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Phase 1 Stream Geomorphic Assessment
Winooski River Watershed
Town of Cabot
Washington County, Vermont

Final Report
November 2, 2004

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TABLE OF CONTENTS

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EXECUTIVE SUMMARY

- A Phase I Stream Geomorphic Assessment of the Winooski River and major tributaries within the Town of Cabot was completed by Bear Creek Environmental during spring 2004. The study included the main stem of the Winooski River, Jug Brook, and two other major tributaries to the Winooski. The watershed was divided into 23 reaches based on confinement, slope, soils, and tributary influence.

- The study followed the Phase 1 assessment protocol developed by the Vermont Agency of Natural Resources. Information from the study came from the Vermont Department of Environmental Conservation, the Vermont Fish and Wildlife Department, the Cabot Conservation Committee, the Vermont Mapping Program, the Vermont Center for Geographic Information, and the windshield survey.

- The dominant surficial geology of the Upper Winooski River consists of alluvium, glacial till, and ice contact deposits. With few exception, the reaches characterized as C channels within the upper Winooski River watershed within the Cabot study reach have alluvium as the dominant geologic material. These soils are frequently flooded, however are only slight to moderately erodable. The majority of the A and B type channels have till as the dominant geologic materials. These soils are rarely flooded and have very severe erodibility.

- Of the four impact categories measured during the Phase 1 Assessment, land use was the primary category identified as being at risk of causing channel adjustments. Seventy percent of the reaches resulted in a watershed/land use impact rating of high, while 61

percent of the reaches resulted in a river corridor land cover/land use impact rating of high. Approximately one-third of the reaches received a high impact rating for riparian corridor, due to over 75 percent of the reach having little or nor buffer on one or more banks.

- The parameter berms and roads, in the Floodplain Modification category, and bank erosion, in the Bed and Bank Windshield Survey Category, also resulted in high impact scores.

- The meander migration, meander width ratio, and meander wavelength indicate the upper Winooski River is in adjustment. Based on the review of current and historical orthophotos, meander migration was evident on the main stem of the Upper Winooski River from reach M07 downstream. Migration, or movement of the channel by eroding its outer bank on meander bends, appeared to be the primary mechanism for lateral migration of the channel. The high bank erosion and the low meander wavelength ratios also indicate the stream is migrating laterally. The low belt width ratio is possibly a reflection of another adjustment process which is occurring simultaneously. Meander width ratios measured on the upper Winooski River indicate the river has become straighter and steeper, possibly resulting in degradation and loss of access to its floodplain. Observations made during the windshield survey confirm channel incision is evident on the main stem.

- The within watershed condition generated from the Phase I database was generally similar to the reach condition based on professional judgment and observations during the Phase I windshield survey.

- Reaches in poor condition were isolated to the main stem below the Village of Cabot (M02 and M03) and the lowest reach on Tributary 2. The majority of the unconfined stream reaches were in the fair category, while only one confined stream reach resulted in a reach condition of fair. Five of the 23 reaches were placed in the good category based on professional judgment and the output from the Phase I database. The stream reaches in good condition were generally located in the middle of the watershed (i.e. not in the headwaters and not near the lower end). Streams in reference condition were found in the headwaters and were all A or B type streams (i.e. confined). None of the unconfined stream channels scored as a reference reach.

- Bear Creek Environmental recommends that reaches M02 through M07 on the main stem of the Upper Winooski be selected for the upcoming Phase 2 Assessment fieldwork.

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1.0 INTRODUCTION

Bear Creek Environmental was retained by the Cabot Conservation Committee (CCC) to conduct a Phase 1 Stream Geomorphic Assessment of the Winooski River and Major Tributaries[1] limited to the Town of Cabot, Vermont. The assessment was conducted on the main stem of the Winooski River, Jug Brook, and two other major tributaries of the Winooski (Figure 1). The primary objective of the study was to provide an overview of the general physical characteristics of the Winooski River watershed and determine which reaches may be in adjustment. A secondary objective of the study was to select reaches to be included in a Phase 2 Assessment. The Phase 2 Assessment would then be used to provide the Town of Cabot with information that can be used for watershed planning and restoration activities.

Data and information for the Winooski River Watershed within the Town of Cabot was obtained from the Vermont Department of Environmental Conservation (VDEC), the Vermont Fish and Wildlife Department (VF&W), the Vermont Center for Geographic Information (VCGI), and the Cabot Conservation Committee. Windshield surveys of the watershed were conducted on May 18, 2004 and June 22, 2004. Mary Nealon (Bear Creek Environmental),

[1] Per the ANR protocols major tributaries constitute ten percent of more of the watershed area at the confluence with the main stem.

Shayne Jaquith (VDEC), and Gary Gulka (CCC) visited the majority of the reaches on May 18, 2004. On June 22, 2004, Mary Nealon and Michael Blazewicz (Bear Creek Environmental) visited the remaining reaches, which were located primarily on Jug Brook.

2.0 BACKGROUND

The Winooski River Watershed has a watershed size of 24.5 square miles just above the confluence of Molly Falls Brook in Marshfield, just south of the Cabot/Marshfield Town lines. This Phase I study included stream reaches on the Winooski River primarily located within the Town of Cabot. The Winooski River within the Town of Cabot forms the headwaters of the Winooski River (see Figure 1).

There are no USGS stream gages within the upper Winooski watershed. In order to better understand the flood history, long term data from the U.S. Department of the Interior, U.S. Geological Survey (USGS) gage on the Dog River in Northfield, VT (gage #04287000) was obtained. The Dog River gage was selected because it is located on a tributary of the Winooski River in Central Vermont . Although the drainage area at the Dog River gage is somewhat larger (76.1 sq. miles) than the upper Winooski River watershed, it does provide some useful information about when large flood events occurred. Sixty-eight years of record are available for the Dog River gage at Northfield Falls. The gage provides a continuous record of flow from 1935 through the present. The long term record shows peak discharges between a ten year and 25 year recurrence interval occurred during water years[2] 1976, 1952, 1987, and 1989. Floods less frequent than the 25 year discharge occurred during water years 1938, and 1973.

[2] A water year is the twelve month period from October 1 through September 30.

