

River Corridor Plan
Lewis Creek: Reaches M14 – M18
Towns of Hinesburg, Monkton, and Starksboro
Chittenden & Addison Counties, Vermont

February 2008 (Revised March 2008)

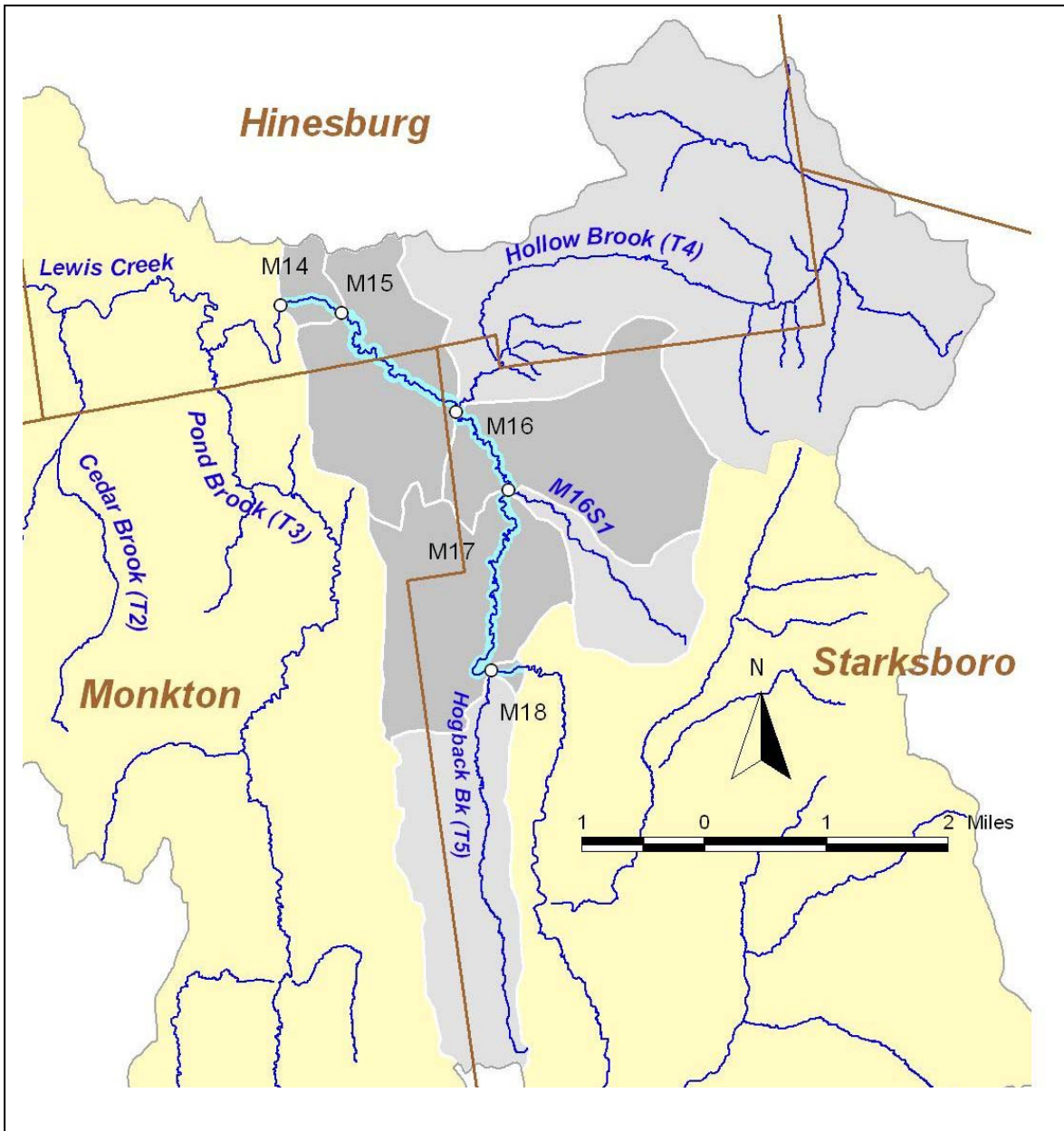


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EXECUTIVE SUMMARY

The Lewis Creek Association (LCA) received a grant from the Vermont Department of Environmental Conservation (VTDEC) to develop a River Corridor Plan for a 6.7-mile length of the Lewis Creek from the States Prison Hollow Road crossing in Starksboro downstream to the vicinity of Silver Street in Hinesburg. Funding has been appropriated through Governor Douglas' Clean & Clear Action Plan. This grant has funded a 9-month outreach and planning process with the long-term objectives of reducing streambank erosion, sediment, and nutrient loading, by managing for the equilibrium channel. This planning project builds upon results of geomorphic studies of the Lewis Creek that have been completed in 2001 through 2006 by the LCA under separate funding.

A Technical Working Group was assembled to guide the corridor planning process: Marty Illick, Lewis Creek Association Executive Director; Alison Wagner and Stevie Spencer, Lewis Creek Association board members; Kristen Underwood, consulting geologist; and Shannon Pytlik and Ethan Swift from the VTDEC Water Quality Division. Planning followed methods outlined in the VT Agency of Natural Resources *River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects* (2007 drafts). A River Corridor Management Plan was prepared for public review in February 2008. The plan identifies and ranks short-term and long-term actions and approaches for implementation, including potential river restoration and conservation projects.

In August of 2007, a direct mailing was sent to approximately 27 landowners along this section of the Lewis Creek, and a press release describing the project was issued to the local newspapers. From August 2007 to December 2007, the LCA and South Mountain R&C conducted outreach with several landowners to discuss the project. Landowner interviews provided an opportunity to discuss the goals of this project; to gather information from landowners about river corridor constraints, land uses, and concerns; and to identify river management alternatives that are acceptable to the landowners.

Between December 2007 and February 2008, LCA and SMRC met with the Starksboro Conservation Commission, Monkton Conservation Commission and Hinesburg Conservation Commission to discuss the project, including the involvement of select town-owned parcels in the corridor. Amy Diller, watershed planner with the Addison County Regional Planning Commission, also attended meetings and participated in presentations of Fluvial Erosion Hazard mapping and the relationship of potential FEH zoning to the corridor planning effort.

A draft River Corridor Plan has been prepared for public review. The plan identifies and ranks short-term and long-term actions for implementation, including potential river restoration and conservation projects.

1.0 INTRODUCTION

A River Corridor Plan has been completed for a 6.7-mile length of the Lewis Creek from the States Prison Hollow Road crossing in Starksboro downstream to the vicinity of Silver Street in Hinesburg. Objectives of the planning process were to:

- a) Improve water quality, restore habitats, and reduce erosion hazards by managing toward the equilibrium channel.
- b) Analyze previous geomorphic assessment work, identify the causes of channel instability, and evaluate options for restoring long-term stability to the river.
- c) Identify sustainable river corridor management strategies through continued outreach to individual landowners and through public meetings.
- d) Evaluate potential channel management choices for their effectiveness and potential consequences to downstream and upstream properties and infrastructure.
- e) Prepare a River Corridor Plan for public review by February 2008. The plan identifies and rank short-term and long-term actions and projects for implementation.

Managing toward dynamic equilibrium of river channels can reduce erosion hazards and improve channel stability in the long term, thereby reducing sedimentation and nutrient loading to our rivers. Decreased sediments and nutrients, in turn, will improve in-stream and Lake Champlain habitats.

Through evaluation of existing geomorphic assessment data and outreach to individual landowners along the corridor, various watershed-, reach- and site-level river corridor management strategies have been identified. This plan is intended to facilitate action, and contains a prioritization of various planning, restoration and conservation projects. Resources are listed so that community members and willing landowners can follow through on recommended implementation strategies, and secure necessary funding and technical support. This community-based river corridor planning process recognizes the public value of riparian areas and the need for public resources to support and facilitate stewardship of these lands in private and public ownership. This plan is intended to support an adaptive management approach to the river corridor, as conditions change and the community's understanding of river dynamics evolves.

This draft plan has been approved by the River Management Section of the VT Department of Water Quality Division, and is offered for public review and comment. It is anticipated that the final, publicly-approved plan would be incorporated by reference in the next updates to the town plans of Hinesburg, Monkton, and Starksboro and to the Natural Resources sections of the Addison County and Chittenden County Regional Plans. This corridor plan should also be considered in the context of future updates to the Addison County and Chittenden County Region-wide All Hazards Mitigation Plans and relevant town sections.

The consequences of channel and watershed management choices made in upstream communities of Starksboro, with respect to increased flows and sediment and nutrient loading, are felt by downstream landowners along the Lewis Creek. Acknowledgement of the science of fluvial geomorphology and the continuity of river networks, will help to ensure compatibility of this corridor plan with other Lewis Creek corridor plans that have been developed (Starksboro, reaches M22 – M19) or may be developed in adjoining communities.

This river corridor planning process has been funded by a Category 2 - Project Development grant through the VTDEC Water Quality Division, River Management Section. Project tasks have been carried out by the Lewis Creek Association (LCA) and South Mountain Research & Consulting (SMRC) of Bristol, VT, under direction of the VTDEC River Management Section. Additional assistance has also been provided by the Addison County Regional Planning Commission (Middlebury, VT).

2.0 BACKGROUND

2.1 Geographic Setting

The Lewis Creek watershed is an 81-square-mile basin located in Addison County (77% by area) and Chittenden County (23%), Vermont. The Lewis Creek drains directly into Lake Champlain at Hawkins Bay near Long Point and Gardner Island. This location is within the Otter Creek Lake Segment defined within the Vermont Water Quality Standards (Vermont Water Resources Board, 1999) and by the Lake Champlain Phosphorus Management Task Force (1993). Under the VTDEC river basin planning process, the Lewis Creek watershed is considered a part of the Otter Creek Basin, although these river systems drain separately to Lake Champlain; the mouth of the Otter Creek is located 2.7 miles to the southwest of the mouth of Lewis Creek (Figure 1).

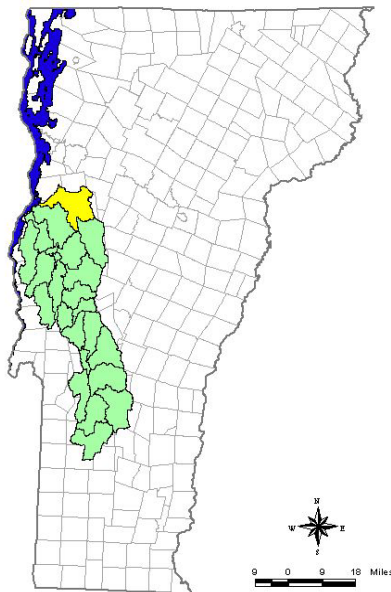


Figure 1. Location of Lewis Creek Watershed (highlighted in yellow) within the Otter Creek Basin (highlighted in green) and Vermont.

The Lewis Creek watershed drains portions of seven towns in Addison and Chittenden Counties:

- Addison County: Bristol, Ferrisburg, Monkton, Starksboro
- Chittenden County: Charlotte, Hinesburg, Huntington

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This corridor plan has focused on five reaches of the Lewis Creek main stem, draining portions of northwest Starksboro, northeast Monkton, and southern Hinesburg, and receiving the Hollow Brook tributary (Figure 2).

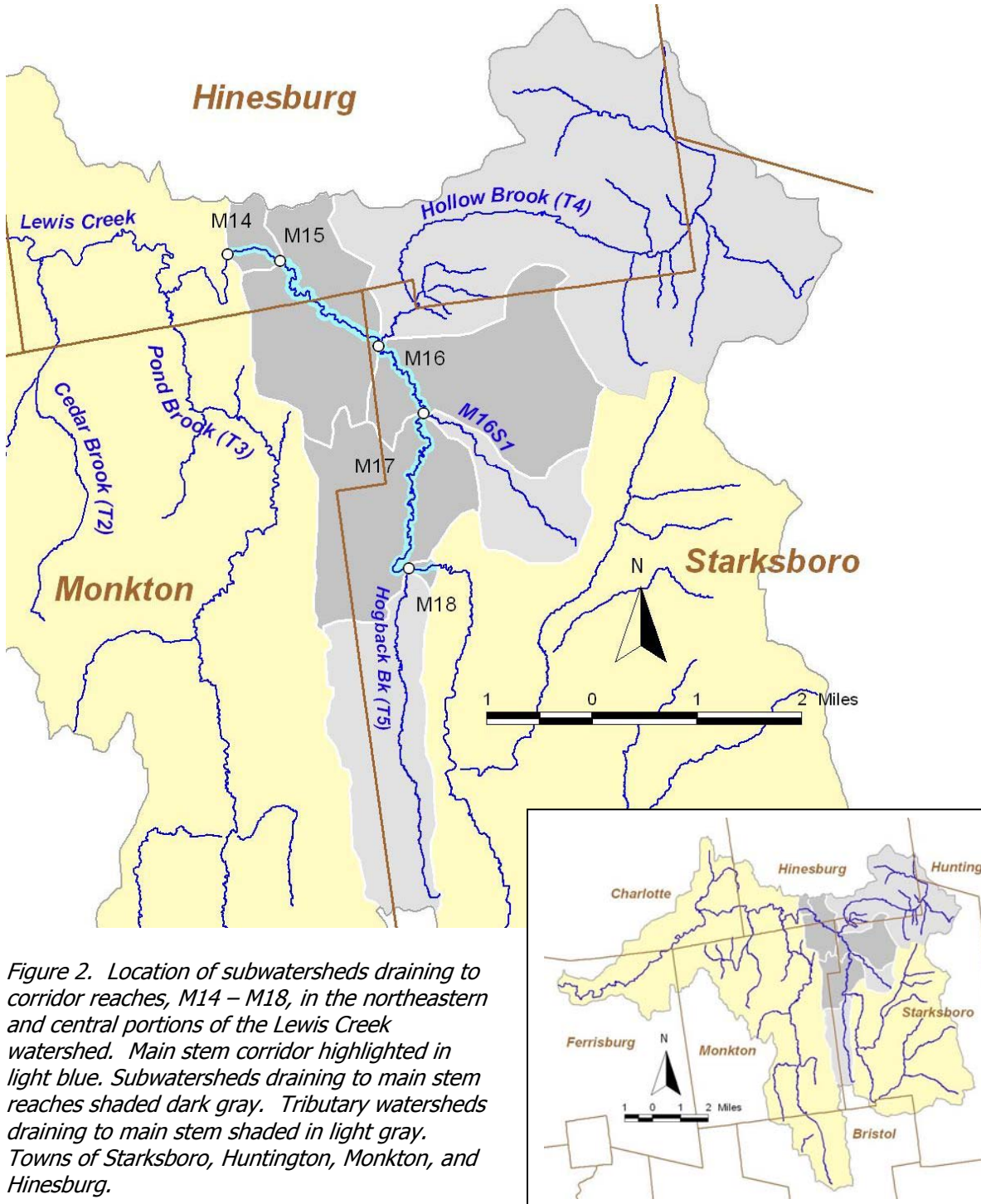


Figure 2. Location of subwatersheds draining to corridor reaches, M14 – M18, in the northeastern and central portions of the Lewis Creek watershed. Main stem corridor highlighted in light blue. Subwatersheds draining to main stem reaches shaded dark gray. Tributary watersheds draining to main stem shaded in light gray. Towns of Starksboro, Huntington, Monkton, and Hinesburg.

These five reaches comprise a 6.7-mile section of the main stem from the States Prison Hollow Road crossing in Starksboro downstream to the intersection of Lewis Creek Road and Silver Street in Hinesburg (Figure 3).

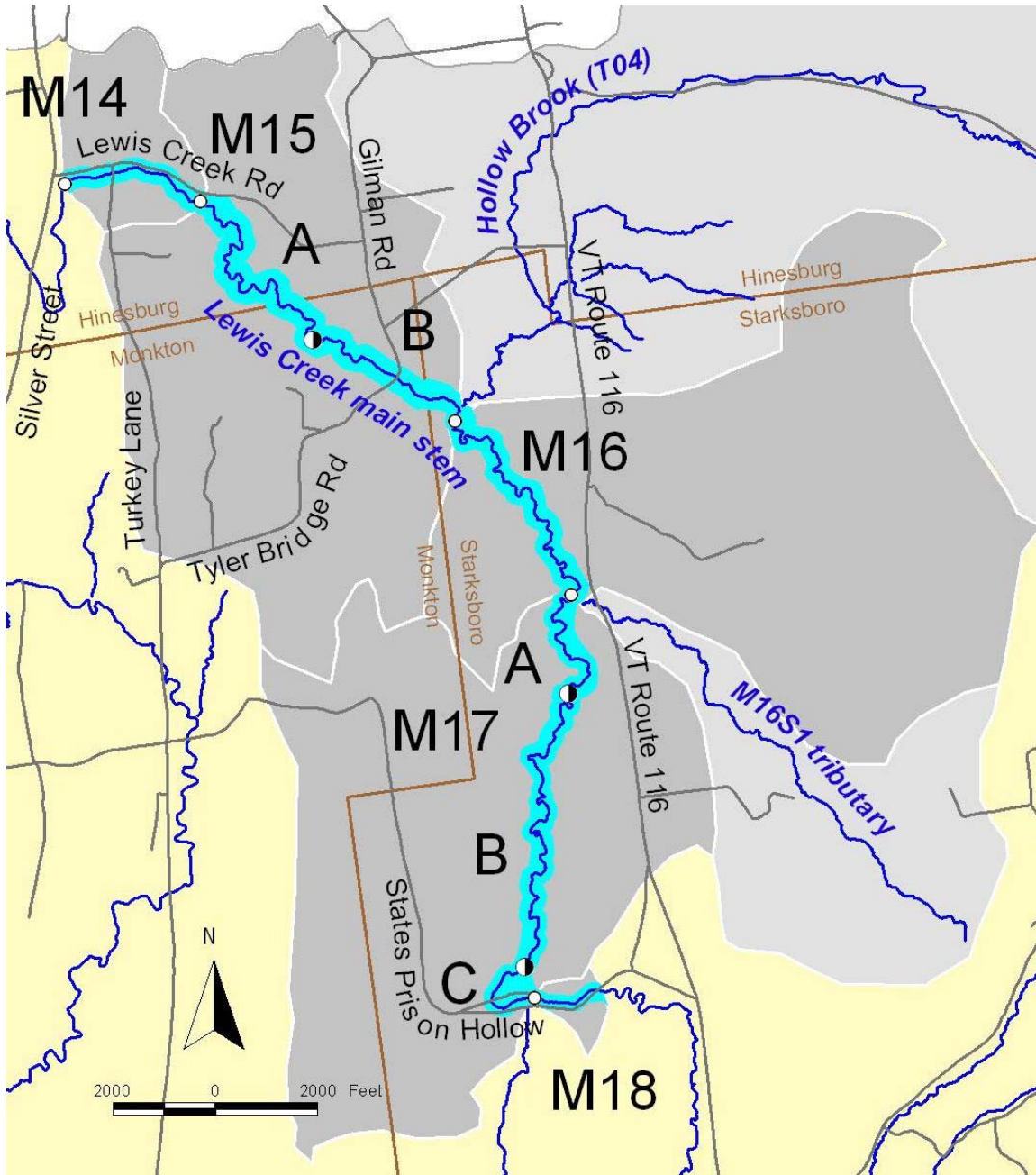


Figure 3. Corridor reaches, M14 – M18, and segments.

2.2 Geologic Setting

The 81-square-mile Lewis Creek watershed spans two major geologic provinces. Approximately 30% of the watershed occupies the till-blanketed bedrock slopes of the Northern Green Mountain province at the steep headwaters of Lewis Creek main stem, High Knob tributary and Hollow Brook in eastern Starksboro and Hinesburg. The remaining 70% of the Lewis Creek watershed is positioned in the broad Champlain Valley province (Capen, 1998; Stewart, 1973).

The Green Mountain province is comprised of high-elevation rocks which have been folded and faulted in a series of ancient mountain-building events. The rock types present in the mountain province are metamorphic in nature, having been formed under extreme temperature and pressure conditions during repeated deformations. The Champlain Valley is underlain by less-intensely-deformed rocks, which have undergone low-angle thrusting and folding, to create locally elevated slabs of crystalline rock. In the western portion of the Lewis Creek watershed, a major thrust fault zone called the Champlain Thrust has resulted in the erosional remnants of Mount Philo, Mount Fuller, and Shellhouse Mountain. Farther to the east, the north-south trending Monkton Ridge of quartzite has been formed by the Monkton Thrust fault. Near the eastern extent of the Champlain Valley at the base of the Green Mountains, the Hogback Anticline (an arch in regionally-folded bedrock) has formed the north-south trending Hogback Mountain (Stewart, 1973). Over geologic time, the Lewis Creek has had to find ways to navigate around and through these higher-relief features.

In recent geologic time (prior to 14,000 years before present) this landscape was occupied by advancing and retreating glaciers, with ice up to a mile or more in thickness above the present land surface. Glacial tills now blanket much of the upper bedrock-controlled slopes in the headwaters of the Lewis Creek watershed. As the global climate warmed and the glaciers receded, a large fresh-water lake inundated the Champlain Valley. At its highest stage, Lake Vermont lapped up along a shoreline located at the foot of the Green Mountains near the present location of Starksboro Village and South Hinesburg. The isolated bedrock knobs and ridges such as Mt. Philo, Monkton Ridge and Hogback Mountain, were islands emerging above the lake surface. Lake Vermont waters receded in stages as natural dams in southern Vermont and New York gave way (Stewart & MacClintock, 1969; Calkin, 1965; Cronin, 1977; Wagner, 1972).

Lake Vermont waters receded in stages. Initially, flow was directed to the south via Lake Albany and the Hudson River valley. Later flows reversed to the north as northward-retreating ice sheets opened up drainage to the Atlantic Ocean via the St. Lawrence Seaway. Subsequently, marine waters filled the Champlain valley from the St. Lawrence Seaway as the rate of rise in ocean water levels far exceeded the rate of rise, or isostatic rebound, of the land surface now relieved of its glacial burden. The maximum elevation of these brackish waters is believed to have extended into the present-day Lewis Creek watershed, perhaps not much farther east than the North Ferrisburg village (Stewart & MacClintock, 1969; Calkin, 1965; Connally and Calkin, 1972).

Champlain Sea waters had receded from the valley by approximately 10,000 years before present, as the rate of land rise began to outpace the rate of sea-level rise. River systems, including Lewis Creek, then continued moving and redepositing sediments left by the glaciers, and further eroding the landscape. As base levels dropped in the Champlain Valley, the Lewis Creek eroded downward through glacial-fluvial kame terrace deposits and Lake Vermont silt and clay lake deposits. Downward incision was apparently arrested at exposures of channel-spanning bedrock along the channel, including the falls at North Ferrisburg, and the short bedrock gorge along States Prison Hollow Road in Starksboro. These bedrock exposures serve as a local base level for upstream reaches of the Lewis Creek and its tributaries.

2.2.1 Bedrock Geology

In general, bedrock geology of the Lewis Creek watershed can be grouped into three main categories:

- the Cambrian crystalline and metamorphosed rocks (e.g., schistose greywacke, phyllites, schist, gneiss) of the north-south trending Green Mountains at the eastern portion of the watershed (DePietro, 1983; Stewart, 1973);
- the Cambrian quartzites forming the ridges within the Champlain Valley province such as Hogback Mountain, Monkton Ridge, and Mount Philo (Stewart, 1973; Doll, 1961); and
- the Cambrian and Ordovician limestones, dolostones and marbles of the Champlain Valley lowland (Stewart, 1973; Doll, 1961).

The underlying bedrock geology of the watershed influences the Lewis Creek river network in many ways. The phyllites, schists, gneiss, and quartzites are relatively resistant to chemical and physical weathering, while the limestones and other calcitic rocks of the Champlain Lowland are less resistant to erosion. In this way, the bedrock geology of the basin has controlled the regional topographic setting. The resistant crystalline rocks form the steeper slopes of the Green Mountains and the less-resistant limestones and dolostones form the broad Champlain Valley Lowland, punctuated by the emergence of moderately resistant quartzites that form the mid-valley ridgelines of Hogback Mountain, Monkton Ridge, Shellhouse Mountain, Mount Fuller, and Mount Philo.

The upper main stem of Lewis Creek flows in the dolomite valley between Hogback Ridge to the west and the Green Mountains to the east. Similarly, Pond Brook tributary flowing from Bristol north to join the main stem in Hinesburg drains a narrow dolomite valley between Monkton Ridge to the west and Hogback Ridge to the east. At the common border of Starksboro, Monkton and Hinesburg, the Lewis Creek main stem curves around the northern extent of these prominent mid-valley quartzite ridges, and flows westward, cross-cutting the regional thrust faults and north-south trending bands of less-resistant quartzite to make its way eventually to Lake Champlain.

Frequent bedrock exposures influence the channel position and profile of the Lewis Creek main stem at its tributaries. In the upper elevations of the watershed, channel gradients and valley confinement are largely controlled by the underlying bedrock topography and structure (joints, faults, strike and dip of bedding planes and schistosity) (Dipietro, 1983; Stewart, 1973). Along the Lewis Creek main stem and tributaries, occasional bedrock exposures along the valley walls control the lateral position of the river channel. Locations of channel-spanning bedrock offer vertical grade control, preventing possible downward erosion of the channel in response to regional or local stressors (at least over the 10 to 100 year time spans this study is focused on).

2.2.2 Surficial Geology

The nature of the surficial sediments and soils present in the Lewis Creek watershed today reflects the glacial and post-glacial lake history of the region. Upland slopes are dominated by shallow- to moderate-thickness glacial till deposits overlying bedrock, with alluvial sands, gravels and cobbles found locally in stream corridors. These till deposits are typically a dense mixture of sediment sizes from silts to cobbles and boulders; the till sediments are typically cohesive and of low permeability (Stewart, 1973; Stewart & MacClintock, 1969).

At the foot of the Green Mountains are kame terrace deposits of sands, gravels and cobbles which formerly developed at the marginal contact between the glaciers and the mountains. Some of these deposits were subsequently re-worked as beach gravels by wave action during the time of Lake Vermont. For example, these deposits form the terraces we recognize along the east side of Route 116 from

Starksboro Village to east of Hinesburg. Geologists theorize that glaciers retreating northward at one time blocked the Winooski River near Burlington, and the river detoured to Lake Vermont through the Hollow Brook of present-day Lewis Creek watershed (Wagner, 1972). Resulting delta deposits are found overlying kame terrace deposits at the Hinesburg Sand & Gravel quarry in south Hinesburg.

Out in the broader Champlain Valley, near South Hinesburg, north of Monkton Ridge and south of Prindles Corner, the landscape is dominated by clay and silt deposits generated during former occupation by Lake Vermont. These locations would have been in deeper sections of the lake, far from the eastern shorelines which were actively receiving runoff from the Green Mountains. Layer upon layer of fine-grained silts and clays were deposited in the quiet lake waters in alternating sequences resulting from annual cycles of spring and summer storm activity followed by winter quiet. Exposures of these varved clays, or rhythmites, are noted today in the Lewis Creek west of Route 116 and north of States Prison Hollow Road, and near the confluence of Hollow Brook. The clay and silt deposits of the Champlain Valley contain frequent large boulders. It is hypothesized that these boulders were contained within or on "rafts" of ice which broke off in large blocks from the edge of the receding ice sheet and floated out into Lake Vermont. As the ice blocks melted, their cargo was released, dropping out to settle in the clay and silt deposits at the bottom of the lake. The higher elevations such as Hogback Mountain and Monkton Ridge which remained isolated above lake-level, today are veneered with relatively thin to negligible deposits of glacial till (Stewart & MacClintock, 1969).

Methods and rates of erosion in the Lewis Creek channel are influenced by the types of sediments blanketing the land surface of the watershed. The kame terrace and beach deposits of eastern Hinesburg and Starksboro represent a transition zone for the Lewis Creek and the Hollow Brook as they pass from steeper bedrock slopes of the headwaters to the broader Champlain Valley. These sand and gravel sediments are loose (non-cohesive) and highly erodible. All but the largest boulders are able to be mobilized by at least the highest annual flows in the Lewis Creek. Over several thousands of years, sands and gravels have been transported downstream by the Lewis Creek, and now form a blanket of alluvial material in the river channel, up to several hundreds of feet downstream of the kame terrace deposits. Where channel downcutting is induced by natural or human stressors, sands and gravels in the channel bed are quite susceptible to erosion. These coarser-grained materials in the channel banks are also very susceptible to widening (if unchecked by stabilizing vegetation). Shear by flowing water at the toe of channel banks can create oversteepened slopes which then collapse under forces of gravity.

Once the Lewis Creek passes north of States Prison Hollow Road in Starksboro, surficial soils are dominated by the lacustrine boulder clay and silt deposits of former Lake Vermont. Clays and silts are more dense and more cohesive than the sand and gravel kame terrace deposits; they are therefore more resistant to downward erosion by the Lewis Creek. However, these cohesive soils are susceptible to lateral erosion in the form of meander migration through progressive stream bank collapse, particularly in reaches absent of woody and mixed vegetative buffers.

Soil survey mapping for the watershed (USDA, 2005; USDA, 2002) indicates soil type distributions consistent with mapped surficial geology. Figure 4 depicts the generalized soil types in the watershed, grouped by geologic parent material. Soil types in the upland, eastern extents of the watershed are dominated by soils derived from glacial till. The central and western portions of the watershed are dominated by silt loams. These silt loams have their origin in silty-clay deposits of marine and freshwater lake environments.

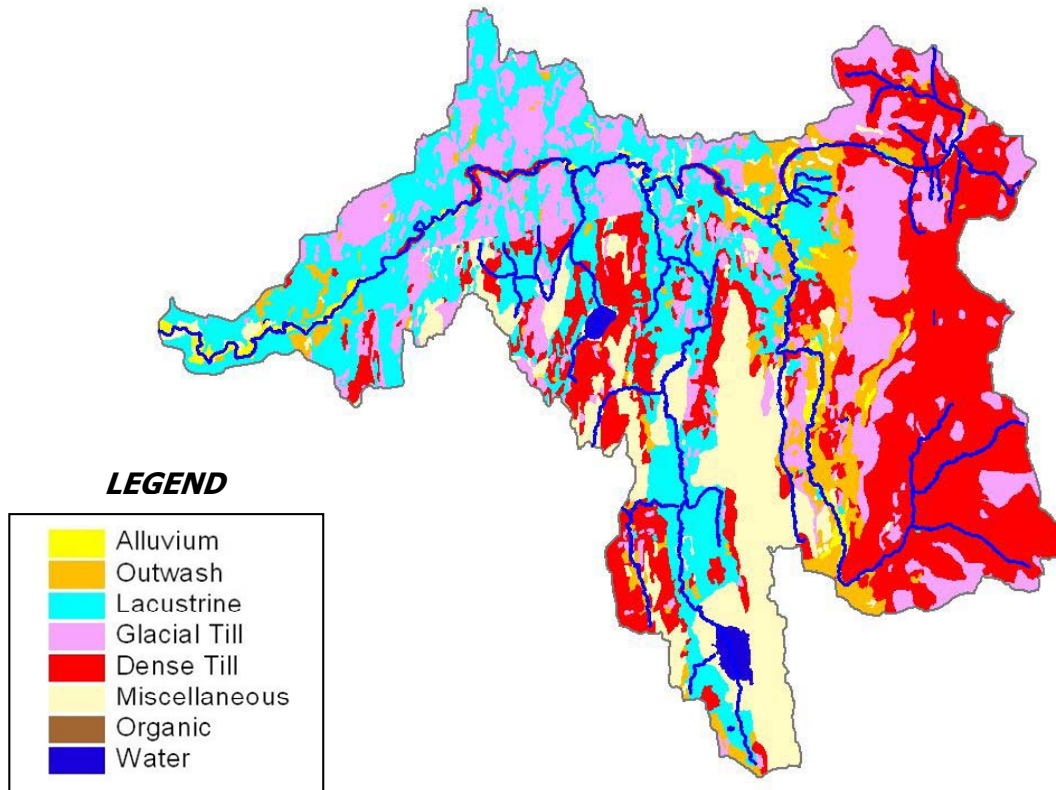


Figure 4. Generalized map of soil parent material in the Lewis Creek watershed. NRCS parent material classification of "lacustrine" does not differentiate between lake silts/clays of glacial versus marine origin.

2.3 Geomorphic Setting

Figure 5 illustrates the Lewis Creek main stem and select major tributaries in longitudinal profile. Generally, valley and river channel slopes become shallower as one progresses downstream toward Lake Champlain. Relief in the watershed varies from highest elevations of nearly 2,250 feet above mean sea level (ft amsl) in the headwaters on the western flanks of Hillsboro Mountain in eastern Starksboro, to approximately 95 ft amsl at the mouth in Lake Champlain.

The corridor reaches vary in elevation from 515 ft amsl (upstream end of reach M18) to 350 ft amsl (downstream end of reach M14). Reach M18 is a steep (6.9%) bedrock gorge located in a semi-confined, forested valley along the States Prison Hollow Road in Starksboro. The channel bed consists of a series of cascading bedrock waterfalls and alternating bedrock and boulder steps and pools. This channel form is classified by geomorphologists as a B-step pool stream type (Rosgen, 1996; Montgomery-Buffington, 1997). In contrast, the Lewis Creek channel downstream of this gorge is generally low-gradient (less than 0.5%), unconfined by the valley walls, and meandering through a very broad floodplain setting (C and E stream types after Rosgen, 1996). Near the downstream end of the corridor in reach M14, the channel is once again partly-confined by steep, bedrock-controlled valley walls, but maintains a shallow slope (0.3%); this stream type is classified as a Bc-channel.

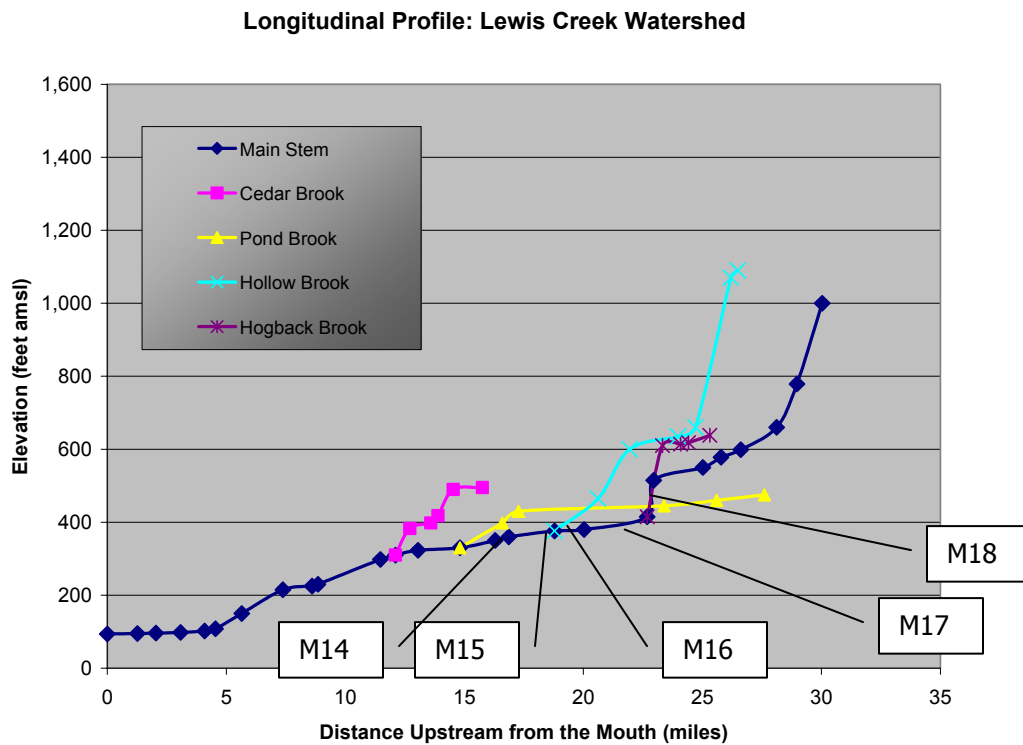


Figure 5. Longitudinal profile of Lewis Creek main stem and select Major Tributaries.

2.4 Hydrology

The United States Geological Survey (USGS) maintains records for three flow gages on the Lewis Creek (see Figure 6). Only one of the three (Station #04282780) is currently active, with real-time data available on the Internet (<http://waterdata.usgs.gov/vt/nwis/>).

- Station #04282780 is located near the Route 7 crossing (Reach M05), and measures flow from an approximate drainage area of 77.2 square miles (or 95% of the watershed). This station has daily flow records dating back to 1990, or approximately 17 years. The maximum peak flow recorded during this period was 3,380 cubic feet per second (cfs) on 28 February 2000; the corresponding daily mean flow for this date was 2,500 cfs.
- Station #04282750 was located on a small unnamed tributary (M16S1) near its confluence with the Lewis Creek main stem at the upstream end of reach M16. The upstream drainage area of this gage was 1.07 square miles. This former gage was in operation for a period of 13.5 years from 1964 through 1977. The maximum recorded peak flow during this time period was 95 cfs on 21 December 1973.
- Station #04282700 was located at the Route 116 crossing of an unnamed tributary to the Lewis Creek (T6, referred to as High Knob Brook) which joins the main stem near the upstream extent of reach M20. The upstream drainage area of this gage was 5.3 square miles. Daily mean and peak flows were recorded at this gage for approximately 11.5 years from 1963 through 1974.

Following a 25-year lapse, peak flows have been calculated for this station beginning in 1999 through the present. Like Station #04282750, the maximum recorded peak flow at Station #04282700 during the indicated time periods was 1,350 cfs on 21 December 1973; the corresponding daily mean flow for this date was 310 cfs.

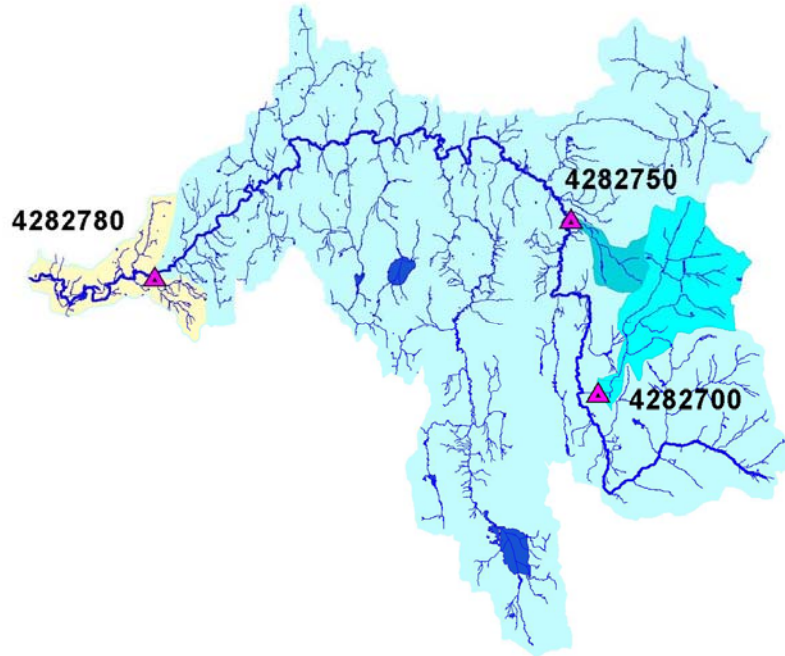


Figure 6. Location of USGS Gaging Stations in Lewis Creek Watershed.

From a relatively limited period of record existing for each gaging station, and relying on relationships established for other regional gaging stations with longer periods of record, the USGS (Olson, 2002) has estimated the approximate magnitude of peak flows for each gaging station (Table 1).

From the actual records for these three gages, it is evident that the Lewis Creek has not experienced a substantial flood event in the previous 15 years (see Figure 7). The maximum peak flow recorded at the Route 7 gage during this period was 3,380 cubic feet per second (cfs) on 28 February 2000; which corresponds to an approximate 10-year flood magnitude, or Q10 (Olson, 2002; see Table 1). Historic records (mid-1960s to mid-1970s) for the smaller tributary gages indicate a significant flood event on 21 December 1973 (a Q50 to Q500 magnitude event).

2.5 Flood History

Flood events, particularly higher magnitude flows, can serve as a stressor to the river network leading to localized or systemic channel adjustments. Available historic data and USGS flow data were reviewed to identify flood events of significance over the last century in the Lewis Creek watershed (Table 2). Limited historical review included review of State-wide flood publications. The 1927 flood was the highest flood on record in the State of Vermont.

Table 1. Estimated flood magnitudes for Lewis Creek watershed

USGS Stn #	4282780	4282750	4282700
USGS Description	Lewis Creek at North Ferrisburg	Lewis Creek Tributary No. 2 Near Rockville	Lewis Creek Tributary at Starksboro (High Knob Trib)
USGS Period of Record	1990 - 2005	1964 - 1978	1963-74, 1999-2000
Upstream Dr. Area, (USGS, 2005) (sq mi)	77.2	1.07	5.31
Upstream Dr. Area, (Olson, 2002) (sq mi)	77.4	1.23	5.34
Geomorphic Reach	M05	N/A	N/A

Storm Magnitude	Data Source	Discharge (cfs)		
Q _{1.5}	(VTDEC, 2001)	1,851	19	106
Q ₂	(Olson, 2002)	2,280	46	118
Q ₅		2,990	63	207
Q ₁₀		3,420	75	266
Q ₅₀		4,270	103	543
Q ₁₀₀		4,590	115	704
Q ₅₀₀		5,290	144	1,210

**Peak Discharges, Lewis Creek at North Ferrisburg, VT
USGS Stn #04282780, 77.2 square miles, Reach M05**

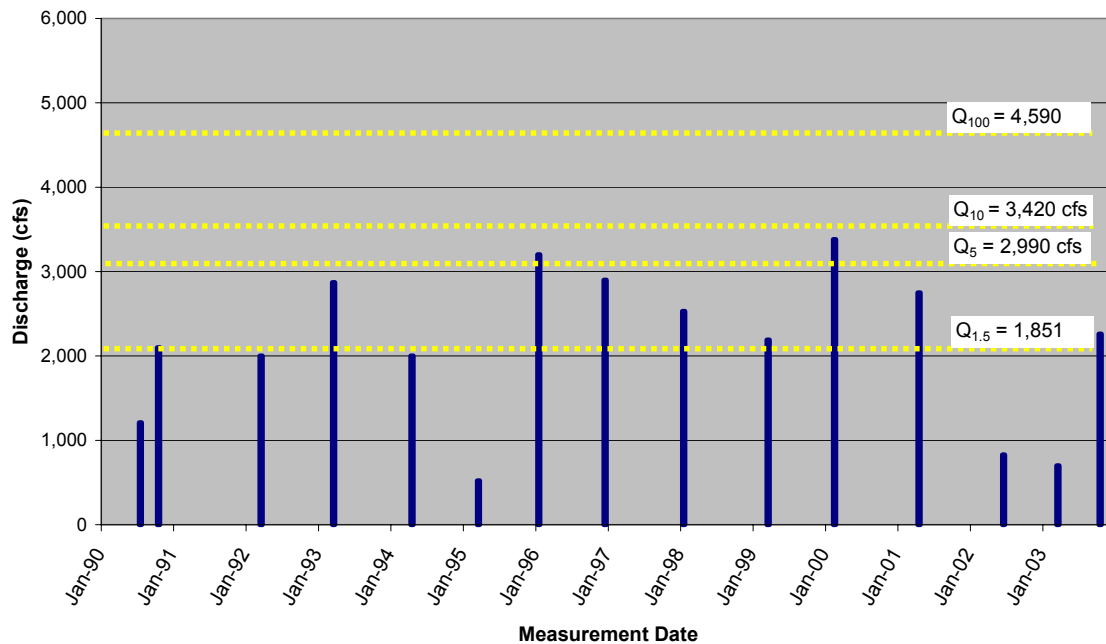


Figure 7. Recorded Peak Flows for Lewis Creek, Route 7 Gage Station #04282780 (compared to estimated flood peaks after Olson, 2002)

Table 2. Notable flood events in Lewis Creek watershed

Notable Flood Dates	Data Source
1913	USGS, 1990
1927	USGS, 1990
1936	USGS, 1990
1938	USGS, 1990
1973, Dec 21 *	USGS, 2007

* Note that the USGS gaging records for Lewis Creek tributaries indicate a Q50 to Q500 flood event peaking on 21 December 1973; this date is different from the 30 June – 1 July 1973 flood event which affected a majority of the State (VTDEC WQD, 1999).

