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Upper Winooski River
River Corridor Management Plan
Cabot, Vermont

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Executive Summary

The Upper Winooski River in Cabot is the centerpiece of the community landscape. Over the years a multitude of resources have been spent on attempting to control the river in an effort to protect property and infrastructure. These efforts have predominately caused further instability, degraded habitat and water quality. This River Corridor Management Plan will make recommendations to restore stable channel conditions by providing a structure for identifying and prioritizing river restoration and corridor protection projects. An overriding objective is to reduce the need for maintenance of traditional channel management applications along the Upper Winooski, and shift the focus of management projects from short term control to long term equilibrium and stability. This plan is meant to be used as part of the local planning process. Annual review of this plan is suggested to identify where progress has been made and to pinpoint areas in need of improvement.

The major goals for the Upper Winooski River Corridor Management Plan are to: reduce flood and erosion hazards along the river corridor; restore river corridor functions that are critical for channel stability; increase riverine recreational opportunities; and improve water quality and aquatic habitat.

Beginning in 2004, fluvial geomorphic assessments of the Upper Winooski using Vermont Agency of Natural Resources (ANR) protocols were conducted by the Cabot Conservation Committee (CCC) and Bear Creek Environmental (BCE). These assessments studied the condition of the river, and made predictions about how the Upper Winooski will adjust in the future. The results provided by the assessments are useful in determining management strategies that will help the Town of Cabot make good decisions about land use within the river corridor.

These assessments concluded that the Upper Winooski is undergoing active channel adjustment. On the majority of the Upper Winooski, historic incision has lowered the elevation of the river bed leaving the floodplain inaccessible. As a result, high flows that would normally access the floodplain are contained within the channel; thereby causing extensive bank erosion, lateral migration, channel widening, loss of aquatic habitat, and general channel instability. The traditional approach of attempting to control this erosion employs bank armoring (rip-rap) and channel straightening, both of which are common on the Upper Winooski, but have lead to further instability in the system. Also, there are many encroachments upon the river corridor in the form of residential and commercial development, as well as roads. The results in a decreased amount of area that is capable of reestablishing equilibrium through lateral channel migration and the creation of a new floodplain. It is important to protect the few areas that still have the space for the river to move; otherwise management of the river will become increasingly difficult and expensive.

This report considers the stage of channel evolution, sensitivity, condition, and major adjustment process for each section, or reach, of the Upper Winooski in order to determine management strategies. The results are management approaches that are appropriate for each section rather than a uniform plan for the entire river. The four major project types identified for the Upper Winooski River are:

- Conservation reaches,
- High Recovery Reaches,
- Moderately Unstable Reaches, and
- Highly Unstable Reaches.

The project types help to define restoration strategies which range from a do-nothing approach to actively attempting to restore in-channel equilibrium.

In addition to identifying restoration strategies, this plan provides recommendations for defining a Fluvial Erosion Hazard Zone and a River Corridor Protection Zone to further assist the Town of Cabot with managing and restoring the Upper Winooski River watershed. The purpose of defining these zones is to minimize property loss and damage due to fluvial erosion; prohibit land uses and development in fluvial erosion hazards areas that pose a danger to health and safety; and discourage the acquisition of property that is unsuited for the intended purposes due to fluvial erosion hazards.

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Upper Winooski River Corridor Management Plan Cabot, Vermont

1.0 PROJECT OVERVIEW

Bear Creek Environmental (BCE) was retained by the Cabot Conservation Committee (CCC) to write a River Corridor Management Plan for the area of the Upper Winooski River which flows through the Town of Cabot, Vermont. The river corridor planning process was funded through a Clean and Clear Category 2 – Project Development grant (FY2005) with the Vermont Department of Environmental Conservation Agency of Natural Resources (ANR), River Management Section. This River Corridor Management Plan will serve to guide future planning within the river corridor. The River Corridor Management Plan will also provide a structure for identifying river restoration and corridor protection project types and effective approaches, as well as identifying areas where more data may need to be collected. Having this Plan will allow the town to prioritize its needs for conservation and to help protect the water quality of the Upper Winooski River.

This Plan is meant to be used as part of the local planning process. This document is meant to be fluid. As the needs for the river or community change, this document may be revised. Annual review of this Plan is suggested to identify where progress has been made and to pinpoint areas in need of improvement.

While this document is specific for the Cabot community, it is also important to consider the context within which it has been developed. The Upper Winooski River in the Town of Cabot is part of the larger Winooski River Basin. The specific components of this River Corridor Management Plan will be incorporated into a Basin Plan that is currently being developed by the ANR for the entire Winooski River. The Winooski River Basin Plan will summarize natural resource information, current and past water quality assessments, and efforts at the state and local level to protect and restore water quality. The Basin Plan will identify and prioritize state and local water quality issues, develop strategies for solving water quality problems, and implement on-the-ground protection and restoration projects. The draft Basin Plan is scheduled for completion in 2008.

In addition to the Basin Plan, there is another project currently underway that will utilize information developed in this River Corridor Management Plan. The Winooski Headwaters Community Project is a collaborative effort to help the residents of Cabot and Marshfield restore and protect the ecological integrity and human enjoyment of the Winooski watershed. The Project was conceived by a diverse group of partners—local and state government, local businesses, nonprofit organizations and interested citizens—to combine their resources and efforts on their common interest in the Winooski headwaters area.

This River Corridor Management Plan outlines the Cabot Conservation Committee's goals for the Upper Winooski River, the current condition of the river and its tributaries, results of field assessments, prioritization of restoration opportunities, and strategies for implementing corridor protection and restoration.

1.1 Local Project Goals

The main goals for the Upper Winooski River set out by the CCC are to increase its value as a recreational resource, improve public access to the river and streams, improve aquatic habitat, and reduce flood and erosion hazards along the river corridor.

1.1.1 Increase the Recreational Opportunities of the Upper Winooski River

Currently, public access to the Winooski River in the Town of Cabot is limited to several town owned properties. The recreational fields north and south of Cabot Village provide riverfront access. Improved public access would enhance the value of the river as an educational and recreational resource. Greater public access may encourage people to spend more time in close proximity to the river, thus resulting in a greater appreciation and recognition of its value to the community.

Improved public access would provide an opportunity to provide educational information to the community, such as what types of fish are in the river, the quality of the water or information about the watershed.

1.1.2 Improve Aquatic Habitat

Recent assessment work conducted in the Upper Winooski River as part of the Phase 2 Geomorphic Assessment indicated that the aquatic habitat is impaired. Healthy fisheries depend on a variety of habitat for cover, shelter, feeding, rest, and spawning. Important habitat features include the depth and speed of the water, quality of the substrates, and amount of organic matter in the channel. Restoring these habitats is essential for supporting a robust aquatic system in the Upper Winooski River.

1.1.3 Reduce Flood and Erosion Hazards

Encroachment of corridors from development can be both damaging to the river as well as to property. The Town of Cabot recognized these concerns and addressed them by including “Prohibited Uses of Floodplain Areas” as section 3.10 of the 1995 Zoning

Regulations. The purpose of the regulation is to prohibit in floodplain areas (as designated on the flood insurance rate map for Cabot dated 9/18/1985) the following as specified in Town of Cabot (1995):

- All residential, commercial, industrial and other buildings intended for human occupancy or employment, excluding recreational, agricultural (except dwelling units), and temporary uses.
- All dumps, junkyards and storage of flammable liquids.
- Private sewage and water facilities, except those approved by the State Agency of Natural Resources.

Sound floodplain ordinances will prevent some unnecessary loss, but inundation maps are not updated frequently enough to reflect the changes in inundation hazard areas that come about as rivers undergo channel adjustment. Nor do inundation maps identify areas of erosion hazards. This River Corridor Management Plan identifies fluvial erosion hazard (FEH) areas and provides guidance on reducing erosion hazards.

1.1.4 Restore River Corridor Functions

The reference stream types for much of the main stem of the Winooski between the Cabot/Marshfield town lines has been classified as “E” and “C” type channels (Blazewicz and Nealon 2006). These stream channels are highly dependent upon vegetation for stability. For this reason, the establishment and protection of vegetated buffers should be high priority in restoration planning and design work. 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.

Additionally, effective protection of river corridors will allow flood flows to be handled by the river system. As mentioned earlier, allowing for a buffer of native vegetation will enhance the river’s capacity to manage the flood flow and reduce downstream erosion. Floodplains also can act as sinks for nutrients and sediment that would otherwise continue downstream and impact receiving waters.

1.2 State of Vermont River Management Goals

The state of Vermont's River Management Program has set out several goals and objectives that are supportive of the local initiative in Cabot. The state management goal is to, "guide and encourage projects that provide increased property and infrastructure protection and maintain or restore the ecological functions and economic values of the river system." The State hopes to achieve river corridor protection, management, and restoration by developing programs that "avoid and reduce flood and fluvial erosion hazards; improve water quality; and restore aquatic and riparian habitat (Vermont Agency of Natural Resources 2006a).

1.2.1 River Geology and its Role in River Management

Geomorphic stability is defined as, "The ability of a stream, over time and in the present climate, to transport the flow **and** sediment of its watershed in such a manner that it maintains its dimension, pattern, and profile without aggrading(building up) or degrading (eroding down) its channel bed materials" (Vermont Agency of Natural Resources 2006a).

Fluvial geomorphic science explains the physical river processes and forms that occur in different landforms and geologic and climatic settings. In applying fluvial geomorphic science, it is assumed that:

- Although rivers are dynamic, with a form or geometry that is ever changing through erosion and depositional processes, there is a central tendency of form and process that has a predictable relationship with surrounding and watershed land forms and which may undergo significant change naturally with climate changes over time;
- Human-related physical change to river channels, floodplains, and watersheds often mimic and/or change the rate of natural physical processes;
- A scientifically sound river corridor management program can be based in part on regional channel evolution models that help predict how an altered river channel may return to a former channel form (or type) when significant

disturbances end, or how the channel may adjust to develop a new form (or type) if the disturbances continue; and

- The distribution and condition of stream types, especially those indicative of reach and watershed scale adjustments, influence erosion and flood hazard risk levels and aquatic habitat quantity and quality.

In the Vermont Stream Geomorphic Assessment Protocols, the term "in adjustment" is used to describe a river that is undergoing change in its channel form and/or fluvial processes outside the range of natural variability. The fluvial processes typically affected in river reaches that are "in adjustment" are those associated with reach hydrology and sediment transport. Channel adjustment typically involves erosion, but the terms are not synonymous. The processes of erosion and sediment deposition are ongoing and often result in changes in channel form and fluvial processes that are well within the range of natural variability. Fluvial geomorphic assessments help us understand whether the observed channel changes (such as eroding banks) are indicative of a river adjustment process, and if so, to what extent and over what period of time the adjustment will occur. With this knowledge river managers can weigh the long-term costs and risks associated with different human activities, including channel and floodplain encroachments or land use conversions at the watershed scale and manage river systems for geomorphic stability. (Vermont Agency of Natural Resources 2006a)

2.0 PROJECT BACKGROUND INFORMATION

2.1 Geographic Setting

2.1.1 Watershed Setting

The Winooski River Watershed has a watershed size of 24.5 square miles above the confluence of Molly Falls Brook in Marshfield, just south of the Cabot/Marshfield Town lines. The Upper Winooski River within the Town of Cabot is the headwaters of the larger Winooski River basin (see Figure 1). The Winooski River flows into Lake Champlain.

The highest elevations in the Cabot Study Area are the hills to the north and west of the watershed. Danville Hill, at approximately 2246 feet above sea level, is the highest point in the watershed. At Molly Falls, near the most downstream point of this study, the Winooski River has an elevation of approximately 895 feet above sea level.

2.1.2 Political Jurisdictions

The Upper Winooski River watershed is located entirely within the state of Vermont, and is predominately located in the Town of Cabot. Its headwaters extend into the surrounding towns of Woodbury and Walden. The Towns of Cabot and Woodbury are located in Washington County, and are members of the Central Vermont Regional Planning Commission. Woodbury and Walden are within Caledonia County, and are members of the Caledonia Regional Planning Commission.

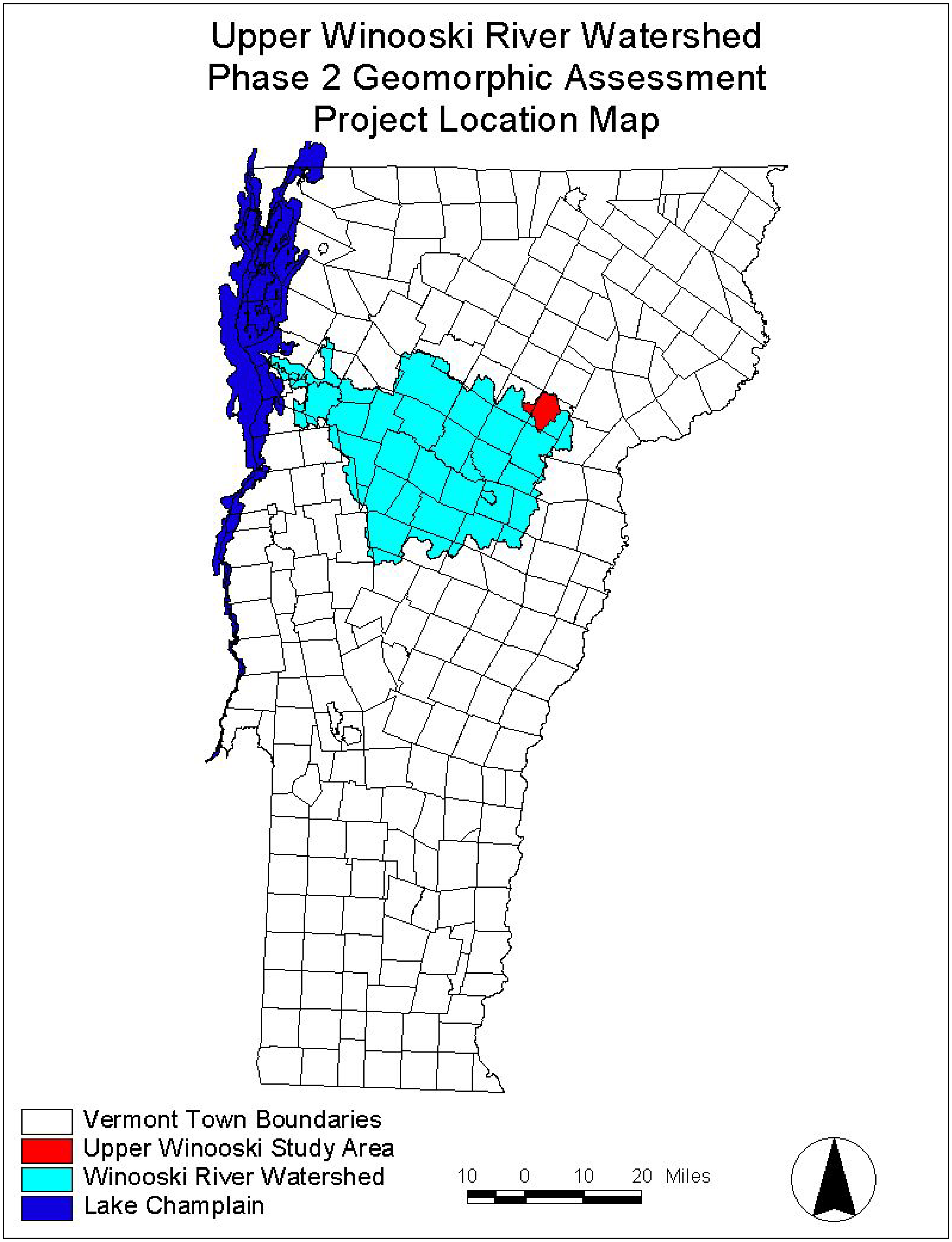

Figure 1: Project Location Map

2.1.3 Land Use History and Current Condition

According to natural history scientists at the Vermont Department of Fish and Wildlife, Native Americans inhabited Vermont for 8,000 years prior to European Settlement. Their impact on the landscape, however, is thought to have been minimal, except along the shores of some of the larger lakes and more fertile river valleys. (Thompson and Sorenson 2005).