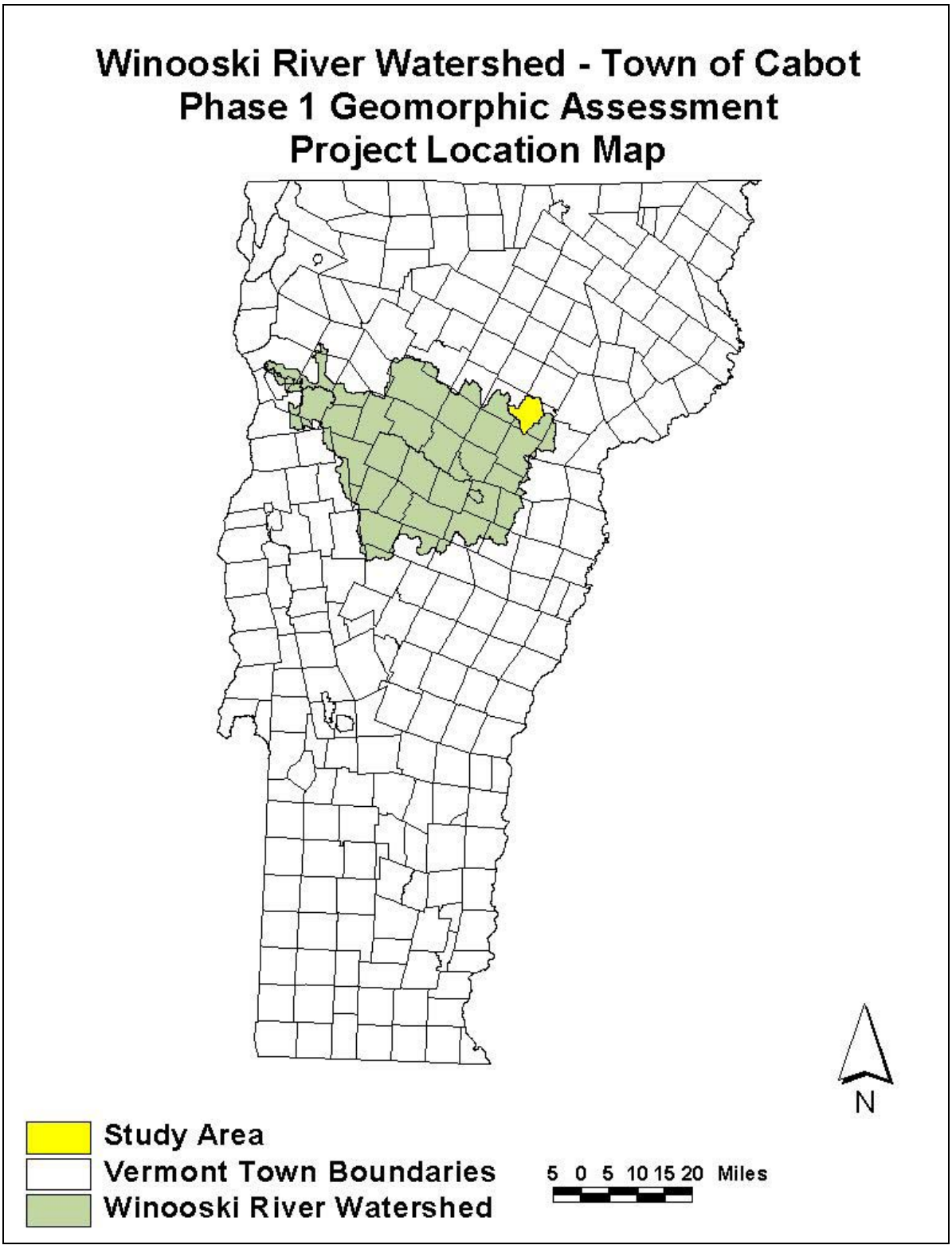

Figure 1. Project Location Map for the Phase 1 Assessment

3.0 METHODOLOGY

The Phase I assessment followed procedures specified in the Vermont Stream Geomorphic Assessment Handbook Phase 1 (Vermont Agency of Natural Resources 2004), and used version 3 of the Stream Geomorphic Assessment Tool (SGAT) GIS extension. All assessment data were recorded on the Agency of Natural Resources (ANR) Phase I data sheets, and were entered in to the most current version of the ANR Phase I database. Christa Alexander (VF&W) provided the reach and subwatershed delineations and ran SGAT.

3.1 Parameters

During the Phase 1 Assessment, each parameter in Table 1 was rated according to the following menu options (NS – not significant, low impact, high impact or No info –no information). A zero was scored for options NS and No info, a one for low impact and a two for high impact.

Table 1. Parameters Included in Impact Scores

Step #	Parameter
4.1	Watershed Land Cover/ Land Use
4.2	Corridor Land Cover/ Land Use
4.3	Riparian Buffer Width
5.1	Flow Regulations and Water Withdrawals
5.2	Bridges and Culverts
5.3	Bank Armoring and Revetments
5.4	Channel Modifications
5.5	Dredging and Gravel Mining History
6.1	Berms and Roads
6.2	River Corridor Development
6.3	Depositional Features
6.4	Meander Migration / Channel Avulsion
6.5	Meander Width Ratio
6.6	Wavelength Ratio
7.2	Bank Erosion – Relative Magnitude
7.3	Ice and Debris Jam Potential

3.2 QA Review

The Phase 1 – Quality Assurance Worksheet was completed by Bear Creek Environmental to document the tools used to collect the Phase 1 data, the confidence level in the data, the date the assessment was completed, and the date each Phase 1 step was checked by the local and state QA teams (see page 1 of the Appendix). The confidence level in the Phase 1 data was rated as moderate to high by Bear Creek Environmental. A few of the reaches could not be accessed due to poor accessibility or lack of landowner permission. For this reason, the Quality of the data was rated as moderate to high rather than high. In addition, it was suspected that some of the historic instream and floodplain modifications were not known.

The Microsoft Access Phase 1 database and the AcrView Shapefiles for the Winooski River Phase 1 study were submitted to Shayne Jaquith of the ANR for a QA review in July 2004. Some revisions were made by Bear Creek Environmental to the plan form parameters (meander migration, belt width, and average wavelength) following this review. Another change made to this report between the draft and final stages include the transfer of the data from the version 3 to the version 4 Phase 1 database. The version 4 database is the most current version available at this time.

4.0 RESULTS

4.1 Reach Locations

The Winooski River Watershed was divided into 23 reaches for the Phase I Assessment. Reach M11, Coits Pond, did not receive a full Phase I assessment, because this reach is not a fluvial system. Report Number 1 on pages 2 and 3 of the Appendix provides the reach locations including reach description, town where the reach is located, and latitude and longitude generated from SGAT. Figure 2 shows the location of study reaches used in the Phase 1 Assessment. Each point represents the downstream end of the reach.

