles too)

#### 3.2 BUFFER VEGETATION TYPE

<b>Coniferous</b>	Trees that keep their leaves year round. i.e. pine, cedar, hemlock
<b>Deciduous</b>	Trees that lose their leaves seasonally. i.e. elm, butternut, maple, oak
<b>Mixed Trees</b>	A fairly even mix of conifers and deciduous trees
<b>Shrubs-Saplings</b>	Small trees, saplings, and brush species, such as alder, willows, sumac, and dogwood
<b>Herbaceous</b>	Native grasses, rushes and sedges, & plants such as asters, goldenrod
<b>Invasives</b>	Non-native invasive plant species: Phragmites, Japanese knotweed, Purple loosestrife, Honeysuckle (note there are native honeysuckles too)

#### 3.1 BANK CANOPY

<b>76 – 100 %</b>	canopy over stream channel
<b>51 – 75%</b>	canopy over stream channel
<b>26 – 50%</b>	canopy over stream channel
<b>1 – 25 %</b>	canopy over stream channel
<b>0 %</b>	no canopy over stream channel

#### 3.3 RIPARIAN CORRIDOR

<b>Forest</b>	Woodlands of deciduous or coniferous trees
<b>Shrub-sapling</b>	Fallow field or wetland
<b>Crop</b>	Agricultural lands planted in row crops, mowed as a hay field, or pastured with livestock. Circle the appropriate type of agriculture.
<b>Pasture</b>	
<b>Hay</b>	
<b>Commercial</b>	Retail businesses with land developed for buildings, roads, and parking areas
<b>Industrial</b>	
<b>Residential</b>	Land developed with houses, lawns, and driveways
<b>Bare</b>	Bare soil, no or very sparse vegetation. Pertains to gravel pits, construction sites, and similar bare ground

## Step 4: Flow Modifiers – Quick Refer Menus and Tables

### 4.1 SPRING, SEEPS AND TRIBUTARIES

<b>Abundant</b>	Numerous small tributaries, springs and/or seeps entering the segment (reach)
<b>Some</b>	Infrequent small tributaries, springs and/or seeps entering the segment (reach)
<b>None</b>	No small tributaries, springs and/or seeps observed entering the segment (reach)

### 4.2 ADJACENT WETLAND

<b>Abundant</b>	Extensive wetlands present along stream site.
<b>Some</b>	Wetlands present but to small extent along stream segment (reach)
<b>None</b>	No wetlands observed along stream segment (reach)

### 4.3 STAGE

<b>Low</b>	Flow in channel low due to drought conditions
<b>Moderate</b>	Flow in channel is typical summer flows
<b>High</b>	Flow in channel is high as a result of flooding

### 4.5 UPSTREAM IMPOUNDMENT

<b>Small</b>	Impoundment created by the dam is not much wider than the river itself.
<b>Large</b>	Impoundment is a reservoir of water that is significantly wider than the river. A large volume of water and sediment may be stored above the dam.
<b>None</b>	No impoundments in the reach or in upstream reaches
<b>Unknown</b>	Presence of dams or impoundments on the main stem or major tributaries upstream is unknown

### 4.7 FLOW REGULATION

<b>Run-of-river dam</b>	Upstream flows are impounded. Flow quantity spilling or released below the dam is the same as flow quantity entering the impoundment at all times.
<b>Store-release dam</b>	Upstream flows are impounded. Flow quantity released below the dam is significantly higher or lower at times than the flow quantity entering the impoundment.
<b>Diversion</b>	Flows are significantly decreased due to flow diversion which bypasses the reach.
<b>None</b>	No upstream flow regulations
<b>Unknown</b>	Impoundment and/or significant decreases in flow at upstream regulations or withdrawal structures is unknown

### 4.8 Channel Constrictions

<b>Instream culverts</b>	Structures under a transportation route through which the stream flows
<b>Bridges</b>	Structures under a transportation route under which the stream flows
<b>Old abutments</b>	Bridge abutments that no longer have a travel deck between them.
<b>Bedrock outcrops</b>	Bedrock outcrops on both the right and left banks between which the stream flows
<b>Other</b>	Other built structures that constrict the channel, for instance rock rip-rap or gabions on both banks that constrict flood flows
<b>None</b>	No structures or features exist within the segment (or reach) that constricts the bankfull or floodprone widths or flows

## Step 5: Channel Bed and Planform Changes – Quick Refer Menus and Tables

### 5.1 BED SEDIMENT STORAGE AND BAR TYPES

<b>Mid-Channel</b>	Sediment deposits in the middle of the channel with split flow
<b>Point</b>	Unvegetated sediment deposits located on inside of channel meander bend
<b>Side (Lateral)</b>	Unvegetated sediment deposits located along the margins of the channel in locations other than the inside of channel meander bends
<b>Diagonal</b>	Bars that cross the channel at sharp oblique angles, associated with transverse riffles
<b>Delta</b>	Sediment deposits where tributary enters the mainstem.
<b>Islands</b>	Well vegetated mid-channel deposits of sediment
<b>None</b>	No deposits of sediment evident.

### 5.2 FLOOD CHUTES, NECK CUT OFFS, CHANNEL AVULSIONS, AND BRAIDING

<b>Yes</b>	Flood chutes, neck cut-offs, channel avulsions, or braiding present within the stream segment.
<b>No</b>	Flood chutes, cut-offs, channel avulsions, or braiding not present within the segment.