European settlement of the region began in the mid-1700s, with a large influx of settlers from 1754 to 1812. Cabot was chartered on August 17, 1781. Land clearing for agriculture and wood products increased dramatically around 1800 and approximately 80 percent of Vermont's land area was cleared of forests by 1900. The "sweet" soils of the Northern Vermont Piedmont are derived from calcium-rich bedrock, a factor leading to heavy early agricultural use in the region. (Thompson and Sorenson 2005). Although Cabot's earliest settlement occurred along the Bayley Hazen military road in the northeastern part of the town, demand for water to power mills brought the community down to the river. Since then, Cabot's settlement patterns, transportation and land use have historically been determined by its waterways.

The major land use patterns have also followed the water courses and the hills between forestry on the steeper and higher slopes with farming and settlements confined to the hillsides and valley. Human use of these resources and associated livestock, especially dairy cattle, has determined the appearance of the land.

Although much of the forest has now regenerated, the structure and species composition of presettlement forests has surely been altered. The Northern Vermont Piedmont remains a region with numerous small farms, forestlands mostly managed for timber production, and a dense network of roads and settlements that leave few large areas of wild nature (Thompson and Sorenson 2005).

The land use within the watershed plays a role in the hydrology of the receiving waters, and is therefore useful in understanding the impacts that are seen today. 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 are 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 influential role in the sediment deposition and erosion which occurs during annual flood events (Vermont Agency of Natural Resources 2004b).

As reported in the Phase 1 Assessment (Nealon and Blazewicz 2004), the dominant watershed land cover/land use within the Upper Winooski River Watershed in Cabot is forest (Figure 2). However, over half of the assessed subwatersheds had high impact ratings for land use due to agricultural and/or development. 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 studied in the Phase 1 Assessment were found to have 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 at a significantly higher risk of experiencing high rates of lateral erosion.

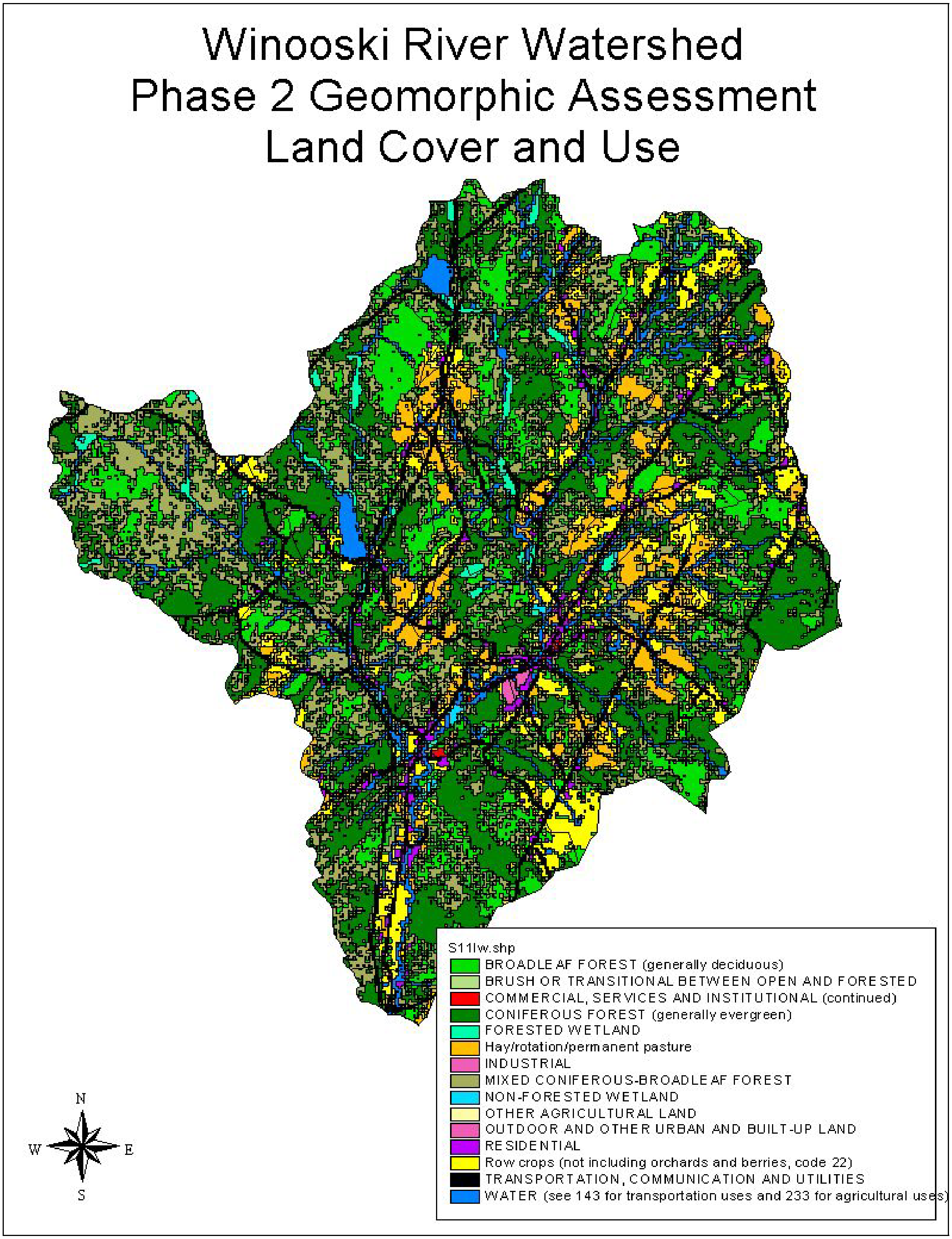

Figure 2: Project Area Land Use/Land Cover Map

2.2 Geologic Setting

The Upper Winooski River watershed is located within the Northern Vermont Piedmont, or New England uplands, physiographic region of Vermont. The geologic formation where the Upper Winooski River watershed is located is a plateau-like landscape that rises gradually inland from the sea. (Van Diver 1987). The rocks of the Northern Vermont Piedmont originated as marine sediments laid down during the Devonian and Silurian Periods. These were later metamorphosed into schists, phyllites, and crystalline limestones during the Acadian Orogeny. These metamorphic rocks of the Northern Vermont Piedmont are generally calcareous (Thompson and Sorenson 2005).

Between 18,000 and 20,000 years ago, Vermont was covered by the most recent of several glacial advances that occurred during the Pleistocene. As part of the Wisconsin glaciation, Vermont was buried under an ice sheet up to a mile thick. During this event, the mountains and hills of the Upper Winooski River watershed were softened further, stripping off the soils and earlier glacial deposits. All over the Upper Winooski River a thin layer of rocks and boulders was laid down under the ice. The rocks and boulders found in the Valley's soil are largely a product of this glacial deposition.

As the glaciers retreated, numerous lakes formed between the ice and the high ground. In the Winooski River basin the very large glacial Lake Vermont was formed; it extended all the way up the Winooski River Valley into the Town of Cabot. The shorelines of these lakes were often the receiving area for copious fine sediments shed from the melting ice and surrounding barren landscape. These glacio-lacustrine deposits, as they are known, are often prone to unpredictable shifting and shearing.

The dominant surficial geology of the Upper Winooski River consists of alluvium, glacial till, and ice contact deposits. With few exceptions, the reaches characterized with unconfined valleys within the upper Winooski River watershed have alluvium as the dominant geologic material. These soils are frequently flooded, however are only slight to moderately erodable. The majority of the higher gradient channels with confined valleys have till as the dominant geologic materials. These soils are rarely flooded and have very severe erodibility.

2.3 Ecological Setting

Forests cover the majority of acreage in the Upper Winooski River watershed. The Northern Hardwood Forest Formation that covers a portion of the landscape is part of a broad forest region where sugar maple, American beech, and yellow birch predominate. The region ranges from the upper-Midwest states of Wisconsin and Michigan east to Maine and southeastern Canada. The Northern Hardwood Forest Formation makes a transition to the Spruce-Fir-Northern Hardwood Forest Formation in colder areas, to the north and at higher elevations such as in the Town of Cabot. The climate of the Northern Hardwood and Spruce-Fir Northern Hardwood Forest Formation is cool-temperate to cold and moist. Summers are warm and winters can be severely cold. Average annual temperatures range from 37° to 52°F. Annual precipitation ranges from 35 to 50 inches in most areas and is distributed more or less evenly throughout the year. Average annual snowfall is about 100 inches. Growing season length averages 100 to 110 days. The Northern Hardwood Forest Formation is characterized by soils that are neither extremely dry nor extremely wet. Soil moisture varies with parent material, topography, and depth to a restricting layer. Soils are mostly developed from glacial till, and bedrock is close to the surface in some areas. Sandy or gravelly soils derived from glacial outwash are found only locally, as are soils formed in lake bed deposits. Spruce-Fir soils may be more shallow, acidic, and infertile due to heavy leaching and acidity of fallen evergreen needles.

2.4 Flood History

Between 1995 and 1998 Vermonters suffered nearly $60,000,000 in flood damages; much of these losses were avoidable. Through Cabot's history, flood waters have destroyed property on numerous occasions. Precipitation trend analysis suggests that intense, localized storms, which can cause flash flooding, are occurring with greater frequency. The June 1998 flood was such an event that caused upland streams to jump their stream beds, carving out new channels and filling Main Street with silt (Town of Cabot 1995).

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) gauge on Ayers Brook at Randolph, VT (gauge #01142500) was obtained. The Ayers Brook gauge was selected for a number of reasons. These reasons are as follows: 1. The Ayers Brook gauge is in close proximity to the Upper Winooski River watershed; 2. the stream flow of Ayers Brook is unregulated; and 3. the drainage area at the Ayers Brook gauge is 30.5 square miles, which is similar to the drainage area of the Upper Winooski River at the Cabot/Marshfield town line. Sixty-four years of record are available for the Ayers Brook gauge at Randolph, VT. The gauge provides a continuous record of flow from 1940 through the present

The long term record for Ayers Brook shows a 10 year discharge occurred in water year[1] 1949 and between a 25 and 50 year discharge occurred in 1952. During water years 1973 and 1998 (when Cabot also experienced flooding), the peak discharge exceeded the projected 50 year discharge. A graph of the flood frequency analysis is provided in Figure 3 below.

[1] A water year is a twelve month period from October 1 through September 30

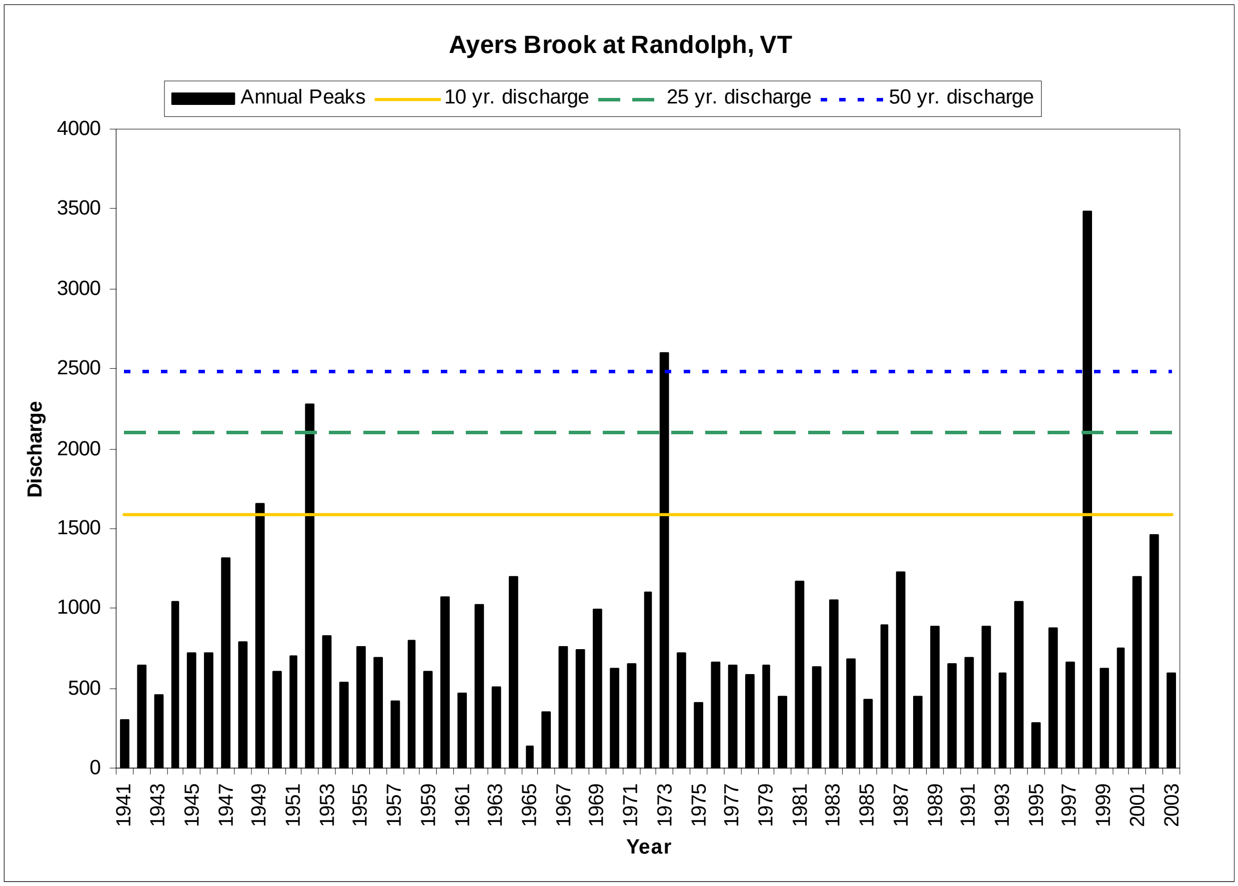

Figure 3: Flood frequency analysis for Ayer's Brook.

2.5 Channel and Floodplain Management History

Functioning floodplains play a crucial role to providing long term stability to a river system (see Figure 4). Natural and anthropogenic impacts may alter the delicate equilibrium of sediment and discharge in natural stream systems and set in motion a series of morphological responses (aggradation, degradation, and widening and/or planform adjustment) as the channel tries to reestablish a dynamic equilibrium. Small to moderate changes in slope, discharge, and/or sediment supply can alter the size of transported sediment as well as the geometry of the channel; while large changes can transform reach level channel types (Ryan 2001). Human-induced practices that have contributed to stream instability within the Winooski watershed include:

- Forest clearing
- Channelization and bank armoring
- Removal of woody riparian vegetation

- Floodplain encroachments
- Urbanization
- Poor road maintenance and installation of infrastructure
- Loss of wetlands

Figure 4: Sediment deposition along an accessible floodplain of the Winooski River.

