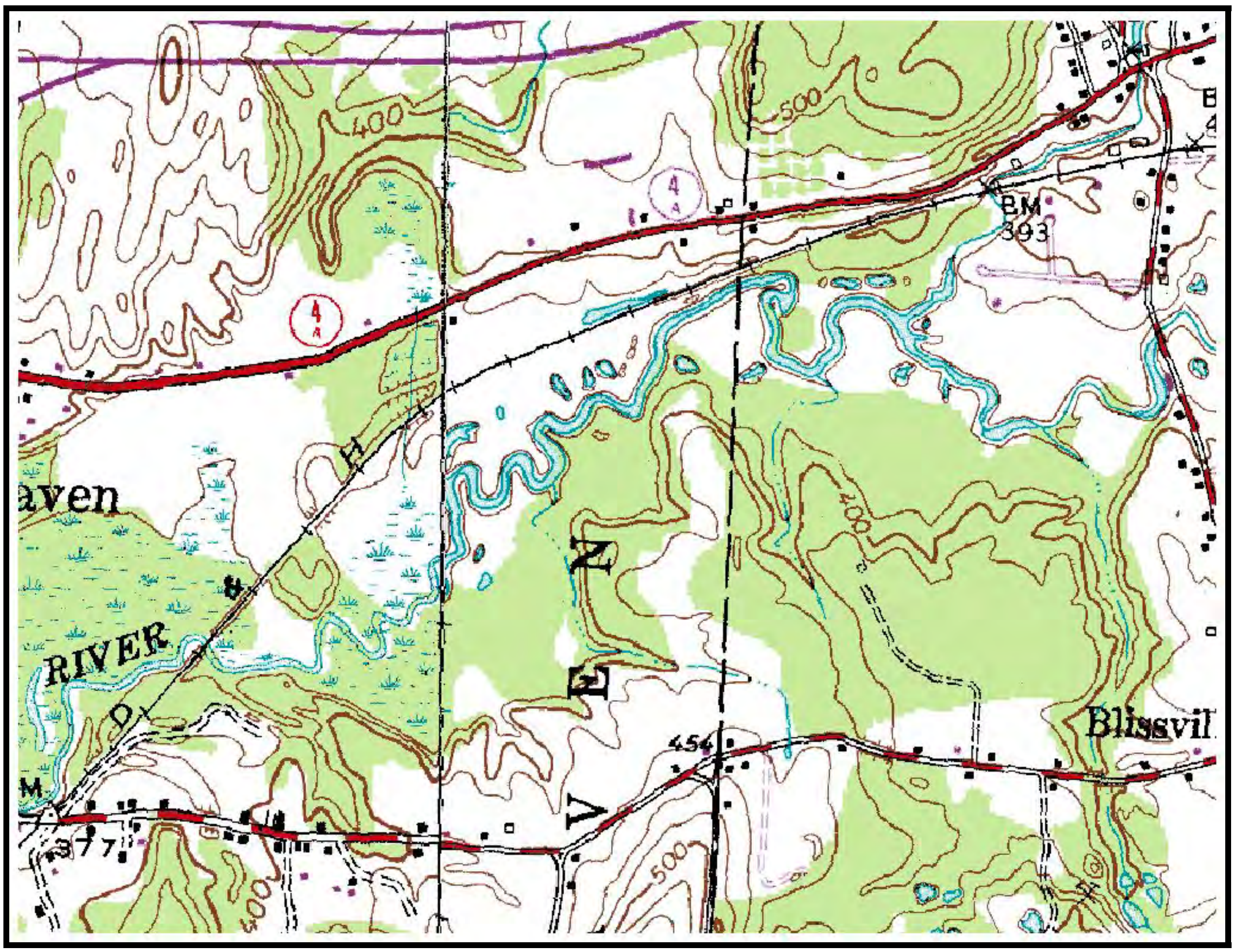
Vermont Stream Geomorphic Assessment
Phase 1 Handbook

WATERSHED ASSESSMENT



USING MAPS, EXISTING DATA, AND WINDSHIELD SURVEYS

Vermont Agency of Natural Resources
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The Phase 1 Handbook may be downloaded from the River Corridor Management, Geomorphic Assessment internet web page at: **www.vtwaterquality.org/rivers.htm**

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* The Vermont ANR Stream Geomorphic Assessment Handbooks, Phases 1 through 3, have a shared set of appendices. Not all appendices are included with the Phase 1 Handbook.

PHASE 1 INTRODUCTION

This Handbook is a guide to the Phase 1 Watershed Assessment, the first of 3 phases of the Vermont Stream Geomorphic Assessment protocols. Phase 1 is carried out using existing data such as topographic maps, orthophotos, agencies' and organizations' databases, local and resource specialists' knowledge, and "windshield surveys." Windshield surveys provide field data through quick observation without extensive field measurements.

The data collected in a Phase 1 assessment provide an overview of the general physical characteristics of a watershed. Maps, aerial pictures, and historic information will be invaluable when combined with field interpretations in piecing together the story of a stream's response to the natural and human disturbances that have occurred over time at the watershed scale.

Where to Complete a Phase 1 Watershed Assessment

Where to complete a Phase 1 watershed assessment is largely a question of scale, as well as local priorities. How much of the main stem should be assessed? Which tributaries should be looked at? It is highly recommended that you and your team review the parameters (or characteristics) described in this handbook. A limited assessment of stream reaches and tributaries will produce information you need to solve problems, but only if your team examines enough of the watershed to interpret the impacts associated with upstream and downstream activities.

Final Products of the Phase 1 Watershed Assessment

Products of a Phase 1 Watershed Assessment include:

1. **Reference Stream Typing,** which involves dividing streams in the watershed into geomorphic "reaches" that are assigned a "reference stream type" based on physical parameters such as geology, valley landform, and valley slope. **Note:** These are NOT the stream types as described in the Vermont Water Quality Standards classification scheme (Water Resources Board, 1999).

2. A **Stream Impact Rating** that results in a priority ranking for each reach in your watershed (Step 8). This is based on impact scores that you assign to channel, floodplain, and land use modifications for each reach as you progress through the assessment. Reaches with high scores may be physically responding to disturbances and warrant further study in the field. Reaches with very low scores may also be candidates for field assessment as they may be suitable reference reaches for streams in adjustment.

3. A **Provisional Geomorphic Condition Evaluation** for each reach (Step 9) that includes:
   - **Reach Condition,** a descriptor that represents an estimate of channel and floodplain change or departure from the reference condition given the types and extent of channel, floodplain, and land use modifications documented in the watershed;
   - **Channel Adjustment Process,** or type of change that may be underway in the stream channel (e.g., vertical, lateral, or channel planform adjustment processes) due to natural causes or human activity that may result in a change to the valley, floodplain, and/or channel; and
   - **Reach Sensitivity** of the valley, floodplain, and/or channel to change due to natural causes and/or human activity.

   These assessment parameters are useful in evaluating the current and future conditions of:
   - **stream and riparian habitat, and**
   - **erosion and flood hazards**.

   The Provisional Geomorphic Condition Evaluation is an appropriate tool for setting priorities and problem solving in a watershed context because it will not only tell you the proximity of adjusting reaches to one another, but you will be able to ascertain how one reach may be affecting the condition of another. If you or someone in your team does not have experience with predicting the channel adjustment processes and conditions that follow in response to channel and floodplain modifications you may want to put the Provisional Geomorphic Condition Evaluation (Step 9) aside until you have spent more time in the field completing Phase 2 and/or Phase 3 assessments. If you opt for going to the field first, it is highly recommended that you revise the provisional condition evaluations in the Phase 1 DMS before setting priorities for protection, management, or restoration projects. An interim way to set priorities within your watershed is provided through the completion of a Stream Impact Rating. The River Management Program has developed guidance for basin planners on reach prioritization that places a high priority on identifying reference-condition reaches for protection and red-flagging "strategic sites" where certain channel adjustments may be occurring that would cause significant landowner conflicts.

4. A **Like Reach Evaluation** that groups the reaches in your watershed assessment by similar valley and stream types and similar geomorphic condition or impact rating (Step 10). Grouping streams by like reaches is useful in selecting a manageable number of reaches on which to conduct the Phase 2 and Phase 3 field assessments. By collecting detailed information on reaches that represent the different reach types in your watershed you are better able to characterize the entire watershed without conducting extensive and time-consuming field surveys on the entire watershed. The information collected on the representative reaches can be used to understand the other "like" reaches in the watershed.

5. **Watershed Maps,** including USGS maps where your assessment team has made field notations during the watershed orientation and windshield surveys, and computer generated GIS watershed maps depicting Phase 1 reaches and data, the provisional geomorphic condition, and the like reach evaluation.

Basic Methods and Skills

Data Sources
The information collected in a Watershed Assessment comes from three primary sources: remote sensing, existing data, and windshield surveys, as defined below. The type of information source used to evaluate a parameter is listed next to each parameter in the Handbook.

1) **Remote Sensing Data** includes data collected from maps, aerial photographs, and orthophotos.

2) **Existing Data** includes, but is not limited to, studies such as NRCS soil surveys, and information, such as dam locations, available from the Vermont Agency of Natural Resources. Other useful existing data, such as the regional hydraulic geometry curves, are included in the Appendices. Existing data may also include first-hand knowledge from resource specialists.

3) **Windshield Survey Data** includes general observations made from a car as you drive about the watershed. These observations will help you verify information interpreted from maps and aerial photos. Please be careful when gathering data from a car. **You need at least two people for this exercise: one to drive and one to record observations.**

Using The GIS Stream Geomorphic Assessment Tool (SGAT)
To support the Phase 1 Watershed Assessment, the Vermont Agency of Natural Resources (ANR) has developed a GIS extension for ArcView called the Stream Geomorphic Assessment Tool (**SGAT)**. Use of GIS and the SGAT program significantly streamlines many of the Phase 1 calculations and measurements. The SGAT program automatically populates dBase tables that can be imported into the Phase 1 DMS. The extension is set up in a user friendly interface format; however, it is expected that the user has a basic understanding of ArcView. Currently SGAT is designed to work with ArcView 3.x.

Evaluation with SGAT:
Throughout the Phase 1 handbook, the term "SGAT" appears in parentheses after each Step # (parameter) for which SGAT can be used to generate data.

A separate handbook has been written to support the use of SGAT (contact the DEC River Management Program). It is recommended that a new user read through the SGAT handbook before using the tool in order to understand how the GIS extension works and which assessment steps can be completed or facilitated by the program. The SGAT user handbook and the extension tool can be obtained on computer CD from the DEC River Management Program.

Using the SGAT Feature Indexing Tool (FIT)
Evaluation of some of these parameters requires identification and measurement of physical features or characteristics such as bank armoring, channel straightening and locations of berms and roads in the corridor. Using the SGAT Feature Indexing Tool (FIT) provides an efficient means for documenting and measuring features of interest. Use of the FIT also results in a data base file that can be imported into the Phase 1 DMS, thus eliminating the need to manually enter the data. Instructions on acquiring and using the FIT are contained in the SGAT manual.

Evaluation with FIT:
Throughout the Phase 1 handbook, the term "FIT" appears in parentheses after each Step # (parameter) for which the FIT can be used to generate data.

The Feature Indexing Tool (FIT) should be used to document the following impacts to a stream during the Phase I (and updated in Phase 2) Assessments:

Phase 1	Phase 2	Shape Type	Impact	Sub-Impact	Location	Option 1	Option 2
3.1	1.2	Point	Alluvial Fan	N/A	N/A	N/A	N/A
5.3	3.1	Polyline	Bank Armoring or Revetment	Rip-Rap Hard Bank Other	Right Bank Left Bank		
N/A	4.9	Point	Beaver Dam	N/A	N/A	Length Affected	
5.2	4.8	Point	Bridge and Culvert	Bridge Culvert Unknown	N/A	Length Affected	
4.3	3.2	Polyline	Buffer Less than 25 feet	N/A	Right Bank Left Bank		
N/A	2.x	Point	Cross Section Location	NOT Representative Representative	N/A	Number	
N/A	4.4	Point	Debris Jam	N/A	N/A		
6.2	1.3	Polyline	Development	N/A	Both Sides One Side		
5.5	5.5	Polyline	Dredging	Commercial Mining Dredging Gravel Mining	Exact Location General Location		
6.1	1.3	Polyline	Encroachment	Berm Improved Path Railroad Road	Both Sides One Side	Height	
7.2	3.1	Polyline	Erosion	N/A	Left Bank Rigth Bank	Height	

5.1	4.5	Point	Flow Regulation and Water Withdrawal	Large Bypass Large Run of River Large Store and Release Large Withdrawal Small Bypass Small Run of River Small Store and Release Small Withdrawal	Drinking Flood Control Hydro-electric Other Recreation		
3.2	1.6	Point	Grade Control	Dam Ledge Waterfall Weir	Picture NO Picture	Height Above Water	Total Height
N/A	3.1	Point	Gully	N/A	N/A	Height	
N/A	3.1	Polyline	Mass Failure	N/A	Left Bank Right Bank	Height	
6.4	5.2	Point	Migration	Avulsion Braiding Flood Chute Neck Cutoff			
N/A	5.3	Point	Steep Riffle or Head Cut	Head Cut Steep Riffle			
N/A	4.7	Point	Storm Water Input	Field Ditch Other Overland Flow Road Ditch Tile Drain Urban Storm Water Pipe			
5.4	5.5	Polyline	Straightening	Straightening With Windrowing			
N/A	5.4	Point	Stream Crossing	Animal Crossing Stream Ford			

N/A = Not Applicable

Using the Web Based Data Management System (DMS)

Vermont ANR has also developed a web based data management system (DMS). The DMS can be used to automatically upload the SGAT & FIT data (stream characteristics, soils, land use data & indexed features) and for manually entering Phase 1 information from data sheets. The DMS also has the following capabilities:

- Built in QA checks to assure data accuracy and consistency between phases of assessment
- Built in reports that simulate the standard reports in Appendix A, as well as other reports that may be of interest
- The ability to export all of the Phase I data in the .dbf format to be used in mapping or other database applications
- Automated upload of both SGAT and FIT data

Remote Sensing Skills

The following remote sensing skills will be needed to complete the Phase 1 Watershed Assessment are:

- Reading topographic maps
- Interpreting aerial/orthophotos
- Calculating some basic mathematical equations (examples are provided in the text)
- Reading soil and geologic surveys
- Use of ArcView 3.X mapping software and extensions

These skills are easily learned with some training. If you are assembling a team of people to complete a Watershed Assessment it is very important to involve someone who has experience reading maps and aerial/orthophotos to assist you. The involvement and technical assistance of specialists in the fields of geology, aquatic ecology, and fluvial geomorphology is also highly recommended. Contact the DEC River Management Program, the Vermont Fish and Wildlife Department, or the Vermont Geological Survey about the availability of professionals in these fields and/or to learn about opportunities and requirements for technical training to complete Phase 1 Assessments.

Reminder
The right bank and left bank of a channel are defined looking downstream. If you have any questions about the definitions of any terms, please refer to the glossary in Appendix Q.

Materials Needed

You will need the following materials to complete the watershed assessment:

- A copy of the topographic maps covering your watershed
- Orthophoto series; two different time periods (most recent and a series from at least 20 years ago)
- Computer mapping program that can measure distances, areas, and latitude/longitude,
- Consistent access to the internet (the ANR data management system is web based)

Materials needed for using SGAT & FIT:

- Arc View 3.1, 3.2 or 3.3
- Most recent version of the SGAT extension and accompanying user handbook (Version 4.56 or above)
- Digital topographic maps
- Digital orthophotos
- GIS layers for streams (1:5000 VHD)
- Manually digitized watersheds, meander center lines, valley walls
- Digital NRCS soils, and 2002 land use theme (lclu)
- GIS computer tools or computer mapping programs are commercially available and are very useful tools for measuring slopes, distances, and other assessment parameters; however, these tools are not required to complete a Phase 1 assessment.

Published data resources are listed throughout this Handbook. Below is a summary table of sources for acquiring topographic maps, orthophotos, and similar basic data sources. Many helpful data layers are available as GIS coverages from the Vermont Center for Geographic Information (VCGI). Check their website at www.vcgi.org.

Materials	Source	Phone
Vermont Hydrography Dataset	Vermont Center for Geographic Information (VCGI) at http://www.vcgi.org	(802) 882-3000
Topographic maps	Retail outlets and Vermont Geological Survey	(802) 241-3608
Orthophotos	Vermont Mapping Program (VT Dept. of Taxes) http://www.state.vt.us/tax/vermontmapping.htm	(802) 241-3552
Surficial geologic map	Vermont Geological Survey	(802) 241-3608
FEMA National Flood Insurance Program (NFIP) maps	Town Clerks, Dept. of Emergency Management, DEC Division of Water Quality	(802) 241-3770
Soil Surveys	Natural Resources Conservation Service (NRCS)	(802) 951-6796
Wetland maps	DEC Division of Water Quality	(802) 241-3770

Getting Started

Read the Handbooks
Each member of your assessment team should read the Phase 1 Handbook before getting started. The team member(s) running SGAT should read the SGAT manual. Understanding the entire protocol and the rationale behind it can save a lot of questions that will undoubtedly arise otherwise.

Contact the ANR
It is *IMPERATIVE* that you set up a project-scoping meeting with the DEC River Management Program before beginning an assessment. This offers several advantages: finding out whether there have been updates of the protocols; receive a login so data can be uploaded and entered into the DMS; receiving information on Phase 1 assessment training opportunities; receiving data quality assurance (QA) assistance; and learning about other assessments that may have occurred or are currently underway in your study area.

> ***It is critical that you contact ANR to find out about other assessments in your watershed, as you need to coordinate your reach numbering assignments with prior assessments completed upstream or downstream from where you plan to work.***

Have a Scoping Meeting
Before starting your project, the various constituents involved in the project should get together to be sure the goals of the project are understood. It is also a good time to review the steps of the process, and if there are multiple partners collecting data that each person understands their part in the project. A "Phase 1 Task Register" table (Appendix A) can be used to assist in this process.

Protocol Steps
Watershed characteristics evaluated as a part of this assessment protocol are referred to as "parameters" and have been organized under seven assessment "steps." For example a protocol for measuring watershed size is found in Step 2.7 (the seventh parameter evaluated in Step 2).

Data Sheets
Paper data sheets (Appendix A) are organized by step and parameter number and have a heading to record the following information:

- ***Stream Name:*** The name of the stream or river printed on the USGS topographic map. For unnamed tributaries, use the tributary numbering system outlined in Step 1 of these protocols.
- ***Sub-watershed*:** It is also helpful to note the name of the receiving water in parentheses. Sub-watersheds are generally at the scale of 16 sq.mls. to 63 sq.mls. (National Hydraulic Unit Code - 10 Scale). Watershed delineations showing the 8 and 10 Scale Hydraulic Units and their codes are available as GIS data layers from the Vermont Center for Geographic Information (VCGI) at www.vcgi.org.
- ***Watershed*:** The name of the main river or lake at the downstream endpoint of your watershed. Watersheds are generally at a scale greater than 63 mi^2. (Hydraulic Unit Code - 8 Scale).
- ***U.S.G.S. Map Name*:** USGS map name(s) on which the watershed is located. Map names are usually located in the bottom right hand corner of the maps.
- ***Observers:*** Name of observer(s) completing the assessment.
- ***Organization/Agency*:** Three (or more)-letter acronym(s) of the organizations and agencies represented in the assessment crew.

Paper Records
You are encouraged to use both the hard paper copy data sheets and DMS report forms to catalogue and store assessment data for all data that is manually collected. **It is not necessary to keep hard copies of data that is collected in SGAT or the FITsince you will have a digital backup of the data.**

The following parameters are evaluated in SGAT and therefore do NOT need to be recorded on the paper data sheets:

Town
Ortho Photo
Topographic Map
HUC 10
Reach Number
Latitude & Longitude
Northing & Easting
Upstream & Downstream Elevations
Valley Length
Channel Length
Valley Width
Watershed Size
Geologic Material (Dominant % and Subdominant %)
Hydrologic Group and %
Flooding and %
Water Table and % (shallow and deep)
Erodibility and %
Current dominant and Subdominant Land Cover in the Watershed – including % urban and % crop in the Watershed
Current dominant and Subdominant Land Cover in the Corridor – including % urban and % crop in the Corridor

Ideally, data sheets are accompanied with paper maps. These base maps will likely be USGS topographic maps, but if you are using GIS you can create your own base maps that contain topography and other useful data layers you may have available. Be sure to include basic information on the map, such as the watershed boundary, the beginnings and ends of each stream reach, and any watershed orientation and windshield survey field notes. Step 7 gives a description of the map notation used in windshield surveys.

Computer Tools & Outputs

Use the DMS to store and manage your assessment data. Appendix B offers guidance on how to use the Phase 1 DMS and provides examples of these forms and data queries used to complete Phase 1 products.

Entering the Phase I Geomorphic data into the web based DMS to the DEC River Management Program to include in the state geomorphic dataset provides the following benefits:

- ensuring that a duplicate copy of the data exists in an alternate location;
- Automated QA reviews to check for data consistency and accuracy;
- building a statewide dataset that will result in a more powerful problem solving tool; and
- receiving assistance from other geomorphic assessment professionals in data interpretation.

Phase 1 Quality Assurance Program

At the start of your Phase 1 assessment establish a QA team that includes the primary data collector(s). This team will be responsible for reviewing the data collected. Members of this team need to be trained in the protocols and use of the Phase 1 DMS, and at least one member of the team should be trained in quality assurance techniques. Training can be obtained from the DEC River Management Program (RMP).

Once data has been collected and entered into the DMS, the standard reports and tables in the DMS can be generated and reviewed by the QA team. The team can determine if there is information that is missing, inconsistent with the protocols, or needs further evaluation. Data that raises concerns or problems can then be assessed and the method of correcting or completing the information can be established. A good first check to ensure data accuracy and completeness is to compare the original data sheets filled out by hand to those generated by the DMS. Though tedious, comparing each data entry line for line will ensure there are no errors resulting from simple “typos” and improper transfers of data from the raw data sheets to the DMS.

Many Phase 1 parameters are assessed in the field during Phase 2 and Phase 3 Stream Geomorphic Assessments. If you have confirmed or changed remote sensing data in the Phase 1 DMS as a result of **reach scale** field assessments, the meta data (see below) needs to be changed. **It is very important that you do not characterize an entire reach in the Phase 1 DMS based on a field assessment of only a segment or part of the reach. Wait until you have field assessed the entire reach before revising the Phase 1 data.**

Revising the Phase 1 DMS with new and/or field verified data may strengthen the use of the data in watershed analysis. After you make these revisions it is essential to document the changes. This should be done by updating the meta data reach by reach, parameter by parameter to ensure that you preserve the ability to pull out certain types of data (i.e., remote sensing versus field verified data).

Everyone who attempts to use your Phase 1 data will appreciate the efforts made to document its quality, including its deficiencies. If you encounter problems with incomplete data for certain parameters, select “Not Evaluated” for that reach and parameter and make a note in the comments box.

Before beginning a Phase 1 assessment read the QA protocol at the end of the Phase 1 Handbook to more fully understand the data documentation process. After the Phase 1 assessment steps are completed, the QA sheet and QA data entry form in the DMS (Appendices A and B) should be completed. The QA sheet is a set of questions that documents which steps were completed and when; what assessment tools and data sources were used; the level of training received by members of the assessment team; and the confidence level of the assessors towards the data collected at each assessment step. These QA sheets should be reviewed and finalized by the QA team. When data is updated or changed, the same process of data review should to be completed. The QA sheet can then be updated to indicate the change in data.

The portions of the QA sheet completed by the assessor will assist in incorporating the data into the State Geomorphic DMS (see Appendix P). As the data is brought into the State DMS, ANR staff will review the data, and the QA process (and QA sheet) will be completed. This ANR-level QA process will be done each time data is updated or changed and resubmitted to ANR.

Phase 1 Meta Data Description

Metadata is used to document the methods and sources used in collecting geomorphic assessment data. The RMP has developed a list of standard metadata options for each of the Phase 1 parameters. Meta data should be documented on the data form provided in Appendix A. The documentation of the metadata is completed during the automated upload of the SGAT and RIT data as well as during the manual data entry task in the DMS where the user will find a drop-down menu listing the options for each parameter. The default for each parameter is the data collection method most commonly used. If you did not use the default method you must manually change the metadata for each applicable reach in the DMS.

If you find that none of the metadata options for a parameter adequately describes the method you used please contact the RMP staff.

Menu Options – No Data versus None versus Not Evaluated:

In order to qualify the completeness and accuracy of a data set the following options are included for most of the Phase I menu options:

No Data	No data sources are available to determine if the impact exists. A selection of "No Data" indicates that the data collector has exhausted all options for obtaining the data (as described by the meta data) and has found that no sources are available to determine if the impact exists.
None	A selection of none indicates the data collector reviewed all available options for obtaining data (as described by the meta data) and found that the impact is not documented anywhere. A selection of "None" indicates that at the Phase I remote sensing assessment level no evidence of the impact can be found.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated. Further work should be completed.

Example:
If you are collecting data for step 6.3, Depositional Features and in reviewing the 1:5000 ortho photos you find that you can't see the stream well enough to determine if any depositional features exist select the "no data" option because you can't tell if the impact exists.

However, if you are collecting data for Step 5.5, Dredging and Gravel Mining, and you have interviewed the DEC, NRCS and town officials and locals and have found no existing evidence of dredging or gravel mining you should select "None" because you have exhausted all reasonable Phase I data sources and have found no evidence of the impact.

It is important to understand the difference between none, no data and not evaluated prior to beginning a Phase I Geomorphic Assessment. Please use these options where applicable.

Starting the Phase 1 Assessment – Defining Stream Reaches

To start the Phase 1 assessment you must first do the following:

1. Delineate the primary watershed
2. Select streams within the watershed to be assessed
3. Visually define a "first cut" of geomorphic reaches for the assessment streams using the ground rules and guidance provided in this section
4. Number reaches according to the numbering systems outlined in this section
5. Conduct a watershed orientation to verify reach delineations and to calibrate your eye as to how features on the maps and orthophotos, which you will be using to complete the Phase 1 assessment, appear on the ground.

1. Delineating the Primary Watershed

Detailed instructions on how to delineate watershed boundaries and how to read topographic maps are provided in Appendix D.

Determine the boundary of the watershed that encompasses the stream(s) you are interested in assessing. This is considered the "primary watershed", and includes all the land area that contributes flow to the assessment stream(s). Draw this watershed boundary on USGS topographic maps, as described in detail in Appendix D. Refer to the SGAT User Manual on how to develop a digital watershed data layer.

2. Selecting Assessment Streams

Once you have determined the primary watershed you are going to assess, you need to identify what sections of stream within the watershed you will complete the Phase 1. It is helpful to delineate the boundaries of the sub-watersheds for each major tributary to gain an understanding of what percentage of the watershed those tributaries comprise. Your assessment goals, local priorities and available resources should be considered when deciding how many tributaries to evaluate in the watershed. If resources are limiting, you can delay conducting steps 1 through 10 of the assessment for some tributaries, but you should define and number reaches for all of the mainstem and the tributaries that you plan to include in the assessment over the long run.

3. Defining Geomorphic Stream Reaches – A Visual "First Cut"

Next, for those streams you have selected for assessment, define geomorphic stream reaches based on the geomorphic characteristics of stream size, valley characteristics, and to some extent, underlying geology as described below. Specifically, you will be looking at stream confinement (valley width compared to stream width), valley slope, geologic materials, and tributary influence to determine distinct geomorphic stream reaches within the watershed.

Background

On the broadest level, streams are classified by the shapes of the valleys in which they flow: steep and confined; moderately steep and narrow; or gentle sloped and broad. Figure 1.1 below shows the different valley types and the typical changes in sediment regime characteristics (source, transfer, and response) and water discharge as a function of drainage area.