### 5.3 STEEP RIFFLES OR HEADCUTS

<b>Yes</b>	Headcuts and/or steep riffles present within the stream segment
<b>No</b>	Headcuts and/or steep riffles not present within the stream segment

## Step 5: Channel Bed and Planform Changes (con't)– Quick Refer Menus and Tables

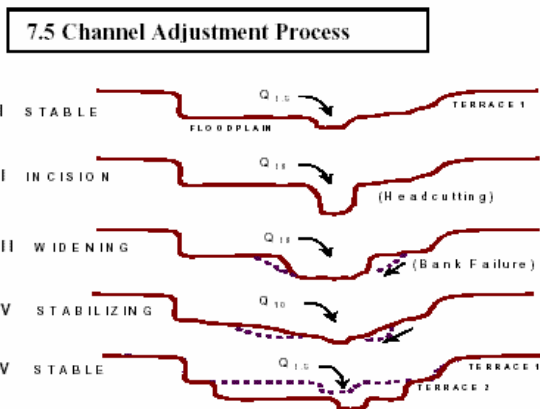
### 5.4: CHANNEL ALTERATIONS

<b>Dredging</b>	Evidence of removal of sediments and other material from the channel.
<b>Straightening</b>	Evidence that there has been the removal of meander bends. Historically done in towns and along roadways, railroads, and agricultural fields.
<b>Bar scalping / gravel mining</b>	Bar scalping: gravel has been removed from the top of bars. Gravel mining: gravel has been removed from bars or bed of river.
<b>None</b>	No evidence that any channel alterations have been done

### 5.5 STREAM FORD OR ANIMAL CROSSING

<b>Yes</b>	A vehicle or animal crossing is evident at the stream site.
<b>No</b>	A vehicle or animal crossing is not evident at the stream site.

## Step 7: Rapid Geomorphic Assessment - Quick Refer Menus and Tables



- D) In regime, reference to good condition, insignificant to minimal adjustment.
- II) Fair to poor condition, major to extreme channel degradation
- III) Fair to poor condition, major to extreme widening and aggradation
- IV) Fair to good condition, major reducing to minor aggradation, widening, and planform adjustments
- V) In regime, reference to good condition, insignificant to minimal adjustment.

Schumm Channel Evolution Model – See Appendix C for Vermont modified versions

### 7.6 Stream Condition

<b>0.85 – 1.0</b>	Reference Condition
<b>0.65 – 0.84</b>	Good Condition
<b>0.35 – 0.64</b>	Fair Condition
<b>0.00 – 0.34</b>	Poor Condition

### 7.7 Phase 2 Stream Sensitivity Ratings

Existing Stream Type	In regime – Reference or good condition	Major Adjustment – Fair Condition	Stream Type Departure or Poor Condition
<b>A1, A2, B1, B2, G1</b>	Very Low	Very Low	Low
<b>B3</b>	Very Low	Low	Moderate
<b>C1, C2, F1, F2</b>	Low	Moderate	High
<b>G2</b>	Low	Moderate	High
<b>B4, B5</b>	Moderate	High	High
<b>C3, E3</b>	Moderate	High	High
<b>C4, C5, E4, E5</b>	High	Very High	Very High
<b>A3, A4, A5, G3, G4, G5</b>	High	Very High	Extreme
<b>F3, F4, F5</b>	Very High	Very High	Extreme
<b>D3, D4, D5</b>	Extreme	Extreme	Extreme

**6a. VT RAPID HABITAT ASSESSMENT FIELD FORM—HIGH GRADIENT STREAMS**

Stream Name: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 \_\_\_\_\_  
 Observers: \_\_\_\_\_  
 Organization /Agency: \_\_\_\_\_  
 USGS Map Name(s): \_\_\_\_\_  
 Weather: \_\_\_\_\_  
 Rain Storm within past 7 days: Y / N

Segment I.D.: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Town: \_\_\_\_\_  
 Elevation: \_\_\_\_\_ ft.  
 Latitude (N/S): \_\_\_\_\_  
 Longitude (E/W): \_\_\_\_\_  
 Drainage Area: \_\_\_\_\_ sq. mi.  
 Segment Length: \_\_\_\_\_ ft.

Habitat Parameter	Condition Category			
	Reference	Good	Fair	Poor
<b>6.1 Epifaunal Substrate and Available Cover</b>	Greater than 70% of stream bed and lower banks covered with <b>mix</b> of substrates favorable for epifaunal colonization and fish cover; substrates include snags, submerged logs, undercut banks, and unembedded cobbles and boulders.	40-70% of stream bed and lower banks covered with a <b>mix</b> of substrates favorable for epifaunal colonization and fish cover	20-40% of stream bed and lower banks covered with substrates favorable for epifaunal colonization and fish cover; few substrate types present	Less than 20% of stream bed and lower banks covered with substrates favorable for epifaunal colonization and fish cover; few substrate types present
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.2a Embeddedness</b>	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.3a Velocity/Depth Patterns</b>	All four velocity/depth patterns present (slow-deep, slow-shallow, fast-deep, fast-shallow). Slow is < 1 ft/s (0.3 m/s), deep is > 1.5 ft (0.5 m).	Only 3 of the 4 patterns present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat patterns present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth pattern (usually slow-deep).
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.4 Sediment Deposition</b>	Little or no enlargement of islands or point bars and < 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; > 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.5 Channel Flow Status</b>	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.6 Channel Alteration</b>	Channelization in the form of dredging, straightening, berms or streambank armoring is absent or minimal; stream with normal pattern.	Some channelization present along 10-20% of segment, usually in areas of bridge abutments; evidence of past channelization, (greater than past 20 yr) may be present, but recent channelization not present.	Channelization along 20-80% of stream segment ; riprap or armoring present on both banks.	Over 80% of the stream segment channelized and disrupted. Instream habitat greatly altered or removed entirely.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	Condition Category			
	Reference	Good	Fair	Poor
<b>6.7a Frequency of Riffles/Steps</b> <b>(Morphological Diversity)</b>  Occurrence of riffles/steps relatively frequent; ratio of distance between riffles is 5-7 times (steps 3-5 times) stream width; variety of habitat is key. In streams where riffles/steps are continuous, presence of boulders or other large, natural obstruction is important.	Occurrence of riffles/steps infrequent; distance between riffles is 7-15 times (steps 5-15 times) stream width.	Occasional riffle/step or bend; bottom contours provide some habitat; distance between riffles/steps is 15 to 25 stream widths.	Generally all flat water or shallow riffles/steps; poor habitat; distance between riffles/steps is >25 stream widths. Mostly runs.	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.8 Bank Stability</b> (score each bank)  <b>Note: determine left and right banks facing downstream</b> SCORE ____ (LB) SCORE ____ (RB)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in segment (or reach) has areas of erosion.	Moderately unstable; 30-60% of bank in segment (or reach) has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
Left Bank	10 9	8 7 6	5 4 3	2 1 0
Right Bank	10 9	8 7 6	5 4 3	2 1 0
<b>6.9 Bank Vegetative Protection</b> <b>(refer to field notes 3.1)</b>  (score each bank)  SCORE ____ (LB) SCORE ____ (RB)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
Left Bank	10 9	8 7 6	5 4 3	2 1 0
Right Bank	10 9	8 7 6	5 4 3	2 1 0
<b>6.10 Riparian Vegetative Zone Width (buffer)</b> <b>(refer to field notes 3.2)</b>  (score each side of channel) SCORE ____ (LB) SCORE ____ (RB)	Width of naturally vegetated riparian buffer >100 ft; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian buffer 50 - 100 ft; human activities have impacted zone only minimally.	Width of riparian buffer 25 - 50 ft; human activities have impacted zone a great deal.	Width of riparian buffer < 25 ft; little or no riparian vegetation due to human activities.
Left Bank	10 9	8 7 6	5 4 3	2 1 0
Right Bank	10 9	8 7 6	5 4 3	2 1 0