These anthropogenic practices have altered the delicate balance between water and sediment discharges within the Winooski River watershed. Channel morphologic responses to these practices contribute to channel adjustment that may further create unstable channels. The most common adjustment processes in the Upper Winooski River are widening and planform migration as a result of historic degradation within the channel. Degradation is the term used to describe the process whereby the stream bed lowers in elevation through erosion, or scour, of bed material. Aggradation is a term used to describe the raising of the bed elevation through an accumulation of sediment. The planform is the channel shape as seen from the air. Planform change can be the result of a straightened course imposed on the river through different channel management activities, or a channel response to other adjustment processes such as aggradation and widening. Channel widening occurs when stream flows are contained in a channel as a result of degradation or floodplain encroachment or when sediments overwhelm the stream channel and the erosive energy is concentrated into both banks.

2.6 Past and Present Water Quality and Biological Data

Biological and water quality data are collected on the Upper Winooski River by both the Vermont Department of Fish and Wildlife and the Vermont Department of Environmental Conservation. A summary of the monitoring that has been conducted by the two departments with the Vermont Agency of Natural resources is provided in Table 1. The locations of the biomonitoring stations are shown in Figure 5.

The Vermont Department of Fish and Wildlife's surveys within the mainstem of the Winooski River, in and above Cabot Village, and in Jug Brook indicate the presence of thriving brook trout populations as well as several nongame fish species. The mainstem populations, however, decline in abundance moving downstream toward and beyond Lower Cabot. Temperature monitoring by VDFW in 2004 provides some explanation for these observations. Water temperature is generally considered to be the primary factor limiting brook trout distribution in Vermont. The maximum temperature observed within the Winooski River above Cabot Village was 67° F in 2004 while daily minimum temperatures usually fell below 60° F. Maximum temperatures just below the Cabot townline (GMP powerhouse) reached 78° F, 11 degrees higher than above Cabot, and well above the limits where brook trout flourish (Kirn 2006).

Sediment is another factor influencing the aquatic health of Cabot's streams. Excess sediment can negatively affect aquatic biota in streams primarily in two ways. Suspended sediment, comprised of fine silts that float in the water column, can affect fish gills, fishing feeding patterns, and plant productivity. Fine sediments like silts and sands can become packed in around cobbles and boulders therefore eliminating important habitat for aquatic organisms.

Table 1: Upper Winooski River Biological Monitoring Stations

River/Stream	Agency	Type	WQ Parameters	Sample Date	Station Description
Winooski River	VTDEC	MF	T, pH, C, A	9/26/2000	Below the Cabot WWTF
Winooski River	VTDEC	NA	Additional set	7/8/2004	Below the Cabot WWTF
Winooski River	VTDEC	M	Additional set	9/21/2005	Below the Cabot WWTF
Winooski River	VTDEC	F	T, pH, C, A	9/20/1988	Below sawmill bridge
Winooski River	VTDEC	M	T, pH, C, A	8/14/1986	Below tributary near Cabot lagoons
Winooski River	VTDEC	F	T, pH, C, A	10/12/1989	Below bridge (south of) Cabot
Winooski River	VTDEC	M	T, pH, C, A	3/24/1988	Above first bridge S of Cabot Village
Winooski River	VTDEC	M	T, pH, C, A	9/19/1988	0.25 Mi below creamery stormwater pipe
Winooski River	VTDEC	M	T, pH, C, A	9/27/1989	0.25 Mi below creamery stormwater pipe
Winooski River	VTDEC	F	T, pH, C, A	10/12/1989	0.25 Mi below creamery stormwater pipe
Winooski River	VTDEC	M	T, pH, C, A	11/2/1990	0.25 Mi below creamery stormwater pipe
Winooski River	VTDEC	F	T, pH, C, A	11/3/1990	0.25 Mi below creamery stormwater pipe
Winooski River	VTDEC	MF	T, pH, C, A	10/14/1991	0.25 Mi below creamery stormwater pipe
Winooski River	VTDEC	MF	T, pH, C, A	10/15/1992	0.25 Mi below creamery stormwater pipe
Winooski River	VTDEC	F	T, pH, C, A	9/26/1994	0.25 Mi below creamery stormwater pipe
Winooski River	VTDEC	M	T, pH, C, A	9/20/1988	20m below creamery stormwater pipe
Winooski River	VTDEC	M	T, pH, C, A	7/20/2005	20m below creamery stormwater pipe
Winooski River	VTDEC	M	T, pH, C, A	9/21/2005	20m below creamery stormwater pipe
Winooski River	VTDEC	M	Additional set	7/20/2005	75 m above creamery stormwater pipe
Winooski River	VTDEC	MF	T, pH, C, A	9/19/1988	30m above Elm Street Bridge
Winooski River	VTDEC	M	T, pH, C, A	9/27/1989	30m above Elm Street Bridge
Winooski River	VTDEC	MF	T, pH, C, A	10/14/1991	30m above Elm Street Bridge
Winooski River	VTDEC	M	T, pH, C, A	9/19/1988	Below small trib near Recreation Field
Winooski River	VTDEC	F	T, pH, C, A	9/26/1994	Below small trib near Recreation Field
Winooski River	VTDEC	M	T, pH, C, A	10/15/1994	Below small trib near Recreation Field
Winooski River	VTDEC	F	Additional set	9/13/2005	Below small trib near Recreation Field
Winooski River	VTFW	F		7/23/1958	GMP Sta 6
Winooski River	VTFW	F		6/23/1960	GMP Sta 6
Jug Brook	VTFW	F		7/21/1958	
Jug Brook	VTFW	F	pH, H	7/21/1958	2nd bridge above mouth
Jug Brook	VTFW	F		7/31/1979	2nd bridge above mouth
Jug Brook	VTFW	F		7/21/1980	2nd bridge above mouth

Notes: VTDEC data include macroinvertebrate and/or all resident fish species.
VTFW fish population data include salmonids.
Community: M = macroinvertebrate, F = fish, NA = not assessed
Water quality parameters: C=conductivity, T=temperature, A=alkalinity, H = hardness
Additional set = Temperature, Color, Dissolved Oxygen, pH, Alkalinity, Conductivity, Chloride, Sulfate, Calcium, Iron, Manganese, Magnesium, Sodium, Potassium, Hardness, Total Phosphorus, Dissolved Phosphorus, Nitrogen, Nitrate, Nickel, Cadmium, Chromium, Copper, Zinc, Aluminum, Arsenic Turbidity, Total Suspended Solids

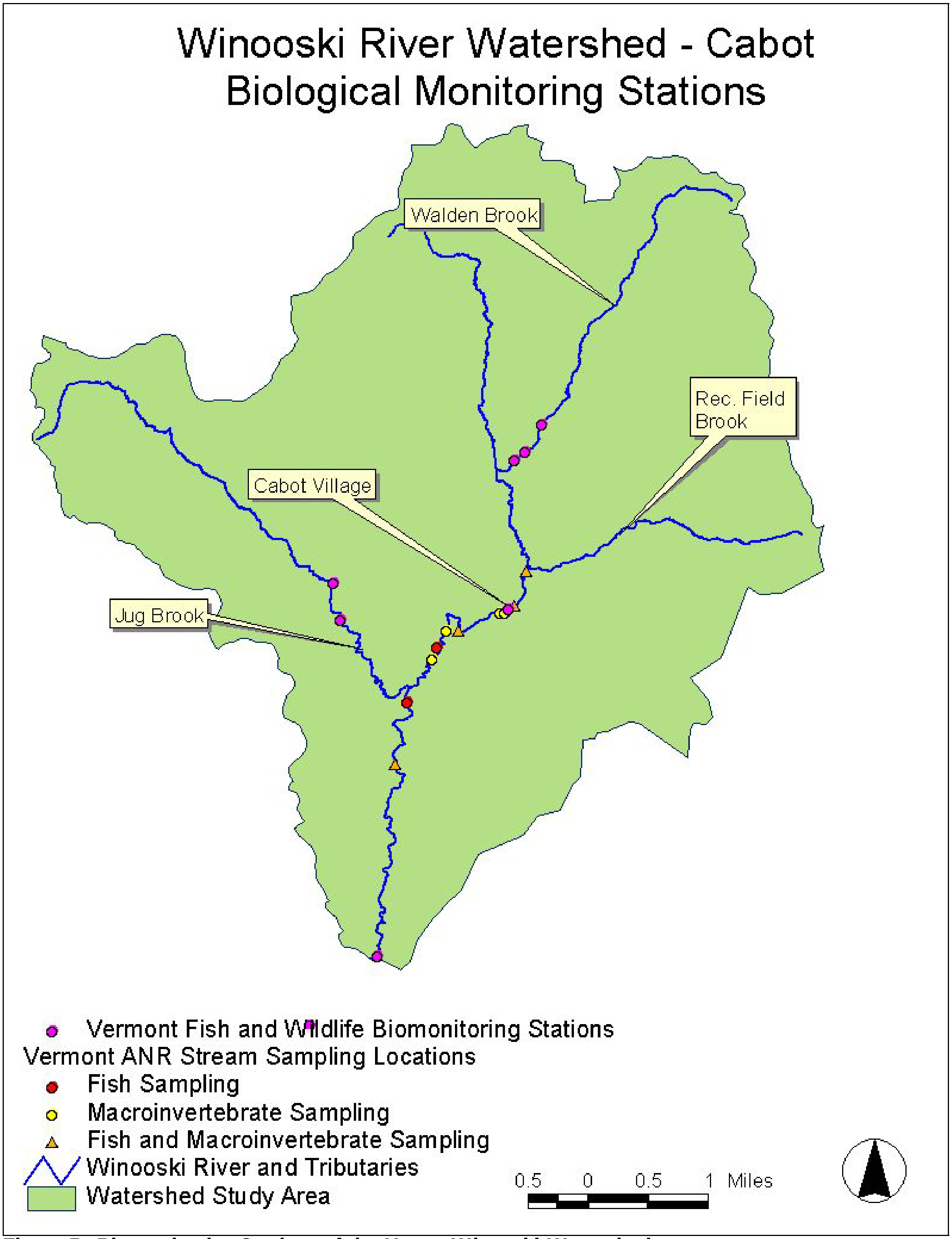

Figure 5: Biomonitoring Stations of the Upper Winooski Watershed

The Vermont Department of Environmental Conservation has conducted biological assessments of fish assemblages from three sites on the Winooski River in Cabot since 1994. Fish population monitoring by the ANR was conducted as recently as September 2005 on the Winooski River just downstream of the Cabot Recreation Field (see Figure 6). According to Langdon (2006), the fish and macroinvertebrate assemblages of the Winooski River in the vicinity of Cabot are in *very good* to *excellent* condition, upstream and across from, the village. The macroinvertebrate assemblage downstream, near Durant Cemetery, was rated as *very good,* but the fish community was only in *fair* condition when sampled in 2000. The macroinvertebrates were sampled again in 2005, providing a similar evaluation of very good. Fish density at all three Upper Winooski River sites was low, indicating a fairly unproductive system (Langdon 2006).

Figure 6: Rich Langdon measures the length of a longnosed sucker during fisheries monitoring conducted by the Vermont Department of Environmental Conservation in September 2005 on the upper Winooski River in Cabot.

3.0 STREAM GEOMORPHIC ASSESSMENT

The Vermont Agency of Natural Resources has developed protocols for conducting geomorphologic assessments of rivers. Various trainings have been held to provide consultants and regional planning commissions with the knowledge necessary to make accurate and consistent assessments of Vermont's rivers.

The stream geomorphic assessments are divided into three phases. The phase one assessment is a rough analysis of the condition of the stream through using aerial photographs, maps, and preliminary field data collection. The phase two assessment is a more detailed analysis of the stream by determining what adjustment processes are taking place and predicting how the river will continue to evolve in the future. Phase three is the identification and implementation of restoration projects.

Bear Creek Environmental was retained by the Cabot Conservation Committee to conduct Phase 1 & 2 geomorphic assessments for the Upper Winooski River (Nealon and Blazewicz 2004, Nealon 2004). These Phase 1 and 2 assessments were funded through a Municipal Planning Grant from the Department of Housing and Community Affairs. Additional Phase 2 Assessments of two of the tributaries in Cabot and a portion of the mainstem within the Village of Cabot (Blazewicz and Nealon 2006) were conducted during fall 2005 and were funded through FEMA Map Modernization Management Support (MMMS) to support the development of fluvial erosion hazard maps. These assessment data also help to pinpoint areas of concern and set the stage for river corridor planning and restoration work needed within the watershed.

3.1 Phase 1 Stream Geomorphic Assessment Results

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. The parameters berms and roads, channel modifications, bank erosion and land use resulted in high impact ratings (Figure 7).

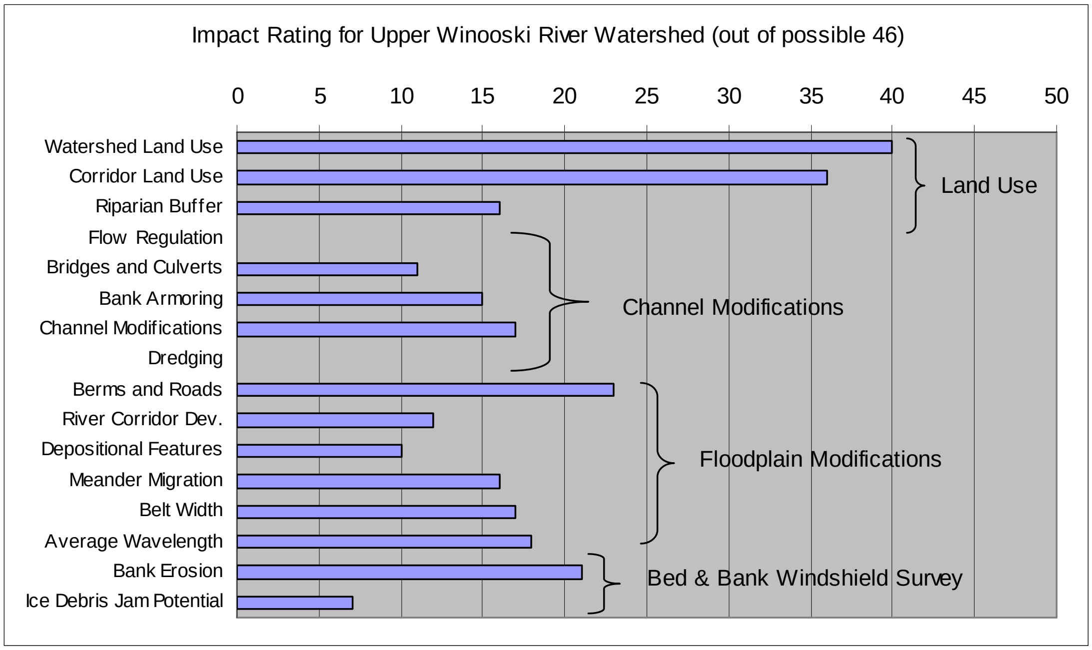

Figure 7. Impact Rating for Upper Winooski River Watershed by Parameter and Category

Figure 8 shows an obvious trend of decreasing impact rating from downstream on the main stem (R36) to the headwaters (R46). This suggests that the upstream reaches are less impacted and are likely in better geomorphic condition than the lower reaches.