2.6 Land Use

Land use within the Lewis Creek watershed is estimated as 57% forested, 26% agricultural fields, and 5% urbanized (developed, transportation, utilities), with the remaining 12% comprised of lakes, ponds, wetlands and brush (VCGI, 2003; Millette, 1997 – source imagery dated 1991 to 1993). Development centers currently include the village of Starksboro, Monkton Ridge, Cedar Lake, North Ferrisburg and the commercial / residential properties built up along Rt. 7 north of Ferrisburg village.

2.7 Water Quality

Summer-time water quality sampling (from 1992 to 2007) at nineteen (19) sample stations (8 regular and 11 occasional) along the main stem and tributaries of Lewis Creek has identified phosphorus and *E. coli* impacts in Lewis Creek, as well as sedimentation from unstable stream reaches and road / culvert maintenance practices (ACRWC, 2005; <http://207.136.225.66/acrcw/wqsitegraph>).

Four monitoring sites are located within, or just upstream of, corridor reaches M14 – M18:

- ◆ LCR 17.2 – located at the Starksboro Ball Fields off States Prison Hollow Road (reach M19) monitored since 1997;
- ◆ LCR 15.6 – located at the Kelly Farm off Route 116 (Lewis Creek segment M17A) – monitored since 2003;
- ◆ LCR 14.0 – located at the Tyler Bridge Road crossing of Lewis Creek (segment M15-B) – monitored since 1997; and
- ◆ LCT 4 – located at the Tyler Bridge Road crossing of Hollow Brook (reach T4.01) – monitored since 1997.

E. coli is consistently above state water quality standards at regularly monitored sampling stations located from river mile 3.7 (old Route 7 bridge in Ferrisburg) to river mile 19.5 (Parsonage Rd bridge in Starksboro). These sites have been sampled at least four times each Summer from 1992 to present. The State of Vermont has listed a 12.3-mile length of the Lewis Creek main stem, from the lower covered bridge (Quinlin) in Charlotte to the vicinity of Parsonage Road bridge in Starksboro (reach M19) as

impaired due to *E. coli* impacts (VTDEC WQD, 2006a). This impaired segment includes the entire length of the Lewis Creek M14-M18 corridor.

Total Phosphorus concentrations have consistently been above levels which would suggest nutrient enrichment in sampling sites from river mile 3.7 to 19.5 on the main stem (1997-2007). No in-stream Vermont water quality standard exists for Total Phosphorus, at present. However, elevated phosphorus levels can lead to algae production in the river and in Lake Champlain. The algae decomposition process consumes oxygen from the water, leading to reduced oxygen levels that may impair populations of fish and other aquatic organisms. In recent years, phosphorus has been linked to the production of toxic blue-green algae along the shores of Lake Champlain (LCBP, 2005).

Under a recent agreement between Vermont, New York, and Quebec, goals have been set for the reduction of phosphorus from tributaries entering the lake (LCBP, 2005). For Lewis Creek, a maximum phosphorus "load" has been established at 14 parts per billion. Phosphorus loading from the Lewis Creek to Lake Champlain for monitoring years 1990 to 2000 exceeded target levels (Medalie & Smeltzer, 2004).

In addition to agricultural and developed land use practices, eroding streambanks have been identified as a contributing nonpoint source of phosphorus in rivers and streams of Vermont (VTANR, 2001; DeWolfe *et al.*, 2004).

3.0 METHODS

The river corridor planning process in the towns of Hinesburg, Monkton, and Starksboro has included the following tasks: (1) departure and sensitivity analysis relying on existing geomorphic data; (2) individualized landowner outreach; (3) public meetings and attendance at municipal board meetings; and (4) identification of management strategies and restoration and conservation projects to support the river's return toward equilibrium.

Corridor planning tasks have been conducted and the outline and content of this corridor plan have been prepared following guidance recently issued by the VT Agency of Natural Resources - where feasible, based on the currency of the geomorphic data (which was collected to earlier versions of VTANR protocols, including versions issued in 2001, 2002, 2004, 2005 and 2006):

- *VTANR River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects* (11 July 2007 draft).

3.1 Analysis of Existing Geomorphic Data

Phase 1 and Phase 2 Stream Geomorphic Assessments have been carried out in the Lewis Creek watershed between 2001 and 2007 following protocols published by the VT Agency of Natural Resources. The objectives of these studies were to assess the geomorphic condition of the river network, to identify local and regional stressors impacting the channel and watershed, and to characterize the sensitivity of river reaches to future lateral and vertical adjustments. Assessments were also conducted to identify structures at risk from expected future channel migration. The reader is referred to summary reports for these previous studies for details of the methodology and results.

Results of the geomorphic assessment of the six corridor reaches – M14 through M18 - are briefly summarized in Tables 3a and 3b. Appendix A contains additional data from the Phase 2 geomorphic assessments, including annotated reach maps.

These existing data were reviewed during the corridor planning process to identify corridor management strategies that could support the river's return toward dynamic equilibrium, thereby reducing erosion hazards and improving water quality over the long term. The analysis included:

- ◆ Classifying corridor reaches into general management categories based on their geomorphic condition. This step involves evaluating (qualitatively) the sediment transport characteristics of the corridor reaches, to identify major sediment deposition and transport modifiers.
- ◆ Identifying sediment sources (e.g., tributaries, stormwater inputs, eroding banks) which may be impacting the sediment transport capacities in the watershed.
- ◆ Acknowledging natural constraints (e.g., bedrock) and human constraints (e.g., roads, buildings, bridges) along the river corridor that limit the river channels' ability to laterally and vertically adjust in response to changing water and sediment conditions.
- ◆ Locating areas of active lateral adjustment and wetland areas contiguous to the channel which may serve important sediment and nutrient attenuation functions in the watershed.

Table 3a. Phase 1 and 2 Stream Geomorphic Assessment Data, Lewis Creek Corridor Reaches, M18 – M14.

Reach / Seg	Phase 1 Data				Phase 2 Data							
	Reference Stream Type	Reference Valley Confinement	Channel Length (ft)	Channel Slope (%)	Ph 2 Valley Confinement	Bankfull Width (ft)	Bankfull Depth (ft)	Incision Ratio (RAF)	Incision Ratio (HEF) Note	Entrenchment Ratio	Width/Depth Ratio	Measured Stream Type
M18 --	B2a-S/P	SC	1,446	6.9	SC	50	4.5	1.00	N/A	2.2	12.8	B2a-S/P
M17 C	C4-R/P *	VB	2,005	0.8	BD	33.7	3.5	1.40	1.46 (1)	19.6	11.7	C4-R/P
M17 B	E4-R/P	VB	8,552	0.2	VB	33.7	6.9	1.00	N/A	14.8	6.8	E4-R/P
M17 A	E4-R/P	VB	3,446	0.1	VB	36.5	5.9	1.25	N/A	36.4	3.4	E4-R/P
M16 --	E4-R/P	VB	6,559	0.1	VB	56	6.2	1.16	N/A	8.9	20.0	C4-R/P
M15 B	C4-R/P	VB	3,989	0.2	VB	57.3	2.8	1.60	N/A	8.0	35.8	C4-R/P
M15 A	E4-R/P *	VB	6,162	0.1	VB	45	6.8	1.00	N/A	20	10.7	E4-R/P
M14 --	B3c-R/P	SC	3,003	0.3	SC	52	3.3	1.00	N/A	1.5	21.1	Bc3-R/P

Abbreviations: R/P = riffle-pool; S/P = step-pool
 VB = Very Broad; BD = Broad; NW = Narrow; SC = Semi-Confined; NC = Narrowly Confined
 RAF = Recently Abandoned Floodplain; HEF = Human-elevated Floodplain (as per 2007 VTANR guidance).
 N/A = Not Applicable.
 * Subreach (as per VTANR protocols, 2007).

Notes: (1) States Prison Hollow Extension gravel road encroaches along right bank, slightly reducing the floodplain width (and increasing valley confinement) and resulting in a human-elevated floodplain.
 Highlighted cell under "Measured Stream Type" indicates that a Stream Type Departure has occurred.

Table 3b. Phase 1 and 2 Stream Geomorphic Assessment Data, Lewis Creek Corridor Reaches, M18 – M14 (Continued).

Reach / Seg	Condition Score (RGA)	Active Adjustment Processes	Incision Historic or Active?	Sensitivity	Channel Evolution Model	Channel Evolution Stage
M18 --	0.78 Good	Bedrock is exposed in channel bed as a series of waterfalls, and also provides lateral grade controls. Minor aggradation is indicated by minor sedimentation in pools. Recent mass failures along the left-bank valley wall occurred associated with washout of the States Prison Hollow Road in 2006.	N/A	Very Low	D-stage	I
M17 C	0.61 Fair	Minor widening and planform adjustment in response to inferred historic channelization & incision. Bedrock grade controls in upstream reach (M18) would limit upstream migration of incision. Widening appears moderated by cohesive streambank sediments and tree buffer (left-bank). Location of marked slope reduction elevates risk of lateral adjustments, particularly in flood events - as evidenced by significant avulsion in 1938 flood.	Historic	Very High	F-stage	III
M17 B	0.65 Good	Moderate planform adjustment (meander extension & migration, neck cutoffs, flood chutes) and minor aggradation. Widening and planform adjustments locally enhanced by beaver activity and absence of tree buffers. Potential for active incision /widening adjacent to discrete sections of channelization and armoring may have been moderated by low overall gradient and cohesive soils, and/or offset by aggradation.	N/A	High	F-stage	IV
M17 A	0.68 Good	Minor to moderate planform adjustment (meander extension and migration), and minor aggradation. Minor degree of historic incision is apparent, possibly related to increased flows resulting from upwatershed channelization, loss of wetlands, and resultant reduced flow attenuation. Widening and planform adjustments locally exacerbated by beaver activity, direct pasturing of livestock, and removal of woody buffers associated with pasture uses. Potential for active incision possibly moderated by cohesive soils and exposed varved clays in the channel thalweg - also by low overall channel gradient.	Historic	High	F-stage	I
M16 --	0.60 Fair	Moderate planform adjustment and widening, especially in downstream half. Minor degree of historic incision apparent, possibly related to increased flows resulting from upwatershed channelization, loss of wetlands, and resultant reduced flow attenuation. Channelization in downstream reach may have also contributed. Widening and planform adjustments locally exacerbated by beaver activity, recent direct pasturing (livestock now excluded), and removal of woody buffers associated with pasture and cropping uses. Potential for active incision possibly moderated by cohesive soils and exposed varved clays in the channel thalweg.	Historic	Very High (STD)	F-stage	III

Table 3b. Phase 1 and 2 Stream Geomorphic Assessment Data, Lewis Creek Corridor Reaches, M18 – M14 (Continued).

Reach / Seg	Condition Score (RGA)	Active Adjustment Processes	Incision Historic or Active?	Sensitivity	Channel Evolution Model	Channel Evolution Stage
M15 B	0.54 Fair	Moderate planform adjustment (recent avulsion, flood chutes, meander extension) and moderate widening and aggradation in response to historic channelization, recent avulsion, and delivery of sediments from upstream erosion and tributary sources. Circa 1994-1995 avulsion downstream of the Tyler Bridge Rd bridge resulted in loss of 1000 feet of channel length, and created an abandoned meander that is hydrologically connected to the channel.	Historic	Very High	F-stage	IV
M15 A	0.61 Fair	Moderate planform adjustment (flood chutes, meander extension & translation, recent avulsion) and aggradation related to upstream and tributary sources of sediment, exacerbated in some locations by lack of tree buffers. Recent (post-1974, pre-1999) avulsion site near downstream end of the segment.	N/A	Very High	F-stage	IV
M14 --	0.83 Good	Bedrock is exposed in the channel bed and banks at discrete locations, and offers vertical and lateral grade control to the reach. Potential for channel adjustments further moderated by well-developed forested buffers and semi-confined valley setting. Reach in minor adjustment (localized aggradation, widening).	N/A	Moderate	D-stage	I

3.2 Individualized Landowner Outreach

Outreach was conducted to several riparian landowners along corridor reaches, M18 – M14.

August 2007 – A direct mailing was sent to approximately 27 riverside landowners, introducing the project, identifying the project participants, and inviting participation. A copy of the landowner letter is provided in Appendix B.

July 2007 – A press release was issued to the local newspapers (*Addison Independent*, *Starksboro Gazette*, *Hinesburg Record*) that introduced the project and invited comments from citizens and other interested parties. A copy of the press release is provided in Appendix B.

August 2007 – December 2007 – Lewis Creek Association Executive Director (Marty Illick) and Board Members (Stevie Spencer, Allison Wagner) and Kristen Underwood South Mountain Research & Consulting (Kristen Underwood) contacted or met with 8 landowners to discuss their riverside properties. Landowner interviews provided an opportunity to discuss the goals of this project and to receive feedback from landowners about river corridor constraints, land uses, concerns, and management alternatives acceptable to the landowners. Some landowner meetings were conducted in person; some were by telephone. Summaries of landowner contacts are provided in Appendix B.

3.3 Public Outreach / Education

Public events were held and meetings were attended to provide outreach and education to the community relevant to this corridor planning process.

29 November 2007: Public Forum hosted by LCA: Impervious Surfaces and Stormwater Planning: *approximately 15 in attendance including Starksboro and Monkton CC members, Hinesburg Zoning Administrator; Ethan Swift (VTDEC) – Presenters: Evan Fitzgerald, Fitzgerald Associates; Kristen Underwood, SMRC.*

4 December 2007: Monkton Conservation Commission: *3 members attending, 1 Selectboard member, Marty Illick (LCA); Kristen Underwood (SMRC).*

28 January 2008: Hinesburg Conservation Commission. *3 members attending; Marty Illick (LCA); Amy Diller (ACRPC); Kristen Underwood (SMRC).*

11 February 2008: Starksboro Conservation Commission. *3 members attending; Marty Illick and Alison Wagner (LCA); Amy Diller (ACRPC); Kristen Underwood (SMRC).*

3.4 Identification of Management Strategies / Restoration and Conservation Projects

Identification of various site-level and watershed-level corridor management strategies followed from the consideration of the geomorphic condition of river corridor reaches and from the feedback received during landowner outreach meetings and public meetings. Existing management plans for two corridor parcels currently conserved were also reviewed for compatibility with corridor management goals and strategies (Appendix C). The site-level and watershed-level strategies are presented in Section 6.0. Select strategies and projects were prioritized, and short-term and long-term implementation plans are outlined in Section 7.0.

4.0 RESULTS

Phase 1 and Phase 2 stream geomorphic assessment data for the Lewis Creek have been reviewed to gain a better understanding of how human-caused disturbances at the watershed and reach level may have altered or constrained the river's ability to convey the water and sediment inputs to the watershed.

As stated in VTANR (2007) guidance: "Within a reach, the principles of stream equilibrium dictate that stream power and sediment will tend to distribute evenly over time (Leopold, 1994). Changes or modifications to watershed inputs and hydraulic geometry create disequilibrium and lead to an uneven distribution of power and sediment. Large channel adjustments observed as dramatic erosion and deposition may be the result of this uneven distribution and may continue until [quasi-]equilibrium is achieved."

The departure analysis and sensitivity analysis presented below characterize the current condition of the corridor reaches, and their degree of departure from reference, or a pre-disturbed state. Consideration of the current state of channel evolution and reach sensitivity will help to ensure that river management strategies and restoration or conservation projects identified will be successful over the long term.

4.1 Departure Analysis

The departure analysis reviews watershed-level and reach-level disturbances to the channel and characterizes the potential nature and extent of these disturbances as stressors to the overall equilibrium of the river network. Changes to the hydrology and/or sediment load are important as they may significantly affect the hydraulic geometry and fluvial processes of the river and lead to an imbalance of the river network. A channel in dis-equilibrium may undergo substantial lateral and vertical adjustments that may be "at odds" with human infrastructure or land uses in the river corridor. Watershed-scale hydrologic and sediment regime stressors are addressed in Section 4.1.1. Changes in sediment loading characteristics that influence sediment regime at both the watershed level and reach level are addressed in Section 4.1.2. Direct disturbances of the channel and/or surrounding floodplain are addressed as possible modifiers of the channel slope, channel depth, and channel and riparian boundary conditions (Sections 4.1.3 and 4.1.4). While these factors are addressed in separate sections below, in reality they are inextricably linked in the overall cause and effect cycles and fluvial processes which together govern the form and function of the river network.

As defined in VTANR guidance (VTANR, 2007), the hydrologic regime of the river system refers to the "input and manipulation of water at the watershed scale" that may modify the timing, volume, duration and periodicity of flows in the river network. In turn, these changes to the hydrologic regime may have the potential to cause adjustments in the channel dimensions, slope, or planform – and influence the sediment transport regime. The sediment regime is defined in VTANR guidance as "the quantity, size, transport, sorting, and distribution of sediments".

4.1.1 Watershed Scale Hydrologic and Sediment Regime Stressors

Data are not sufficient to know with certainty whether (and to what extent and in what locations) a given change in the water or sediment inputs to a river corridor will cause the channel to incise or aggrade, widen or shift its planform. However, potential influences on the hydrology of the Lewis Creek watershed can be identified in a qualitative sense as a possible contributor(s) to channel dis-equilibrium. Watershed-level hydrologic and sediment regime stressors are identified through a review of existing Phase 1 and Phase 2 stream geomorphic data and include deforestation, stormwater inputs, dams, flow regulations, land use (degree of urbanization), ditching, and wetland loss. Watershed stressors are summarized in Table 4 and described further in the sections below.

Deforestation

Widespread deforestation of Vermont's landscape occurred during the mid- to late-1880s (Thompson & Sorensen, 2000). Deforestation is inferred to have caused increased water and sediment loads to be mobilized from the Lewis Creek watershed. Rainfall, which would previously have been intercepted by tree leaves and branches, and which would have been taken up by tree roots and evapo-transpired, instead ran off the land surface. Infiltrative capacities of the soils would have been reduced by compaction of the soils during harvesting. And these increased volumes of stormwater runoff would have had increased energies for entrainment of soils and sediments from the land surface, delivering increased sediment loads to the river network.

By the late 1890s the lumber industry in Burlington was declining (Amrhein, 1958), and populations in surrounding lumber towns began to decline. Farms, mills and factories were abandoned, and previously cleared farmlands and areas clear-cut of their lumber began to re-vegetate. As the Lewis Creek watershed began to reforest beginning in the early to mid-1900s, the water and sediment balance would have again shifted (independent of global climate cycles) back to lesser volumes of runoff and reduced sediment loading.

Floods

Floods are natural events which influence the sediment and hydrologic regimes of river networks. Increased flows can lead to channel widening and incision, where the increased scour energy exceeds thresholds for erosion in the streambank and bed materials. In turn, flood-event streambank and bed erosion mobilizes sediments and can lead to downstream aggradation and lateral adjustment. Large-magnitude flood events occurring decades in the past can still be influencing the condition and adjustment processes of river channels today.

Lewis Creek watershed appears to have been spared the impacts of major flood events of the 1990s and 1970s that impacted neighboring watersheds. Available historic resources indicate that the watershed was affected by the large events of 1927 and 1938 (see Section 2.5). Anecdotal accounts and pictures in a Starksboro history book indicate that a significant avulsion occurred in corridor reaches M18 and M17 during the 1938 flood (Jennings, 2002; Hanson, 1998). The Lewis Creek channel jumped its banks at the downstream end of reach M18 and cut across the broad meander comprising segment M17-C (Figure 8). The front porch of the upstream-most house on the right bank was washed away, and several other homes in this area were inundated (Jennings, 2002; Paskiewicz, 2007). Reportedly, two historic bridges over Lewis Creek were washed out (Jennings, 2002). At the time, the States Prison Hollow Road followed the alignment of what is now named States Prison Hollow Extension. Straightening with windrowing is inferred associated with this post-flood response, based on a picture recorded in *Bertha's book: a view of Starksboro's history* (Hanson, 1998). Boulder/cobble berms are present along both banks near the transition between reach M18 and M17.

Table 4. River Stressor Identification Table (Watershed Level)

Reach / Segment	Stressor Type	Watershed Input Stressors	
		Hydrologic Regime	Sediment Regime
Lewis Creek main stem: All corridor reaches: M18 through M14	Floods	Events (such as the floods of 1938, 1936, 1927, and 1913) imparted event-based increase in hydrologic loading to the watershed (see Section 2.5).	Increased sediment loading from active channel adjustments in upstream reaches, would be expected as a result of major flood events, such as the 1938, 1936, 1927 and 1913 floods (see Section 2.5).
	Deforestation	Increased hydrologic loading due to deforestation in mid-to late 1800s; subsequent decreased hydrologic loading as slopes reforested through the 1900s.	Increased sediment loading due to deforestation in mid-to late 1800s; subsequent decreased sediment loading as slopes reforested through the 1900s.
	Urbanization	Insignificant increased hydrologic loading inferred due to development and increased road densities of reach subwatersheds and upstream drainage areas in recent decades. Upstream watershed development percentages (3.4 to 4.4%) are less than the threshold of concern (5%) noted in VTANR guidance.	Insignificant increased sediment loading inferred due to development and increased road densities of reach subwatersheds and upstream drainage areas in recent decades. Upstream watershed development percentages (3.4 to 4.4%) are less than the threshold of concern (5%) noted in VTANR guidance.
	Stormwater Inputs	Minor increased hydrologic loading inferred due to road ditch, field ditch, and engineered stormwater inputs. Drainage area of corridor reaches (18 to 38 square miles) exceeds the VTANR indicated drainage area (0 - 15 sq mi) likely to be influenced by stormwater inputs.	Minor increased sediment loading inferred due to road ditch, field ditch, and engineered stormwater inputs. Drainage area of corridor reaches (18 to 38 square miles) exceeds the VTANR indicated drainage area (0 - 15 sq mi) likely to be influenced by stormwater inputs.
	Dams / Impoundments	No current dams on the Lewis Creek in reaches M18 through M14. Closest downstream dam is at Scott Pond (reach M09) approximately 7.5 river miles downstream. Bedrock exposures in M14 and M10 are expected to isolate the corridor reaches from potential impoundment effects of Scott Pond Dam. Late 1800s: historic dam depicted at the head of the bedrock gorge in reach M18 supporting a grist mill and saw mill. Unknown construction specifications, impound height, or duration of dam. Small impoundment depicted on Beers Atlas of 1871 suggests that this dam would have had no significant influence on flow characteristics of the Lewis Creek - beyond that which would be naturally imparted by the bedrock grade control and confined valley setting of the gorge.	No current dams on the Lewis Creek in reaches M18 through M14. Closest downstream dam is at Scott Pond (reach M09) approximately 7.5 river miles downstream. Bedrock exposures in M14 and M10 are expected to isolate the corridor reaches from potential impoundment effects of Scott Pond Dam. Late 1800s: historic dam depicted at the head of the bedrock gorge in reach M18 supporting a grist mill and saw mill. Unknown construction specifications, impound height, or duration of dam. Small impoundment depicted on Beers Atlas of 1871 suggests that this dam would have had no significant influence on sediment transport continuity in the Lewis Creek - beyond that which would be naturally imparted by the bedrock grade control and confined valley setting of the gorge.
	Diversions / Water Withdrawals	Not Applicable	Not Applicable
	Loss of Wetlands	Possible increase in hydrologic loading to the corridor reaches as a result of conversion of wetlands (hydric soils) to agricultural uses through tributary channelization and ditching.	Possible increase in sediment loading to the corridor reaches as a result of conversion of wetlands (hydric soils) to agricultural uses through tributary channelization and ditching.

Table 4. River Stressor Identification Table (Watershed Level) - Continued

Reach / Segment	Stressor Type	Watershed Input Stressors	
		Hydrologic Regime	Sediment Regime
Lewis Creek main stem: All corridor reaches: M18 through M14	Crop Lands	Possible increase in hydrologic loading to the corridor reaches as a result of moderate percentage of crop land use (implying possible ditching, tile networks) in the upstream watershed. Potential significance tempered by the size of the Lewis Creek at this location in the watershed (upstream drainage area of the corridor reaches ranges from 18 to 38 square miles).	Possible increase in sediment loading to the corridor reaches as a result of moderate percentage of crop land use (implying exposed soils and erosion) in the upstream watershed. Potential significance moderated by the size of the Lewis Creek watershed at this location. Also, % crop lands does not directly correlate to erosion; hydrologic connection of crop lands within the watershed to the Lewis Creek has not been established; does not take into account possible crop management practices to reduce erosion.
	Upstream Erosion & Deposition		Possible increase in sediment loading to the corridor reaches as a result of low to high percentage of streambank erosion, few mass failure sites, and tributary deltas in select corridor reaches and upstream reaches.

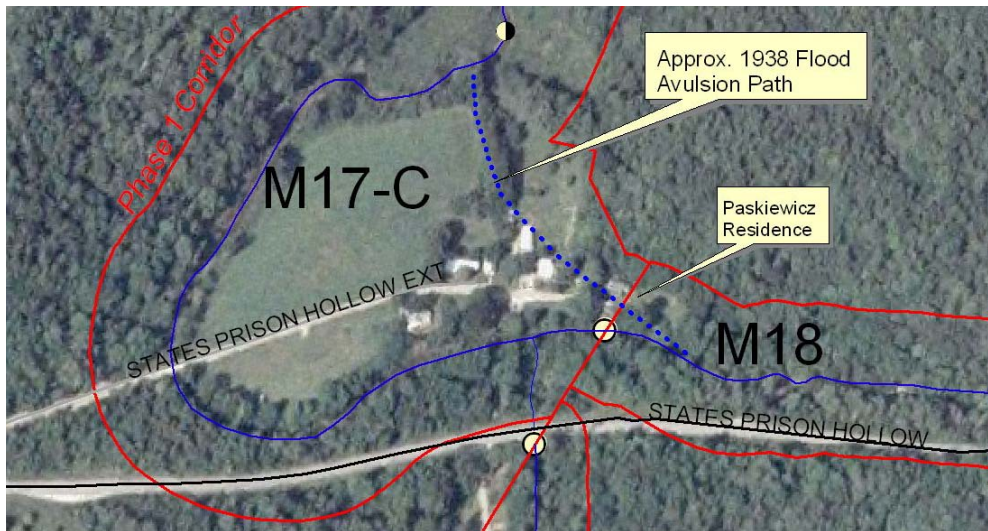


Figure 8. Avulsion site on reaches M18 and M17 (Segment C) in 1938 flood.

Urbanization

Regionally, the balance of water and sediment loads conveyed within a watershed is altered by the density of settlements on the landscape and its effect on the percent of land area impervious to rainfall. Impermeable (or partially impermeable) surface types associated with development can include roof-tops, pavement, roads, and dense gravel-pack roads or driveways. Percent imperviousness refers to the proportion of the land surface converted to impermeable or reduced-permeability surfaces. In general, development results in a reduction in total land area remaining pervious to rainfall. Rainfall and snowmelt waters quickly run off the land surface to the nearest swale or stream; they are not able to infiltrate through the surface soil layers and flow diffusely through the subsurface to the river network. Instead, stormwaters are delivered in higher magnitudes to our stream networks and over shorter durations, leading to a prevalence of “flashy” runoff conditions. Stormwaters diverted overland in this way have high velocities and therefore an increased capability to erode soils and debris from the land surface. Urbanized land uses in the watershed draining to the river can be a source of increased runoff that may serve as a stressor to the channel.

Since the late 1900’s, populations of the upper watershed towns (Starksboro, Hinesburg) have begun to rise. Recent development trends include clearing home lots in the forested uplands or converting previously agricultural land to residential use. These development patterns can lead to increased runoff caused by increased impervious surfaces (i.e., more rooftops, driveways, lawn spaces occupying previously forested or agricultural surfaces). Upland development can also bring more localized stressors to the river channel including: (1) additional bridge and culvert crossings which may be undersized with respect to the bankfull widths and (2) floodplain encroachment by roads, driveways, and crossing structures which reduce the floodplain area available to the river during flood stage. Such floodplain access is a critical need of the river channel in order to dissipate energies associated with flood stage flows – serving as a kind of pressure release valve for the river.

VTANR guidance suggests evaluating the Land Cover / Land Use data developed in the Phase 1 Stream Geomorphic Assessment (Step 4.1) to identify the potential for changes to the hydrologic regime from urbanization. Caution should be applied in using these data, due to: (1) the fact that % development

does not necessarily equate to % imperviousness (particularly in rural watersheds such as Lewis Creek); (2) the fact that developed (impervious) surfaces are hydrologically connected to the river to varying degrees; and (3) scale, minimum mapping units, age, and accuracy of the land cover / land use data sets utilized.

The upstream watersheds draining to each of the corridor reaches, M14 through M18, have urbanized land percentages ranging from approximately 3.4 to 4.4% (Phase 1 data; see Table 5). This range of values is below the percentage (5%) suggested as a threshold of concern in VTANR guidance (2007).

Table 5. Urbanization in Corridor Reaches

Reach / Segment	% urbanized land use in the upstream watershed draining to the reach*	Stressor Categorization (VTANR, 2007)
M18	4.0	Not Significant
M17	3.6	Not Significant
M16	3.4	Not Significant
M15	4.3	Not Significant
M14	4.4	Not Significant

* *Sum of Commercial, Industrial, and Residential land cover / land use categories.*

It is important to note that percent urbanized estimates in the Phase 1 database for Lewis Creek watershed rely on the following data set:

- *Landcover / Landuse for Vermont and Lake Champlain Basin (LandLandcov_LCLU, edition 2003). Source dates of 1991 to 1993. Further details of this land cover / land use data set are available at: http://www.vcqi.org/metadata/LandLandcov_LCLU.htm.*

Some development has occurred in these corridor watersheds since 1993, and percent urbanized values may have approached the 5% threshold in the meantime. Moreover, present zoning in each of the corridor towns (Starksboro, Monkton, Hinesburg) permits development densities that may result in future % urbanized cover above thresholds for concern. To the extent that stormwater runoff is not controlled or managed through treatments prescribed by State or local regulations, future development may increase to densities that present a significant impact to Lewis Creek. Recent Vermont-based studies linking % imperviousness to geomorphic and biologic condition of streams suggests that low-order streams (headwaters tributaries) may experience impacts at thresholds lower than 5% impervious cover (Fitzgerald, 2007).

Stormwater inputs

The previous section indirectly addressed the potential for stormwater runoff, through review of urbanized land cover at the watershed scale. This section more directly evaluates stormwater inputs to the channel, including such features as road ditch outlets, road culvert outlets (connected to road ditches), agricultural ditch or tile outlets, designed stormwater system outlets, and other outlets such as building foundation drains. While the flow of an individual stormwater outlet may be quite small, cumulatively stormwater inputs can have a measurable effect on a receiving channel, depending on the magnitude of the cumulative stormwater input versus the flow of the receiving water. The concentration of flows from stormwater runoff can also lead to increased power to erode sediments in the stormwater channel, thereby leading to increased sediment mobilization to the river and a potential impact on the sediment regime of the river.

Table 6 notes the stormwater inputs identified in the Lewis Creek corridor reaches. Because the upstream drainage area of these reaches is quite large (ranging from 18 to 38 square miles), the potential influence of these stormwater inputs on the hydrologic and sediment regimes of the river is considered negligible. VTANR guidance suggests that stormwater inputs are significant only for drainage areas less than 15 square miles. Also, it is important to note that the two reaches in Table 6 for which several stormwater inputs were noted, have significant exposures of bedrock in the channel margins, which would be expected to offer lateral and vertical stability to the channel and moderate potential impacts of increased stormwater flows.

Table 6. Stormwater Inputs in the Corridor Reaches

Reach/ Seg	No. of Features						Total #
	Field Ditch	Road Ditch	Tile Drain	Urb Stormwr Pipe	Overland Flow	Other	
M18	0	5	0	0	0	0	5
M17-C	0	0	0	0	0	0	0
M17-B	0	0	0	0	0	0	0
M17-A	0	0	0	0	0	0	0
M16	0	0	0	0	0	0	0
M15-B	1	0	0	0	0	0	1
M15-A	0	0	0	0	0	0	0
M14	0	2	0	0	1	1	4

Dams

Dams disrupt the flow dynamics (and sediment transport continuity) of rivers to varying degrees and extents, depending on their size, height, topographic setting, and operational status, and depending on the hydrologic, geomorphic and geologic characteristics of the river being impounded (Williams and Wolman, 1984; Kondolf, 1997). Sediments are trapped in the impoundment upstream of a dam; bed load and a portion of the suspended sediment load settle out in the still water environment of the reservoir. Water leaving the impoundment is essentially devoid of its sediment (bed) load, and possesses enhanced energy to erode the stream bed and banks. Depending on the nature of sediments in the channel margins and underlying surficial deposits, and vegetative boundary conditions, this increased erosional potential can lead to channel incision and/or widening downstream of the dam as the river seeks to restore its sediment load – a condition often termed “hungry water” (Kondolf, 1997). If scour is significant, the channel can incise below the surrounding floodplain. On the other hand, if flows are regulated so as to significantly reduce flood peaks and magnitudes, channel aggradation and/or narrowing may result downstream of the dam. Sediments may accumulate in the downstream channel, where they are mobilized from tributaries, if flushing effects of bankfull flows and low-magnitude flood events have been eliminated or reduced as a result of flow regulation (Kondolf, 1997).

There are presently no dams on the Lewis Creek in the corridor reaches. One dam exists just below Scott Pond in Charlotte in reach M09, approximately 7.5 river miles downstream of the corridor reach M14. It is expected that channel-spanning bedrock exposures in reaches M14, M11, and M10 serve to

isolate the corridor reaches from Scott Pond Dam, and impoundments at this current dam are not expected to significantly influence water and sediment loads within reaches M14 through M18.

Historically, a grist mill, saw mill and black smith shop were located in reach M18 in the vicinity of a present-day Bed & Breakfast. On the 1871 Beers Atlas, a small impoundment (mill pond) appears to be depicted just downstream of the States Prison Hollow Road crossing; this location would correspond with the upstream end of the bedrock gorge. Further details of the construction specifications or length of operation of this historic dam were not available.

While this structure no longer impounds the Lewis Creek, knowledge of its historic presence aids in characterizing the overall sensitivity of the river reaches and their degree of departure from reference condition, where applicable. In some cases, the present condition and adjustment processes in a river channel can still be influenced in the present day by the disruption of fluvial and sediment transport processes imparted by a historic dam.

Just as the presence of a dam influences the natural river balance, the subsequent removal of a dam can have an impact on future adjustment of the river channel. As the river readjusts to the lowered base level, incision and widening might be expected to migrate upstream from the former dam site. Sediments mobilized from the incising areas might contribute to aggradation, widening or planform adjustments downstream of the former dam site.

The historic dam at the Bed & Breakfast site appears to have created a very small impounded area (based on the Beers Atlas depiction), and therefore the height of the dam is inferred to have been minor in nature - typical of construction methods of the times for operation of grist mills and saw mills, and constituting a vertical profile much less than the vertical drop in elevation of the bedrock gorge (estimated at 100 feet over a channel length of 1,446 feet). It is likely that such a low-profile dam would have caused a minor degree of increased upstream sedimentation, over and above the sedimentation naturally induced by the bedrock falls at this location. Similarly, hungry water effects downstream of such an impoundment would not be expected to be significantly greater than that which would be generated by the natural impoundment of sediments above the fixed elevation of the bedrock falls.

Diversions, Water Withdrawals (flow regulation)

Changes in the flow characteristics of a river imparted by diversion structures or substantial water withdrawal sites can influence the magnitude of flows and interrupt the sediment transport functions of rivers, potentially resulting in areas of exacerbated erosion or system-wide instability in the river. No historic diversion structures were revealed from a review of historic maps and orthophotos. No significant withdrawal or diversion sites were located in the corridor reaches. A couple of very small pipe withdrawals for small-scale irrigation were observed (e.g., left bank of M15-B for tree nursery; left bank of M14 to adjacent field). However, these withdrawals are very small compared to the total flow in Lewis Creek, and were therefore deemed "Not Significant".

Ditching

In agricultural areas of the river corridor and surrounding region, ditches are often installed and maintained as a means of improving field drainage. While these measures may improve overall drainage in the fields, they result in more rapid delivery of flows to receiving tributaries and rivers. Based on 2001-2006 field assessments, ditching of the floodplain within and near the corridor surrounding reaches M18 through M14 was not prevalent. (Note: Geographic indexing of ditch and/or tile inputs was not a requirement of the protocols in place at the time of assessment for some of these corridor reaches). Some ditching was noted, however, associated with potential loss of wetlands in land areas draining to tributaries of reaches M17 and M16, as discussed in the next section.

In rural watersheds, particularly on upland slopes (such as those draining the Green Mountain province in eastern Starksboro and Hinesburg), road and driveway ditches are a significant contributor of stormwater and sediment to receiving tributaries and rivers. A study of imperviousness in the Lewis Creek watershed determined that roads and driveways accounted for the vast majority of impervious surface percent in these rural areas (SMRC, 2005). Often road ditch networks terminate at stream crossings without provision for sediment and stormwater retention, detention or treatment. Where apparent, these stormwater inputs are indexed along the main stem in corridor reaches M14 through M18 (as presented in the previous section). However, there are many more tributary road crossings in the headwaters of the Lewis Creek that may be accepting road ditch runoff.

While a full inventory of these tributary road crossings was beyond the scope of Phase 2 assessments to date, the potential impact of road ditch networks on the watersheds draining to the corridor reaches can be qualitatively evaluated by summing the total length of roads in each sub-watershed draining to the corridor reaches and calculating road density on a per-reach-subwatershed and per-upstream-watershed basis (Tables 7 and 8). The subwatersheds draining to reaches M14 and M15 appear to have the highest road network densities. In M14, the high density is related in part to the very small size of the reach subwatershed. The reach subwatershed draining to M15 is quite large and encompasses the Hollow Brook tributary watershed, where road networks are fairly extensive, providing access to upland residential development. A literature search is underway to characterize the degree of road density which will be considered a stressor to river channels under Vermont guidance (VTANR, 2007).

Table 7. Reach Subwatershed Road Density

Reach	Sub-watershed Area (sq mi)	Total Road Lengths (miles)	Reach Subwatershed Road Density (miles/sq mile)
M18 *	2.46	3,553	1,443
M17	2.26	18,440	8,151
M16 **	3.49	11,929	3,420
M15 ***	11.33	115,487	10,195
M14	0.28	4,223	15,014

* including Hogback Brook (T5)

** including unnamed right-bank tributary (M16S1)

*** including Hollow Brook (T4)

Table 8. Upstream Watershed Road Density

Reach/ Seg	Upstream Watershed Area (sq mi)	Total Road Lengths (miles)	Upstream Watershed Road Density (miles/sq mile)
M18 *	18.42	171,175	9,293
M17	23.10	189,616	8,208
M16 **	26.59	201,545	7,580
M15 ***	37.92	317,032	8,361
M14	38.20	321,255	8,410

* including Hogback Brook (T5)

** including unnamed right-bank tributary (M16S1)

*** including Hollow Brook (T4)

Loss of Wetlands

Channel-contiguous wetlands offer important flood attenuation functions in the river corridor, slowing the velocity of flows and thereby reducing erosion of the stream bed and banks. Over the last 200 or more years, wetland or hydric soils along the floodplains of Vermont rivers have commonly been converted to agricultural fields. Often this is accomplished by channelization of small tributaries or through installation of a network of constructed ditches or underground tiles. Conversion of channel-contiguous wetlands to agricultural uses can increase runoff volumes and velocities in the receiving river channel. In turn, those increased flows can exceed erosion thresholds in the channel bed and banks. This factor, along with periodic ditch maintenance, can result in increased sediment mobilization to the river.

The degree of wetland loss or conversion in a watershed is difficult to estimate with accuracy. However, a qualitative evaluation can be performed by reviewing the presence of hydric soils across a watershed, and comparing their aerial extent to mapped wetlands. When this review was performed for the portion of the Lewis Creek watershed draining directly to corridor reaches M18 through M14, significant areas of possible wetland loss were apparent (Table 9, Figure 9).

Table 9. Comparison of Areal Extent Hydric Soils to Mapped Wetlands in watershed draining directly to corridor reaches.

	Area (sq mi)	Direct Watershed Area (sq mi)	Percent Watershed Area (%)
Hydric Soils	2.73	19.8	13.79%
Vermont Significant Wetlands Inventory	0.73	19.8	3.69%
National Wetlands Inventory	0.79	19.8	3.97%

While hydric soils comprise approximately 13.8% of the 19.8 square-mile area draining directly to reaches M14 through M18, mapped wetlands cover approximately 4% of this area (depending on whether Vermont Significant Wetlands Inventory [VSWI] or the National Wetlands Inventory [NWI] data are consulted, mapped wetlands range from approximately 3.7 to 4.0%).