6.11 Total Score: \_\_\_\_ / 200 = \_\_\_\_

Condition: \_\_\_\_\_

0.85 – 1.0	Reference Condition
0.65 – 0.84	Good Condition
0.35 – 0.64	Fair Condition
0.00 – 0.34	Poor Condition

**6b. VERMONT RAPID HABITAT ASSESSMENT FIELD FORM – LOW GRADIENT STREAMS**

Stream Name: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 \_\_\_\_\_  
 Observers: \_\_\_\_\_  
 Organization /Agency: \_\_\_\_\_  
 USGS Map Name(s): \_\_\_\_\_  
 Weather: \_\_\_\_\_  
 Rain Storm within past 7 days: Y / N

Segment i.d: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Town: \_\_\_\_\_  
 Elevation: \_\_\_\_\_ ft.  
 Latitude (N/S): \_\_\_\_\_  
 Longitude (E/W): \_\_\_\_\_  
 Drainage Area: \_\_\_\_\_ sq. mi.  
 Segment Length: \_\_\_\_\_ ft.

Habitat Parameter	Condition Category			
	Reference	Good	Fair	Poor
<b>6.1 Epifaunal Substrate and Available Cover</b>	Greater than 50% of stream bed and lower banks covered with <b>mix</b> of substrates favorable for epifaunal colonization and fish cover; substrates include snags, submerged logs, undercut banks, and unembedded cobbles and boulders.	30-50% of stream bed and lower banks covered with a <b>mix</b> of substrates favorable for epifaunal colonization and fish cover	10-30% of stream bed and lower banks covered with substrates favorable for epifaunal colonization and fish cover; few substrate types present	Less than 10% of stream bed and lower banks covered with substrates favorable for epifaunal colonization and fish cover; few substrate types present
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.2b Pool Substrate Characterization</b>	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.3b Pool Variability</b>	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.4 Sediment Deposition</b>	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.5 Channel Flow Status</b>	Water reaches base of both lower banks, and <10% of channel bed substrate is exposed	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.6 Channel Alteration</b>	Channelization in the form of dredging, straightening, berms or streambank armoring is absent or minimal; stream with normal pattern.	Some channelization present along 10-20% of segment, usually in areas of bridge abutments; evidence of past channelization, (greater than past 20 yr) may be present, but recent channelization not present.	Channelization along 20-80% of stream segment ; riprap or armoring present on both banks.	Over 80% of the stream segment channelized and disrupted. Instream habitat greatly altered or removed entirely.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	Condition Category			
	Reference	Good	Fair	Poor
<b>6.7b Channel Sinuosity</b>	The bends in the stream increase the stream length 2.5 to 4 times longer than the straight down-valley length.	The bends in the stream increase the stream length 1.5 to 2.5 times longer than the straight down-valley length.	The bends in the stream increase the stream length 1 to 1.5 times longer than the straight down-valley length.	Channel straight; waterway has been channelized for a long distance.
<b>SCORE</b>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
<b>6.8 Bank Stability</b> (score each bank) <b>Note: determine left and right banks facing downstream</b>	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in segment (or reach) has areas of erosion.	Moderately unstable; 30-60% of bank in segment (or reach) has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
<b>SCORE ____ (LB)</b>	Left Bank 10 9	8 7 6	5 4 3	2 1 0
<b>SCORE ____ (RB)</b>	Right Bank 10 9	8 7 6	5 4 3	2 1 0
<b>6.9 Bank Vegetative Protection</b> <b>(refer to field notes 3.1)</b>  (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
<b>SCORE ____ (LB)</b>	Left Bank 10 9	8 7 6	5 4 3	2 1 0
<b>SCORE ____ (RB)</b>	Right Bank 10 9	8 7 6	5 4 3	2 1 0
<b>6.10 Riparian Vegetative Zone Width (buffer)</b> <b>(refer to field notes 3.2)</b>  (score each side of channel)	Width of naturally vegetated riparian buffer >100 ft; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian buffer 50 - 100 ft; human activities have impacted zone only minimally.	Width of riparian buffer 25 - 50 ft; human activities have impacted zone a great deal.	Width of riparian buffer < 25 ft; little or no riparian vegetation due to human activities.
<b>SCORE ____ (LB)</b>	Left Bank 10 9	8 7 6	5 4 3	2 1 0
<b>SCORE ____ (RB)</b>	Right Bank 10 9	8 7 6	5 4 3	2 1 0

6.11 Total Score: \_\_\_\_ / 200 = \_\_\_\_

Condition: \_\_\_\_\_

0.85 – 1.0	Reference Condition
0.65 – 0.84	Good Condition
0.35 – 0.64	Fair Condition
0.00 – 0.34	Poor Condition

**VT RAPID GEOMORPHIC ASSESSMENT ----- CONFINED STREAMS**

For narrowly and semi-confined valley types (confinement ratio < 4)