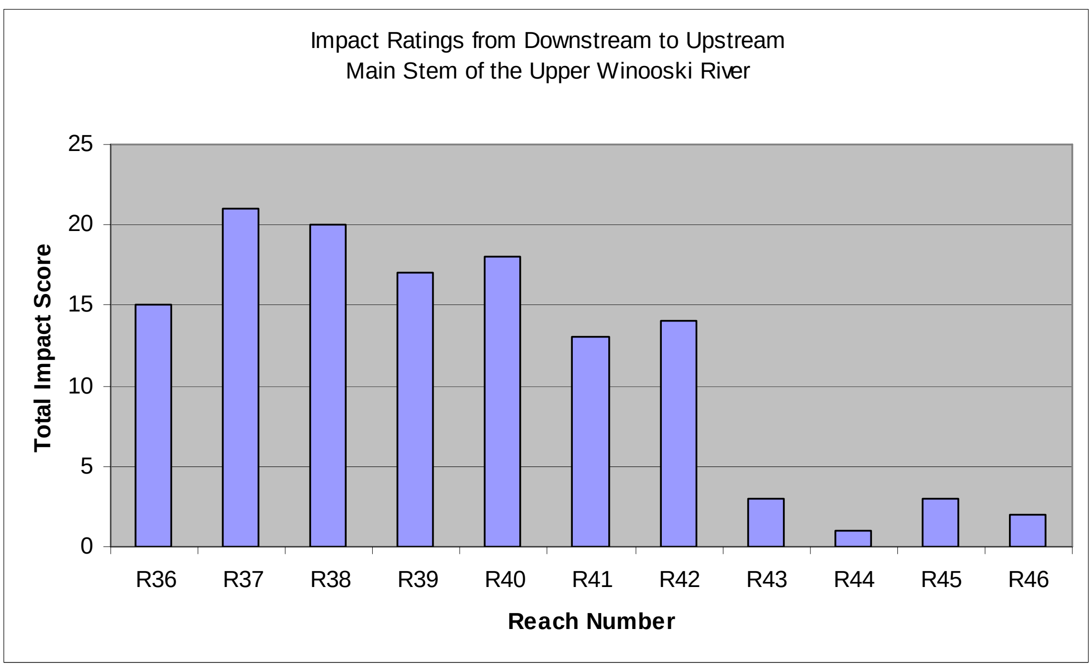

Figure 8. Impact Ratings from downstream to upstream on the main stem of the Upper Winooski River

3.2 Phase 2 Stream Geomorphic Assessment Results

A Phase 2 Stream Geomorphic Assessment of targeted reaches was conducted within the Upper Winooski River watershed by Bear Creek Environmental in 2004 and 2005 (Nealon 2004; Blazewicz and Nealon 2006). The study included six reaches on the main stem of the Upper Winooski River and six reaches of two tributaries. The twelve targeted reaches were further divided into 32 segments based on changes in confinement, stream type and stage of channel evolution.

Information from the study came from the ANR, the Vermont Mapping Program, and the Vermont Center for Geographic Information (VCGI 2003), the Town of Cabot, and field data collected by Bear Creek Environmental. The Phase 2 Rapid Stream Assessment included field observations and measurements that are used to verify the Phase 1 stream geomorphic data, to provide field evidence of channel adjustment processes, and rate the health and condition of the riparian corridor and aquatic habitat. The channel dimensions were measured within each of the segments using a tape and measuring rod as shown in Figure 9. These measurements were used to determine variations in channel dimensions. The collection and synthesis of the Phase 2 information can be used in watershed planning, for the establishment of erosion hazard zones, and for the identification of watershed improvement projects.

Figure 9. Michael Blazewicz of Bear Creek Environmental measures the cross-sectional area of the channel above Cabot Village during a Phase 2 Assessment in fall 2005.

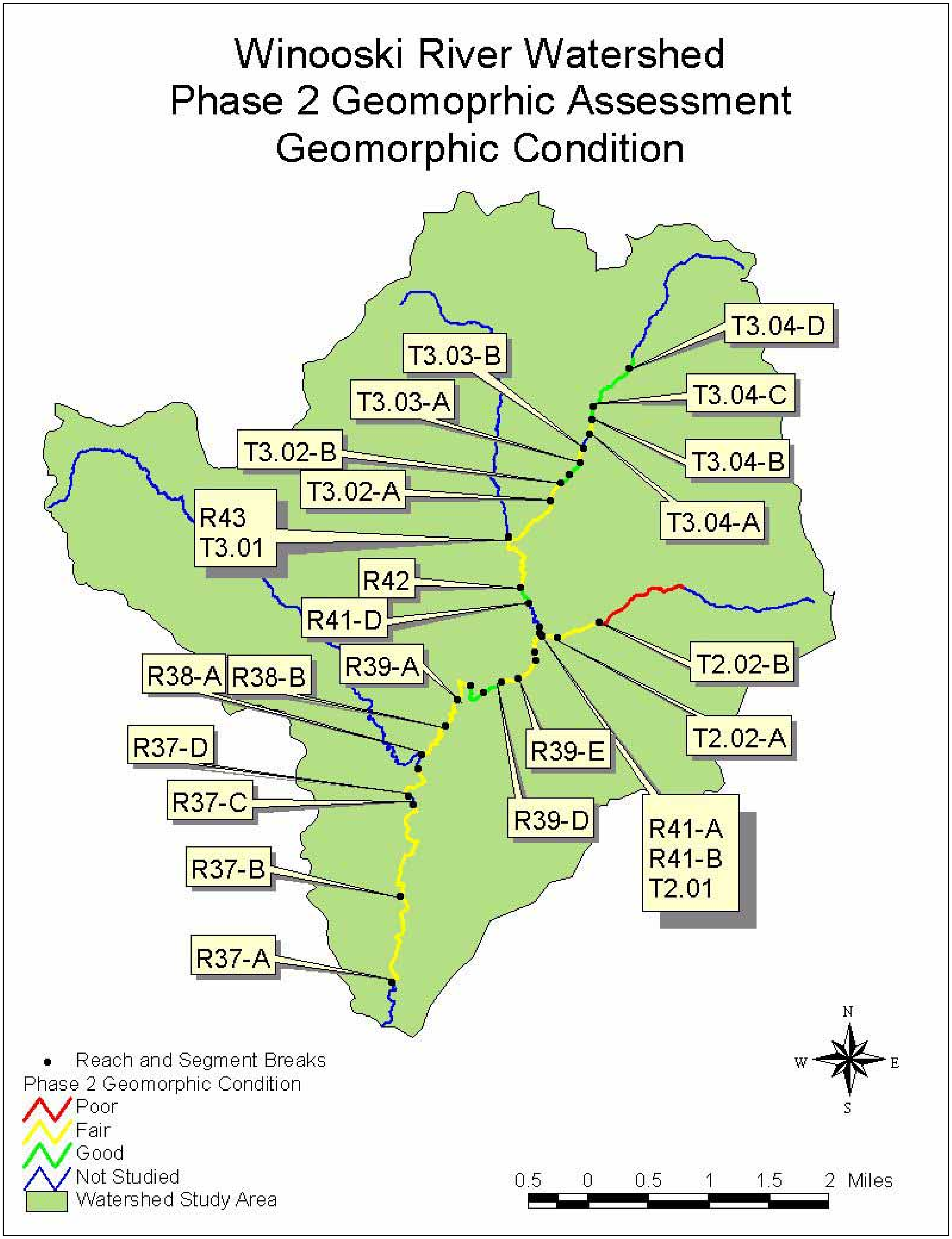

Figure 10: Phase 2 Geomorphic Condition of the Winooski Watershed

The Phase 2 Rapid Geomorphic Assessment (RGA) provides information on the geomorphic condition of each segment within the study area (Figures 10). Many of the tributaries and the main stem of the Upper Winooski River in Cabot are experiencing high rates of bank erosion. The bank erosion has been accelerated due to land use activities and channel and floodplain modifications. Significant channel straightening, bank armoring, berming, and floodplain encroachment have occurred within this river system both on the mainstem and on the lower ends of the tributaries. These impacts have resulted in the loss of natural energy dissipation of the river system via meandering and flooding the fields along the river. Over time, the river has down cut into the streambed resulting in loss of floodplain access and increased energy within the channel. The increased energy within the channel has lead to severe bank erosion and subsequent channel widening. Along much of the main stem, the river channel is currently migrating laterally to recreate a new floodplain at a lower elevation to dissipate the energy and to become more stable (see Figure 11).

Figure 11. The upper Winooski River is working to create a new floodplain bench just upstream of Durant Cemetery.

The disturbance and removal of the riparian vegetation in Cabot has decreased the resistance of the streambanks to the erosive forces of the river. Rates of lateral adjustment are influenced by the presence and condition of riparian vegetation. For this reason, the acquisition of easements, streamside plantings, and buffer protection should be a high priority for restoration planning and design work. As the river works toward a more stable equilibrium, the Cabot Community has the opportunity to reestablish floodplain, improve riparian vegetation and protect the river from further encroachments.

4.0 WATERSHED SCALE HYDROLOGIC AND SEDIMENT MODIFIERS

Changes to the Upper Winooski River watershed have resulted in changes to the volume and timing of runoff as it makes its way down into the stream channels. Changes in land use have also affected the amount and sources of sediment that enter the river system.

4.1 Hydrologic Alterations

Hydrology refers to the study of water as it moves over (and within) the land. Channel shape and pattern develops over time in relationship to climatic and landscape conditions. Changes to the landscape or the amount and velocity of water that moves into a stream will have significant effects on the characteristics of the stream channel.

4.1.1 Land Use and Wetland Loss

During rain storms and snow melt events, the amount of water running over the surface of the land increases, and in severe storms, flooding may result. Many wetlands, particularly floodplain wetlands, have the capacity to temporarily store flood waters, during high runoff events. As flood waters recede, the water is released slowly from the wetland soils. By holding back some of the flood waters and slowing the rate that water re-enters the stream channel, wetlands can reduce the severity of downstream flooding and erosion.

In watersheds where wetlands have been lost, flood peaks may increase by as much as 80 percent (Vermont Agency of Natural Resources 2006b). Wetlands within and upstream of urban areas are particularly valuable for flood protection. The impervious surface in urban areas greatly increases the rate and timing of runoff.

Cabot Village and Lower Cabot were once part of a northern white cedar wetland bordering the Winooski River that was drained and developed (Cabot Planning Commission 2003). Many other wetlands in Cabot have been either drained or filled and put to use – usually for agriculture. Loss of wetlands and an increase in clearing and impervious surfaces (roads, driveways, rooftops, parking lots, etc.) leads to changes in the hydrology of this watershed and therefore affects the flood hazard, geomorphology, and habitat of the streams. Protection of existing wetlands in the Upper Winooski River watershed should be an important land use goal for the Town of Cabot.

4.1.2 Roads

According to the State 911 roads shapefile, the Upper Winooski River study area has a combined total of 50.2 miles of improved road (not including driveways, logging roads, and or other unimproved roads). That is a density of 2 miles of improved road per square mile of watershed. Forman and Alexander (1998) summarize road impacts on stream morphology and hydrology. They write that in hilly and mountainous terrain, runoff from impervious surfaces is "insignificant compared with the conversion of slow-moving groundwater to fast-moving surface water at cutbanks by roads." They then go on to say that, "Increased runoff associated with roads may increase the rates and extent of erosion, reduce percolation and aquifer recharge rates, alter channel morphology, and increase stream discharge rates. Peak discharges or floods then restructure riparian areas by rearranging channels, logs, branches, boulders, fine-sediment deposits, and pools. In forests, the combination of logging and roads increases peak discharges and downstream flooding as well as flood frequency."

4.2 Sediment Modifiers

From a geomorphic perspective, researchers and land managers are increasingly interested in the response of erosion and sedimentation to changes occurring on watershed hillslopes or in stream channels. Managers need to predict how land use will alter erosion and sedimentation rates and the relative importance of different sediment sources in order to assign priorities for erosion control. They also must anticipate where sediment will be deposited (or captured), how long it will be stored, and how it will be re-mobilized.

Common modifiers of sediment load and transport in the Upper Winooski River study area are:

Increase Sediment Load:

Unvegetated tilled cropland – is exposed to wind and water.

Cleared, exposed soils from forestry, agriculture, or for development – are exposed to wind and water.

Town sand and gravel storage area – is adding sediment into the river system.

Sanding of town roads – increases the amount of fine sediment that is running off of the landscape.

Accelerated bank erosion due to riparian vegetation removal and/or channel alterations – adds sediment to the river system.

Decrease Sediment Load (and therefore increases bank erosion and channel migration):

Gravel extraction from the river channel – decreases available sediment that river needs to move thus making it sediment deficient and causing erosion or scour downstream.

Increase Sediment Transport:

Straightened stream channels – increase the velocity of the stream and therefore its ability to transport sediment.

Stormwater ditches - increase the velocity of water and therefore its ability to transport sediment.

Decrease Sediment Transport:

Undersized stream crossings – capture sediment in unnatural patterns, may create scour downsteam.

Overwidened channels – are unable to move sediment effectively through them.

5.0 REACH SCALE STRESSORS

Stream condition and stability is determined by a combination of many factors. Often, small impacts tend to accumulate into reach scale impairment. The maps in the Appendix depict some of the major impacts that are occurring within the study area. The maps are laid out from upstream to downstream starting with the tributary in the north of the watershed which has been labeled Walden Brook. The second tributary that drains from the east into Cabot Village has been labeled the Rec. Field Brook.

5.1 Vertical Constraints

Grade controls are critically important features in maintaining bed elevation and overall channel stability, and in determining upstream migration of many aquatic organisms, primarily fish. By definition, grade controls must extend across the entire bankfull channel from bank to bank in order to function as true controls. Natural or man made features which may serve as grade controls include:

***Waterfall* -** Bedrock that extends across the channel and forms a vertical, or near vertical, drop in the channel bed
***Ledge* -** Bedrock that extends across the channel and forms no noticeable drop in the channel bed, or only a gradual drop in the channel bed
***Dam* -** High cross-channel structures
***Weir* -** At-grade or low cross-channel structures

5.2 Lateral Constraints

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 (Vermont Agency of Natural Resources 2005a).

Berms and roads, 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. 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.

Structures that encroach into the river corridor (see Figure 12) are not only threatened by the river, but the armoring and berming of the river banks often deemed necessary to protect these investments may pose a threat to downstream areas, by limiting slope adjustments and increasing flood velocities and stream power of the confined stream. Floodplain encroachments typically concentrate flow in the channel during floods, increasing the stress of flood flows on the channel bed and banks. They can also effectively turn a response or depositional stream into a transfer stream, which may lead to an increase in sediment loading and aggradation, as well as bank erosion, in downstream reaches.

Figure 12: An example of encroachments within the river corridor below Clark's Saw Mill Dam.

5.3 Bridge and Culverts

Stream crossings can disrupt the sediment transport and/or the movement of fish and wildlife within a stream reach. Forman and Alexander (1998) summarize bridge and culvert impacts on stream morphology and hydrology. They write that, "Streams may be altered for considerable distances both upstream and down-stream of bridges…. The fixed stream (or river) location at a bridge or culvert reduces both the amount and variability of stream migration across a floodplain. Therefore, stream ecosystems have altered flowrates, pool-riffle sequences, and scour, which typically reduce habitat-forming debris and aquatic organisms."

Furthermore, the Vermont Department of Fish and Wildlife (2005) states, "The biological consequences of improper culvert installation to aquatic communities are many, and may include:

- direct loss of aquatic habitat
- loss of resident aquatic populations (by preventing recolonization of upstream habitat after catastrophic events, such as floods or toxic discharges)
- loss of access to critical spawning, rearing, feeding or refuge habitat for aquatic organisms
- altered aquatic community structure (e.g. species composition, distribution)
- altered genetic composition of aquatic populations"

Within the Upper Winooski River study area, improperly sized bridge and culvert crossings were identified during the Phase 2 Stream Geomorphic Assessment as contributors to localized channel instabilities (Figure 13). A more detailed assessment of stream crossings using the Vermont Agency of Natural Resources Bridge and Culvert Assessment is recommended to better understand and catalog the geomorphic instability caused by stream crossings on a reach level. The geomorphic context of stream crossings should be given strong consideration when designing new and rehabilitating existing structures. The Town of Cabot could establish ordinances or identify zoning requirements which would ensure adherences to proper siting and design practices for future development, especially on private crossings.