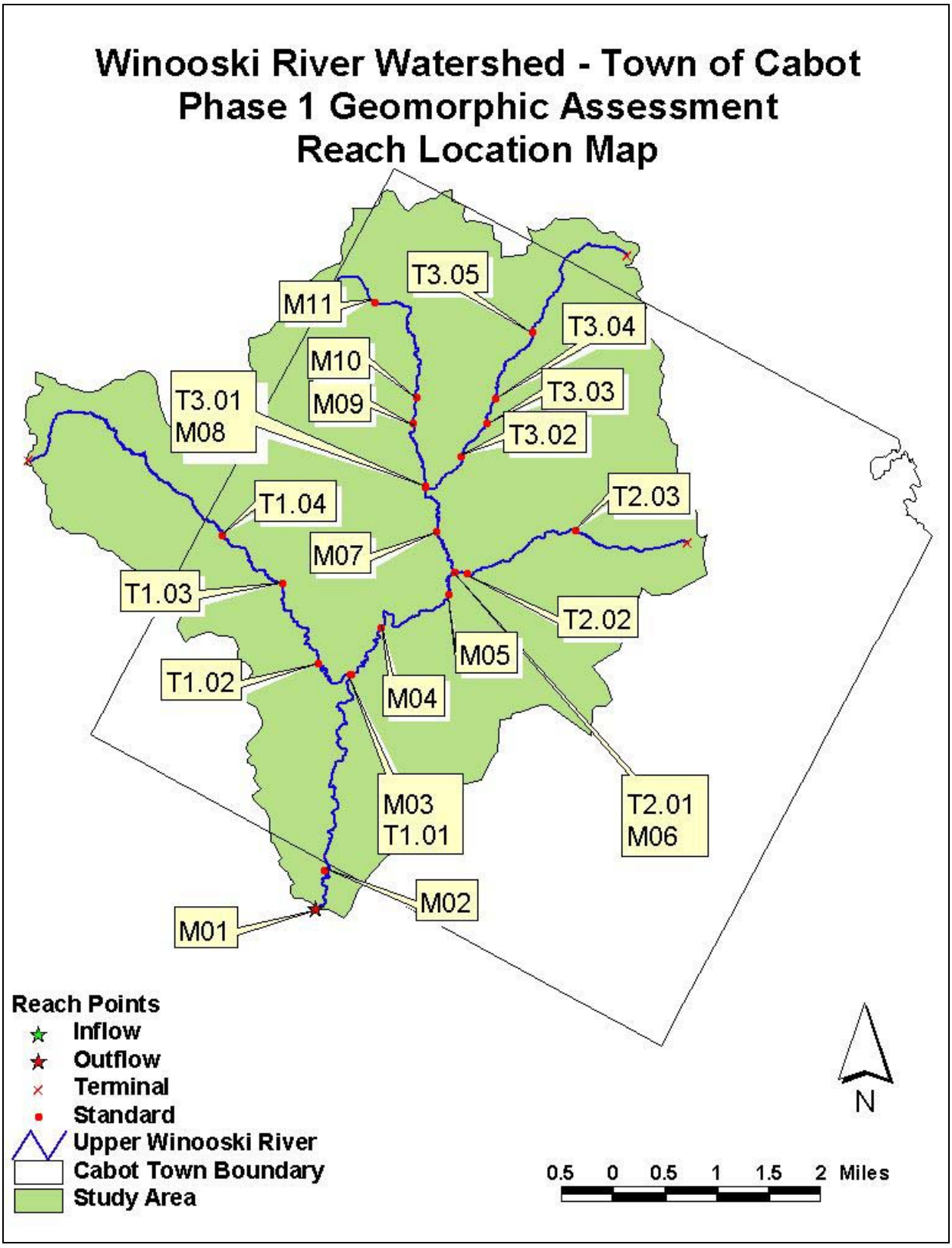

Figure 2. Reach Location Map for the Phase I Stream Geomorphic Assessment

4.2 Stream Typing

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

Report 2 on page 4 and 5 of the Appendix provides a complete listing of reference stream types for each reach within the project area. The reference stream types, based on the Phase 1 Geomorphic Assessment are shown in Figure 3. The majority of the stream reaches fall within the B stream type (see Table 2). A few of the reaches in the upper part of the watershed were not easily accessible and were not visited during the windshield survey. Best professional judgment was used to assign a bed form (eg. step-pool, plane bed) to these reaches that were not visited during the windshield survey.

Table 2. Reference Stream Type

Stream Type	Confinement	Channel Slope	Bed Material	Percentage by channel length of Assessed Reaches
A/ Cascade	Narrowly confined	Very steep	Boulder	6
B/Step-pool	Semi confined	Steep	Cobble	26
B/ Plane Bed	Semi confined or Narrow	Moderate to Steep	Cobble-gravel	31
C/Riffle-pool	Narrow, Broad or Very Broad	Moderate to gentle	Gravel or finer	37