Stream Name: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 Observers: \_\_\_\_\_  
 Organization /Agency: \_\_\_\_\_  
 Reference Stream Type \_\_\_\_\_  Modified  
(If bedrock controlled gorge, alluvial fan, or naturally braided system see Handbook Protocols)

Segment I.D.: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Town: \_\_\_\_\_  
 Elevation: \_\_\_\_\_ ft.  
 Weather: \_\_\_\_\_  
 Rain Storm within past 7 days: Y / N

Adjustment Process	Condition Category			
	Reference	Good	Fair	Poor
<b>7.1 Channel Degradation (Incision)</b> <ul style="list-style-type: none"> <li>Exposed till or fresh substrate in the stream bed and exposed infrastructure (bridge footings).</li> <li>New terraces or recently abandoned flood prone areas.</li> <li>Headcuts, or nickpoints significantly steeper bed segment and comprised of smaller bed material than typical steps.</li> <li>Freshly eroded, vertical banks.</li> <li>Alluvial sediments that are imbricated (stacked like dominos) high in the bank.</li> <li>Tributary rejuvenation, observed through the presence of nickpoints at or upstream of the mouth of a tributary.</li> <li>Depositional features with steep faces, usually occurring on the downstream end.</li> </ul> <b>STD - Stream Type Departure</b> <input type="checkbox"/> C to a B/F/G <input type="checkbox"/> B to an F/G <input type="checkbox"/> Other:	<input type="checkbox"/> Little evidence of localized slope increase or nickpoints.	<input type="checkbox"/> Minor localized slope increase or nickpoints.	<input type="checkbox"/> Sharp change in slope and / or multiple small head cuts present.	<input type="checkbox"/> Sharp change in slope and / or multiple large head cuts present.
	<input type="checkbox"/> Incision Ratio $\geq 1.0 < 1.2$ <b>and</b> Where channel slope < 4% Entrenchment ratio > 1.4 Where channel slope $\geq 4\%$ Entrenchment ratio > 1.2	<input type="checkbox"/> Incision Ratio $\geq 1.2 < 1.4$ <b>and</b> Where channel slope < 4% Entrenchment ratio > 1.4 Where channel slope $\geq 4\%$ Entrenchment ratio > 1.2	<input type="checkbox"/> Incision Ratio $\geq 1.4 < 2.0$ <b>and</b> Where channel slope < 4% Entrenchment ratio > 1.4 Where channel slope $\geq 4\%$ Entrenchment ratio > 1.2	<input type="checkbox"/> Incision ratio $\geq 2.0$ <b>and</b> Where channel slope < 4% Entrenchment ratio $\leq 1.4$ Where channel slope $\geq 4\%$ Entrenchment ratio $\leq 1.2$
	<input type="checkbox"/> Full complement of expected bed features, complete steps comprised of coarser sediment in step-pool systems.	<input type="checkbox"/> Full complement of expected bed features, complete steps in step-pool systems.	<input type="checkbox"/> Step-pool systems with incomplete steps, dominated by runs.	<input type="checkbox"/> Bed features in step-pool systems replaced by plane bed features.
	<input type="checkbox"/> No change in confinement ratio.	<input type="checkbox"/> No change in confinement ratio.	<input type="checkbox"/> Human caused change in confinement ratio but no change in valley type.	<input type="checkbox"/> Human caused change in valley type
	<input type="checkbox"/> No evidence of historic / present channel straightening, dredging, and/or channel avulsions.	<input type="checkbox"/> Evidence of minor historic dredging and/or channel avulsions.	<input type="checkbox"/> Historic channel straightening, dredging, or gravel mining, and/or channel avulsions.	<input type="checkbox"/> Extensive historic channel straightening, commercial gravel mining, and/or recent channel avulsions.
	<input type="checkbox"/> No known flow alterations (i.e., increases in flow or decreases in sediment supply).	<input type="checkbox"/> Minor flow alterations, some flow increase.	<input type="checkbox"/> Significant historic flow alterations, greater flows or reduction of sediment load.	<input type="checkbox"/> Significant existing flow alterations, greater flows or reduction of sediment load.
<b>Score: Historic</b> <input type="checkbox"/>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>7.2 Channel Aggradation</b> <ul style="list-style-type: none"> <li>Shallow pool depths.</li> <li>Abundant sediment deposition on side bars and unvegetated mid-channel bars and extensive sediment deposition at obstructions, channel constrictions. Islands may be present</li> <li>Most of the channel bed is exposed during typical low flow periods.</li> <li>Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel.</li> </ul> <b>STD - Stream Type Departure</b> <input type="checkbox"/> A/B/C to a D Channel <input type="checkbox"/> Other:	<input type="checkbox"/> Full complement of expected bed features, complete steps and deep pools in step-pool systems.	<input type="checkbox"/> Full complement of bed features. Some filling of pools with fine sediment; pools may only be slightly deeper and wider than runs.	<input type="checkbox"/> Step-pool systems with incomplete steps, dominated by runs. Pools filling with sediment, pools may be absent with runs prevailing.	<input type="checkbox"/> Bed features in step-pool systems replaced by plane bed features.
	<input type="checkbox"/> Minor mid-channel, side or diagonal bars present. Depositional features typically submerged under low flow conditions.	<input type="checkbox"/> Minor to moderate mid-channel, side or diagonal bars present. Depositional features typically submerged under low to moderate flow conditions.	<input type="checkbox"/> Multiple unvegetated mid-channel, side or diagonal bars present. Sediment buildup at constrictions leading to steep riffles and chute cutoffs.	<input type="checkbox"/> Multiple unvegetated mid-channel, side or diagonal bars or islands present, splitting or braiding flows even under low flow conditions.
	<input type="checkbox"/> No apparent increase in small cobble/gravel/sand substrates (pebble count).	<input type="checkbox"/> Some increase in small cobble/sand substrates that may comprise over 50% of the sediments.	<input type="checkbox"/> Large increase in small cobble/ gravel/sand substrates that may comprise over 70% of the sediments.	<input type="checkbox"/> Homogenous, small cobble/ gravel/sand substrates may comprise over 90% of the sediments. Fine sediment feels soft underfoot.
	<input type="checkbox"/> Low width/depth ratio $\leq 20$ for channel slopes < 4% $\leq 14$ for channel slopes $\geq 4\%$	<input type="checkbox"/> Low to moderate W/d ratio $> 20 \leq 30$ for slopes < 4% $> 14 \leq 20$ for slopes $\geq 4\%$	<input type="checkbox"/> Moderate to high W/d ratio $> 30 \leq 40$ for slopes < 4% $> 20 \leq 30$ for slopes $\geq 4\%$	<input type="checkbox"/> High width/depth ratio $> 40$ for channel slopes < 4% $> 30$ for channel slopes $\geq 4\%$
	<input type="checkbox"/> No known flow alterations (i.e., decrease in flow or increase in sediment supply).	<input type="checkbox"/> Some increase in flow or sediment load. Flood-related sediment working through reach, seen as enlarged bars.	<input type="checkbox"/> Major flow alterations, reduction in flows and / or increase in sediment load.	<input type="checkbox"/> Significant existing flow alterations, extreme reduction in flows and / or increase in sediment load.