Figure 13: An example of an undersized culvert on Walden Brook.

5.4 Dams

Located below the confluence of Jug Brook, the aging Clark's Saw Mill Dam has a length of 135 feet and is 14 feet high. This dam is impacting natural sediment transport within the Upper Winooski River and poses a threat to downstream property should it fail catastrophically. It is recommended that a dam removal feasibility study be conducted in order to determine the best management strategy for the dam and the reaches that it impacts.

6.0 Stream Adjustment, Sensitivity, and Fluvial Erosion Hazard Mapping

6.1 Channel Adjustment and Evolution

The stability of a stream channel is based on maintaining a certain flow of water, shape and slope of the channel, and sediment load. When any of these change significantly, the river channel must change, typically resulting in erosion of the stream bed or banks. Between the 1700's and the 1800's, the building of roads and railroads within the floodplains, deforestation, and moving streams to accommodate agricultural fields and villages resulted in unstable river channels. Even in recent decades, large-scale channelization practices have been employed to reclaim damaged lands after large flood events. The 1970's and 1980's were also a period of extensive gravel mining in many Vermont streams. Post-flood channel straightening and gravel mining of point bars have the effect of steepening stream channels. A steep channel in a relatively flat valley may initiate a bed degradation, or downcutting, process referred to as "headcutting." Once a stream begins to headcut, it will typically erode its way through an evolution process until it has created a new floodplain at a lower elevation in the landscape. The common stages of channel evolution, as shown below in Figure 14, include:

- A pre-disturbance period
- Incision – Channel degradation and headcutting
- Aggradation and channel widening
- The gradual formation of a stable channel with access to its floodplain at a lower elevation.

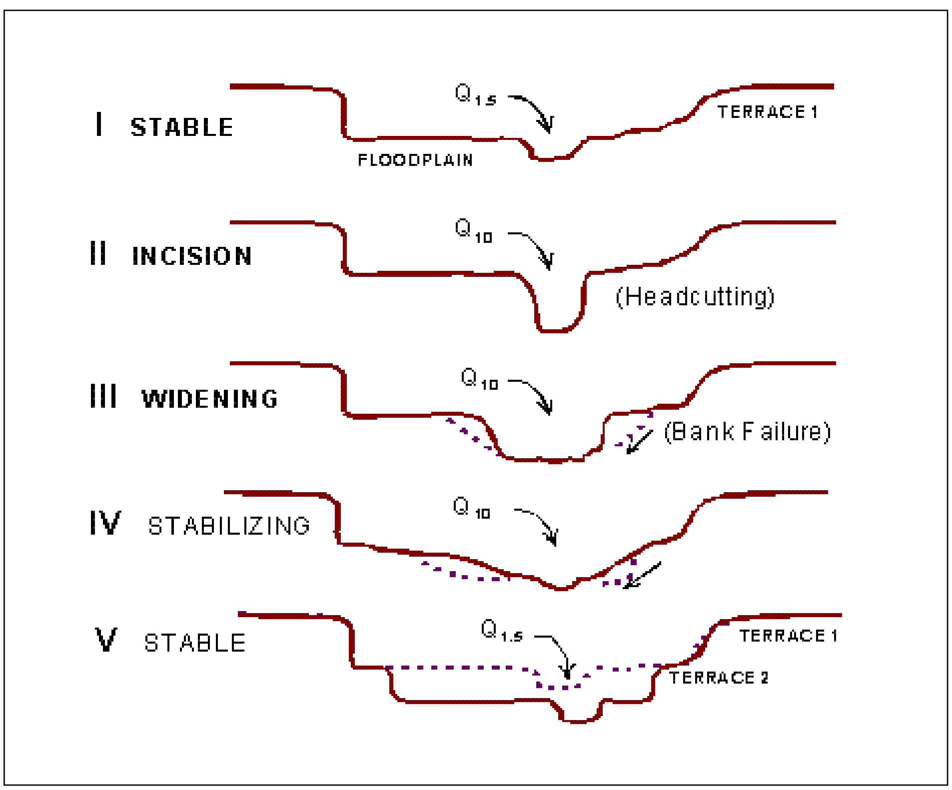

Figure14. F-stage Channel Evolution Process (from Vermont Agency of Natural Resources, 2003)

The bed erosion that occurs when a meandering river is straightened in its valley is a problem that translates to other sections of the stream. Headcuts will travel upstream and into tributaries eroding sediments from otherwise stable streambeds. These bed sediments will move into and clog reaches downstream leading to lateral scour and erosion of the streambanks. Channel evolution processes may take decades to play out. Even landowners that have maintained wooded areas along their stream and riverbanks may have experienced eroding banks as stream channel slopes adjust to match the valley slopes.

It is difficult for streams to attain a new equilibrium where the placement of roads and other infrastructure has resulted in little or no valley space for the stream to access or to create a floodplain. Landowners and government agencies have repeatedly armored and bermed reaches of Vermont's rivers to contain floodwaters in channels. These efforts have proven to be temporary fixes at best, and in some cases have lead to disastrous property losses and natural resource degradation. A more effective solution is to limit encroachments within the riparian corridor and maintain a buffer of woody vegetation between the stream and adjacent land uses. Maintaining vegetated riparian corridors and offsetting development limits the conflict between property investments and the natural processes of flooding and channel migration that occurs gradually over time. Given room, a channel can adjust its shape and slope to changes in flow and sediment load. In general, the space provided by an established riparian corridor allows the river or stream system to be more resilient to watershed changes, thereby protecting the fish, wildlife, and humans that depend on Vermont's rivers and streams (Vermont Agency of Natural Resources 2005d).

The reach condition ratings of Upper Winooski River indicate that many of the reaches are actively, or have historically, undergone a process of minor or major geomorphic adjustment. The most common adjustment processes in the Upper Winooski River are widening and planform migration as a result of historic degradation within the channel.

Most of the reaches studied in the Upper Winooski River watershed are undergoing a channel evolution process in response to large scale changes in its sediment, slope, and/or discharge associated with the human influences on the watershed. Table 2 below summarizes the channel evolution of each study reach and the primary adjustment processes that are occurring.

Table 2. Stream Type and Channel Evolution Stage

Segment Number	Entrenchment Ratio	Width to Depth Ratio	Reference Stream Type	Existing Stream Type	Channel Evolution Stage	Major Active Adjustment Process
R37-A	24.1	11.5	E5	E5	III	**Aggradation** **Widening** **Planform**
R37-B	14.9	9.8	E4	E4	III	**Planform** **Widening** Aggradation
R37-D	13.9	9.8	E4	E4	III	**Widening** Aggradation Planform
R38-A	21.0	9.1	E4	E5	III	**Planform** **Aggradation** Widening
R38-B	24.2	8.6	E4	E4	III	**Planform** Aggradation Widening
R39-A	3.9	17.8	C3	C3	III	Aggradation Widening Planform
R39-B	2.3	19.7	C3	C3	IV	Widening Planform
R39-C	1.5	16.5	B2	B2	V	Aggradation
R39-D	2.2	19.7	C4	B4	IV	**Aggradation** Widening
R39-E	1.3	14.1	B3	F3b	II	Aggradation Widening Planform
R40-A	10.5	11.4	E4	E4	III	Aggradation Widening Planform
R40-B	16.3	12.0	E4	C4	III	**Planform** **Widening** **Aggradation**
R41-A	21.8	11.5	E5	E5	III	**Aggradation**
R41-B	1.3	40.0	B2	B3	I	Aggradation Widening Planform
R41-D	6.4	11.2	E4	E4	I	Aggradation Widening Planform
R42	17.5	7.7	E4	E4	III	**Planform** Widening Aggradation

Table 2. Stream Type and Channel Evolution Stage

Segment Number	Entrenchment Ratio	Width to Depth Ratio	Reference Stream Type	Existing Stream Type	Channel Evolution Stage	Major Active Adjustment Process
T2.01	1.3	18.7	C4	F3b	III	Widening Planform
T2.02-A	1.5	26.8	C4	B4	III	**Widening Planform** Aggradation
T2.02-B	1.1	21.7	C4	F4b	II	**Degradation Widening Planform** **Aggradation**
T3.01	13.8	6.9	E4	E4	III	**Widening Planform** Aggradation
T3.02-A	4.8	13.7	C4	C4	III	Widening Planform
T3.02-B	1.9	17.1	B4	B4	I	Widening Planform
T3.02-C	6.6	13.3	C4	C4	III	Degradation Widening Planform
T3.03-A	13.5	6.7	E4	E4	III	**Widening Planform**
T3.04-A	22.4	10.6	E4	E4	III	Aggradation Widening Planform
T3.04-B	11.2	9.9	E4	E4	III	Aggradation Widening Planform
T3.04-C	2.1	15.4	B4	B4	I	Planform
T3.04-D	5.3	13.5	C4b	C4b	I	None

Red Bold lettering – denotes extreme adjustment process
Bold Black lettering – denotes major adjustment process
Black lettering (no bold) – denotes minor adjustment process

In terms of the ANR channel evolution model, the Upper Winooski River and its tributaries are predominately at stage III of the "F-stage" channel evolution model (see Figure 14). In many reaches the channel has undergone historic degradation. Many of the cross sections on study reaches were found to be incised. The incision ratio ranged form 1.0 to 2.9. Four of the segments were found to have a bankfull elevation that was at least one mean bankfull depth lower than the top of the low bank indicating a high level of bed degradation. Along many of the main stem reaches and near the mouths of the tributaries, the system is actively adjusting to this lower bed elevation by moving laterally and widening in order to create a new floodplain at a lower elevation. This widening and planform adjustment is leading to another adjustment process, aggradation. Aggradation in the Upper Winooski River study area seems to be a combination of autochthonous sediment that is created as the stream widens and erodes its banks to reestablish a new floodplain as well as from allochthonous sources such as gravel roads and land clearing. Unvegetated mid- channel bars, point bars in "E" type channels, side bars and impending neck cutoffs confirm the channel is undergoing extensive lateral migration.

6.2 Stream Sensitivity

Sensitivity refers to the likelihood that a stream will respond to a watershed or local disturbance or stressor, such as; floodplain encroachment, channel straightening or armoring, changes in sediment or flow inputs, and/or disturbance of riparian vegetation. Assigning a sensitivity rating to a stream is done with the assumption that some streams, due to their setting and location within the watershed, are more likely to be in an episodic, rapid, and/or measurable state of change or adjustment. A stream's inherent sensitivity may be heightened when human activities alter the setting characteristics that influence a stream's natural adjustment rate including: boundary conditions; sediment and flow regimes; and the degree of confinement within the valley. Streams that are currently in adjustment, especially those undergoing degradation or aggradation, may become acutely sensitive (Vermont Agency of Natural Resources 2005b).

Figure 15 is a map presenting the existing stream types found in the Upper Winooski River watershed. Most of the reaches are Rosgen (1996) "E" or "C" channels by reference. E and C channels have wide valleys and moderate to gentle gradients. The difference between E and C channels is largely due to the difference in the shape of the channel. E channels have very low width to depth ratios and are highly sinuous by reference. This means that E channels are narrow and deep and have a long channel length relative to the valley length. C channels are typically wider and shallower and have moderate to high width to depth ratios and sinuosity. B channels have moderate to steep slopes and have narrower valleys than E or C channels. The stream sensitivity of these reaches, generalized according to stream type and condition as per the ANR protocol, is depicted in Table 3 and in Figure 16.

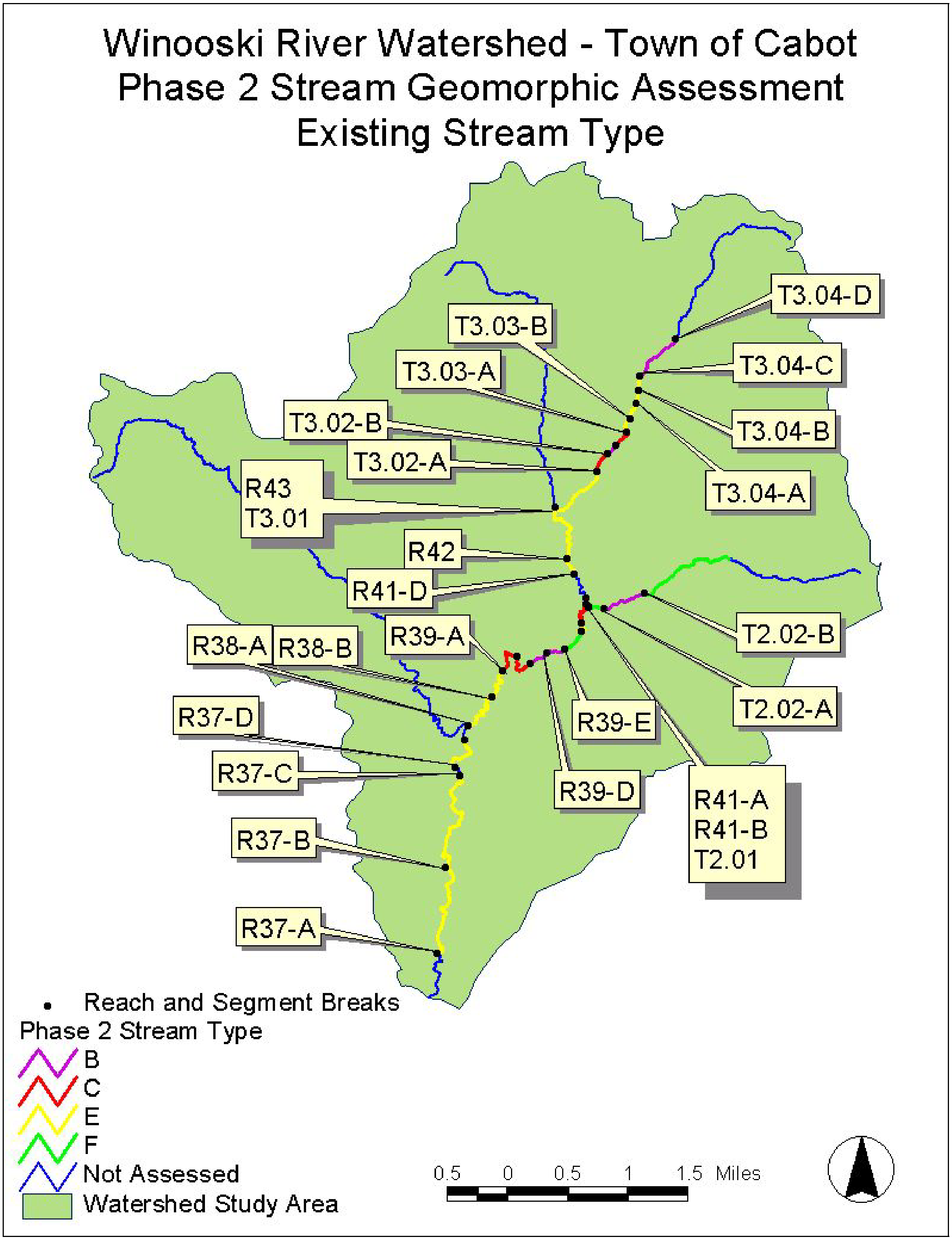

Figure 15. Phase 2 Existing Stream Types

Table 3. Stream Sensitivity for Phase 2 Reaches

Segment Number	Existing Stream Type	Stream Type Departure	Geomorphic Condition	Sensitivity
R37-A	E5	No	Fair	Very High
R37-B	E4	No	Fair	Very High
R37-D	E4	No	Fair	Very High
R38-A	E5	No	Fair	Very High
R38-B	E4	No	Fair	Very High
R39-A	C3	No	Fair	High
R39-B	C3	No	Good	Moderate
R39-C	B2	No	Good	Very Low
R39-D	B4	Yes	Fair	Very High
R39-E	F3b	Yes	Fair	Extreme
R40-A	E4	No	Fair	Very High
R40-B	C4	Yes	Fair	Very High
R41-A	E5	No	Fair	Very High
R41-B	B3	No	Good	Moderate
R41-D	E4	No	Good	High
R42	E4	No	Fair	Very High
T2.01	F3b	Yes	Fair	Extreme
T2.02-A	B4	Yes	Fair	Very High
T2.02-B	F4b	Yes	Poor	Extreme
T3.01	E4	No	Fair	Very High
T3.02-A	C4	No	Fair	Very High
T3.02-B	B4	No	Good	Moderate
T3.02-C	C4	No	Good	High
T3.03-A	E4	No	Fair	Very High
T3.04-A	E4	No	Fair	Very High
T3.04-B	E4	No	Good	High
T3.04-C	B4	No	Good	Moderate
T3.04-D	C4b	No	Good	High