This comparison does not directly or accurately reveal the area of wetlands drained or otherwise converted to agricultural or urbanized use, since VSWI and NWI coverages do not include smaller Class III wetlands which are present in the watershed. As with any spatial data sets, there are also issues of mapping methods, mapping resolution, scale, accuracy, and currency, that would render the two data sets not directly comparable. Nevertheless, this comparison serves as a coarse measure of potential wetland loss in the portion of the Lewis Creek watershed draining to the corridor reaches.

Natural flood attenuation functions of wetlands may have been compromised to significant degrees in these reach subwatersheds as a result of tributary channelization and ditching and wetland loss. Water and sediment loading to the Lewis Creek corridor reaches may have been increased as a consequence.

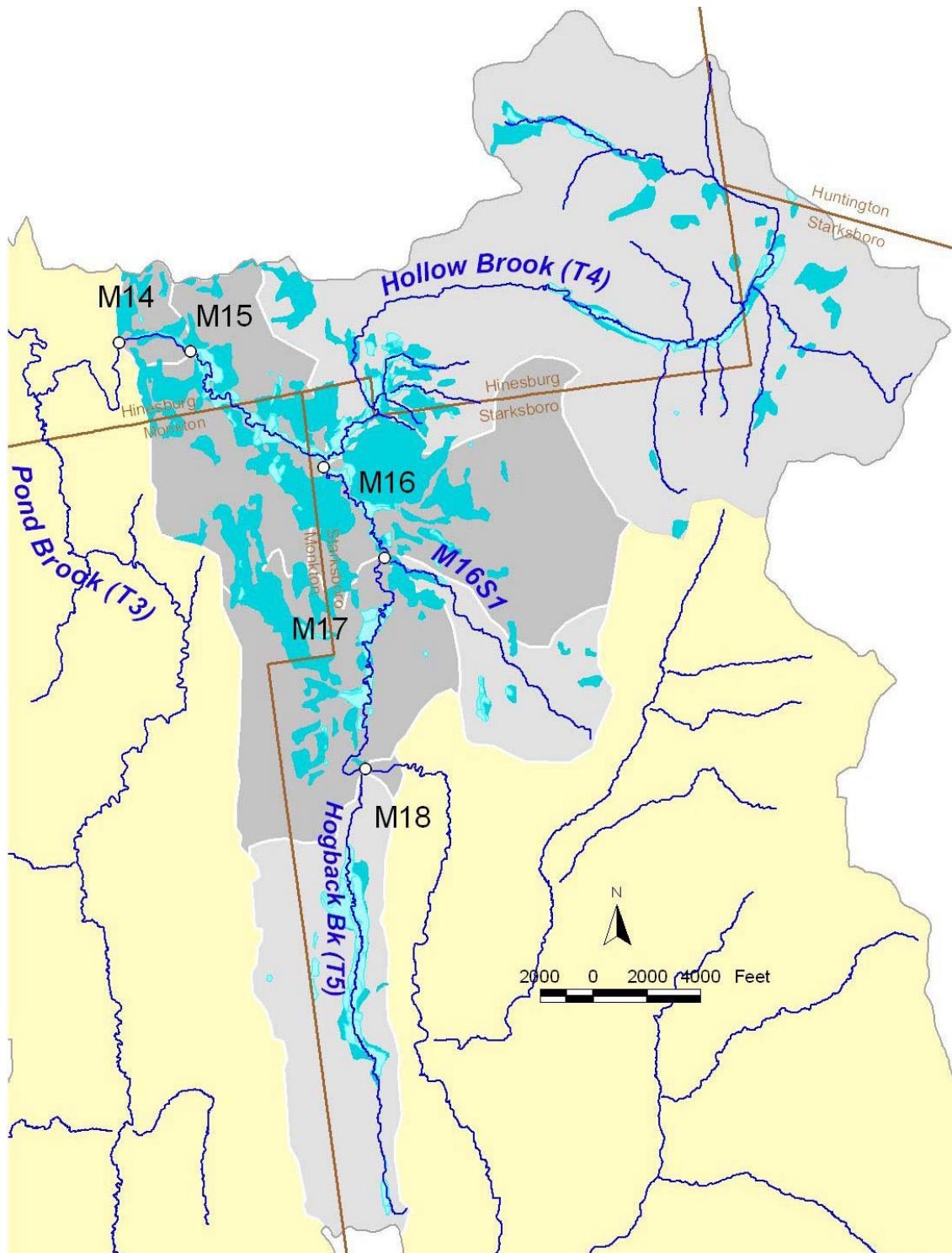


Figure 9. Aerial extent of hydric soils (dark teal) versus NWI wetlands (lighter teal) compared in portion of Lewis Creek watershed draining directly to corridor reaches.

Crop Lands – Exposed Soils

VTANR guidance (2007) specifies that evaluation of the area of cultivated lands draining to each reach can suggest the potential for land surface erosion and sediment mobilization to corridor reaches. Phase 1 stream geomorphic data were analyzed to summarize the percentage of crop lands in the upstream watershed and reach-based subwatershed of each corridor reach (Table 10).

Table 10. Crop lands in the watersheds draining to Lewis Creek corridor reaches

Reach / Segment	% crop land in the upstream watershed draining to the reach	Stressor Categorization (VTANR, 2007)
M18	4.8	Low (< 5%)
M17	5.5	Moderate (≥5% <10%)
M16	6.0	Moderate (≥5% <10%)
M15	6.3	Moderate (≥5% <10%)
M14	6.3	Moderate (≥5% <10%)

Caution should be applied, as such an evaluation does not take into account the degree of hydrologic connection of the noted crop lands to the receiving waters. Nor does it adjust for potential erosion prevention measures or practices in place on the indicated crop lands. Further limitations of this methodology are related to the scale, accuracy, and currency of the land cover / land use data sets utilized to summarize the data. Land cover / land use data (summarized in Step 4 of Phase 1) rely on the following data set available from the Vermont Center for Geographic Information (www.vcqi.org):

- *Landcover / Landuse for Vermont and Lake Champlain Basin (LandLandcov_LCLU, edition 2003). Source dates of 1991 to 1993. Further details of this land cover / land use data set are available at: http://www.vcqi.org/metadata/LandLandcov_LCLU.htm.*

Crop land use identified in Table 5 above refers to land cover / land use categories 22 (Orchard/ Tree Farm), 24 (Other Agricultural Land), 211 (Row Crops), and 212 (Hay / Pasture).

4.1.2 Sediment Regime Stressors (Watershed and Reach Scale)

Sediment regime stressors for the Lewis Creek corridor reaches are summarized in Table 4 (Watershed Level Stressors) and in Table 12 (Reach Level Stressors); they are discussed briefly in the following sections. Following VTANR guidance (2007), the purpose of this section is to evaluate the “cumulative impact of erosion and subsequent deposition at the watershed scale” through review of reach-based features. Features were compiled from a review of Phase 1 and Phase 2 Stream Geomorphic Assessment data and included: (1) depositional bars / planform migration features; (2) bank erosion; (3) mass wasting / gully sites; and (4) rejuvenating tributaries.

Depositional bars and planform migration features

Select depositional and migration features are identified in VTANR guidance as indications of potential enhanced sediment loading or a decreased sediment transport capacity of the river channel, or both. Features include steep riffles, mid-channel bars, delta bars, flood chutes, avulsions and channel braiding.

Sediment contained in the depositional bars theoretically has its source from upstream, as well as in-stream, erosion. As sediment accumulates in the channel it can cause flow in the channel to diverge and create flood chutes or avulse into a different path altogether. Thus, multiple bars and lateral adjustments in a reach may indicate a reduction in sediment transport capacity and reflect the cumulative effects of erosion at the watershed scale.

The number of each of these features in each of the corridor reaches has been summarized in Table 11. As prescribed in VTANR guidance (2007), the feature numbers have been normalized to the reach length and a stressor category has been assigned. Particularly noteworthy are the numbers of depositional features in segments M15-A and M17-B which are dominated by planform adjustment processes. Both a decreased sediment transport capacity and increased sediment loading from upstream and in-stream erosion and tributary sources are inferred in these segments. Based on windshield surveys and Phase 2 data (2001-2006), many upstream reaches and tributaries are undergoing significant erosion, and likely are contributing to sediment loads within the Lewis Creek corridor reaches M14 – M18.

Table 11. Depositional and planform features indicative of high sediment loads.

Reach/ Seg	No. of Features						Total #	Total # Normalized to segment length	Stressor Categorization (VTANR, 2007)
	Steep Riffles (5.3)	Mid-channel Bars (5.1)	Delta Bars (5.1)	Flood Chutes (5.2)	Avulsions (5.2)	Braiding (5.2)			
M18	0	0	0	1	0	1	2	7	Extreme
M17-C	0	1	0	2	0	0	3	8	Extreme
M17-B	0	8	0	2	1	0	11	7	Extreme
M17-A	0	1	0	1	0	0	2	3	High
M16	0	2	0	3	1	0	6	5	High
M15-B	1	1	1	4	1	1	9	12	Extreme
M15-A	0	9	0	6	1	1	17	15	Extreme
M14	0	0	2	0	0	1	3	5	Extreme

Table 12. River Stressor Identification Table (Reach Level)

Reach / Segment	Watershed-Scale Stressors		Reach-Scale Stressors			
	Hydrologic	Sediment Load	Stream Power		Boundary Resistance	
M18	I Past Floods	I Past Floods	I Slope	Encroachment: berm, right bank, at base of gorge	D Bank	Removal of woody vegetation related to residential use and former mills, upstream end.
	I Deforestation (1800s)	I Deforestation (1800s)	I Slope	Encroachment: States Prison Hollow Rd, LB (negligible impact, elevated above channel on valley wall)		
	I Wetland loss (tributaries)	I Wetland loss (tributaries)	I Depth	Stormwater: localized flow increases below road culvert outfalls (minor).		
		I Upstream erosion & tributary sources	D Slope	States Prison Hollow bridge and wooden footbridge are FPW constrictors; absence of apparent deposition suggests impact is minor.	I Bed, Banks	Frequent bedrock exposures in bed and banks.
	D Reforestation (1900s)	D Reforestation (1900s)			I Bank	Armoring (some)
M17-C	I Past Floods	I Past Floods	I Slope, Depth	Straightening w/ windrowing, berming (base of gorge, post-1938-flood recovery)	D Bed, Banks	Windrowing, snagging (base of gorge, post-1938-flood recovery)
	I Deforestation (1800s)	I Deforestation (1800s)	I Slope	Encroachment: States Prison Hollow Rd Extension and berms along both banks at base of gorge	D Bank	Reduction of woody buffers related to road encroachments, residential and agricultural use.
	I Wetland loss (tributaries)	I Wetland loss (tributaries)	I Slope	Reduction sediment supply (natural): below bedrock gorge of reach M18		
		I Upstream erosion & tributary sources	D Slope	States Prison Hollow Ext bridge and old abutment are FPW constrictors; absence of apparent deposition suggests impact is minor.	I Bank	Armoring (some)
	D Reforestation (1900s)	D Reforestation (1900s)				
M17-B	I Past Floods	I Past Floods	I Slope	Straightening (discrete sections, circa 1940s - agricultural)	D Bank	Removal of woody vegetation and reduction of buffer widths related to agricultural use (now mostly fallow).
	I Deforestation (1800s)	I Deforestation (1800s)				
	I Wetland loss (tributaries)	I Wetland loss (tributaries)	D Slope	Farm bridge is bankfull constrictor; moderate upstream aggradation; site of debris jams.	I Bank	Armoring (some)
		I Upstream erosion & tributary sources	D Depth	Beaver dams (transient, localized, but cumulative)		
	D Reforestation (1900s)	D Reforestation (1900s)				
M17-A	I Past Floods	I Past Floods			D Bank	Removal of woody vegetation related to agricultural use, direct-pasturing of livestock.
	I Deforestation (1800s)	I Deforestation (1800s)				
	I Wetland loss (tributaries)	I Wetland loss (tributaries)	D Slope	Farm bridge is bankfull constrictor; minor aggradation apparent.	I Bank	Armoring (some)
		I Upstream erosion & tributary sources	D Depth	Beaver dams (transient, localized, but cumulative)		
	D Reforestation (1900s)	D Reforestation (1900s)				

Table 12. River Stressor Identification Table (Reach Level) - Continued

Reach / Segment	Watershed-Scale Stressors		Reach-Scale Stressors			
	Hydrologic	Sediment Load	Stream Power		Boundary Resistance	
M16	I Past Floods	I Past Floods			D Bank	Removal of woody vegetation related to agricultural use (cropping and pasture); livestock excluded in 2007.
	I Deforestation (1800s)	I Deforestation (1800s)				
	I Wetland loss (tributaries)	I Wetland loss (tributaries)			I Bank	Armoring (some) and cedar revetments.
	D Reforestation (1900s)	D Reforestation (1900s)	D Depth	Beaver dams (transient, localized, but cumulative)		
M15-B	I Past Floods	I Past Floods	I Slope	Straightening (associated with Tyler Bridge Rd bridge crossing)	D Bank	Reduction of woody buffers related to road encroachments, residential and agricultural use.
	I Deforestation (1800s)	I Deforestation (1800s)	I Slope	Encroachment: short section of driveway, left bank		
	I Wetland loss (tributaries)	I Wetland loss (tributaries)	D Slope	Tyler Bridge Rd bridge is bankfull constrictor; persistent downstream deposition/mid-channel bar.	I Bank	Armoring (some)
	D Reforestation (1900s)	D Reforestation (1900s)	D Depth	Sediment accumulation at upstream end of segment due to Hollow Brook tributary confluence bar.		
M15-A	I Past Floods	I Past Floods	I Slope	Straightening (discrete sections, circa 1940s - agricultural)	D Bank	Removal of woody vegetation related to former agricultural use.
	I Deforestation (1800s)	I Deforestation (1800s)	I Slope	Encroachment: Lewis Creek Rd, right bank		
		I Upstream erosion & tributary sources	D Slope	Moderate constriction at downstream end of reach as channel transitions from Very Broad to Semi-Confined (bedrock-controlled) confinement.	I Bank	Armoring (some)
	D Reforestation (1900s)	D Reforestation (1900s)	D Depth	Beaver dams (transient, localized, but cumulative)		
M14	I Past Floods	I Past Floods	I Slope	Encroachment: Lewis Creek Rd, right bank (negligible impact, elevated above channel on valley wall)	D Bank	Reduction of woody buffers related to road encroachments, and residential use.
	I Deforestation (1800s)	I Deforestation (1800s)	I Depth	Stormwater: localized flow increases below road culvert outfalls (minor).		
		I Upstream erosion & tributary sources	D Slope	Turkey Lane bridge is bankfull constrictor; persistent upstream deposition/island.	I Bed	Bedrock exposures in channel bed.
	D Reforestation (1900s)	D Reforestation (1900s)			I Bank	Armoring (some)

Abbreviations:

I = Increase; D = Decrease

Notes:

Text in blue denotes a natural stressor or modifier. Text in black indicates a human-caused modification. See Table 4 for more detailed explanation of Watershed-Scale Stressors.

Bank Erosion

Bank erosion for the left and right banks (facing downstream) is summarized for each of the corridor reaches in Table 13. The corresponding Phase 1 impact rating has been assigned following VTANR guidance (2007). This table indicates that corridor reaches themselves are contributing to sediment loading within the reaches, particularly M15 and M16. In bedrock-controlled reaches M18 and M14 (which also have well-established forested buffers), sediment contributions from bank erosion are much less significant. These corridor reaches are also the recipients of sediments from bank erosion in upstream reaches and tributaries (e.g., reaches M19 through M22, High Knob Brook [T6], Hollow Brook [T4]).

Table 13. Erosion as an indication of high sediment loads.

Reach/ Seg	Left Bank		Right Bank	
	% Reach Length Eroding	Phase 1 Impact Rating	% Reach Length Eroding	Phase 1 Impact Rating
M18	13.4%	Low	0.0%	Not Significant
M17-C	8.1%	Low	13.5%	Low
M17-B	15.4%	Low	17.5%	Low
M17-A	17.6%	Low	14.2%	Low
M16	19.2%	Low	43.4%	High
M15-B	23.9%	High	19.6%	Low
M15-A	33.4%	High	21.9%	High
M14	0.0%	Not Significant	0.0%	Not Significant

Mass wasting and gully sites

Four mass failure sites were identified during Phase 2 assessments on corridor reaches (Table 14; see also reach maps in Appendix A):

Table 14. Mass Failure sites on corridor reaches.

Reach / Segment	Description	Approx. Height (ft)	Approx. Length (ft)	Stressor Characterization
M18	LB, 2 separate sites along States Prison Hollow Road related to 2006 road washout. Stabilized with rip-rap and steel sheet piling in 2007 by road crew.	30	93	One-time source of bedload and suspended sediments to downstream reaches in Lewis Creek. Volume of sediment inferred to be small compared to overall bedload of the stream in this channel with upstream drainage area of 18 square miles.
M17-A	LB, mostly-healed (vegetated) mass failure site near downstream end of reach. Groundwater seepage over clay revealed near toe of slope.	80	86	One-time source of bedload and suspended sediments to downstream reaches. Volume of sediment inferred to be small compared to overall bedload of the stream in this channel with upstream drainage area of 23 sq. miles.
M17-A	LB, active (non-vegetated) mass failure site near downstream end of reach exposing sands over varved clays.	35	66	Ongoing source of bedload & suspended sediments to downstream reaches. Volume of sediment inferred to be small compared to overall bedload of the stream in this channel with upstream drainage area of 23 sq. miles.

No gully sites were observed draining directly to the corridor reaches M14 through M18.

Rejuvenating tributaries

No rejuvenating tributaries were identified on the Lewis Creek corridor reaches during Phase 1 or Phase 2 assessments.

4.1.3 Reach Scale Modifiers

Valley, floodplain and channel modifications to accommodate human infrastructure and land uses can alter the channel cross section, profile and position in the landscape. Natural features of the river network, such as bedrock grade controls or tributary confluences, also influence the hydraulic geometry of the river. These modifications and features can be categorized broadly into:

- ◆ changes in channel slope and channel depth, which influence the energy gradient (stream power) of the river and the capacity to transport sediment, and
- ◆ changes in the boundary conditions (channel bed, banks, and riparian vegetation) which influence the resistance to erosion.

The impacts of reach-scale modifiers on the hydraulic geometry of the channel are complex and interrelated. The influence of multiple stressors may overlap within a reach. The following sections describe these reach-scale modifications in more detail. Table 12 presents a summary of the reach-scale modifiers catalogued for each of the Lewis Creek corridor reaches, together with the flow and sediment load modifications previously described.

Stream Power Modifiers

Channel Slope

Channel slope modifiers include stressors that lead to an **increase** in stream power, such as:

- ◆ channelization (straightening),
- ◆ floodplain encroachments (roads, berms, railroads),
- ◆ localized reduction of sediment supply below grade controls (bedrock, dams) or channel constrictions;

as well as stressors that can be expected to lead to a **decrease** in stream power, such as:

- ◆ a downstream grade control (dams, weirs),
- ◆ a downstream constriction (undersized bridge or culvert, bedrock constriction, armoring).

Channel Depth

Channel depth modifiers include stressors that lead to an **increase** in stream power, such as:

- ◆ dredging and berming,
- ◆ localized flow increases below stormwater and other outfalls;
- ◆ localized flow increases below constrictions (undersized bridge or culvert; armoring);

as well as stressors that can be expected to lead to a **decrease** in stream power, such as:

- ◆ gravel mining, bar scalping, where such activities result in overwidened conditions;
- ◆ localized increases of sediment supply occurring at tributary confluences and backwater areas, and impoundments behind beaver dams.

(VTANR guidance, 2007)

A stressor imparting an increase in stream power may or may not lead to channel incising or widening. Effects are dependent on the magnitude of the stream power increase, the resistance to erosion offered by the unique set of boundary conditions, and whether there are other stressors acting on the reach that may decrease stream power, or lead to channel aggradation.

A stressor imparting a decrease in power may or may not lead to channel aggradation or planform adjustment. Effects are dependent on the magnitude of the stream power decrease, the degree of valley or infrastructure confinement of the channel, and whether there are other stressors acting on the reach that may increase stream power, or lead to channel incision.

Erosion Resistance Modifiers (Boundary Conditions / Riparian Vegetation)

The nature of sediments in the channel banks (e.g., grain sizes, cohesiveness) and the vegetative cover (e.g., type and density) or other “treatments” (e.g., rip-rap, gabion baskets, revetments, large woody debris) along the stream banks control the strength of the banks and their resistance to erosion. These boundary conditions in turn influence the degree and rate of channel widening or other lateral movement, thus influencing the ability of the river to adjust its cross-sectional dimensions to most effectively convey the water and sediment inputs to the channel. Boundary conditions also influence the nature and amounts of sediment available to be transported to downstream reaches.

Channel Bed

Channel bed modifications that lead to a **decrease** in erosion resistance include:

- ◆ snagging (removal of large woody debris),
- ◆ dredging, and
- ◆ windrowing.

Channel bed modifications that lead to an **increase** in erosion resistance include:

- ◆ grade controls (dams, weirs, channel-spanning bedrock), and
- ◆ bed armoring.

Streambank and Near-bank Riparian Area

Bank and riparian modifications that lead to a **decrease** in erosion resistance include:

- ◆ removal of vegetation.

Bank and riparian modifications that lead to an **increase** in erosion resistance include:

- ◆ bank armoring (rip-rap, gabion baskets, revetments, large woody debris).
(VTANR guidance, 2007)

It is important to note that enhanced erosion resistance offered by the boundary conditions in one location along a river network may translate into increased stream power at a downstream site. For example, it is very common to observe streambank erosion beginning at the downstream end of a length of channel armoring, or bed scour downstream from a bedrock grade control or dam site.

4.1.4 Sediment Regime Departure, Constraints to Sediment Transport & Attenuation

Within a given reach, the watershed-level and reach-level flow and sediment load modifications, combined with the reach-scale modifiers of stream power and boundary resistance, together govern adjustments in the channel dimensions, profile and planform over time. These lateral and vertical adjustments, in turn, influence how the river channel transports its sediment and water inputs.

Channel and watershed disturbances that exceed thresholds for change can upset the dynamic equilibrium of stream systems. Imbalance in the channel affects the sediment transport capacity of the stream system, and has significant consequences for erosion hazards, water quality and riparian habitats. Equilibrium can be disturbed locally and result in channel adjustments that are limited in magnitude and extent (for example, scour at an undersized culvert crossing). Alternately, the disturbance (or an overlapping combination of disturbances) can be of sufficient size, duration, or frequency to cause substantial channel adjustments that result in a system-wide imbalance extending far upstream and downstream through the river network.

Such imbalances, whether localized or systemic, interfere with the river's ability to efficiently convey its water and sediment loads. These interruptions are either expressed as a sediment transport deficiency where sediment accumulates in the channel (which itself may lead to further imbalances - e.g., flow widens and splits to erode streambanks on either side, or flow may avulse or jump its banks in a flood event). Alternately, the imbalance can be expressed as an increase in sediment transport capacity. For example, a channel that has been straightened, dredged, armored and bermed has a local increase in channel slope, which creates higher flow velocities, and an increased power to erode the streambed. If the channel bed is scoured, this condition often leads to further channel adjustments including streambank collapse and widening.

Sediment transport capacity of the channel can be inferred from the geomorphic features observed during field work and from the stressors catalogued in Table 12. Even a qualitative understanding of these processes can help to identify and prioritize appropriate management strategies for the river that will facilitate a return toward dynamic equilibrium.

The **Departure Analysis Table** (Table 15) summarizes the apparent status of each of the corridor reaches as either transport- or attenuation-dominated. Table 15 also indicates the natural constraints (e.g., bedrock) and human constraints (e.g., roads, development, land uses) to channel adjustment that are, in part, influencing the current transport or attenuation status. The corridor section is bounded on either end by semi-confined, bedrock-controlled reaches: the bedrock gorge in reach M18 at the upstream end and the reach M14 with channel-spanning bedrock exposures at the downstream end. These are natural transport-dominated reaches, where it is likely that the sediment entering the reach is balanced by the sediment carried out of the reach.

The middle three reaches (M17, M16 and M15) are in an unconfined, low-gradient (0.06 to 0.25%) valley setting, and contain no bedrock exposures. Under natural circumstances these reaches would be expected to deposit fine sediments in their floodplains through periodic bankfull and flood-stage flows, and balance the transport of coarser sediments (bed load), such that the bedload volumes entering the reach would be similar to bedload volumes leaving the reach averaged over a one- to two-year period. One localized exception to this generalization is the upstream 2000 feet of reach M17 comprising Segment C. This segment is located where the Lewis Creek transitions from the semi-confined bedrock gorge of upstream reach M18 to an unconfined, low-gradient channel meandering through a wide valley setting (downstream segments, M17-B, M17-A). A substantial reduction in channel gradient occurs from 6.9% in M18 to 0.8% in Segment C of reach M17. Naturally, enhanced bedload deposition and braiding would be expected at this location of marked reduction in slope. Sediment deposition would probably be more active in earlier post-glacial environments (1,000s of years before present), under more intense hydrologic and sediment regimes, and prior to widespread vegetation of the landscape. This location may have seen renewed sedimentation and lateral adjustments during colonial times, during widespread deforestation of upland slopes in the 1800s. Under present sediment and hydrologic regimes, excessive sedimentation and braiding would be evident during large flood events (as was the case in the 1938 flood).

Table 15. Departure Analysis Table, Lewis Creek Corridor Reaches M18 through M14.

Reach / Segment	Constraints		Transport		Attenuation (storage)			
	Vertical	Lateral	Natural	Converted	Natural	Decreased	Increased	Asset
M18	Bedrock Falls / Gorge	N: Bedrock Banks, Bedrock-controlled Semi-confined Valley H: right-bank berm H: Residential Development H: Bridge - States Prison Hollow Rd (FPW) H: Bridge - footbridge (FPW)	X		None			
M17-C	None - no channel-spanning bedrock or dams.	H: berms, both banks H: Residential Development H: agricultural fields (hay) H: Road: States Prison Hollow Ext H: Former Bridge Abutments (FPW) H: Bridge - States Prison Hollow Ext (FPW)		X	Slope Reduction at Base of Gorge	X Due to historic incision, floodplain encroachment (berms, road), and residential development.		
M17-B		H: Bridge - farm bridge (BKFL)			None - no alluvial fans or downstream, significant bedrock gorges.		X Due to upstream sediment sources, and in-reach meander extension facilitated by lack of forested buffers and close-cropped pasture. Enhanced locally by beaver activity (dams).	X
M17-A		H: Bridge - farm bridge (BKFL)				(X) Somewhat, due to historic incision (minor degree), and removal of riparian woody vegetation (direct pastured).	X Due to upstream sediment sources, and in-reach meander extension facilitated by lack of forested buffers and close-cropped pasture. Enhanced locally by beaver activity (dams).	X
M16						(X) Somewhat, due to removal of riparian woody vegetation (direct-pastured) - livestock recently excluded, crops set back and buffers planted.	X Due to upstream sediment sources, and in-reach meander extension facilitated by lack of forested buffers. Enhanced locally by beaver activity (dams).	X

Abbreviations:

H = Human constraint; N = Natural constraint; BKFL = bankfull; FPW = Flood Prone Width; VB = Very Broad; SC = Semi-Confined.

Table 15. Departure Analysis Table, Lewis Creek Corridor Reaches M18 through M14. - Continued

Reach / Segment	Constraints		Transport		Attenuation (storage)			
	Vertical	Lateral	Natural	Converted	Natural	Decreased	Increased	Asset
M15-B	None - no bedrock or dams.	H: driveway H: Bridge - Tyler Bridge Rd (BKFL) H: Residential Development H: agricultural fields (tree nursery)		X	None	X Due to historic incision, inferred historic straightening, floodplain encroachment (driveway, bridge), and residential development.	(X) Locally, at and just upstream of Hollow Brook tributary confluence bar. Locally, at beaver dam sites.	
M15-A		H: Road: Lewis Creek Rd H: Residential Development			Upstream of bedrock grade controls; VB to SC transition.		X Due to upstream sediment sources, natural constriction at downstream reach, and in-segment meander extension facilitated by lack of forested buffers. Enhanced locally by beaver activity (dams).	X
M14	Channel-spanning bedrock, Semi-confined valley	N: Bedrock Banks, Bedrock-controlled Semi-confined Valley H: Residential Development H: Road: Lewis Creek Rd H: Bridge: Turkey Lane (BKFL)	X		None	(X) Somewhat, locally, due to removal of riparian woody vegetation and residential development (right bank).		

Abbreviations:

H = Human constraint; N = Natural constraint; BKFL = bankfull; FPW = Flood Prone Width; VB = Very Broad; SC = Semi-Confined.

Two segments of the unconfined reaches (M17, M16, M15) have been converted from depositional or equilibrium conditions to transport-dominated conditions by virtue of various channel and watershed disturbances: M17-C and M15-B. Attenuation functions that might be expected in these unconfined valley settings have been decreased substantially as a result of:

- ◆ channelization, removal of meanders (M17-C, M15-B);
- ◆ residential development (M17-C, M15-B);
- ◆ historic incision and the resultant decrease in degree of floodplain connection (M17-C, M15-B);
- ◆ windrowing (post-1938 flood) (M17-C);
- ◆ floodplain encroachments (berming and roads in M17-C).

Also in reach M14, the few floodplain pockets that did exist in this naturally transport-dominated reach have been encroached upon by residential development, further enhancing the transport function of this reach. Woody vegetation has been cleared to create lawn areas adjacent to residential buildings, which would have the effect of reducing the roughness of floodplain surfaces, further reducing potential for sediment attenuation in those limited floodplain areas.

On the other hand, reaches/segments M17-B, M17-A, M16, and M15-A have experienced increased sediment attenuation in recent years, related to the upstream and in-reach production of sediments. These reaches are minimally constrained or largely unconstrained by infrastructure such as roads and development. They have maintained reasonable access to the floodplain ($IR_{RAF} = 1.0$ to 1.25 ; $ER = 9$ to 36). In locations of previous channelization, substantial lateral adjustments have occurred (meander extension, meander translation, neck cut-offs, avulsions), facilitated in discrete locations by absence of woody buffers and erodible streambank sediments. Sediment attenuation has been increased in vicinity of beaver dams which tend to persist for a few to several months each year, and then wash out during bankfull or higher storm events. Sediment deposition at the confluence of Hollow Brook may be contributing to aggradation and lateral adjustments at the downstream end of M16 (Figure 10). In the case of M15-A, the transition from a Very Broad confinement to a bedrock-controlled Semi-confined valley in reach M14, has probably contributed to aggradation and planform adjustments in M15-A (Figure 11). Enhanced aggradation has been associated with a recent (1994-1995) avulsion in segment M15-B (Figure 12).

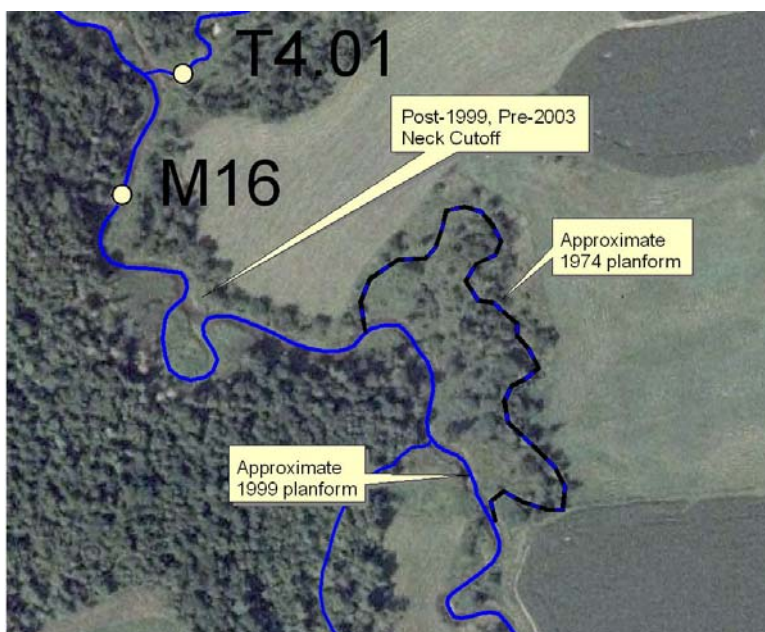


Figure 10. Localized slope reductions related to sedimentation at the confluence of Hollow Brook tributary (T4.01) may have contributed to recent lateral adjustments in the Lewis Creek main stem. A post-1974, pre-1999 avulsion resulted in a large abandoned meander northeast of the present channel. A post-1999, pre-2003 neck cutoff has created a small oxbow south of the channel.

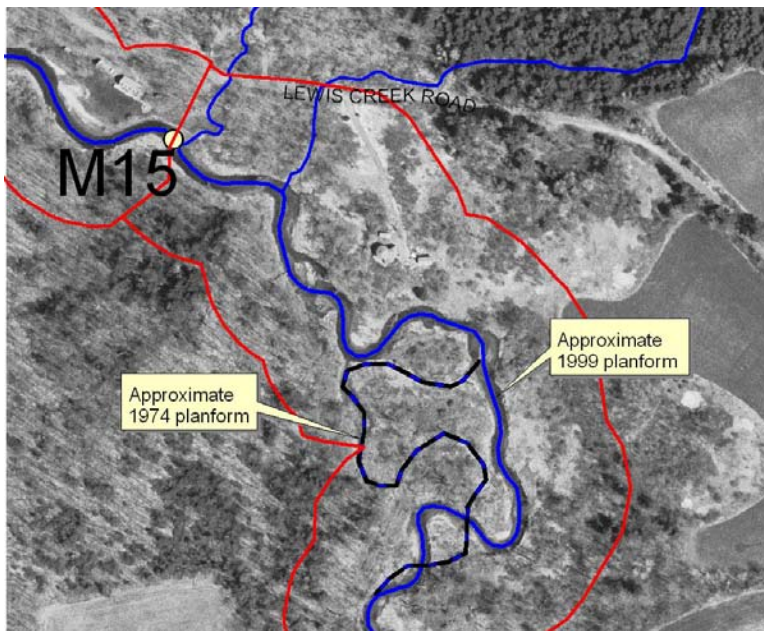


Figure 11. Channel migration area at downstream end of reach M15 (Segment A). Based on review of orthophotos and a local landowner's aerial view indicates that this apparent avulsion occurred post-1983 and pre-1999, and resulted in a loss of 510 feet of channel.

(Red line is Phase 1 corridor. Base map is 1999 orthophoto).



Figure 12. Abandoned meander at mid-section of reach M15 (Segment B) downstream of the Tyler Bridge Rd bridge. Review of annual fly-over images at the NRCS Middlebury office indicates that this avulsion occurred over a period of time from 1994 to 1995. Cut off of this broad meander resulted in a loss of 1000 ft of channel length. The avulsion and subsequent channel adjustments may have contributed to recent aggradation in Segment A. (Base image is dated 2003)

The current geomorphic condition of these corridor reaches, as modified by human factors, is summarized in the Sediment Regime Departure Maps in Figures 13 and 14. Preparation of these maps follows methods outlined in VTANR guidance (2007).

Phase 1 (Reference) Sediment Regime

Figure 13 displays the inferred reference sediment regimes that would be characteristic of the river in a pre-disturbed state (say, 300 years before present).

Transport (coded blue in Figure 13)

Bedrock-controlled reaches M14 and M18 are in this category.

Coarse Equilibrium & Fine Deposition (coded green in Figure 13)

Between the bedrock reaches, it is theorized that the river would have had a natural meandering planform (altered locally by exposures of bedrock and variable sediment types in the stream bed and banks). The channel would have had ample access to the Very Broad valley floodplains – similar to present-day conditions in segments M17-B or M15-A. Fine sediments would be deposited in the floodplain through periodic bankfull and flood-stage flows, and the transport of coarser sediments (bed load) would be balanced, such that the bedload volumes entering the reach would be similar to bedload volumes leaving the reach averaged over a one- to two-year period. Deposition and erosion cycles would have been balanced, such that there would be no net change in overall channel dimensions, gradient and planform (i.e., a channel in dynamic equilibrium). The channel would have moved within its floodplain in its reference (pre-disturbed) condition, but there would be no net change in average, reach-wide geometry such as slope and average meander width and amplitude.

Phase 2 (Existing) Sediment Regime

Figure 14 displays the existing sediment regimes, theorized based on Phase 2 assessment results and the departure analysis previously described. The contrast in coding of the reaches in the two figures illustrates the degree of departure from reference that is inferred. A majority of the reaches have not experienced a significant sediment regime departure:

Transport (coded blue in Figure 14)

Reaches M14 and M18 have not undergone significant lateral or vertical adjustments in response to channel and watershed disturbances, given the stability offered by the underlying bedrock. Thus, a *Transport* classification has been maintained for these reaches.

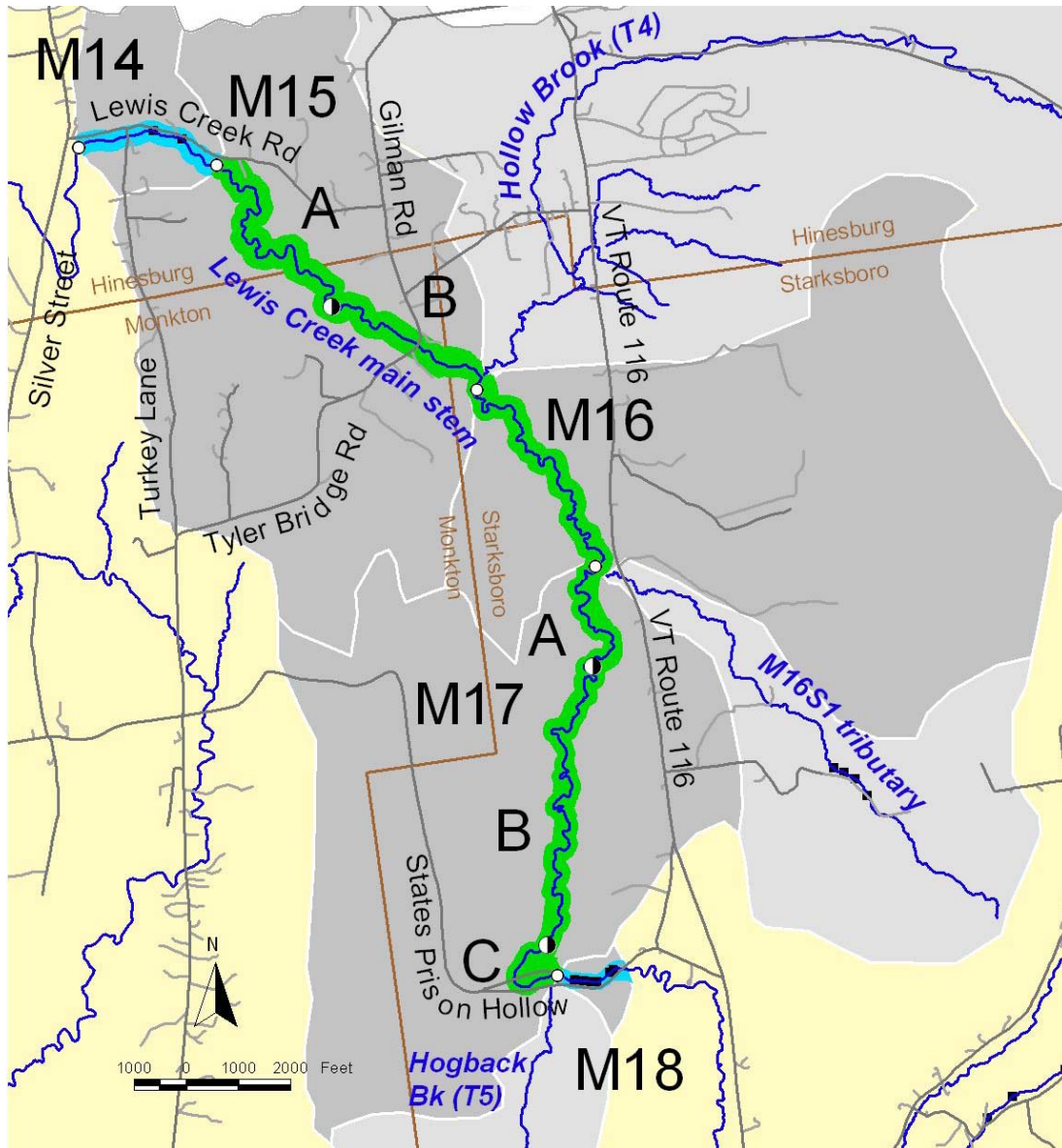
Coarse Equilibrium & Fine Deposition (coded green in Figure 14)

Reaches / segment M15-A, M16, M17-A and M17-B have maintained a *Coarse Equilibrium & Fine Deposition* classification, since they have exhibited only minimal to moderate lateral or vertical adjustments in response to channel and watershed disturbances. Segments M15-A and M17-B have good floodplain connection during bankfull events ($IR_{RAF} = 1.0$). M16 and M17-A have a minor degree of disconnection to the surrounding floodplain resulting from inferred historic incision ($IR_{RAF} = 1.16$ and 1.25 , respectively). Fine deposition in the floodplain has likely been somewhat reduced in frequency as compared to the reference state of these reaches.

On the other hand, a degree of sediment regime departure is theorized for segments M15-B and M17-C.