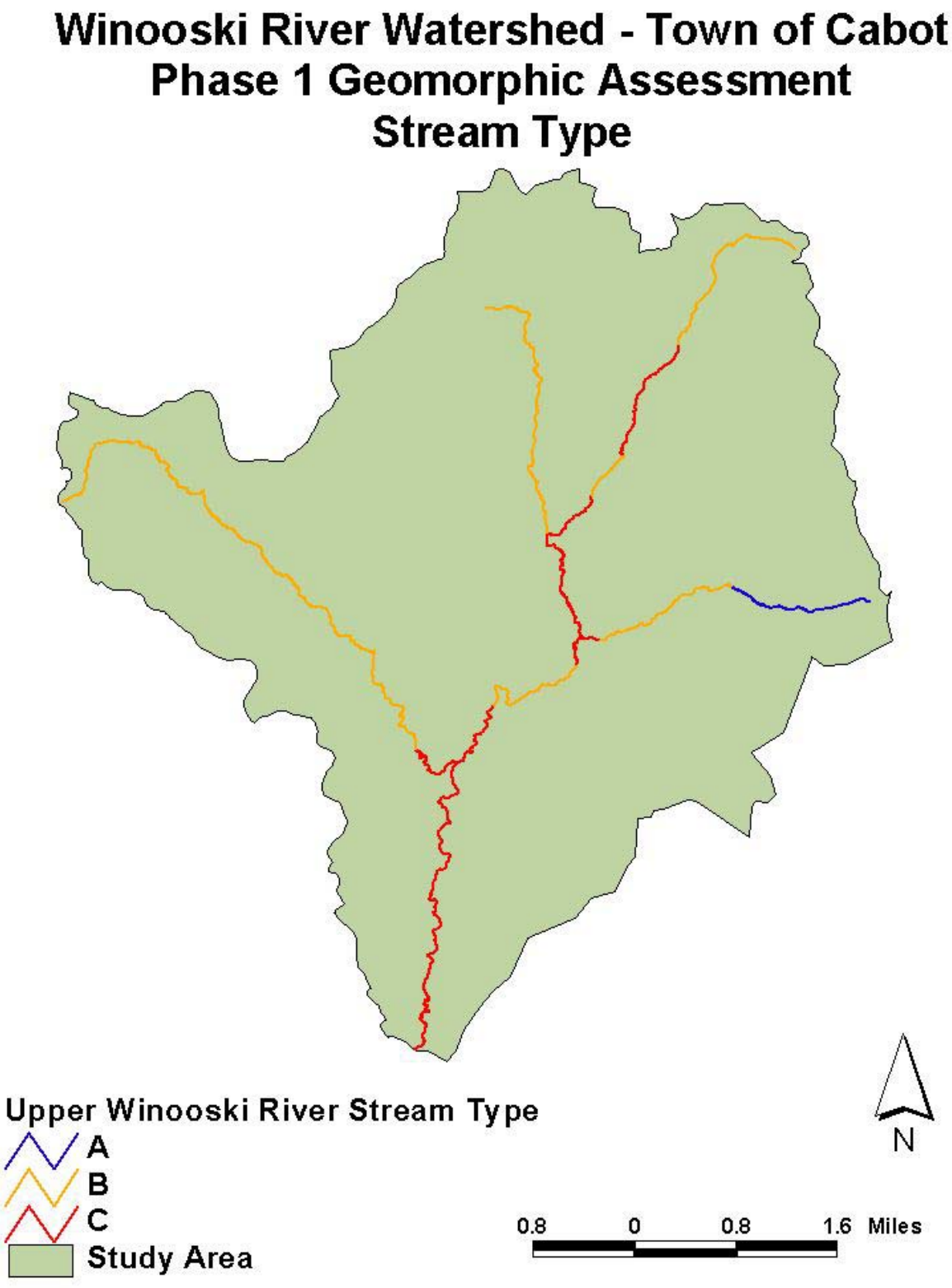

Figure 3. Stream Typing for Phase I Assessment Reaches

One reach, comprising approximately 6 percent of the study area, by length, falls into the A stream type. Cascade systems are narrowly confined, very steep (channel slope greater than 6.5%), with boulder or cobble dominated bed material.

Eleven of the 23 reaches (approximately 37 percent of the study area by stream length) fall within the C stream type and were noted to be riffle-pool systems. These C streams are unconfined, have moderate to gentle slopes, and gravel or finer bed material.

4.3 Basin Geology and Soils

The characteristics of the Upper Winooski watershed were determined using a combination of soils data, review of topographic maps, and information acquired during the windshield survey. Report Number 3, located on page 6 and 7 of the Appendix, provides a summary of the basin characteristics, such as alluvial fans, grade control structures, geologic materials, valley side slopes, and soil characteristics.
No alluvial fans were identified within the study reaches. Grade control structures such as ledge and dams were noted during the windshield survey. Channel spanning ledge was noted in six of the 23 reaches (M01, M06, M08, T3.02, T1.02, and T1.03). Ledge acts as a grade control by keeping the base elevation of a river from being lowered, and prevents the river from incising in that location. Bob Finucane, Vermont Dam Safety Program, Agency of Natural Resources, was contacted regarding the presence of dams within the study reach. Only one dam, Clarks Saw Mill Dam, is located within the study area. Clarks Saw Mill Dam is located at the upper end of reach M02 on the main stem. The dam is 135 feet long with a dam height of 14 feet.

The steepness of the valley side slopes was determined using a combination of a topographic map and the soils layer. The valley side slope steepness was variable, but overall steep to extremely steep side slopes dominated the watershed.

The dominant surficial geology of the Upper Winooski River consists of alluvium, glacial till, and ice contact deposits. With few exception, the reaches characterized as C channels within the upper Winooski River watershed within the Cabot study reach have alluvium as the dominant geologic material. These soils are frequently flooded, however are only slight to moderately erodable. The majority of the A and B type channels have till as the dominant geologic materials. These soils are rarely flooded and have very severe erodibility.

4.4 Land Cover – Reach Hydrology

The land use within the watershed plays a role in the hydrology of the receiving waters. The percentage of urban and cropland development within the watershed are factors which change a watershed's response to precipitation. The most common effects of urban and cropland development is increasing peak discharges and runoff by reducing infiltration and travel time (United States Department of Agriculture 1986). The land use/land cover within the stream corridor itself is also an important parameter to evaluate. This land use/land cover plays an important role in the sediment deposition and erosion which occurs during annual flood events (Vermont Agency of Natural Resources 2004).

As outlined in the Phase I handbook, impact ratings were assigned for watershed land cover/land use and stream corridor land cover/land use as follow:

High – 10% or more is crop and/or urban
Low – Between 2 and 10 % is crop and/or urban
NS – Not Significant – Less than 2 % is crop and/or urban

As provided in Report Number 4 (see appendix pages 8 and 9) the dominant watershed land cover/land use within the Upper Winooski River watershed in Cabot is forest. Sixteen of the reaches resulted in a watershed /land use impact rating of high.

The dominant land cover/land use within the river corridor is also summarized in Report Number 4. Fourteen of the reaches resulted in a high impact rating for corridor land cover/use.

Riparian buffers provide many benefits. Some of these benefits are protecting and enhancing water quality, providing fish and wildlife habitat, providing streamside shading, and providing root structure to prevent bank erosion. Eight of the stream reaches had over 75 percent of the reach with little or no buffer on one or more banks. These stream reaches which lack a high quality riparian buffer are a significantly higher risk of experiencing high rates of lateral erosion.

4.5 Historic Channel Modifications

Channel modifications may impact a stream reach by affecting the hydraulics and the sediment regime. Historic channel modifications were assessed in this Phase I study by evaluating flow regulations, bridges and culverts impacts, bank armoring, windrowing, straightening, and dredging. The percentage by length of reach impacted by one or more of these channel modifications was estimated and is summarized in Report Number 5 (see Appendix pages 10 and 11).

Flow Regulations

None of the stream reaches were found to be currently impacted by flow regulation. One dam at the upstream end of M02 was researched by contacting the Vermont Water Quality Division and the Facilities Engineering, Dam Safety Section, and is not believed to be used for water withdrawal or flow regulation.

Bridges and Culverts

As part of the Phase I Stream Geomorphic Assessment, the number of bridges and culverts within the study reach were counted by identifying stream crossings on the topographic map and orthophotos. These stream crossings were confirmed during the windshield survey. The percentage of the reach impacted by stream crossing structures

was estimated during the windshield survey and from orthophotos. Impact ratings for bridge and culverts were evaluated by determining the percentage of the reach length that is channelized, has split flow, or makes a sharp "S" bend upstream or downstream of bridges or culverts. With the exception of reach T1.01, the impact from bridge and culverts on stream dimension, pattern or profile appeared to be low or not significant.

Bank Armoring

The amount of bank armoring within a watershed is often indicative of the occurrence of channel processes, which result in bank erosion. Bank armoring, also called revetments, can be made of a variety of material including wooden cribs, gabions, logs, and rock riprap. The most common type of revetment in Vermont is rock riprap. Stream alteration permits can typically be used to identify bank revetments within a watershed of interest.

Rock riprap and tree revetments were the only type of revetment noted within the study area. The amount of revetment mapped from the Phase I windshield survey may be an underestimation of the total amount with the assessed reaches given the windshield surveys included a portion of each reach. The following criterion was used to provide an impact rating for human placed bank armoring.

H	High – Greater than 30% of the reach length is armored
L	Low – Between 10 and 30% of the reach length is armored
NS	Not Significant – Less than 10% of the reach length is armored
No Info	Bank armoring has not been evaluated for the entire reach and impact at the reach level is unknown

During the windshield survey, rock riprap was noted in 8 of the 23 reaches. Of these reaches, riprap received an impact rating of low for 7 of the reaches and high for reach T2.01, located adjacent to the recreation field. Tree revetments had been installed within reach M06 on Larry Thompson's property. These tree revetments were placed

on tight meanders, and no longer appeared to be stable. For this reason, these tree revetments were not counted as bank revetments.