	<input type="checkbox"/> Human-made constrictions causing only minor upstream deposition.	<input type="checkbox"/> Human-made constrictions smaller than floodprone width, causing minor to moderate upstream deposition.	<input type="checkbox"/> Human-made constrictions significantly smaller than floodprone width, causing major upstream deposition.	<input type="checkbox"/> Human-made constrictions significantly smaller than bankfull width, causing extensive upstream deposition and splitting of flow.
<b>Score: Historic</b> <input type="checkbox"/>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Adjustment Process	Condition Category			
	Reference	Good	Fair	Poor
<b>7.3 Widening Channel</b> <ul style="list-style-type: none"> <li>Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together.</li> <li>Erosion on both right and left banks.</li> <li>Recently exposed tree roots (fresh roots are 'green' and do not break easily, older roots are brittle and will break easily in your hand).</li> <li>Fracture lines at the top of the bank that appear as cracks parallel to the river.</li> <li>Evidence of landslides and mass failures.</li> <li>Mid-channel bars and side bars may be present.</li> <li>Urbanization and stormwater outfalls leading to higher rate and duration of runoff and channel enlargement.</li> </ul>	<input type="checkbox"/> Low width/depth ratio $\leq 20$ for channel slopes $< 4\%$ $\leq 14$ for channel slopes $> 4\%$	<input type="checkbox"/> Low to moderate W/d ratio $> 20 \leq 30$ for slopes $< 4\%$ $> 14 < 20$ for slopes $> 4\%$	<input type="checkbox"/> Moderate to high W/d ratio $> 30 \leq 40$ for slopes $< 4\%$ $> 20 \leq 30$ for slopes $> 4\%$	<input type="checkbox"/> High width/depth ratio $> 40$ for channel slopes $< 4\%$ $> 30$ for channel slopes $> 4\%$
	<input type="checkbox"/> Little to no scour and erosion at the base of both banks. Only occasional bank overhangs, fracture lines at top of banks, leaning trees or freshly exposed tree roots.	<input type="checkbox"/> Minimal to moderate scour and erosion at the base of both banks. Some overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	<input type="checkbox"/> Moderate to high scour and erosion at the base of both banks. Many bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	<input type="checkbox"/> Continuous and laterally extensive scour and erosion at the base of both banks. Continuous bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.
	<input type="checkbox"/> Incision Ratio $\geq 1.0 < 1.2$ and Where channel slope $< 4\%$ Entrenchment ratio $> 1.4$ Where channel slope $\geq 4\%$ Entrenchment ratio $> 1.2$	<input type="checkbox"/> Incision Ratio $\geq 1.2 < 1.4$ and Where channel slope $< 4\%$ Entrenchment ratio $> 1.4$ Where channel slope $\geq 4\%$ Entrenchment ratio $> 1.2$	<input type="checkbox"/> Incision Ratio $\geq 1.4 < 2.0$ and Where channel slope $< 4\%$ Entrenchment ratio $> 1.4$ Where channel slope $\geq 4\%$ Entrenchment ratio $> 1.2$	<input type="checkbox"/> Incision ratio $\geq 2.0$ and Where channel slope $< 4\%$ Entrenchment ratio $\leq 1.4$ Where channel slope $\geq 4\%$ Entrenchment ratio $\leq 1.2$
	<input type="checkbox"/> Minor mid-channel or side bars present. Depositional features typically submerged under low flow conditions.	<input type="checkbox"/> Minor to moderate mid-channel or side bars present. Depositional features typically submerged under low to moderate flow conditions.	<input type="checkbox"/> Multiple unvegetated mid-channel or side bars present. Sediment buildup at the head of constrictions leading to steep riffles and chute cutoffs.	<input type="checkbox"/> Multiple mid-channel or side bars present splitting or braiding flows even under low flow conditions. (A/B/C to a D Channel)
	<input type="checkbox"/> No known channel and / or flow alterations (i.e., increase in flow and / or change in sediment supply).	<input type="checkbox"/> Some increase in watershed input of flows or sediment. Episodic (flood-related) discharges through reach resulting in short-term enlargement.	<input type="checkbox"/> Significant channel and / or flow alterations, increase in flows and / or change in sediment load (increase or decrease).	<input type="checkbox"/> Significant and extensive channel and / or flow alterations, increase in flows and / or change in sediment load (increase or decrease).
<b>Score:</b> Historic <input type="checkbox"/>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>7.4 Change in Planform</b> <ul style="list-style-type: none"> <li>Flood chutes present.</li> <li>Channel avulsions evident or impending.</li> <li>Change or loss in bed form structure, sometimes resulting in a mix of plane bed and step-pool forms.</li> <li>Island formation and/or multiple thread channels.</li> </ul>	<input type="checkbox"/> Low bank erosion on outside bends, little or no change in sinuosity within the reach	<input type="checkbox"/> Low to moderate lateral bank erosion on outside bends, may include minor change in sinuosity within the reach.	<input type="checkbox"/> Moderate to high lateral bank erosion on most outside bends, may include moderate change in sinuosity within the reach.	<input type="checkbox"/> Extensive lateral bank erosion on most outside bends, may include major change in sinuosity within the reach.
	<input type="checkbox"/> Little evidence of only minor mid-channel or side bars.	<input type="checkbox"/> Evidence of minor to moderate unvegetated mid-channel or side bars. Some potential for channel avulsion.	<input type="checkbox"/> Evidence of channel avulsion, islands, and unvegetated mid-channel or side bars.	<input type="checkbox"/> Evidence of recent channel avulsion, multiple thread channels, islands, and unvegetated mid-channel or side bars.
	<input type="checkbox"/> No human-caused alteration of channel planform and / or the width of the floodprone area.	<input type="checkbox"/> Floodplain Encroachment, channel straightening, or dredging resulting in a minor to moderate alteration of channel planform and / or the width of the floodprone area.	<input type="checkbox"/> Historic encroachment, dredging, or channel straightening resulting in a major alteration of channel planform and / or the width of the floodprone area.	<input type="checkbox"/> Recent and extensive encroachment, dredging, or channel straightening resulting in a major alteration of channel planform and / or the width of the floodprone area.
	<input type="checkbox"/> Human-made constrictions causing only minor upstream deposition.	<input type="checkbox"/> Human-made constrictions smaller than floodprone width, causing minor to moderate upstream deposition.	<input type="checkbox"/> Human-made constrictions significantly smaller than floodprone width, causing significant upstream deposition.	<input type="checkbox"/> Human-made constrictions significantly smaller than bankfull width, causing extensive upstream deposition and flow bifurcation.
<b>Score:</b> Historic <input type="checkbox"/>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