Fine Source & Transport / Coarse Deposition reach (coded red in Figure 14)

Segment M15-B is exhibiting a moderate degree of incision ($IR_{RAF} = 1.6$) which has probably reduced the frequency of overbank fine deposition. Floodplain access (and the associated sediment



Reach / Seg	Phase 1 Reference Stream Type
M18 --	B2a-S/P
M17 C	C4-R/P *
M17 B	E4-R/P
M17 A	E4-R/P
M16 --	E4-R/P
M15 B	C4-R/P
M15 A	E4-R/P *
M14 --	B3c-R/P

* Subreach (per VTANR protocols, 2007)

- Reach Break
- Segment Break
- 1999, 1995 channel
- Bedrock grade control

Phase 1 Sediment Regime

- Transport
- Confined Source & Transport
- Unconfined Source & Transport
- Fine Source & Transport & Coarse Deposition
- Coarse Equilibrium & Fine Deposition

Figure 13. Phase 1 (Reference) Sediment Regime Map
Lewis Creek Corridor Reaches M14 through M18

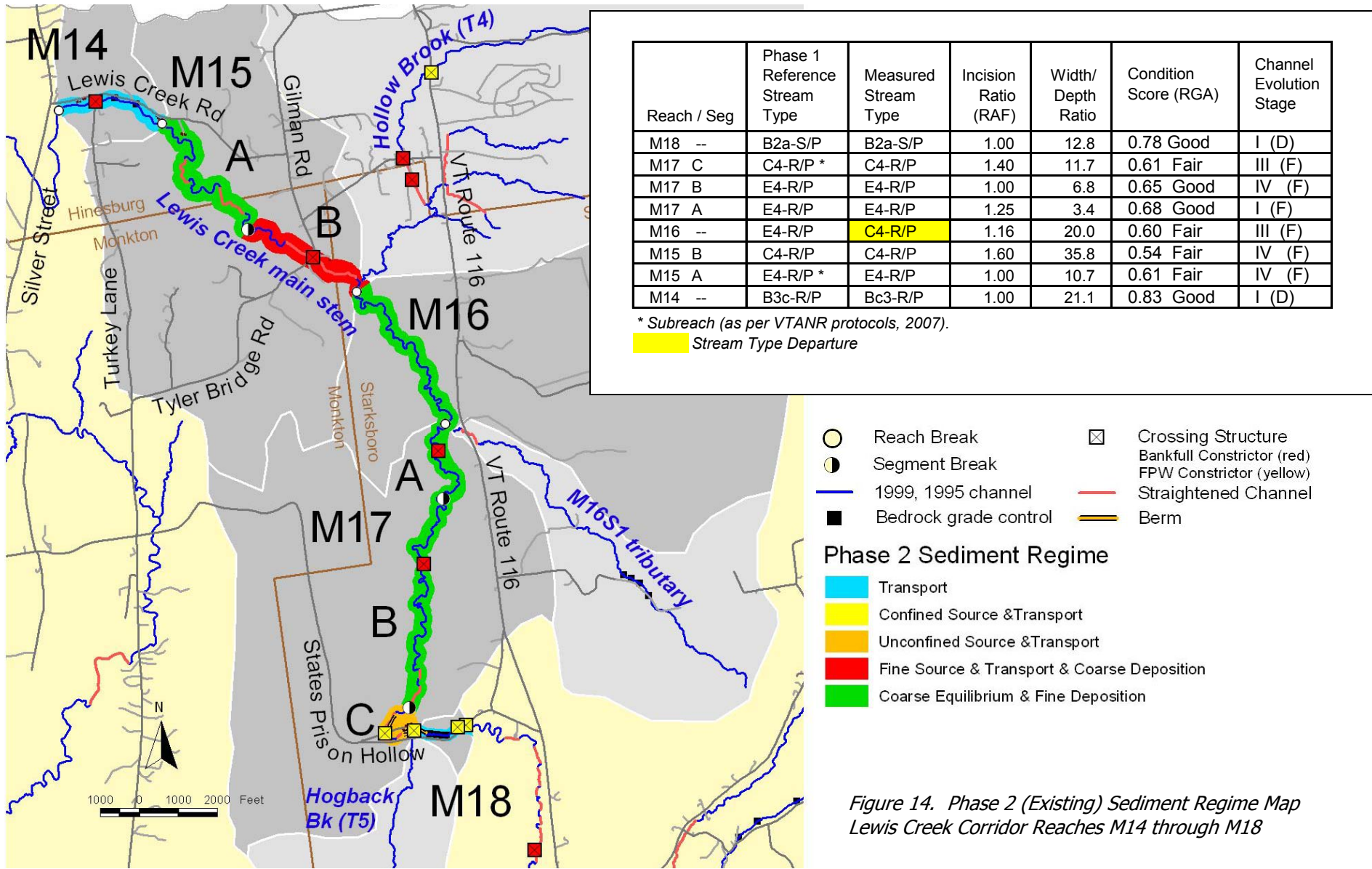


Figure 14. Phase 2 (Existing) Sediment Regime Map
Lewis Creek Corridor Reaches M14 through M18

attenuation) has been further compromised by limited encroachment of residential development, commercial development (tree nursery), and historic channelization and removal of meanders. As a consequence of the moderately incised status, the enhanced scour energy of bankfull and low-magnitude flood flows would tend to be trapped within the banks of the channel, rather than dissipated out in the floodplain. Such increased scour energy is likely contributing to streambank erosion and local widening within the segment. Thus, rather than supporting net deposition of fine-grained sediments through regular overbank flooding, segment M15-B has been converted to a *Fine Source & Transport* segment. In-segment and upstream erosion is, in turn, contributing to coarse sediment deposition within the segment, locally enhanced by beaver dams, debris jams and entrained large woody debris. The channel is locally overwidened in vicinity of these features and appears to be building a floodplain at a slightly lower elevation through channel widening and planform adjustments. Thus, the segment has been converted from a Coarse Equilibrium condition to Coarse Deposition.

Unconfined Storage & Transport (coded orange in Figure 14)

In segment M17-C at the base of the bedrock gorge along States Prison Hollow Road, the channel has undergone historic incision ($IR_{RAF} = 1.4$), likely related to the channelization, windrowing, armoring and berming which occurred in response to the 1938 flood (and possibly during previous large floods including the 1927 and 1913 events). The degree of disconnection to the floodplain in the reach has been exacerbated by corridor encroachments ($IR_{HEF} = 1.46$), including berms along both banks in discrete sections, the States Prison Hollow Road Extension, and floodplain filling associated with a cluster of residential homes (some present since the late 1800s). Minimal-width, but mature, tree buffers are present along both banks. Thus, the potential for widening or avulsions of the channel has been moderated. Storage of fine and coarse sediment fractions has been reduced by the reduction in floodplain access and enhanced transport capacity resulting from channelization. This reach has been converted from an expected reference state of *Coarse Equilibrium & Fine Deposition* to a transport-dominated *Unconfined Storage & Transport* classification.

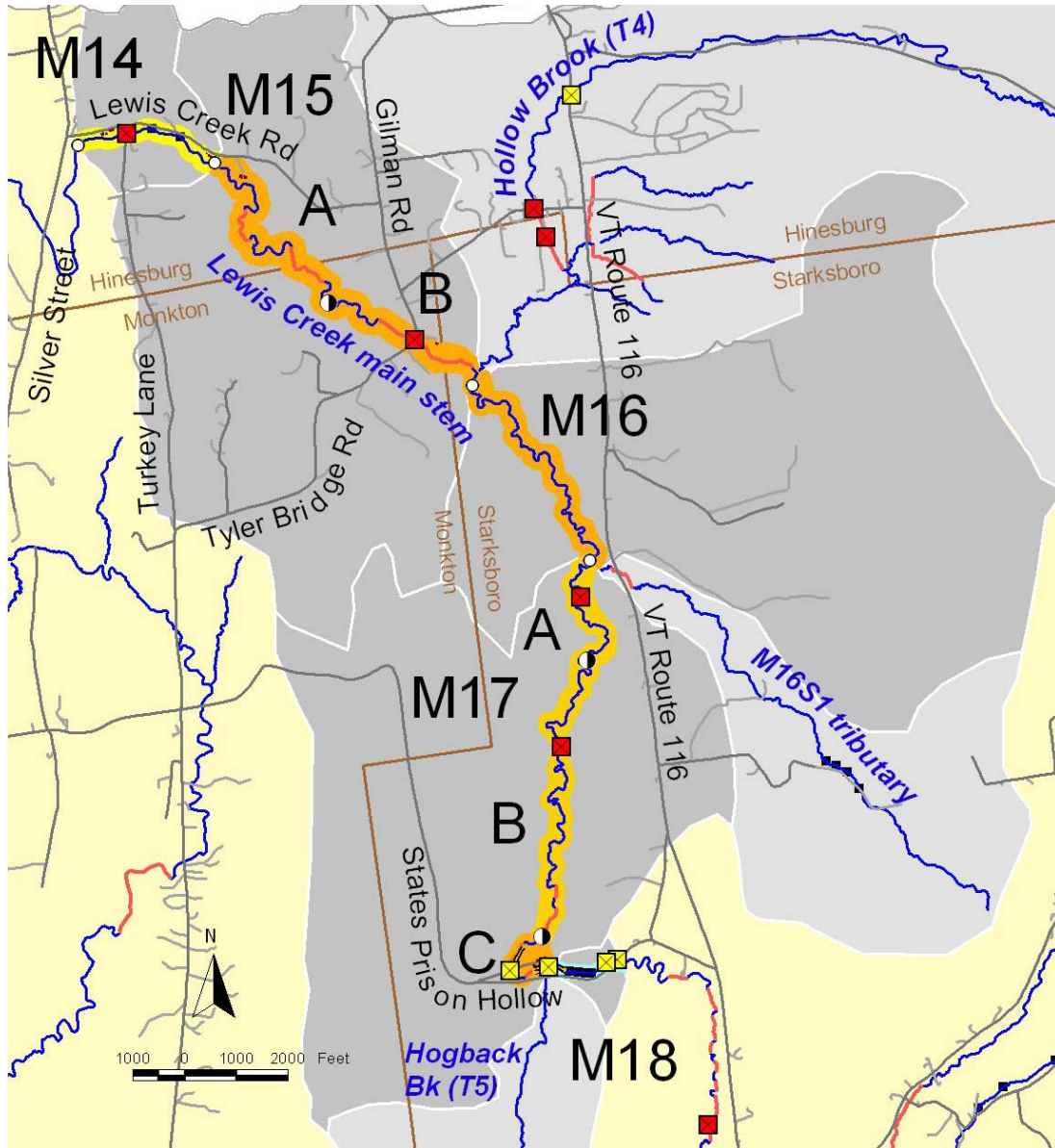
4.2 Sensitivity Analysis

The ***Stream Sensitivity Map*** (Figure 15) identifies the sensitivity classification for each of the corridor reaches assigned based on the Phase 2 stream geomorphic assessment data (see Tables 3a and 3b). Inherent in the stream sensitivity rating are:

- ◆ the natural sensitivity of the reach given the topographic setting (confinement, gradient) and geologic boundary conditions (sediment sizes) – as reflected in the reference stream type classification (after Rosgen, 1996 and Montgomery & Buffington, 1997); and
- ◆ the enhanced sensitivity of the reach given by the degree of departure from reference (or dynamic equilibrium) condition – as reflected in the existing stream type classification and the condition (Reference, Good, Fair to Poor ratings in the Rapid Geomorphic Assessment).

The sensitivity classification is intended to identify “the degree or likelihood that vertical and lateral adjustments (erosion) will occur, as driven by natural and/or human-induced fluvial processes” (VTANR 2007).

These stream sensitivity data were utilized during subsequent planning steps to inform the identification and prioritization of corridor restoration and protection projects and practices (Sections 5 and 6).



Reach / Seg	Condition Score (RGA)	Channel Evolution Stage	Sensitivity
M18 --	0.78 Good	I (D)	Very Low
M17 C	0.61 Fair	III (F)	Very High
M17 B	0.65 Good	IV (F)	High
M17 A	0.68 Good	I (F)	High
M16 --	0.60 Fair	III (F)	Very High
M15 B	0.54 Fair	IV (F)	Very High
M15 A	0.61 Fair	IV (F)	Very High
M14 --	0.83 Good	I (D)	Moderate

- Reach Break
- ◐ Segment Break
- 1999, 1995 channel
- Bedrock grade control
- ⊠ Crossing Structure
- Bankfull Constrictor (red)
- FPW Constrictor (yellow)
- Straightened Channel
- Berm

- Sensitivity**
- Extreme
 - Very High
 - High
 - Moderate
 - Low
 - Very Low

Figure 15. Sensitivity Map
Lewis Creek Corridor Reaches M14 through M18

5.0 PRELIMINARY PROJECT IDENTIFICATION / PRIORITIZATION

Landowners, community members, and resource agencies, including Lewis Creek Association, Addison and Chittenden County Regional Planning Commissions, the Natural Resources Conservation Service, and Vermont Agency of Natural Resources, can use geomorphic data to inform future management strategies for the river corridor. For a given reach or segment, the active adjustment processes, degree of departure from reference, and sensitivity ranking will define the short-term compatibility and long-term sustainability of various restoration or conservation options and future land use or channel management activities.

The preliminary identification and prioritization of corridor restoration and protection projects and practices outlined below has been informed by:

- stream sensitivity data (Section 4.2);
- qualitative observations of sediment transport and attenuation characteristics (summarized for each reach in Table 15 and Sections 4.1.1 through 4.1.4); and
- preliminary departure analysis contained in Sections 4.1.1 through 4.1.4.

This provisional listing follows the outline of management actions identified in the *Step-Wise Procedure for Identifying Technically Feasible River Corridor Restoration and Protection Projects* included in VTANR guidance (2007). Per VTANR guidance, the listed approaches can be classified under three broad management approaches:

Active Geomorphic: Restore or manage rivers to a geomorphic state of dynamic equilibrium through an **active** approach that may include the removal or reduction of human-placed constraints or the construction of meanders, floodplains, and bank stabilization techniques. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.

Passive Geomorphic: Allow rivers to return to a state of dynamic equilibrium through a **passive** approach that involves the removal of constraints from a river corridor thereby allowing the river, utilizing its own energy and watershed inputs to re-establish its meanders, floodplains, and self maintaining equilibrium condition over an extended time period. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.

Active-Passive Combination: Use a sequenced combination of active and passive approaches to accommodate the varying constraints that typically occur along a project reach.
(VTANR, 2007)

Generally speaking the projects identified in the following **Protects and Practices Table** can be classified as passive geomorphic approaches to river management – except where noted as “active” in Table 16.

This listing has formed the basis for project development and implementation efforts in the context of this corridor planning project. Section 6.0 provides more detailed descriptions of these proposed projects. A few of these projects (e.g., buffer plantings) can be considered for immediate implementation, independent of other watershed projects, and will require only minimal feasibility analysis and project development activities. Other identified projects may require further evaluation and efforts to complete alternatives analyses, conduct landowner outreach and negotiations, and identify potential stakeholders and funding sources.

Table 16. Projects and Practices Table – Reach/Segment Priorities.

	Corridor Reaches/ Segments (in order, upstream to downstream)								Next Steps
	M18	M17-C	M17-B	M17-A	M16	M15-B	M15-A	M14	
Protect River Corridor and channel-contiguous wetlands	Low	Very High	High	Mod	Very High	Very High	High	Low	Work with landowners to understand land use constraints, willingness to protect the corridor. Work with towns to incorporate FEH planning concepts. Identify structures at risk of erosion hazards in County and Town All-Hazards Mitigation Plans, and communicate risks to landowners. Work with towns to implement educational programs.
Plant Stream Buffer	Low	Low	Mod	Mod	Mod			Low	Plant to demarcate outside edge of corridor; anticipate further planform adjustments. Inquire about landowner's willingness to increase pasture setbacks allowing for establishment of buffer plantings (M17-A).
Exclude livestock from the Creek				High	High				Outreach to landowners; match with appropriate technical / financial resources (Note: cattle in reach M16 were excluded in 2007).
Stabilize Streambank							High		Landowner already initiated streambank stabilization separately. Pending landowner willingness, project could be enhanced with restoration of woody buffer.
Remove berm; restore floodplain (active)		Low							Outreach to landowner
Remove or Replace Structures:									Low priority bridge crossings: supply geomorphic evaluations to towns/RPCs for consideration in capital budgeting and replacement scheduling.
- Bridge & Culverts	Low	Low	High	High		Mod		Mod	High priority bridge crossings (M17-B, M17-A): work to provide appropriate technical/ financial resources to landowner for replacement of private bridge crossings with wider spans and higher clearances.
- Old Bridge Abutments		High							Determine ownership / consult responsible party. Evaluate consequence of removal on sediment transport continuity.
Restore Incised Reach (active)		Low							Outreach to landowner.
Treat gullies / significant sediment sources		Low				High			Outreach to landowner; Evaluate causal factors; design solution.
Wetland Restoration			High	High					Outreach to landowner.

Watershed stakeholders which may look to this data for guidance include (but are not necessarily limited to):

- landowners
- towns of Starksboro, Monkton, and Hinesburg
- Lewis Creek Association
- Hinesburg Area Land Trust
- Addison County Regional Planning Commission
- Chittenden County Regional Planning Commission
- Addison County Natural Resources Conservation District
- VT Department of Environmental Conservation, Water Quality Division –
 - River Management Section and
 - Wetlands Section
- Vermont Agency of Agriculture
- Vermont Department of Transportation
- Vermont Land Trust
- Vermont River Conservancy
- Northern Vermont Resource Conservation and Development Council (Better Back Roads)
- US Fish and Wildlife, and
- US Department of Agriculture, Natural Resources Conservation Service.

5.1 Protecting River Corridors

Protection of river corridors is an essential element to all passive and active geomorphic restoration and conservation projects. River corridor protection can support multiple objectives:

- **Dynamic Equilibrium** - Preserve (or support a return to) reference sinuosity, slope, and channel dimensions through active or passive geomorphic approaches. Refrain from future channel management, such as channelization, dredging, berming, armoring.
- **Floodplain Access** – Preserve or restore a channel’s access to its surrounding floodplain in bankfull and higher flow events through active or passive geomorphic approaches. Refrain from future channel management, such as channelization, dredging, berming, armoring.
- **Sediment Attenuation** – Preserve, restore, or enhance the storage of sediments (from in-reach or upstream sources) within the channel margins, floodplain, and channel-contiguous wetlands.
- **Flow Attenuation** – Preserve, restore, or enhance the storage and detainment of flood flows through overbank flooding, increased channel length (sinuosity), increased channel roughness (e.g., buffers), and inundation of channel-contiguous wetlands.
- **Avoidance** – Refrain from developments and infrastructure in the corridor to minimize future fluvial erosion losses

Under a passive geomorphic approach, the river channel is allowed to freely meander within the area defined as the belt-width-derived river corridor. For a reach that is already close to reference condition or exhibiting only minor adjustments, preserving a river corridor will ensure the river’s ability to continue to meander through the valley unconstrained by human infrastructure. In turn, human investments in the landscape will be protected from future channel adjustments. For a reach that has seen significant channel management in the past, and has lost some degree of floodplain connection and some measure

of its sinuosity and balanced planform and profile, the channel is allowed to adjust unimpeded to a more sinuous, meandering planform closer to regime conditions. During ongoing adjustments, the river will re-establish greater floodplain access (where access has been lost) and adjust channel dimensions for optimum conveyance of its water and sediment loads. Restoring channel equilibrium will reduce instream production of sediment and nutrients and enhance sediment and nutrient attenuation over the long term.

Under an active geomorphic approach, protection of the river corridor will prevent future channel management that might unravel constructed features of a recently restored reach.

Lower priority reaches for river corridor protection include “wooded corridors experiencing very little threat from encroachment and less sensitive reaches not playing a significant flow or sediment load attenuation role in the watershed” (VTANR, 2007). Of the Lewis Creek corridor reaches, this category would include:

- ◆ M18 – the bedrock gorge reach which is afforded stability by the underlying bedrock and which was assigned a Very Low sensitivity; and
- ◆ M14 – the bedrock-controlled, Semi-confined valley reach with channel-spanning bedrock exposures which was assigned a Moderate sensitivity.

Highest priority reaches for river corridor protection include “highly sensitive reaches critical for flow and sediment attenuation from upstream sources or sensitive reaches where there is a major departure from equilibrium conditions and threats from encroachment (VTANR, 2007)”. Limited term or permanent corridor easements are possible mechanisms for corridor protection, with the willingness of landowners. Protection of the river corridor in these reaches can serve the functions listed above. As summarized in Table 17, there are additional strategic factors that may raise the priority of corridor protection for a given reach, including:

- ◆ **Locations Upstream of Constrained / Altered Reaches**
Reaches / segments which are constrained by the topographic setting (e.g., bedrock outcroppings) or by human infrastructure (e.g., berms, roads, development) are less able to adjust their dimensions, planform, and profile in response to excess sediment and water loads delivered from upstream. Corridor protection measures implemented upstream of these constrained / altered reaches will enhance sediment and flow attenuation, maintain or improve floodplain access and reduce streambank erosion over the long term. Sediment production and delivery and hydrologic stresses to the constrained / altered reach will be decreased given the flow and sediment attenuation achieved in the upstream protected corridor.
- ◆ **Locations Downstream of Constrained / Altered Reaches**
Protection of segments downstream of constrained / altered reaches will help to offset the impacts of human encroachments in the disturbed reach which may have constrained the channel, reduced floodplain access, and converted a naturally deposition-dominated segment into a transport-dominated segment.
- ◆ **Sediment attenuation areas**
Where increased attenuation functions are observed, and lateral adjustments can be tolerated given the adjacent land uses, such areas can be capitalized on as attenuation assets to offset the reduced floodplain access and sediment storage in upstream or downstream reaches that have been converted to a transport-dominated status. These sites are high-priority candidates for outreach and eventual conservation with the willingness of landowners.

- ◆ **Reaches with channel-contiguous wetlands**
Where wetlands and backwater areas are hydrologically connected to the channel, flow attenuation and suspended sediment (and nutrient) attenuation functions can be maximized.
- ◆ **Reaches at alluvial fans or points of marked valley slope reduction** that contributes to increased sediment aggradation and planform adjustment. Carefully manage land use changes in the upstream watershed to reduce the potential for increases in sediment or flows that may induce channel adjustments in the subject reach/segment.
- ◆ **Reaches downstream of major sediment sources or tributary confluence bars** that contribute to increased sediment aggradation and planform adjustment.
- ◆ **Reaches where there is a major departure from equilibrium conditions** – these are reaches where protection against fluvial erosion hazards (through local planning and zoning mechanisms) is especially critical as the channel is susceptible to sudden streambank erosion or avulsion in high flow events.
- ◆ **Reaches Identified for Passive or Active Restoration** – To support a channel where there is a moderate to major departure from equilibrium as it evolves to regain floodplain and natural meander patterns.

Table 17. River Corridor Protection opportunities in the Lewis Creek corridor reaches

Reach / Segment	Town	Priority	Protection Upstream of Constrained or Altered Reaches	Protection Downstream of Constrained or Altered Reaches	Key Sediment Attenuation Area	Channel-contiguous wetlands	Alluvial Fan or Point of Marked Valley Slope Reduction	Downstream from Major Tributary or Other Large Sediment Source	Moderate or Major Departure from Equilibrium	Accompany Passive or Active Restoration
M18	Starksboro	Low								
M17-C	Starksboro	Very High		√			√		√	√
M17-B	Starksboro	High		√	√	√				
M17-A	Starksboro	Mod			√					
M16	Starksboro	Very High	√		√	√			√	√
M15-B	Monkton	Very High			√	√		√	√	√
M15-A	Hinesburg	High	√	√	√	√				
M14	Hinesburg	Low								

5.2 Planting Stream Buffers

Forested riparian buffers serve to improve water quality and contribute to greater flow and sediment attenuation in the floodplain. They will also help to restore and maintain dynamic equilibrium of the channel by increasing resistance to boundary shear stresses along the channel margins. Tree buffers will

provide the additional benefits of organic matter, detritus, and LWD recruitment for aquatic and riparian habitats, as well as increased shading to reduce river temperatures. Connectivity of buffer areas from reach to reach along a river network is also supportive of mammalian terrestrial habitats by providing wildlife corridors. According to VTANR guidance (2007), highest priority for buffer plantings should be given to high sensitivity reaches that are vertically stable. Lower priority is assigned to reaches/segments that are expected to undergo continued, substantial planform adjustments (such as at points of reduced valley slope [M17-C] or in segments that are located downstream of major sediment sources [M15-B]). Table 18 summarizes reaches/segments in the corridor where planting of buffers is recommended, provides rationale and lists relative priorities. It will take some time for trees to establish, and sediment loading from eroding banks will continue in the short term until the vegetation matures and takes hold. However, as long as floodplain connection is maintained, suspended sediments can be attenuated in the corridor floodplain (e.g., M17-B, M17-A, M16). Corridor protection efforts will ensure that no infrastructure continues to be at risk from lateral adjusting channel. In the short term, sediment from these stabilizing banks may serve a useful purpose in the re-establishment of the incipient floodplain of downstream segment M15-B.

Table 18. Buffer planting opportunities in the Lewis Creek corridor reaches

Reach / Segment	Town	Priority	Stability: Mark corridor boundary (ST)	Stability: slow lateral channel migration and reduce erosion (ST)	Stability: accompany a stream stabilization or incised restoration project (ST)	Stability: Provide LWD recruitment (LT)	Stability: increase roughness along channel margins (ST, LT)	Water Quality: increase shading, attenuate nutrients and sediments (ST, LT)	Habitat: increase shading, provide detritus, and LWD (ST, LT)
M18	Starksboro	Low					√	√	√
M17-C	Starksboro	Low			√		√	√	√
M17-B	Starksboro	Mod	√	√		√	√	√	√
M17-A	Starksboro	Mod	√	√		√	√	√	√
M16	Starksboro	Mod	√	√		√	√	√	√
M15-B	Monkton	Low			√		√	√	√
M15-A	Hinesburg	Low					√	√	√
M14	Hinesburg	Low					√	√	√

Abbreviations: ST = short term; LT = long term.

Associated with buffer restoration in select watershed reaches is the exclusion of livestock to reduce channel trampling and allow trees and other native species to re-vegetate the channel margins. Opportunities for livestock exclusion in the Lewis Creek corridor reaches include the following reaches / segments (both high priority):

Table 19. Livestock Exclusion Opportunities in the Lewis Creek corridor reaches

Reach / Segment	Town
M17-A	Starksboro
M16 *	Starksboro

* Note: cattle excluded in 2007.

5.3 Stabilizing Stream Banks

Streambank stabilization can be considered in “laterally-unstable, [but vertically stable] reaches where human-placed structures are at high risk and not taking action may result in increased risk of erosion, to not only the structure, but lands that would provide the opportunity to establish a buffer” (VTANR, 2007). Any bank stabilization project should be considered in the broader context (both in time and space) for the channel adjustment processes such management will set in motion and for the consequences to upstream and downstream reaches.

Table 20. Potential Streambank Stabilization Site on the Lewis Creek corridor reaches

Reach/ Seg	M15-A
Location	Right bank near downstream end of segment, Monkton parcel 12-01-38.000 (see Appendix B for location and further description).
Rationale	Protect residential buildings within 50 feet of the laterally adjusting channel.
Description	Install toe armoring, and bioengineering over the top of bank.
Priority	Low. The landowner initiated streambank stabilization in 2006 separate from this corridor planning project. Additional efforts could include re-establishment of woody buffer – with landowner willingness.
Other Considerations	Accompanied by corridor protection (see Section 5.1); accompanied by reduction of sediment loading in the upstream watershed (Section 5.9)

5.4 Arresting Head Cuts and Nick Points

No head cut sites or sections of actively incising channel were noted in the corridor reaches M18 through M14.

5.5 Removing Berms / Other Constraints to Flood & Sediment Load Attenuation

Removing berms or other constraints to the full meander expression and floodplain connection of a river channel may accelerate a return to dynamic equilibrium in the channel, and reduce impacts to downstream segments, by creating more opportunities for sediment and flow attenuation along the corridor. Further study is necessary to evaluate the feasibility of various active geomorphic and engineering techniques. The benefits of such projects would need to be evaluated in light of the costs and potential short-term consequences in terms of sediment and nutrient mobilization, and risk to infrastructure and public safety.

Table 21. Potential Berm Removal / Floodplain Reconnection Site on the Lewis Creek corridor reaches

Reach/ Seg	M17-C
Location	Right bank, downstream of States Prison Hollow Road Extension; Starksboro parcel C131W
Rationale	Restore floodplain access and remove constraints to full meander expression for increased flow and sediment load attenuation
Description	Evaluate the feasibility of active geomorphic measures (e.g., lowering elevation of near-bank areas) where berms/armoring presently constrain the channel and limit floodplain access.

Priority	Low. Restoration segment is short; ample floodplain access and sediment/flow attenuation opportunities are present immediately downstream in segment M17-B. Thus, cost/benefit ratio of active floodplain restoration in downstream half of M17-C would be relatively high.
Other Considerations	Accompanied by restoration of incised condition (see Section 5.7); accompanied by corridor protection (see Section 5.1)

5.6 Removing / Replacing Structures

Human-placed structures which span and “constrain the vertical and lateral movement of the channel and/or result in a significant constriction of the floodplain” can be considered for removal or replacement to support dynamic equilibrium of the channel.

5.6.1 Old Abutments

Remaining abutments for derelict or unused bridges can continue to constrict channel flows, constrain lateral adjustment of the channel, and contribute to aggradation (generally upstream) or scour (at or downstream) local to the structure. Where these abutments contribute to the formation of debris jams, they may initiate channel avulsion.

Table 22. Potential Old Abutment Removal
Lewis Creek corridor reaches

Reach / Segment	Town	Former Road Alignment	Road Class	Constriction Status	Replacement Priority
M17-C	Starksboro	States Prison Hollow Rd		BKFL	High

Abbreviations: BKFL = Bankfull Width constrictor; FPW = Flood-prone-width constrictor.

5.6.2 Bridges and Culverts

Several bridge crossings are present on corridor reaches M18 through M14. Their status as either a bankfull or flood-prone-width constrictor is summarized in Table 23 (see also reach maps in Appendix A). These data can be utilized by landowners, town road crews and regional planning commissions when establishing schedules and budgets for crossing rehabilitation and replacement. Additional watershed- and town-scale strategies for installation and maintenance of bridge and culvert structures are discussed in Section 6.2.6.

Table 23. Potential Bridge & Culvert Structure Replacements
Lewis Creek corridor reaches

Reach / Segment	Town	Road	Road Class	Constriction Status	Replacement Priority
M18	Starksboro	States Prison Hollow Rd	2	FPW	Low
M17-C	Starksboro	States Prison Hollow Rd Extension	3	FPW	Low
M17-B	Starksboro	Private farm lane	Private	BKFL	High
M17-A	Starksboro	Private farm lane	Private	BKFL	High
M15-B	Monkton	Tyler Bridge Road	2	BKFL	Moderate
M14	Hinesburg	Turkey Lane	3	BKFL	Moderate

Abbreviations: BKFL = Bankfull Width constrictor; FPW = Flood-prone-width constrictor.

5.7 Restoring Incised Reaches

Restoring incised reaches may accelerate a return to dynamic equilibrium of the channel, and reduce impacts to downstream segments, by creating more opportunities for sediment and flow attenuation along the corridor. Further study is required to evaluate the feasibility of various active geomorphic and engineering techniques for restoring incised reaches. The benefits of such active geomorphic measures would need to be evaluated in light of the costs, risks and potential short-term consequences in terms of sediment and nutrient mobilization.

Based on the Phase 2 geomorphic assessments in the Lewis Creek corridor reaches to date, one possible incised-reach candidate for restoration is the downstream half of the historically incised segment M17-C. While close encroachment by residential buildings, berms and the States Prison Hollow Extension Road would significantly limit the feasibility of restoration in the upstream half of this segment, the lower half (downstream of States Prison Hollow Road Ext) could be restored to reconnect the channel to the surrounding floodplain. The low-profile berm along the right-bank hay field could be removed, and floodplain connection could be restored through a combination of structures to induce channel-bed aggradation and/or excavation to lower the elevation of the right top of bank. The cost / benefit ratio of such an active restoration process is likely to be high, considering that this section of segment M17-C is rather short in length, and that ample floodplain access is achieved in the next downstream segment (M17-B) where approximately 1.6 miles of channel and contiguous wetlands offer significant flow and fine sediment attenuation. Thus, this potential berm removal / floodplain reconnection project has been assigned a Low priority (Table 24).

Table 24. Potential Active Restoration of Incised Reach on the Lewis Creek corridor reaches

Reach/ Seg	M17-C
Location	Right bank, downstream of States Prison Hollow Road Extension; Starksboro parcel C131W
Rationale	Restore floodplain access and remove constraints to full meander expression for increased flow and sediment load attenuation
Description	Evaluate the feasibility of active geomorphic measures (e.g., lowering elevation of near-bank areas) and/or adding structures to locally aggrade the channel.
Priority	Low. Restoration segment is short; ample floodplain access and sediment/flow attenuation opportunities are present immediately downstream in segment M17-B. Thus, cost/benefit ratio of active measures to restore floodplain access in downstream half of M17-C would be relatively high.
Other Considerations	Accompanied by removal of right-bank berm (see Section 5.5); accompanied by corridor protection (see Section 5.1)

5.8 Restoring Aggraded Reaches

Further study could evaluate the feasibility of various active geomorphic and engineering techniques to restore aggraded reaches which could accelerate a return to dynamic equilibrium of the channel, by restoring equilibrium of sediment transport processes. The benefits of such active geomorphic measures would need to be evaluated in light of the costs, risks and potential short-term consequences in terms of sediment and nutrient mobilization. No aggraded reach candidates for active restoration were identified in the Lewis Creek corridor.

5.9 Other Related Projects

5.9.1 Mitigating Point Sources of Increased Sediment Loading

Gullies

Gullying along perennial or ephemeral tributaries draining to the corridor can be a significant source of fine and coarse sediment (and nutrients) to the corridor reaches. Pending landowner permission, site reconnaissance and evaluation is required to establish the governing factors in gully development. Further study would characterize the feasibility of various active geomorphic and engineering techniques to control the driving forces and stabilize the gully.

Table 25. Potential Gully Restoration Site on the Lewis Creek corridor reaches

Reach/ Seg	M17-B
Location	Left bank, just upstream of Tyler Bridge Road bridge; draining from residential lands across a driveway and across lands of the Cobble Creek tree nursery at Monkton Padua parcel.
Rationale	Reduce point sources of sediment runoff to the Lewis Creek.
Description	Evaluate the driving factors behind formation of the gully, including blockage of undersized culvert under a nearby residential driveway, and increased stormwater runoff.
Priority	High. Left untreated, headcutting in the channel could progress headward and destabilize driveway and agricultural soils with an expected nutrient legacy. If stabilized sooner than later, the cost/benefit ratio of restoration measures will be relatively low.
Other Considerations	Accompanied by corridor protection (see Section 5.1)

Unauthorized dredging on tributaries

Periodic unauthorized (unpermitted) dredging, channelization, berming and gravel extraction along Hollow Brook has occurred in recent years. These actions appear to have been motivated by the desire on the part of a landowner to protect his house constructed within 10 feet of the Hollow Brook. These activities are suspected of contributing to sedimentation of the Hollow Brook and Lewis Creek in vicinity of the confluence (segment M15-B).

Restoration of the channel in Hollow Brook, accompanied by potential wetland restoration could be addressed in future corridor planning activities focused on the Hollow Brook.

Meanwhile, the town of Starksboro should consider working with partners (such as the Lewis Creek Association, Addison County RPC, and VTDEC River Management Section) to carry out educational programs to increase awareness of permit requirements for stream alteration, stream crossings, and gravel extraction. Also, low-impact development practices, and enhanced zoning regulations (involving stream setbacks, buffers, or FEH overlay districts) would help to ensure that future homes are not located within the channel migration zone of the Lewis Creek and its major tributaries (see Section 6.2).

5.9.2 Mitigating Increased Flows

Restoration of channel-contiguous wetlands

Restoration of channel-contiguous wetlands can increase the flow and sediment attenuation role of the riparian areas surrounding the corridor reaches. The following are High priority sites for active wetland restoration.

Table 26. Potential Wetland Restoration Sites on the Lewis Creek corridor reaches

Reach/ Seg	M17-B	M17-A
Location	Left bank, downstream of States Prison Hollow Road Extension; Starksboro parcel C131W – Hansen Farm	Both banks, west of VT Route 116; Starksboro parcel B211614W – Kelly Farm
Rationale	Restore wetland functions contiguous to the Lewis Creek for increased flow and sediment (nutrient) attenuation.	
Description	Evaluate the feasibility of active and/or passive measures to restore riparian wetland functions. Hydric soils are mapped on the parcel – no NWI wetlands (prior converted). Extensive NWI wetlands are mapped on immediately adjacent properties – areas which could serve as a local model and source for restoration species.	
Priority	High (Area minimally disturbed)	High (Area in active pasture)
Other Considerations	Accompanied by corridor protection (see Section 5.1)	

In addition, *passive* restoration and conservation measures are recommended for several sites of channel-contiguous wetlands listed in Table 27.

6.0 PROJECT DEVELOPMENT

This section builds on the *Projects and Practices Table* presented in Section 5.0 and documents the status of various project development activities completed to date within the Lewis Creek corridor, reaches M14 through M18. Specific projects have been identified on both the site or reach scale (Section 6.1) and at the watershed scale (Section 6.2) and are further described in the sections below. Project development to date has involved partners at the citizen level, as well as town, regional, and state organizations. Many resources are available to convert these project opportunities into action. Appendix D provides a listing of some of these resources.

6.1 Site/Reach – Level Management Alternatives

Based upon the stream conditions summarized in Sections 4 and 5, and feedback obtained from public outreach events and landowner meetings, site-level and reach-level projects have been identified in the following *Project and Strategy Summary Table* (Table 27). Various local, regional, state and federal agencies are available as project partners to provide financial and technical resource support for identified projects (see listing under Section 5.0). Appendix D provides a key to the abbreviations under potential partners in Table 27.

In accordance with VTANR guidance (2007), the identified projects are designed to meet the following goals with regard to technical feasibility:

1. The overall project or activity contributes to and accommodates stream equilibrium conditions.
2. The project alternative chosen, at least in the long-term, results in an overall reduction of sediment and nutrient production from within the river corridor and increases sediment and nutrient storage in the watershed.
3. If the project is completed, there is little likelihood that it will fail because of unmitigated constraints or anticipated channel adjustment processes in the river reach or in the watershed.
4. The project will not lead or contribute to disequilibrium in upstream or downstream reaches.
(VTANR, 1 June 2007, draft guidance)

Technically-feasible projects were prioritized based on landowner approval, gross measures of cost (low, medium, high), and the extent to which each project addressed the primary objectives of equilibrium restoration, and sediment and nutrient reduction in the watershed.

Results of landowner outreach efforts in Appendix B provide more details as to the status of landowner concerns, degree of willingness to further develop identified projects, and/or the degree of agreement with the principles put forth in this corridor plan.

Table 27. Project and Summary Strategy Table.