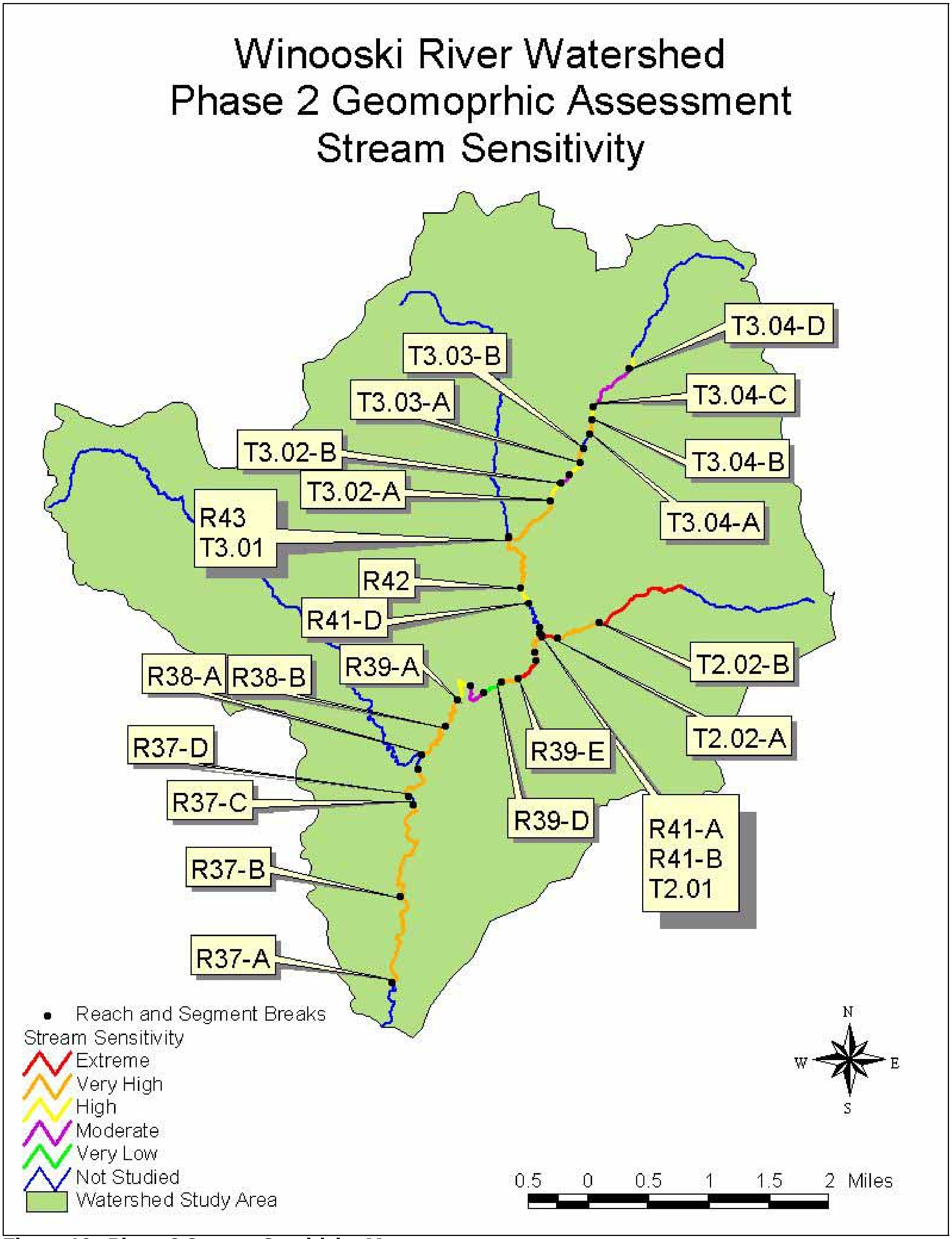

Figure 16: Phase 2 Stream Sensitivity Map

6.3 Fluvial Erosion Hazard Zones

Of all types of natural hazards experienced in Vermont, flash flooding represents the most frequent disaster mode and results in by far the greatest magnitude of damage suffered by private property and public infrastructure. While inundation-related flood loss is a significant component of flood disasters, the predominant mode of damage is fluvial erosion[2]. These adjustments often result in bed and bank erosion and are commonly the result of debris and ice jams, structural failures, flow diversion, or flow modification by man made structures. These channel adjustments and their devastating consequences are often related to historic channel management activities, floodplain encroachments, adjacent land use practices and/or changes to watershed hydrology associated with land use and drainage.

One of the primary uses of Fluvial Erosion Hazard (FEH) Zones is to inform local fluvial erosion hazard mitigation efforts. Effective town planning and zoning informed by FEH maps can minimize flood-related property prevent increases in fluvial erosion resulting from uncontrolled development in identified fluvial erosion hazard areas; minimize property loss and damage due to fluvial erosion; prohibit land uses and development in fluvial erosion hazards areas that pose a danger to health and safety.

One of the best and most cost effective ways to mitigate flood and fluvial erosion hazards is avoidance: limiting human investments in river corridors. In addition to preventing future flood losses, this approach limits the need for costly structural mitigation actions (armoring, dredging, etc.) which may even increase flood hazards to other properties and prevent a river from ever adjusting toward a more stable, equilibrium condition. Fluvial Erosion Hazard (FEH) zones define the river corridor which should be needed, on average, to allow a river to adjust toward and maintain equilibrium. This zone includes lands adjacent to and including the course of a river. The width of the corridor is based on a prediction of meander belt width (lateral extent of the river meanders), and is informed by Phase 2 geomorphic assessment data. The width of the FEH zone is also governed by the stream

[2] The dynamic, and oftentimes catastrophic, physical adjustment of stream and channel dimensions during high flow events.

type and sensitivity and ranges from one-half to three channel widths on each side of the meander centerline. River corridors, defined through ANR Geomorphic Assessments (2004), are intended to provide landowners, land use planners, and river managers with a meander belt width which would accommodate the meanders and slope of a balanced or equilibrium channel, which when achieved, would serve to maximize channel stability and minimize fluvial erosion hazards. Figure 17 represents a draft Fluvial Erosion Hazard Map for the Town of Cabot.

6.4 River Corridor Protection Zone

A River Corridor Protection (RCP) Zone includes lands adjacent to and including the course of a river. Riparian landowners are encouraged to work on a voluntary basis with the Cabot Conservation Committee to protect and enhance riparian corridors along the Upper Winooski River through the implementation of river corridor projection projects. RCP zones recommended in this plan are the same width as those proposed for FEH zones with the exception of E type stream channels (see Figure 18). The FEH zone, based on three channel widths on each side, provides adequate space to protect against erosion hazard; however it does not provide adequate space to provide for a healthy riparian buffer and floodplain for E type channels, whose significant meander belt width requires more adjacent land than other channel types. Therefore, protecting a corridor of five channel widths on each side of the meander centerline for E channels is recommended for the Upper Winooski River within the Town of Cabot.

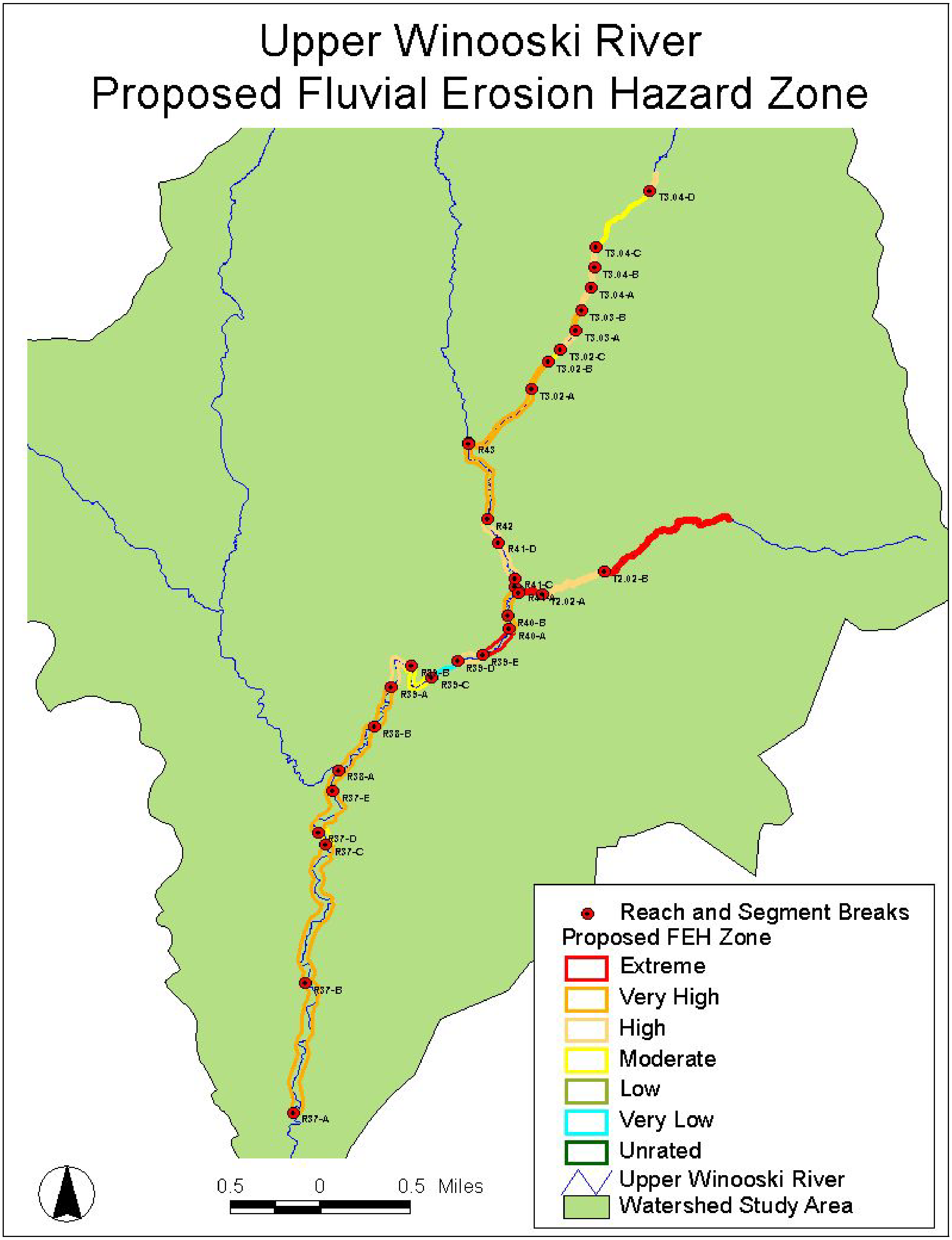

Figure 17: Draft Fluvial Erosion Hazard Map

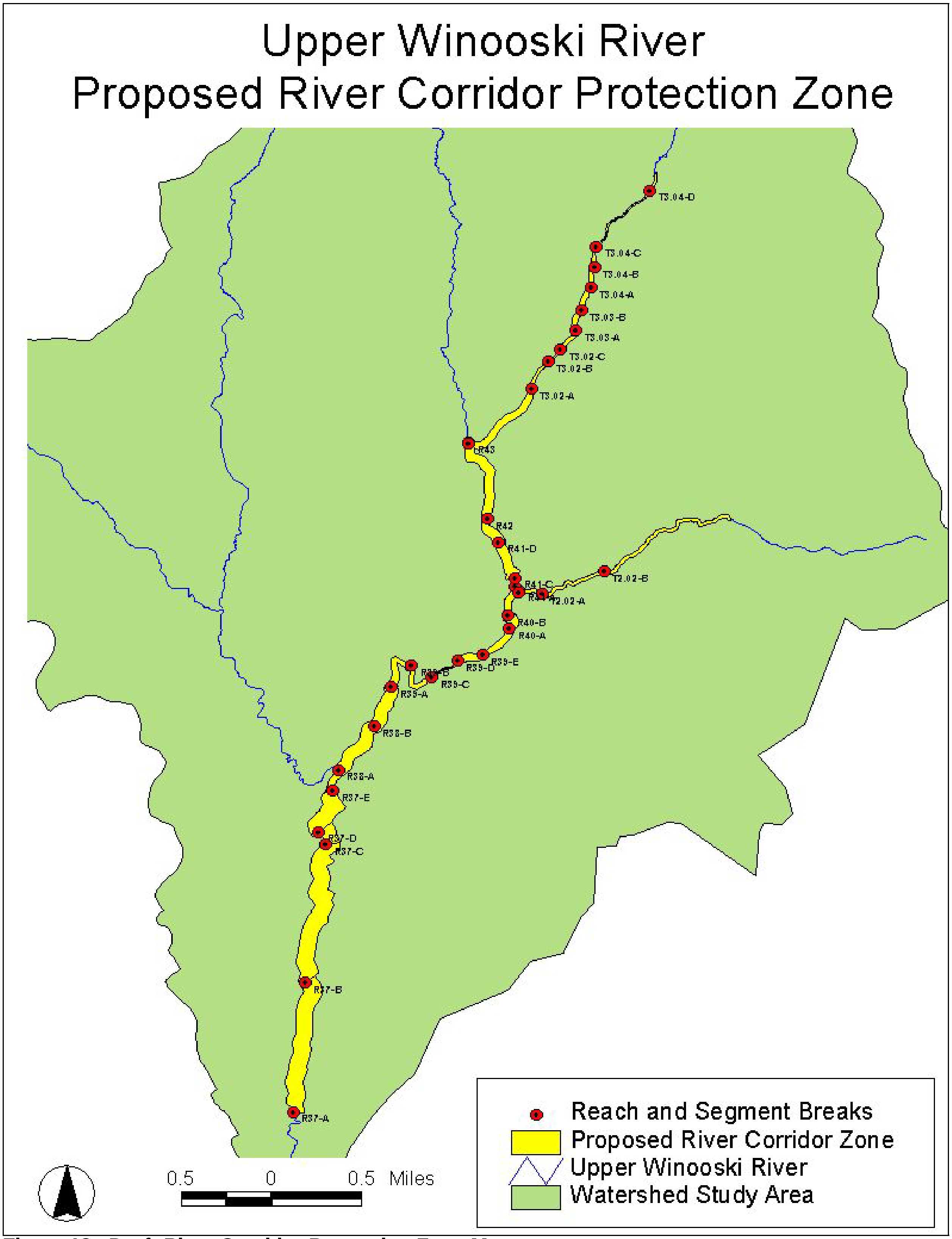

Figure 18: Draft River Corridor Protection Zone Map

Many of these E type channels have been historically channelized along the edge of farm fields. As a result of this channel straightening the river had increased energy and slope that resulted in degradation of the bed and loss of floodplain access. Steeper, straightened channels in Cabot are now adjusting or "evolving" back into gentler gradient, more sinuous channels through an aggradation process. The narrower belt widths observed during Stages II and III of channel evolution, which held for decades and encouraged human encroachment, have now begun to widen during recent floods as new sediments deposit and longer meanders develop putting human encroachments at risk. The practice of dredging sediment to avoid flood hazards has typically worked until there is another flood. Berming and armoring may hold longer, but tend to cause the unbalanced condition to extend upstream and downstream. Such practices are unsustainable and will eventually unravel, requiring extensive maintenance operations. With this in mind, a River Corridor Protection Zone provides a cost-effective, geomorphic approach to identifying, avoiding and minimizing encroachments and investments in river corridors.