### 7.5 Channel Adjustment Scores – Stream Condition – Channel Evolution Stage

Condition	Reference	Good	Fair	Poor	STD*	Historic	Condition Rating: (Total Score / 80)	Channel Evolution Stage:
Departure	N/S	Minor	Major	Extreme				
Degradation							7.6 Stream Condition:	
Aggradation								
Widening								
Planform								
Sub-totals:					Total Score:			

Channel Adjustment Processes: \_\_\_\_\_

\*STD = Stream Type Departure where existing stream type is no longer the same as the reference stream type.

7.7 Stream Sensitivity: Low / Moderate / High / Extreme

**VT RAPID GEOMORPHIC ASSESSMENT ----- UNCONFINED STREAMS**

For narrow and broad to very broad valley types (confinement ratio  $\geq 4$ )

Stream Name: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 Observers: \_\_\_\_\_  
 Organization /Agency: \_\_\_\_\_  
 Reference Stream Type: \_\_\_\_\_  Modified  
(If alluvial fan or naturally braided system see Handbook Protocols)

Segment I.D.: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Town: \_\_\_\_\_  
 Elevation: \_\_\_\_\_ ft.  
 Weather: \_\_\_\_\_  
 Rain Storm within past 7 days: Y / N

Adjustment Process	Condition Category																			
	Reference	Good	Fair	Poor																
<b>7.1 Channel Degradation (Incision)</b> <ul style="list-style-type: none"> <li>Exposed till or fresh substrate in the stream bed and exposed infrastructure (bridge footings).</li> <li>New terraces or recently abandoned floodplains.</li> <li>Headcuts, or nickpoints that are 2-3 times steeper than typical riffle.</li> <li>Freshly eroded, vertical banks.</li> <li>Alluvial (river) sediments that are imbricated (stacked like dominos) high in the bank.</li> <li>Tributary rejuvenation, observed through the presence of nickpoints at or upstream of the mouth of a tributary.</li> <li>Bars with steep faces, usually occurring on the downstream end of a bar.</li> </ul>	<input type="checkbox"/> Little evidence of localized slope increase or nickpoints.	<input type="checkbox"/> Minor localized slope increase or nickpoints.	<input type="checkbox"/> Sharp change in slope and / or multiple small head cuts present.	<input type="checkbox"/> Sharp change in slope and / or multiple large head cuts present.																
	<input type="checkbox"/> Incision Ratio $\geq 1.0 < 1.2$ <b>and</b> Entrenchment ratio $> 2.0$	<input type="checkbox"/> Incision Ratio $\geq 1.2 < 1.4$ <b>and</b> Entrenchment ratio $> 2.0$	<input type="checkbox"/> Incision Ratio $\geq 1.4 < 2.0$ <b>and</b> Entrenchment ratio $> 2.0$	<input type="checkbox"/> Incision ratio $\geq 2.0$ <b>and</b> Entrenchment ratio $\leq 2.0$																
	<input type="checkbox"/> Full complement of expected bed features, complete riffles comprised of coarser sediment in riffle-pool systems.	<input type="checkbox"/> Full complement of expected bed features, complete riffles in riffle-pool systems.	<input type="checkbox"/> Incomplete riffles / dunes and dominated by runs.	<input type="checkbox"/> Riffle-pool / ripple-dune features replaced by plane bed features.																
	<input type="checkbox"/> No change in confinement ratio or valley type.	<input type="checkbox"/> Human caused change in confinement ratio but no change in valley type.	<input type="checkbox"/> Human caused change in confinement ratio enough to change valley type, but still unconfined.	<input type="checkbox"/> Human caused change in valley type, unconfined to confined																
	<input type="checkbox"/> No evidence of historic / present channel straightening, gravel mining, dredging and/or channel avulsions.	<input type="checkbox"/> No historic dredging; evidence of minor bar scalping on a point bar and/or channel avulsion.	<input type="checkbox"/> Historic channel straightening, dredging, gravel mining and/or channel avulsions.	<input type="checkbox"/> Extensive historic channel straightening, commercial gravel mining, and/or recent channel avulsion.																
	<input type="checkbox"/> No known flow alterations (i.e., increases in flow or decreases in sediment supply).	<input type="checkbox"/> Minor to insignificant flow increases or sediment load decreases.	<input type="checkbox"/> Significant historic flow alterations, greater flows or reduction of sediment load.	<input type="checkbox"/> Significant existing flow alterations, greater flows or reduction of sediment load.																
<b>STD - Stream Type Departure</b> <input type="checkbox"/> C/E to a B/F/G <input type="checkbox"/> B to an F/G <input type="checkbox"/> Other:																				
<b>Score:</b> <b>Historic</b> <input type="checkbox"/>	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
<b>7.2 Channel Aggradation</b> <ul style="list-style-type: none"> <li>Shallow pool depths.</li> <li>Abundant sediment deposition on point bars and mid-channel bars and extensive sediment deposition at obstructions, channel constrictions, and at the upstream end of tight meander bends. Islands may be present.</li> <li>Most of the channel bed is exposed during typical low flow periods.</li> <li>High frequency of debris jams.</li> <li>Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel.</li> </ul>	<input type="checkbox"/> Full complement of expected bed features, complete riffles and deep pools in riffle-pool systems.	<input type="checkbox"/> Complete riffles in riffle-pool systems. Some filling of pools with fine sediment; pools may only be slightly deeper and wider than runs.	<input type="checkbox"/> Incomplete riffles / dunes and dominated by runs. Significant filling of pools with sediment, pools may be absent with runs prevailing.	<input type="checkbox"/> Riffle-pool / ripple-dune features replaced by plane bed features.																
	<input type="checkbox"/> Minor mid-channel or diagonal bars present. Depositional features typically submerged under low flow conditions.	<input type="checkbox"/> Minor to moderate mid-channel or diagonal bars present. Depositional features typically submerged under low to moderate flow conditions.	<input type="checkbox"/> Multiple unvegetated mid-channel or diagonal bars present. Sediment buildup at the head of bendways leading to steep riffles and chute cutoffs.	<input type="checkbox"/> Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.																
	<input type="checkbox"/> No apparent increase in fine gravel/sand substrates (pebble count).	<input type="checkbox"/> Some increase in fine gravel/sand substrates that may comprise over 50% of the sediments.	<input type="checkbox"/> Large increase in fine gravel/sand substrates that may comprise over 70% of the sediments. Fine sediment feels soft underfoot.	<input type="checkbox"/> Homogenous fine gravel/sand substrates may comprise over 90% of the sediments. Fine sediment feels soft underfoot.																
	<input type="checkbox"/> Low width/depth ratio $\leq 20$	<input type="checkbox"/> Low to moderate W/d ratio $>20 \leq 30$	<input type="checkbox"/> Moderate to high W/d ratio $> 30 \leq 40$	<input type="checkbox"/> High width/depth ratio $> 40$																
	<input type="checkbox"/> No known flow alterations (i.e., decrease in flow or increase in sediment supply).	<input type="checkbox"/> Some increase in flow or sediment load. Flood-related sediment working through reach, seen as enlarged bars.	<input type="checkbox"/> Major flow alterations, reduction in flows and / or increase in sediment load.	<input type="checkbox"/> Significant existing flow alterations, extreme reduction in flows and / or increase in sediment load.																
	<input type="checkbox"/> Human-made constrictions causing only minor upstream deposition.	<input type="checkbox"/> Human-made constrictions smaller than floodprone width, causing minor to moderate upstream deposition.	<input type="checkbox"/> Human-made constrictions significantly smaller than floodprone width, causing major upstream deposition.	<input type="checkbox"/> Human-made constrictions significantly smaller than bankfull width, causing extensive upstream deposition and flow bifurcation.																