Reach / Segment; Condition	Site Description	Project Description	Technical Feasibility	Priority	Other Social Benefits	Cost	Landowner Approval	Potential Partners - Programs
1 M17-C RGA: Fair; Sens: VH C4-R/P IR = 1.4 CES: III (F)	Starksboro - various properties States Prison Hollow Extension Residential lots are at risk of fluvial erosion hazards, similar to those experienced in the 1938 flood (documented in Bertha's Book: A History of Starksboro). Inundation flooding is also a risk. FEMA-FIRM maps do not represent areas at risk of fluvial erosion hazard.	Fluvial erosion hazard planning. Work with Town of Starksboro to communicate fluvial erosion hazard risks to landowner(s). Consider adoption of fluvial erosion hazard overlay district in town zoning to prevent future development at this high-hazard location. Incorporate erosion hazards of this location in the Addison County All-Hazards Mitigation Plan (and Starksboro Annex). Develop plans for emergency response to this area in the event of flooding. River Corridor Protection.	High	Very High	Public safety. Historical record.	Low	Unknown	Town of Starksboro Lewis Creek Assoc VTDEC RMS ACRPC
2 M17-C RGA: Fair; Sens: VH C4-R/P IR = 1.4 CES: III (F)	Starksboro Tax Parcel: xxxxxxxx States Prison Hollow Extension Old bridge abutments for former alignment of States Prison Hollow Road have a constricting span (less than bankfull width). Debris jams at this constriction could initiate a channel avulsion to the north which could put at risk residential homes in the area.	Remove old bridge abutments. Determine ownership of / responsibility for old abutments through review of parcel mapping, grand list and land records. Assess potential consequences of abutment removal on the sediment transport continuity of the Lewis Creek and local erosion / deposition cycles. Work with landowner(s) and/or Town of Starksboro to develop a plan for removal of the abutments.	High	High		Mod	Unknown	Town of Starksboro Lewis Creek Assoc VTDEC RMS ACRPC
3 M17-C RGA: Fair; Sens: VH C4-R/P IR = 1.4 CES: III (F)	Starksboro Tax Parcel: C131W States Prison Hollow Extension downstream of the bridge, right bank Past channelization, armoring, and berming have resulted in historic incision (IR = 1.4) of the channel now pinned between the forested valley wall along left bank and hay field along right bank.	Consider berm removal and active or passive restoration of the incised channel. Assess potential consequences of berm removal and active floodplain restoration on the sediment and nutrient loading to Lewis Creek.	Mod	Low (High cost to benefit ratio)		High	Unknown	Lewis Creek Assoc VTDEC RMS USFW - Partners USDA - CRP, EQIP
4 M17-B RGA: Good; Sens: High E4-R/P IR = 1.0 CES: IV (F) Attenuation Asset	Starksboro Tax Parcel: C131W north of States Prison Hollow; west side of river bordering Town of Starksboro Northern Riparian Parcel Channel has good floodplain connection; rebuilding meanders following past channelization / armoring. Channel-contiguous wetlands mapped to the north; hydric soils underlie subject	Protect River Corridor - possible limited term or permanent corridor easement. Support a return to reference sinuosity, enhanced sediment attenuation function, and protect floodplain access through reestablishment of woody buffers.	High	High	Educational Recreational (enhanced access to and protection of Northern Riparian Parcel)	Mod	Unknown	Town of Starksboro VTDEC RMS, WS Lewis Creek Assoc USDA-WHIP
		Potential Wetlands Restoration	Mod	High		High	Unknown	USFW - Partners
		Plant Stream Buffers	High	Mod		Low	Unknown	USDA - CRP, EQIP VTAA - CREP, BMPs

Table 27. Project and Summary Strategy Table. (Continued)

Reach / Segment; Condition	Site Description	Project Description	Technical Feasibility	Priority	Other Social Benefits	Cost	Landowner Approval	Potential Partners - Programs
5 M17-B RGA: Good; Sens: High E4-R/P IR = 1.0 CES: IV (F) Attenuation Asset	Town of Starksboro Northern Riparian Parcel (conserved) Channel has good floodplain connection; rebuilding meanders following past channelization / armoring. Channel-contiguous wetlands and hydric soils mapped at subject parcel.	Protect River Corridor - possible limited term or permanent corridor easement. Support a return to reference sinuosity, enhanced sediment attenuation function, and protect floodplain access and flow attenuation functions.	High	High	Educational Recreational Wildlife (enhanced protection of Northern Riparian Parcel)	Mod	Already Conserved	Town of Starksboro VTDEC RMS, WS Lewis Creek Assoc Vermont Land Trust
		Wetlands Conservation / Restoration (passive)	High	High		Mod	Conserved	USFW - Partners
		Plant Stream Buffers	High	Mod		Low	Possible	
		Review existing conservation management plan to ensure protection of river corridor and flow / sediment attenuation functions. (See Appendix C).	High	High		Low	Willing	
6 M17-B RGA: Good; Sens: High E4-R/P IR = 1.0 CES: IV (F) Attenuation Asset	Starksboro Parcel: C21163AW1 LaRue Channel has good floodplain connection. Channel-contiguous wetlands and hydric soils mapped at subject parcel. Normal streambank erosion associated with meander translation. Localized sedimentation / widening at beaver dams. Bankfull-constricting farm bridge has been the site of past debris jams; sediment deposition has occurred upstream, and scour downstream.	Protect River Corridor - possible limited term or permanent corridor easement. Protect floodplain access and flow and sediment (and possible nutrient) attenuation functions.	High	High	Wildlife Habitat connectivity	Mod	Interested in learning more	Lewis Creek Assoc VTDEC RMS, WS Vermont Land Trust Vermont Rivers Cons
		Wetlands Conservation	High	High		Mod	Possible	USFW - Partners
		Plant Stream Buffers	High	Mod		Low	Possible	USDA - CRP, EQIP VTAA - CREP, BMPs
		Replace Undersized (and Collapsed) Farm Bridge	High	High		Mod	Possible	
7 M17-B RGA: Good; Sens: High E4-R/P IR = 1.0 CES: IV (F) Attenuation Asset	Starksboro Parcel: C2116L1N Lallo Channel has good floodplain connection. Channel-contiguous wetlands and hydric soils mapped at subject parcel. Normal streambank erosion associated with meander translation. Localized sedimentation / widening at beaver dams.	Protect River Corridor - possible limited term or permanent corridor easement. Protect floodplain access and flow and sediment (and possible nutrient) attenuation functions.	High	High	Wildlife Habitat connectivity	Mod	Unknown	Lewis Creek Assoc VTDEC RMS, WS Vermont Land Trust Vermont Rivers Cons
		Wetlands Conservation	High	High		Mod	Unknown	USFW - Partners
		Plant Stream Buffers	High	Mod		Low	Unknown	
8 M17-A RGA: Good; Sens: High E4-R/P IR = 1.25 CES: I (F) Attenuation Asset	Starksboro Parcel: B211614W Kelly Channel has good floodplain connection. Channel-contiguous wetlands and hydric soils mapped at subject parcel. Normal streambank erosion associated with meander translation. Localized sedimentation / widening at beaver dams. Bankfull-constricting farm bridge. Livestock are pastured with direct access to stream.	Protect River Corridor - possible limited term or permanent corridor easement. Protect floodplain access and flow and sediment (and possible nutrient) attenuation functions.	High	High	Wildlife Habitat connectivity	Mod	Unknown	Lewis Creek Assoc VTDEC RMS, WS Vermont Land Trust Vermont Rivers Cons
		Wetlands Conservation	High	High		Mod	Unknown	USFW - Partners
		Plant Stream Buffers	High	Mod	Improved Water Quality	Low	Unknown	USDA - CRP, EQIP
		Exclude Livestock	High	High		Low	Unknown	USDA-WHIP
		Replace Undersized (and Collapsed) Farm Bridge	High	High		Mod	Unknown	VTAA - CREP, BMPs

Table 27. Project and Summary Strategy Table. (Continued)

Reach / Segment; Condition	Site Description	Project Description	Technical Feasibility	Priority	Other Social Benefits	Cost	Landowner Approval	Potential Partners - Programs
9 M16 RGA: Fair; Sens: VH C4-R/P IR = 1.16 CES: III (F) Attenuation Asset	Starksboro Parcel: B21166E Clifford Channel has reasonable floodplain connection. Channel-contiguous wetlands and hydric soils mapped at subject parcel. Channel is actively widening resulting in stream type departure from E to C. Localized sedimentation / widening at beaver dams. Livestock pastured with direct access to stream (until 2007).	Protect River Corridor - possible limited term easement. Restore floodplain access and protect flow and sediment (and possible nutrient) attenuation functions.	High	Very High	Wildlife Habitat connectivity	Mod	Crop setbacks, buffer plantings 2006-2007	Lewis Creek Assoc VTDEC RMS, WS Vermont Land Trust Vermont Rivers Cons USFW - Partners
		Potential Wetlands Restoration	Mod	Mod	Improved Water Quality	High	Unknown	USDA - CRP, EQIP
		Plant Stream Buffers	High	Mod	Water Quality	Low	Continue	USDA-WHIP
		Exclude Livestock	High	High	Water Quality	Low	Done 2007	VTAA - CREP, BMPs
10 M15-B RGA: Fair; Sens: VH C4-R/P IR = 1.6 CES: IV (F)	Starksboro Parcel: B25L5S Monkton Parcels: 206-10 and 206-20.4 Padua (tree nursery) Channel has limited floodplain access. Historic incision related to inferred past channelization. Building incipient floodplain at lower elevation through localized widening and planform adjustment facilitated by LWD recruitment and beaver activity. Floodprone-width-constricting bridge - Tyler Bridge Rd. Left-bank ephemeral tributary receiving stormwater runoff from local residences and the tree nursery has formed an erosional gully near confluence with Lewis Creek.	Protect River Corridor - possible limited term or permanent corridor easement. Support passive restoration of floodplain access and flow and sediment (and possible nutrient) attenuation functions.	High	Very High	Wildlife Habitat connectivity	Mod	Interested	Lewis Creek Assoc VTDEC RMS, WS Vermont Land Trust Vermont Rivers Cons USFW - Partners
		Potential Wetlands Restoration - ephemeral trib	High	Low	Improved Water Quality	Mod	Unknown	USFW - Partners
		Evaluate Gully Formation and Stabilize - ephemeral trib	High	High	Water Quality	Mod	Interested	USDA - CRP, EQIP USDA-WHIP VTAA - CREP, BMPs
11 M15-B RGA: Fair; Sens: VH C4-R/P IR = 1.6 CES: IV (F)	Multiple Landowners Monkton, Hinesburg Channel has limited floodplain access. Historic incision related to inferred past channelization. Building incipient floodplain at lower elevation through localized widening and planform adjustment facilitated by LWD recruitment and beaver activity. Floodprone-width-constricting bridge - Tyler Bridge Rd.	Protect River Corridor - possible limited term or permanent corridor easement. Support passive restoration of floodplain access and flow and sediment (and possible nutrient) attenuation functions.	High	Very High	Wildlife Habitat connectivity, Improved Water Quality,	Mod	Interested	Lewis Creek Assoc VTDEC RMS, WS Vermont Land Trust Vermont Rivers Cons USFW - Partners
		Wetlands Conservation - especially abandoned meander bend to north of channel	High	High	Access to public trail off Tyler Bridge Rd.	Mod	Possible	USFW - Partners
11 M15-A RGA: Fair; Sens: VH E4-R/P IR = 1.0 CES: IV (F) Attenuation Asset	Multiple Landowners Monkton, Hinesburg Channel has good floodplain connection and very few encroachments; rebuilding meanders following limited past channelization. Channel-contiguous wetlands and hydric soils.	Protect River Corridor - possible limited term or permanent corridor easement. Support passive restoration of floodplain access and flow and sediment (and possible nutrient) attenuation functions.	High	High	Wildlife Habitat connectivity, Improved Water Quality,	Mod	Already Conserved	Lewis Creek Assoc VTDEC RMS, WS Vermont Land Trust Vermont Rivers Cons USFW - Partners
		Wetlands Conservation / Restoration (passive)	High	High	Access to public trail off Tyler Bridge Rd.	Mod	Conserved	USFW - Partners
		Plant Stream Buffers	High	Mod	Water Quality	Low	Possible	
		Review existing conservation management plan for Copp/Welch I parcel to ensure protection of river corridor and flow / sediment attenuation functions. (See Appendix C).	High	High	Water Quality	Low	Willing	

Table 27. Project and Summary Strategy Table. (Continued)

Reach / Segment; Condition	Site Description	Project Description	Technical Feasibility	Priority	Other Social Benefits	Cost	Landowner Approval	Potential Partners - Programs
12 M15-A RGA: Fair; Sens: VH E4-R/P IR = 1.0 CES: IV (F) Attenuation Asset	Hinesburg Tax Parcel: 12-01-38.000 Lorance Substantial planform adjustment and aggradation related to upstream and tributary sources of sediment, exacerbated by minimal tree buffers and a downstream constriction (reach M14) where the channel transitions into a bedrock-controlled, semi-confined valley setting. Laterally adjusting channel within 50 feet of residential buildings. Streambank armoring installed by landowner in 2006.	Streambank stabilization. Enhance buffer with larger tree plantings between the top of bank and the house to increase longterm protection of house in the event of armoring failure.	High	High		Low	Unknown	Lewis Creek Assoc
13 M18 M17-C M15-B M14	States Prison Hollow Rd (FPW) States Prison Hollow Ext (FPW) Tyler Bridge Road (BKFL) Turkey Lane (BKFL)	Bridge Replacement. At next opportunity with wider span and higher clearance to reduce constriction of the Lewis Creek.	Mod	Low		High	N/A - Town initiative	Towns of Starksboro, Monkton, Hinesbug ACRPC Vtrans
14 M18 M17-C M15-B M15-A M14	Various residential buildings Starksboro, Hinesburg, Monkton	Fluvial erosion hazard planning. Work with Towns to communicate fluvial erosion hazard risks to landowner(s). Consider adoption of fluvial erosion hazard overlay district in town zoning to prevent future development in the river corridor. Incorporate erosion hazards of these locations in the Addison County and Chittenden County All-Hazards Mitigation Plans (and town Annex).	High	High	Public safety	Low	N/A - Town initiative	Towns of Starksboro, Monkton, Hinesbug ACRPC, CCRPC Lewis Creek Assoc VTDEC RMS

6.2 Watershed-Level Management Strategies

The following sections identify watershed-level management strategies that should be undertaken to achieve nutrient / sediment reductions, reduce potential for future fluvial erosion hazards, and restore and conserve riparian habitats. Reductions in sediment loading are especially critical in the upstream watershed areas of Starksboro (reaches M19 – M26, and their respective tributaries) and in the watershed draining to Hollow Brook (T4.01) which enters reach M15. Corridor planning activities are ongoing in reaches M19 through M22 – under a previously completed corridor plan.

Watershed-level management strategies are a combination of regulatory and nonregulatory approaches. Since the Lewis Creek and its tributaries cross town boundaries, and many issues of river corridor management are shared by the watershed towns, efficiency can be gained by inter-town cooperation for certain education and outreach tasks. Partners available to provide technical and financial resource support for watershed-level strategies include the same listed under Section 5.0.

To enable the watershed-level strategies discussed below, as well as the relevant site-specific projects recommended in Section 6.1, towns should include the appropriate enabling language in next updates to their respective Town Plans.

6.2.1 Town Planning Incorporating Fluvial Erosion Hazards

The present degree of residential / commercial development along the Lewis Creek corridor is relatively minor. This presents the opportunity for communities to discuss the hazards associated with fluvial erosion along the river corridor and to incorporate geomorphic data into town plans and zoning documents. A proactive planning process can support the river's ability to move toward an equilibrium condition and reduce losses and expensive repairs in future flood events. Planning efforts can include "avoidance" strategies to ensure that new development does not further encroach on the river corridor, reduce the sediment and flow attenuation functions of the floodplain area, and place infrastructure at risk of fluvial erosion losses. Currently, funding and technical resources are available to the town through Addison County and Chittenden County Regional Planning Commissions (FEMA Pre-Disaster-Mitigation funds) as well as VTDEC River Management Section to support a public planning process to review the possible role of a corridor overlay district in town planning and to develop a viable draft ordinance for public review.

A river corridor management area that acknowledges the dynamic nature of rivers and which is based on the geomorphic condition of the channel has advantages over a simple, no-build setback from the river. River channels vary in width along their length, depending on the size and nature of the upstream watershed draining to a given location, and the valley setting of the channel. Rivers are also continuously adjusting their position in the landscape, both vertically and laterally, in an attempt to optimize their slope and channel dimensions to efficiently carry the water and sediment loads supplied from the upstream watershed. A default setback is often inadequate and difficult to administer where a river is adjusting laterally at a rate of several feet per year.

A river corridor is a footprint in the landscape, which encompasses the dynamically-adjusting river channel. The corridor varies in width along its length, accounting for the actual width of the river channel at various locations, the size and nature of the watershed draining to that particular reach, the sensitivity of the reach (Section 4.2), knowledge of historic migration patterns of the river, and the position of the valley walls adjacent to the channel.

Definitions

Setback – a specified distance perpendicular to a channel or waterbody, in which specific standards are established concerning structures, land use activities, and/or vegetative conditions. For example, setbacks could be established to prevent new structures adjacent to waterways. While new structures would not be allowed, the area of land within the setback could be considered to count toward density requirements under zoning.

Buffer – zone of undisturbed natural vegetation alongside a channel or waterbody, in which no new structures are permitted, and disturbance of the natural land surface is minimized. The vegetated buffer represents a transition zone which functions to protect the waterway from disturbances and adjacent land uses. Buffers can be established at a default distance perpendicular to the channel or waterbody. Ideally, for rivers and streams, buffer distances should be informed by geomorphic assessments, and will be wider for adjusting reaches, narrower for stable reaches (e.g., following VTANR Riparian Buffer Guidance).

Overlay District – an area of variable size and width surrounding a channel or waterbody, in which specific standards are established concerning structures, land use activities, and/or vegetative conditions. Overlay Districts are informed by geomorphic assessments and developed to meet specific functions, such as reducing streambank erosion losses and reducing sediment and nutrient loading to receiving waters by managing toward the equilibrium channel.

A river corridor overlay district with the objective of reducing fluvial erosion hazards can be developed for the towns of Starksboro (M18 through M15-B), Monkton (M15-B and M15-A) and Hinesburg (M15-A and M14). Generally, speaking this corridor delineation method relies on the meander belt-width concept as outlined in the following fact sheets:

River Corridor Protection and Management: Fact Sheet #1

http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rcprotectmanagefactsheet.pdf
(VTDEC River Management Program, 2005a)

Defining River Corridors: Fact Sheet #2.

http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_definingrcfactsheet.pdf
(VTDEC River Management Program, 2005b)

Technical Guidance for Determining Floodway Limits Pursuant to Act 250 Criterion 1(D).

http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_floodwaytechguidance.pdf
(VT Agency of Natural Resources, May 2003)

A meander belt is defined by connecting the outside point of meander bends along the left and right banks of a channel. In a river system in dynamic equilibrium that has not been subjected to intensive floodplain encroachment and channel management, the meanders will theoretically have full expression, and connecting the outside points of each meander will approximate an area which is subject to erosion hazards as the river channel migrates laterally and longitudinally through time.

Since many of Vermont's streams have been channelized and straightened with the meanders removed or significantly reduced in amplitude, connecting the points at the outside edge of these straightened meanders would result in a narrow "meander belt" that was insufficient in width to describe the area at risk of future lateral adjustments. Therefore, Vermont guidance calls for the meander belt width to be buffered at a specified distance off the meander center line. The meander center line, is a line connecting each successive meander cross-over point, proceeding down-valley (see the above fact sheets for more detailed explanation).

The distance buffered off the meander center line is determined by the (1) approximate channel width in the reach and (2) by the present geomorphic condition and sensitivity of that reach to further adjustments. Channel widths and sensitivity ratings are determined during Phase 1 and Phase 2 Stream Geomorphic Assessments. The Sensitivity ranking (from Very Low to Extreme) is dependent on the stream type (e.g., steep, narrow channels in mountainous settings versus shallow, meandering channels in broader valley settings) and the geomorphic condition of the reach (Reference, Minor Adjustment, Major Adjustment, Stream Type Departure). Further details of the Phase 1 and 2 Stream Geomorphic Assessment protocols are available at:

http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm

Following VTDEC guidance documents, the reach Sensitivity is used to define a Fluvial Erosion Hazard rating from Very Low to Extreme. Depending on the Sensitivity (FEH) Rating, the channel is buffered to varying widths, which increase with increasing sensitivity (Table 28). In the Lewis Creek corridor, the unconfined reaches (M17 through M15) would have a meander belt width buffered at six times the channel width (due to sensitivity ratings ranging from High to Very High – see Section 4.2). The FEH corridor beltwidth for bedrock gorge reach M18 would be equal to the reference channel width due to the Very Low sensitivity assigned to this reach. Reach M14 would have a beltwidth of four times the channel width, based on the Moderate sensitivity rating of that reach.

Table 28. Belt Width Dimensions based on Geomorphic Sensitivity

FEH Rating (Sensitivity)	Belt Widths based on reference channel widths
Very Low	Equal to the reference channel width
Low	Equal to the reference channel width
Moderate	Four (4) channel widths
High	Six (6) channel widths
Very High	Six (6) channel widths
Extreme	Six (6) channel widths

*Reference: Vermont Fluvial Erosion Hazard Mitigation Program
VT DEC River Management Program, 2005d (14 February draft)*

The process of corridor delineation in GIS, as prescribed in VTANR protocols, will identify where the above meander belt width impinges on a valley wall. In those cases, the meander belt width is clipped to the valley wall and the clipped area is re-distributed to the opposite side of the channel (where available). In some cases, (e.g., in some sections of reach M14), the valley walls are so narrowly-confining, that the full dimension of the meander belt width is not expressed, and the corridor width may become defined by the left and right valley walls. The corridor delineation process also provides for manual adjustments of the corridor taking into account site-specific knowledge of channel migration zones or avulsion sites (e.g., in M15, M16 – Figures 10, 11, and 12) that may extend outside of the corridor generated based on regional hydraulic geometry relationships.

The meander belt width is a close *approximation* of the area surrounding an alluvial channel which is at risk of fluvial erosion hazards in the short term. To comprehensively map fluvial erosion hazard risk with greatest confidence and accuracy would require detailed survey work along the entire river section of interest; field-based evaluation of soil types, geotechnical properties and erodibilities; analysis of historic channel positions; as well as hydrologic and hydraulic modeling (FEMA, 2003; Rapp & Abbe, 2003). Such an intensive study would be cost-prohibitive for most towns, and such an endeavor Statewide would require resources beyond what is reasonably available at the present time.

The meander belt width provides a first approximation that can be quickly derived with reasonably limited resources. As suggested in *Defining River Corridors: Fact Sheet #2*, the belt-width derived corridors “provide an area within which channel adjustments may occur, in order to re-establish an equilibrium condition, and there can be a reasonable expectation that fluvial erosion hazards will be minimized” (VTDEC RMS, 2005b).

6.2.2 Buffers for waterways not covered by FEH Overlay District

At present, geomorphic data sufficient for the development of a Fluvial Erosion Hazard (FEH) overlay district exists for Lewis Creek main stem reaches through Starksboro, Monkton and Hinesburg (up to Turkey Lane, reach M14). Phase 2 geomorphic data also exist for select reaches of the Hollow Brook (T4.01) passing through Hinesburg and Starksboro. (Note that geomorphic data exist for portions of the LaPlatte River watershed in Hinesburg, and FEH corridors have been or will be mapped for select reaches under a separate project).

With additional Phase 2 geomorphic assessment, FEH corridors could be developed for the following major tributaries of the Lewis Creek watershed (in corridor towns Starksboro, Monkton, Hinesburg) that have been delineated in Phase 1 Stream Geomorphic Assessments:

- ◆ T2 – Cedar Lake tributary – Hinesburg, Monkton
 - ◆ T3 – Pond Brook tributary – Monkton, (Bristol)
 - ◆ T5 – Hogback Brook tributary - Starksboro
 - ◆ T6 - High Knob Brook tributary - Starksboro
 - ◆ T7 – Headwater tributary - Starksboro
- (Note: Some of these tributary sections are dominated by wetlands and/or lakes and impoundments - where FEH corridors are not applicable).*

Several additional tributaries exist and are small enough in size that complete geomorphic assessment is either not practical or affordable in the near term. Yet, protection of these smaller tributaries from encroachment, channelization, dredging, berming and other impacts is still critical to the overall watershed goals of mitigating for increased flows and sediment loading. While impacts to any one small tributary may be small in degree, impacts to several small-order tributaries can accumulate in the watershed to result in significant impacts to the Lewis Creek and its major tributaries.

For maximum protection of surface waters, towns can implement a combined approach of FEH corridors for larger waterways, and a default buffer for smaller tributaries. A minimal 50-foot setback maintained with natural vegetation (i.e., a buffer) is recommended by the VT Agency of Natural Resource buffer guidance. Table 29 summarizes current protections for surface waters in place under zoning regulations in the three corridor towns Starksboro, Monkton, and Hinesburg. Where appropriate, recommendations for more comprehensive protection are also offered.

6.2.3 Education / Outreach Regarding Management of Riparian Lands

Towns of Starksboro, Monkton and Hinesburg can implement a variety of educational programs or public forums, in partnership with other organizations, to improve management of riparian lands to reduce sediment and nutrient mobilization and prevent fluvial erosion losses.

Table 29. Summary of Stream / River Protections under Current Town Regulations, Corridor Towns

Town	Stream / River Protection	Ref	Recommendation
Starksboro	Stream Setbacks: 100 foot setback <i>unless</i> the applicant can demonstrate “no adverse effect” on the subject waterway. (No definition of “no adverse effect”).	1	Protection for streams/ rivers could be strengthened by removing the clause about demonstrating no adverse effect. Alternately, “adverse effect” could be more clearly defined, to be less subjective in nature. Protections for surface waters could also be increased by changing all or a portion of the setback dimension to a buffer. A simple no-build setback would still permit removal of native vegetation along the river banks, which can lead to bank de-stabilization and accelerated erosion. Naturally vegetated buffers filter sediment and nutrients from stormwater runoff, and attenuate flood flows.
Monkton	No setback or buffer protections are apparent in zoning regulations. Suggested riparian buffer widths, contingent upon size of the water body and slope of adjacent land, are offered for the protection of water quality and riparian habitat in the Wildlife Maintenance section (p.38) of the Town Plan. These suggested buffer widths range from 25 to 110 ft.	2	A regulated, appropriately-sized setback of new development from streams and rivers would provide protection against fluvial erosion hazard losses and would permit the channel to adjust unconstrained to equilibrium meander beltwidth, slope, and dimensions. Protections for surface waters could also be increased by changing all or a portion of the setback dimension to a buffer. Naturally vegetated buffers filter sediment and nutrients from stormwater runoff, and attenuate flood flows.
Hinesburg	Stream Setbacks: <i>All structures including accessory structures shall be set back a minimum of seventy five (75) feet from the top of bank of any stream or body of water Paved parking lots must also meet the seventy-five (75) foot setback requirement. The Development review board may provide relief to stream setbacks to allow for expansion of existing, non-complying structures and improvement of existing parking lots under conditional use review provided that the conditions listed below are satisfied. However, in all cases, sewage disposal systems shall be set back a minimum of fifty (50) feet from the top of bank of any stream or body of water excluding swimming pools.</i> 1. <i>Water quality and stream values shall be protected.</i> 2. <i>Structures shall not be located in a flood plain.</i> 3. <i>Expansion or improvements do not impact adjoining uses in any manner.</i>	3	Protection for streams/ rivers could be strengthened by a requirement that at least a portion of the setback dimension be maintained in a naturally vegetated state (i.e., buffer). A simple no-build setback would still permit removal of native vegetation along the river banks, which can lead to bank de-stabilization and accelerated erosion. Naturally vegetated buffers filter sediment and nutrients from stormwater runoff, and attenuate flood flows.

1. Starksboro Zoning Regulations, adopted March 1993, as amended July 6, 2006 – Section 2.14.
2. Monkton Zoning Regulations (current, no date provided); Monkton Development Plan, adopted September 2007.
3. Hinesburg Zoning Regulations, adopted November 7, 1972, as amended September 19, 2005 – Section 2.52.

Education / outreach topics may include:

- ◆ Stream Alteration – impacts and consequences, state and ACOE permit requirements.
- ◆ Stream Crossings – impacts and consequences of bridge and culvert crossings, proper sizing, state permit requirements.
- ◆ Gravel Extraction / Dredging - impacts and consequences, state and ACOE permit requirements.
- ◆ ATV use – discussion of local ordinances, restrictions on town-owned conserved parcels, review of state regulations.
- ◆ Stream Dynamics and the importance of managing toward dynamic equilibrium of river systems.
- ◆ Riparian Wildlife and the importance of buffer continuity along stream corridors.
- ◆ Flood Insurance Workshop (FEMA Flood Insurance Rating Maps in comparison to VTRMS Fluvial Erosion Hazard areas).

There are several public lands along the Lewis Creek corridor reaches which can serve as an outdoor classroom for communication and outreach to citizens of all three towns:

- ◆ In Starksboro, town-owned lands include: (1) the Ball Fields along States Prison Hollow Road (with kiosk and gazebo), (2) the Southern Riparian parcel and the nature trail leading south toward Starksboro village, and (3) the Northern Riparian parcel.
- ◆ In Monkton, a pending conservation project will result in a public-access nature trail leading along the north bank of the Lewis Creek from the Tyler Bridge Road bridge crossing.
- ◆ In Hinesburg, Copp/Welch I conservation lands provide for public access and non-motorized recreational use of 42.9 acres of land with approximately 2/3 mile frontage along Lewis Creek.

6.2.4 Additional Planning / Zoning Strategies to Mitigate Stormwater / Sediment Impacts

Towns can consider a variety of additional planning and zoning strategies to reduce stormwater and sediment runoff to the Lewis Creek and its tributaries, such as:

- ◆ Implement Low Impact Development techniques:
 - Establish or Increase Minimum Lot Sizes
 - Establish or Reduce Maximum Lot Coverages / Minimize Percent Impervious
 - Minimize land disturbance / compaction during construction
 - Prevent stormwater outfalls from crossing vegetated buffers and entering rivers and streams without treatment or energy dissipation.
 - Specify maximum road and driveway widths.
 - Review parking space ratios for minimum impacts.
- ◆ Incorporate practices for area-based zoning, transfer-of-development rights and clustering into zoning and subdivision regulations to encourage protection of river corridors.
- ◆ Add relevant language to zoning and subdivision regulations for protection against fluvial erosion hazards – Special Flood Hazard Area regulations established for floodways defined on FEMA-FIRM maps are designed to protect against inundation (rising water) flooding. These practices do not necessarily adequately protect against erosion hazards (or sudden streambank erosion, avulsion) during flooding events.

- ◆ Adopt Fluvial Erosion Hazard Corridor Overlay Districts – to avoid future development and encroachment of infrastructure within proximity to the adjusting river channel.
- ◆ Consider forested (vegetative) buffers and erosion control along tributaries and unnamed streams that are not covered by corridor plans and/or Fluvial Erosion Hazard overlay districts.
- ◆ Consider local-level stormwater ordinances for development projects that fall under the thresholds for triggering Act 250 review or the States Stormwater Management rule (e.g., Charlotte – ½ acre disturbed).
- ◆ Consider local road & driveway and bridge & culvert ordinances or review standards.

Grants are available from a variety of sources to provide the technical and financial resources to implement the above recommendations - such as Municipal Planning Grants from the VT Department of Housing & Community Affairs, and River Corridor Grants or VT Watershed Grants from the VT Water Quality Division (see Appendix D). Likely partners would include the Addison County Regional Planning Commission, Chittenden County Regional Planning Commission, and Lewis Creek Association.

6.2.5 Improved Road Maintenance Practices to Mitigate Stormwater/Sediment Impacts

Several stormwater runoff / road maintenance concerns were identified in the watersheds draining to the Lewis Creek corridor reaches. These sites contribute to the overall accumulation of sediments in the corridor from reaches M18 through M14.

Road maintenance practices to mitigate for stormwater and sediment runoff to the Lewis Creek and tributaries may include: stabilization of road surfaces (different gravel materials), improvement of roadside ditches (excavation, stone lining and/or seeding and mulching), alternative grading practices (turnouts, check-basins); re-orientation of culvert crossings; and culvert header protection. Project sites include but are not necessarily limited to:

Grants are available from the Better Back Roads program (see Appendix D). Likely partners would include the towns of Starksboro, Monkton and Hinesburg; the Better Back Roads program; the Addison County Regional Planning Commission; and the Chittenden County Regional Planning Commission.

6.2.6 Maintenance and Replacement of Crossing Structures

Undersized bridge crossing structures were identified as contributors to localized channel instabilities in the Lewis Creek corridor reaches (Table 15 and Section 5.6.2). Sediments mobilized at these undersized crossing structures are contributing to the aggradation noted in corridor reaches. Debris jams at a few of these structures have lead to channel scour and avulsions during past flood events.

For future development, the towns of Starksboro, Monkton and Hinesburg could establish ordinances or identify zoning requirements which would ensure adherence to proper siting and design practices for bridge and culvert crossings. The geomorphic context should be considered when designing new and rehabilitated structures within the watershed:

- New or replacement bridges and culverts should ideally have openings which pass the bankfull width without constriction. Bankfull widths and flood-prone widths have been measured during Phase 2 assessment for select main stem and tributary reaches in the Lewis Creek watershed; these data are available to the watershed towns for future crossing structure designs.

- Bridges and culverts should be designed to cross the river without creating channel approaches at an angle to structures. Such sharp angles can lead to undermining of fill materials and structural components.
- The historic channel migration pattern of the river should be considered when installing new or replacement crossing structures, and when constructing new roads, driveways, and buildings. Corridor protection strategies that prevent or limit placement of infrastructure within the corridor will protect structures from future erosion and flood losses.
- Planned build-out for watershed communities and resultant channel enlargement (from increased percent imperviousness) should be considered when designing new or replacement bridges and crossing structures.
- Road ditch runoff should be diverted to side-slopes where energy can be dissipated, stormwaters can infiltrate, and sediment / detritus loads can be deposited on the land and not directly to streams.

Potential funding sources to support public planning and development of such ordinances for crossing structures include: Better Back Roads grants, Municipal Planning Grants (VT Department of Housing and Community Affairs), or Vermont Watershed Grants (see Appendix D). Likely partners would include the towns of Starksboro, Monkton and Hinesburg; the Better Back Roads program; the Addison County Regional Planning Commission; and the Chittenden County Regional Planning Commission.

7.0 PLAN IMPLEMENTATION

Implementation of this River Corridor Plan will be achieved through both short-term and long-term approaches.

7.1 Short-term

7.1.1 Review of the draft plan by riverside landowners, town officials

In the Winter of 2008, this draft plan will be shared with riverside landowners as well as Starksboro, Monkton, and Hinesburg officials, including the Conservation Commissions, Planning Commissions and Selectboards. Feedback will be incorporated in a subsequent draft of the plan. Respective roles for continued stewardship of the plan will be determined through discussions with the relevant boards in each town.

7.1.2 Public review and comment / Education and Outreach

Once the draft plan has been reviewed by landowners and town officials, public meetings will be held to share the revised plan with area citizens. With the assistance of towns, the Lewis Creek Association will coordinate a public meeting(s) to obtain feedback on the plan.

7.1.3 Proceed with further development of a Fluvial Erosion Hazard corridor

The River Management Section, Lewis Creek Association, Addison County Regional Planning Commission, and Chittenden County Regional Planning Commission will continue to work with the towns of Starksboro, Monkton, and Hinesburg to review the possible role of a Fluvial Erosion Hazard Overlay District in town planning and zoning.

Technical and financial resources to support this process may be provided under FEMA Pre-Disaster Mitigation grant funds currently being administered by the CCRPC and the River Corridor Grants Program administered through the VTDEC (Governor’s Clean & Clear Program).

7.1.4 Proceed with identified projects

Pending available funding, the Lewis Creek Association will continue to reach out to landowners identified in Table 27 to develop identified river corridor protection strategies, in cooperation with appropriate resource agencies.

7.2 Longer-term

7.2.1 Town Plans

Each of the corridor towns (Starksboro, Monkton, Hinesburg) can consider enabling language in relevant sections (Land Use, Natural Resources) of their respective town plans to encourage consideration of fluvial erosion hazard mapping and zoning, buffers along smaller waterways, planning/zoning strategies for addressing stormwater impacts, and improved maintenance and rehabilitation practices for roads and crossing structures. Lewis Creek reach conditions and sensitivities (outlined in Sections 3.1 and 4.0) can be summarized in background sections of the Natural Resources section and Land Use section. Watershed-level and site-level strategies in Section 6.0 can inform goals and implementation tasks in the Town Plan.

7.2.2 Regional Plans

This corridor plan should also be considered in the context of future updates to the:

- Addison County Region-wide All Hazards Mitigation Plan (ACRPC, 2005) and its Starksboro and Monkton sections;
- Chittenden County Region-wide All Hazards Mitigation Plan and its Hinesburg annex;
- Addison County Regional Plan and its natural resources section; and the
- Chittenden County Regional Plan and its natural resources section.

7.2.3 Vermont Basin Planning

The VTDEC Water Quality Division will seek to incorporate the finalized Lewis Creek Corridor Plan (reaches M14 – M18) within the larger Otter Creek Basin Plan. The intent of the basin plan is to be able to leverage resources that are needed for implementation of strategies outlined in the River Corridor Plan.

7.2.4 Periodic Plan Updates

Pending available funding, updates to the Lewis Creek Corridor Plan should be performed periodically (approximately every 5 years) by the Lewis Creek Association or other local stewardship organization to:

- Update management strategies with the results of updated geomorphic assessments as they become available.
- Identify additional site-level and watershed-level management options.
- Update feasibility and willingness of landowners to participate in implementation of identified projects.
- Report on ongoing needs of riparian landowners for financial and technical support to achieve plan objectives.
- Report on the ways in which the plan is supporting officials of Starksboro, Monkton, and Hinesburg.

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February 2008 (Rev. March 2008)

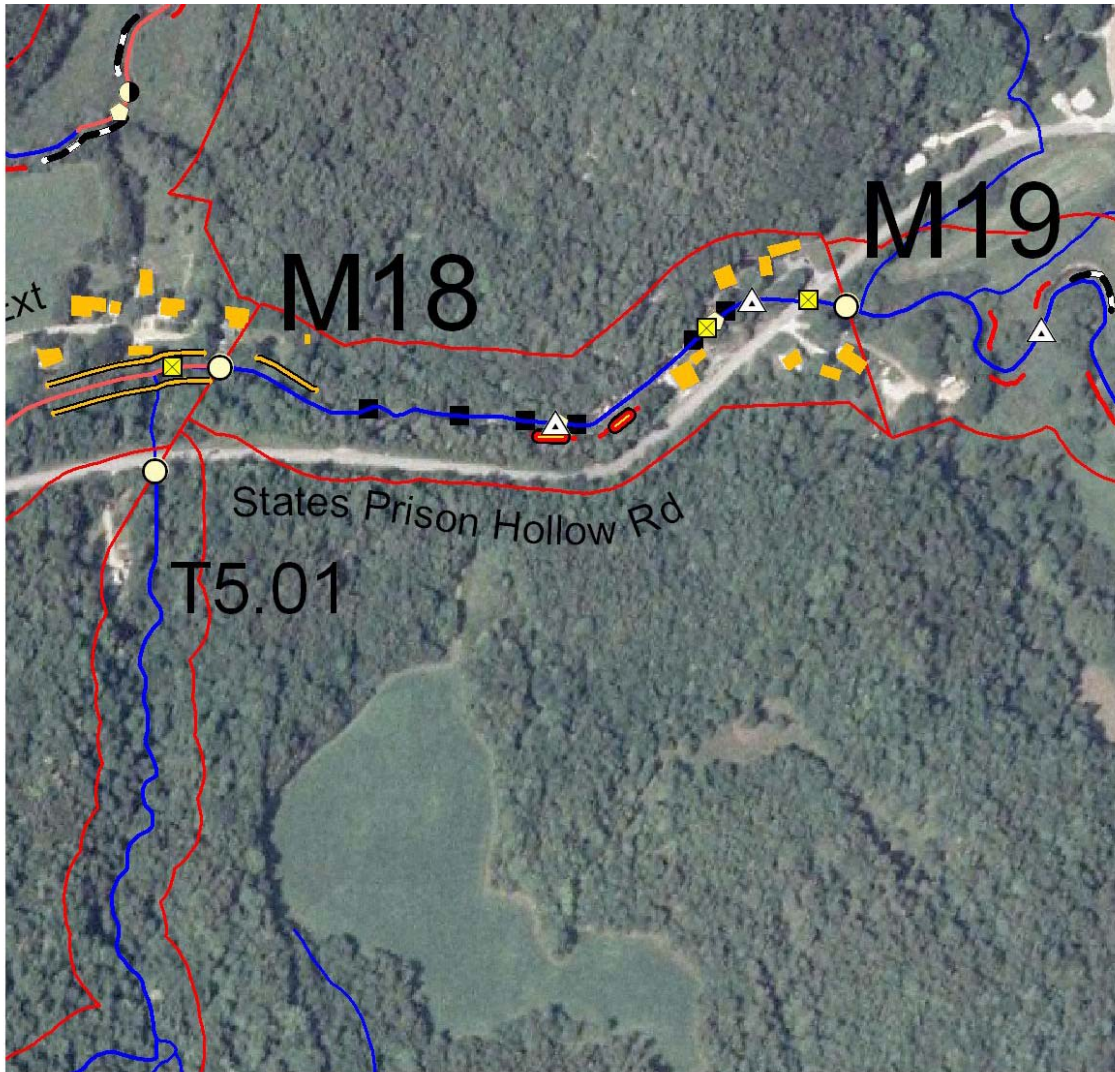
*Lewis Creek Corridor Plan: Reaches M14 – M18
Towns of Hinesburg, Monkton, and Starksboro*

Reach Data

**APPENDIX A
River Corridor Plan
Lewis Creek: Reaches M14 – M18**

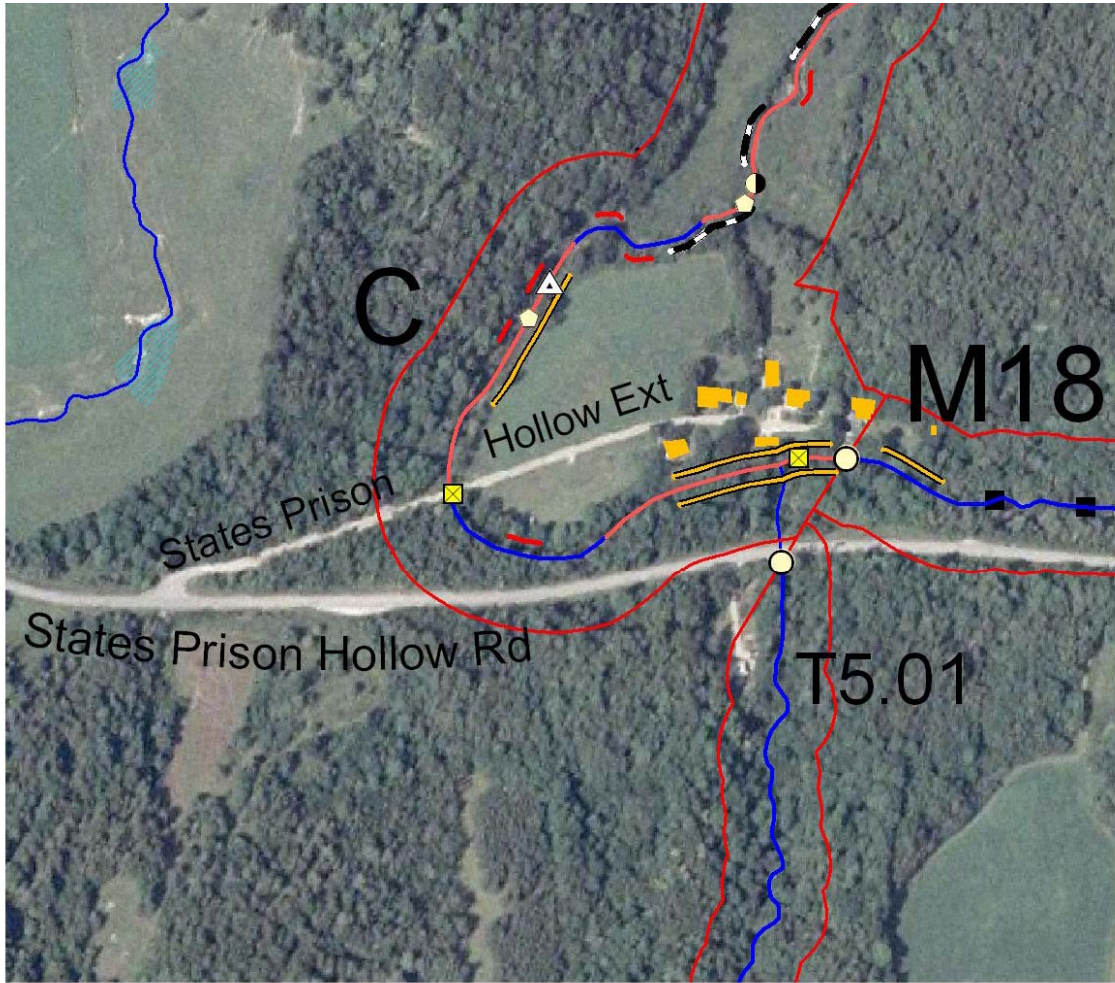
**Hinesburg, Monkton, & Starksboro
Chittenden & Addison Counties, Vermont**

February 2008



Reach: M18
 Lewis Creek Watershed
 Starksboro, Addison County, VT
 Base Map: 2003 NAIP color imagery