Channel Modifications (Windrowing and Straightening)

During the windshield survey evidence of historic channelization projects were recorded. The total reach length (in feet) and the percentage of the reach length directly impacted by the channel modification were noted. Categories considered as part of the Step 5.4 (channel Modifications) included the following menu options:

- Windrowing – pushing gravel up from the stream bed onto the top of either bank
- Straightening – Dredging, windrowing, and bulldozing the stream into a straight course
- Multiple – Multiple channel modification, where neither windrowing nor straightening are the dominant channelization type
- None – No known modifications.

.

The only channel modification noted within the upper Winooski River in Cabot was straightening. Channel straightening was identified by reviewing orthophotos and through field confirmation during the windshield survey. Portions of stream reaches that have been historically channelized or straightened are identified below in Figure 4.

Dredging History

Barry Cahoon of the Vermont Agency of Natural Resources was contacted regarding the dredging and gravel mining history of the Upper Winooski watershed. According to Cahoon, there is no record of significant gravel or sediment mining operations for the Upper Winooski River watershed within the Town of Cabot.

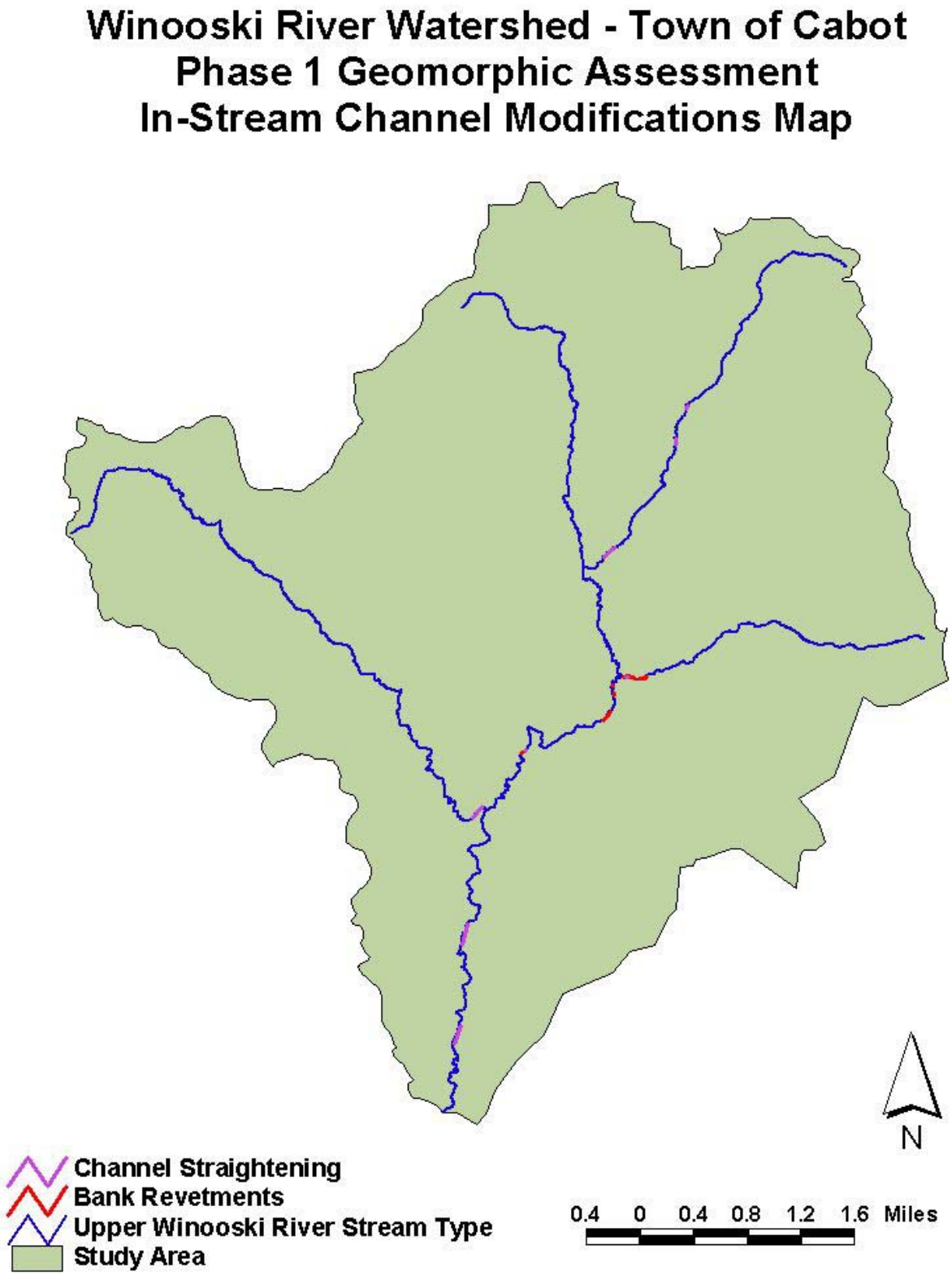

Figure 4. Instream Channel Modifications Identified for Phase I Reaches

4.6 Floodplain Modifications

In this step of the Phase I assessment, careful attention is paid to infrastructure and other development which restricts access to the floodplain, resulting in vertical or lateral confinement of flood flows. The parameters included in this step are: Berms and Roads, River Corridor Development, Depositional Features, Meander Migration/Channel Avulsion, Meander Width Ratio, and Wavelength Ratio. Some of the primary factors, which may influence floodplain function in the upper Winooski River, are discussed below: Report 6, which is included on pages 12 and 13 of the Appendix, contains the Phase 1 information for Floodplain and Planform changes.

Berms and Roads

Using information from maps, orthophotos, and the windshield survey, the percentage of the river corridor length along which berms, roads, railroad, or improved paths run parallel to the stream was estimated. Reaches where berms, roads, railroads or improved paths were located along 20 percent or more of the river corridor were given impacted ratings of high. Reaches (M01-M04), located on the main stem below Cabot village, three of the four reach on Tributary 3, and two of the four reaches on Jug Brook received an impact rating of high for berms and roads. Cabot Road (Route 215 S) is the primary impact from berms and roads along the main stem. South Walden Road runs along much of Tributary 3, and a few reaches of Jug Brook flow adjacent to West Hill Pond Road.

River Corridor Development

The river corridor development parameter looks at whether developments within the river corridor are effectively decreasing the belt width. The percentage of the reach length with houses, fill, parking lots or other development within the river corridor was tabulated using maps, orthophotos, and knowledge from the windshield survey. With the exception of one reach (T2.01), river corridor development was given an impact rating of low or not significant.