<b>STD - Stream Type Departure</b> <input type="checkbox"/> B/C/E to a D Channel <input type="checkbox"/> Other:																				
<b>Score:</b> <b>Historic</b> <input type="checkbox"/>	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Adjustment Process	Condition Category			
	Reference	Good	Fair	Poor
<b>7.3 Widening Channel</b> <ul style="list-style-type: none"> <li>Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together.</li> <li>Erosion on both right and left banks in riffle sections.</li> <li>Recently exposed tree roots (fresh roots are "green" and do not break easily, older roots are brittle and will break easily in your hand).</li> <li>Fracture lines at the top of the bank that appear as cracks parallel to the river.</li> <li>Mid-channel bars and side bars may be present.</li> <li>Urbanization and stormwater outfalls leading to higher rate and duration of runoff and channel enlargement.</li> </ul>	<input type="checkbox"/> Low width/depth ratio $\leq 20$	<input type="checkbox"/> Low to moderate W/d ratio $>20 \leq 30$	<input type="checkbox"/> Moderate to high W/d ratio $> 30 \leq 40$	<input type="checkbox"/> High width/depth ratio $> 40$
	<input type="checkbox"/> Little to no scour and erosion at the base of both banks at the riffle section. Only occasional bank overhangs, fracture lines at top of banks, leaning trees or freshly exposed tree roots.	<input type="checkbox"/> Minimal to moderate scour and erosion at the base of both banks at the riffle section. Some overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	<input type="checkbox"/> Moderate to high scour and erosion at the base of both banks at the riffle section. Many bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	<input type="checkbox"/> Continuous and laterally extensive scour and erosion at the base of both banks at the riffle section. Continuous bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.
	<input type="checkbox"/> Incision Ratio $\geq 1.0 < 1.2$ and Entrenchment ratio $> 2.0$	<input type="checkbox"/> Incision Ratio $\geq 1.2 < 1.4$ and Entrenchment ratio $> 2.0$	<input type="checkbox"/> Incision Ratio $\geq 1.4 < 2.0$ and Entrenchment ratio $> 2.0$	<input type="checkbox"/> Incision ratio $\geq 2.0$ and Entrenchment ratio $\leq 2.0$
	<input type="checkbox"/> Minor mid-channel or diagonal bars present. Depositional features typically submerged under low flow conditions.	<input type="checkbox"/> Minor to moderate mid-channel or diagonal bars present. Depositional features typically submerged under low to moderate flow conditions.	<input type="checkbox"/> Multiple unvegetated mid-channel or diagonal bars present. Sediment buildup at the head of bendways leading to steep riffles and chute cutoffs.	<input type="checkbox"/> Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
	<input type="checkbox"/> No known channel and / or flow alterations (i.e., increase in flow and / or change in sediment supply).	<input type="checkbox"/> Some increase in watershed input of flows or sediment. Episodic (flood-related) dis-charges through reach resulting in short-term enlargement.	<input type="checkbox"/> Significant historic channel and / or flow alterations, increase in flows and / or change in sediment load (increase or decrease).	<input type="checkbox"/> Significant existing channel and / or flow alterations, increase in flows and / or change in sediment load (increase or decrease).
<b>Score:</b> <b>Historic</b> <input type="checkbox"/>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>7.4 Change in Planform</b> <ul style="list-style-type: none"> <li>Flood chutes or neck cut-offs may be present.</li> <li>Channel avulsions may be evident or impending.</li> <li>Change or loss in bed form structure, sometimes resulting in a mix of plane bed and riffle-pool forms.</li> <li>Island formation and/or multiple thread channels.</li> <li>Additional large deposition and scour features in the channel length typically occupied by a single riffle-pool sequence (may result from the lateral extension of meander bends). Thalweg not lined up with planform. (i.e., in meandering streams the thalweg (or deepest part of the channel) typically travels from the outside of a meander bend to the outside of the next meander bend. Pools are located on downstream third of the concave bends. Riffles are at the cross-over between the pools on successive bends. During planform adjustments, the thalweg may not line up with or follow this pattern.</li> </ul>	<input type="checkbox"/> Low bank erosion on outside bends, little or no change in sinuosity within the reach	<input type="checkbox"/> Low to moderate lateral bank erosion on outside bends, may include minor change in sinuosity within the reach.	<input type="checkbox"/> Moderate to high lateral bank erosion on most outside bends, may include potential neck cut-offs and moderate change in sinuosity.	<input type="checkbox"/> Extensive lateral bank erosion on most outside bends, may include impending neck cut-offs and major change in sinuosity within the reach.
	<input type="checkbox"/> Little evidence of flood chutes crossing inside of meander bends, only minor mid-channel or diagonal bars.	<input type="checkbox"/> Minor flood chutes crossing inside of meander bends, evidence of minor to moderate unvegetated mid-channel or diagonal bars. Some potential for channel avulsion.	<input type="checkbox"/> Historic or active flood chutes crossing inside of meander bends, evidence of channel avulsion, islands, and unvegetated mid-channel or diagonal bars.	<input type="checkbox"/> Active large flood chutes crossing inside of most meander bends, evidence of recent channel avulsion, multiple thread channels, islands, and unvegetated mid-channel or diagonal bars.
	<input type="checkbox"/> No additional deposition and scour features in the channel length typically occupied by a single riffle-pool sequence. Thalweg lined up with planform.	<input type="checkbox"/> Additional minor deposition and scour features in the channel length typically occupied by a single riffle-pool sequence.	<input type="checkbox"/> Additional large deposition and scour features in the channel length typically occupied by a single riffle-pool sequence. Thalweg not lined up with planform.	<input type="checkbox"/> Multiple sequences of large deposition and scour features in the channel length typically occupied by a single riffle-pool sequence.
	<input type="checkbox"/> No human-caused alteration of channel planform and / or the width of the floodprone area.	<input type="checkbox"/> Floodplain encroachment, channel straightening, or dredging resulting in a minor to moderate alteration of channel planform and / or the width of the floodprone area.	<input type="checkbox"/> Historic floodplain encroachment, dredging, or channel straightening resulting in a major alteration of channel planform and / or the width of the floodprone area.	<input type="checkbox"/> Recent and extensive floodplain encroachment, dredging, or channel straightening resulting in a major alteration of channel planform and / or the width of the floodprone area.
	<input type="checkbox"/> Human-made constrictions causing only minor upstream deposition.	<input type="checkbox"/> Human-made constrictions smaller than floodprone width, causing minor to moderate upstream deposition.	<input type="checkbox"/> Human-made constrictions significantly smaller than floodprone width, causing significant upstream deposition.	<input type="checkbox"/> Human-made constrictions significantly smaller than bankfull width, causing extensive upstream deposition and flow bifurcation.
<b>Score:</b> <b>Historic</b> <input type="checkbox"/>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