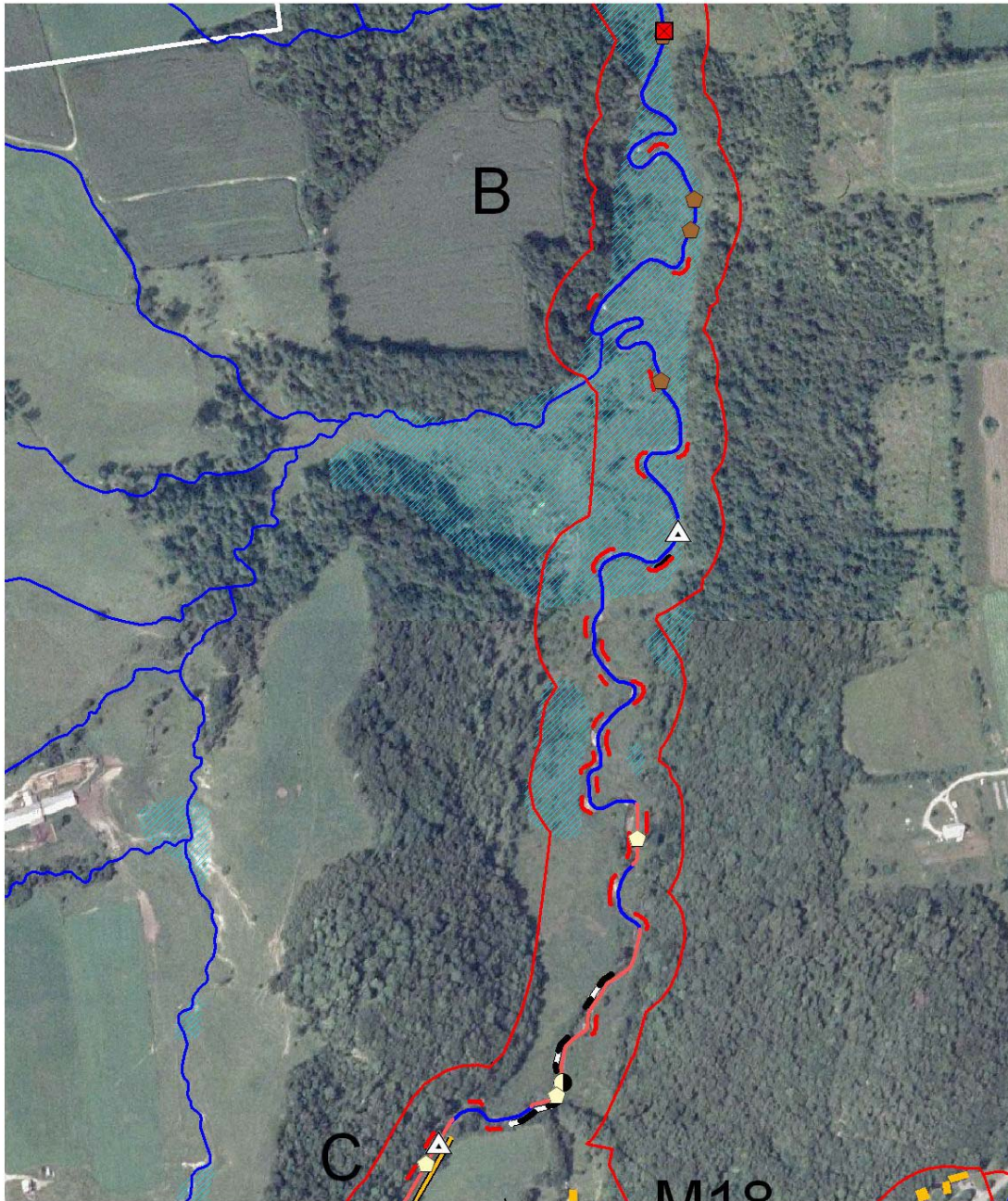
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| | Reach Break | | Beaver Dam | | Crossing Structure |
| | Segment Break | | Debris Jam | | Bankfull Constrictor (red) |
| | 1974 channel | | Mass Failure | | FPW Constrictor (yellow) |
| | 1999, 1995 channel | | Erosion | | Development in Corridor |
| | Straightened Channel | | Wetlands (NWI) | | Streambank Revetment |
| | Phase 1 Corridor | | Bedrock grade control | | Berm |
| | | | | | Ph 2 Cross Section |



200 0 200 400 Feet

Reach: M17-C
 Lewis Creek Watershed
 Starksboro, Addison County, VT
 Base Map: 2003 NAIP color imagery

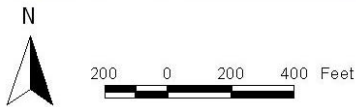
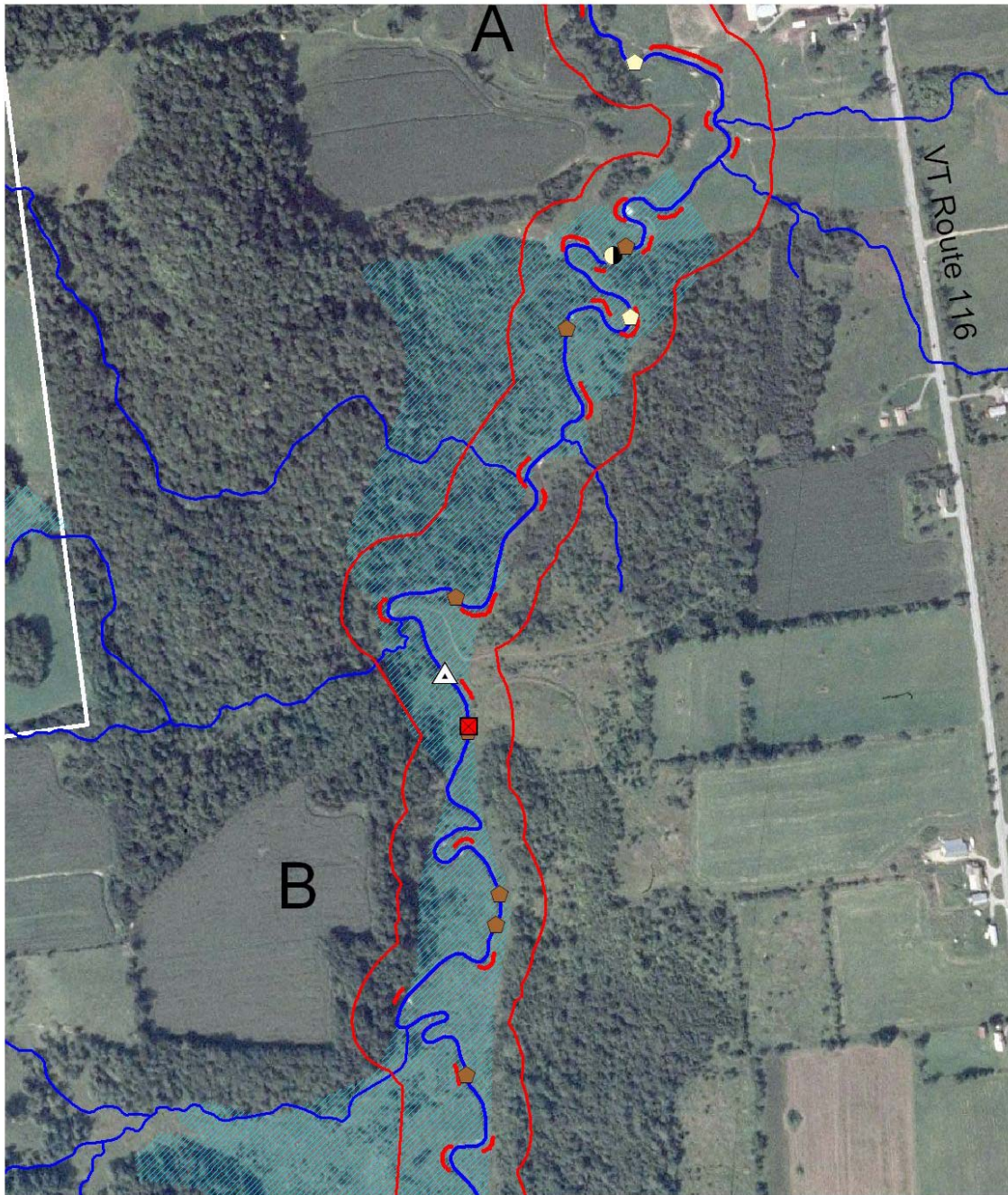
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| | Reach Break | | Beaver Dam | | Crossing Structure |
| | Segment Break | | Debris Jam | | Bankfull Constrictor (red) |
| | 1974 channel | | Mass Failure | | FPW Constrictor (yellow) |
| | 1999, 1995 channel | | Erosion | | Development in Corridor |
| | Straightened Channel | | Wetlands (NWI) | | Streambank Revetment |
| | Phase 1 Corridor | | Bedrock grade control | | Berm |
| | | | | | Ph 2 Cross Section |



200 0 200 400 Feet

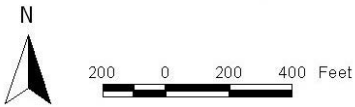
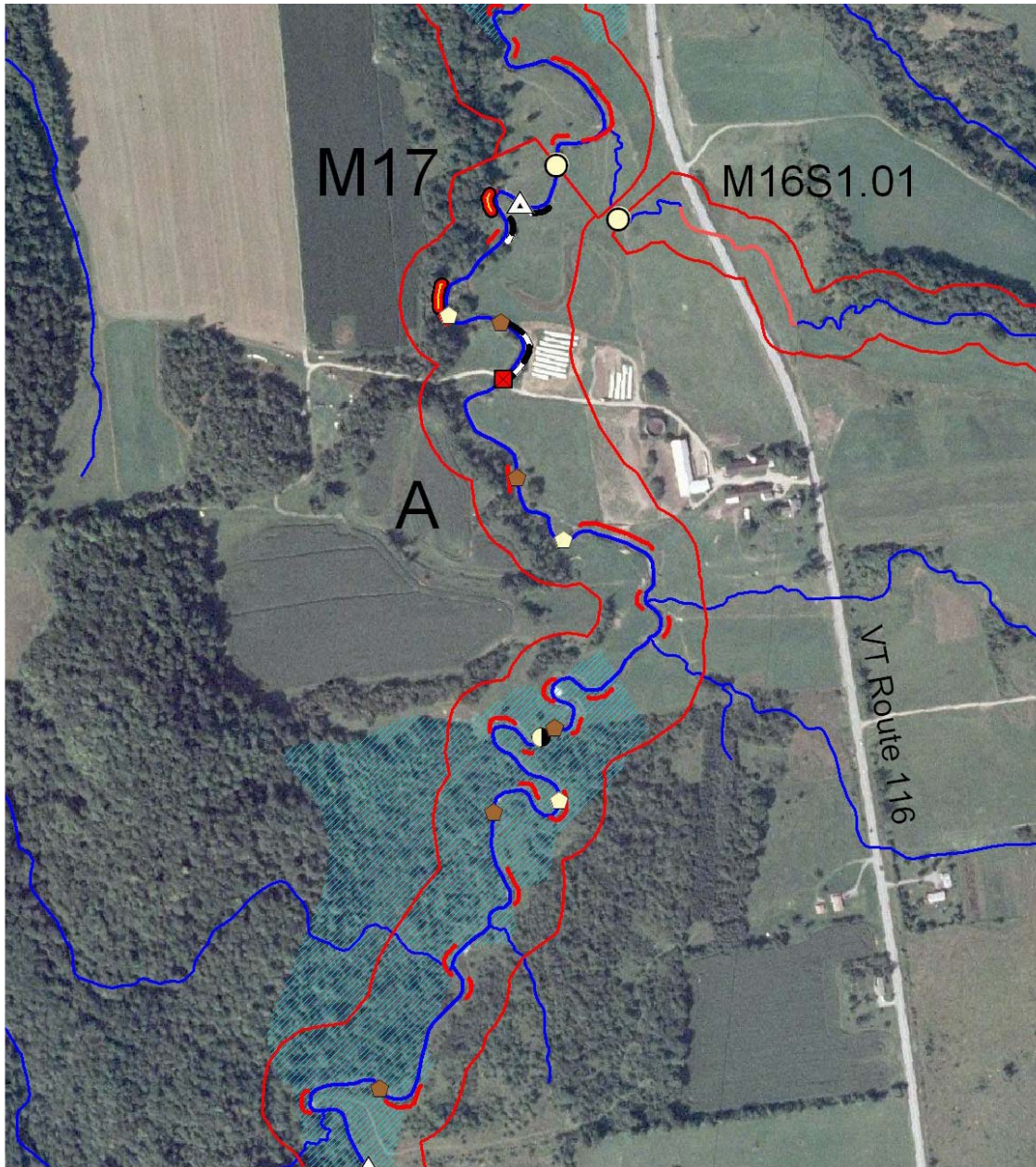
Reach: M17-B upstream
 Lewis Creek Watershed
 Starksboro, Addison County, VT
 Base Map: 2003 NAIP color imagery

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| Reach Break | Beaver Dam | Crossing Structure |
| Segment Break | Debris Jam | Bankfull Constrictor (red) |
| 1974 channel | Mass Failure | FPW Constrictor (yellow) |
| 1999, 1995 channel | Erosion | Development in Corridor |
| Straightened Channel | Wetlands (NW1) | Streambank Revetment |
| Phase 1 Corridor | Bedrock grade control | Berm |
| | | Ph 2 Cross Section |



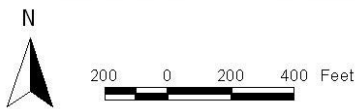
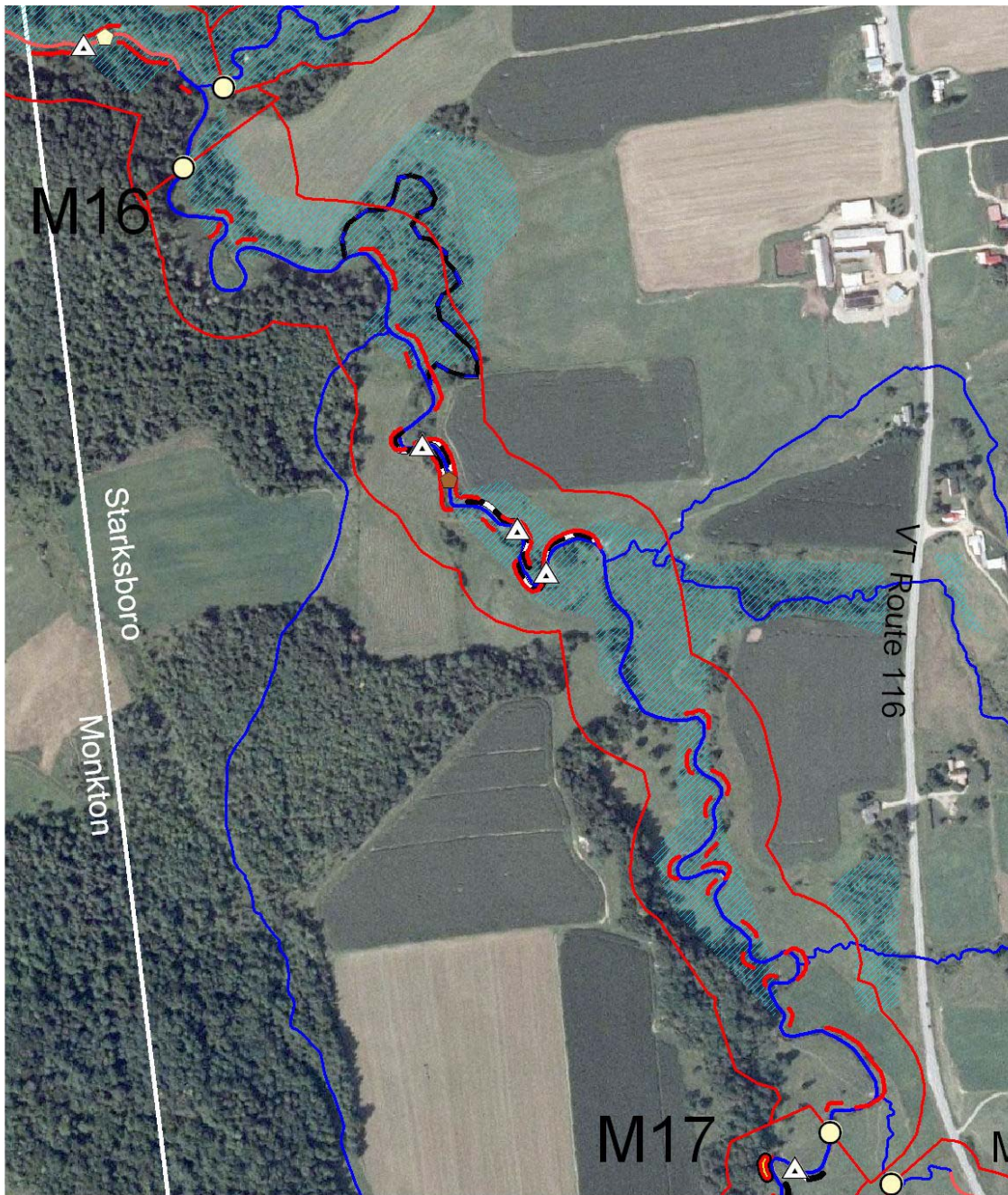
Reach: M17-B downstream
 Lewis Creek Watershed
 Starksboro, Addison County, VT
 Base Map: 2003 NAIP color imagery

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| | Reach Break | | Beaver Dam | | Crossing Structure |
| | Segment Break | | Debris Jam | | Bankfull Constrictor (red) |
| | 1974 channel | | Mass Failure | | FPW Constrictor (yellow) |
| | 1999, 1995 channel | | Erosion | | Development in Corridor |
| | Straightened Channel | | Wetlands (NWI) | | Streambank Revetment |
| | Phase 1 Corridor | | Bedrock grade control | | Berm |
| | | | | | Ph 2 Cross Section |



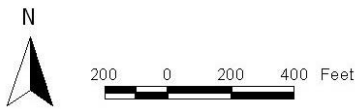
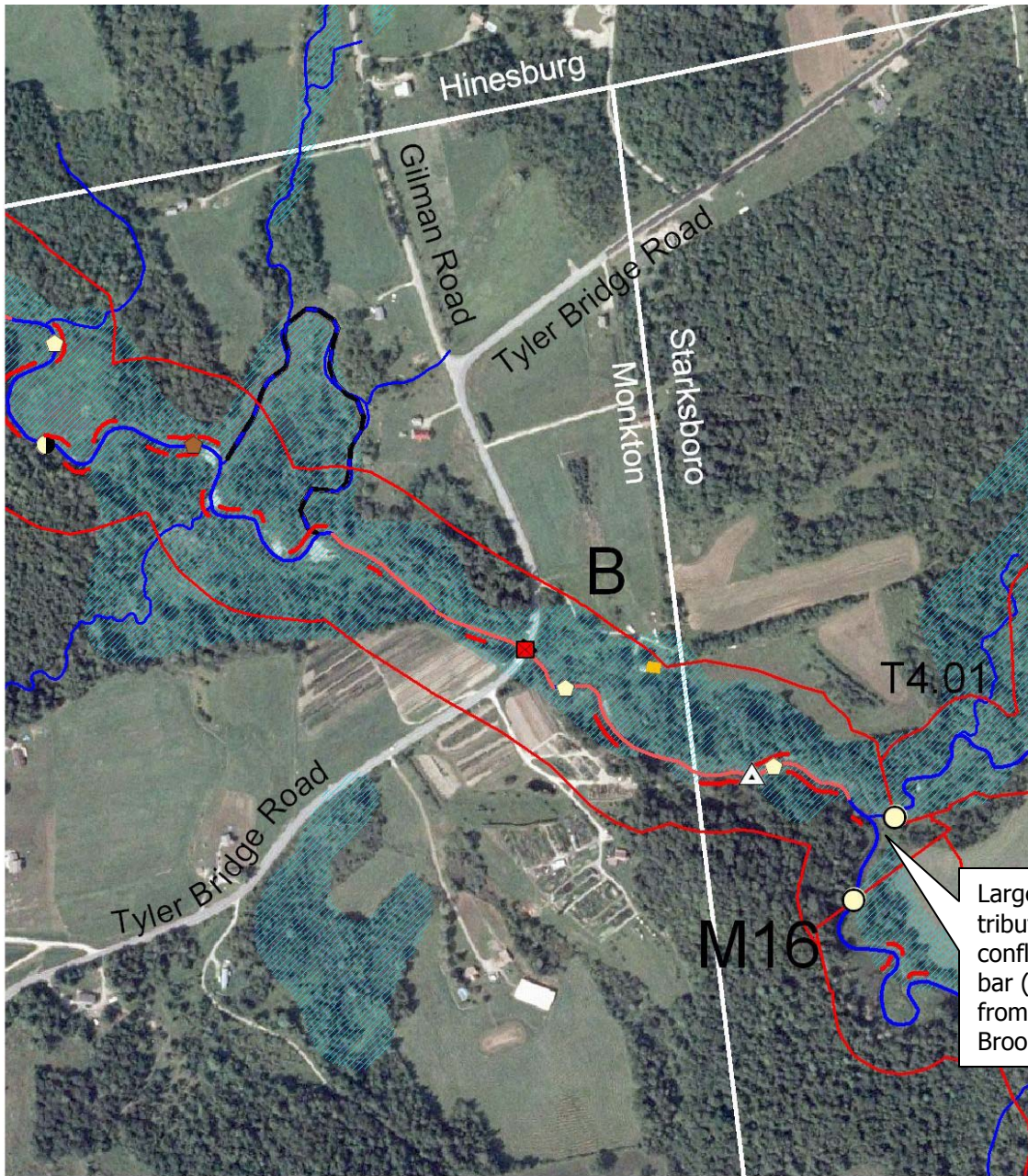
Reach: M17-A
 Lewis Creek Watershed
 Starksboro, Addison County, VT
 Base Map: 2003 NAIP color imagery

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| | Reach Break | | Beaver Dam | | Crossing Structure |
| | Segment Break | | Debris Jam | | Bankfull Constrictor (red) |
| | 1974 channel | | Mass Failure | | FPW Constrictor (yellow) |
| | 1999, 1995 channel | | Erosion | | Development in Corridor |
| | Straightened Channel | | Wetlands (NWI) | | Streambank Revetment |
| | Phase 1 Corridor | | Bedrock grade control | | Berm |
| | | | | | Ph 2 Cross Section |



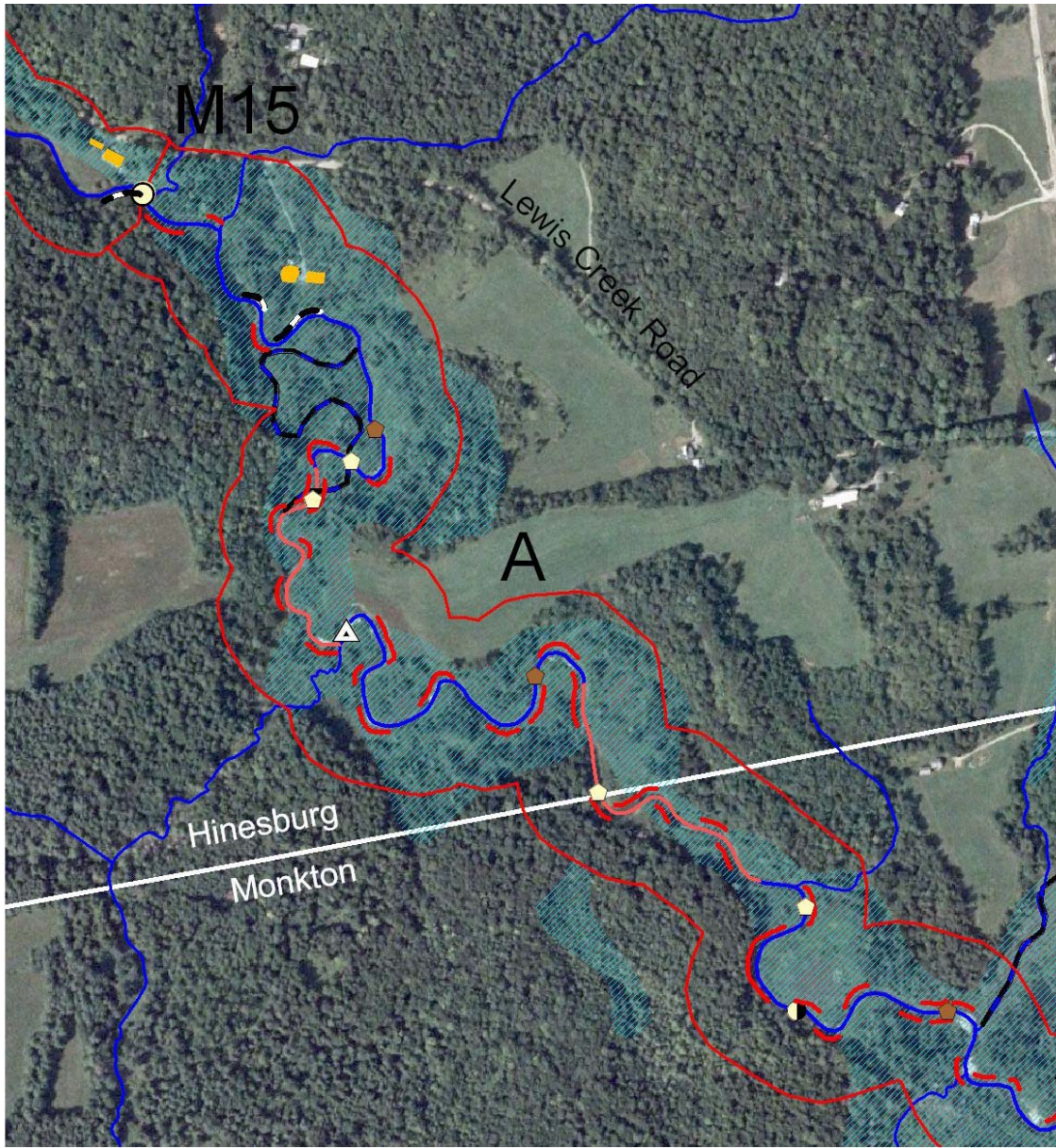
Reach: M16
 Lewis Creek Watershed
 Starksboro, Addison County, VT
 Base Map: 2003 NAIP color imagery

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| Reach Break | Beaver Dam | Crossing Structure |
| Segment Break | Debris Jam | Bankfull Constrictor (red) |
| 1974 channel | Mass Failure | FPW Constrictor (yellow) |
| 1999, 1995 channel | Erosion | Development in Corridor |
| Straightened Channel | Wetlands (NWI) | Streambank Revetment |
| Phase 1 Corridor | Bedrock grade control | Berm |
| | | Ph 2 Cross Section |



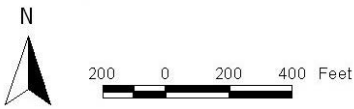
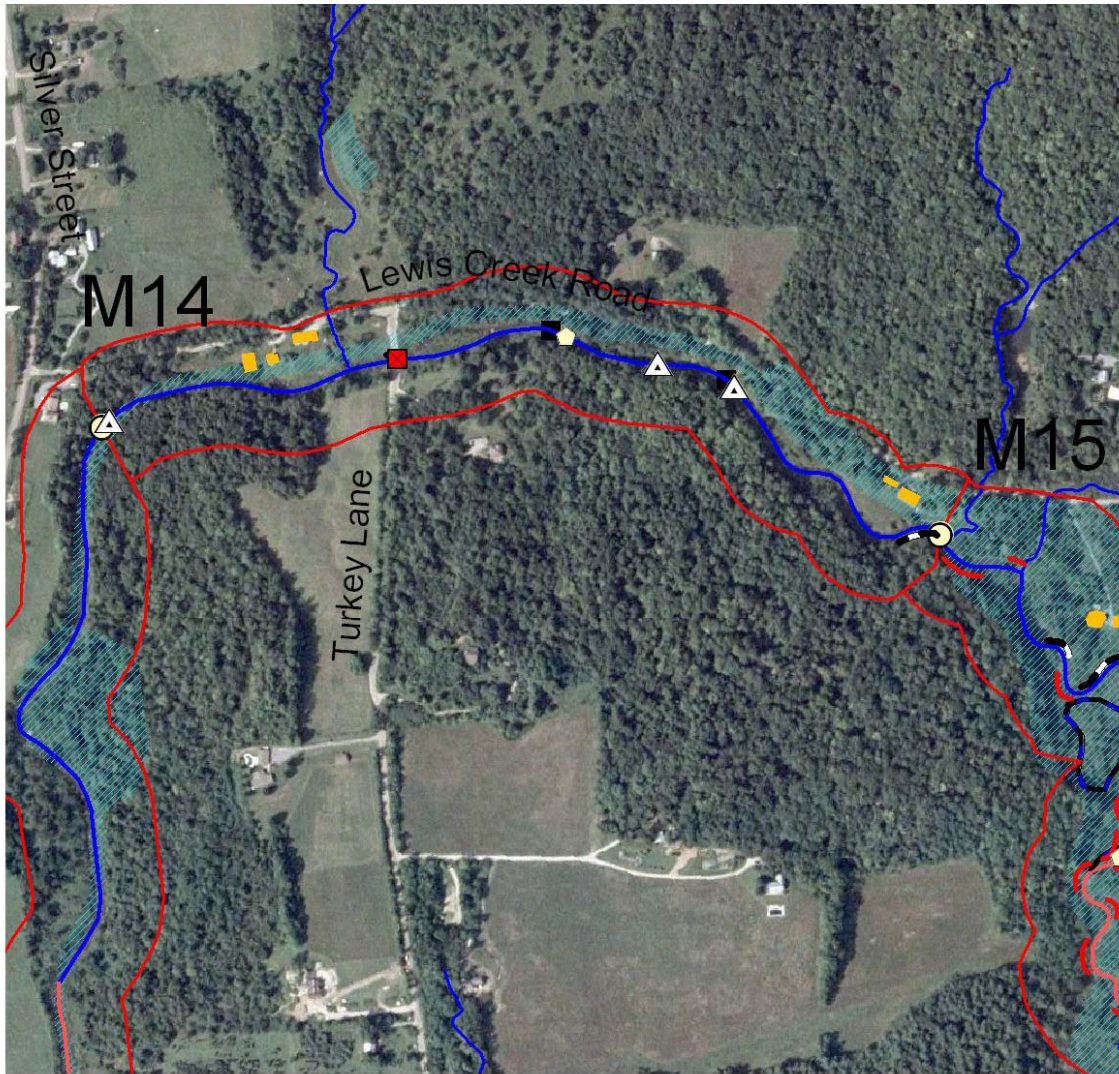
Reach: M15-B
 Lewis Creek Watershed
 Starksboro & Monkton, Addison County, VT
 Base Map: 2003 NAIP color imagery

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| | Reach Break | | Beaver Dam | | Crossing Structure |
| | Segment Break | | Debris Jam | | Bankfull Constrictor (red) |
| | 1974 channel | | Mass Failure | | FPW Constrictor (yellow) |
| | 1999, 1995 channel | | Erosion | | Development in Corridor |
| | Straightened Channel | | Wetlands (NWI) | | Streambank Revetment |
| | Phase 1 Corridor | | Bedrock grade control | | Berm |
| | | | | | Ph 2 Cross Section |



Reach: M15-A
 Lewis Creek Watershed
 Monkton & Hinesburg, VT
 Base Map: 2003 NAIP color imagery

- | | | |
|----------------------|-----------------------|----------------------------|
| Reach Break | Beaver Dam | Crossing Structure |
| Segment Break | Debris Jam | Bankfull Constrictor (red) |
| 1974 channel | Mass Failure | FPW Constrictor (yellow) |
| 1999, 1995 channel | Erosion | Development in Corridor |
| Straightened Channel | Wetlands (NWI) | Streambank Revetment |
| Phase 1 Corridor | Bedrock grade control | Berm |
| | | Ph 2 Cross Section |



Reach: M14
 Lewis Creek Watershed
 Hinesburg, Chittenden County, VT
 Base Map: 2003 NAIP color imagery

- | | | | | | |
|--|----------------------|--|-----------------------|--|----------------------------|
| | Reach Break | | Beaver Dam | | Crossing Structure |
| | Segment Break | | Debris Jam | | Bankfull Constrictor (red) |
| | 1974 channel | | Mass Failure | | FPW Constrictor (yellow) |
| | 1999, 1995 channel | | Erosion | | Development in Corridor |
| | Straightened Channel | | Wetlands (NWI) | | Streambank Revetment |
| | Phase 1 Corridor | | Bedrock grade control | | Berm |
| | | | | | Ph 2 Cross Section |

Outreach / Project Development

**APPENDIX B
River Corridor Plan
Lewis Creek: Reaches M14 – M18**

**Hinesburg, Monkton, & Starksboro
Chittenden & Addison Counties, Vermont**

March 2008

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Press Release

Lewis Creek Corridor Plan

The Lewis Creek Association has received a grant from the Vermont Department of Environmental Conservation to develop a River Corridor Management Plan for a 6.7-mile section of the Lewis Creek from States Prison Hollow Road in Starksboro to the Turkey Lane crossing in Hinesburg. Funding has been appropriated through Governor Douglas' Clean & Clear Action Plan. This grant will fund a 9-month alternatives analysis process with the long-term objectives of reducing streambank erosion and sediment and nutrient loading, by managing for the equilibrium channel. This project will consist of an analysis of previous assessment work, identification of the causes of channel instability, and an evaluation of alternatives for restoring long-term stability to the river. A River Corridor Management Plan for public review will be prepared by February 2008. The plan will identify and rank short-term and long-term actions and approaches for implementation, including potential river restoration and conservation projects.

From July through October, members of a Technical Working Group will meet with landowners along the river corridor. Through outreach to individual landowners and through meetings with town boards of Starksboro, Monkton and Hinesburg, the Technical Working Group will identify sustainable river corridor management alternatives which are compatible with public and individual goals and visions. Potential channel management choices will be reviewed for their effectiveness and potential consequences to downstream and upstream properties and infrastructure. Individuals with questions or comments are encouraged to contact Marty Illick, Lewis Creek Association Executive Director, at 425-2002 or martylewiscreek@gmavt.net.

Landowner Letter



1 August 2007

Dear

The Lewis Creek Association has received a grant from the Vermont Department of Environmental Conservation to develop a River Corridor Management Plan for a 6.7-mile section of the Lewis Creek from States Prison Hollow Road in Starksboro to the Turkey Lane crossing in Hinesburg. This grant will fund a 9-month alternatives analysis project with the long-term objectives of reducing streambank erosion and sediment and nutrient loading, by managing for the equilibrium channel. This project will consist of an analysis of previous assessment work, identification of the causes of channel instability and an evaluation of alternatives for restoring long-term stability to the river.

This letter is reaching you as a landowner identified along the river in one of these areas. Lewis Creek Association would like to invite your participation to ensure that the River Corridor Management Plan which results from this process reflects the individual as well as public visions and goals for management of these river reaches.

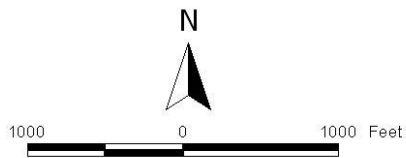
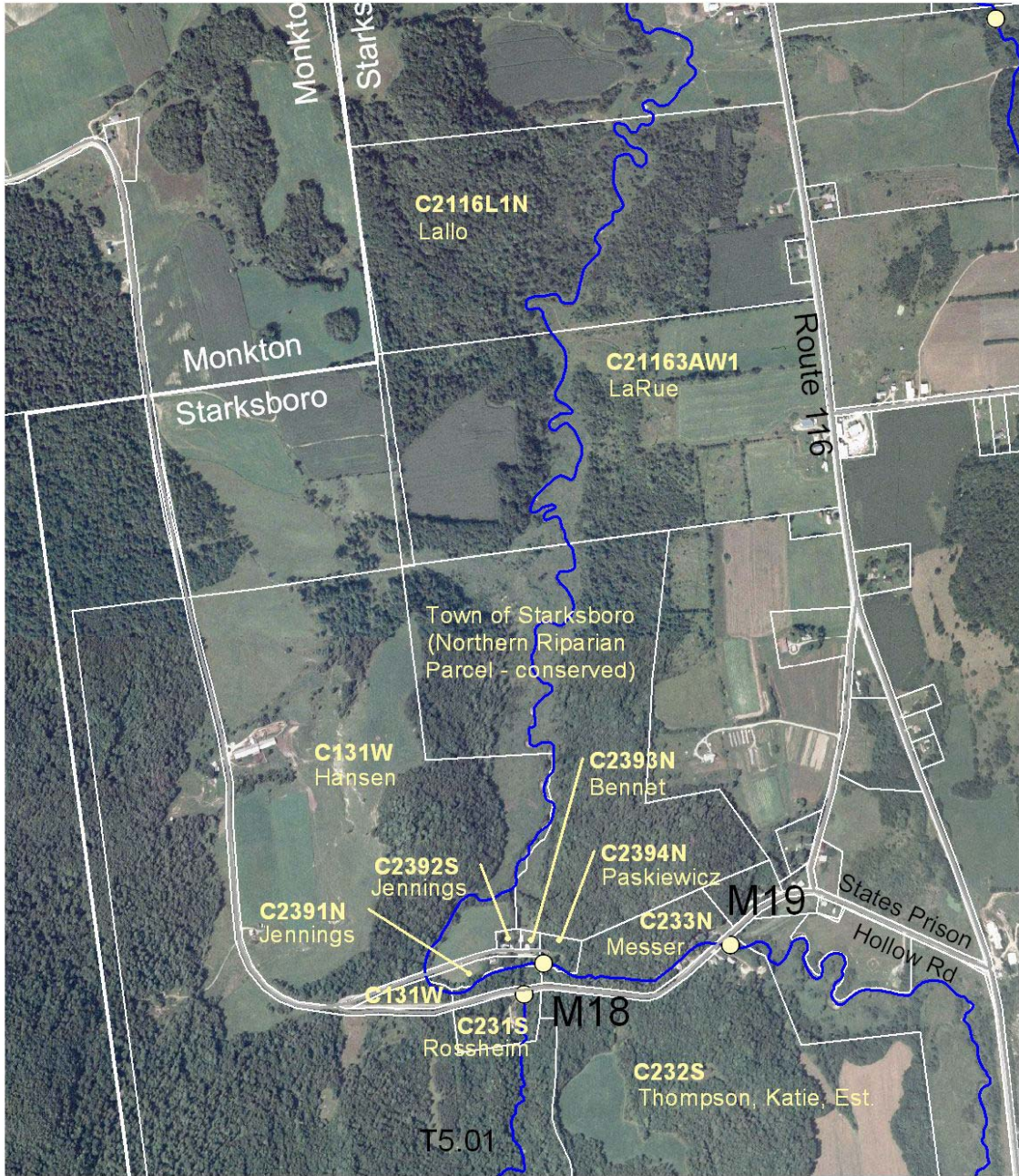
A Technical Working Group has been assembled to guide the corridor planning process: Marty Illick, Lewis Creek Association Executive Director; Alison Wagner and Stevie Spencer, Lewis Creek Association board members; Kristen Underwood, consulting geologist; and Shannon Hill and Ethan Swift from the VTDEC Water Quality Division. A River Corridor Management Plan for public review will be prepared by February 2008. The plan will identify and rank short-term and long-term actions and approaches for implementation, including potential river restoration and conservation projects.

In the next few weeks, Alison Wagner or Stevie Spencer will be contacting you by phone or in person to share more of the details of this project, and have a discussion about possible alternatives to alleviate streambank erosion and reduce sediment and nutrient loading. This feedback will be incorporated into the corridor plan. In the meantime, if you have questions or comments, please feel free to contact Marty Illick, Lewis Creek Association Executive Director, at 425-2002 or martylewis creek@gmavt.net.