7.0 REACH SCALE PROJECT IDENTIFICATION AND PRIORITIZATION

7.1 Restoration Approaches

The restoration of the Upper Winooski River may focus on one or a combination of the following strategic approaches.

Active Geomorphic: This approach seeks to restore or manage rivers to a geomorphic state of dynamic equilibrium through an **active** approach that may include human-constructed meanders, floodplains, and bank stabilization techniques. This approach tends to have high upfront cost. Typically, the active approach involves the design and construction of a management application or river channel restoration project in an attempt to achieve stability in a relatively short period of time. This approach may involve restoring sections of river to their reference condition or may involve recognizing new valley conditions imposed by human constraints and working within those constraints. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.

Passive Geomorphic: A **passive** geomorphic approach is targeted at allowing rivers to return to a state of dynamic equilibrium by removing constraints from a river corridor thereby allowing the river, utilizing its own energy and watershed inputs to re-establish its meanders, floodplains, and self maintaining, sustainable equilibrium condition over an extended time period. This approach is typically less expensive, however, may take much longer to achieve desired results. Active riparian buffer revegetation and long-term protection of a river corridor is also essential to this alternative (Vermont Agency of Natural Resources 2005c).

7.2 River Corridor Project Types

The State of Vermont River Management Program has outlined five project types to further identify opportunities and address major issues on a reach level. River restoration within the Upper Winooski River will likely combine a variety of these project types and restoration approaches in order to manage for systemic equilibrium. The five project types are:

Conservation Reaches - least disturbed, where river structure, function and the riparian buffer are relatively intact. These conservation reaches would provide a good base to work out from, into more degraded reaches in the watershed.

High Recovery Reaches - These reaches show signs or potential for self-adjustment, in a manner that fits the present-day setting and stream type. Management efforts that work with the current tendencies of the river could achieve quick and visible success. High Recovery Reaches are those undergoing lateral adjustments where minimally invasive approaches to increase bank stability will accelerate recovery while meeting the concerns of the landowner.

Moderately Unstable Reaches - Moderately unstable reaches may be defined as over-widened with only localized vertical instability and have a reasonable potential to recover. An active geomorphic approach would require an invasive management strategy (consisting of changes to dimension and some bed form restoration). In most cases, restoration of moderately unstable reaches should only go forward at sites where watershed deposition and transport stressors have been evaluated and have either been treated or deemed to pose only minor risk to the stability of the project.

Incising Reaches - These are very high priority river reaches which are sensitive to disturbance, and where adjustments may trigger off-site responses. These projects involve a pro-active management strategy, with an emphasis on reaches where disturbances may threaten the integrity of Conservation Reaches. If action is not taken at these sites, the adjustments set in motion may lead to watershed-scale changes that would be uncontrollable without inordinate, impractical expense. The key example is the management of nick points (head cuts) or streambed instability. If bed level issues are not addressed, significant upstream and downstream instability may develop.

Highly Unstable Reaches - typically involve large scale vertical adjustments where the river/floodplain relationship is significantly different from that of equilibrium conditions. An active geomorphic approach would require an invasive management strategy (consisting of changes to dimension, pattern, and profile). Highly unstable reaches have a natural recovery potential considered in terms of decades (10-50 yrs.) and are found to be high-sediment source and/or accumulation zones. Given the costs and risks associated with actively restoring vertically unstable reaches, highly unstable reaches may be ideal candidates for a passive geomorphic approach. Physical intervention in highly-unstable reaches is often expensive with an uncertain outcome. In most cases, restoration should only go forward once upstream (and in some cases, downstream) sites have been dealt with and watershed-wide sediment and vegetation management plans have been implemented.

7.3 Specific Project Strategies

The following sections provide information on the six river corridor project types defined by the ANR. Each project type includes a brief summary strategy followed by general recommendations for the implementation of these projects Table 4 and Figure 19 provide a summary of these project strategies in the Upper Winooski study area.

Table 4: Classification of River Corridor Project Types

Segment Number	Stream Condition	River Project Type
R37-A	Fair	Highly Unstable Reach
R37-B	Fair	Highly Unstable Reach
R37-D	Fair	Highly Unstable Reach
R38-A	Fair	Highly Unstable Reach
R38-B	Fair	Highly Unstable Reach
R39-A	Fair	Moderately Unstable Reach
R39-B	Good	High Recovery Reach
R39-C	Good	Conservation Reach
R39-D	Fair	Highly Unstable Reach
R39-E	Fair	Highly Unstable Reach
R40-A	Fair	Moderately Unstable Reach
R40-B	Fair	Highly Unstable Reach
R41-A	Fair	High Recovery Reach
R41-B	Good	Conservation Reach
R41-D	Good	Conservation Reach
R42	Fair	High Recovery Reach
T2.01	Fair	Highly Unstable Reach
T2.02-A	Fair	Highly Unstable Reach
T2.02-B	Poor	Highly Unstable Reach
T3.01	Fair	Moderately Unstable Reach

Table 4: Classification of River Corridor Project Types		
Segment Number	**Stream Condition**	**River Project Type**
T3.02-A	Fair	Moderately Unstable Reach
T3.02-B	Good	Conservation Reach
T3.02-C	Good	High Recovery Reach
T3.03-A	Fair	Highly Unstable Reach
T3.04-A	Fair	Moderately Unstable Reach
T3.04-B	Good	High Recovery Reach
T3.04-C	Good	Conservation Reach
T3.04-D	Good	Conservation Reach

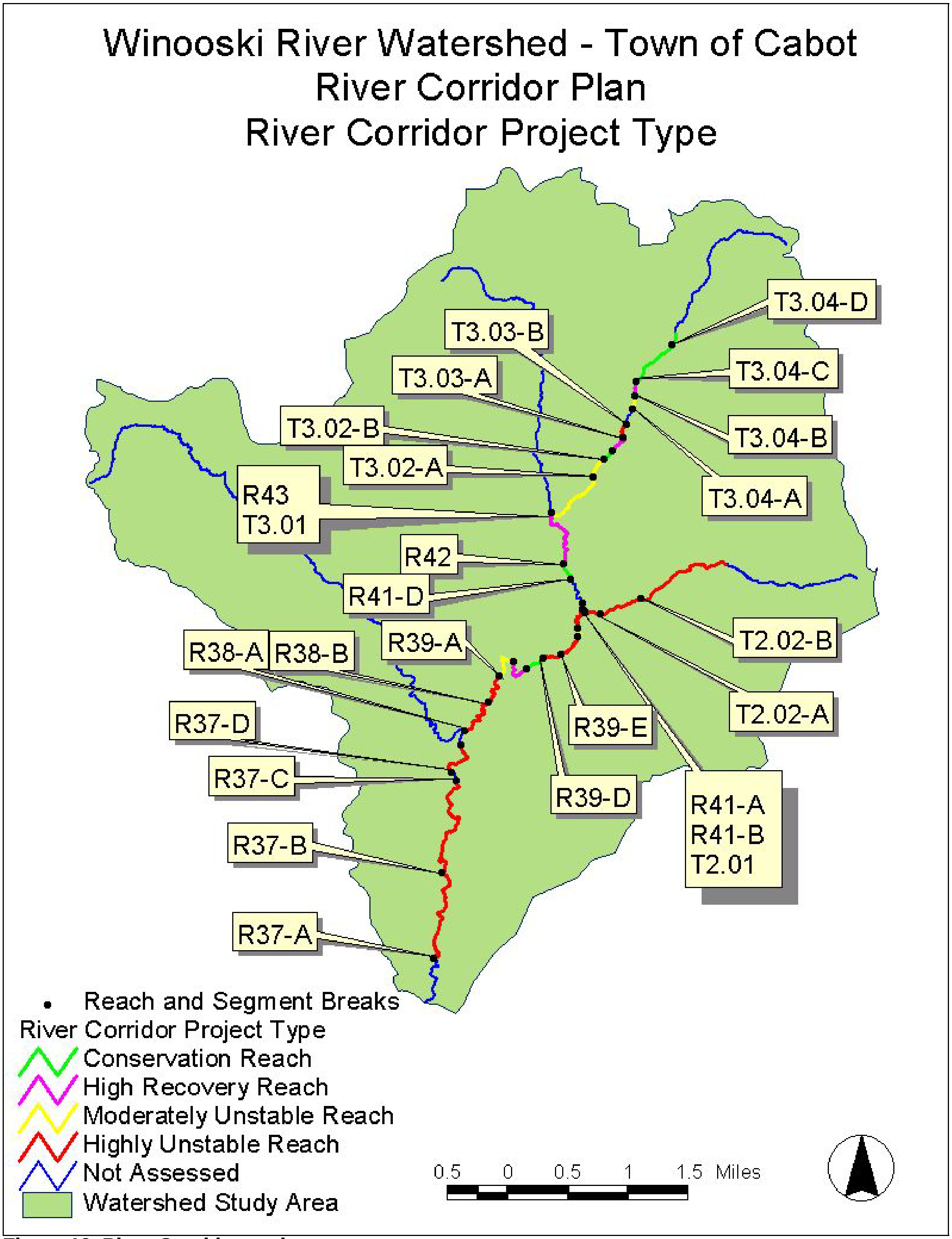

Figure 19: River Corridor project types.

7.3.1 Conservation Reaches

Conservation reaches are generally in stable geomorphic condition and need little restoration work (see example in Figure 20). In Cabot, three of the four conservation reaches identified flow through bedrock controlled channels that help to define their width and depth. Conserving a riparian corridor along these reaches is good policy. General strategies for implementation include the following:

- IMPLEMENT FEH ZONES AND CORRIDOR PROTECTION ZONE
- OBTAIN CONSERVATION EASEMENTS
- REPLACE UNDERSIZED STRUCTURES IF NECESSARY

Figure 20: Reach T3.04-D, an exemplary conservation reach in the headwaters of Walden Brook.

7.3.2 High Recovery Reaches

High recovery reaches are generally in good to fair geomorphic condition and exhibit channel dimensions, profile, and patterns that are within an expected range. These reaches may have already undergone significant adjustment already (see Figure 21) or may be prevented from undergoing a major adjustment process. Restoration of these reaches is best approached with a passive or light active approach to restoration.

Strategies for returning these river segments to health may include the following:

- IMPLEMENT FEH ZONES AND CORRIDOR PROTECTION ZONE
- OBTAIN CONSERVATION EASEMENTS
- REPLACE UNDERSIZED STRUCTURES IF NECESSARY
- PLANT RIPARIAN BUFFERS
- ATTENUATE STORMWATER IF NECESSARY
- TREAT STREAMBANK FAILURE THROUGH MINIMALLY INVASIVE APPROACHES, IF THERE IS A THREAT TO PROPERTY OR INFRASTURE.
- CONDUCT PHASE 3 (IF NECESSARY)

Figure 21: Reach T3.02-C, of Walden Brook, is an exemplary high recovery reach.

7.3.3 Moderately Unstable Reaches

Moderately unstable reaches may not have expected channel dimensions, patterns, or profile (see Figure 22). They are best approached through conducting alternatives analysis in order to determine the best strategy for restoration. General strategies for implementation may include the following:

- IMPLEMENT FEH ZONES AND CORRIDOR PROTECTION ZONE
- OBTAIN CONSERVATION EASEMENTS
- REPLACE UNDESIZED STRUCTURES
- PLANT RIPARIAN BUFFERS
- ATTENUATE STORMWATER IF NECESSARY
- CONDUCT A PHASE 3 ASSESSMENT AND ALTERNATIVES ANALYSIS

Figure 22: Due to historic channel straightening, reach T3.01, has incised and is considered a moderately unstable reach.

7.3.4 Highly Unstable Reaches

Restoration of highly unstable reaches is best approached with caution. These reaches are often severely incised, aggrading, or exhibiting major planform or widening processes (see Figure 23). Passive restoration techniques are preferred, as active geomorphic restoration of unstable reaches is often very expensive and unsuccessful. The very dynamic nature of these streams lends to the challenge of active restoration. The best technique may be to relieve the stream of obvious stressors such as undersized structures or other impairments to sediment transport and then to look for opportunities to develop a new floodplain. General strategies that are appropriate for these river segments are to:

- IMPLEMENT FEH ZONES AND CORRIDOR PROTECTION ZONE
- OBTAIN CONSERVATION EASEMENTS
- REPLACE UNDERSIZED STRUCTURES
- PLANT RIPARIAN BUFFERS (SET AWAY FROM THE TOP OF BANK)
- ATTENUATE STORMWATER IF NECESSARY

Figure 23: Reach R37-B, is highly incised and has been classified as a highly unstable reach.

8.0 PRIORITY PROJECT IDENTIFICATION

8.1 General Recommendations for Project Prioritization

The following topics have been prepared by the Mike Kline (ANR) to help guide communities in prioritizing river restoration projects.

Prioritizing River Corridor Protection:

Higher Priority – Give higher priority for river corridor protection for highly sensitive reaches that are critical for attenuating floodwaters and sediment (from upstream to downstream) or sensitive reaches where there is a major departure from equilibrium conditions and development is threatening the stream corridor.

Lower Priority – Wooded corridors experiencing very little threat from encroachment and less sensitive reaches not playing a significant role in storing floodwaters and sediment in the watershed should be given lower priority for river corridor protection.

Prioritizing River Buffer Planting:
Higher Priority – It is important to establish a buffer of vegetation on all reaches from a water quality and habitat standpoint. From a stream stability standpoint, give higher priority to tree planting, as a stand alone treatment or in combination with stream bank stabilization, on those sensitive reaches that are vertically stable.

Lower Priority – Give lower priority to tree planting, as a stand alone treatment or in combination with streambank stabilization, on those reaches, while exhibiting stable conditions, are extremely sensitive due to their watershed location. On areas where active adjustment is occurring, use low cost native grasses and shrubs in the near bank region and more expensive tree stock that may mature and lend to long term stability should the stream migrate to the outer extent of its belt width.

Prioritizing Streambank Stabilization:
Higher Priority - *Give* priority to geomorphically stable reaches where stabilization would slow down lateral movement enough to allow for the re-establishment of a riparian buffer. Also give priority to areas where human-placed structures are at high risk and not taking action may result in increased erosion risk to lands that may otherwise have the opportunity to establish a riparian buffer.

Lower Priority - A lower priority may be given to reaches where there is no conflict with the erosion process and the increase in sediment to downstream reaches may contribute beneficially to the floodplain development process.