In general, these valley types have different physical characteristics. As you travel from steeper to gentler sloped valley segments, the bed material transitions from larger boulders and cobbles to finer sands and gravel. The amount of sediment deposited in the channel increases as the slope of the channel decreases. Typically, steeper headwater streams flow in relatively straight channels through narrow valleys. The streams are confined in the valleys. As the water moves downstream, valleys generally become wider and the slopes become gentler. Streams begin to wind around more, becoming more sinuous, with gentle channel gradients and finer bed materials.

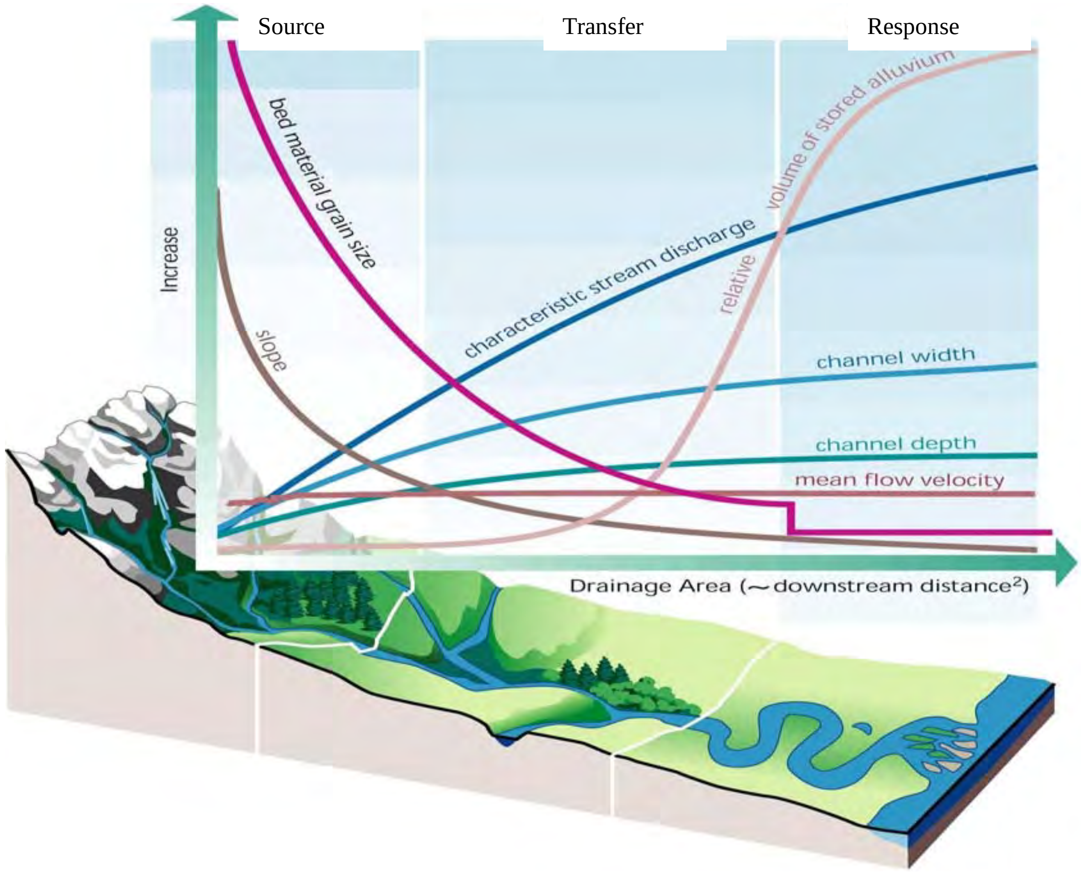


Figure 1.1 Confined, narrow, and broad valley types (from the Stream Corridor Restoration Manual, Federal Interagency Stream Restoration Working Group, 1998).

With these valley types in mind take a first cut at defining reaches based on the following reach defining characteristics, generally listed in order of priority: **stream confinement (or valley width), valley slope, geologic materials, and tributary influence** (described below).

Evaluation

Use the USGS 1:24,000 topographic maps overlain with the Vermont Hydrography Dataset (VHD) 1:5,000 stream layer to do this evaluation. There are no measurements taken during this first cut of defining reaches. It is based solely on the visual differences you observe on the maps for the reach-defining characteristics.

Before you formally label the map with the reach numbers, complete the Watershed Orientation (described at the end of this section) and Step 2 to see if any of your reach determinations will need to be refined. You may decide as you start measuring the various parameters in Step 2 that some reaches should be combined or separated. If you are using SGAT, however, which automates most of the Step 2 measurements, you will likely not want to change reach breaks once you have digitized sub-watersheds for these reaches. Be sure to give careful thought to your reach breaks and use the Watershed Orientation to quickly verify them in the field. The Watershed Orientation is particularly helpful in identifying valley walls and in understanding valley slope and confinement.

By the end of Step 2, you will have assigned each reach a "reference stream type" classification (as defined in the Program Introduction). The following discussion offers general guidelines for determining reach breaks and evaluating valley form, geology, and tributary influence to define distinct geomorphic stream reaches.

Ground Rules for Defining Reaches: Stream reaches designate a length of channel based on reference stream type characteristics that can be distinguished in some way from the reaches immediately upstream or downstream. You are encouraged to verify initial reach breaks in the field during the Watershed Orientation to see if your visual "first cut" of reaches makes sense on the ground. During Phase 2 and Phase 3 field assessments, additional stream type characteristics beyond the Phase 1 parameters of stream size, geology, valley confinement and valley slope, may influence where you decide to make reach breaks, either dividing or combining reaches based on your field observations and measurements. For reach breaks defined later in the assessment process (i.e., during Phase 2 or Phase 3) there is a "sub-reach" numbering and tracking system provided to allow for this later distinction of reaches without having to renumber and reassess Phase 1 reaches. See the Phase 2 Handbook Introduction for guidance on numbering sub-reaches.

- Choose one person to review all the reaches visually defined in your watershed in order to ensure consistency between different assessors' reach designations.
- Start defining reaches from downstream to upstream on the mainstem first and then determine the reaches on the major tributaries (again downstream to upstream).
- When a large tributary enters the mainstem, this defines a new reach on the mainstem **just above** the confluence of the tributary. (See discussion under "tributary influence" later in this section.)
- Consider creating reach breaks on the upstream and downstream ends of large alluvial fans (see Step 3.1 on alluvial fans) due to the sensitivity of these streams to both vertical and lateral adjustment.
- Consider creating reach breaks on the upstream and downstream ends of large impoundments that have changed the general shape and fluvial processes of the stream or river. Impoundments that warrant their own reach are those that are substantially wider than the natural channel. In addition, the dams creating these impoundments are typically constructed on natural grade controls (i.e., bedrock), which influence vertical channel adjustments. Small riverine impoundments may not warrant reach breaks. Though Phase 1 reaches are intended to represent reference conditions, large impoundments are a necessary exception to this rule, as they are often too modified to determine reference valley confinement and slope, thus the reason for breaking them out as their own reaches.

Evaluating Stream Confinement (valley width): Reach breaks are often made where the valley width changes. Valley width is important because it is an indicator of how confined the stream is and whether it will have access to a floodplain at different flood levels. To determine valley width differences look for relative changes in the distance between toes of opposing valley walls. The toe of a valley wall can be identified as the bottom of the more steeply sloped portion of the valley. This is evident on a topographic map as the place where the contour lines change from being widely spaced (on the gentle sloped valley floor) to being more closely

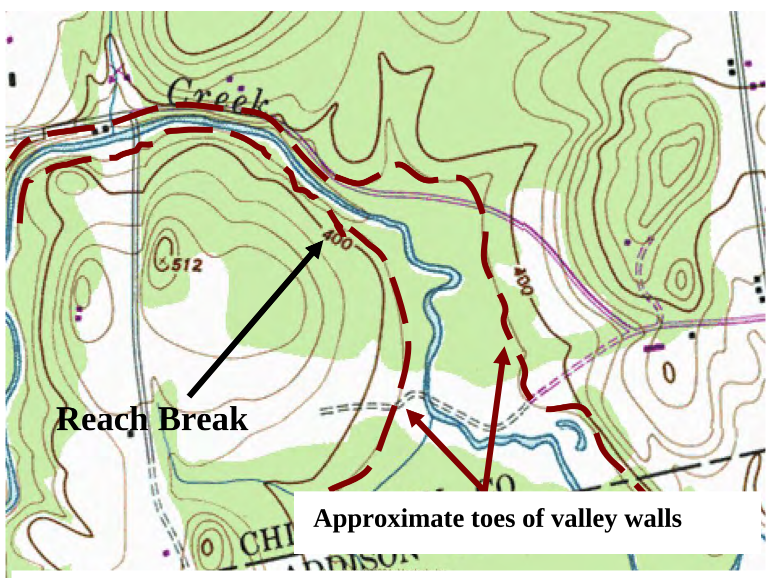


Figure 1.2 Reach break based on a change in the valley width.

spaced (on the steep valley wall). A significant change in the confinement of the stream, for example where a wide valley transitions to a narrow valley, is usually a good place to make a reach break (Figure 1.2). There may be small sections of valley that are somewhat narrower or wider than the average valley width for a given stretch of stream. If the section is less than a ¼ mile long it may not be necessary to break it out as its own reach, but rather to "lump it" within the larger section of stream. Use your judgment. If the section is significantly narrower or wider, make a reach break no matter how long the resulting reach is.

Evaluating Valley Slope: Another important valley characteristic to consider when defining reaches is the slope of the valley. To visualize the valley slope look at the distance between contour lines that cross the stream and valley floor. Widely spaced contour lines indicate a gentle slope and tightly spaced contour lines indicate a steeper slope. Make reach breaks where there is a substantial change in the valley slope. If there is only a short section of valley, less than ¼ mile, which has a different slope than the rest of the valley, it may not be necessary to break out that section as its own reach.

Table 1.1 Guide to valley slopes in defining "first cut" stream reaches.

Percent Slope	Description of slope	Approximate contour interval spacing on 1:24,000 map
> 4%	Very Steep	<0.2 in.
2-4%	Steep	~0.2 - 0.5 in.
0.5-2%	Moderate	>0.5 in.
<0.5%	Gentle	>1 in.

Another indication of valley slope and confinement is channel sinuosity, which is a ratio of channel length to valley length. Changes in channel sinuosity can be determined on topographic maps. Generally, channels in steep, confined valleys have low sinuosity, and channels in broad, gentle-sloped valleys have high sinuosity. Reach breaks may be appropriate where there is a significant change in valley slope and confinement as indicated by a channel's sinuosity (Figure 1.3). Caution is recommended, however, in using sinuosity as the basis for making a reach break, especially in those situations where the straightness of the channel may be explained by changes in land use or modifications to the channel, valley or floodplain. Do not make a separate reach for a section of a stream within a valley of similar characteristics based solely on a change in the channel sinuosity. If, for instance a high sinuosity stream within a broad, gentle-sloped valley becomes straight (low sinuosity) for a short distance and then becomes sinuous again, do not create a separate reach if the straighter section cannot be explained by differences in local soils and/or geology (as determined in Step 3).

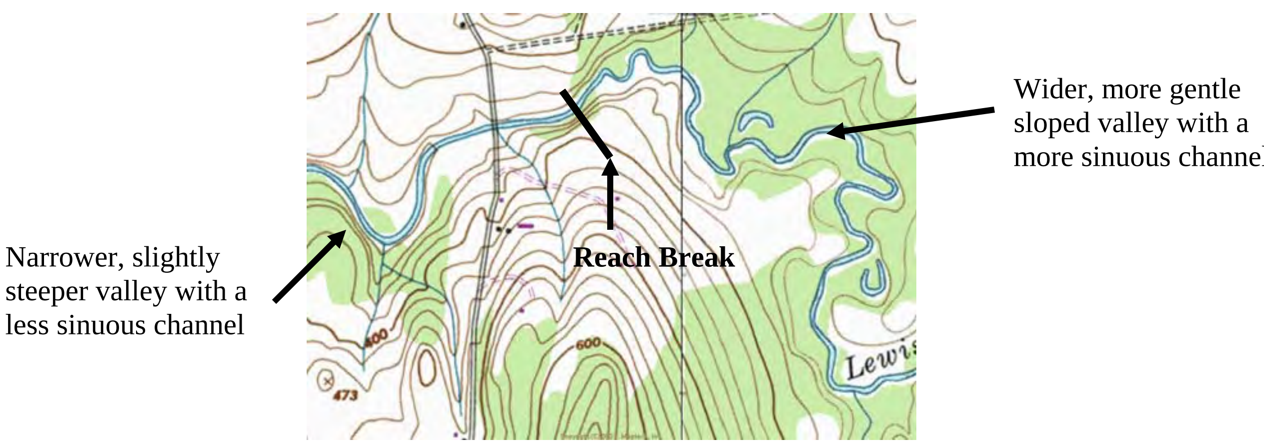


Figure 1.3 Reach break due to a change in valley slope and confinement as indicated by a change in the channel sinuosity.

Evaluating Geologic Materials: A major change in the erodibility of soils or geologic materials along the stream may justify a reach break. If you are familiar with evaluating the characteristics of soils and surficial geologic materials, you may want to consider using this type of information in determining reach breaks. This data can be found on NRCS soil survey maps available through NRCS and surficial geologic maps available through the Vermont Geological Survey. To determine if there are any significant geologic changes within your watershed, find the streams and rivers of interest on the soils and surficial geologic maps, and note any major changes in the surficial materials' characteristics, particularly erodibility. Consider these locations as possible reach breaks. Be sure to read about geologic materials in Step 3 of this Handbook and Appendix F before finalizing your reach breaks.

Evaluating Tributary Influence: The confluence of **major** tributaries is a place to consider making a reach break on the mainstem stream receiving the tributary. **Major tributaries are those that constitute 10 % or more of the primary watershed area at their confluence with the mainstem**. Delineating the watersheds of major tributaries within the primary watershed will help you identify where to make reach breaks on the mainstem based on tributary watershed size. Break the mainstem reach just above the confluence of the major tributary. This same rule applies when breaking reaches on the tributaries themselves – consider the influence of **minor** tributaries (those that feed major tributaries).

In the interest of practicality, as you begin making reach breaks in the headwaters of the watershed, you may choose to discontinue using tributary influence to determine reach breaks. In headwater areas the mainstem typically becomes a steeper, more confined channel of similar stream type throughout. Often numerous tributaries of similar watershed size come together over a short distance to make up the main channel. In these cases, you may choose to consider all of these as **minor** tributaries together, and perhaps only break a reach on the mainstem upstream of a group of confluences of these tributaries, rather than at each one.

4. Reach Numbering

Reach numbering is necessary to efficiently organize, track, and communicate reach-related data. The following objectives are also met by the reach numbering conventions described below:

- The ability to discern where a reach is located within its watershed and to be able to query for data upstream of a reach, provided by the **hydrologic number**; and
- The ability to link stream geomorphic and physical habitat data with other water resource data that has been stored electronically in other State databases, by including fields for those databases' record identifiers, such as the Vermont Waterbody ID.

Though the numbering system described below is a bit complex, this provides the flexibility needed to permit users to conduct watershed assessments at different scales, at different levels of detail, and at different times, and still be able to mesh assessment data together into a single statewide database.

Hydrologic Number: The hydrologic number is an alpha-numeric identifier that describes where a reach is located within the watershed drainage network. This number, combined with a unique project code assigned by the Data Management System, creates unique reach identifiers for reaches from different watershed assessments. This numbering system indicates into which reach a tributary enters, allowing one to evaluate the upstream watershed inputs to a reach through database queries that sort by reach number. It also provides the information needed to locate a reach within the watershed. The SGAT program facilitates the assignment of reach hydrologic numbers. See the SGAT User Manual for details.

The following numbering conventions are used to assign reach hydrologic numbers:

- **R#** designates reaches on the mainstem of select large streams within the state of Vermont (see list below). These reaches are numbered sequentially from downstream to upstream as R01, R02, R03, etc. Rivers that should be labeled with R for the mainstem include the White, Missisquoi, Lamoille, Winooski, Otter, Ompompanoosuc, Ottauquechee and the Passumpsic. If your assessment area is located within one of the watersheds listed above please contact the River Management section for further detail on how to number the reaches appropriately.

- **M#** designates reaches on the mainstem of the remaining HUC 10 size streams (those not listed above), which are numbered sequentially from downstream to upstream as M01, M02, M03…etc (Figure 1.4).
- **M#T#** or **R#T#** designates **major** tributaries on the mainstem, those that drain 10% or more of the watershed area at their point of confluence with the mainstem. These major tributaries are numbered sequentially from downstream to upstream along the mainstem as T1, T2, T3… etc. They are preceded by the M# (or R#) that designates the mainstem reach into which they flow. Individual reaches on each tributary are designated with a period and number following the tributary number (e.g., T3.01 is assigned to the first reach on the third major tributary up the mainstem).
- **M#S# or R#S#** designates **minor** tributaries to the mainstem river, those comprising less than 10% of the watershed at their confluence with the mainstem (e.g., M02S2 is assigned to the second minor tributary on the mainstem that flows into mainstem reach M02). Minor tributaries are numbered sequentially from downstream to upstream; however, the S# sequence starts over for each mainstem reach (Figure 1.5). For example, the first two minor tributaries entering into the mainstem reach M01 would be M01S1 and M01S2, and the first two minor tributaries entering into reach M02 would be M02S1 and M02S2. Individual reaches on each minor tributary are designated with a period and a number following the tributary number (e.g. M01S3.4 is assigned to the fourth reach of the third minor tributary that enters the first reach of the mainstem).
- **M#T#S# or R#T#S#** designates **minor** tributaries to the major tributaries. Additional "S" letters are added as needed to designate tributaries of tributaries of tributaries, etc. Individual reaches on minor tributaries are designated with a period and number following the tributary number. For example, M03T1.02S1.04 represents the fourth reach of the first tributary that flows into the second reach of the first major tributary, which flows into the third reach of the mainstem.

Figure 1.4 The impounded segment of stream is assigned a reach number using the SGAT ArcView extension. The reach is excluded from further geomorphic assessment in the DMS using the "exclude" option.

When starting the assessment it is essential to determine all mainstem reaches and to label at least all the major and minor tributaries to the mainstem (M#T# and M#S#) before starting to collect other data. Even if you plan to complete a Phase 1 assessment over several iterations, you should label all mainstem tributaries on the topographic maps up front to ensure that you have included all major tributaries in your numbering system. This will avoid reach numbering errors in future assessment work, preserving the capability to sort the watershed data hydrologically from downstream to upstream according to the drainage pattern. If you need assistance on where to start the numbering process contact the DEC River Management Program.

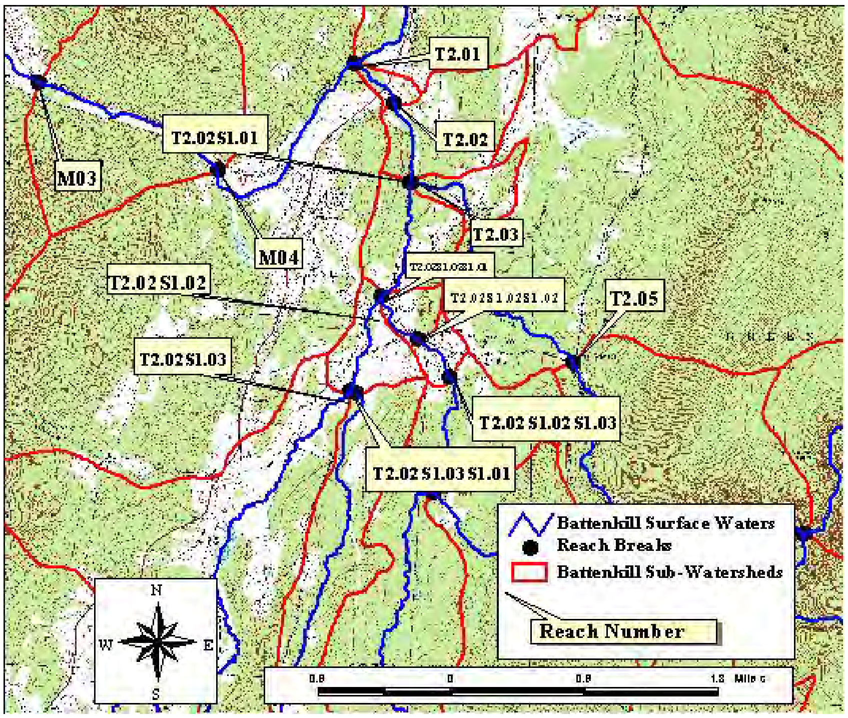


Figure 1.5 Example of reach numbering system. All reaches on tributary T1 would be preceded by M01, for example, M01T1.01, M01T1.02, etc.; for graphical presentation, it has been left off for this example.

5. Special Circumstances – Where NOT to collect data

Surface waters that are not functioning as a fluvial system, such as wetlands, ponds, lakes, and impoundments, should not be assessed using this protocol. However, to run the SGAT ArcView tool the surfacewater theme must be contiguous. Therefore if a wetland, pond, lake or other impoundment is located between reaches in the stream system it should be assigned a reach number in SGAT (Figure 1.4). SGAT will automatically collect some data, such as soils and land use, for the waterbody, and this data will be imported into the DMS. You will have an oportunivy in the DMS to "exclude" the reach from further assessment by selecting a checkbox that indicates the section of stream is impounded.

In order to prevent data entry and analysis errors in the DMS, the user can use the "exclude" button to eliminate from the dataset those reaches for which data was collected in SGAT but the complete set of Phase 1 data was not completed. **Refer to the DMS directions in Appendix B for further detail on excluding reaches.**

6. Watershed Orientation

While you may be familiar with your watershed, before beginning an assessment you may not have viewed the watershed in the context of a watershed assessment. Getting out to see the watershed and its streams by car or boat at the start of an assessment can facilitate the assessment process by answering many questions that will arise later during the assessment.

The Watershed Orientation is useful in refining and verifying the "first-cut" reach breaks. Specifically, it allows for a more detailed mapping of valley walls and field verification of valley confinement. It also provides an on-the-ground look at parameters that you will later assess from maps and orthophotos, allowing you to calibrate your eye as to how features you see on the ground appear on the maps and orthophotos. The types of information that may be collected during the orientation are listed in the table below. The Phase 1 protocol step number is listed next to each parameter and the "Notes" column suggests what to look for during the orientation.

First, read the Phase 1 protocols. Before starting the watershed orientation, overview the protocols, paying particular attention to the parameters listed in the table below so you know which features are important to note during the watershed orientation. For example, reading Steps 1 and 2 and Appendices D and E will help you successfully identify valley wall features on the topographic map.

The Watershed Orientation is not intended to be an exhaustive survey of the entire watershed that captures all notable features in the watershed. Spend as much time as you can, but do not expend so much time that it keeps you from completing the rest of the assessment. For example, it is not expected that you will see every mile of stream in your watershed and record all grade controls present. The Windshield Survey in Phase 1 Step 7 and Phase 2 assessments are designed to confirm Phase 1 observations and help fill in the data gaps over time.

Table 1.2 Parameters and map codes for use in watershed orientation surveys.

Step Number	Parameter	Map Code	Notes
2.10 and "First-cut reach breaks"	Valley Type and Confinement	Record valley toe locations on map, and generally note valley widths relative to channel widths. **Verify visual first-cut reach breaks.**	
3.1	Alluvial Fan	**AF**	Map locations of any observed alluvial fans.
3.2	Grade Controls	**GC**	Map locations and types of any grade controls observed.
4.2	Corridor Land Use / Land Cover	Become familiar with how land use/cover types appear on maps and orthophotos.	
4.3	Riparian Buffer	Become familiar with how riparian vegetation appears on orthophotos. Generally note riparian buffer widths and vegetation types.	
4.4	Groundwater Inputs	**Trib** **SS**	Map locations of any observed small tributaries and groundwater inputs (wetlands, seeps, springs) not already visible on maps
5.1	Flow Regulation / Water Withdrawal Snowmaking withdrawal Irrigation withdrawal	**Dam** **Weir** **Snow** **Irrig**	Map locations of any observed flow regulation and water withdrawal structures
5.3 and 5.4	Channel and Bank Modifications Rip-rap Tree Revetments	**rprp** **trvt**	Become familiar with how channel modifications and bank revetments appear on orthophotos.
6.1 and 6.2	Corridor Encroachments Berms Roads Development-Resid./Comm.	**B** **RD** **D-R/C**	Become familiar with how corridor encroachments appear on maps and orthophotos. Map locations of observed features that are not viewable on maps and photos.
6.3	Sediment storage Mid-channel bar Point bar Delta bar	**Mbr** **Pbr** **Dtbr**	Become familiar with how sediment deposits appear on orthophotos. Map locations and types of any observed sediment deposits not viewable on orthophotos.

Make good field maps. Take field copies of your topographic maps and orthophotos with you on the orientation surveys to record the watershed features and characteristics you observe. . You can use the maps to record new features that are not visible on the maps/photos and to verify those features that are visible on the maps/photos. Reference the field maps when completing the rest of the assessment. Standard map codes for field mapping are provided in Table 1.2. See Appendix A for additional map codes and symbols.

Using a GPS: You may choose to use a handheld GPS (Global Positioning System) unit to document feature locations that can later be imported into GIS software as a data layer. This is particularly useful in recording grade control and valley wall toe locations that are not apparent on the topographic maps, but are obvious in the field. You can then use these GPS points later to create digital data layers of grade controls and valley walls, the latter of which can be used in the SGAT program. Depending on how you plan to use the data, you may or may not need the greater level of accuracy that GPS can provide. Using a GPS unit is not required for the Phase 1 assessment and should only be considered when project goals demand a high level of accuracy for location data, as data collection and management can be time consuming. See http://www.dnr.state.wi.us/maps/gis/documents/gps_tools.pdf for information on how to use GPS.

Take good pictures to document unique features (such as grade controls) and general watershed characteristics (such as channel size and valley form) throughout the watershed. Be sure to record the number of the picture and the location that it was taken using the standard photo log form (Appendix A). If you change roles of film mark the roll with tape as to which area/locations the roll represents, and be sure to transfer this information to the envelope in which you submit your film for processing. Reference these pictures when completing the rest of the assessment.

Step 1. Reach Location

Overview

Once the geomorphic reaches have been delineated and numbered, as described in the previous section, you are ready to begin the first step in the Phase 1 assessment process, which is to formally locate your reaches. Locating the reaches involves writing a location description, identifying the Vermont municipality in which the reach is located, and providing a latitude and longitude for the upstream and downstream ends of the reach.

Reach location information serves the purpose of helping you and others find the reach on the ground during windshield surveys and later phases of Stream Geomorphic Assessment. The process of sorting, mapping, retrieving, and collating Phase 1 data is also facilitated by reach location information.

Data Sheet 1. Reach Locations

1.1 REACH DESCRIPTION

Evaluation
The reach description should help someone unfamiliar with the area to locate the reach. Try to provide as much detail to your description as you can; for example, give a distance and compass heading from a named landmark, road crossing, or road mile marker to the upstream end of the reach. All reaches should be marked on a topographic map and labeled with reach numbers.

Example: Reach M01: Off Rt. 100, 2 miles up from Rt.100 / Bridge St. intersection in Granville. Reach begins NE approximately 1/2 mile off Rt.100 just above tributary entering on the east bank.

1.2 TOWN (SGAT)

Evaluation
Version 4.56 of SGAT will automatically determine the town(s) where the reach is located. If a reach is located in more than one town**,** th**e**n SGAT lists all towns in which the physical stream, not the sub-watershed, is located. When the SGAT data is uploaded to the DMS the **town (s)** will automatically be imported for each reach.