Thank you,

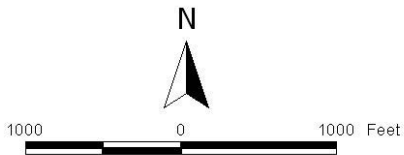
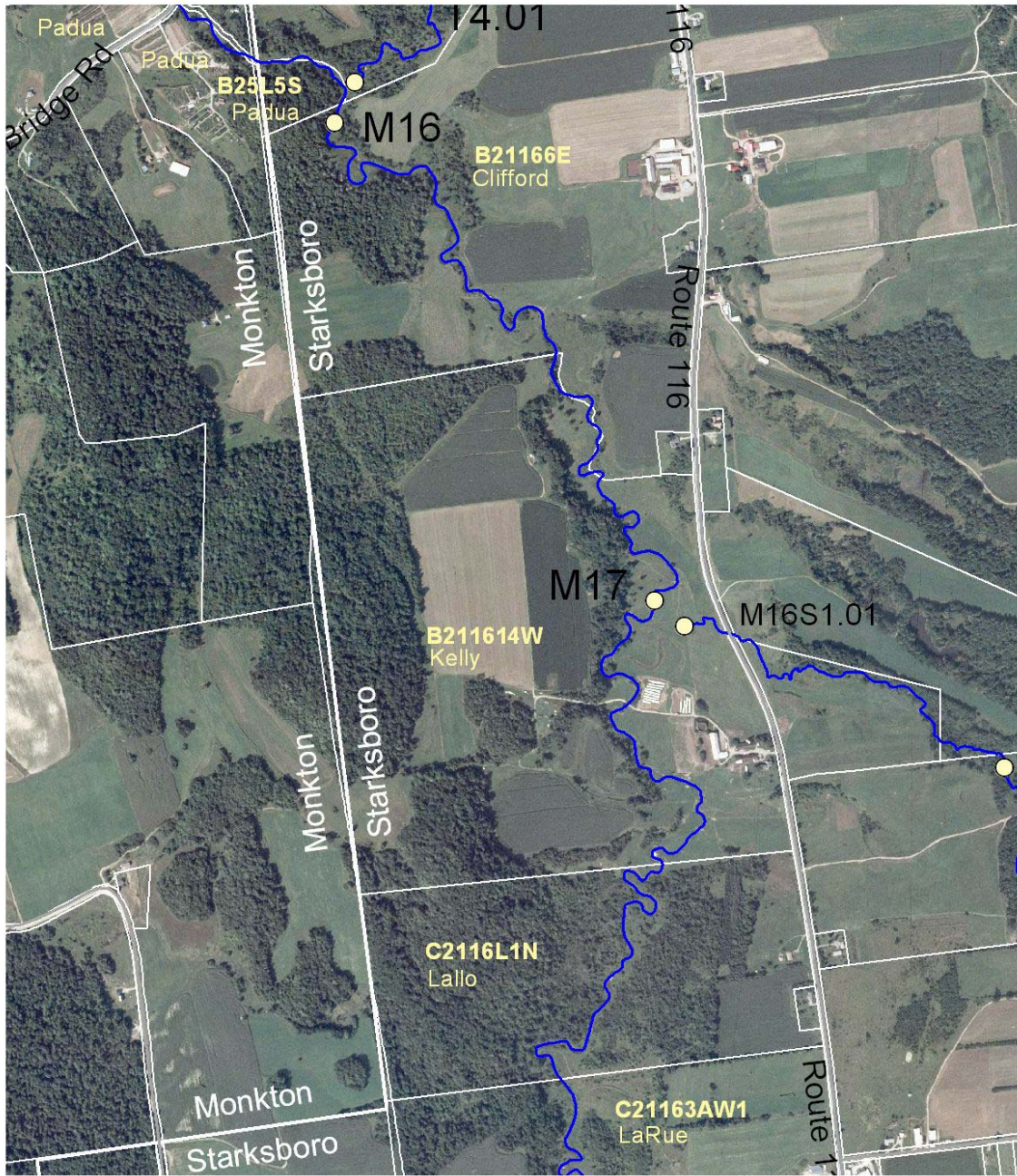
Marty Illick
Executive Director

Tax Parcel Maps



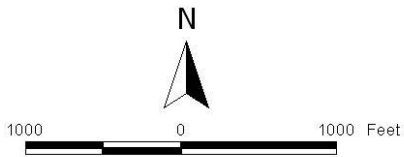
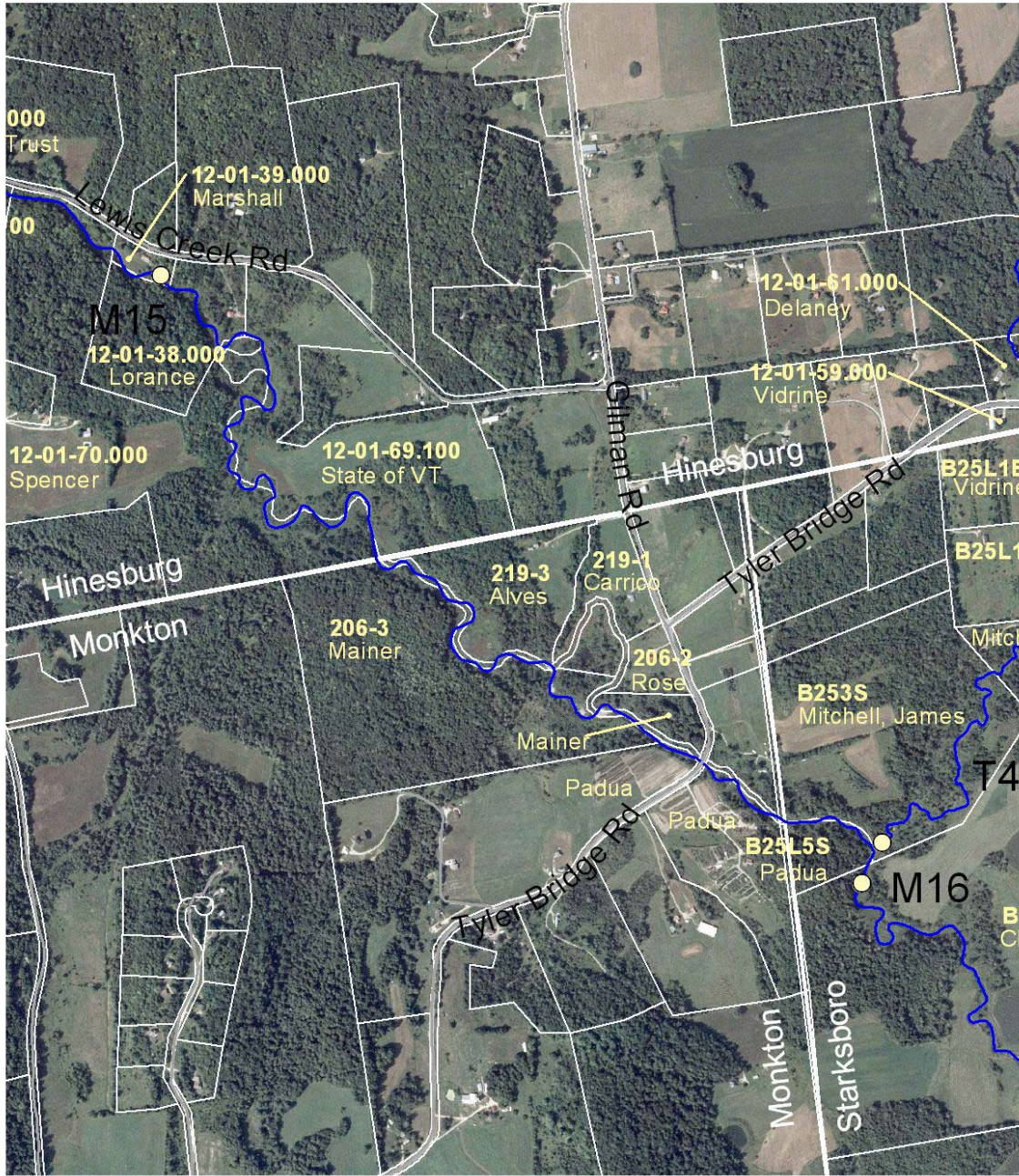
Corridor Plan: Reaches M14 - M18
Lewis Creek Watershed

M18, M17 Parcel Mapping



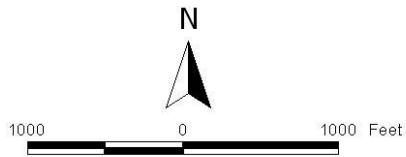
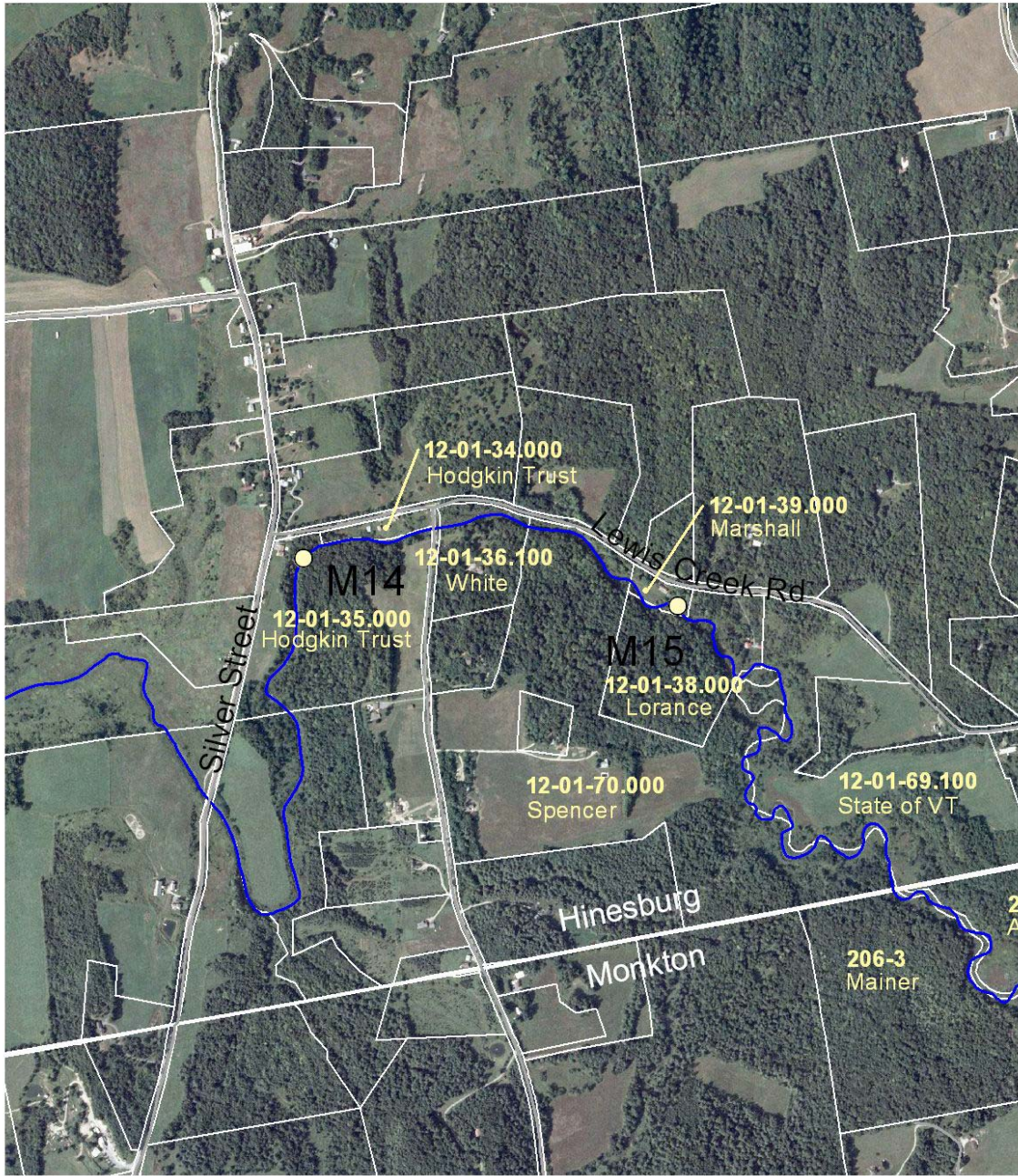
Corridor Plan: Reaches M14 - M18
Lewis Creek Watershed

M17, M16 Parcel Mapping



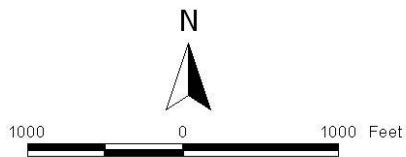
Corridor Plan: Reaches M14 - M18
Lewis Creek Watershed

M15 Parcel Mapping



Corridor Plan: Reaches M14 - M18
Lewis Creek Watershed

M14 Parcel Mapping



Corridor Plan: Reaches M14 - M18
Lewis Creek Watershed

T4.01 Parcel Mapping

Landowner Contacts

Following sections summarize the status of landowner contacts for riverside parcels along the Lewis Creek corridor reaches M14 through M18 as of February 2008. Entries are organized by Town, parcel number and reach number.

Landowner outreach was conducted by representatives of Lewis Creek Association, including Marty Illick (Executive Director), Stevie Spencer and Alison Wagner (Board members), and Kristen Underwood (consulting geologist under contract to LCA) from September 2007 through February 2008.

Principal goals of landowner outreach were to:

- Promote an understanding of the dynamics, or “behavior”, of Lewis Creek and the influence of land use activities and channel management choices on these dynamics;
- Gather the river-side community to discuss issues affecting all;
- Encourage landowners to review their land use practices along the river in the context of an adjusting river and the river’s need to seek a more balanced condition;
- Identify where adjustment of land use practices or plans might be necessary to encourage a more balanced state of the Lewis Creek, thereby reducing flood erosion risks in the longterm and improving water quality; and
- Match willing landowners with technical and financial resources to support river restoration and conservation projects.

Specific projects identified in Section 6.1 of the Corridor Plan were also discussed with individual landowners, where appropriate.

Starksboro C2394N – Reach M17, Segm C - Paskiewicz

Landowner: Linda G. Paskiewicz
Street Address: 291 States Prison Hollow Road, Starksboro
Mailing Address: same

Description: Residential parcel along right bank at the base of the bedrock gorge. Located at the transition from semi-confined to unconfined valley setting, with slope reduction from approximately 6.9% to 0.8%. Site of avulsion in 1938 flood. Berm along right bank protects the house.

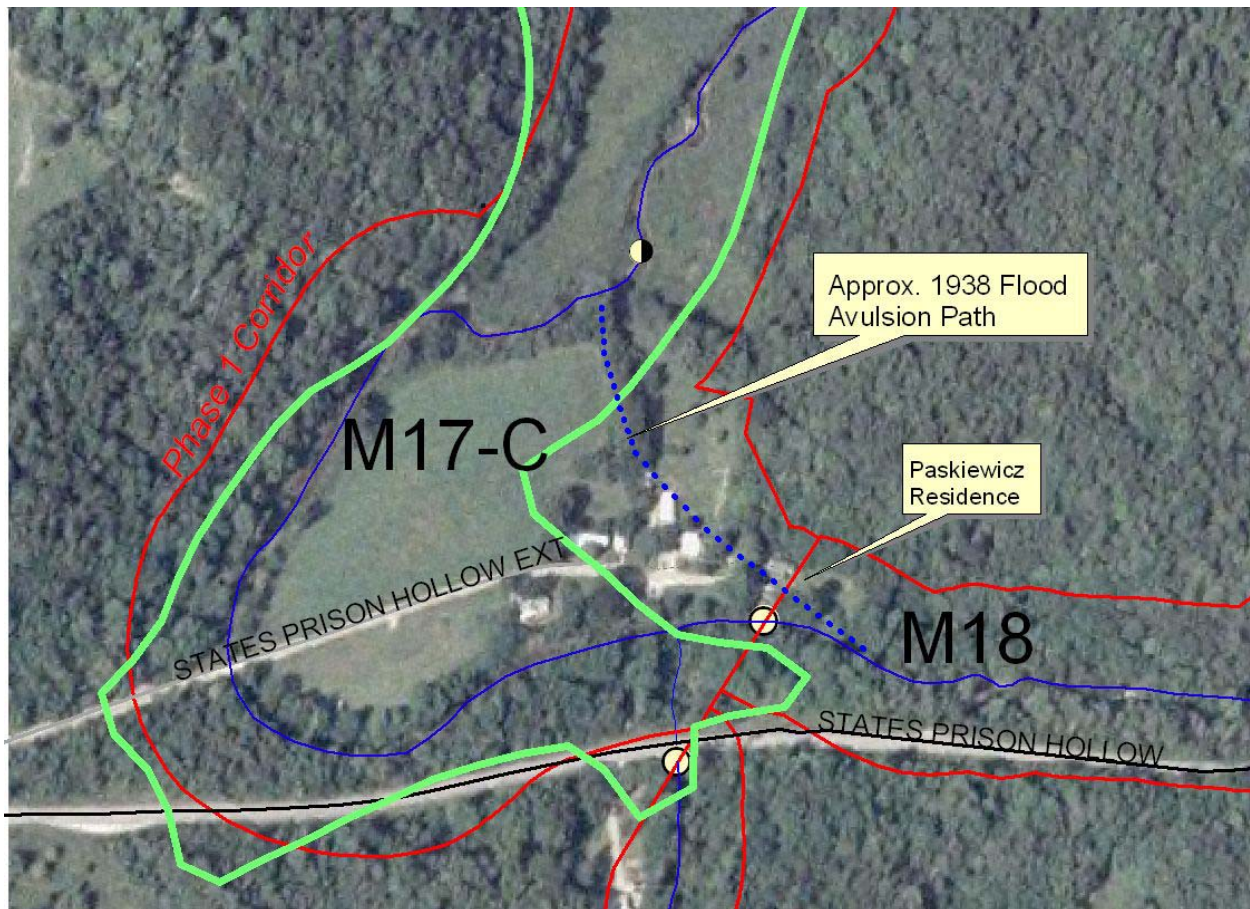


Figure 1. Location of Paskiewicz residence. River corridor (Phase 1) outlined in red. 2003 base photograph. Blue line represents surface waters digitized from 1995 orthophotographs. Green line indicates area of 100-year flood digitized by ACRPC from Town of Starksboro, VT Flood insurance Rate Map Panel 05, effective date: December 4, 1985.

Starksboro C2394N – Reach M17, Segm C
9/18/2007 – 6:00 PM Personal Visit – Linda Paskiewicz
Attending: Marty Illick, Alison Wagner, Kristen Underwood

Background

Ms. Paskiewicz purchased the property approximately 6 years ago. The house was constructed c1840. Ms. Paskiewicz has noted that States Prison Hollow Road Extension was inundated once in the past 6 years – from stormwater drainage off the fields west of the house. Local anecdotal information indicates that the front porch of her house was washed away in the 1938 flood (see Figure 1). A small right-bank flood chute adjacent to the channel is active during Spring flows, but water has not extended beyond the cobble / boulder/ earthen berm separating the river from her lawn area in the 6 years she has lived there. Her house is supplied by a shallow well, located within one bankfull width of the Lewis Creek channel. Documents generated during the purchase of her property stated that the house is not located within the 100-year flood plain. Ms. Paskiewicz does not have flood insurance.

Land uses and long-term commitments within the corridor:

This lot has been in residential use for over 150 years. No plans to change the residential use of this parcel were articulated by Ms. Paskiewicz.

River Corridor Constraints

Following the 1938 flood, debris was cleared from the Lewis Creek channel (Hanson, 1998) and a cobble/boulder/earthen berm was constructed along the right bank to protect the house. This berm continues downstream of the house adjacent to other residential buildings along States Prison Hollow Extension; and a left-bank berm is also present downstream of the house. A small wooden outbuilding is present on the lot approximately 130 feet to the east (upstream) of the house (adjacent to reach M18 of Lewis Creek).

Current Concerns of the Landowner

Ms. Paskiewicz recalled the 2006 wash out of the States Prison Hollow Road and noted that sedimentation in pools at the base of the gorge appears to have increased in the months since the mass failures. Ms. Paskiewicz has previously reported her concerns for fish health and habitat to the State of Vermont.

Ms. Paskiewicz acknowledges the flood damages that occurred in 1938 in the hollow and shared a picture of the flood damage found in *Bertha's Book: a view of Starksboro's history* (Hanson, 1998). Until our meeting, future flood risks to the property did not appear to be a concern of Ms. Paskiewicz.

River Corridor Alternatives Acceptable to Landowner

During the September 2007 meeting, Kristen Underwood brought up the topic of the FEMA-FIRM maps (see Figure 2) – their degree of accuracy in locating areas at risk of inundation flooding at the base of the gorge, and also the fact that erosion hazards are not well captured by the FEMA-FIRM maps. Historic accounts of the 1938 flood and the placement of the berms along Lewis Creek (see Figure 3) appear to suggest the high risk of erosion and inundation flooding damage to the Paskiewicz property. Ms. Paskiewicz indicated that she would like to learn more about the potential flood risks at her location.

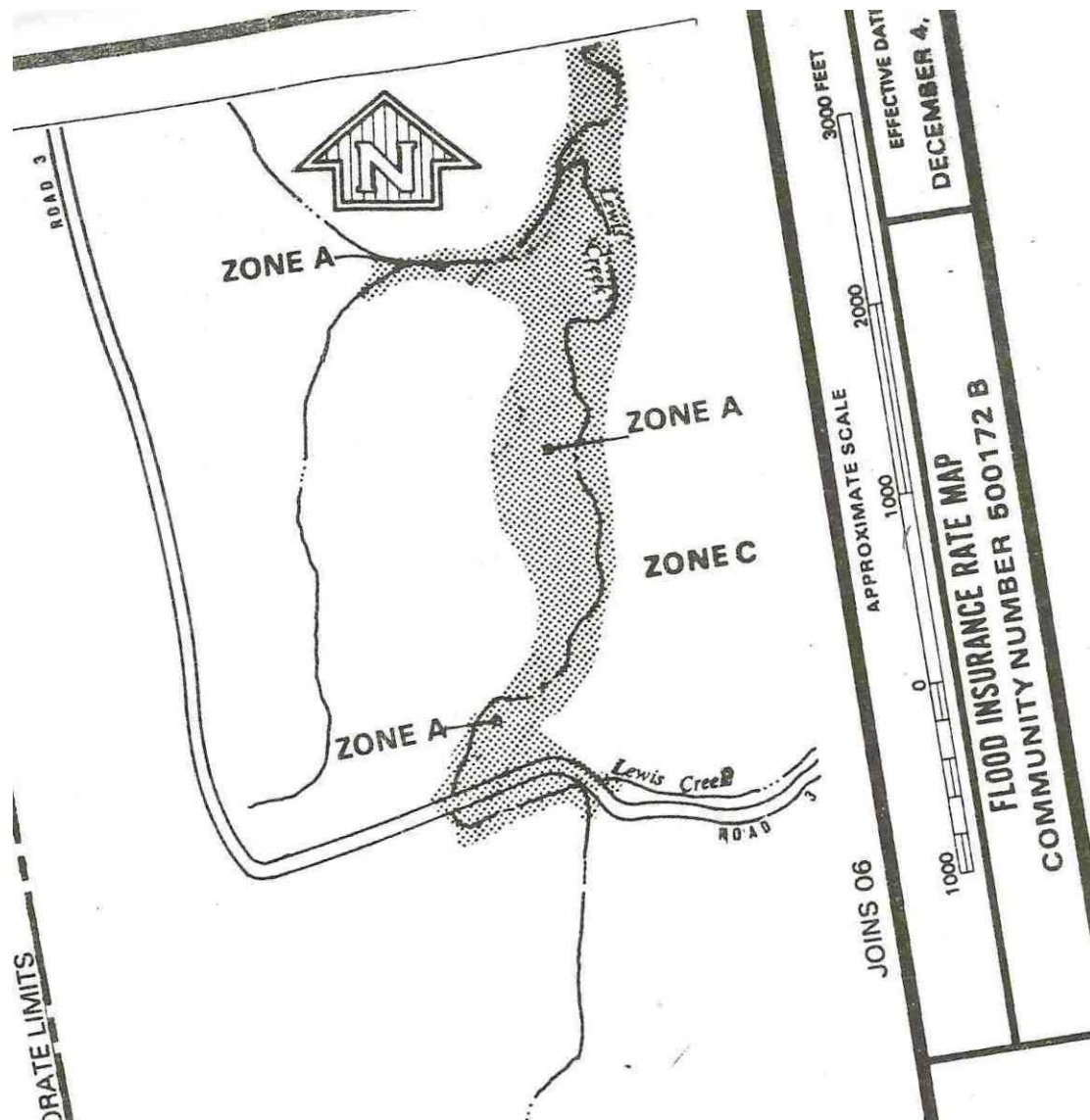


Figure 2. Reprint of Town of Starksboro, VT Flood Insurance Rating Map, panel 05 for vicinity of Paskiewicz residence. Former alignment of States Prison Hollow Road depicted. Zone A indicates Areas of 100-year flood: base flood elevations and flood hazard factors not determined. Town of Starksboro, VT Flood insurance Rate Map Panel 05, effective date: December 4, 1985.

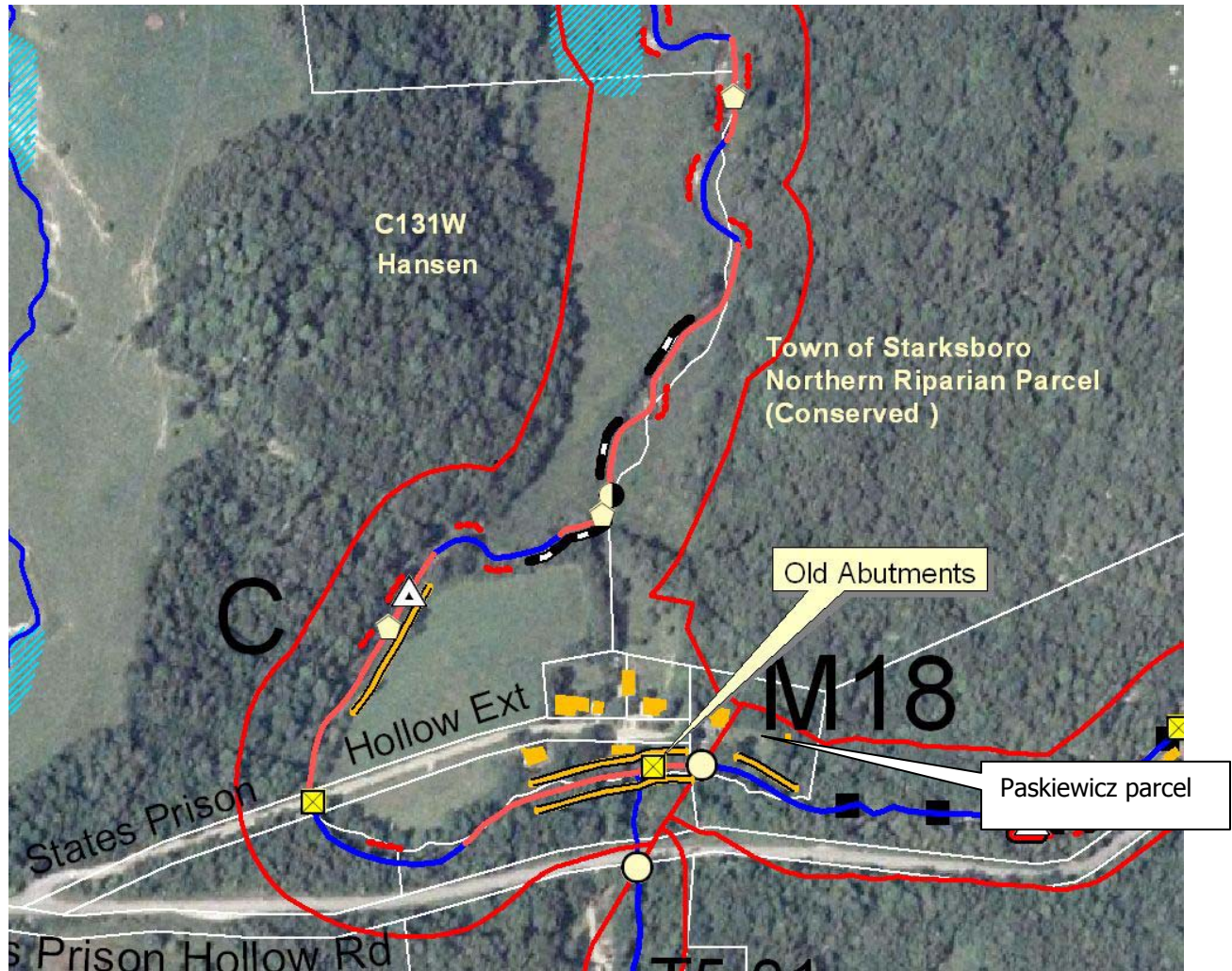


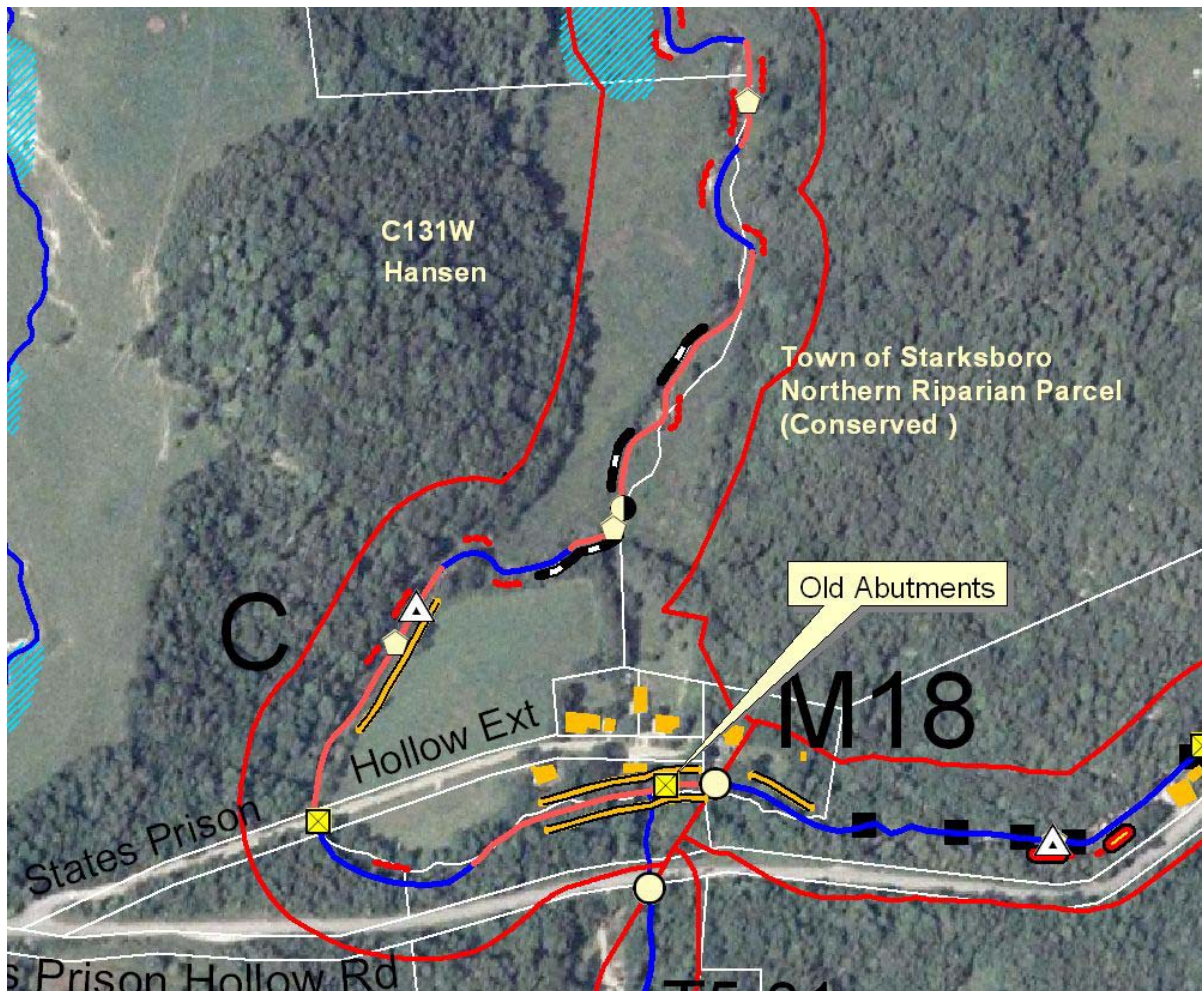
Figure 3. Phase 2 stream geomorphic assessment data for Segment C of reach M17 in vicinity of Paskiewicz residence. *Old abutments are present, just downstream of Paskiewicz residence at the location of the former crossing of States Prison Hollow Road, a portion of which now remains as States Prison Hollow Extension. White lines indicate parcel boundaries. Base photograph, dated 2003.*



Starksboro C131W – Reach M17, Segments C, B - Hanson

Landowner: Steven & Sylvia Hanson
 Street Address: 1363 States Prison Hollow Road, Starksboro

Description: Agricultural lands along right and left banks downstream of States Prison Hollow Road Extension. Bordered on north and east by Town of Starksboro lands – Northern Riparian Parcel (conserved). Berm along right bank immediately downstream of States Prison Hollow Extension (Segment C); limited armoring and historic channelization on fallow lands further downstream (Segment B).



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| | Reach Break | | Beaver Dam | | Crossing Structure |
| | Segment Break | | Debris Jam | | Bankfull Constrictor (red) |
| | 1974 channel | | Mass Failure | | FPW Constrictor (yellow) |
| | 1999, 1995 channel | | Erosion | | Development in Corridor |
| | Straightened Channel | | Wetlands (NWI) | | Streambank Revetment |
| | Phase 1 Corridor | | Bedrock grade control | | Berm |
| | | | | | Ph 2 Cross Section |

Starksboro C131W – Reach M17, Segm C, B
Steven Hanson, Sylvia Hanson

Following several letters and phone calls, a meeting was not able to be convened with the Hanson's in the available time frame.

See Corridor Plan Table 27,

Project 3 – Potential berm removal and active / passive restoration of incised channel.

Project 4 – Protection River Corridor, Potential Wetlands Restoration, Stream Buffer plantings

Starksboro – Reach M17, Segment B – Town of Starksboro lands Northern Riparian Parcel (conserved)

Landowner: Town of Starksboro
 Street Address: VT Route 116, Starksboro

Description: Former Cota Farm lands – fallow agriculture and forest - along right and left banks downstream of States Prison Hollow Road Extension. Bordered on south by Hanson Farm and on north by LaRue lands. Limited armoring and historic channelization, especially near southern extent of parcel. Conservation easement held by Vermont Land Trust.

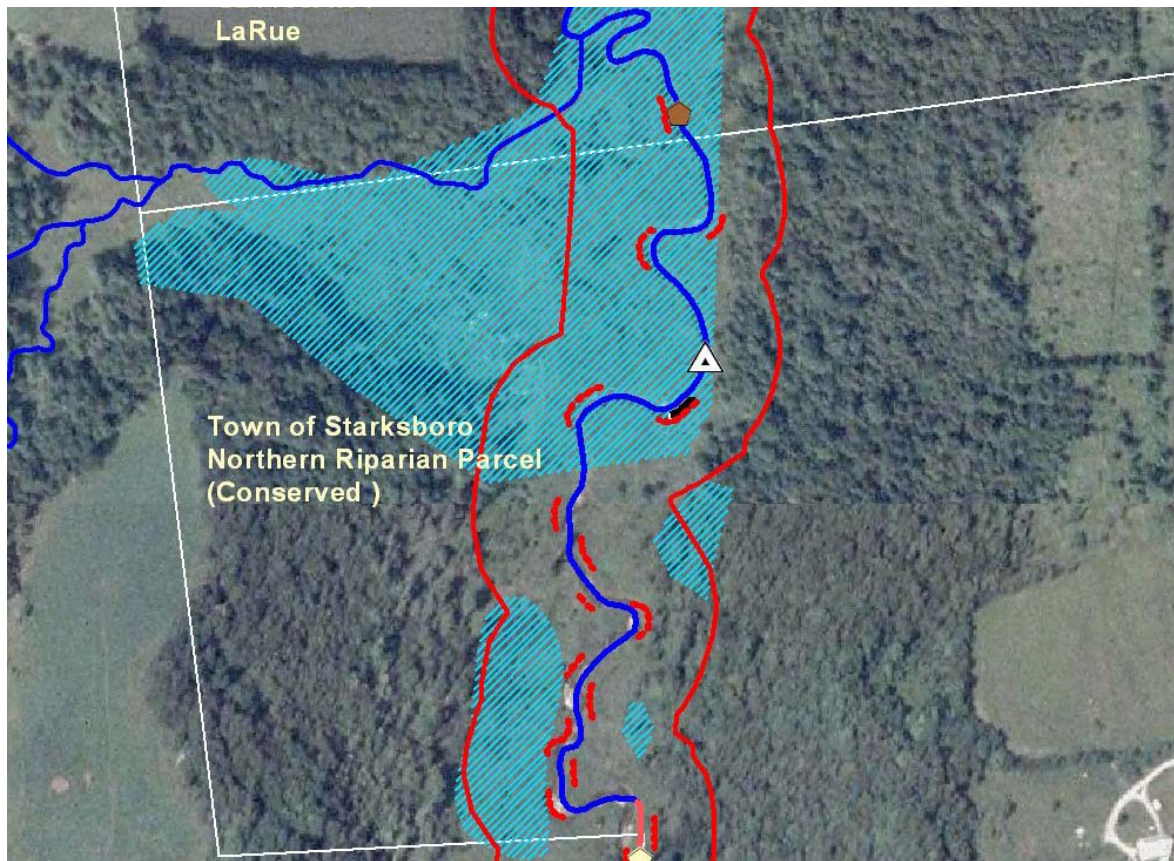


Figure 1. Northern Riparian Parcel, Lewis Creek Reach M17-B.

Starksboro – Reach M17, Segm B – Town of Starksboro Northern Riparian Parcel

Background

The Town of Starksboro Northern Riparian Parcel is approximately 92 acres in area comprised of former Cota Farm lands north of States Prison Hollow Road. These lands were transferred to the Town of Starksboro in December of 1998, along with the Southern Riparian Parcel encompassing portions of Lewis Creek reach M19 south of States Prison Hollow Rd. These two parcels are part of a multi-acre conservation project involving the Town of Starksboro, Vermont Land Trust, and the Vermont Housing Conservation Board. The Starksboro Conservation Commission is primary steward of these lands and Lewis Creek Association partners with the Commission regarding management of the activities that pertain to the Lewis Creek.

A total of 3,200 feet of Lewis Creek frontage is estimated for this Northern Riparian Parcel. The Lewis Creek forms the western boundary of the parcel in its southern portion, and bisects the northern portion of the parcel (See Figure 2).

The 28 July 2003 Management Plan for the Cota Lands Conservation Parcels states that access to the Northern Riparian Parcel "is via a 50-foot right-of-way extending from Green Mountain Cemetery Road on the east" (Town of Starksboro, 2003).

Land uses and long-term commitments within the corridor:

Management goals for the Northern Riparian Parcel, expressed in the Town of Starksboro, 28 July 2003 *Management Plan for the Cota Lands Conservation Parcels*, include:

- "to conserve and protect the public outdoor recreational, scenic, environmental, ecological, cultural, forestry, agricultural and open space resources of the Protected Property";
- to "provide opportunities for educational activities";
- to "permit the maintenance of public trails incidental to appropriate public recreational use", and
- "to conserve wildlife habitats associated with the Protected Property for present and future generations." (p. 6)

The management plan further outlines that:

- structures are prohibited (p. 7);
- vehicular traffic is prohibited (p. 7);
- "Management will encourage vegetation buffers...by plantings as needed" (p.7).
- "Future efforts at streambank stabilization will likely be limited to planting" (p.8).
- "Since the stream channel in this area meanders in a well defined corridor, no streambank protection measures are anticipated" (p.10).

In summary, the Northern Riparian Parcel "is to be managed primarily to conserve wildlife habitat, maintain or improve water quality, provide education opportunities for local school children and adults, and for non-motorized recreation" (p. 10).

River Corridor Constraints

Historically, the Northern Riparian Parcel was part of the Cota Farm. Former hay and/or pasture use is inferred from review of 1942 and 1962 aerial photographs. Historic channelization is also inferred from review of these photographs. At present, lands along the Lewis Creek corridor in the Northern Riparian Parcel are mostly fallow, and dominated by wetlands (NWI). Short sections of old rip-rap armoring constrain the channel planform to a limited degree. Pockets of rip-rap are being eroded and undermined by active lateral adjustments of the channel.

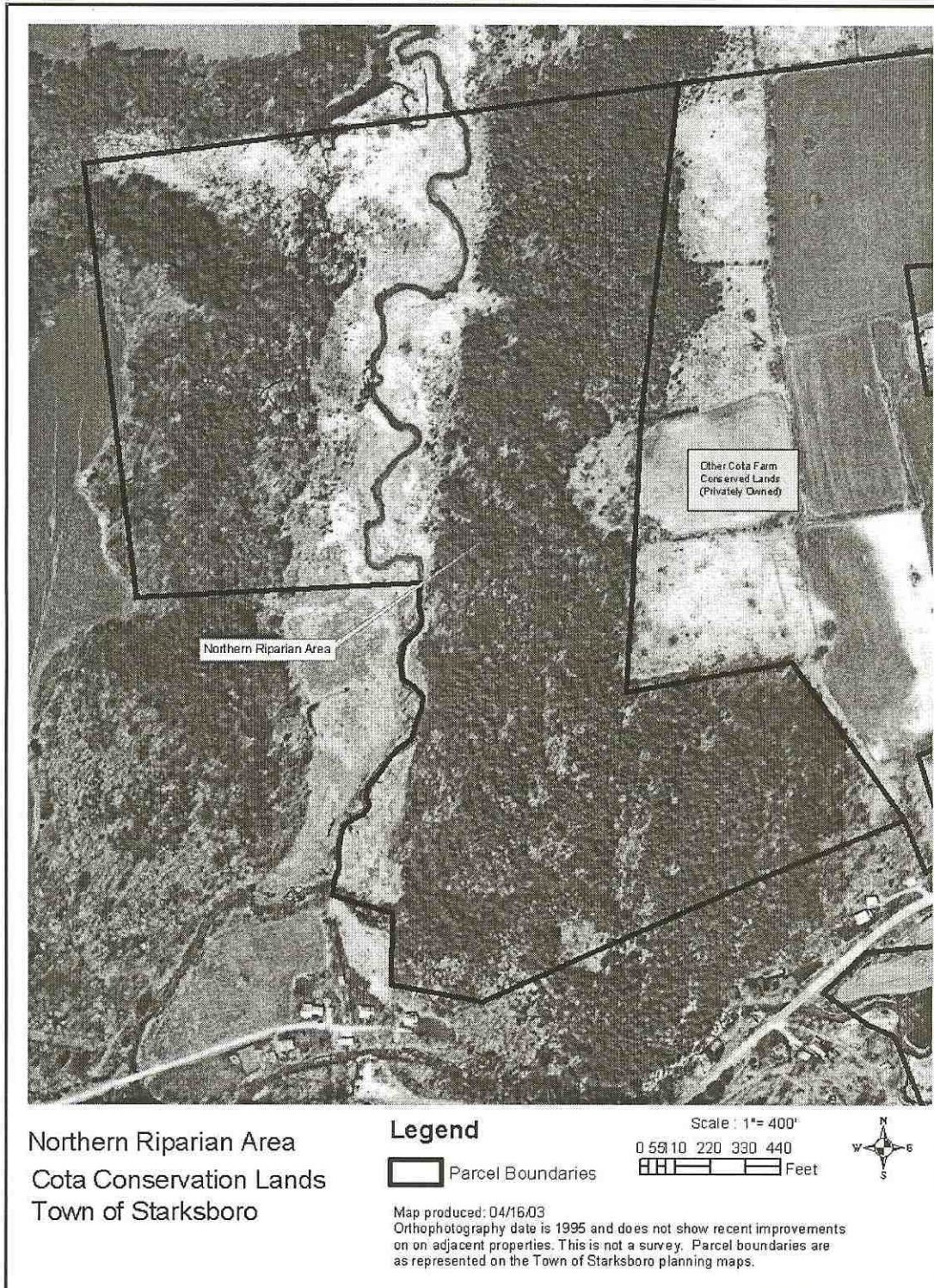


Figure 2. Location of Northern Riparian Parcel, excerpted from Town of Starksboro, 28 July 2003 Management Plan for the Cota Lands Conservation Parcels, Appendix B.

Starksboro C21163AW1 – Reach M17, Segment B – LaRue / Morgan

Landowners: Robbin LaRue, Chris Morgan
 Street Address: 4857 VT Route 116, Starksboro

Description: Fallow pasture spanning Lewis Creek, with corn and hay fields in outlying areas from the Creek valley, fronting on VT Route 116. Wetlands contiguous to the Creek. One bankfull-constricting farm bridge crossing, in a state of disrepair.