**7.5 Channel Adjustment Scores – Stream Condition – Channel Evolution Stage**

Condition	Reference	Good	Fair	Poor	STD*	Historic	Condition Rating: (Total Score / 80)	Channel Evolution Stage:
Departure	N/S	Minor	Major	Extreme				
Degradation							7.6 Stream Condition:	
Aggradation								
Widening								
Planform								
<b>Sub-totals:</b>					<b>Total Score:</b>			

Channel Adjustment Processes: \_\_\_\_\_

7.7 Stream Sensitivity: Low / Moderate / High / Extreme

\*STD = Stream Type Departure where existing stream type is no longer the same as the reference stream type.

**Phase 2 – Quality Assurance Worksheet**

Stream Name: \_\_\_\_\_  
 QA Team Leader: \_\_\_\_\_  
 ANR Team Leader: \_\_\_\_\_

Watershed: \_\_\_\_\_ Date: \_\_\_\_\_  
 Organization /Agency: \_\_\_\_\_

Check one or more boxes to indicate the types of ANR sponsored training received by field team members	<b>Phase 2</b>	
	<b>QA</b>	

Segment/Reach Sketch and Map Documentation completed	
Phase I Assessment used in Phase 2 analysis of geomorphic condition	
ANR SGA Handbook Protocols and Database used exclusively	
Other protocols used:	

Phase 1 Step Number	Tool Used to Collect Data	Confidence Level	Date Completed	Date Updated	Date of Local QA Team Review	Date of State QA Team Review	Comments
<b>Step 1</b>		Low to Moderate Moderate Moderate to High High					
<b>Step 2</b>		Low to Moderate Moderate Moderate to High High					
<b>Step 3</b>		Low to Moderate Moderate Moderate to High High					
<b>Step 4</b>		Low to Moderate Moderate Moderate to High High					
<b>Step 5</b>		Low to Moderate Moderate Moderate to High High					
<b>Step 6</b>		Low to Moderate Moderate Moderate to High High					
<b>Step 7</b>		Low to Moderate Moderate Moderate to High High					

## **Appendix F: Data Management System Instructions**

### **Spreadsheet and Database Instructions for Phase 2 Stream Geomorphic Assessment Data**

(Email Attachment)