1.3 LATITUDE / LONGITUDE & NAD 83 State Plane Coordinates (SGAT)

Evaluation
Latitude and longitude are north/south and east/west values, respectively, recorded as degrees, minutes, and seconds. Record the latitude and longitude values for the upstream end of the reach and the downstream end of each reach. Computer mapping tools such as GIS, Maptech Terrain Navigator®, and Delorme Topo USA® provide latitude and longitude as degrees/minutes/seconds. For example: Longitude 44^o 17’ 00’’N and Latitude 73^o 17’ 30’’W. If you plan to access the data in the future using ArcView or other GIS mapping software, it is important to use 1983 datum and to use decimal degrees. It is possible to convert degrees/minutes/seconds into decimal degrees by dividing the minutes and the seconds each by 60 and then adding these to the degrees: [degrees + (minutes/60) + (seconds/60)]. GIS data sets from VCGI and the ANR are generally in NAD 83 State Plane Coordinates (in meters). **SGAT will automatically generate the latitude and longitude and the NAD 83 State Plane Coordinates for each reach break.** When the SGAT data is uploaded to the DMS the latitude/longitude and NAD 83 state plane coordinates will automatically be imported for each reach.

Step 2. Reference Stream Types

Overview

Background:
Reference stream types are designated to describe stream channel forms and processes that would exist in the absence of human-related changes to the channel, floodplain, and/or watershed. Given the long history of stream channelization and human-related changes to the Vermont landscape, reference stream types are based largely on characteristics of the valley, geology, and climate of the reach.;

Evaluation:
In Step 2 you will measure stream characteristics, including valley slope and confinement, to start the process of designating a reference stream type to each geomorphic reach in the watershed. Only those stream characteristics that can be efficiently measured using maps and other remote sensing tools are evaluated in Step 2 of the Phase 1 protocols. The refinement of reference reach characteristics will continue through the entire Phase 1, 2, and 3 protocols. Verification and refinement of reference stream types is done by observing sediment and hydrologic characteristics, as well as channel, floodplain, and terrace land forms. At the end of Phase 1 Step 2 you will have a **preliminary** reference stream type designated for each reach in the watershed.

At this phase of assessment do not expect your measurements to reflect on-the-ground conditions exactly. These measurements are broad characterizations for a large area of land.

Evaluation with SGAT:

You MUST use the SGAT GIS extension to complete the assessment.

The term "SGAT" appears in parentheses after each parameter for which SGAT can be used to generate data. SGAT will generate data for the following Step 2 parameters:

2.2 valley length
2.4 channel length
2.8 valley width

Valley width and length values are only generated in SGAT for those reaches where you choose to delineate valley walls by creating a GIS polygon theme (usually done along most mainstem rivers, larger tributaries, and in some cases smaller tributaries in wider valleys). **The user MUST enter valley lengths for all reaches where the valley walls were not drawn. This data can be entered directly into the DMS or the SGAT Step 10 dialog. For those reaches which do not have valley walls in the user-supplied valley wall theme, the user has two options for determining the confinement ratio**:

1) If you can accurately estimate the valley width you should measure it and enter the values into either the Step 10 SGAT dialog or directly into the DMS. When the SGAT data is uploaded to the DMS the values will automatically be imported for each reach and the DMS will calculate the confinement ratio for you.
2) If you cannot accurately estimate the valley width than you **should not** enter any values in the Step 10 SGAT dialog box. Once the SGAT data is imported into the DMS you will have an opportunity to manually estimate the confinement for the reach.

Read the discussion under Valley Width (2.9) and Appendix E for further definition and explanation of delineating valley walls. Refer to the SGAT User's Manual for information on how to create a valley wall GIS polygon theme.

Data Sheet 2. Stream And Valley Type

2.1 DOWNSTREAM AND UPSTREAM ELEVATIONS (SGAT)

Meta Data:

- USGS 1:24,000 topographic maps
- 1:5,000 DEM
- 1:24,000 DEM

Evaluation:
Using one of the data sources listed above, record the elevation of the **downstream** end of each reach into the SGAT Step 10 data entry dialog box. The DMS uses the elevations for successive reach breaks to determine the change in elevation between reach breaks in calculating valley and channel slopes.

When reading elevations from computer mapping programs it is important to verify the elevations given by the program with those interpreted from an original USGS topographic map. Not all computer programs use corrected digital elevation models (DEMs) for their base map and this can lead to incorrect elevations. *Do not assume that the elevation given by the computer is correct.* Also, be sure that elevations on all of the topographic maps you are using are in feet (NOT METERS), as slope measurements will be incorrect if elevation units are not in feet.

Record the elevation of the contour line crossing the stream nearest the reach endpoints. If contour lines are far apart and a reach endpoint lies between, interpolate the elevation based on the distance between the contour lines. For example, a reach endpoint located halfway between the 720' and 740' contour lines would be recorded as 730'.

For reaches in gentle gradient valleys (typically < 2%), it may not be possible to discern between downstream and upstream elevations. Where this is the case, do not guess. Do not record elevations for these reaches, and check the "Gentle Gradient" check box on the datasheet and in the DMS. Phase 3 field surveys involving an established elevation benchmark are required to accurately set upstream and downstream elevations for these gentle gradient stream reaches. If the elevations are determined with a survey during a Phase 3 assessment change the meta-data in the DMS.

Data Entry:
If the downstream elevations are entered in the Step 10 dialog for each reach in SGAT then when the SGAT data is uploaded to the DMS the elevations will automatically be imported for each reach. Otherwise you have an opportunity to enter both the upstream and downstream elevations for each reach directly into the DMS.

2.2 VALLEY LENGTH (SGAT)

Meta Data:

- SGAT automated
- 1:24K topos
- 1:24K topos & 1:5K orthos

Background:

The valley length represents the straight-line distance parallel to the valley walls between the reach end-points (see Figure 2.1). Do not follow the meanders of the stream. Be sure not to "leap over" any hill-sides when measuring the valley length.

Evaluation:
Valley length values are only generated in SGAT for those reaches where you choose to delineate valley walls by creating a GIS polygon theme (usually done along most mainstem rivers, larger tributaries, and in some cases smaller tributaries in wider valleys). **For those reaches which do not have valley walls in the user-supplied theme, the user must manually measure the valley length** and enter the values in the Step 10 SGAT dialog box.

Data Entry:
When the SGAT data is uploaded to the DMS the values for valley length will automatically be imported for each reach. **If you do not enter a valley length in SGAT, you must enter them in the DMS, or the DMS will not be able to calculate the valley slope and you will not have the data necessary to determine the reference stream type.** Use the meta data in the DMS to indicate whether the valley length has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

Read section 2.4 (channel length) to understand the difference between valley length and channel length. The length of the valley (in feet) is the straight-line distance parallel to the valley walls between the reach endpoints (see Figure 2.1).

If you are using paper maps, use the scale at the bottom of the map to determine the valley length, or read the length directly from your map wheel if it has the same scale as your map. If necessary, lengths measured in miles can be converted to feet by multiplying miles by 5,280 (1 mile = 5,280 feet). If you are using computer mapping software to measure valley length and subsequent parameters, utilize the software's measuring tool and otherwise follow the same procedure for using a map wheel on a paper topographic map.

Figure 2.1 Example of valley length versus stream length.

2.3 VALLEY SLOPE (SGAT)

Data Sources:

- Step 2.1 and Step 2.2

Evaluation:
The DMS will automatically calculate the valley slope for each reach that has values for upstream and downstream elevations as well as the valley length. The DMS uses the reach endpoint elevations recorded in the SGAT Step 10 dialog box to subtract the reach's downstream elevation from its upstream elevation to get the change in elevation for the reach. Next the DMS will divide the change in elevation by the reach valley length determined in SGAT to calculate the reach valley slope. The valley slope is multiplied by 100 to get percent slope.

Example – Calculating Valley Slope

1140 ft	**upstream elevation**
- 1000 ft.	**downstream elevation**
140 ft	**change in elevation**

$$\frac{\textbf{difference in elevation (ft.)}}{\textbf{length of valley (ft.)}} = \frac{140}{4{,}000} = 0.035 \times 100 = 3.5\ \%\ \text{valley slope}$$

Data Entry:
If you did not enter upstream and downstream elevations in Step 2.1 due to an indiscernible change in elevation along the reach, use the "Gentle Gradient" check box on the data sheet (and in the DMS) to indicate valley slope.

2.4 CHANNEL LENGTH (SGAT)

Meta Data:

- SGAT automated
- Field - tape measure
- Field – GPS
- Field - survey

Evaluation:
SGAT will generate the channel length based on the 1:5000 VHD surface water theme that is registered in SGAT. Read section 2.2 (valley length) to understand the difference between measuring valley length and channel length.

Data Entry:
When the SGAT data is uploaded to the DMS the values for channel length will automatically be imported for each reach. Use the meta data in the DMS to indicate whether the channel length has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

2.5 CHANNEL SLOPE (SGAT)

Data Sources:

- Step 2.1 and Step 2.4

Evaluation:
The DMS will automatically calculate the channel slope for each reach that contains data for upstream and downstream elevations as well as the channel length. The DMS uses the reach endpoint elevations recorded in SGAT Step 10 to subtract the reach's downstream elevation from its upstream elevation to get the change in elevation for the reach. Next the DMS will divide the change in elevation by the reach channel length recorded in Step 2.4 to calculate the channel slope. The channel slope is multiplied by 100 to get percent slope. See example below.

Example – Calculating Channel Slope

1140 ft	**upstream elevation**
- 1000 ft.	**downstream elevation**
140 ft	**change in elevation**

$$\frac{\text{difference in elevation (ft.)}}{\text{length of channel (ft.)}} = \frac{140}{6{,}000} = 0.023 \times 100 = 2.3\ \%\ \text{channel slope}$$

Data Entry:
None, this is a calculation automated by the DMS.

2.6 SINUOSITY (SGAT)

Data Sources:

- Step 2.2 and 2.4 results

Evaluation:
Sinuosity is the ratio of channel length to valley length. The DMS will calculate sinuosity for those reaches where SGAT was used to measure the channel length and either the SGAT generated valley length or the valley length entered by the user into the SGAT Step 10 dialog.

In general, the narrower the valley, the closer the stream length is to the valley length, with both becoming nearly equal in length in narrowly confined valleys, resulting in a sinuosity close to 1. If the DMS generates sinuosity values less than 1 there is an error in how the valley length measurement was generated in the program. Measure the valley length on-screen to determine if a different value should be entered into the SGAT Step 10 dialog for valley length.

Example – Calculating Sinuosity

$$\frac{\text{channel length (ft.)}}{\text{valley length (ft.)}} = 6000 / 4000 = 1.5\ \text{sinuosity}$$

Data Entry:
None, this is a calculation automated by the DMS.

2.7 WATERSHED SIZE (SGAT)

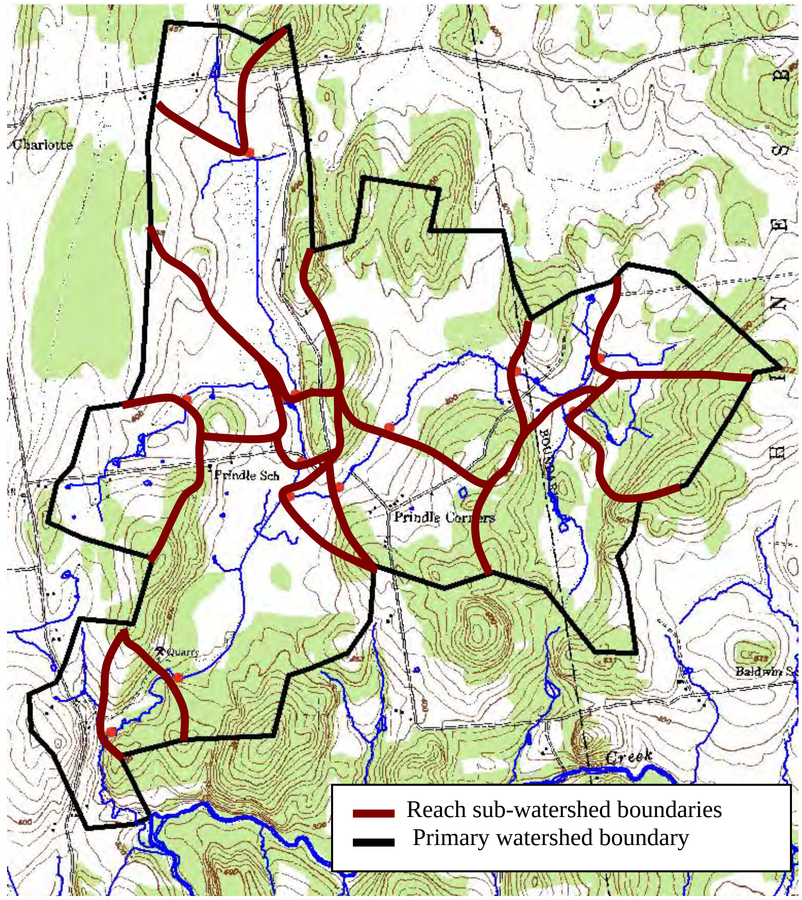


Figure 2.2 Example of reach sub-watersheds.

Meta Data:

- 1:24K DEM
- 1:24K topos, 1:5K NHD
- 1:5K DEM

Background:
Watershed size, or drainage area is defined as the area of a river basin, measured in a horizontal plane that is enclosed by a topographic divide such that direct surface runoff from precipitation normally would drain by gravity into the river basin (The National Handbook of Recommended Methods for Water-Data Acquisition, USGS, 1977). Watershed size is used for calculating reference channel width (Step 2.8), which is in turn a factor in calculating confinement (Step 2.9), meander width ratio (Step 6.5), wavelength ratio (Step 6.6), and in delineating river corridors and subsequently evaluating them for soils and land use/land cover and floodplain modification impacts (Steps 4 and 5).

Evaluation:
SGAT will determine watershed size for each reach, as well as the primary watershed size, from manually digitized reach sub-watershed GIS polygons.

Data Entry:
When the SGAT data is uploaded to the DMS the values for watershed size will automatically be imported for each reach.

2.8 REFERENCE CHANNEL WIDTH (SGAT)

Meta Data:

- HGC - SGAT Automated
- Field - range finder
- Field - tape measure
- Field - survey

Background:
Channel width, as referred to in the phase 1 protocols, means the width of the reference condition stream or river at bankfull flows, measured across the channel at the flood height that occurs on an annual to biennial basis. The channel width is generated for all reaches for the purpose of calculating confinement ratios and generating river corridors.

Evaluation:
At the Phase 1 stage of assessment you will have to rely on existing field data or a prediction of bankfull channel width calculated from the Vermont regional hydraulic geometry curve (HGC). HGCs for bankfull discharge, and channel cross sectional area, width, and depth have been developed by the River Management Program (Appendix J). At this time the curves are recommended for estimating channel width only on streams and rivers that are similar to those from which the curves were developed. This would include mid-to-large sized streams in unconfined, moderate-gentle gradient, alluvial settings. You should not rely on the curves to characterize channel dimensions for other types of streams throughout your watershed. The HGC for channel width follows the equation below, where "X" is drainage area in square miles. The DMS automatically calculates the channel width in feet by using the watershed size in square miles (calculated in section 2.7) to the 0.50 power (using the y^x function key on your calculator), then multiply this value by 10.18. Round the calculated value to the nearest foot.

Example – Calculating Channel Width

$W = 13.1(X)^{0.44}$, where X = drainage area in sq. mi.
if X = 20 sq. mi. then,
$W = 13.10\ (20)^{0.44} = 49$ feet

For some stream reaches field data exists from surveys that may have included measurements of bankfull channel width. Check for stream-related studies and other developments that would have involved cross-sectional surveys. You should consider all Phase 1 channel width data to be provisional until you can go into the field and measure reference channel width. After conducting a Phase 2 assessment you can update the Phase 1 value for channel width in the Phase 1 DMS with the measured value for those reaches where you are fairly certain that your Phase 2 data is representative of the reach's **reference** condition. *You should not enter field measured channel width values into the Phase 1 DMS if they are from a segment or reach that is in adjustment, especially those measured on over-widened streams or streams undergoing planform adjustment.*

Data Entry:
None, this is a calculation automated by the DMS. Use the meta data in the DMS to indicate whether the channel width has been confirmed or changed based on Phase 2 or 3 assessments.

2.9 VALLEY WIDTH (SGAT)

Meta Data:
- SGAT automated
- 1:24K topos
- Field - range finder
- Field - tape measure

Background:
For purposes of Phase 1 assessment the valley may be described as that land area through which the river is free to move laterally over time. A river can be prevented from moving laterally by geologic material of specific quality or quantity. Material such as bedrock, which is resistant to erosion, will limit a river's ability to migrate laterally over time. Erodible material, if in large enough quantities, may also significantly impede the lateral migration of a river over time. For example, a river that migrates into a large hillslope of erodible sand may erode the toe of the hillslope, but as material from the toe is transported downstream it is replaced by sands that slide into the river from above. Therefore, the margins of non-erodible materials and tall hillslopes are considered valley walls.

Valley width is the horizontal distance across the valley floor that is between and perpendicular to the valley side slopes (valley walls). The change from the relatively flat valley bottom to the side slope is marked by significant breaks in slope indicated by the tightening of contour lines as the valley side slopes become steeper. Some low valley terraces, depending on their soil or geologic make-up, may confine or effectively stop the lateral movement of a stream channel. In such instances it is helpful to have knowledge of soils and geologic parent material when determining valley walls, and thus valley widths. Soil and geology maps will provide some insight as to whether a stream has deposited material there before or whether the soils are erodible.

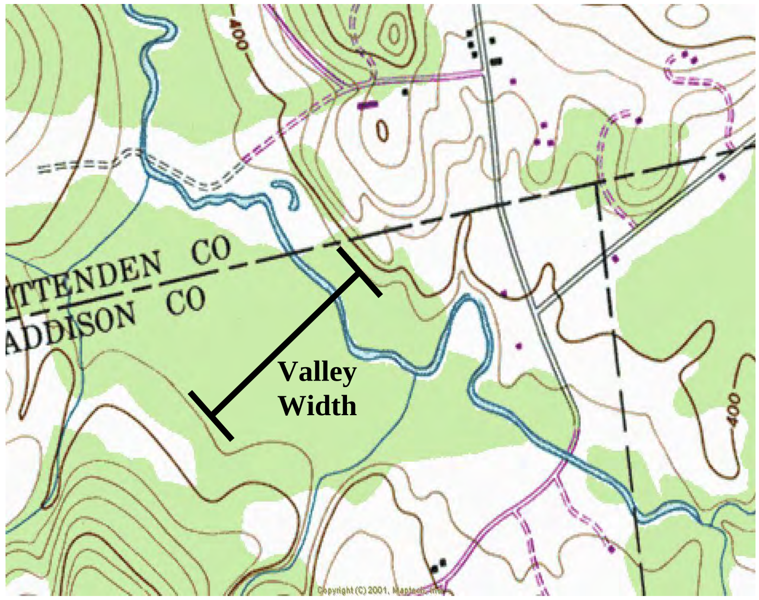


Figure 2.3 Example of valley width on a topographic map

Evaluation:
Valley width values are only generated in SGAT for those reaches where you choose to delineate valley walls by creating a GIS polygon theme (usually done along most mainstem rivers, larger tributaries, and in some cases smaller tributaries in wider valleys). **For those reaches which do not have valley walls in the user-supplied valley wall theme, the user has two options:**

1) If you can accurately estimate the valley width you should enter the values in the Step 10 SGAT dialog box. When the SGAT data is uploaded to the DMS the values will automatically be imported for each reach and the DMS will calculate the confinement ratio for you.
2) If you cannot accurately estimate the valley width than you should NOT enter any values in the Step 10 SGAT dialog box. Once the SGAT data is imported into the DMS you will have an opportunity to manually select the confinement for the reach.

If you elect to manually measure the valley widths they should be measured using the USGS topographic maps (Figure 2.3). Along the reach, measure several widths with a ruler, map wheel, or computer measuring tool and record the average valley width in feet. It may be hard to get a map-based measurement in narrow, V-shaped valleys because there is not enough topographic detail to show the true valley bottom. Use valley slope as a guide. Where it is difficult to get a sense for the width of the valley bottom and the valley slope is greater than 1.5%, label the valley as “confined” (valley types 1-NC or 1-SC, Table 2.1) pending field verification. Often in these cases, valley width is equal to or only slightly greater than channel width, but do not be surprised if this does not always hold true. Valley floors that appear narrow on a 1:24,000 topo map with 20-foot contour intervals may actually contain a floodplain that is broad in comparison to the small stream that is flowing there.

Data Entry:
When the SGAT data is uploaded to the DMS the values for valley width will automatically be imported for each reach. Use the meta data in the DMS to indicate whether the valley width has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

2.10 CONFINEMENT: Ratio of Channel Width to Valley Width (SGAT)

Meta Data:
- 1:24K topos
- 1:24K topos, SG data
- Field observation
- Field - tape measure

Evaluation:
To calculate the confinement ratio the DMS divides the valley width measured in Step 2.9 by the channel width calculated in Step 2.8. The DMS uses the categories listed in the table below to determine the confinement type. For those reaches that did not have a valley width come out of SGAT, use the table below as well as the guidance under the valley width category to estimate and manually enter the confinement ratio into the DMS.

Table 2.1 Confinement Ratios

Valley Type	**Confinement**	Ratio = Valley Width/Channel Width
NC	Narrowly Confined	≥ 1 and < 2
SC	Semi-confined	≥2 and <4
NW	Narrow	≥4 and <6
BD	Broad	≥6 and <10
VB	Very Broad	≥10 -with abandoned terraces on one or both sides

This ratio is only as accurate as the channel and valley widths used in the derivation. You should consider all Phase 1 confinement ratios and valley types to be provisional until you can go in the field, measure the reference condition channel width and the natural valley width. Where channel and valley widths are difficult to determine using remote sensing techniques, it is recommended to at least nominate a valley type for every reach. While there will be exceptions that will have to be corrected later, the analytical power of the Phase 1 DMS will be much greater when provisional valley types have been assigned to each reach.

Data Entry:
When the SGAT data is uploaded to the DMS the valley width will automatically be imported for each reach and the DMS will calculate the confinement ratio and determine the appropriate valley type. For those reaches that did not have a valley width come out of SGAT manually enter the estimated confinement type into the DMS.

2.11 REFERENCE STREAM TYPE

Meta Data:
- 1:24K topos
- Field observation
- Cross-sections, pebble counts
- Profile, cross-sections, pebble counts

Background:
Several stream classification systems have been developed to describe the physical characteristics of streams. Two of the most commonly used systems are those of Rosgen (1996) and Montgomery-

> "Delineating stream types provides an initial sorting of types within large basins and allows a general level of interpretation. Field checking the "remote sensing" mapping effort that utilizes aerial photographs and topographic maps can lead to proper interpretations. Delineation of stream types at this broad level leads to data organization and the ability to develop a set of analysis priorities for the next, more detailed level of stream classification inventory." (Rosgen, 1996)

Buffington (1997). Table 2.2 below combines several features of these systems. The reference stream type describes the natural central tendency of channel form and process that would exist in the absence of human-related changes to the channel, floodplain, and/or watershed. Given the long history of stream channelization and of human-related changes to the Vermont landscape, the reference stream type is based largely on characteristics of the valley, geology, and climate of the stream.

The Phase 1 DMS serves as a repository for reference stream type information and other provisional data until Phase 2 and Phase 3 field assessments can be conducted. Remote sensing data in the Phase 1 DMS provide a powerful tool for guiding watershed-level decisions, especially when conducting field assessments on every reach in the watershed is impractical in the near term. As the Phase 1 DMS becomes populated by reference stream type evaluations and impact ratings refined by field data, it will become an even more rigorous guidance tool for watershed planners and managers.

In a Phase 1 assessment, reference stream types are defined for each reach by evaluating reach valley slope and confinement in Step 2 and are further refined using bed form and channel substrate data collected during the windshield survey (Step 7). Assigning a reference stream type using remote sensing and windshield survey data should be considered "provisional." Field assessments (Phase 2 and Phase 3) consider other channel characteristics to assign "existing" stream types, such as the degree to which the channel can access its floodplain. Where field assessments indicate the absence of major human-related stressors and little or no channel adjustment, the field data used to type the reference condition can be used to refine the reference stream type assigned in the Phase 1 assessment (and to update the Phase 1 DMS). The Phase 1 DMS is reserved for reference stream type data in order to maintain a consistent data layer for reaches throughout the watershed (even though some evaluations may be more provisional than others). This reserves the data necessary to contrast reference stream types with the existing stream types determined in Phases 2 and Phase 3.

Evaluation:
Using Table 2.2 as well as the more detailed descriptions below to determine the stream type for each reach based on the confinement and valley slope. Record the letter/text description of the stream type on the data sheet. During windshield surveys (Step 7) you may have an opportunity to verify valley confinement, dominant bed materials, and bed forms, and thus further define the reference stream type designation. More detailed information on the variables and descriptors used in field stream typing are provided in Appendix I and described further in the Phase 2 Handbook, Step 2.14 and in the Phase 3 Handbook, Step 6.

Table 2.2 Phase 1 – Reference Stream Typing Chart

Reference Stream Type	Confinement (Valley Type)	Valley Slope
A	Narrowly confined (NC)	Very Steep > 6.5 %
A	Confined (NC)	Very Steep 4.0 - 6.5 %
B	Confined or Semi-confined (NC, SC)	Steep 3.0 - 4.0 %
B	Confined or Semi-confined or Narrow (NC, SC, NW)	Mod.- Steep 2.0 – 3.0 %
C or E	Unconfined (NW, BD, VB)	Mod.- Gentle < 2.0 %
D	Unconfined (NW, BD, VB)	Mod.- Gentle < 4.0 %

* Use the Gentle Gradient descriptor rather than a calculated slope value for those reaches where elevations were not recorded in Step 2.1. In this table the D / Braided channels may have the same valley confinement and slope characteristics as C stream types. Only set the provisional reference stream type as a D / Braided channel after observing a braided channel on the topographic maps, orthophotos, or windshield survey, or based on the presence of an alluvial fan (see Step 3.1). Only choose the E stream type (rather than C) where sinuosity values are greater than 1.5 and where windshield survey observations support this stream type assignment.

DOMINANT BED FORM / MATERIAL

Background:
The type and distribution (sorting) of material found in the bed of the stream reflects the source and supply of sediments as well as the competency of the channel to transport the sediment (a function of the channel depth and slope). Measurements of the bed material and observation of bed form help characterize the stream's ability to carry different size material.

The Phase 1 windshield survey will give you an opportunity to field verify your selected stream types consistent with the Montgomery-Buffington Stream Classification System (1997). Bed forms are examined in more detail in Phase 2 and Phase 3 field assessments when the entire stream reach is assessed.

Steeper reaches of a watershed generally have cobbles and boulders sorted into step-pool bed forms. This is because the stream easily transports smaller materials downstream and scours larger materials over relatively shorter distances into lines called steps. As you go further down in the watershed, where slopes are more shallow, the bed material generally becomes finer, moving towards sands and gravels near the mouth of most large rivers in Vermont.

Evaluation:
Choose the bed form and dominant bed material size class which best describe the reach from the menus below. Indicate "No Info" if you cannot see enough of the reach to make a determination.

Menu

Bed Forms	**Description**
Cascade	Generally occur in very steep channels, narrowly confined by valley walls. Characterized by tumbling jet and wake flow, disorganized bed materials (typically bedrock, boulders, and cobbles). Small, partial channel-spanning pools spaced < 1 channel width apart common.
Step-Pool	Often associated with steep channels in confined 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.
Plane Bed	Occur in low to high gradient and relatively straight channels 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 in reference stream condition. Channel lacks discrete bed features (such as pools, riffles, and point bars) and may have long stretches of featureless bed.
Riffle-Pool	Occur in moderate to low gradient and moderately sinuous channels, generally in unconfined valleys, and have well-established floodplains. Channel has undulating bed that defines a sequence of riffles, runs, pools, and point bars.