Prioritizing the Arresting of Head cuts:
Higher Priority - Reaches where the bed lowering process will lead to a significant loss of floodplain and/or human-placed structures if a channel evolution process were to be initiated should be given higher priority for arresting head cuts.

Lower Priority – Reaches where natural grade controls exist upstream of the head cut and where the reach is sensitive to high bed load deposition and the head cuts are a result of meander cutoffs and braiding should be given lower priority for arresting headcuts. In these instances floodplain reconnection may be a relatively rapid process.

Prioritizing Berm Removal:
Higher Priority – Reaches where a significant (>50%) portion of the river corridor would become accessible to the stream for meander redevelopment and/or floodplain access, if the berm were removed, should be given higher priority. Berm removal should also be of higher priority if the berm constitutes the predominate reason why the reach is incised and/or human structures would not be at greater risk to flood inundation or erosion if the berm were removed.

Lower Priority – Berms vegetated with mature trees should be given lower priority for removal. The removal of such berms may cause major land disruption and habitat impacts, and the benefits to the channel are less certain. Berm removal as a stand alone treatment on reaches that would be severely incised even if the berm were removed should also be of lower priority.

Prioritizing the Removal or Replacement of Structures:
Higher Priority – Those structures which are derelict (i.e., no longer serving as stream crossing or flow control structure), which contribute to a significant increase in erosion hazard due to a constriction-related disruption of sediment transport in the system (i.e., major aggradation upstream and/or degradation downstream of the constriction) and/or are likely to result in an avulsion of the channel during a storm event due to blockage or alignment issues should be given higher priority for the removal or replacement of structures.

Lower Priority – Those structures which, if removed, would result in little change in level of erosion hazard at the site and the removal would potentially result in the need for restoration of the channel due to changes in stream conditions and/or sediment transport should be given lower priority.

Prioritizing Restoration of Incised Reaches:
Higher Priority – Give higher priority to restoration of incised reaches where it is possible, due to the lack of encroachment, to either passively or actively restore some degree of floodplain function at a lower elevation. This may include the rare, but important, opportunities to restore the river from a recent channel avulsion that has disconnected from the former floodplain.

Lower Priority – Reaches with little to no opportunity to restore meanders and floodplain and the restoration would mainly involve placing structures to minimize erosion hazards, ensure sediment transport, and improve habitat should be given lower priority for restoration. Also of lower priority should be the active restoration of reaches that incised due to changes in the hydrologic and sediment regimes of the watershed.

Prioritizing Restoration of Aggraded Reaches:
Higher Priority – Reaches aggrading and widening at a localized scale due to bank erosion should be targeted for restoration.

Lower Priority – Active restoration of reaches that are aggrading due to changes in the hydrologic and sediment regimes of the watershed should be of lower priority.

8.2 Specific Project Recommendations for Cabot

Specific project recommendations are listed in Table 5 and Figure 24.

Table 5: Prioritization of River Corridor Project Types

Project Number	Segment Number	River Project Type	Specific Strategy					Project Description (including Potential Constraints and/or Opportunities)	Priority
			River Corridor Protection	Replace Undersized Structure(s)	Develop New Floodplain and Plant Buffer	Plant Riparian Buffer	Other		
1	R37-A	HU	√	√	√			Extensive historic straightening has led to incision. As no infrastructure is threatened, stream should be allowed to readjust by preventing development in the corridor and allowing for the reestablishment of a riparian buffer.	L
2	R37-B	HU	√	√	√			Bank armoring at cemetery has caused further instability. Development of a floodplain on the opposite bank would relieve pressure on the cemetery and allow for attenuation of sediment and floodwaters through this reach. Opposite bank is agricultural land.	H
3	R37-D	HU	√	√	√			Section has been significantly straightened and is highly incised. Redevelopment of a floodplain through this reach would give the river some relief from flooding. Land use is currently open.	H

Table 5: Prioritization of River Corridor Project Types

Project Number	Segment Number	River Project Type	Specific Strategy					Project Description (including Potential Constraints and/or Opportunities)	Priority
			River Corridor Protection	Replace Undersized Structure(s)	Develop New Floodplain and Plant Buffer	Plant Riparian Buffer	Other		
4	R37-E		√				Conduct dam removal feasibility study	Old mill dam appears to be failing. Alternatives analysis should be conducted to determine feasibility of removing dam. Removal may alleviate flooding upstream, reduce potential of catastrophic failure, and improve fish habitat and passage.	H
5	R38-A[3]	HU	√					Prevent further corridor encroachment and await results of dam removal study.	M
6	R38-B	HU	√	√				Reach is highly unstable. Prevent further corridor encroachment and await results of dam removal study.	M
7	R39-A	MU	√	√			Remove berm	Remove berm on right bank upstream of bridge. Also consider retro fit of bridge to allow for floodwaters to pass unrestricted.	H
8	R39-B	HR	√					Protect corridor from further encroachment.	L
9	R39-C	CR	√				Preserve existing buffer	Protect corridor from further encroachment.	L
10	R39-D	HU	√					Protect corridor from further encroachment.	L

[3] Consideration of active restoration projects in Reach 38 not recommended until dam removal feasibility study is completed.

Table 5: Prioritization of River Corridor Project Types

Project Number	Segment Number	River Project Type	Specific Strategy					Project Description (including Potential Constraints and/or Opportunities)	Priority
			River Corridor Protection	Replace Undersized Structure(s)	Develop New Floodplain and Plant Buffer	Plant Riparian Buffer	Other		
11	R39-E	HU	√	√				Protect corridor from further encroachment. Consider removing undersized structures.	**M**
12	R40-A	MU	√	√				Protect corridor from further encroachment. Consider removing undersized structures.	**M**
13	R40-B	HU	√		√			Work with landowners to redevelop floodplain in this incised reach.	**H**
14	R41-A	HR	√					Protect corridor from further encroachment.	L
15	R41-B	CR	√				Preserve existing buffer	Protect corridor from further encroachment.	L
16	R41-C	HR	√			√		Excellent floodplain access and channel dimensions. Current land use is agricultural. Work with CREP or similar program as this reach is a priority for buffer planting.	**H**
17	R41-D	CR	√				Preserve existing buffer	Protect corridor from further encroachment.	**M**
18	R42	HR	√	√		√		Stream has some floodplain access through this reach. Protect corridor from further encroachment. Actively plant buffer to create long term stability and improve habitat through this reach. Replace undersized structures.	**H**

Table 5: Prioritization of River Corridor Project Types

Project Number	Segment Number	River Project Type	Specific Strategy: River Corridor Protection	Replace Undersized Structure(s)	Develop New Floodplain and Plant Buffer	Plant Riparian Buffer	Other	Project Description (including Potential Constraints and/or Opportunities)	Priority
19	T2.01	HU	√			√		Consider removing berm on lower left bank. Plant willows or other low growing shrubs on ball field side to provide some shade/habitat to the reach.	L
20	T2.02-A	HU	√		√			Relocate town sand storage yard and redevelop floodplain in that area. Upstream, protect corridor from further encroachment.	H
21	T2.02-B	HU	√	√				Stream is highly unstable. Protect corridor from further encroachment. Replace culvert at upstream end of reach.	M
22	T3.01	MU	√	√		√		Stream has been historically straightened and lost access to floodplain however is only moderately unstable. Buffer plantings could help to improve habitat and long term stability. Undersized structures should be prioritized for replacement.	M
23	T3.02-A	MU	√	√			Remove berm, replace bridge	Berm on right bank should be removed to provide floodplain access within this reach. Private bridge at upstream end of reach is a channel constriction, should be replaced.	H

Table 5: Prioritization of River Corridor Project Types

Project Number	Segment Number	River Project Type	Specific Strategy: River Corridor Protection	Specific Strategy: Replace Undersized Structure(s)	Specific Strategy: Develop New Floodplain and Plant Buffer	Specific Strategy: Plant Riparian Buffer	Specific Strategy: Other	Project Description (including Potential Constraints and/or Opportunities)	Priority
24	T3.02-B	CR	√				Preserve existing buffer	Protect corridor from further encroachment.	L
25	T3.02-C	HR	√					Protect corridor from further encroachment.	L
26	T3.03-A	HU	√	√				Protect corridor from further encroachment, remove undersized structure.	H
27	T3.04-A	MU	√			√		Replant buffer, prevent further encroachment into corridor.	M
28	T3.04-B	HR	√	√		√		Remove undersized structures in this reach.	H
29	T3.04-C	CR	√	√			Preserve and enhance existing buffer	Protect corridor from further encroachment by conserving this important headwaters reach. Replace undersized private stone culvert. Enhance buffer where it has been removed.	H
30	T3.04-D	CR	√				Preserve existing buffer	Protect corridor from further encroachment by conserving this important headwaters reach.	H

River Corridor Project Type:
CR = Conservation Reach
HR = High Recovery Reach
MU = Moderately Unstable Reach
HU = Highly Unstable Reach
Priority Ranking:
H = Higher
M = Medium
L = Lower

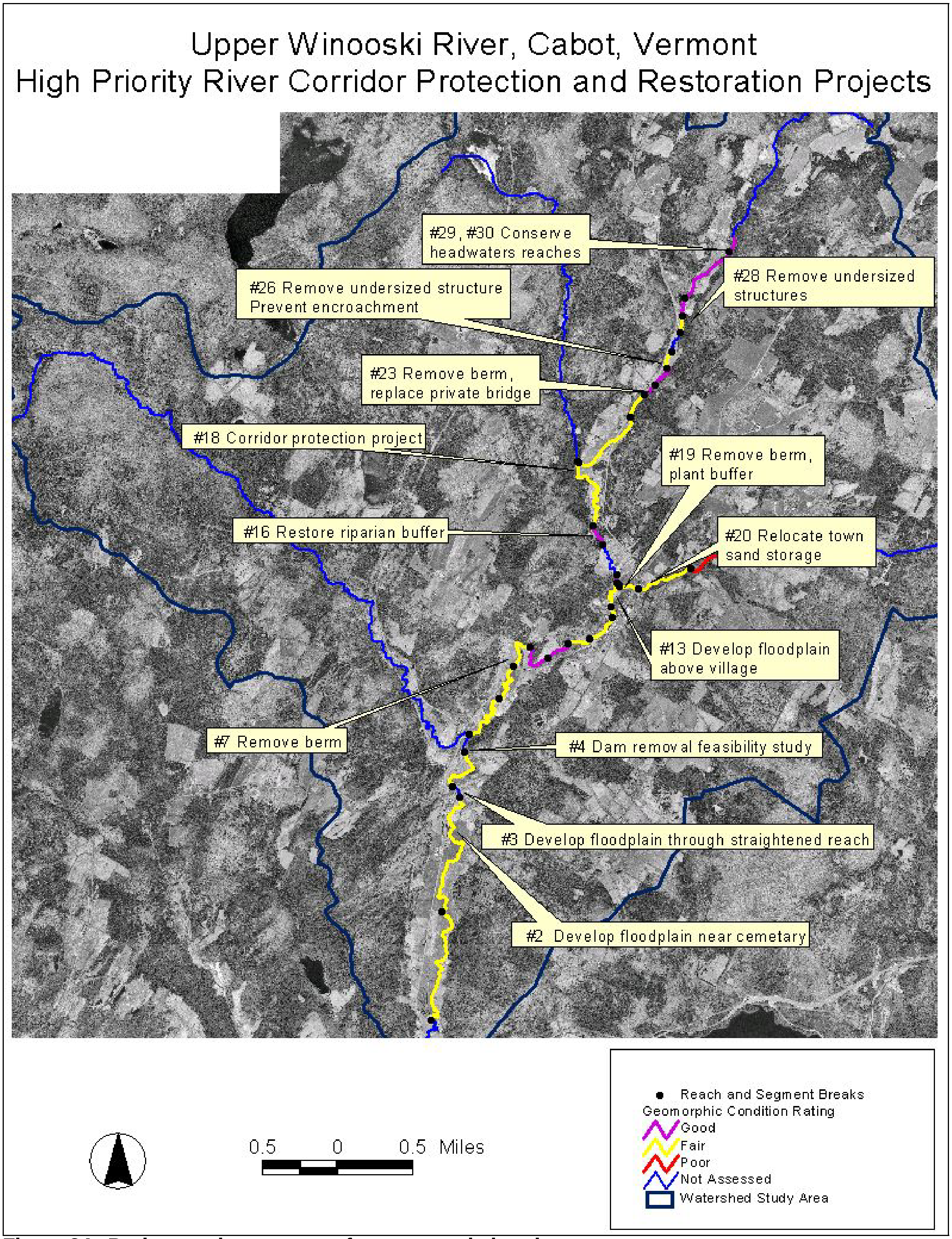

Figure 24: Project study area map of recommended projects.

9.0 PLAN IMPLEMENTATION

Implementation of this River Corridor Management Plan will require participation of town, state, federal and local organizations and most importantly local landowners.

9.1 Recommendations For Further Assessment Work

Although the Upper Winooski River has been extensively studied, there still exist areas where further assessment would improve our understanding and ultimately management of the Upper Winooski River. The following are recommendations for further studies:

- **Bridge and culvert assessment data for the Town of Cabot:** It would be useful to identify and catalog additional areas where stream crossings are affecting the geomorphic stability. The survey should use the assessment work that the town completed in combination with the ANR protocols in order to prioritize replacement of structures.
- **Stream Geomorphic Assessment of Molly's Brook:** Conduct a Phase I Assessment of Molly's Falls Brook to identify areas of potential instability.
- **Phase 2 data for Jug and Molly's Brooks:** As major tributaries to the Upper Winooski River, the collection of geomorphic data on these two streams would help to complete the systemic understanding of the Upper Winooski in the Cabot area and would allow for the development of FEH zones.
- **Sawmill Road Dam:** A feasibility study is recommended to examine the condition of the dam and the possibility of its removal. This feasibility study is not only important for public safety but is also an important consideration in terms of geomorphic stability and aquatic organism passage.

9.2 Public Review and Revision of River Corridor Management Plan

River Corridor protection is best accomplished at a community level. While specific landowners may have key roles in restoring certain pieces of the river, the entire watershed is subject to the quality of stewardship provided to the land by each and every landowner, whether they live next to the river or up on the ridgeline. Review and continuing revision of this River Corridor Management Plan by the Cabot community will encourage community awareness and participation in the restoration of the Upper Winooski River.

9.3 Develop and Adopt a River Corridor Overlay District and FEH Zone

It would be of great value for the Town of Cabot to continue to work with the River Management Section and the Central Vermont Regional Planning Commission in a public planning process to review the role of a River Corridor Overlay District in town planning and to develop a draft ordinance for public review. Incorporation of FEH maps in the town planning process may also make Cabot eligible for additional incentives, including priority for State restoration, flood recovery, and community development funding. More importantly, however, adoption of an FEH zone will transition the Cabot community from a reactionary role in river management to a proactive role that recognizes the dynamic nature of river systems. This will allow planning to minimize future flood damage, minimize maintenance and repair costs of infrastructure, and maximize the health of the fishery and water quality.

9.4 Proceed with Conservation / Restoration Projects

The Cabot Conservation Committee and local watershed groups have the opportunity to work closely with the ANR and river scientists to continue to develop and implement restoration and conservation projects in the Upper Winooski River watershed based on the recommendations of this plan.

9.5 Adoption of River Corridor Management Plan

Adoption of a River Corridor Management Plan will signify the completion of an important phase in the restoration of the Upper Winooski River and will lead to more directed identification and prioritization of restoration projects and the eventual reduction of future flood damage and improvement in the health of the Upper Winooski River in the Town of Cabot.

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