Channel Bars

The 1990s orthophotos series (1:5000) as well as results from the windshield survey were used to evaluate depositional features within the upper Winooski River watershed. The presence of bars (mid channel or point bars) and deltas were noted in each of the study reaches. The ANR has included depositional features as a component of the Phase I analysis because these features are indicative of an increased sediment load and a high likelihood that the streambed is actively aggrading and/or undergoing lateral migration. An unvegetated bar indicates the bar has recently formed or is in the process of growing.

Mid channel bars were the predominant depositional feature noted within the upper Winooski River watershed. Six of the 23 reaches had an impact rating of low for channel bars, while the other reaches were given ratings of not significant.

Meander Migration

Orthophotos were used to evaluate areas where the upper Winooski River has migrated, bifurcated, or avulsed[3]. Current orthophotos from 1998 and historic orthophotos from 1982 were overlayed to compare the location of the river channel over time. The current and the historic orthophotos span a range of approximately 16 years. 1963 aerial photos were also reviewed to provide information about how the river course has changed over time. Five reaches on the main stem of the Winooski River received an impact rating of high for meander migration, while three reaches received an impact rating of low. Migration, or movement of the channel by eroding its outer bank on meander bends, appeared to be the primary mechanism for lateral migration of the channel. Channel avulsions were noted for reaches T1.01 (Jug Brook) and M02.

[3] An avulsion is a change in planform resulting form a meander cut-off.

Meander Width and Wavelength

The 1990 series (1:5000) orthophotos in conjunction with topographic maps were used to determine the meander belt width and the meander wavelength for streams typed in Step 2.10 as C or E riffle-pool or ripple dune reference stream types (i.e. unconfined systems). The topographic maps were used to determine the valley direction, while the most current orthophoto series was used to provide the accurate location of channel meanders.

The meander belt width is the horizontal distance between to opposite, outside banks on fully developed meanders. The meander width ratio is calculated by dividing the average belt width for the reach by the bankfull width. The ANR Phase 1 protocol considers unconfined, gravel dominated streams with moderate to gentle gradients, which are in regime, to have belt widths in the range of 5 to 8 times the channel width. Ninety percent of the unconfined reaches (10 of 11) fell outside of the range expected for channels which are in regime. Seven of the study reaches were rated as high impact for meander width ratio, and three reaches received an impact rating of low.

All ten of the stream reaches which resulted in a low or high impact rating had meander width ratios of less than 5. These low values may indicate the stream has become straighter and steeper, possibly resulting in degradation and loss of access to its floodplain. Field observations confirm the finding that the upper Winooski has lost access to its floodplain in many locations. Stream channel incision was particularly evident within reaches M02, M03, M05, M06 and M07 on the main stem.

The meander wavelength consists of two bendways. The wavelength ratio is calculated by dividing the average wavelength by the bankfull channel width. Leopold 1994 and Williams 1985 (cited in Vermont Agency of Natural Resources, 2004a) have shown unconfined, gravel dominated streams in shallow-sloped valleys to have wavelengths in the range of 10 to 12 times the channel width. Five of the reaches resulted in a low impact rating for meander wavelength. Nine of the eleven stream reach received an

impact rating of high for wavelength ratio. For all nine of these reaches, the wavelength ratio was less than 8, suggesting the stream is starting to aggrade and become more sinuous. This has resulted in a decrease in channel slope as the stream migrates laterally. The high amount of meander migration and bank erosion noted on the mainstem supports the finding that the upper Winooski is aggrading.

4.7 Bed and Bank Windshield Survey

The dominant bed form, dominant bank material, bank erosion/bank height, and debris/ ice jam potential were recorded during the windshield survey, and these results are summarized in Report 7, on page 14 and 15 of the Appendix. The dominant bed form and dominant bank material were previously discussed under Section 4.2, Stream Typing. The amount of bank erosion observed along a reach and the bank height were evaluated in conjunction with each other to provide a bank erosion impact rating. Bank erosion was rated as low or high impact for eleven of the 23 reaches. As illustrated in Figure 5, high bank erosion is an issue on the main stem on reaches M02, M03, and M05, located above and below the Village of Cabot.

Debris/Ice Jam Potential

Undersized culverts or bridges with spans less than the average channel width or bridges with piers in the middle of the channel were the primary factors identified as potential for ice and debris jams. These structures, which are likely to cause constrictions during high flow events may result in lateral erosion or channel avulsions or may even endanger infrastructure. Seven reaches received an impact rating of low for debris/ice jam potential, however none of the reaches resulted in an impact rating of high.

Figure 5. Streambank Erosion Impact Rating for Upper Winooski River Watershed

5.0 DATA ANALYSIS

5.1 Impact Scores

The Phase 1 evaluates parameters that may cause channel adjustment. These parameters are grouped into four major categories: land use, instream modifications, floodplain modifications, and bed and bank windshield survey. For each parameter, the maximum impact score for the entire watershed is 46 (23 reaches times impact score of 2). As shown below in Figure 6, all three parameters in the land use category received high impact ratings for the watershed. The parameters berms and roads and bank erosion also resulted in high scores.

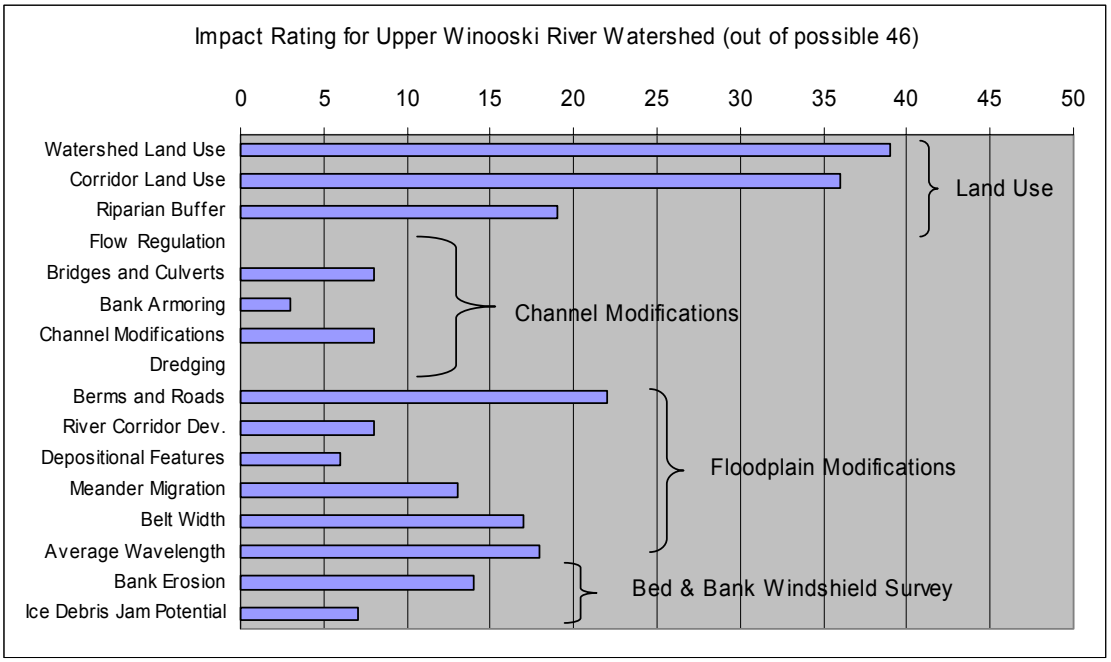

Figure 6. Impact Rating for Upper Winooski River Watershed by Parameter and Category