Bed Forms (cont)	Description (cont.)
Dune-Ripple	Usually associated with low gradient and highly sinuous channels. Dominated by sand-sized substrates. Channel may exhibit point bars or other bed forms forced by channel geometry. Typically undulating bed does not establish distinct pools and riffles.
Braided	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.
Bedrock	Lack a continuous alluvial bed. Some alluvial material may be temporarily stored in scour holes, or behind obstructions. Often confined by valley walls.
Not Evalu-ated	The reach was not accessed during the windshield survey.

Be careful, as casual observations of dominant bed material type are often biased toward the larger particles. If you can get down close to the stream, observe the smaller particles that are often entrained around larger substrates, and be sure to consider these in your evaluation of dominant bed material.

Menu

Bed Materials	Millimeters	Inches	Relative Size
Bedrock			Ledge outcrop
Boulder	256 – 4096	10.1 – 160	Basketball to Volkswagen Bug
Cobble	64 – 256	2.5 – 10.1	Tennis ball to basketball
Gravel	2 – 64	0.08 – 2.5	Pepper corn to tennis ball
Sand	0.062 – 2.00	0.002 -0.08	Silt size to pepper corn
Silt	<.062	<.002	Smaller than sand
Not Evaluated	The reach was not accessed during the windshield survey.		

Sub Class Slope:
In a Phase 1 assessment, the slope subscript is only used if the confinement and slope do not fit into one stream type category, as listed in Table 2.2. The "primary" stream type always describes the confinement and a subscript is only used if the streams slope is not within the range for the confinement type.

For Example: If a stream is semi-confined with a slope around 1.0% that it would be a stream type B_c based on a confinement of a "B" and the slope of a "C".

Menu

Slope Subscript	Slope %
a	>4
b	2-4
c	<2
None	N/A

Data Entry:
Enter stream type, subclass slope, bed form and dominant bed material size class data into the Phase 1 DMS under Step 2. Use the meta data in the DMS to indicate whether the reference stream type has been

confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

Data Entry:
The Phase 1 DMS contains menus to choose from the full complement of stream type descriptors used in the Rosgen (1996) and Montgomery-Buffington (1997) classification schemes. This way, further details of reference stream characteristics determined later in Phase 2 or Phase 3 field assessments can be incorporated in the Phase 1 watershed-wide DMS. For instance, during a Phase 1 assessment you may provisionally set the reference stream type of a reach as "B / Plane bed." Then in the field, you may determine that the dominant bed material type of the reference condition is cobble-sized. In this case, you would want to revise the reference reach stream type to a "B3 Plane bed."

Use the meta data field in the DMS to indicate whether the reference stream type for the reach was refined or changed based on windshield surveys or Phase 2 or Phase 3 assessments.

Stream Types and Aquatic Habitat

As indicated in Table 2.2, stream types are associated with specific bed forms and valley characteristics, which determine, in part, the types of habitat available for stream-dwelling organisms. In general, different species utilize different stream types, as they have adapted to specific physical, chemical, and biological components found in these different stream types. Many species will utilize more than one stream type, but few species are adapted to utilizing all stream types well. Some generalizations can be made about what species you might expect to find in certain stream types. For example, the Northern Spring salamander (*Gyrinophilus porphyriticus*) commonly inhabits very cold, well-oxygenated headwater streams and spring seeps, which are usually associated with A type, and possibly B type, streams. The physical characteristics of A and B stream types that contribute to keeping these streams cold and well-oxygenated are their narrow, steep valleys, which are typically still forested, since these valleys are often unsuitable for other land uses. The narrow valley helps shade the stream, and the forest cover slows run-off, shades the ground surface, and enhances groundwater recharge, all of which contribute to cold water temperatures in the stream. In addition, steep, confined valleys result in stream bed forms that are more turbulent (cascades and steps) which, along with cold water temperatures, result in well-oxygenated water. In contrast, the Northern Spring salamander is not likely to be found in low gradient, large rivers that are typically warmer and support other organisms, such as fish, which compete with and prey on these salamanders. Similarly, a species which is adapted to warm water temperatures and is not a strong swimmer, such as a Pumpkinseed (*Lepomis gibbosus*) will not likely be found in an A or B type streams, which are typically cold water systems with faster flows. The pumpkinseed is common, however, in low gradient, slow moving streams and rivers, which are usually C and E stream types. Due to their broad, low gradient valleys, mix of land cover types, and generally larger watershed sizes, C and E type streams are usually warmer, slower moving, and possibly less well-oxygenated than headwater A type streams and most B type streams.

Step 3. Basin Characteristics: Geology and Soils

Overview

Background:
The stream types identified in Step 2 provide basic information on how streams function, or work, to transport the water and sediment produced in their watersheds. This is critical to understanding the adjustment processes a stream may go through in response to the channel and floodplain modifications examined in Steps 5 and 6. Sediment supply, as a factor in stream equilibrium, is also related to the geology and soils of a stream's watershed. The geologic materials underlying a watershed have a strong influence on stream processes. These materials include both the solid ledge, or bedrock, and the unconsolidated sediments that overlie the bedrock. 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.

Stream reaches that have beds and banks composed of surficial geologic materials such as gravel, sand, silt, clay, or mixes of these are far more erodible than any of the types of unweathered bedrock found in Vermont. This leads to a fundamental distinction between the bedrock-controlled reaches and those underlain by surficial deposits. Stream reaches that have bedrock-controlled beds and banks are relatively static systems. The planform of a stream flowing over bedrock is largely controlled by preexisting weaknesses such as relatively soft geologic units, bedding and other layering within the rock units, and fractures in the rock such as faults or joints. Thus, a straight reach constrained by bedrock may owe its shape to a fault in the underlying rocks and a sharp bend in the stream may be due to one or more joints in the rock. Such fractures can provide an easy path for the stream to follow because the rock weathers faster along the fractures. Under present stream flow conditions, bedrock-controlled streams in Vermont are essentially fixed in position, even when viewed over time frames of a hundred years or longer.

Reaches underlain by surficial deposits can, in contrast, respond to changing watershed inputs over very short time periods. A single flood may drastically alter such a channel and the stream may be able to respond to the new conditions over a period of months, years, or decades in order to reestablish the dynamic equilibrium described in the Program Introduction.

Evaluation:
Step 3 will help you to make the distinction between bedrock and non-bedrock dominated stream systems and to subdivide the non-bedrock systems based on the erodibility of the materials in the bed and banks. You will also note features that control or accentuate certain erosion processes, such as grade controls and the steepness of valley side slopes.

The River Corridor (Created in SGAT): From Step 3 on you will be evaluating several parameters within the river corridor, which is described in detail in Appendix E. It is highly recommended that you secure the resources and expertise needed to undertake analysis of soils and geologic materials using GIS software, the SGAT extension and digital data layers. The monetary investment is well worth the time saved in reviewing and piecing together soils information from soils surveys and other geologic maps.

SGAT automates delineation of the river corridor and the characterization and summation of soil properties within the river corridor for each reach (see below). SGAT delineates the river corridor based on valley walls, meander centerlines, and standard buffer algorithms built into the software. Appendix E explains the general process that SGAT uses to draw the river corridor and the rationale behind the river corridor delineation process.

DATA SHEET 3: BASIN CHARACTERISTICS - GEOLOGY AND SOILS

3.1 ALLUVIAL FAN - CHANGE IN VALLEY SLOPE (FIT)

Meta Data:
1:24K topos
1:24K topos, SG data
1:24K topos, SG data, geologic studies
1:24K topos, field observation

Background:
An alluvial fan may form where a steep, confined stream valley becomes abruptly less confined and shallower in slope. When the stream becomes shallower, it loses velocity, which reduces its ability to transport sediment. The sediment drops out of the water, blocking the channel and leading to frequent shifts in channel location. Viewed from above, an alluvial fan often has the shape of a wedge of pie, with the narrow point at the upstream end where the confined valley widens out (see Figure 3.2). In Vermont, these fans can range from a few tens of feet to several hundred feet or more across. Excavations on alluvial fans in Vermont show that although much of the material accumulated in the first few thousand years after the end of glaciation, sediment accumulation increased dramatically on many fans in the 19th century in response to the large-scale land clearing associated with increased settlement throughout Vermont (Bierman et.al., 1997 and Jennings et.al., 2003). Since the reforestation of much of Vermont's landscape in the late 19th century and the 20th century, sediment accumulation on the fans has decreased.

Evaluation:
It is difficult to determine from map-work alone if the reach has formed on an alluvial fan. This parameter is meant to assess the **possibility** that the reach is located on an alluvial fan. A "yes" answer to this question indicates that further field work may be required. Figure 3.1 shows a possible alluvial fan. Mark possible alluvial fan locations on the topographic map with the symbol "AF". Be sure to only record an alluvial fan that occurs in the reach you are assessing, and not those in tributaries entering the reach you are assessing. These fans should be recorded for the appropriate reaches in those tributaries.

Menu

Yes	Maps suggest an alluvial fan exists in the reach.
No	Maps do not suggest an alluvial fan exists in the reach.
No Data	No data sources are available to determine if an alluvial fan exists.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Data Entry:
Use the Feature Indexing Tool (FIT) in SGAT to note the locations of alluvial fans. When the FIT data is uploaded into the DMS the data will be automatically populated for each reaches where an alluvial fan is indicated. For reaches with "no", "no data" or "none" the data field must be manually entered into the DMS.

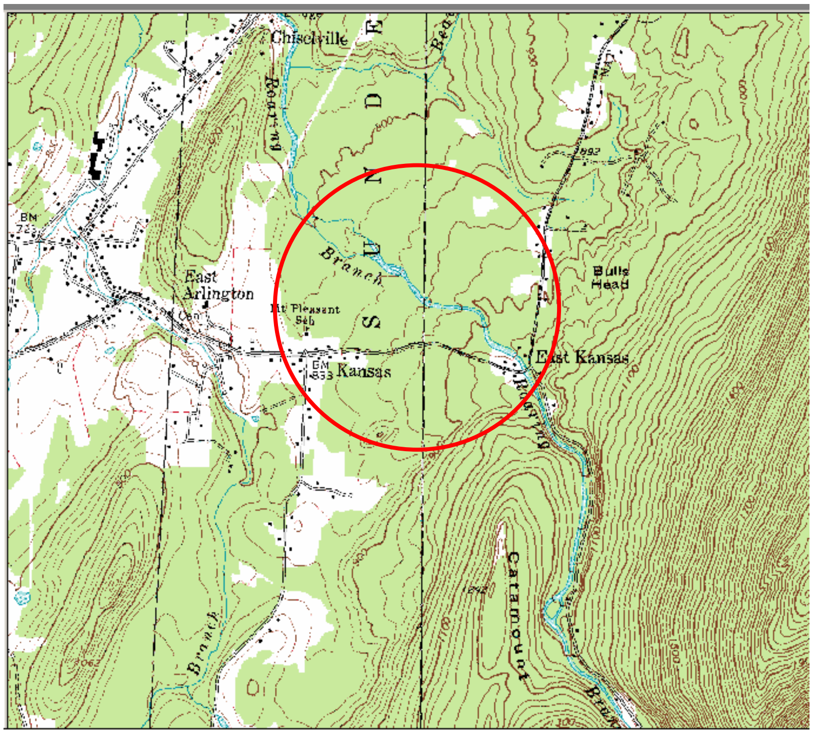


Figure 3.1 Large alluvial fan indicated by series of parallel, undulating topographic lines.

3.2 GRADE CONTROLS (FIT)

Meta Data:

- 1:24K topos
- 1:24K topos, bedrock map
- 1:24K topos, bedrock map, dam inventories
- 1:24K topos, field observation.

Background:

Grade control, as defined here, is a permanent feature that may impound or slow the water upstream of the feature and limit the ability of a river to cut down into its bed. These physical features provide grade control (Figure 3.3)**.** These features **must** be channel spanning, meaning they go from bank to bank across the channel. Features that provide grade control include:

- dams and weirs;
- bedrock: waterfalls and ledge drops that span the width of the river channel

Grade control is important because it keeps the base elevation of a river from being lowered. When the base elevation is lowered several adjustments typically occur:

- bed forms such as steps and riffles are eroded and floodplain access may be lost;
- vertical channel adjustments propagate upstream, causing channel incision and bank erosion;
- the channel widens during floods introducing sediment into the river system from bank erosion;
- the water table may lower, affecting channel flows, riparian vegetation, and domestic wells; and
- human investments, particularly roads and bridges, can be undermined.

Some grade controls may serve as barriers to movement and migration of aquatic biota. Dams, weirs, and falls, may prevent the upstream and, in the case of some dams, downstream movement of stream-dwelling organisms, particularly fish. Phase 1 results for grade controls can be used to guide further assessments of aquatic habitat connectivity in Phase 2. Bridge and culvert assessments are also important components of assessing aquatic habitat connectivity (see Appendix G: ANR Bridge and Culvert Assessment protocols). Vermont Fish and Wildlife Department fisheries biologists can provide information about known fish migration barriers and can help evaluate suspected barriers.

Evaluation:
Indicate known dams, weirs, waterfalls, or bedrock ledges that completely cross the channel. Mark these on the topo map with the letters "GC." Most grade controls are identified in the field, so make sure to note them during the watershed orientation (Step 1) and during the windshield survey (Step 7).

Menu

Dam	Constructed dam or weir
Ledge	Bedrock ledge
Waterfall	Bedrock that extends across the channel and forms a vertical, or near vertical, drop in the channel bed
Weir	At-grade or low cross-channel structures
No Data	No data sources are available to determine if grade controls exist.
None	The parameter was researched and no evidence of grade controls can be found.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Data Entry:
Use the Feature Indexing Tool (FIT) in SGAT to note the locations of grade controls. When the FIT data is uploaded into the DMS the data will be automatically populated for each reaches where a grade control is indicated. For reaches with "none", "no data" or "not evaluated" the data field must be manually entered into the DMS.

Figure 3.2 Natural, ledge grade control (left) and dam grade control (right).

3.3 GEOLOGIC MATERIALS (SGAT)

Meta Data:

- NRCS digital soil survey

Background:

Stream equilibrium is, in large part, a function of the size and quantity of sediment which is transported by the stream (i.e., stream type is dictated by sediment regime). Insights to stream type and sediment regime may be made by evaluating the surficial geologic materials available for transport in the watershed and river corridor. The Soil Surveys of the NRCS contain a wealth of information, including interpretations of the surficial geologic materials. Every soil series (the basic soil subdivision) has been assigned a parent material classification. The parent material is defined by NRCS as "...the unconsolidated material, mineral or organic, from which the soil develops" (Natural Resources Conservation Service, 1999, Part 618.40). Geologic materials can also be determined from the surface geologic maps produced by the Vermont Geological Survey, though these maps are at a fairly coarse scale. Descriptions of geologic materials and sources of geologic information are provided in Appendix F.

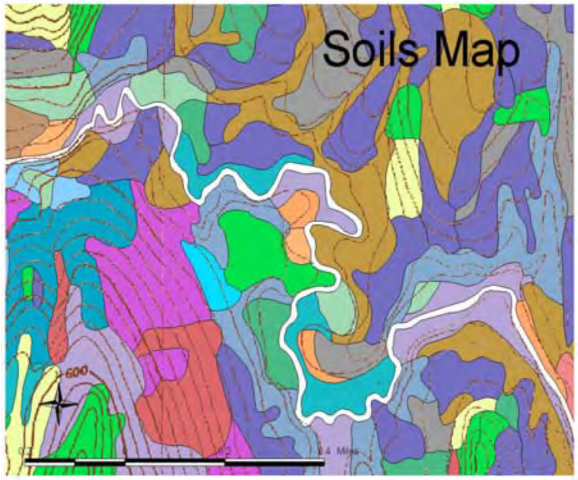


Figure 3.3 Example of NRCS soil survey

Evaluation:

This step is automated with the use of SGAT. SGAT delineates the river corridor as a polygon and then uses the corridor polygon to clip soils information from the NRCS soils maps. SGAT automatically excludes any surface water in the NRCS theme in the analysis. From this SGAT generates a table named "S14SC12." **When the SGAT data is uploaded to the DMS the Soil Properties will automatically be imported for each reach.**

Menu

Material	**Description**	**Soils** **Top 20 Table* Codes**	**Erodibility**
Alluvium	Alluvial – river sediments	A = alluvial	High
Ice-Contact	Glacio-fluvial – glacial river deposits	GF = outwash	High
Glacial Lake	Glacio-lacustrine – glacial lake deposits	GL = lacustrine	Moderate – High
Glacial Sea	Glacio-marine – glacial sea		Moderate – High
Till	Till – glacially deposited sediments	DT = dense till GT = glacial till	Moderate – High
Colluvium	Rock fall and landslide deposits	NA	Variable
Bedrock	Bedrock	NA	Low
Other		M = miscellaneous O = organic deposits	

Data Entry:

When the SGAT data is uploaded to the DMS the percentage of each geologic material will automatically be determined for each reach.

3.4 VALLEY SIDE SLOPES

Meta Data:
- 1:24K topos
- 1:24K topos, soils slope data
- 1:24K topos, field observation.

Background:
Identifying the presence of steep adjacent side slopes in combination with data on the erodibility of the soils and geologic materials in the river corridor will enable you to query the Phase 1 database for information on erosion potential, watershed sediment supply, and potential mass failure sites.

Menu:

Classification	Percent Slope
Flat	0-3%
Hilly	4-8%
Steep	9-15%
Very Steep	16-25%
Extremely Steep	>25%

Evaluation:
Using topographic maps, describe the typical valley side slopes on the right and left sides of the valley, as viewed looking downstream, using the categories provided in the menu table. Valley slopes can be measured off of USGS topographic maps in the same way as described for calculating valley and channel slopes in steps 2.3 and 2.5.
Use the Windshield Survey (Step 7) to verify valley side slope data.

The NRCS soil surveys (Figure 3.4) are also useful for estimating valley side slopes. The last letter in the three-letter abbreviation for soil types indicates the slope of the land. For example, on a soil survey map a soil polygon may be labeled "BeC," which is a Berkshire (Be) soil with a C slope. The breaks between the various NRCS slope classes vary between soil series. Thus, in one soils series an "A" may range from 0 to 2%, while in another an "A" slope may range from 0-3%. There are guides in each NRCS soil survey explaining different soils and their properties.

With a GIS program digital topographic maps can be overlain, using the DRG Tools extension, onto the digital soils layer. Since each soil type has a slope range, using the soil slope values in conjunction with the topographic lines will result in a more accurate evaluation of valley side slope.
Link the attribute table of the soils layer with the NRCS Top20 table to determine the slope range of each soil type.

Data Entry:
Manually enter the data for valley side slope for the right and left valley into the DMS for each reach.
Note: The right and left bank are determined facing downstream.

3.5 SOIL PROPERTIES (SGAT)

Meta Data:
- NRCS digital soil survey

Background:
Similar to geologic materials, soils information contributes to the understanding of sediment regime and may be particularly useful in explaining the channel condition (stream type and departure) and the adjustment processes occurring in a reach. In addition, knowing the types of soil and their properties within the river corridor may be valuable in an assessment of water quality, where soils are subject to erosion during stages of channel evolution.

There are several categories of information contained in the NRCS soil surveys that are particularly useful in watershed analysis. These include detailed information on engineering properties of the different soil types, such as permeability, grain size, hydrologic group, depth to bedrock, and depth to seasonal high water table. Soils information can help to characterize the erodibility of the soils, the ability of water to infiltrate into the soils, and the ways in which the soils were created.

Evaluation:
SGAT delineates the river corridor as a polygon and then uses the corridor polygon to clip soils data from the digital NRCS soils surveys. SGAT generates a table named "S14SC12," which sums the soil types and dominant soil property characteristics (for the four soil properties discussed above) within the river corridor for each reach. **When the SGAT data is uploaded to the DMS the Soil Properties will automatically be imported for each reach.**

Data Entry:
When the SGAT data is uploaded to the DMS the percentage of each of the soil properties will automatically be determined for each reach.

Hydrologic Group: Hydrologic groups for soil types are listed in the NRCS Top 20 table and are grouped according to their runoff characteristics. Some soils are assigned to two hydrologic groups. Dual grouping is used for one of two reasons: (1) Some soils have a seasonal high water table but can be drained. In this instance the first letter applies to the drained condition of the soil and the second letter to the undrained condition. (2) In some soils that are less than 20 inches deep to bedrock, the first letter applies to areas where the bedrock is cracked and pervious and the second letter to areas where the bedrock is impervious or where exposed bedrock makes up more than 25 percent of the surface of the soil.

The chief consideration is the inherent capacity of soil, when bare of vegetation, to permit infiltration. Soils are assigned to four groups. Group A consists of soils that have a high infiltration rate when thoroughly wet and a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. Group D, at the other extreme, consists of soils that have a very slow infiltration rate and thus, high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over impervious bedrock or other hard material.

Menu

Hydrologic Group	**Description**
A	High infiltration rate – low runoff potential.
A/D*	Seasonally variable: high infiltration rate with low runoff potential **OR** undrained, slow infiltration rate with high runoff potential.
B	Medium/High infiltration rate
B/D*	Seasonally variable: Medium/High infiltration rate - low runoff potential **OR** undrained, slow infiltration rate with high runoff potential.
C	Medium/Slow infiltration rate.
C/D*	Seasonally variable: Medium/slow infiltration rate- low runoff potential **OR** undrained, slow infiltration rate with high runoff potential.
D	Slow infiltration rate – high runoff potential.
Not Rated	Not rated or no hydrologic group assigned.
No Data	Soils data is not available for the study area.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Flooding: Flooding characteristics for soil types are listed in the Top 20 table under the "frequency of flooding" category. Soils formed in floodplains are indicative of areas where historical channel migration has occurred. Silts and sands are carried by floodwaters and deposited in the floodplain. Over time these floodplain soils can build into deep, rich deposits. The presence of floodplain soils can be used to determine historic channel migration areas. This information is listed under the description of each soil.

Menu

Flooding	Description
None or Rare	Soil texture not indicative of frequent flooding.
Occasional	Soil texture indicative of occasional flooding.
Frequent	Soil texture indicative of frequent flooding.
Not Rated	Frequency of flooding not indicated for soil type.
No Data	Soils data is not available for the study area.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

HEL Class : Determine the erodibility of soils and estimate the percentage of the reach that contains soil materials that are highly or potentially highly erodible. One option for evaluating this parameter is to read the general description of each soil and use the erosion potential of the soil with no vegetation as the erodibility value assigned to the soil. The overall percentage of highly and/or potentially highly erodible soil values for the reach can be used to choose an appropriate value from the menu below. For example, if the value for highly erodible is 20% and the value for potentially highly erodible is 35%, the overall percentage is 55% and the reach would be considered in the "severe" category for erodibility.

Highly Erodible Land (HEL) is soil erodibility factor which represents both susceptibility of soil to erosion and the rate of runoff, as determined by the USDA Natural Resource Conservation Service (NRCS). The NRCS uses a number of equations, including the Universal Soil Loss Equation (USLE) to determine, for each map unit, a relative index of susceptibility of bare, cultivated soil to particle detachment and transport by rainfall.

This value is for the erosion caused by overland flow on unvegetated soils and does not directly indicate the erodibility of the soils as it relates to the power of the stream working on them. So be aware that a soil type that is listed as being "not highly erodible" may still erode when a stream is working against it. Contact NRCS soil scientists for more information about soil erodibility

Menu

Erodibility	Percentage of reach which contains soils with HELCLASS highly erodible and/or potentially highly erodible
Slight	0 – 25 %
Moderate	26 – 50 %
Severe	51 – 75 %
Very Severe	76 – 100 %
No Data	Soils data is not available for the study area.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

***Water Table*:** Water Table information is usually listed in the Top 20 table or the Water Features table of NRCS soil surveys. Enter the values under both the "watershall" and "waterdeep" categories. Choices are in feet below ground surface, ranging from 0 to >6 feet. This information can be used to determine groundwater inputs to the stream.

Hydric: A hydric soil is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. The concept of hydric soils includes soils developed under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation. The presence of a hydric soils may indicates that wetlands are present. Vegetation and hydrology must also be considered when making a wetland determination.

Hydric	Description
Yes	At least one of the major components in the map unit is hydric
No	None of the major components in the map unit is a hydric soil.
Unknown	Unknown if the major components of the map unit is hydric.
Not Rated	Hydric classification was not noted for the map unit.

Geology and Aquatic Habitat

The geological setting in which a stream is located influences a stream's valley form and bed and bank substrate size and erodibility. These geological influences affect channel form and sediment transport processes, which in turn determine, in part, instream habitat suitability for stream-dwelling organisms. Instream physical habitat is evaluated in detail in Phase 2.

In addition to these physical effects, geology also largely determines a stream's water chemistry, another critical component of aquatic habitat. The weathering of rocks results in various carbonate compounds dissolved in surface waters. These compounds determine a stream's buffering capacity and pH levels, the latter of which can directly influence an organism's health. In general, highly calcareous rocks (those that contain a lot of calcium carbonate, such as limestone) foster streams with high buffering capacity that can maintain a fairly stable pH level within a range that supports aquatic biota. Most igneous rocks, such as granite, do not contain abundant carbonate minerals, and typically result in streams with low buffering capacity. These streams have greater susceptibility to pH swings and low pH levels that can be detrimental to aquatic biota. Figure 3.5 shows a general distribution of calcareous and non-calcareous bedrock types in Vermont. Various studies have also shown that streams rich in cations (especially calcium and magnesium, which are often associated with bicarbonate) are more productive biologically (Allan: 1995), supporting more abundant, and often more diverse, aquatic communities.

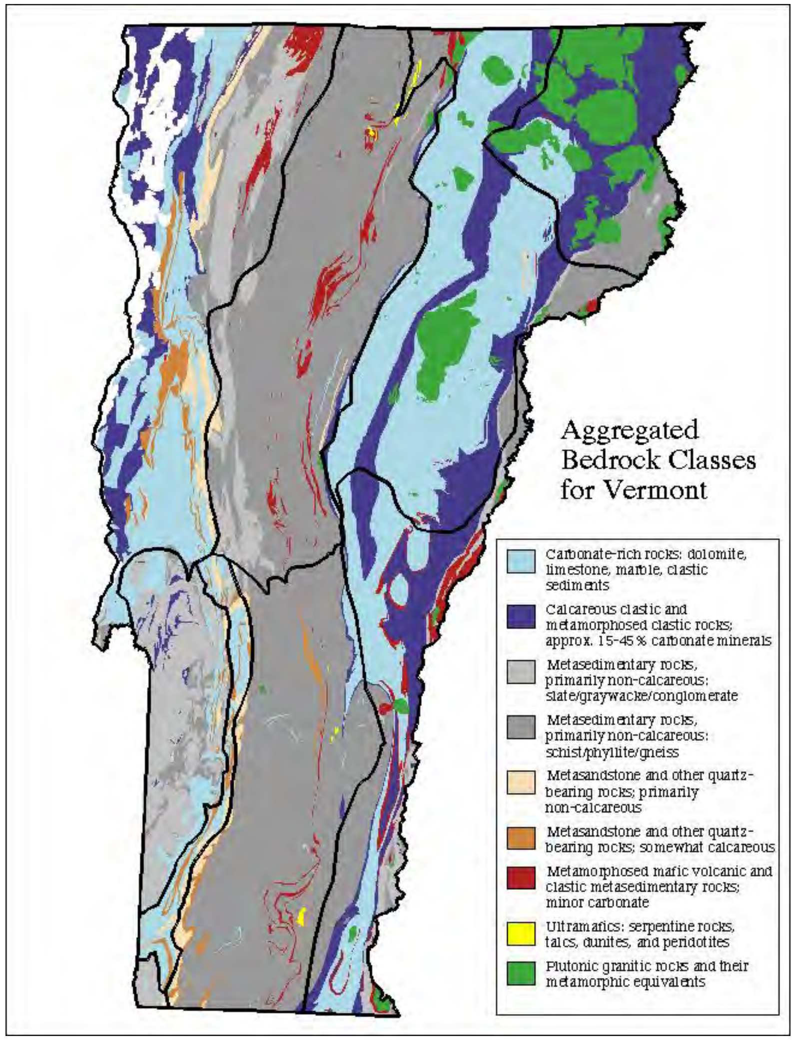


Figure 3.4 This map shows the distribution of calcareous and non-calcareous bedrock types in Vermont. Lake water quality studies conducted by the Vermont Department of Environmental Conservation have shown that bedrock type heavily influences lake buffering capacity, with those lakes having the lowest alkalinities (generally < 25 mg/l) occurring in areas dominated by non-calcareous bedrock types (Clarkson 1982). Though data is insufficient to compare stream alkalinity with bedrock type in Vermont, it can be presumed that, in general, stream alkalinity levels follow a similar pattern.

Step 4. Land Cover and Reach Hydrology

Overview

Background:
Step 4 evaluates how watershed land use, riparian vegetative cover, and other hydrologic features influence the quantity and rate of water and sediment run-off that may occur in a reach after storm events. Changes in runoff characteristics may explain observed changes in channel size and shape, why the channel is adjusting, or why the channel may be sensitive to further modifications. For instance, two watersheds with similar valley shapes, geology, and soils, may have very different sized streams due to markedly different amounts of vegetative cover next to their channels or within their watersheds. A relatively narrow, deep, riffle-pool stream may become very wide and aggraded (filled in with sediment) if the riparian vegetation is removed.

Evaluation:
You will interpret changes in run-off characteristics in the steps using the data sources listed below. You may also have first-hand knowledge of land cover/land use changes that you want to consider when interpreting map and orthophoto information.

Land cover/land use (LcLu) analysis will be conducted using SGAT, which automates delineation of the river corridor and the summation of LcLu types within the river corridor and watershed for each reach (see below).

Data sources:

- GIS coverages - A statewide land cover / land use GIS coverage is available from the Vermont Center for Geographic Information (VCGI). Please contact the River Management Section to obtain the LcLu statewide land use data. The data from which it was created was produced in 2002, possibly making the data obsolete for areas that have developed recently. It is important that you field verify LcLu data, particularly within the river corridor. Many regional planning commissions and towns also have GIS coverages available and can provide printed maps for a fee upon request. When using a GIS coverage be sure to note when the data was created. In some areas even data collected 10 years ago may be obsolete for determining current land cover.
- Aerial photos and orthophotos - Photographs are available at most NRCS offices, the Department of Environmental Conservation Water Quality Division, and some regional planning commissions. Your town office may also have aerial and orthophotos available. Orthophotos are available for purchase from the VT Tax Department Mapping Program. Note that the Vermont Mapping Program provides every town with a set of orthophotos for the town's geographic area, and that these photos are usually available for use at town offices.
- Local knowledge - If you suspect rapid land use changes in your watershed, consult land managers, town officials, and citizens who can inform you of recent land use changes. Town tax maps can assist in tracking changes in residential and commercial development.

Evaluation with SGAT:
SGAT generates total surface area for each land cover/land use (LcLu) type within each reach's watershed (Step 4.1) and river corridor (Step 4.2).

Data Sheet 4. Land Cover-Reach Hydrology

4.1 WATERSHED LAND COVER / LAND USE (SGAT)

Meta Data:
- Land use – land cover (2002 statewide)
- Land use - land cover (1990s statewide)

Background:
Lakes, wetlands, and perennial vegetation play an important role in a watershed by storing water and trapping sediment, which helps to reduce flood peaks and maintain summer base flows in rivers and streams. Urban development and cropland typically increase the peak and change the duration of storm-water and sediment runoff events.

Evaluation:
SGAT clips the current LcLu layer to the reach sub-watersheds and generates a table named "**S14LW13**" that sums the percent area of each LcLu type in the reach watershed. This is done in Step 13 of SGAT. This table can be imported into the DMS where the dominant and sub-dominant LcLu types and percent composition for each reach's watershed are automatically calculated and stored.

For **historic** LcLu consult the 1970's series orthophotos. Older aerial photos, town tax maps, and local knowledge may also indicate or confirm land cover changes.

In consideration of the time commitment necessary to conduct an accurate assessment of LcLu from historic orthophotos that have not been digitized, you may decide to focus only on those sub-watersheds where visually significant changes have occurred (i.e., noticeable increases or decreases in urban or crop land). Since you will be looking at the 1970s orthophotos later in Step 6.4 to assess meander migration, this may be the most efficient time to red flag those sub-watersheds that merit an assessment of historic land cover/land use. Visually estimate dominant historic LcLu from maps, aerial photos, and orthophotos, or find the resources and/or assistance to have the historic orthophotos for sub-watersheds of interest digitized to complete the same GIS-based analysis that can be done with digital layers for current LcLu.

Menu

Wetlands	Open water (lakes, ponds, reservoirs, streams) and wetlands.
Forest	Coniferous and/or deciduous forest – rural **low** density development.
Shrub	Small trees, shrubs, and unmanaged grasses.
Field	Agriculture – pasture or hayfield / orchard.
Crop	Agriculture – land tilled to grow crops.
Urban	Moderate to high density residential, commercial, industrial, roads.

Impact Rating for Watershed Land Cover/Land Use

H	High - 10% or more of the reach watershed is crop and/or urban
L	Low - Between 2 and 10% of reach watershed is crop and/or urban
NS	Not Significant - Less than 2 % of reach watershed is crop and/or urban

Data Entry:
When the SGAT data is uploaded to the DMS the percentage of each land use in the watershed will automatically be determined for each reach. The historical land use in the watershed must be manually entered into the DMS.

4.2 CORRIDOR LAND COVER / LAND USE (SGAT)

Meta Data:

- Land use – land cover (2002 statewide)
- Land use - land cover (1990s statewide)
- Digital corridor land use - land cover

Background:

Land use/land cover within the stream corridor is particularly important with respect to sediment deposition and erosion during annual flood events. Wetlands, ponds, and perennial vegetation moderate storm water and sediment runoff, while the impervious surfaces within urban areas and the exposed soils found in cropland have the potential to increase watershed inputs.

Evaluation with SGAT:

SGAT will clip the current digital LcLu layer to the reach corridor and generate tables that can be automatically uploaded into the DMS where the dominant and sub-dominant LcLu types and their percent coverages within each reach's river corridor will be calculated and stored. Be sure **not** to sum the data for the entire corridor area upstream of the reach break; skip SGAT Step 13 for this parameter. This parameter is only for the corridor of the reach. The SGAT table needed for this step is **S14LC12**.

Menu

Wetland	Open Water (lakes, ponds, reservoirs, streams) and wetlands.
Forest	Coniferous and/or deciduous forest.
Shrub	Small trees, shrubs, and unmanaged grasses.
Field	Agriculture - pasture or hayfield / orchards, groves, nurseries.
Crop	Agriculture - land tilled to grow crops.
Residential	Developed land with rural roads and houses and land that is managed as lawn.
Commercial	Developed land with retail businesses and larger state roads and Interstate highways.
Industrial	Developed land with industry.

Impact Rating for Corridor Land Cover/Land Use

H	High - 10% or more of reach corridor is crop **and/or** developed
L	Low - Between 2 and 10% of reach corridor is crop and/or developed
NS	Not Significant - Less than 2 % of reach corridor is crop and/or developed

Data Entry:

When the SGAT data is uploaded to the DMS the percentage of each land use in the corridor will automatically be determined for each reach. The historical land use in the corridor must be manually entered into the DMS.

4.3 RIPARIAN BUFFER WIDTH (FIT)

Meta Data:

- 1:5K orthos
- Digital corridor land use - land cover
- 1:5K orthos, recent coverages & photos, field observation

Background:
The riparian buffer is the area of land directly adjacent to the channel along the channel's banks and floodplain which is covered with native woody vegetation and largely unmanaged (i.e. allowed to grow naturally with no cutting or cultivation). Riparian buffers protect and enhance water quality, fish and wildlife habitats, aesthetics, and recreational values associated with streams and rivers. The roots of grasses, shrubs, and trees are critical to the ability of stream bank soils to withstand the erosive power generated during high water events. Streams without riparian vegetation often experience high rates of lateral erosion and may see such large increases in sediment that they undergo major adjustment of channel dimension, pattern, and profile. Riparian vegetation plays an important role in aquatic ecosystems by providing food and cover for stream-dwelling organisms as well as habitat and travel and dispersal corridors for terrestrial wildlife.

Evaluation:
Using orthophotos, estimate the dominant and sub-dominant buffer width category along the right and left banks (determined facing downstream) of the reach. It is likely that the reach you are evaluating has varying buffer widths along its length. *The dominant width is not the average width* but rather the width category (from the menu) that occurs most often throughout the reach (see example in Figure 4.1). If you are using GIS software you can overlay the VHD stream layer on the orthophotos and use the software's buffering tool to delineate the buffer width categories in order to help visualize the buffer condition.

Menu

5 to 25 feet
26 to 50 feet
51 to 100 feet
> 100 feet

Fallow land, historically cleared and/or cultivated and now reverting back to woody vegetation, may be difficult to interpret using orthophotos. If during windshield surveys or Phase 2 assessments you encounter fallow fields reverting to woody vegetation along a stream reach (but assessed here as having no buffer), you should revise the Phase 1 data. Agricultural and lawn or other highly managed household vegetation is not considered part of the riparian buffer.

Using the FIT in SGAT index the sections of the stream that have a buffer width less than 25 feet in width. This will help in the identification of potential buffer enhancement projects.

Impact Rating for Riparian Buffer Width (Automated by the DMS)

H	High – Greater than 20% of the right and/or left bank has a buffer <25 feet.
L	Low – Between 5-20% of the right and/or left bank has a buffer <25 feet
NS	Not Significant – Less than 5% of the right and/or left bank has an inadequate buffer.
No Data	No data sources are available to determine the width of the riparian buffer.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Data Entry:
Enter the dominant and sub-dominant buffer width into the DMS. Use the FIT to index areas of stream with less than 25 feet of buffer.

4.4 GROUNDWATER & SMALL TRIBUTARY INPUTS

Meta Data:
- 1:24K topos, 1:5K NHD
- 1:24K topos, 1:5K NHD, NWI maps
- 1:5K NHD, NWI maps, field observation

Data Sources:
- USGS 1:24,000 topographic maps (hard copy, or digital)
- Vermont Hydrography Data Set (VHD) 1:5,000 stream coverage (if you don't have access to this coverage use surface waters on USGS 1:24,000 topographic maps)
- National Wetlands Inventory (NWI) maps
- The NWI maps for Vermont are produced by the U.S. Fish and Wildlife Service and are developed from aerial photo interpretation and limited field checking. The Vermont maps are mostly based on 1:80,000 scale color infrared aerial photos taken in 1978. These maps show the general locations of wetlands, ponds, lakes, and streams and are available in digital format from the U.S. Fish and Wildlife Service National Wetlands Inventory at http://www.nwi.fws.gov/. Paper copies of the maps can be obtained from the DEC Water Quality Division.
- Vermont Significant Wetland Inventory (VSWI) maps
- The VSWI maps are regulatory wetland maps produced from the NWI maps by the Vermont Agency of Natural Resources. A GIS data layer has been produced from these maps and is available from VCGI. Note that the regulatory wetlands shown on the VSWI maps are a subset of all of the various wetland and deepwater habitats shown on the NWI maps. For more information, contact the Vermont Wetlands Office at 802-241-3770.
- Local Knowledge

Background:
Groundwater plays an important role in maintaining healthy aquatic ecosystems. When Vermont's streams and rivers are experiencing temperature extremes (during both winter and late summer), groundwater inputs are essential in moderating water temperatures such that streams remain habitable and productive for aquatic organisms. Fish adapted to cold water habitats, such as Brook Trout (*Salvelinus fontinalis*), are particularly sensitive to water temperature, and will often move to areas of a stream that are fed by groundwater upwellings, springs, or seeps to overwinter or seek refuge during the hot summer months. In addition to moderating water temperatures, ground water is essential in maintaining stream flows, and thus available habitat, during late summer and during drought years when most of the base flow in streams is provided by groundwater.

Evaluation:
Using the VHD 1:5000 stream coverage, wetland maps (see below), and local knowledge, estimate the abundance of groundwater inputs that flow directly to the channel from adjacent wetlands, small tributaries, springs and seeps. If you do not have access to a 1:5,000 stream coverage, use the 1:24,000 USGS topographic maps. Although small tributaries may not be shown as blue lines on topographic maps, they are usually present in areas where contour lines form tight upside-down V's (see Appendix D about reading topographic maps).

Menu

Abundant	Frequent wetlands, seeps, springs, or small tributaries adjacent to channel.
Minimal	Occasional wetlands, seeps, springs, or small tributaries adjacent to channel.
None	No wetlands, seeps, springs, or small tributaries adjacent to channel.
No Data	No data sources are available to determine if the impact exists.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Data Entry:
Manually enter the data for groundwater and tributary influence into the DMS for each reach.

Step 5. Instream Channel Modifications

Overview

Background:
Most of the information you have collected so far, with the exception of riparian corridor and watershed land use, has defined the natural fluvial geomorphic setting of the stream reaches within your watershed. Before assessing the impacts associated with instream channel modifications, it is important to remember these assumptions made for conducting these stream geomorphic assessments:

- Although rivers are dynamic, changing their channel form (or geometry) continually through erosion and depositional processes, they have a central tendency of form and process that has a predictable relationship with surrounding watershed land forms and which may undergo significant change naturally with climate changes over time; and
- Human-related physical change to river channels, floodplains, and watersheds often mimic and/or change the rate of natural physical processes in the watershed.

Because human-related changes often produce predictable channel responses, we can establish reference, or "equilibrium," conditions for different stream types and then analyze how different modifications to a channel cause a channel response, adjustment, or departure from the reference condition of the stream.

In Step 5, you will look at the instream channel modifications that have occurred over time. These parameters will be useful in predicting the condition, current adjustment process, and sensitivity of the stream reaches in your watershed.

Data Sheet 5. Instream Channel Modifications

5.1 FLOW REGULATION AND WATER WITHDRAWALS (FIT)

Meta Data:
- 1:24K topos, 1:5K NHD & orthos
- 1:24K topos, 1:5K NHD & orthos, files
- 1:24K topos, 1:5K NHD & orthos, files, field obs.

The following DEC Programs maintain information about flow regulations:
  - Water Supply Division – 241-3400 (public water supply withdrawals)
  - Facilities Engineering, Dam Safety Section – 241-3454

Background:
Structures that completely span a channel, such as dams, can significantly alter the quantity and duration of water and sediment runoff and may cause a stream to undergo both vertical and lateral channel adjustment processes. Depending on the timing and magnitude of flow regulation and the stream types and conditions above and below the facility, these adjustment processes may occur annually or they may occur quickly when the flow alteration first occurs and then slow as the stream adjusts to new flow and sediment regimes.

Impoundments and water withdrawals can impact instream habitat and biota, especially during naturally low flow periods that typically occur in Vermont in August, September, and February. In addition to channel adjustments that may affect the structure of instream habitat, additional withdrawal of water can expose streambed substrates, effectively reducing the amount of habitat area available for aquatic organisms. In high-gradient streams, cobble and gravel substrates in riffles are exposed; in low-gradient streams, the decrease in water level exposes logs and snags and lowers the water away from near-bank cover, thereby reducing available habitat. Impoundment of stream flow can also warm waters substantially due to longer periods of and greater surface area of solar exposure, making streams less habitable for many aquatic organisms, especially for cold-water fish species such as Brook Trout (*Salvelinus fontinalis*).

Evaluation:
Most large dams are shown on the USGS topographic maps as a short black line crossing the stream blue line. Another source of data is the ArcView dam shapefile from VCGI named "Emergencyother_Dams". This can help you locate these large dams, but you will still need to contact other sources to find out how they are operated. Consult with DEC Facilities Engineering, Dam Safety Section and Water Supply programs, town records, utilities, landowners, and businesses that may be able to provide information on projects and facilities that regulate the flow or withdraw water from the stream reach. Choose from the menu list to describe the type of withdrawal or flow regulations present in the reach.

Menu

Type

Withdrawal	A withdrawal of water from the stream
Bypass	The water is diverted away from the channel and re-enters down stream.
Run of River	Upstream or in reach flows are impounded. Flow quantity spilling or released below the dam is the same as flow quantity entering the impoundment at all times.
Store and Release	Water is impounded and stored and released only during certain times.
None	No known flow regulation or water withdrawals. Select "none" if you have completed the appropriate research and have found no evidence of flow regulations.
No Data	No data sources are available to determine if a flow regulation or water withdrawal exists.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Size

Small	Impoundments not much wider than river itself or withdrawals not affecting the channel forming flow.
Large	Impoundments much wider than river itself (creating a reservoir) or withdrawals significantly affecting the channel forming flow.

Use

Drinking
Irrigation
Flood Control
Hydro-electric
Recreation
Other

Impact Rating for flow regulation and withdrawals

H	High - stream flows and channel geometry are affected by a cross-channel weir or dam with a water intake structure and /or a visible instream impoundment that has affected sediment depositional patterns or a withdrawal large enough to alter the channel forming flow.
L	Low – cross-channel weir and intake structures present but there is no apparent change in channel geometry and depositional patterns or change in sediment deposition due to water withdrawals.
NS	Not Significant – either no flow regulation OR small water intake structure with no cross-channel weir.
No Data	Unknown if there are flow regulations
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Data Entry:
Use the Feature Indexing Tool (FIT) in SGAT to note the locations of flow regulations and water withdrawals within the reach. When the FIT data is uploaded into the DMS the data will be automatically populated for each reaches where a flow regulation or withdrawal is indicated. For reaches with "none", "no data" or "not evaluated" the data field must be manually entered into the DMS.

5.2 BRIDGES & CULVERTS (FIT)

Meta Data:
- 1;24K topos, 1:5K NHD & orthos
- 1;24K topos, 1:5K NHD & orthos, files
- 1;24K topos, 1:5K NHD & orthos, files, field obs.

Background:
Stream crossing structures are often undersized to handle the stream's annual high flow events and present serious impediments to less frequent flood flows. Undersized bridges and culverts essentially act as dams during high water and may cause vertical and lateral stream adjustments similar to those caused by dams. Undersized structures may also be inadequate to move sediment, which may collect upstream in the middle of the channel causing the stream to split, or bifurcate. Eventually, these mid-channel bars push the flow to the right or left of the bridge resulting in the often sharp "S" bend in the channel observed on the orthophoto. This process can result in a hazardous situation if the stream outflanks the bridge or culvert during a flood and also may lead to major channel adjustments. Supplemental bridge and culvert assessment protocols are included in the Stream Geomorphic Assessment program (see Appendix G). These protocols, the ANR Bridge and Culvert Assessment, are not required during a Phase 1 assessment but they will help in identifying structures that are potentially impacting the geomorphic condition of stream reaches.

Figure 5.1 Perched culverts often restrict the movement and migration of fish and other stream dwelling organisms.

The ANR Bridge and Culvert Assessment protocols can also help you identify those structures that are impediments to fish and wildlife movement and migration. Stream crossing structures can act as migration barriers to fish and wildlife that move through the stream channel or along the adjacent riparian areas. Culverts, in particular, present migration barriers to many fish species, when constructed too steep or too long, such that flow velocities in the culvert may be too great for fish to swim through. Undersized culverts also become barriers when the outlet becomes perched above the channel bed due to the lack of sediment movement through the structure and the resulting channel bed degradation that occurs downstream (Figure 5.1). In general, bridges usually are less likely than culverts to impede fish and wildlife movements. Culverts installed large enough and at-grade with the channel bed, such that natural stream bottom conditions are maintained within the culvert, are less likely to become migration barriers to aquatic species movement.

Evaluation:
Record the number of bridges or instream culverts within the reach by counting the number of times the reach is crossed by roads and driveways as shown on topographic maps and/or orthophotos. Identify other bridges and culverts, especially those on driveways or recently constructed roads that do not appear on the maps and orthophotos, during your windshield survey. Bridges and culverts are likely to be located near reach breaks, as reach breaks often coincide with bedrock outcrops or a narrowing of the valley, which are also good locations for building stream crossing structures. Make sure not to double-count bridges and culverts from one reach to the next. Calculate and record the length of the reach that is impacted by stream crossing structures, as described in the menu below.

Impact Rating for bridges and culverts

H	High - $\geq$ 20 % of reach length is channelized, has split flow, or makes a sharp "S" bend upstream or downstream of bridges or culverts
L	Low – 5 to 20 % of reach length is affected by bridges or culverts (as described in menu above)
NS	Not Significant – < 5 % of the reach is impacted by bridges or culverts
No Data	No data sources are available to determine if the impact exists.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Data Entry:
Use the FIT in SGAT to locate the stream crossings. If you know whether it is a bridge or culvert enter than into the FIT, otherwise enter Unknown in the DMS. You will enter the crossings as a point file and manually enter length of reach affected by the crossing in the "length field" in the FIT within the SGAT extension. Once uploaded the DMS will automatically populate the DMS and determine the length of impact from bridges and culverts for each reach.

5.3 BANK ARMORING or REVETMENTS (FIT)

Meta Data:
- 1:24K topos & orthos
- 1:24K topos, orthos, files
- 1:24K topos, orthos, files, field obs.

Background:
Bank revetments intended to "fix" stream channels in place often contribute to channel movement and adjustment. This is because revetments are typically applied to the symptom of bank erosion while the underlying channel adjustment processes that are causing the bank erosion are overlooked. Attempts to

lock in the vertical and lateral position of a channel while it is under adjustment may set back the channel adjustment process, prolonging or preventing recovery of the stream channel back into a state of equilibrium or imposing a new state of equilibrium dependent upon the stream type and the maintenance of the armored condition. Furthermore, many revetments typically fail and/or cause further channel adjustments to propagate upstream or downstream. This is especially true where a stream has vertically incised (or cut down into its stream bed), losing access to its floodplain. Where this channel adjustment process is occurring, rock rip-rap frequently becomes undermined, fails, and then contributes to aggradation and widening of the channel.

Bank armoring (also called revetments) can be made from natural material such as whole trees or stumps, or wooden cribs filled with stone and willow shoots. Typically in Vermont, bank revetments have been made of rock rip-rap to protect the bank from scour and undercutting, particularly along the outside bends of channels where the current is the strongest (Figure 5.2).


Figure 5.2 Examples of Vermont stream banks hard armored with rock rip-rap. Note the continued erosion and bank failure upstream of the rip-rap sections.

Evaluation:
Use the orthophotos, information from the NRCS and DEC Stream Alteration Engineers, and windshield surveys to document the location and length of the stream channel (in feet) that is armored, either on the **right bank** and/or the **left bank**. Record the type of bank armoring present using the menu choices. Use the ArcView extension, Feature Indexing Tool (FIT), to document the locations and lengths of bank armoring and revetments. Follow the directions in Appendix P for using the FIT.

Streambank condition surveys have been a popular water resource assessment activity for decades. Check with NRCS and the Regional Planning Commission in your area to see if streambank surveys which include erosion and bank revetment mapping have been completed. This information may be useful here. You may even consider having a couple summer interns complete a streambank survey.

Menu

Rip-rap	Rock or stone rip-rap
Hard bank	Concrete or other hard bank treatments
Multiple	Multiple bank revetments
Other	Other bank stabilization, including tree revetments and log cribbing
None	No bank armoring in the reach. Only select this option if you have seen the entire reach.
No Data	No data sources are available to determine if bank armoring exists.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Impact Rating for human-placed bank armoring

H	High – ≥ 20 % of the right and/or left bank
L	Low – 5 to 20 % of the right and/or left bank
NS	Not Significant – < 5 % of the right and/or left bank
No Data	No data sources are available to determine if bank armoring exists.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Data Entry:
Use the Feature Indexing Tool (FIT) in SGAT to note the locations of bank armoring and revetments. When the FIT data is uploaded into the DMS the data will be automatically populated for each reaches where a bank armoring or revetments are indicated. For reaches with "none", "no data" or "not evaluated" the data field must be manually entered into the DMS.

5.4 CHANNEL STRAIGHTENING (FIT)

Meta Data:
- 1:24K topos, 1:5K NHD & orthos
- 1:24K topos, 1:5K NHD & orthos, files
- 1:24K topos, 1:5K NHD & orthos, files, field obs.

Background:
Channel straightening is the process of changing the natural path of a river through activities such as windrowing and straightening.

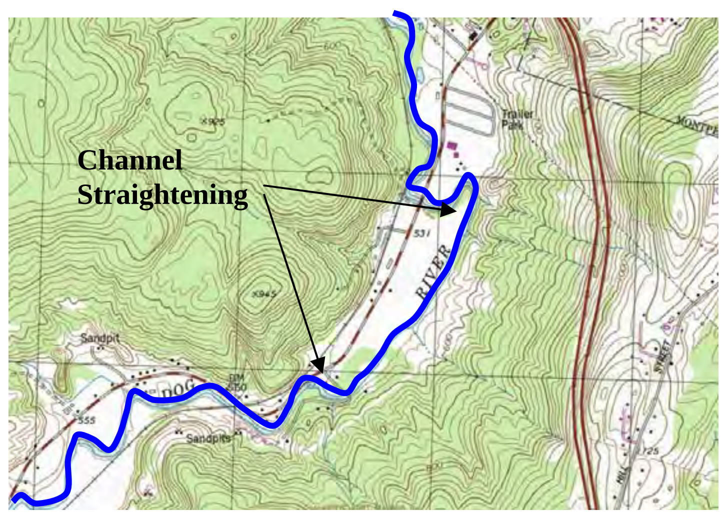


Figure 5.3 Channel modifications identified on a topographic map.

Channel straightening may increase the downstream hazard potential due to an increase in water velocity and power from the increased channel slope, loss of access to the floodplain, and disturbance of the channel bed armor (larger substrates that typically cover the upper layer of the channel bed). When the channel slope is increased, the velocity increases. This extra force may cause the river to degrade, or cut down vertically into its bed. Often the sediment that used to be in the bottom of the river of the now straightened area is re-deposited downstream of the straightened area. This results in aggradation, or building up, of the channel bed in this downstream area. Aggradation, in turn, can result in channel widening, bank instability, and other channel responses, most of which are detrimental to both riverside land and aquatic habitat (MacBroom, 1998).

Pushing gravel to the stream margins without physically removing it from the stream is called windrowing, which may impact the morphology of the river. For example, many reaches of the White River and its tributaries in central Vermont were windrowed following the floods of the 1970's. Gravel was bermed up, and gravel bars were removed from the river to "improve" the channel's capacity to move flood waters. During the following decades some reaches experienced major damage caused by the changed morphology of the river. Damages included widening and bank erosion, downcutting, and significant changes in the cross-sectional geometry of the river. These reaches remain sensitive to change and adjustment due to these instream modifications, especially during flood events (NRCS 2001).

Evaluation:
Check with the DEC stream alteration engineers, NRCS staff, and town road commissioners for documentation of historic channel straightening projects. Some straightened reaches are easy to read off of topographic maps or orthophotos (Figure 5.2). Use the FIT to measure and document the total reach length (in feet) of reach length that has been straightened. Record the type of channel straightening along the reach, using the menu choices below. Follow the directions in Appendix P for downloading and using the RIT.