The total impact scores for the Phase 1 assessment are provided in Report 8, on page 16 and 17 of the Appendix and are mapped below in Figure 7. As shown in Tables 3 and 4, the within watershed condition generated from the Phase 1 database was generally

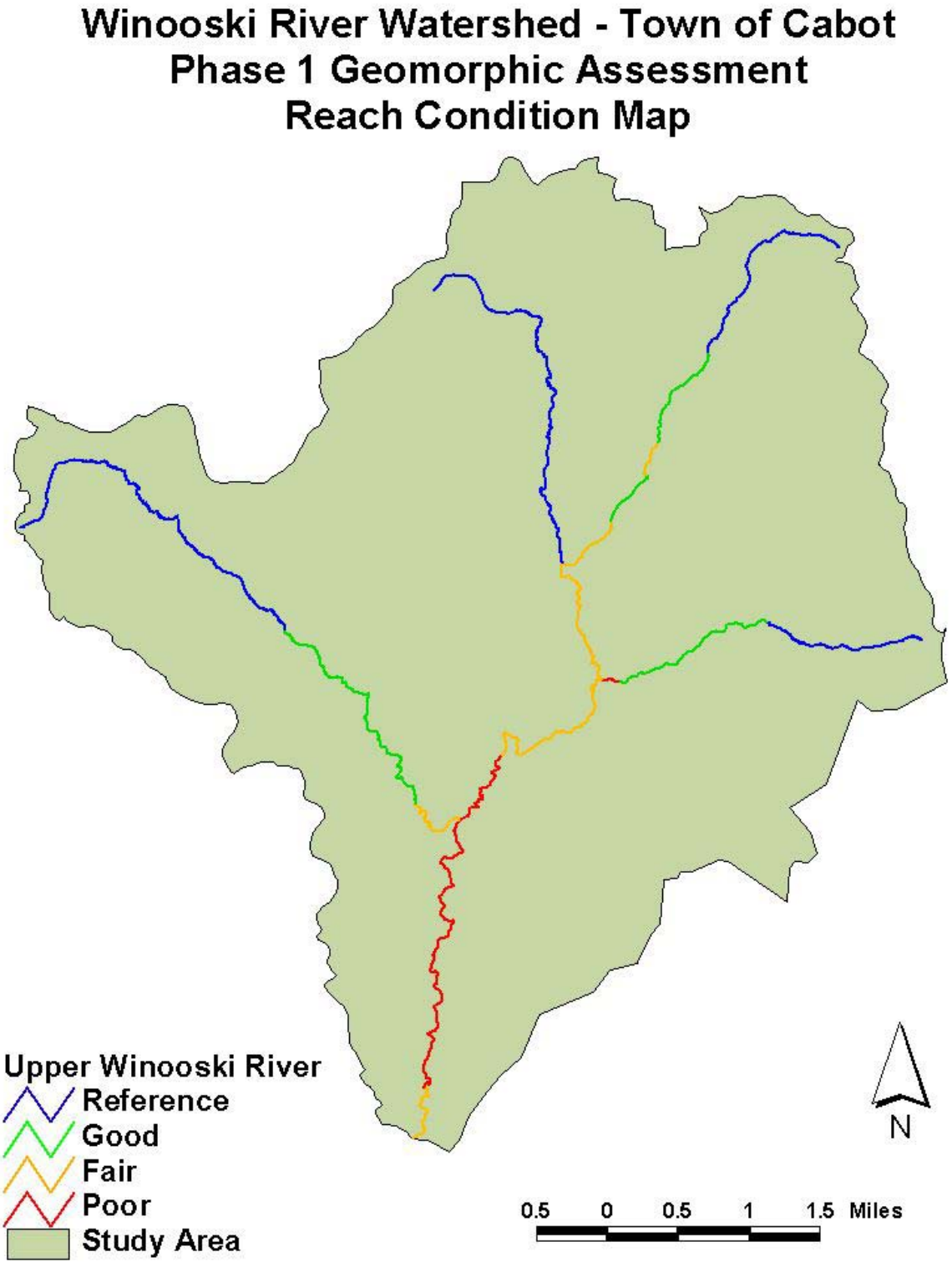

Figure 7. Reach Condition

similar to the reach condition based on professional judgment and observations during the Phase I windshield survey.

Table 3. Reach Assessment for Unconfined Channels

Reach Number	Confinement	Total Impact Score	Watershed Size	Within Watershed Condition (from Phase I Database)	Reach Condition (based on Professional Judgment)
M02	VB[4]	19	24.21	Poor	Poor
M03	VB	17	14.1	Poor	Poor
T2.01	VB	18	2.58	Poor	Poor
T1.01	VB	18	7.36	Fair	Fair
T3.01	BD[5]	16	4.27	Fair	Fair
M05	VB	14	11.24	Fair	Fair
M06	VB	14	8.54	Fair	Fair
M01	BD	14	24.45	Fair	Fair
M07	VB	13	7.65	Fair	Fair
T3.03	NW[6]	9	2.45	Fair	Fair
T3.04	NW	8	1.74	Fair	Good

Table 4. Reach Assessment for Confined Channels

Reach Number	Confinement	Total Impact Score	Watershed Size	Within Watershed Condition (from Phase I Database)	Reach Condition (based on Professional Judgment)
M04	SC[7]	13	13.27	Fair	Fair
T1.02	SC	8	6.96	Reference	Good
T1.03	SC	8	3.27	Reference	Good
T3.02	SC	7	4.09	Good	Good
T2.02	SC	6	2.55	Reference	Good

[4] Very Broad
[5] Broad
[6] Narrow
[7] Semi-confined

Table 4. Reach Assessment for Confined Channels

Reach Number	Confinement	Total Impact Score	Watershed Size	Within Watershed Condition (from Phase I Database)	Reach Condition (based on Professional Judgment)
M08	SC	3	3.03	Reference	Reference
T2.03	NC[8]	3	1.19	Reference	Reference
T3.05	SC	3	0.70	Reference	Reference
T1.04	SC	2	2.74	Reference	Reference
M10	SC	2	2.00	Reference	Reference
M11	SC	2	0.62	Reference	Reference
M9	SC	1	2.17	Reference	Reference

Reaches in poor condition were isolated to the main stem below the Village of Cabot (M02 and M03) and the lowest reach on Tributary 2. These reaches have undergone significant channel and floodplain modifications which may have resulted in a change in planform, profile, and dimension such that the stream is no longer in balance with the flow and sediment regime of its watershed.

Streams in fair condition are fully in adjustment and are experiencing major and rapid changes due to recent floodplain and channel modifications, land cover changes, and/or loss of riparian buffer. The majority of the unconfined stream reaches were in the fair category, while only one confined stream reach resulted in a reach condition of fair. Five of the 23 reaches were placed in the good category based on professional judgment and the output from the Phase 1 database. The streams in the good category had experienced some degree of human-induced change to their watershed, floodplain and/or channel and appeared to be undergoing only minor adjustments. The stream reaches in good condition were generally located in the middle of the watershed (i.e. not in the headwaters and not near the lower end).

[8] Narrowly confined

A reference reach has no significant channel or floodplain modifications and has a forested buffer, adjacent to the channel. In other words, these reaches are close to the natural condition. Streams in reference condition were found in the headwaters and were all A or B type streams (i.e. confined). None of the unconfined stream channels scored as a reference reach. Figure 8 shows an obvious trend of decreasing impact rating from downstream on the main stem to the headwaters.

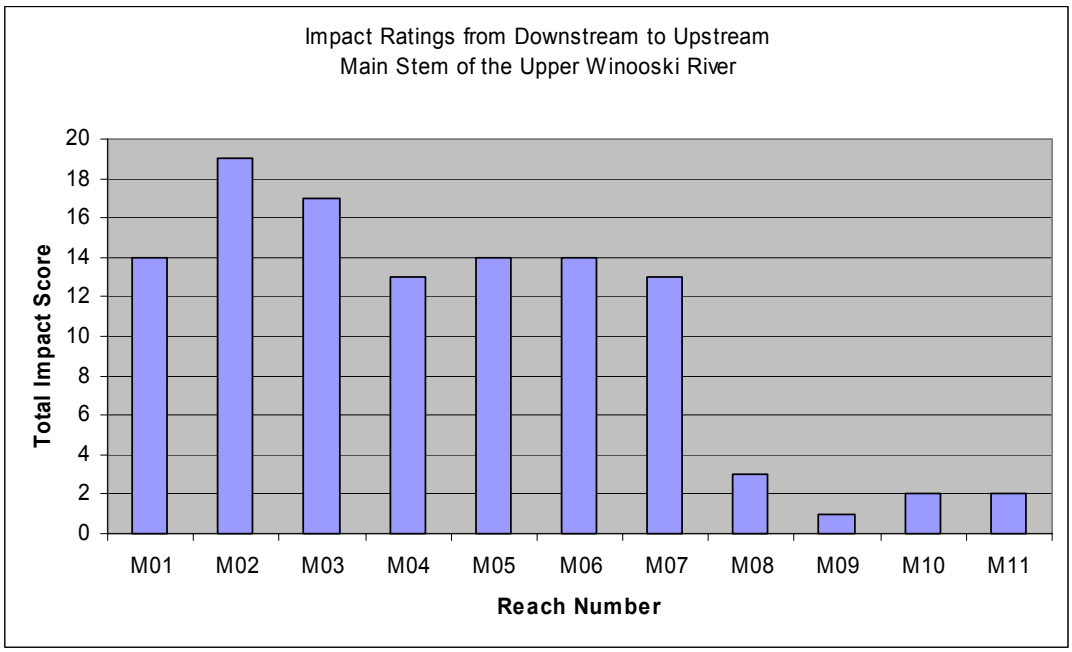

Figure 8. Impact Ratings from downstream to upstream on the main stem of the Upper Winooski River

5.2 Adjustment Processes

Report Number 9, on pages 18 and 19 of the Appendix, provides a summary of the primary adjustment processes that were predicted based on the Phase 1 Stream Geomorphic Assessment. For six of the 23 reaches, no adjustment process is indicated. The Phase 1 data suggest that most of the stream reaches are experiencing more than one type of channel adjustment process.

5.3 Reach Sensitivity

The Phase 2 Handbook (Vermont Agency of Natural Resources, 2004b) was used to assign a stream sensitivity based on existing stream type and condition. Highly sensitive reaches are more likely to be in adjustment, and are very sensitive to land use changes within the watershed. The reach sensitivity is summarized in report 9 on pages 18 and 19 of the Appendix. In general, all of the stream reaches which are unconfined resulted in a reach sensitivity of high, while the confined channels resulted in a reach sensitivity of low.

6.0 RECOMMENDATIONS FOR PHASE 2

The Phase I results are valuable for providing recommendations for reaches to select for the Phase 2 Assessment. Phase 2 Assessment work in the Upper Winooski River watershed is scheduled for late summer/early fall 2004. Seven days of funding is available for a Field Team Leader from Bear Creek Environmental to work with community volunteers to collect Phase 2 field data. Bear Creek Environmental recommends this fieldwork include M02 through M07 on the main stem. As summarized in Table 5, the Phase 2 field work for these six reaches is expected to take approximately seven days. The combined length of the stream reaches is about 6 miles. The unconfined channels (Reference stream Type C) will be given highest priority in completing the Phase 2 Assessment, and will be completed first. Reach M04, which is characterized as a semi confined, plane bed system, will be assessed if time allows. The reach condition from the Phase I study for the proposed Phase 2 Assessment reaches range from poor to fair.

Table 5. Reaches Recommended by Bear Creek Environmental for Inclusion in the Phase 2 Assessment to be Completed During Late Summer/Early Fall 2004

Reach No.	Channel Length (Miles)	Confinement Type	Channel Slope	Stream Type/ Bed form	Reach Condition	Estimate of days required for fieldwork
M02	2.6	3-VB	0.40	C5 Riffle-pool	Poor	2

Table 5. Reaches Recommended by Bear Creek Environmental for Inclusion in the Phase 2 Assessment to be Completed During Late Summer/Early Fall 2004

Reach No.	Channel Length (Miles)	Confinement Type	Channel Slope	Stream Type/ Bed form	Reach Condition	Estimate of days required for fieldwork
M03	0.8	3-VB	0.23	C4 Riffle-pool	Poor	1
M04	1.1	1-SC	1.87	B3 Plane Bed	Fair	1
M05	0.3	3-VB	0.56	C4 Riffle-pool	Fair	1
M06	0.6	3-VB	1.03	C4 Riffle-pool	Fair	1
M07	0.6	3-VB	0.96	C4 Riffle-pool	Fair	1

REFERENCES

United States Department of Agriculture. 1986. Urban Hydrology for Small Watersheds. Soil Conservation Service, Engineering Division, Technical Release 55. Washington, D.C.

Vermont Agency of Natural Resources. 2004a. Vermont Stream Geomorphic Assessment Phase 1 Handbook. Watershed Assessment Using Maps, Existing Data, and Windshield Surveys. Waterbury, Vermont

Vermont Agency of Natural Resources. 2004b. Vermont Stream Geomorphic Assessment Phase 2 Handbook. Rapid Stream Assessment, Field Protocols. Waterbury, Vermont