Menu

Straightening	Manual straightening of a channel without windrowing
With Windrowing	Pushing gravel up from the stream bed onto the top of either bank as a part of the straightening of the river.
None	No known channel straightening. If you have completed the appropriate research and have found no evidence of channel straightening, select "none".
No Data	No data sources are available to determine if the channel has been straightened.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Impact Rating for channel modification

H	High – $\geq$ 20% or reach has been channelized
L	Low – 5 to 20 % channelized
NS	Not Significant – < 5% of the reach affected by channel modifications
No Data	No data sources are available to determine if the channel has been straightened.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Data Entry:
Use the Feature Indexing Tool (FIT) in SGAT to note the locations of channel straightening. When the FIT data is uploaded into the DMS the data will be automatically populated for each reaches where a channel straightening is indicated. For reaches with "none", "no data" or "not evaluated" the data field must be manually entered into the DMS.

5.5 DREDGING AND GRAVEL MINING HISTORY (FIT)

Meta Data:
- Interviews - DEC, NRCS
- Interviews - DEC, NRCS, Towns, others

Background:
Dredging and mining gravel bars from a channel may initiate a channel evolution process (see Appendix C). Such activities straighten and steepen the channel and cause the river to cut down and erode its bed. The stream channel eventually aggrades with sediments supplied from upstream reaches as headcuts in the streambed move up-valley (Kondolf, 2001).

Evaluation:
Using information and records from the DEC Stream Alteration Engineers and NRCS field office staff , determine if dredging or gravel mining has occurred in the reach, and if so, determine the relative fre-

quency and volume of gravel extraction. Some of this information may also be available from local excavators and road commissioners. Record the dominant type of gravel removal which occurred in the reach using the menu below. For instance, if landowner gravel mining is occurring today where the reach was historically used for commercial mining, you would choose commercial mining as the dominant type, because of the relatively high frequency and volume of gravel removal. Dredging for flood conveyance may be intermediary between landowner gravel removal and commercial mining with respect to frequency and volume.

Menu

Gravel Mining	Recent or historic landowner removal of gravel from channel for personal use.
Dredging	Recent or historic removal of bed materials to increase channel cross-section for flood conveyance or navigation purposes.
Commercial Mining	Historic (pre-1988) large-scale commercial extraction of gravel from channel.
None	No known dredging or gravel mining. If you have completed the appropriate research and have found no evidence of channel modification select "none".
No Data	No data sources are available to determine if dredging or gravel mining occurred.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Impact Rating for dredging and gravel mining

H	High - Used historically for commercial gravel mining, dredged for flood remediation
L	Low – Used occasionally for annual 50 cubic yards of gravel extraction by landowner
NS	Not Significant - No gravel mining or post-flood dredging operations
No Data	No data sources are available to determine if dredging or gravel mining occurred.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Data Entry:
Use the Feature Indexing Tool (FIT) in SGAT to note the locations of dredging and gravel mining. When the FIT data is uploaded into the DMS the data will be automatically populated for each reaches where a dredging or gravel mining is indicated. For reaches with "none", "no data" or "not evaluated" the data field must be manually entered into the DMS.

Step 6. Floodplain Modifications and Planform Changes

Overview

Background:
These protocols examine changes to lands adjacent to rivers and streams that may affect the vertical and lateral containment of flood flows. River corridors, first delineated in Step 3, are used to examine those lands that may be important primarily to the lateral (or horizontal) movement of flows. Infrastructure and other developments that restrict the lateral movement of flood flows, however, also directly or indirectly (through channel adjustment) restrict the vertical access of a channel to its floodplain.

Though we often associate floodplains with large rivers, over time, even streams in semi-confined valleys will have created a certain amount of floodplain. In addition to providing floodwater storage and attenuation, a floodplain is often the space (or river corridor) through which stream channels meander over time, undergoing planform adjustment and thereby slope adjustment. The availability of space for slope adjustment is critical to the stream in reaching equilibrium with the size and quantity of sediment produced in the watershed. A stream cut off from its floodplain may have less room to meander and be forced into a higher gradient form. If this higher gradient translates into stream power that can move even larger particles in the stream bed, the channel may begin to degrade (or incise), cutting down into its streambed and initiating the channel evolution process (see Appendix C).

Evaluation:
Similar to the evaluation of channel modifications in Step 5, in this step you will evaluate floodplain modifications and planform changes that have occurred over time in order to help predict whether reaches are in adjustment. The floodplain modification and planform change parameters examined in Step 6 will be very useful in predicting the condition, current adjustment process and sensitivity of the stream reaches in the watershed.

Data Sheet 6. Floodplain Modifications And Planform Changes

6.1 BERMS, ROADS, IMPROVED PATHS, RAILROADS (FIT)

Meta Data:
- 1:24K topos, 1:5K orthos
- 1:24K topos, 1:5K orthos, files
- 1:24K topos, 1:5K orthos, files, field obs

Data Sources:
- o USGS 1:24,000 topographic maps (digital or hard copy)
- o 1990 series 1:5000 Orthophotos (digital or hard copy)
- o Berms—NRCS Flood Damage Remediation (Emergency Watershed Protection, EWP) Reports
- o Berms—DEC Stream Alteration Engineers

Background:
Berms, roads, railroads and improved paths and the hardened embankments often used to protect them, limit the lateral adjustments of the stream within the corridor and may contribute to onset of vertical adjustments within the channel (Figure 6.1). Developed land, including highways, roads, and railroads, in close proximity to the stream may be a clue that the stream bank has been bermed to protect the infrastructure and investments. For instance, after the 1973 flood many berms, or levees, intended to elevate

the stream embankment to prevent flooding of adjacent lands, were built. In some places, trees have grown on these berms, and are young forests (about 25 years old).

Evaluation:
Determine the location of the river corridor length along which berms, roads, railroads, or improved paths run *parallel* to the stream on either bank (see Appendix E for river corridor delineation). Use the Feature Indexing Tool (FIT) in SGAT to document the locations of berms, roads, railroads and improved paths. Indicate whether these floodplain encroachments occur on one bank at a time or both banks at the same time (Figure 6.2. Berms are difficult to identify on orthophotos and are best identified as part of the Step 7 windshield survey or through other data sources such as flood damage remediation reports. Write *None* if you know there are no berms, roads, railroads, or improved paths (as defined in Glossary, Appendix Q) in the river corridor. Also write *None* if there are no roads or railroads and you have no information about berms or improved paths. If, during windshield surveys or Phase 2 assessments, you find berms, new roads, or improved paths, the Phase 1 evaluation of this parameter should be modified. Follow the directions in Appendix P for using the FIT.

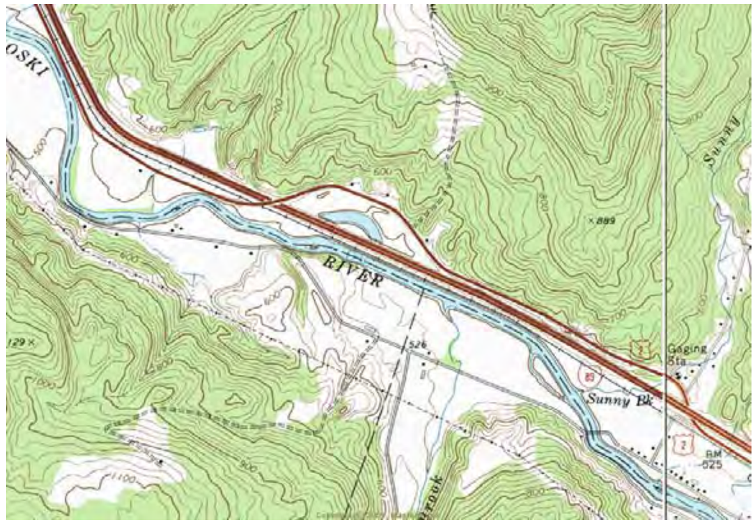


Figure 6.1 Route 2, Interstate 89 and the railroad are all located within the corridor of the Winooski River. The meander bends were likely cut off when the railroad was built.

Stream crossings, where the road, berm, railroad or improved paths runs perpendicular to the stream, are considered under Step 6.2 and are not a part of this parameter. These structures are not necessarily a problem with respect to floodplain function unless berms and fill were used to elevate the road, bridge or culvert. Note berms on the watershed map with a "B." Retain a paper map or digital GIS shape file of berm and road encroachments for later use in quality assurance documentation, field verification and for display purposes.

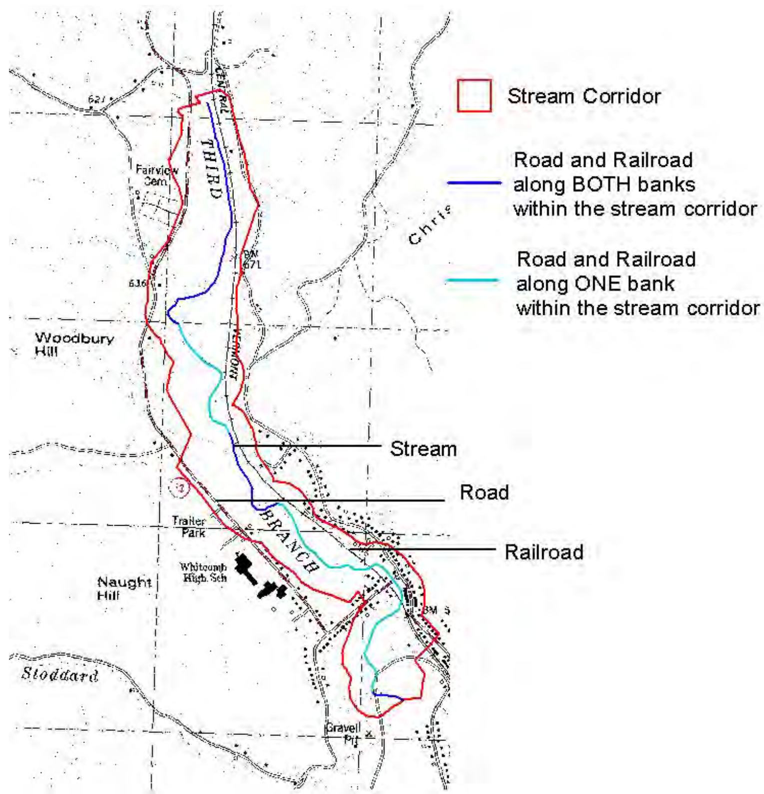


Figure 6.2 Note the difference between a berm or road along one bank versus both banks at the same time.

Menu

One Side	berms, roads, railroads, or improved paths located within river corridor on one side of the stream at a time
Both Sides	berms, roads, railroads, or improved paths located on both sides of the stream
None	No evidence of berms, roads, railroads, or improved paths in river corridor
No Data	No data sources are available to determine if an impact from berms, roads or improved paths exists in the river corridor.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated. Further work should be completed.

Impact Rating for berms, roads, railroads, and improved paths

H	High – berms, roads, railroads or improved paths are within river corridor along ≥ 20 % of the right and/or left bank
L	Low - berms, roads, railroads or improved paths are within river corridor along between 5% to 20% of the right and/or left bank
NS	Not Significant - berms, roads, railroads or improved paths are within river corridor along < 5% of the right and/or left bank
No Data	No data sources are available to determine if an impact from berms, roads or improved paths exists in the river corridor.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated. Further work should be completed.

Data Entry:
Index the berms, roads, railrods and improved paths under "encroachments" in the FIT in SGAT. For the berms, roads, railroads and improved paths, if used properly, the Feature Indexing Tool (FIT) in SGAT will create a dbf table that can be automatically uploaded into the DMS. Once the FIT data is uploaded into the DMS, the impact rating will be attributed based on the percent of the reach length that has been encroached upon for each separate impact of berms, roads, improved paths and railroads. Use the meta data in the DMS to indicate whether the percent of reach paralleled by berms, roads, railroads or improved paths for the reach have been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

6.2 RIVER CORRIDOR DEVELOPMENT (FIT)

Meta Data:
- 1:24K topos, 1:5K orthos
- 1:24K topos, 1:5K orthos, files
- 1:24K topos, 1:5K orthos, files, field obs

Data Sources:
- USGS 1:24,000 topographic maps (digital or hard copy)
- 1990 series 1:5000 orthophotos (digital or hard copy)
- Emergency 911 GIS coverage (available from VCGI website at http://www.vcgi.org.)

Background:
Development encroaching on the floodplain and river corridor may result in a confinement of flood flows, as described above in section 6.1, and may also effectively decrease the lateral extent to which the outside meanders of a stream can migrate away from one another (Figure 6.3). The extent to which a channel migrates laterally, as measured by the distance between the outer limits of its meander bends on opposite banks, is called the "meander belt width" and is described further in section 6.5. Decreasing the meander

belt width of a channel may limit the ability of the channel to adjust to changes in channel slope, thereby leading to an increase in channel slope, which in turn can lead to bed degradation as stream power increases, potentially triggering a channel evolution process (Appendix C).

Houses and other structures that encroach into the river corridor and floodplain may represent a flood hazard and may, in addition, pose threats to infrastructure, investments, and habitat downstream due to the increased flood velocities and stream power if the encroachments result in a confined and steeper stream.

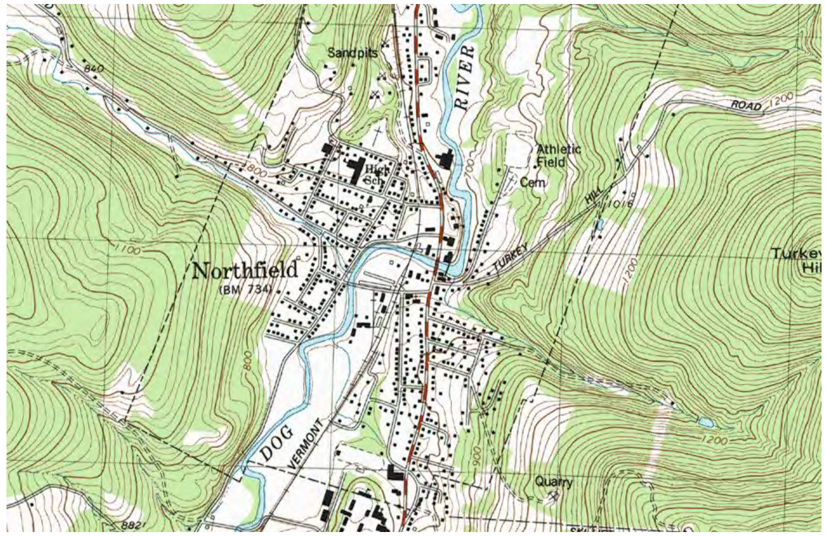


Figure 6.3 Development within the river corridor and floodplain.

Evaluation:
Use the FIT in SGAT to indicate the location of development on either the one bank or both banks at the same time. Index the locations of houses, fill (including bridge and culvert fills), parking lots or other development within the river corridor on either bank (see Appendix E for river corridor delineation). Indicate whether the development occurs on **one bank at a time or both banks at the same time**. Write *None* if you know there are no developments within the river corridor along the reach. Do not include roads, railroads, berms or improved paths parallel to the stream and within the stream corridor. These roads should be included in Step 6.1 Berms and Roads.

Menu

One Bank	Development located within the corridor on one bank only
Both Banks	Development located within the corridor on both banks in the same location
None	No known development within the river corridor
No Data	No data sources are available to determine if river corridor development exists.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated. Further work should be completed.

Impact Rating for river corridor development (DMS)

H	High – developments are within river corridor along $\geq$ 20% of the right and/or left bank
L	Low – developments are within river corridor along between 5% to 20% of the right and/or left bank
NS	Not Significant – developments are within river corridor along < 5% of the right and/or left bank
No Data	No data sources are available to determine if river corridor development exists.
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated. Further work should be completed.

Data Entry:
Use the FIT in SGAT to index the location of river corridor development on one bank or both banks at the same time. Once the FIT file is uploaded, the DMS will automatically determine the impact rating based on the percent of the reach impacted. Use the meta data in the DMS to indicate whether the impact from river corridor development has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

6.3 DEPOSITIONAL FEATURES

Meta Data:
- 1:5K orthos
- 1:5K orthos, other aerial photos
- 1:5K orthos, field obs.

Background:
Bars are deposits of sediment located within the channel margins that have a height in excess of the mean water level. A point bar is adjacent to the bank and located on the inside bank of a bend in the channel (i.e., a meander bend), whereas a mid-channel bar is not attached to the banks, has stream flow to either side of it, and is generally found in straight reaches.

An unvegetated bar is a sign that the bar has recently been formed and is growing. Mid-channel bars, large unvegetated point bars, and delta bars may indicate an increased sediment load (from upstream) and the high likelihood that the streambed is actively aggrading and/or undergoing rapid lateral movement. The sediment source for these bars may be from bank failures or the degradation of the channel bed up-stream. It may also be from upland sources such as construction sites, road washouts, or valley side slope failures. (Note that in some situations equal-sized, alternating unvegetated point bars in a naturally high sediment yielding watershed may be a part of the reference, or "equilibrium," channel condition.)

Evaluation:
For large and medium sized rivers and streams, large unvegetated bars are often visible on orthophotos. If you are examining the orthophoto on the computer, zoom in on the channel to observe gravel bars. Note the presence of unvegetated mid-channel, point, or delta bars and record the appropriate menu item on the data sheet. These bars can also be noted in the field during the windshield survey. Small streams, particularly those in forested areas will be difficult to impossible to evaluate using orthophotos. These streams will need to be assessed during the Step 7 windshield survey and Phase 2 or 3 assessments.

When evaluating bars in the Phase 1 assessment you will only note those bars that are largely unvege-tated, either devoid of vegetation or have only sparse pioneer vegetation occupying less than 25 percent of the surface area of the bar. In the field, during Phase 2 and Phase 3 Assessments, you may observe bars that are well vegetated.

Menu

Mid-channel	Flows evident on either side of mid-channel sediment deposit
Point	Large unvegetated sediment deposits located at the inside of meander bends—choose this menu item only if bars are greater in width than the observed wetted channel
Delta	Sediment deposits where tributary enters mainstream channel
Multiple	Multiple types of sediment deposition features in reach—use only where none of the above deposit types are dominant
Side (Lateral)	Unvegetated sediment deposits located along the margins of the channel in locations other than the inside of channel meander bends
Diagonal	Bars that cross the channel at sharp oblique angles, associated with transverse riffles
Islands	Well-vegetated mid-channel deposits of sediment
None	No evidence of mid-channel, point, or delta bars
No Data	Unknown if there are depositional features—unable to see the stream on orthophoto due to forest cover and/or inability to access entire reach during windshield survey
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Impact Rating for depositional features

H	High – Numerous, large unvegetated mid-channel, point and/or delta bars present (channel may appear braided)
L	Low – Some mid-channel bars and intermittent large point bars
NS	Not Significant – Typical point bars, no mid-channel bars present
No Data	Unknown if there are unvegetated depositional features—due to forest cover and/or inability to access entire reach during windshield survey
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

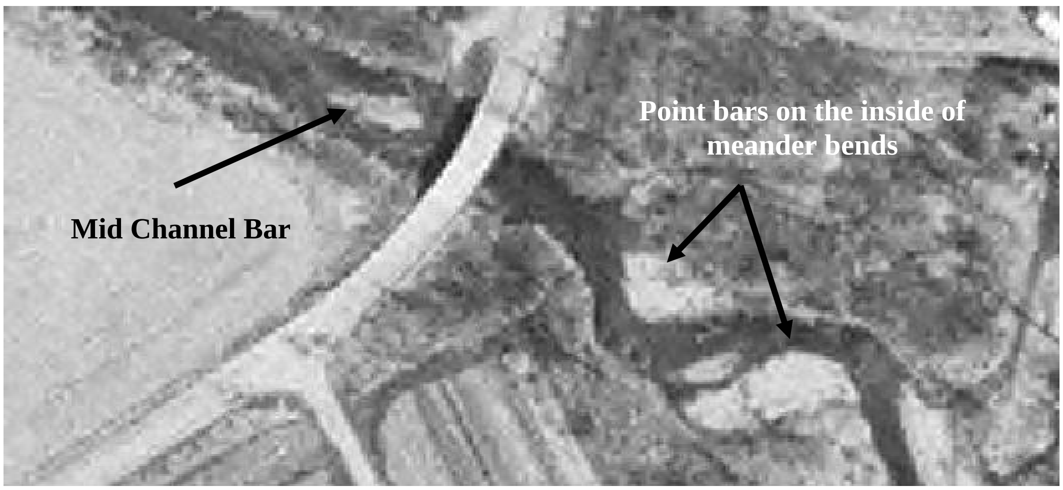


Figure 6.4 Mid channel and point bars as viewed on a digital orthophoto viewed in GIS software..

Data Entry:
Manually enter the data and associated impact from depositional features into the DMS for each reach. Use the meta data in the DMS to indicate whether the impact from depositional features has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

6.4 MEANDER MIGRATION / CHANNEL AVULSIONS (FIT)

Meta Data:
- 2003 NAIP color photos
- 1:5K orthos (1990s & 1970s)
- 1:5K orthos (1990s & 1970s), other aerial photos
- 1:5K orthos (1990s & 1970s), field obs.

Background:
A migrating channel moves by eroding the outer banks of its meander bends such that the channel's bends move sideways and downstream over time. Some amount of lateral migration is natural in most alluvial streams systems, but the rate of migration may be increased in streams that are out of balance with their watershed inputs. A bifurcated, or braided, channel is one that has split into two or more active channels. An avulsed channel is one that has suddenly changed location and cut a new section of channel within its valley, abandoning the old section of channel, which may appear as a dry river or long, narrow wetland on the valley bottom.

Channels change course for various reasons. Streams often undergo dramatic migrations and avulsions due to changes in the sediment supply and/or sediment transport capacity of the channel. Sediment building up on the channel bed can force flows laterally to the outside of a channel bend, eroding even the most stable stream banks (migration), or can divert flow to the inside of a channel bend, cutting off entire meander bends (avulsion). Streams can change course as the result of catastrophic channel avulsions due to floods, debris jams, undersized road crossings structures, or because of past channelization practices. Often the loss of woody riparian vegetation causes or exacerbates channel migration and increases avulsion occurrences on certain sensitive, depositional stream types.

Orthophotos can be used to look for areas where the river has migrated, bifurcated, or avulsed. By comparing orthophotos from different time periods, reaches that have migrated, bifurcated, or avulsed extensively can be distinguished from reaches that have stayed in the same location over the same period of time (Figures 6.4A and 6.4B). Substantial changes in channel location usually occur in the lower, depositional zone of the watershed. On large streams, migration, bifurcation, and avulsions can be easily seen on the orthophotos (Figure 6.4A), but channel avulsions on small streams in the upper watershed cannot easily be determined from orthophotos, even though they may occur in that area. The presence of channel avulsions on small streams can only be confirmed through a field visit.

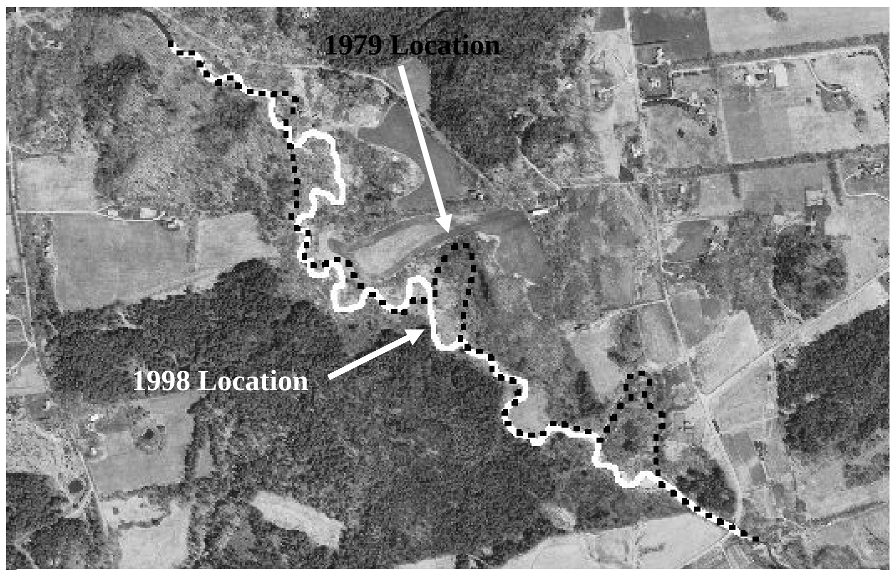


Figure 6.5A Meander Migration and Avulsion: High Impact

Evaluation:
To identify channel migration, bifurcation, and/or avulsions on large and medium sized rivers and streams, compare the path of the channel from similarly scaled orthophotos of different years. You should use the most recent orthophotos series that span a period of approximately 20 years. For instance the orthophotos produced in the late 1970's should be compared with the series produced in the 1990's. Digitize on the computer or manually trace on mylar or paper overlays the historic and current channel locations. Look for places where the two channel lines diverge to identify channel migration and/or avulsions that have occurred during the time period covered by the photos. See detailed instructions below.

Overlay method for evaluating channel migration: Place the tracing paper or mylar on top of a historic orthophoto (i.e. the 1970s orthophotos). Mark a north arrow on the tracing paper, write the name and date of the underlying orthophoto on the tracing paper. Using a colored pencil, mark reference points (a silo, a cross-roads, a V-shaped intersection, etc.) that also appear on the recent series of photos that you are using. Using this same color pencil, trace the course of the river. Mark the active channel and all abandoned channels.

Next overlay the tracing paper or mylar on the recent orthophoto (i.e. the 1990's orthophotos) for the same location. If necessary, adjust the scale of the recent orthophoto to match that of the historic photo with the aid of the computer or copy machine. Line up the reference points on the tracing paper that you marked from the historic photo with the same landmarks on the recent photo (silo, cross-roads, V-shaped intersection). Using a *different* colored pencil, trace the course of the river and all abandoned channels onto the tracing paper.

Compare the recent and historic channel locations to identify areas of extensive channel migration and channel avulsions. Since the late 1930's at least eight complete statewide sets of aerial photos have been taken over Vermont. Since the late 1970's these photos have been orthogonally corrected (see list in Appendix D). Photos earlier than the 1970's series can be used to further examine channel movement and meander migration.

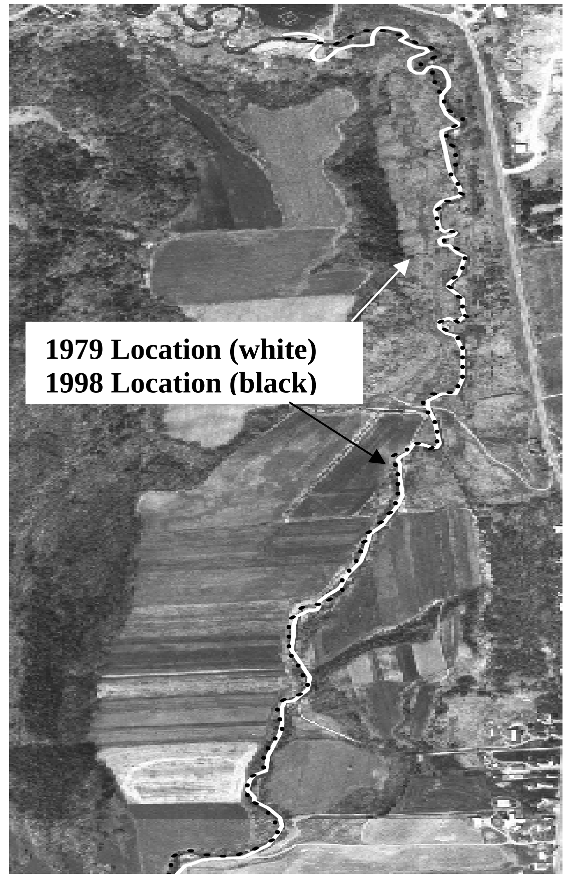


Figure 6.5B Meander Migration: Low Impact

Menu

Migration	Channel has migrated by eroding its outer banks on meander bends
Flood Chute	During high flow the channel accesses an area outside the channel, normally on the inside of a meander bend.
Bifurcation /Braiding	Stream flow has split into two or more active channels
Avulsion	Channel planform has changed due to meander cut-offs
Neck Cut-off	A neck cutoff forms as two meanders migrate towards one-another and the neck of land between them is *about* to be cut off
None	None of the above
No Data	Unknown if there are channel migrations or avulsions— unable to see the stream on orthophoto due to forest cover and/or inability to access entire reach during windshield survey
Not Evaluated	All data sources (as described by the meta data) HAVE NOT been evaluated.

Impact Rating for meander migration

H	High - Frequent occurrences of channel migration, flood chutes, bifurcation and braiding, channel avulsions an/or neck cut-offs along reach evident in historic orthophoto comparison
L	Low - Few occurrences of channel migration, flood chutes, bifurcation and braiding, channel avulsions an/or neck cut-offs evident in historic orthophoto comparison
NS	Not Significant - No channel migration, flood chutes, bifurcation and braiding, channel avulsions an/or neck cut-offs evident
No Data	Unknown if there are channel migrations, bifurcations, or avulsions—due to forest cover and/or inability to access entire reach during windshield survey

Data Entry:
Manually enter the data and associated impact for meander migration into the DMS for each reach. Use the meta data in the DMS to indicate whether the impact from meander migration has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

6.5 MEANDER WIDTH RATIO

Meta Data:
- 1:5K NHM, 1:5K orthos
- Field - survey

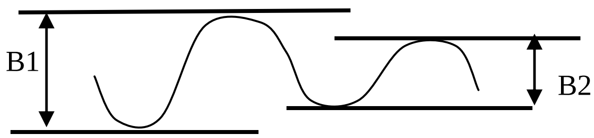
Background:
The meander belt width is the horizontal distance between the opposite outside banks of fully developed meanders determined by extending 2 lines (one on each side of the channel) parallel to the valley (and parallel to each other) from the lateral outside extent of each meander bend along both sides of the channel (Figure 6.5).

The meander belt width can change radically within a reach due to channel constrictions from floodplain encroachment, surficial and bedrock geology, small changes in valley slope, and other factors. Unconfined, gravel-based streams in shallow-sloped valleys that are in regime have belt widths generally in the range of 5 to 8 times the width of the channel (Leopold 1994 and Williams 1986). Lower values may indicate that the stream has become straighter and steeper, possibly degrading its bed and losing access to its floodplain. Higher values may indicate that the stream, possibly due to an increase in fine sediment, has started to aggrade and become more sinuous, decreasing its channel slope as it migrates laterally.

Evaluation:
This parameter is only evaluated for those reaches you typed in Step 2.10 as C or E riffle-pool or ripple-dune reference stream types in narrow (NW) and unconfined (BD and VB) valleys. For these reaches calculate the meander width ratio (MWR) by dividing the belt width (B) by the bankfull channel width (W_{bkf}), determined in Step 2.8. For reaches that have been straightened for more than half (50%) of the reach length, do not measure belt width, but rather enter the channel width under the belt width column on the data sheet. This will result in a meander width ratio value of one (“1”) for the reach, which is rated as “high” impact. For naturally confined and braided stream types, do not enter a value for belt width. Instead, select the Not Evaluated check box in the DMS.

Determining Belt Width: Use orthophotos in conjunction with topographic maps to determine the reach’s average belt width. Topographic maps help you discern the valley direction, and recent orthophotos offer the most accurate location of channel meanders. Two rules to remember when drawing the meander belt width are: 1) do not cross the toe of either valley wall (generally); and 2) follow the direction of the valley (i.e., draw the parallel lines that represent the belt width roughly parallel to the valley walls).

After establishing the two parallel lines containing the belt width, measure and record the average (to the nearest foot) of at least three belt widths in the reach. Divide the average belt width (B) by the channel width (Wbkf) to calculate meander width ratio (MWR) (Figure 6.5). Retain a paper map or digital GIS shape file of locations used for belt width measurements for later use in quality assurance documentation, field verification and for displaying the data.



$$\mathbf{MWR = B / W_{bkf}}$$

Figure 6.6 Example of measuring average belt width in a broad unconfined valley. In this example the belt width is the average of B1 and B2 values.

Appendix H provides more background information on meander width ratios and several examples of belt width measurements using Vermont orthophotos.

Impact Rating for meander width ratio

H	High - calculated MWR is < 3 **or** > 10
L	Low - calculated MWR is ≥3 and <5 **or** >8 and ≤ 10
NS	Not Significant - calculated MWR is ≥5 and ≤ 8
N/A	Not applicable for certain stream types (where MWR entered as "0")

Data Entry:
Manually enter the value for belt width into the DMS for each reach. The DMS will use the belt width to automatically calculate the meander width ratio and attribute an associated impact rating. Use the meta data in the DMS to indicate whether the impact from meander width ratio has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

6.6 WAVELENGTH RATIO

Meta Data:
- 1:5K NHM, 1:5K orthos
- Field - survey

Background:
Like the meander width ratio, the wavelength ratio can also change radically within a reach due to channel constriction from floodplain encroachment, surficial and bedrock geology, small changes in valley slope, and other factors (see Figure 6.7). Unconfined, gravel-based streams in shallow-sloped valleys have wavelengths generally in the range of 10 to 12 times the width of the channel (Leopold 1994 and Williams 1986). Higher values may indicate that the stream has become straighter and steeper, possibly degrading its bed and losing access to its floodplain. Lower values may indicate that the stream, possibly due to an increase in fine sediment, has started to ag-

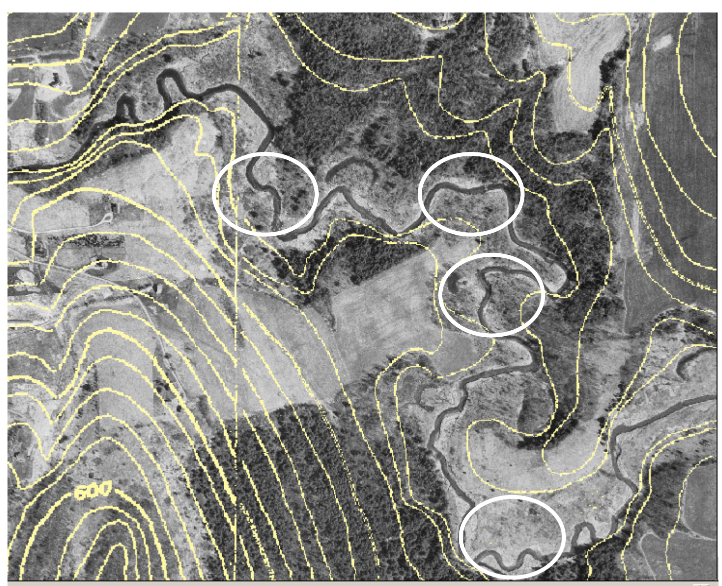


Figure 6.7 Example of a reach with both regular and irregular meanders. Representative wavelengths measured to generate wavelength ratios are circled.

grade and become more sinuous, decreasing its channel slope as it migrates laterally.

Evaluation:
This parameter is only evaluated for those reaches you typed in Step 2.10 as C or E riffle-pool or ripple-dune reference stream types in narrow (NW) and unconfined (BD and VB) valleys. For these reaches calculate the wavelength ratio (WLR) by dividing the wavelength (L_m) by the bankfull channel width (W_{bkf}), determined in step 2.8. For reaches that have been straightened for more than half of the reach length, do not measure the wavelength, but rather enter the channel width in the wavelength column on the data sheet. This will result in a wavelength ratio value of one ("1") for the reach, which is rated as "high" impact. For naturally confined and braided stream types, do not enter a value for belt width. Instead, select the Not Evaluated check box in the DMS.

Determining Wavelength: Meander wavelength is measured as the distance in feet between two lines drawn perpendicular with the fall line of the valley, one drawn at the beginning and one at the end of the meander wavelength (Figure 6.6). The beginning and end points of the meander wavelength are located at thalweg inflection points, or cross-over points. Alternatively, the beginning and end points may be set at the apex of bendway curves. A meander wavelength consists of two bendways. Use orthophotos in conjunction with topographic maps to determine the reach's average meander wavelength. Topographic maps help you discern the valley direction, and recent orthophotos offer the most accurate location of channel meanders and thalweg inflection points. Measure at least three wavelengths in the reach to determine the average wavelength for the reach. Remember that this is not the same parameter as sinuosity. Calculate wavelength ratio (WLR) by dividing the average wavelength (L_m) by bankfull channel width (W_{bkf}).

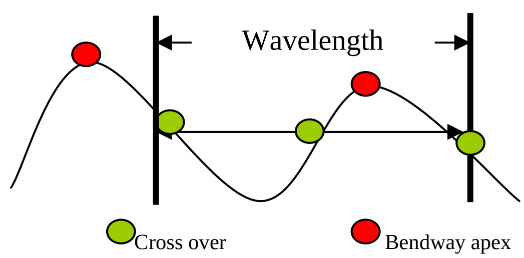


Figure 6.8 Meander wavelength measured from cross-over to cross-over

$$\mathbf{WLR = L_m / W_{bkf}}$$

Retain a paper map or digital GIS shape file of locations used for wavelength measurements for later use in quality assurance documentation, field verification and for displaying the data. Appendix H provides more background information on wavelength ratios and several examples of wavelength measurements using Vermont orthophotos.

Impact Rating for wavelength ratio

H	High – calculated WLR is < 6 **or** > 16
L	Low - calculated WLR is ≥6 and <8 **or** >14 and ≤16
NS	Not Significant - calculated WR is ≥8 and ≤14
N/A	Not applicable for certain stream types

Data Entry:
Manually enter the value for wavelength into the DMS for each reach. The DMS will use the wavelength to automatically calculate the wavelength ratio and attribute an associated impact rating. Use the meta data in the DMS to indicate whether the impact from wavelength ratio has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

Step 7. Bed and Bank Windshield Survey

Overview

Background:
The Bed and Bank Windshield Survey is an essential component of the watershed assessment. In this step you have the opportunity to field verify the reaches you have described using maps and other remote sensing techniques. Even though you will not be able to see all reaches from the roads, you may be able to see enough to assess certain parameters and pick out obvious problems and/or verifications of Phase 1 data. You may also choose to float larger, low gradient rivers and streams by canoe to complete the windshield survey, as this is an efficient way to see a lot of the stream system in a short period of time.

Evaluation:
The main focus of the Windshield Survey is to field check Phase 1 data collected so far, as well as note the condition of and materials that make up the stream bed and banks. Based on the amount of time you have, and figuring on an average of 30 minutes per stop (including drive time), plan your driving route and stops to ensure that you survey a good representation of the different stream types in the watershed.

Be aware that the bed and bank conditions at or near the road crossing may not represent the conditions of the reach as a whole. As discussed in Step 5.2, bridges and culverts may have profound impacts on the fluvial processes and geomorphic conditions of the stream reaches. To further evaluate the potential impacts of road crossing structures on geomorphic and habitat conditions and connectivity of the watershed use the ANR Bridge and Culvert Assessment protocol and field forms (Appendix G).

Before you begin your windshield survey, print out the Phase 1 Reach Summary Report from the Phase 1 database (see Appendix B) and review the Phase 1 data for each reach. Note any data you feel is questionable and verify this data during the windshield survey. Take the reach summary reports and topographic maps for each reach and the watershed with you to make notations or corrections to the data. Table 7.1 lists the parameters which particularly benefit from field verification. Standard map codes and symbols for field maps are included in Appendix A.

In addition to filling out Data Sheet 7 (described below), take photographs of notable features and typical reach conditions. Keep a photo log so you can label your photos by reach number. A standard photo log form is provided in Appendix A.

Table 7.1 Phase 1 parameters which particularly benefit from field verification

Step No.	Parameter	Notes
2.11	Reference Stream Type	Verify the stream type, bed form, bed material and sub-class slope
2.10	Valley Type and Confinement	Verify reach breaks as defined by valley form
3.2	Grade Controls	Verify locations of known grade controls, record on map the types and locations of any additional grade controls observed
4.3	Riparian Buffer	Verify dominant riparian buffer width category for the reach
4.4	Groundwater Inputs	Record locations of any observed small tributaries and groundwater inputs (wetlands, seeps, springs) not already noted
5.1	Flow Regulation / Water Withdrawal	Verify locations of known flow regulation and water withdrawal structures, record any additional structures observed
5.3 and 5.4	Channel and Bank Modifications	Verify types, locations, and extent of channel modifications and bank armoring
6.1 and 6.2	Corridor Encroachments – Berms, Roads, and Development	Verify locations and extent of berms, roads and development in reach river corridor
6.3	Sediment Storage	Verify type and relative size of sediment deposits, record any additional sediment deposit features observed

Data Sheet 7: Bed And Bank Windshield Survey

7.1 BANK EROSION - RELATIVE MAGNITUDE (FIT)

Background:
All stream banks erode to some degree. Bank erosion is a natural ongoing process, and it is unrealistic to think that bank erosion can be or should be totally eliminated. While bank erosion is occurring naturally over time, it is a process that may be accelerated or decelerated by human activities. The concern is not that erosion occurs, but rather the location and rate at which it occurs.

Henderson and Shields (1984) define natural erosion as the processes that occur without significant human activities in the drainage basin or catastrophic natural events such as volcanic eruptions or forest fires. They define accelerated erosion as erosion that is atypically high in magnitude and is different in nature than the erosion experienced at the site or reach in question in the recent past. Both natural events (e.g., high flows) and human activities (e.g., changes in land use) can cause accelerated erosion (Johnson and Stypula 1993).

Accelerated bank erosion is both a symptom and cause of channel adjustment processes. High, vertical banks with low root density and a high percentage of non-cohesive, fine-grained sediments (i.e., sand and gravel) have the highest potential to erode. Eroding banks may not only change the cross-section of the channel where they occur, but they can contribute to aggradation and other channel adjustments downstream, adding tons of sediment to stream reaches that are depositional and sensitive to an imbalance in the sediment load.

Bank erosion can be an important source of sediment to a stream system over time; however, rapid and extensive bank erosion can result in large quantities of sediment entering a stream system, potentially threatening aquatic habitats and biota. Fine sediments can embed gravel and cobble stream bottoms, reducing available habitat for aquatic insects, fish and other biota and potentially even smothering fish and salamander eggs and young.

Evaluation:
Bank erosion is evident by the presence of bare soil extending up the bank, fallen vegetation or slumped soil at the base of the bank, or undercut fractured banks that look like they are going to fall off into the river. Mark the presence of bank erosion on the map with the letters "BF," and record whether it occurs on the right or left bank.

Retain a paper map or digital GIS shape file of bank erosion locations for later use in quality assurance documentation, field verification and for displaying the data.

Use the Feature Indexing Tool (FIT) in SGAT to document the location of erosion within the reach on both the **right bank and left bank**.

Menu

Bank Erosion	Description
High	Bank erosion observed along ≥ 20% of the right and/or left bank
Low	Bank erosion observed along between 5 and 20% of the right and/or left bank
None	Bank erosion observed along < 5% of the right and/or left bank
Not Evaluated	The reach was not accessed during the windshield survey.

Data Entry:
Use the FIT in SGAT to identify the locations of erosion on both the right and left bank. When the FIT

data is imported the lengths of erosion for each reach will be automatically calculated and the impact will be assigned. Use the meta data in the DMS to indicate whether the bank height or erosion has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

7.2 DEBRIS / ICE JAM POTENTIAL

Background:
Debris jams are important to channel stability and aquatic habitat. In general, woody debris promotes stream equilibrium and high quality instream habitat. On the other hand, hazards from debris jams associated with lateral erosion or channel avulsion may endanger infrastructure, such as bridges that are too narrow, as well as land uses or development occurring close to the channel. Debris jams are a common cause of channel avulsions, especially on alluvial fans.

Understanding where ice jams may occur is important for several reasons. Flooding associated with ice jams may be significantly higher than the for the same discharge in open channel conditions. Flooding from an ice jam occurs very quickly. Ice jams can cause damage to stream crossings, when the jam form against them. Ice jams may also cause damage to buildings, roadways and utilities as the ice blocks begin moving when the jam is released.

Figure 7.1 Ice jam formation at a dam on the Winooski River

Evaluation:
Look for places where an unconfined channel suddenly becomes constricted or where a relatively straight reach takes a dog-leg or tight radius turn. One example of a place with a high potential for debris or ice jamming would be where a river has to make a tight turn under a bridge that is too narrow. Over-widened, shallow streams with mid-channel bars associated with channel slope transitions or changes in channel confinement are also places with high potential for debris or ice jamming. A large, channel-spanning, dead-fall tree, if suspended above the bed but firmly lodged against channel banks or valley side slopes, may also catch debris during high flow events. Mark your map with the location of known debris or ice jams with the letters “DJ”.

DEC River Management Engineers, road and highway foreman, river resource professionals, town officials, and local residents may all be sources of information on where ice and debris jams have occurred historically.

Menu

Bend	Sharp angle (>90 degree) turn in channel planform
Bridge	Narrow or low clearance bridge and/or multiple bridge piers
Culvert	Small diameter compared to stream width and/or multiple culvert openings
Shallow	Wide-shallow channel with mid-channel bars
Debris	Observed jams of woody debris
Multiple	More than one type of potential cause for debris jam
None	No potential debris or ice jam
Not Evaluated	The reach was not accessed during the windshield survey.

Impact Rating for debris/ice jam potential

H	High - Existing jams causing erosion and stream migration near infrastructure, or recorded history of jams and flooding impacts
L	Low - Channel dimension, pattern, and profile suggest jams are possible but there is not a recorded history of flooding and erosion impacts
NS	Not Significant – No noticeable sharp bends, narrow stream crossings, or wide, shallow channel areas that may lead to ice and debris jamming, no recorded history of jamming
Not Evaluated	The reach was not accessed during the windshield survey.

Data Entry:
Enter the potential debris jam type and associated impact rating into the Phase 1 DMS under Step 7. Use the meta data in the DMS to indicate whether the debris jam potential has been confirmed or changed based on windshield surveys or Phase 2 or 3 assessments.

Step 8. Stream and Watershed Impact Ratings

Overview

Background:
Since the Phase 1 Watershed Assessment is largely dependent on remote sensing data, it is assumed that the channel and floodplain modifications identified elicit predictable responses by the various stream types due to assumed changes in channel slope and watershed inputs of sediment and water caused by these modifications.

An example would be the well-documented response that certain riffle-pool streams undergo following channelization and floodplain development. The increased channel slope and stormwater runoff initiate major adjustment processes. Such streams exhibit a high degree of vertical and lateral adjustment and at times may become high erosion hazard areas, threatening channel equilibrium in both upstream and downstream reaches, and possibly containing little or no habitat value.

The Step 8 Impact Rating and Priority Ranking process involves adding up the impact scores for the various Phase 1 parameters, and using this total impact rating as a "red-flagging" tool top identify reaches that may be in adjustment and outside the range of natural variability.

Data Sheet 8: Stream And Watershed Impact Rating

8.1 TOTAL IMPACT SCORE

Evaluation:
Once each parameter in Steps 4, 5, 6, and 7 have been assigned an impact rating of High, Low, or Not Significant, these ratings are translated into a total impact score. To do this the impact ratings are assigned numeric values of 2, 1, and 0 for High, Low, and Not Significant, respectively. To calculate the impact rating for each reach, the DMS automatically assigns the appropriate values to the impact ratings from Data Sheets 4 through 7. For those parameters where you did not have adequate information to rate impacts, and you selected the "No Data" or "Not Evaluated" choice on the impact rating menu, the DMS will use a "0" impact rating value when determining the total impact for the reach.

Next the DMS sums all the impact rating values to determine a total impact scores for each reach. Although this could be completed manually if you choose, this step is done automatically for you in the DMS . The DMS report titled "Stream and Watershed Impact Ratings" summarizes the range of impact scores for all the reaches you evaluated in the watershed. A DMS report named "Summary of Categorical Impacts" also provides categorical impact scores, which are sub-total scores for each of the following categories: Land Cover and Reach Hydrology (Step 4); Channel Modifications (Step 5); Floodplain Modifications and Planform Changes (Step 6); and Bed and Bank Condition (Step 7).

Reaches which scored low impact ratings because you were unable to collect information for one or more parameters should be tracked using the Step 8 DMS report. As complete information is gathered for a given parameter, enter this data into the Phase 1 DMS and it will re-calculate the impact ratings for that parameter and recalculate the total impact rating for the reach. Remember to update Phase 1 data, impact ratings and meta data with field verified information collected during windshield surveys and Phase 2 and Phase 3 assessments.

Menu

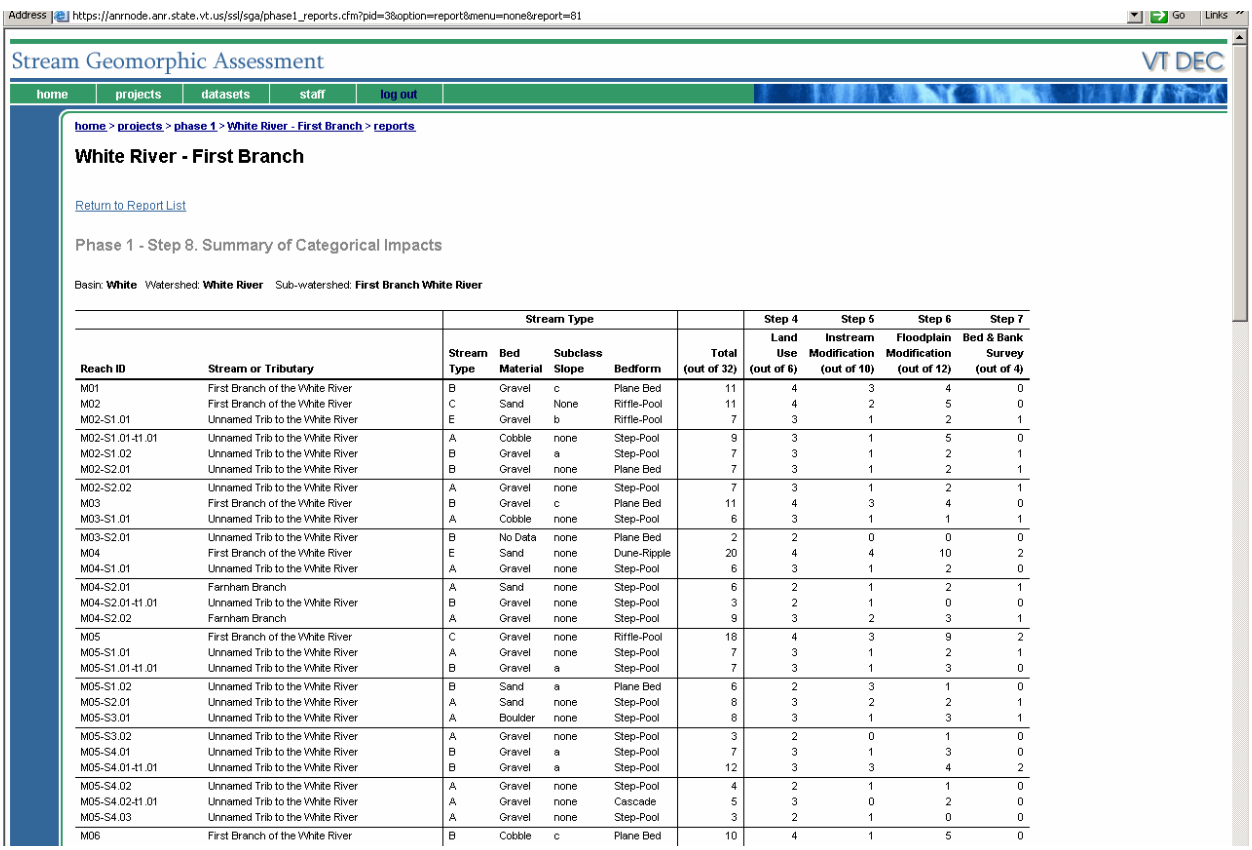
2	High (H)	Strongly Evident – Highly Significant
1	Low (L)	Evident – May Be Significant
0	Not Significant (NS)	Not Evident – Insignificant
0	No Data or Not Evaluated	Unknown – No data collected

8.2 PRIORITY RANKING

Evaluation:
The DMS report "Summary of Categorical Impacts" provides total and categorical impact scores. You can use this report to rank reaches for different stream management priorities. For instance, reference reaches (indicated by low impact ratings) may be identified to aid in the evaluation of impacted reaches having similar stream and valley settings.

When establishing the priority ranking of the reaches within a watershed, be sure to track those reaches that received low total impact ratings due to one or more parameters being rated as "No Data" or "Not Evaluated". For instance, there may be reaches for which no information was initially available to complete an impact rating for bank erosion, flow modification, bank armoring, and dredging history. If further assessment revealed that each of these parameters would be rated as a "high" impact, the total impact would be significantly higher and potentially result in a much higher priority ranking for the reach.

There are many different ways to prioritize your reaches, based on your goals and objectives for the watershed. There is a place on the data sheet for you to make notes on what criteria you used to prioritize your reaches for further assessment. The priority ranking is not entered into the database because the ranking may change from season to season or as your assessment goals and objectives.



		Stream Type					Step 4	Step 5	Step 6	Step 7
Reach ID	Stream or Tributary	Stream Type	Bed Material	Subclass Slope	Bedform	Total (out of 32)	Land Use (out of 6)	Instream Modification (out of 10)	Floodplain Modification (out of 12)	Bed & Bank Survey (out of 4)
M01	First Branch of the White River	B	Gravel	c	Plane Bed	11	4	3	4	0
M02	First Branch of the White River	C	Sand	None	Riffle-Pool	11	4	2	5	0
M02-S1.01	Unnamed Trib to the White River	E	Gravel	b	Riffle-Pool	7	3	1	2	1
M02-S1.01-t1.01	Unnamed Trib to the White River	A	Cobble	none	Step-Pool	9	3	1	5	0
M02-S1.02	Unnamed Trib to the White River	B	Gravel	a	Step-Pool	7	3	1	2	1
M02-S2.01	Unnamed Trib to the White River	B	Gravel	none	Plane Bed	7	3	1	2	1
M02-S2.02	Unnamed Trib to the White River	A	Gravel	none	Step-Pool	7	3	1	2	1
M03	First Branch of the White River	B	Gravel	c	Plane Bed	11	4	3	4	0
M03-S1.01	Unnamed Trib to the White River	A	Cobble	none	Step-Pool	6	3	1	1	1
M03-S2.01	Unnamed Trib to the White River	B	No Data	none	Plane Bed	2	2	0	0	0
M04	First Branch of the White River	E	Sand	none	Dune-Ripple	20	4	4	10	2
M04-S1.01	Unnamed Trib to the White River	A	Gravel	none	Step-Pool	6	3	1	2	0
M04-S2.01	Farnham Branch	A	Sand	none	Step-Pool	6	2	1	2	1
M04-S2.01-t1.01	Unnamed Trib to the White River	B	Gravel	none	Step-Pool	3	2	1	0	0
M04-S2.02	Farnham Branch	A	Gravel	none	Step-Pool	9	3	2	3	1
M05	First Branch of the White River	C	Gravel	none	Riffle-Pool	18	4	3	9	2
M05-S1.01	Unnamed Trib to the White River	A	Gravel	none	Step-Pool	7	3	1	2	1
M05-S1.01-t1.01	Unnamed Trib to the White River	B	Gravel	a	Step-Pool	7	3	1	3	0
M05-S1.02	Unnamed Trib to the White River	B	Sand	a	Plane Bed	6	2	3	1	0
M05-S2.01	Unnamed Trib to the White River	A	Sand	none	Step-Pool	8	3	2	2	1
M05-S3.01	Unnamed Trib to the White River	A	Boulder	none	Step-Pool	8	3	1	3	1
M05-S3.02	Unnamed Trib to the White River	A	Gravel	none	Step-Pool	3	2	0	1	0
M05-S4.01	Unnamed Trib to the White River	B	Gravel	a	Step-Pool	7	3	1	3	0
M05-S4.01-t1.01	Unnamed Trib to the White River	B	Gravel	a	Step-Pool	12	3	3	4	2
M05-S4.02	Unnamed Trib to the White River	A	Gravel	none	Step-Pool	4	2	1	1	0
M05-S4.02-t1.01	Unnamed Trib to the White River	A	Gravel	none	Cascade	5	3	0	2	0
M05-S4.03	Unnamed Trib to the White River	A	Gravel	none	Step-Pool	3	2	1	0	0
M06	First Branch of the White River	B	Cobble	c	Plane Bed	10	4	1	5	0

Figure 8.1: Example of DMS report summarizing impacts by category

The DMS report titled "Downstream and Upstream Impact Graph" can be used to graph the total impact scores for each reach along the longitudinal profile of the mainstem or tributaries. This graphical organization of the data shows the upstream/ downstream position and proximity of reaches with different impact levels, which can inform management decisions. For instance, if a highly impacted reach, which may potentially be in-adjustment, is located just upstream of a reach that has received a very low impact rating; you may be concerned about adopting a strategy to protect the low impact reach.

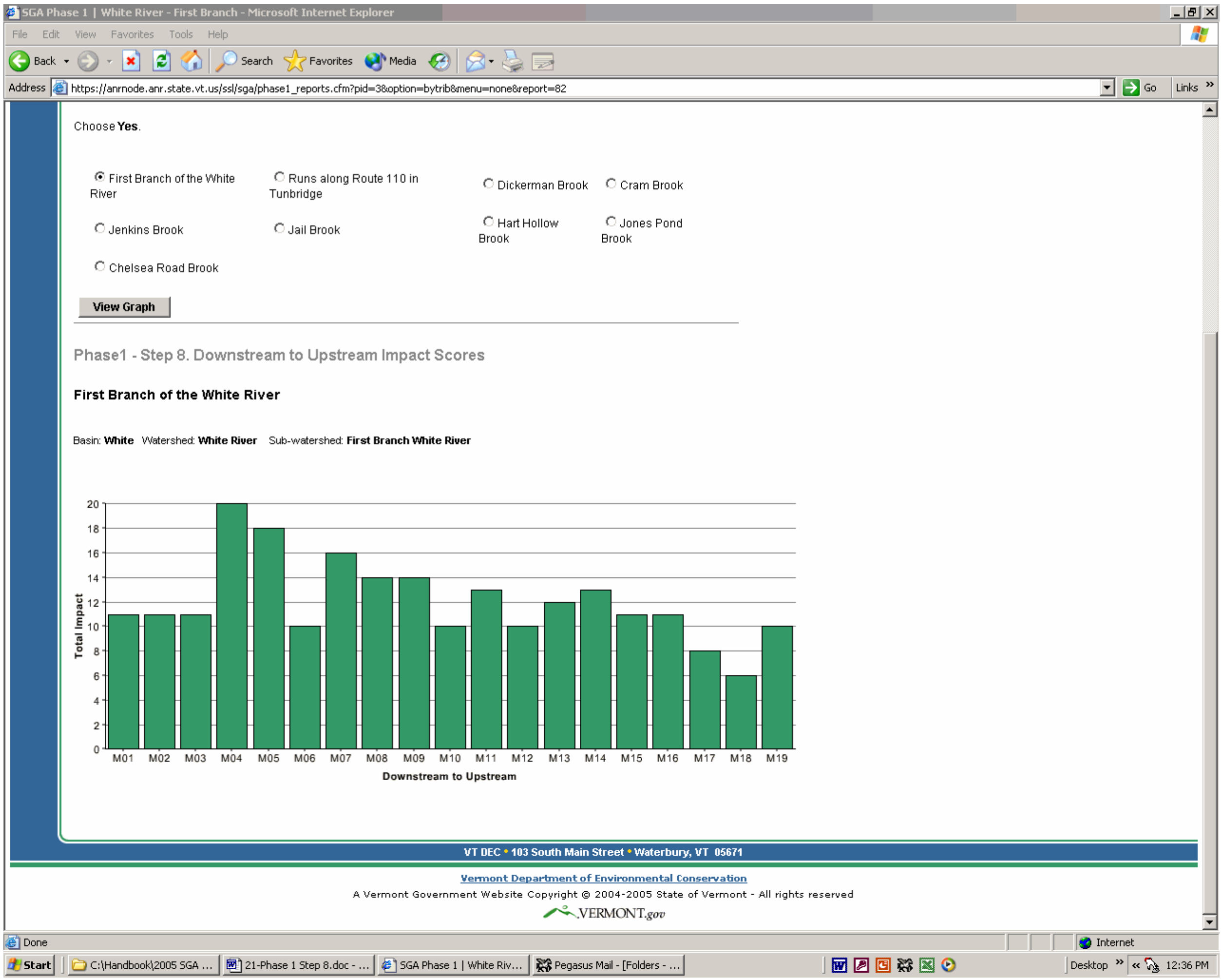


Figure 8.2 - Example of downstream to upstream locations of impacted reaches.

Steps 9. Provisional Geomorphic Condition Evaluation

Overview

Background:
The Provisional Geomorphic Condition Evaluation is comprised of three separate, yet interrelated, evaluations of the reaches in your watershed, which are: adjustment process, reach condition, and reach sensitivity. These evaluations will prove to be valuable information at the watershed level. Once the Phase I data is entered, the DMS will automatically generate a report listing the ratings for the reach adjustment process, condition and sensitivity.

The DMS tools described below help determine the geomorphic condition of reaches by examining the impact ratings and characterizations that were made for sixteen of the Phase 1 parameters. The value in completing this process, however, is that Phase 1 evaluates the parameters that may **cause** channel adjustment (i.e., floodplain modifications or land use/land cover), while Phase 2 and Phase 3 assessments evaluate **effects** of those modifications by measuring direct signs of impacts and channel adjustment within the channel and riparian area. Together the cause and effect factors provide a more complete picture of potential adjustment processes occurring in a reach and within your watershed.

As with any Phase 1 parameter, observations and measurements made in the field for the **same** parameter should supercede remote sensing and computer generated data. Values entered into the Phase 1 DMS should be changed if a field exercise shows they are wrong or that they mischaracterize the reach. *Remember to indicate where you supplant Phase 1 data with data generated from Phase 2 or 3 assessments by changing the meta data in the DMS.* As the ANR statewide DMS becomes populated with data generated in the field for different stream types and watersheds from around Vermont, the Phase 1 impact ratings and reach condition evaluations will increasingly provide a more complete picture of how to assess reach conditions watershed-wide and offer more powerful guidance in setting field assessment priorities.

Step 9 does not require any data entry into the DMS. The DMS generates a report named “Adjustment Process and Reach Condition” that lists a Phase I score for the four adjustment processes as well as the provisional condition and sensitivity.

Data Sheet 9: Geomorphic Condition

9.1 CHANNEL ADJUSTMENT PROCESS

Notes on Channel Evolution, Exceptions, and Outliers: The Phase 1 Step 9 DMS Report attempts to factor in the sequence of adjustments that occur in one of the more common channel evolution process seen in Vermont. It is important, however, to remember the sequential and temporal aspects of the channel evolution process (Appendix C). For instance, channel degradation may be followed by channel widening, which is often followed by channel aggradation and plan form adjustment. If your provisional Phase 1 assessment shows channel degradation as the current process, it may be reasonable to find (in the field) an incised, widened channel that is currently aggrading. In this example, the Phase 1 may have correctly picked up on **causal** factors that should indicate channel degradation, but perhaps due to interceding flood events, the channel evolution process continued to the adjustment processes that often follow degradation. Such discrepancies do not necessarily represent assessment error. They are important to explore because they provide important insights into the situations where cause and effect did not play out as expected; or where the evolution process has continued and your reach is experiencing a different adjustment process beyond what the causal factors indicate. Finding out why a reach did not respond or adjust to certain stressors as predicted, or has moved to a different stage of channel evolution and /or adjustment process, is important to developing a management plan for the reach.

Background: Detailed descriptions of channel evolution and channel adjustment processes are provided in Appendix C and Step 6 of the Phase 3 Handbook. Phase 1 data can be used to set a hypothesis and provisionally assign adjustment processes that may be occurring in the reaches in your watershed based on modifications of their channels, floodplains, and/or watershed and riparian vegetation.

Evaluation:

Vermont ANR has developed a DMS Report named "Adjustment Process and Reach Condition" that adds together impact scores (2, 1, or 0) for specific Phase 1 parameters that have been shown to initiate or influence different channel adjustment processes (see DMS query flow chart in Appendix B). The query provides a score for each of the four adjustment processes in the Phase 1 DMS and displays the values in the report mentioned above. This report provides total impact ratings and provisional adjustment process (Table 9.1) scores for each reach (Figure 9.1).

Initially the highest scoring adjustment process may be considered the current adjustment process occurring in the reach. Many reaches may have a high score for two or more adjustment processes. Usually if a stream is undergoing one type of adjustment (especially degradation or aggradation) then it will be undergoing other forms of adjustment as well. You may consider the second highest score the "concurrent adjustments". Since channel adjustment processes are typically the result of the cumulative effect of different stressors, a minimum cut-off value of 4 has been established to recognize that, while all reaches will likely have some impacts, they may not necessarily be in adjustment. There may be multiple adjustment processes with the same or nearly the same score, greater or equal to 4, which may indicate multiple adjustments under way in the reach. If none of the adjustment processes have a score greater than or equal to the cut-off value, it may indicate that the reach is in equilibrium (not in adjustment).

Table 9.1 Phase 1 adjustment process options

Degrading	Downward erosion of stream bed via a head-cutting process
Aggrading	Excessive sediment build up on streambed and bars
Widening	Erosion of both banks leading to an over-widened streambed
Planform	Rapid and/or irregular meander movement and pattern
None	No significant adjustment process indicated
Multiple	Multiple adjustments indicated

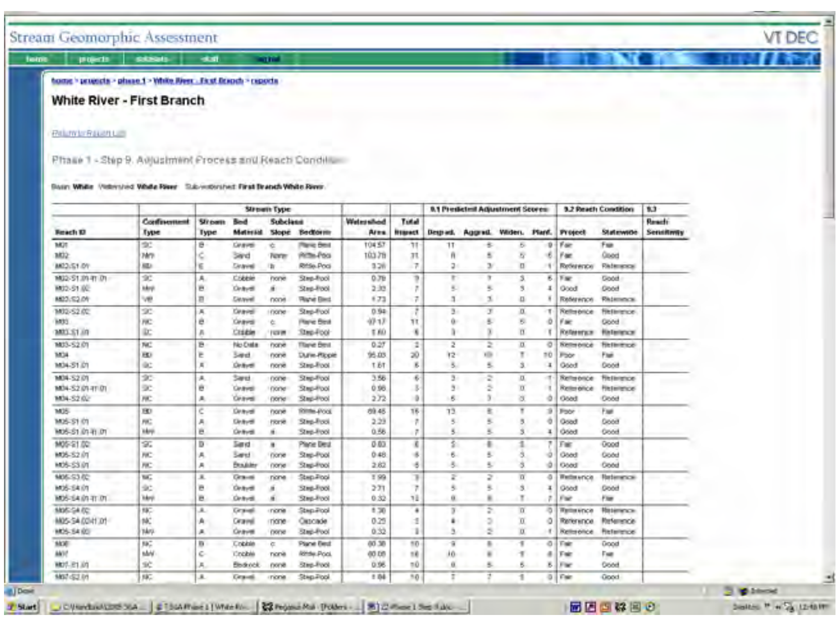


Figure 9.1 Example of a DMS query output of provisional adjustment process scores.

See Appendix B to learn how the query generates Phase 1 Provisional Adjustment Scores.

9.2 REACH CONDITION

Background:
A Provisional Geomorphic Condition Evaluation process has been established in the Phase 1 protocols to use the provisional adjustment process ratings to derive a condition rating for each reach. To support the prioritization of reaches in Step 10, derivation of geomorphic conditions are made relative to the most impacted reaches ***within*** your watershed, as well as those in relation to other highly impacted streams throughout Vermont. Reach conditions are defined using the following four categories:

Reference: A reach with no significant channel or floodplain modifications and an adjacent forested riparian buffer should score as a **reference reach** in a near-natural condition. Other reaches that have been modified or lack a buffer are evaluated on the extent to which their condition has departed from the reference condition of the same stream type.

Good: Most streams in Vermont have experienced some degree of human-induced change to their watershed, floodplain, and/or channel. Where a stream is undergoing only minor adjustments or has substantially adjusted to previous modifications and is returning to a dimension, pattern, and profile in regime with watershed inputs, it should be evaluated as a reach in **good condition**. For instance, streams that have undergone planform adjustments in response to watershed clear-cutting or road building decades ago may be near a reference condition today (e.g. entering Stage V of the channel evolution process, Appendix C). A stream in good condition differs from a reference condition stream in that it is still undergoing adjustments due to current or historic modifications, land cover changes, or riparian buffer re-establishment. Streams in good condition may still be adjusting their belt width or building a floodplain but compared to the stream in fair condition they are within the range of natural variability expected for the reference condition of the stream.

Fair: Streams in **fair condition** are fully in adjustment, possibly already experiencing or heading toward major and rapid changes due to recent floodplain and channel modifications, land cover changes, and/or loss of riparian buffer. Channels undergoing incision (i.e. head-cutting), widening, or rapid lateral movement (i.e. planform adjustment) should score in fair condition.

Poor: An entrenched reach, for instance in a narrow or unconfined valley (Stage II of channel evolution – Appendix C), or one that is severely over-widened and out of regime with respect to sediment transport (i.e., aggrading) should be evaluated as a reach in **poor condition**. Unless the stream has started to braid, with large mid-channel bars that can be seen on the orthophotos, it may be difficult to know whether the stream is in fair or poor condition without further field assessments.

The DMS generates a "within watershed" reach condition score from the provisional adjustment process scores using the following formula:

Condition Score:

$$\frac{(HS - deg) + (HS - aggr) + (HS - wid) + (HS - plan)}{(4 \times HS)}$$

Where:

HS = Highest adjustment process score (for any reach in your watershed)
deg = reach degradation score
aggr = reach aggradation score
wid = reach widening score
plan = reach planform score

In the example shown in Figure 9.1, a value of 10 was the highest adjustment process score (reach T4.1/S1 for planform adjustment) in the set of reaches. The database query would assign 10 as the HS value and calculate condition scores. For example, reach M19 in Figure 9.1 would have a condition score of [(10-6) + (10-9) + (10-7) + (10-8) / (4 x 10) = 0.25 = Poor

Evaluation:
The DMS report generated for Step 9.1, "Adjustment Process and Reach Condition," calculates condition scores **based** on the formula in the box above and provides provisional stream conditions for each reach based on the scores in menu above (Figure 9.1).

It is important to note that the DMS is using the highest score within your project area to calculate the "project" reach condition rating. These results are calibrated to fall within the possible range of scores assessed within **your** watershed. This has the advantage of helping you target the reaches within your watershed that have the highest impacts.

A between watershed or "statewide" reach condition is also generated in this report. The Vermont River Management Program uses Phase 1 assessments completed in Vermont and uses a statewide high adjustment score value to generate a statewide reach condition using the computation process described above. This value will allow you to compare the condition ratings of your reaches to each other as well as with those from assessed reaches around Vermont.

Menu

0.85 – 1.0	**Reference**	In Equilibrium – no apparent or significant channel, floodplain, or land cover modifications; channel geometry is likely to be in balance with the flow and sediment produced in its watershed
0.65 – 0.84	**Good**	In Equilibrium but may be in transition into or out of the range of natural variability – minor erosion or lateral adjustment but adequate floodplain function; any adjustment from historic modifications nearly complete
0.35 – 0.64	**Fair**	In Adjustment – moderate loss of floodplain function; or moderate to major planform adjustments that could lead to channel avulsions
0.00 – 0.34	**Poor**	In Adjustment and Stream Type Departure - may have changed to a new stream type or central tendency of fluvial processes – significant channel and floodplain modifications may have altered the channel geometry such that the stream is not in balance with the flow and sediment produced in its watershed

9.3 REACH SENSITIVITY

Background:
Step 7 of the Phase 2 Handbook and Step 6 of the Phase 3 Handbook have more detailed discussion and guides on the factors affecting stream reach sensitivity and may be useful reading prior to reviewing the stream sensitivity.

Evaluation:
The DMS automatically assigns a sensitivity rating to the reaches in your watershed based on the reference stream type. This sensitivity rating represents the inherent characteristics of the stream "in regime" and does not take into consideration any adjustments. Table 9.2 outlines the sensitivity ratings that will be assigned to each of the reference stream types. The sensitivity rating can be viewed for each reach in the DMS report named "Adjustment Process and Reach Condition".

Table 9.2 Phase 1 reach sensitivity assigned based on reference stream type

Reference Stream Type	Reference Stream Sensitivity
A1, A2, B1, B2, C1, C2	Very low
G1, G2, F1, F2	Low
B3, B4, B5, C3, E3	Moderate
C4, C5, E4, E5, A3, A4, A5, G3, F3	High
G4, G5, F4, F5	Very High
D3, D4, D5	Extreme

Step 10. Like Reach Evaluation

Background
The purpose of a "Like Reach Evaluation" is to group reaches in the watershed by similar stream types (product of Step 2) and similar geomorphic condition assessments (product of Step 9).

Grouping streams by like reaches is useful in selecting a manageable number of reaches for which to conduct the more detailed Phase 2 and Phase 3 assessments.   By collecting detailed information on a few reaches that represent all the stream types in your watershed you are better able to characterize the entire watershed without conducting extensive and time-consuming field surveys on the entire watershed.

Evaluation
The DMS report titled "Like Reach Evaluation" assists with the evaluation of like reaches by creating the following table. The user must supply the sorting criteria (See Figure 10.1).

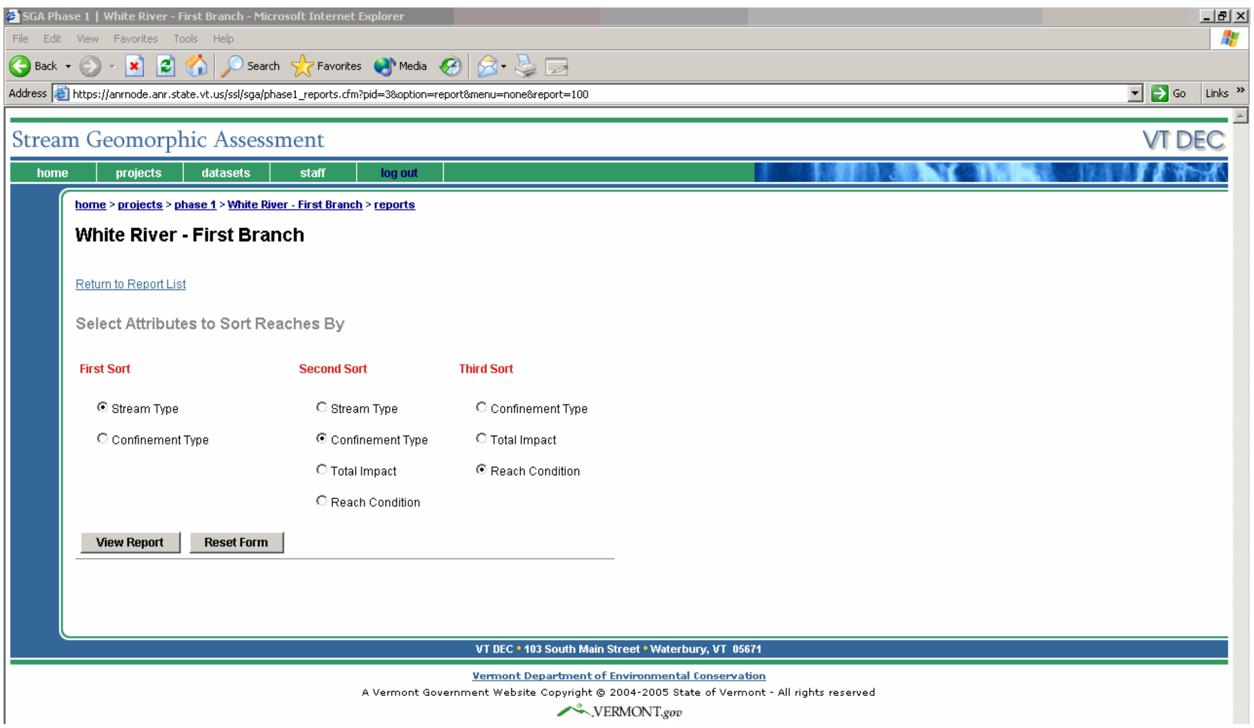


Figure 10.1. The user must supply the sorting criteria for the Like Reach Evaluation report. The DMS allows for a first, second and third sort.

Once the user has specified the sorting criteria the DMS will generate a report (See Figure 10.1). The user can update the sorting criteria and re-run the report to generate different like reach groupings.

Phase 1 Quality Assurance Protocol

Background:
Completing the Quality Assurance Protocol is critically important to the data documentation process, which will allow your assessment team and local, regional, state, and federal partners to ascertain the accuracy and completeness of your geomorphic assessment work.

High quality data, which is complete and accurate, may form the basis of meaningful natural resource and river management projects, and is therefore one of the primary goal of any assessment program. Often, both time and budgetary constraints do not support the collection of high quality data throughout a watershed. Documentation of any assessment deficiencies should not necessarily be viewed as failure, but rather as the first step in identifying future assessment needs.

Evaluation:
After completing all or parts of Steps 1 through 10 of the Phase 1 Stream Geomorphic Assessment Handbook, you should complete the Quality Assurance Sheet in Appendix A and enter the information in the Phase 1 QA DMS. Use the following protocols in completing the QA sheet.

QUALITY ASSURANCE WORKSHEET

QA Team Leader: The name of the local quality assurance team leader.

ANR Team Leader: The ANR staff member serving on the quality assurance team who will conduct the State QA review.

Training: Indicate the types of ANR sponsored training received by one or more members of your assessment team:

- **Phase 1:** Training on the completion of a watershed orientation and Steps 1 – 10.
- **SGAT:** Training on the use of the Stream Geomorphic Assessment Tool, including the GIS extension and the SGAT handbook.
- **Quality Assurance (QA):** Specialized training to complete quality assurance reviews.

Watershed Orientation Completed: Indicate whether or not a watershed orientation was completed.

Reach Break Review: Indicate whether a trained member of the assessment team reviewed the reach breaks that were made in Step 1 and verified in Steps 2 and 3. This review is conducted to ensure reach break consistency, and is ideally done by the local or State QA team leader.

Exclusive Use of Protocols and DMS: The Vermont ANR Handbooks are one of many different geomorphic assessment protocols that have been published by agencies, organizations and private companies. Indicate whether you used the ANR protocols exclusively, and if not, what other protocols were used. If the protocols are sufficiently divergent from the ANR protocols, data will not be entered into the State DMS.

Tools Used to Collect Data: Transcribe the information about the tools and materials used to complete a protocol step, as was recorded at the bottom of the Step 1 through 7 data sheets.

Confidence Level: Using the following definitions, circle the level that best describes the confidence that you and your assessment team have in the Phase 1 data collected for each step in the protocols:

Low to Moderate – Unsure of protocols and/or used minimal historic data sources; 1:5000 stream coverages were not available; little to no field verification.
Moderate – Understood and followed Phase 1 Protocols; used at least one historic data resource for parameters where appropriate; little of no field verification; suspect some watershed, channel, or floodplain modification activities not known.
Moderate to High – Understood and followed Phase 1 Protocols; used many historic data resources for parameters where appropriate; some field verification; suspect some watershed, channel, or floodplain modification activities not known.
High – Used many data resources; historical activities in area well-documented; field verified all questionable assessments; suspect few modification activities not known.

Data Completed**:** Date the protocol step was initially completed.

Data Updated: Date the Phase 1 data for a protocol step was revised based on new or additional data sources or field assessments, including windshield surveys.

Date of Local QA Team Review: Date a quality assurance review of the Phase 1 data for a protocol step was completed by the local QA team leader.

Date of State QA Team Review: Date a quality assurance review of the Phase 1 data for a protocol step was completed by the State QA team member.

Comments: Any comments relaying details about the tools and materials that were used or why a confidence level was selected. Document any issues, things missing and why, questions, problems you may have had along the way.

Basic QA checks to be completed before sending data to the River Management Program
The following list a QA checks has been developed to help you improve your QA documentation and find some of the more common errors that have been encountered during the Phase 1 quality assurance process. In some cases, DMS QA reports have been developed to assist with these checks. Completing these checks before requesting the final QA review by the DEC River Management Program will ensure a more timely State QA check.

1) Print out the DMS report tables 1- 8. Using a map of the watershed, review the data to see if it makes sense.

- Check to see that the slopes and stream types seem true to what you see on the map. Some maps in VT are in meters, and it is easy to take the elevations in meters, while the lengths are collected in feet. If you see what appears to be a steep narrow valley and the slopes in steps 2.3 and 2.5 are shallow; indicating a "C" stream type, be sure that the data was collected in the same units. (Stream types may have to be adjusted accordingly if there are changes made to slope values.)
- Review the confinement types. Where there is a steep narrow looking valley, "V" shaped, on the map check to see what confinement type chosen was. Where an attempt was made to measure the valley width in these steeper valleys a large confinement ratio may be derived, giving a "broad" or "very broad" confinement type. If "broad" or "very broad" was chosen, does it seem reasonable. Guidance in the handbook suggest choosing a "narrow to confined valley type for these "V" shaped valleys; pending field verification.

- In Step 3 you can check for alluvial fan and valley side slopes to see that the chosen characteristic seems reasonable. Remember that the alluvial fan is only counted on the reach itself, not on tributaries entering the reach.

2) Document information for the reach itself:
   - If there are parameters where information was evaluated, but a "No Data" was chosen as the impact score, make a note in the comments field as to why; for example: "bank erosion seen at bridge crossing, but total amount not determined so no impact chosen."
   - Use the meta data where data is supplemented by windshield survey, Phase 2, or Phase 3 data. It is important to keep track of where data has been confirmed or collected in the field, by using the check boxes.

3) Comparing channel straightening impacts (Step 5.4) with belt width and meander ratios (Steps 6.5, and 6.6) for consistency. For Step 5.4; if you chose a <u>high</u> impact for channel modification, that is 30% of reach was modified, then the impact score for steps 6.5 and 6.6 should also be <u>high</u> (these measurements are only done for C / E streams). For step 6.5 and 6.6, no measurement is taken if more than 50% of the reach is straightened, the channel width will be entered for the values in step 6.5 and 6.6, this will make the impact high. If there are discrepancies, note if there was a meander that may have been measured in Step 6.5 / 6.6. In some cases, the assessor measured a single "nice" looking meander in an otherwise straightened reach. For an accurate impact score, assess the average condition for the reach, and pass over measuring the outlier, albeit regime-looking meander.

These basic checks will help the data collector and RMP understand the limitations, concerns, and potential needs of the data which has been collected to date. Please contact the RMP with any questions or comments as you go through your review.

State QA reviews are greatly enhanced by providing the State QA leader with a CD containing the following data and information at the completion of the assessment:

- All assessment data recorded on the ANR Stream Geomorphic Assessment Phase 1 Data Sheets and entered into the current version of the ANR Phase 1 DMS.

- The entire SGAT project burned onto a CD.

- The FIT theme documenting the locations of:
  - Alluvial Fans
  - Bank Armoring or Revetments
  - Bridges and Culverts
  - Buffers Less Than 25' wide
  - Development
  - Dredging
  - Encroachments
  - Erosion
  - In stream Flow Regulations
  - Grade Controls
  - Migration
  - Straightening
  - Any additional spatial data for any of the Phase I parameters.

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