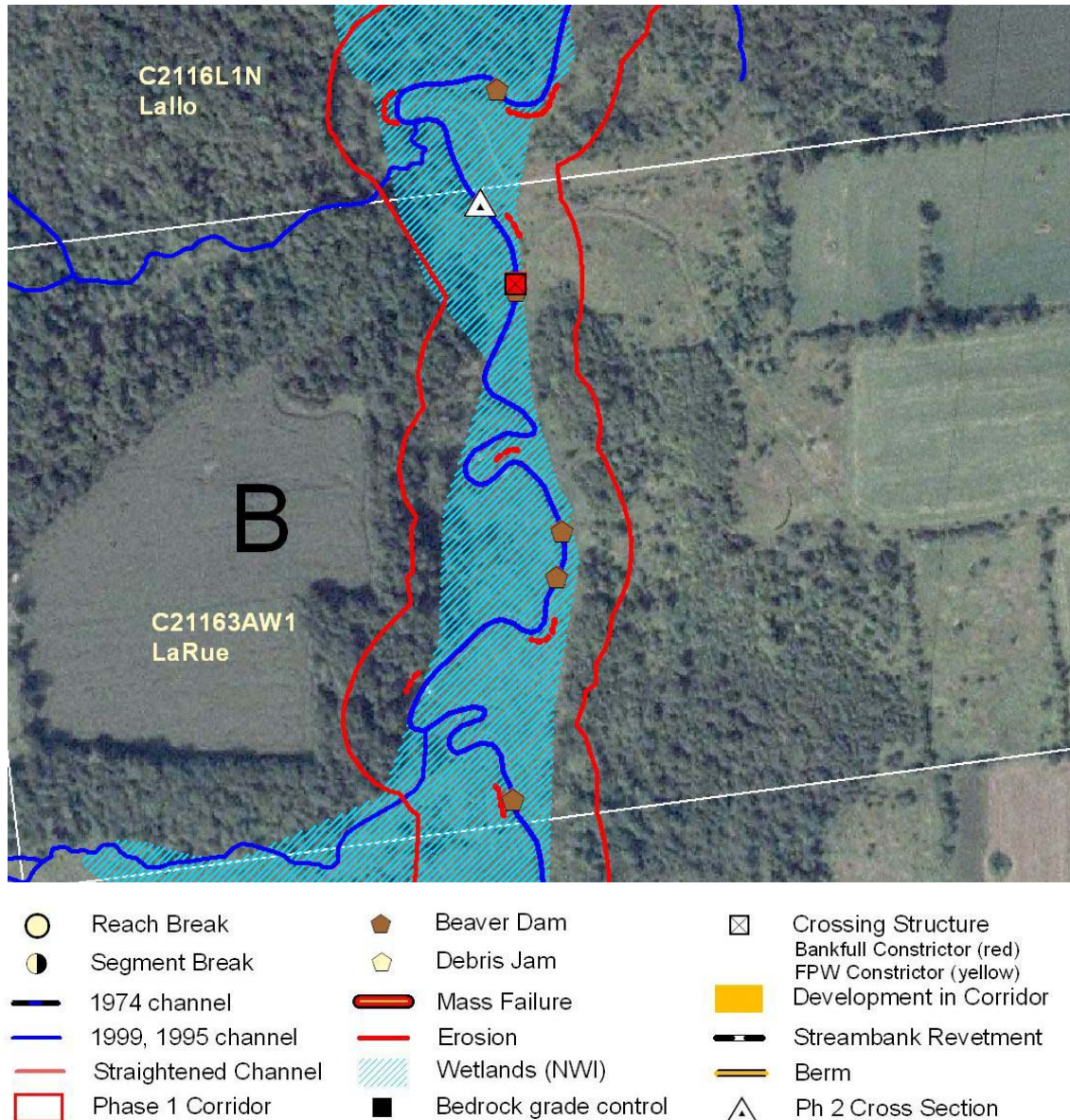


Figure 1. Phase 2 stream geomorphic assessment data for Segment B of reach M17 in vicinity of LaRue property. *White lines indicate parcel boundaries. Base photograph, dated 2003.*

Starksboro C21163AW1 – Reach M17, Segm B – LaRue / Morgan

9/10/2007 – 4:00 PM Meeting with Robbin LaRue

Attending: Kristen Underwood

Reference Corridor Plan, Table 27, Project 6

Background

Kristen Underwood met with Robbin LaRue and walked the Lewis Creek from States Prison Hollow Road Ext downstream to the LaRue private bridge.

LaRue and Morgan acquired the property in 1994. Fields are leased to local farmers for corn production (in the western half of the parcel) and hay (in the eastern half). The parcel is enrolled in the current use program. There are no conservation easements on the parcel. Former Cota lands abutting to the south are owned by the Town of Starksboro and have been placed into conservation (easement held by the Vermont Land Trust).

The corridor itself is a combination of forest cover and wetland vegetation. Aside from the bridge crossing, agricultural land uses have not encroached significantly within the corridor in the last several years. Possible historic pasture use was evident on the 1962 and 1942 photos spanning the channel in vicinity of the crossing. Robbin noted that the Shepards farmed the land from the 1940s to the 1980s, and grazed cows in this area (now fallow). Trees have revegetated in the corridor considerably since the 1942 and 1962 photographs.

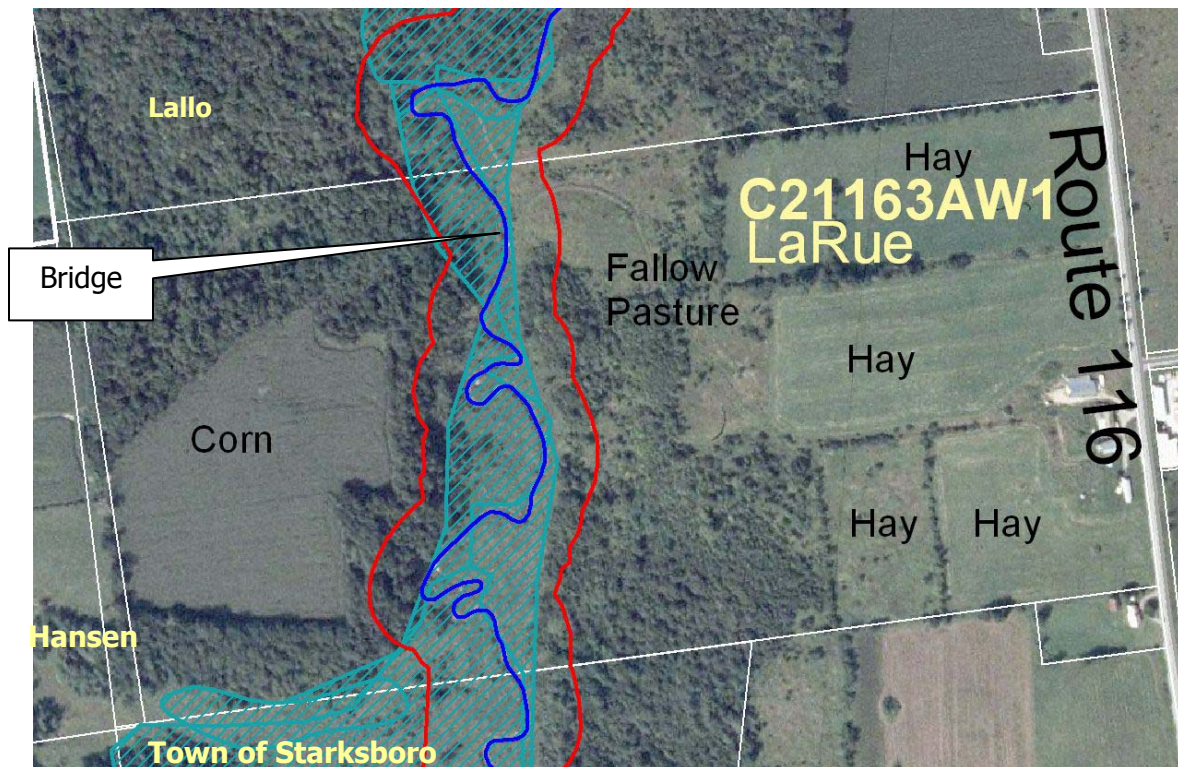


Figure 2. Present land use constraints within the LaRue corridor.
(2003 NAIP base image; red line indicates Phase 1 corridor (SGAT v.4.50); turquoise hatched lines indicate NWI wetlands)

River Corridor Constraints

There is a private bridge crossing near the middle of the property which permits access to fields and forest along the western half of the property from the eastern half which has frontage along Route 116. While secondary access is possible to the western half of the property across private lands from States Prison Hollow Road, there is no deeded right-of-way or other legal access through these private lands from States Prison Hollow Road. At present, the bridge is used primarily for private recreation, but Robbin and Chris would like to restore the bridge to a condition which could support farm vehicles.

The bridge is constructed of wooden planking over steel I-beams supported on a laid-up stone abutment (right bank) and a concrete abutment (left bank). The approximate bridge span is 18 feet, and clearance to the stream bed is approximately 6.3 feet (measured September 2002). This crossing is significantly undersized with respect to the reference bankfull width (52.2 feet) and the measured bankfull width (33.7 feet). A downstream scour pool was observed in Sept 2002. On 10 September 2007, a beaver dam was present within 3 feet upstream of the bridge. Debris from spring runoff (according to Robbin) was observed on the deck of the bridge. The bridge is in considerable disrepair. Several small sticks have been placed between remaining wooden planks. Robbin suspects this has been done by area residents who use the bridge (against her and Chris' wishes) to access the property with ATVs. Robbin expressed concern for riders' safety and will be talking with their neighbors – there is also concern for liability.



Figure 3. LaRue private bridge,
Reach M17, Segment B
10 September 2007

Land uses and long-term commitments within the corridor:

As present land owners, Robbin and Chris do not foresee future encroachments within the corridor – other than improving the existing crossing to support farm vehicle access to the western side of the property. They would like not to constrain their abilities in the future to possibly farm more intensively and/or build a home(s) on the property (outside the corridor).

Current Concerns of the Landowner

Robbin expressed concerns for overall health of the river. She would like to learn more about the geomorphic conditions, as well as overall ecology of the full parcel. (They have seen black bear, deer, beaver, porcupine, wild turkey, ducks, geese. We observed a heron, and deer and raccoon tracks on 10

September, as well as several beaver dams, beaver slides, and trails up into the adjacent woods). She would be very willing to have a UVM or Middlebury student(s) study the parcel and offer suggestions for wildlife management, invasives management, etc.

We encountered many items of household and farm rubbish in the river (much more than Kristen recalls from walking the river in 2002) - several tires, pottery and glass shards, plastic bottles and bags, one drum, etc. We speculate that the large mass failure and road collapse that occurred last year along the States Prison Hollow Road may have “liberated” a household or farm dump. A river cleanup day with LCA volunteers would be appreciated, if at all possible.

Most importantly, they would like to rehabilitate the bridge crossing. She understands that a wider span and higher clearance of the bridge crossing would be less constricting for the river, and would improve longevity of the bridge – but would also involve more resources than they have typically been able to invest in maintenance of the bridge. They would appreciate any technical / financial assistance that might be available.

River Corridor Alternatives Acceptable to Landowner

Robbin stated that she and Chris are open to many possibilities. She would like to see the river restored to its historic condition and encourage practices that would support a diversity of wildlife. She would prefer private over public access to the property, discouraging hunting (through posting) and ATV access. As present landowners, they are committed to supporting a passive geomorphic approach and preserving sediment and nutrient attenuation functions offered by the ample floodplain connection and channel-contiguous wetlands. They would be open to hearing more about possible conservation options.



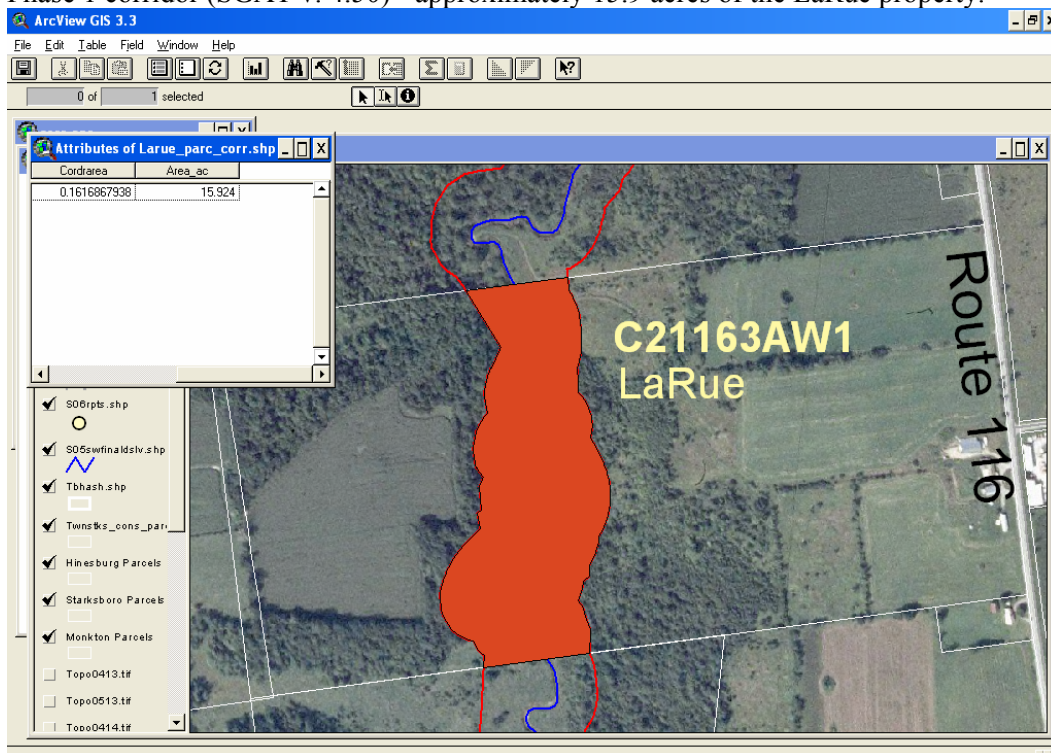
Figure 4. View upstream (south) from center of LaRue property; beaver dam in foreground; Hogback Mountain in background.



Figure 5. View upstream (south) from vicinity LaRue private bridge.

Provisional Data

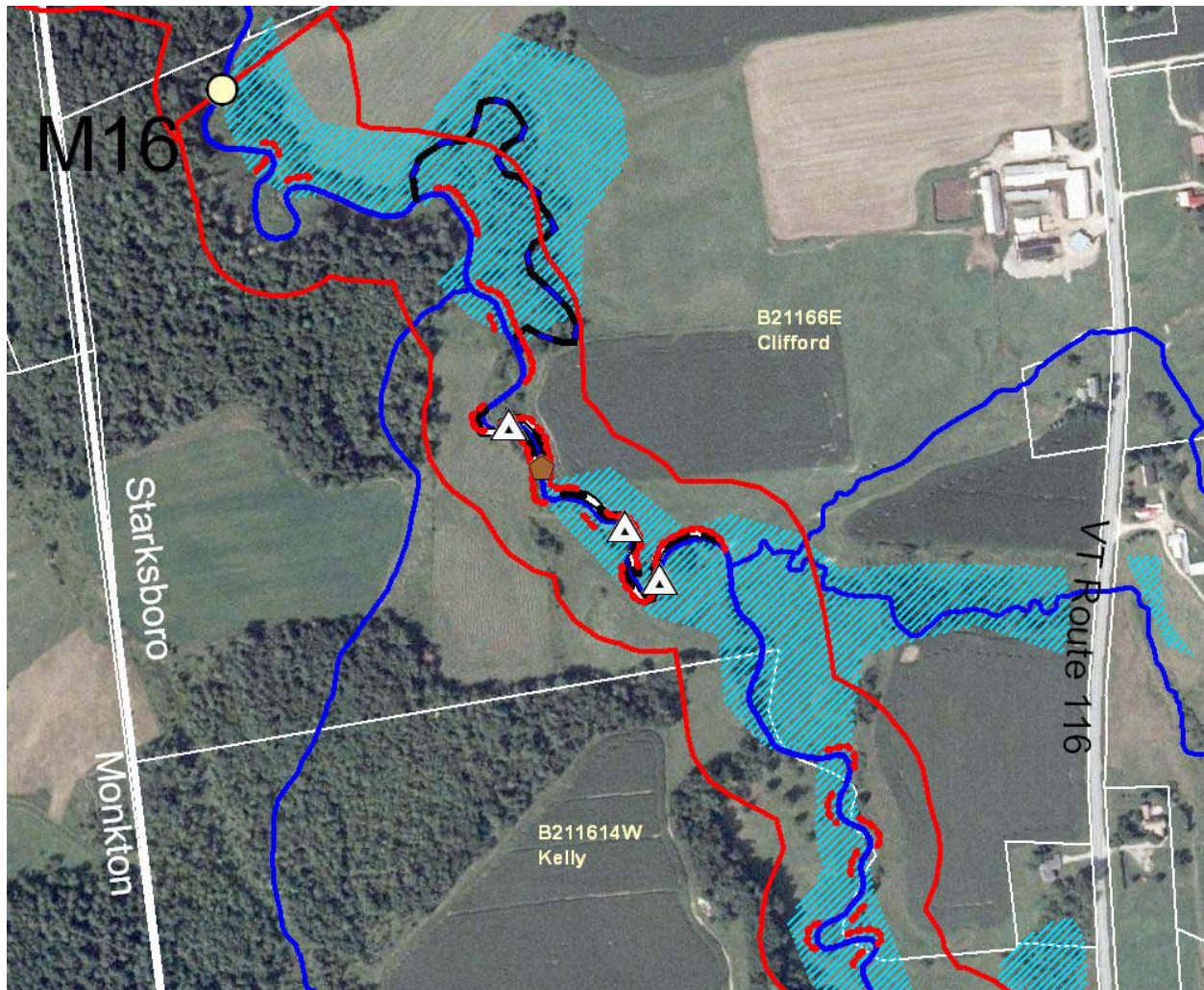
Phase 1 corridor (SGAT v. 4.50) - approximately 15.9 acres of the LaRue property.



Starksboro B21166E – Reach M16 – Clifford

Landowners: Clifford, Eric
 Street Address: 6147 VT Route 116, Starksboro, VT 05487

Description: Dairy farm lands spanning Lewis Creek. Mixture of forest, corn fields, hay fields, and pasture land uses comprising the corridor. Wetlands (NWI and prior-converted) contiguous to the Creek.



- | | | |
|----------------------|-----------------------|----------------------------|
| Reach Break | Beaver Dam | Crossing Structure |
| Segment Break | Debris Jam | Bankfull Constrictor (red) |
| 1974 channel | Mass Failure | FPW Constrictor (yellow) |
| 1999, 1995 channel | Erosion | Development in Corridor |
| Straightened Channel | Wetlands (NWI) | Streambank Revetment |
| Phase 1 Corridor | Bedrock grade control | Berm |
| | | Ph 2 Cross Section |

Figure 1. Phase 2 stream geomorphic assessment data for reach M16 in vicinity of Clifford property. White lines indicate parcel boundaries. Base photograph, dated 2003.

Starksboro B21166E – Reach M16 – Clifford Farm
Reference Corridor Plan, Table 27, Project 9

Background

The Clifford farm along Lewis Creek is located west of Route 116 in the town of Starksboro (see Site Location Map, Attachment 1). Unstable streambanks have been a concern at this site for several years; stream bank erosion has been exacerbated by direct pasturing of cattle, beaver activity, and lack of forested riparian buffers. The site has undergone several phases of restoration from 2001 to 2005 involving the participation of the landowner and several partner groups including the Natural Resource Conservation Service, US Fish & Wildlife, Lewis Creek Association, Youth Conservation Corps, the University of Vermont and local school groups. Restoration activities have included: installation of cedar revetments, installation of willow waddles, planting of acorn seeds, and planting of tree seedlings (see Table 1 for a summary and timeline of major restoration efforts). Pastured livestock (dairy cattle) had direct access to the stream until 2007 when fencing was installed under a CRP / CREP project. Access to the Lewis Creek is now limited to one stabilized equipment / livestock crossing located in the middle of the parcel.

VT Agency of Natural Resources, in partnership with Lewis Creek Association, conducted a Phase 1 and Phase 2 Stream Geomorphic Assessment of the Clifford site in August of 2001 (VTDEC, 2003). At this time two prominent meander bends at the Clifford site had been treated with cedar revetments by NRCS earlier in the Summer (see Meander Bend A and B in attached Map 1).

The second geomorphic assessment was conducted by LCA in May/June of 2005 using then current Phase 2 and Phase 3 (survey-level) protocols. In the intervening years between the two geomorphic assessments, NRCS and partners had installed cedar revetments on both banks along a majority of the site, cows had been fenced out of the Creek, a minimum 35 foot buffer had been established along the right bank of the Creek (facing downstream) along the western boundary of the Clifford corn field, and tree seedlings had been planted along the right bank buffer area (approximately 0.7 acre). These features are depicted on the attached 2001-2005 Restoration Map (Map 1).

By 2005, erosion along the prominent meander bends treated in 2001 was mostly healed and these banks were no longer actively slumping (see Figure 2). Conversely, erosion along other segments of restored streambank was active, and seedlings planted in 2003 were being carried on slump blocks into the channel (see Figure 3). Based on the width of these slump blocks, lateral migration was estimated at 2 to 3 feet in two years. It should be noted that some of these slumping banks (but not all) were associated with the location of a breached beaver dam, and beaver impoundments and activities may have compromised the effectiveness of the revetments in some areas.

Soils along the streambank and bed of the Lewis Creek are somewhat cohesive, but highly erodible. Medium brown and gray fine sands with silt and clay were noted along streambank profiles sampled in May 2005 (see Table 1). Underlying these sands is a layer of varved clays at depths typically submerged below Summer low water levels. Cross section profiles completed during a Phase 3 survey in June 2005 indicated that the dominant streambed material was fine to medium gravel, and all streambed particle sizes observed appeared to be mobile in a bankfull or higher-magnitude flow event.

Peter Lossmann of the NRCS noted that between 2001 and 2005, pools had scoured to underlying clays along the extent of restoration (interview, 11 May 2005). Mr. Lossmann theorized that installation of cedar revetments may have increased roughness elements along the channel margins, and translated erosive energies into downward vertical scour. Several exposures of varved clays were noted in pool features along the profile of the Clifford site in 2005 geomorphic assessments. Clay was noted in 2001

also, but the accuracy of location and elevation data were not sufficient in the two assessments to quantify vertical or lateral adjustments.



Figure 2. Meander Bend A at Clifford site (reference Map 1). (Above) - meander in August 2001 exhibiting active slumping and erosion; note cedar revetments along water line. (Right) - meander in May 2005, erosion mostly healed.

Figure 3. Active bank slumping noted May 2005 along banks treated with cedar revetments in 2003.



On some streambank sections (for example on approach to Meander Bend B in Map 1), the cedar revetments installed in 2003 were noted to be laterally outflanked (Figure 4). This bend is one of four bends along the profile that have radii of curvature much less than regime equations would predict for the given channel width (see Attachment A). Meanders are continuing to broaden and migrate, and the radius of curvature calculations detailed in Attachment A indicate those tighter meander bends (i.e., ones with very small radius of curvature) can be expected to erode more severely than others along the profile. Such increased erosion on approach to this tight meander bend may have contributed to lateral outflanking of the cedar revetments. It is also possible that vertical scour would have lead to undermining of the revetments in this location.

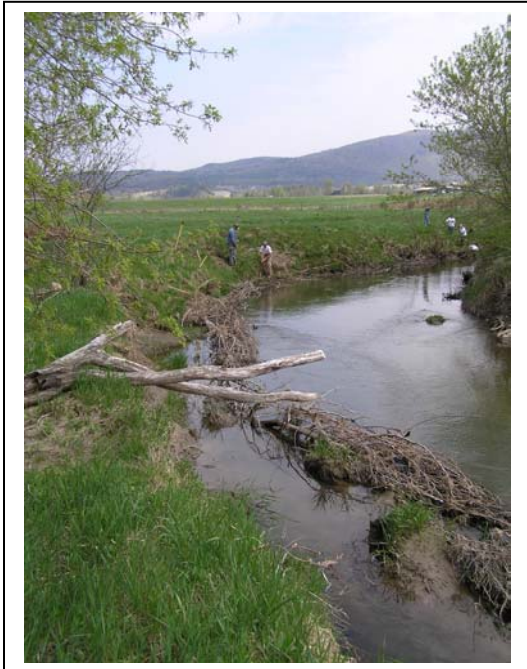


Figure 4. View upstream from Meander B in Map 1 (May 2005). Cedar revetments along right bank (facing downstream) installed in 2003 were laterally outflanked. Background: volunteers installing willow waddles along top of cedar revetments.

Based on these observations, and in consideration of the geomorphic information made available by Lewis Creek Association and the VTDEC River Management Section, NRCS began to recognize the importance of corridor protection at this highly-sensitive site experiencing increased lateral adjustment and sedimentation. Active restoration techniques were traded for a more passive approach – i.e., stepping back from the river banks with the more intensive pasture and cropping uses and providing a considerably-wide corridor within which the river can begin to seek a more balanced planform, profile and dimension. In the process of unconstrained meander extension, the Lewis Creek will be gaining length, reducing its slope, reducing the erosional energies, and building more point bar areas for sediment deposition.

The concept of corridor easements to protect a meander beltwidth (6 to 8 times channel width area) surrounding the channel was discussed with the Cliffords. In the end a narrower protected area was identified as a compromise (see Map 3), but the riparian buffer is still greater than the minimum called for under Acceptable Agricultural Practices or traditional CRP agreements.

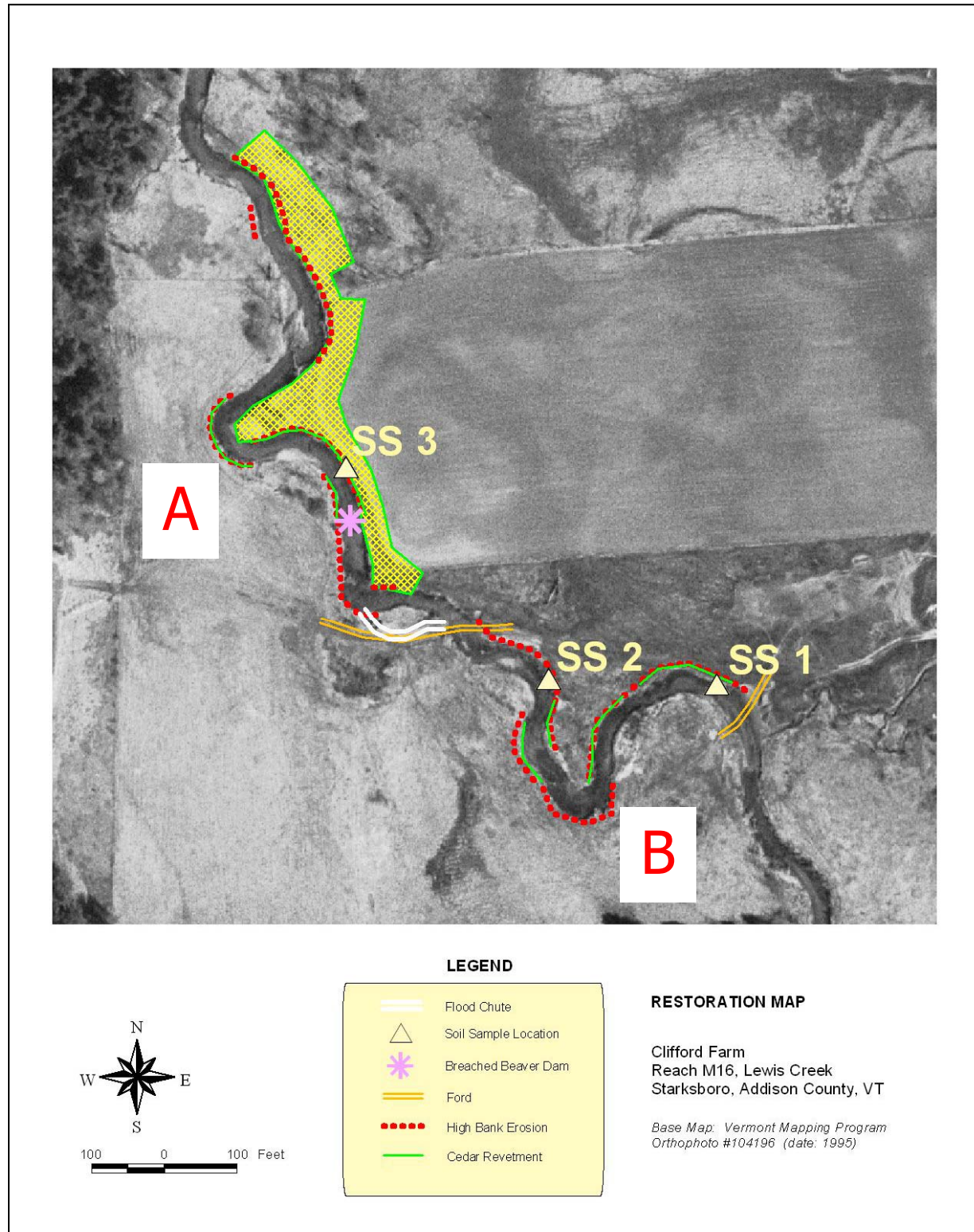
Livestock have been excluded from the channel, except at a single, stabilized equipment / livestock ford. Alternate watering sources have been established for the cattle. A riparian buffer has been established along more than 1000 feet of the channel that ranges in width from 35 to more than 100 feet in many places (see Map 4). Active cropping and pasturing no longer occurs within this buffer area. Essentially

the corridor area will remain undisturbed. These actions will reduce *E. Coli*, nutrient, and sediment impacts to Lewis Creek – both by substantially reducing direct fecal inputs to the Creek and streambank trampling, as well as by reducing the legacy of phosphorus and other nutrients to floodplain soils within the corridor, which may be subject to erosion in the future as the river adjusts to regain a more balanced condition.

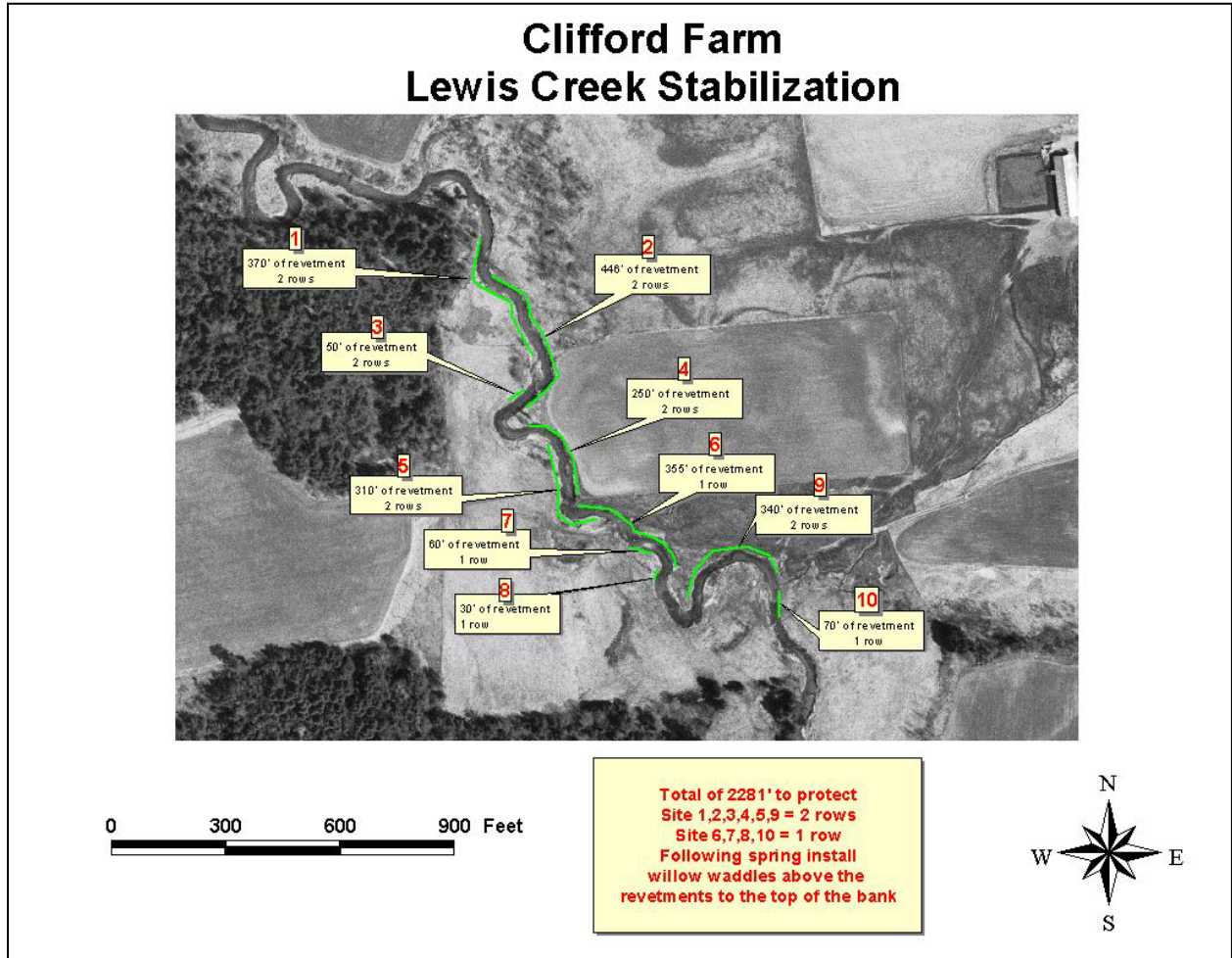
From 2001 through 2007, a series of seed and sapling, tree and shrub plantings has been implemented by the Cliffords, assisted by NRCS, USFW (Partners for Wildlife), UVM students, CVU students, Hannaford Technical Center students, Stark Mountain Woodworking of New Haven, The Nature Conservancy, and the Lewis Creek Association. These plantings will gradually mature into a forested buffer, offering greater roughness along the channel margins and further slowing the rate of lateral channel adjustments.

**Table 1. Restoration and Assessment History
Clifford Farm, Reach M16, Lewis Creek, Starksboro, VT**

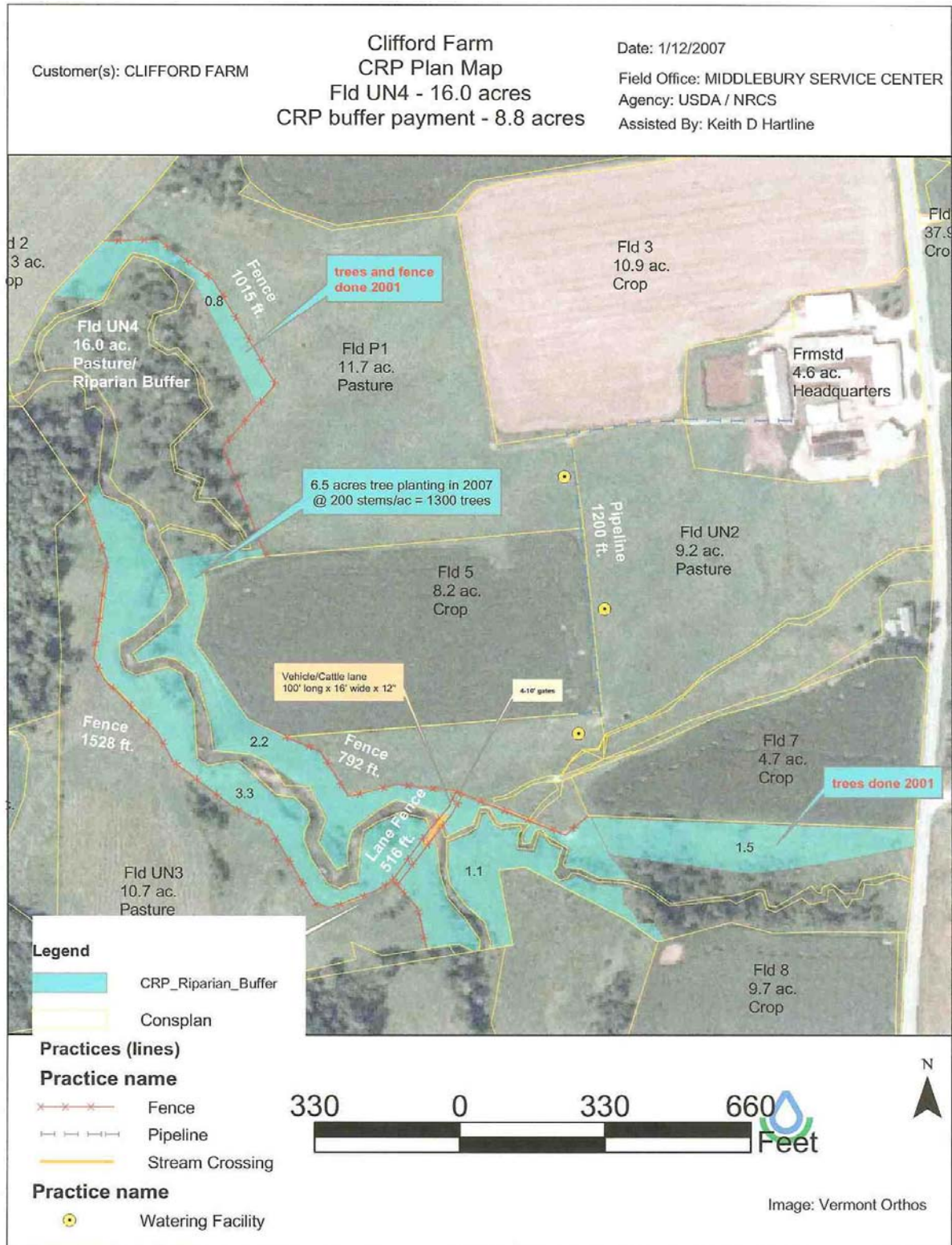
Year	Left Bank	Right Bank	Description	Partners
Fall 2001			Acorn seed planting April 2003 assessment by NRCS showed 90% germination	NRCS, LCA
2001	X		Cedar revetments, outside meander bend of two tight meanders (Sites A and B on Figure 2-1. Restoration Map).	NRCS, YCC
2001 (23 August) Phase 2 Stream Geomorphic Assessment – VTDEC River Management Section				
2002		X	Tree plantings – bare root trees/shrubs – 220 plants/Ac April 2003 assessment by NRCS showed 70% survival	NRCS, LCA UVM –Watzin/Keeton
2003	X	X	Cedar revetments on all but Sites 9 & 10 (see Figure 2-2: Sept 2003 NRCS Map “Clifford Farm: Lewis Creek Stabilization”)	NRCS
2004		X	Cedar revetments at Sites 9 & 10	NRCS
2005 May 11		X	Stream-co willow waddles – 2 rows above revetments at sites 9 & 10	NRCS, LCA, Bill Scott & Hannaford technical center students
2005 (11 May) Streambank Composite Soil Sampling for Total Phosphorus content – Lewis Creek Association				
2005 (11 May, 24 June) Phase 2 and Phase 3 Stream Geomorphic Assessments – Lewis Creek Association				
2007 April	X	X	1300 seed plantings – trees and shrubs – starting from fence line and working toward the river, both left and right banks.	NRCS, USFW, (Partners), LCA, Stark Mountain Woodworking, UVM (Gund Institute students), CVU students (Environmental Club), TNC (supplied seeds)
2007	X	X	Fence line and stabilized stream crossing installed (see 2007 Clifford Farm CRP Plan Map)	NRCS



Map 1. 2001-2005 Restoration Map of Clifford Farm, Reach M16, Lewis Creek.
 Notes: Site A and B indicate large left-bank meander bends that were first treated with cedar revetments in 2001 (NRCS). Yellow hatched pattern denotes areas of tree plantings and buffer established, 2003. Map prepared by South Mountain Research & Consulting from observations on 11 May 2005.



Map 2. NRCS Revetment Plan, Clifford Farm, Reach M16, Lewis Creek.
Map prepared by NRCS – Middlebury (Keith Hartline)



Map 3. 2007 Clifford Farm CRP Plan Map, Reach M16, Lewis Creek.
 Map prepared by NRCS – Middlebury (Keith Hartline)

**Attachment A.
 Radius of Curvature Data**

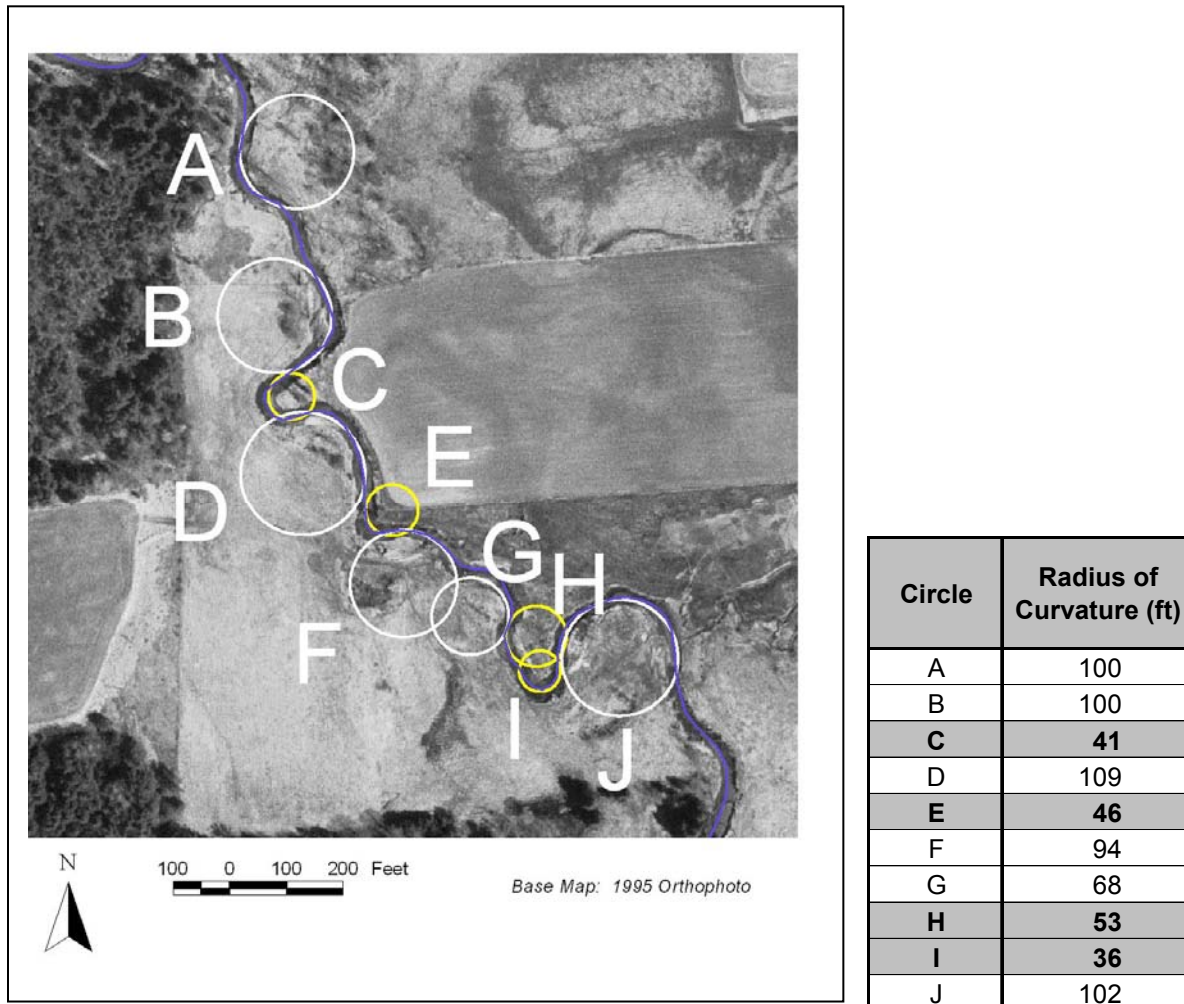


Figure A-1. Radius of Curvature of meander bends at Clifford project site, Reach M16, Lewis Creek.

Blue line indicates center line of Lewis Creek channel (1995). Circles approximate the radius of curvature of individual meander bends along the channel planform. Circles highlighted in yellow (C, E, H, and I) indicate a meander radius of curvature that is undersized with respect to predicted radius of curvature for the indicated channel width, based on equation from Williams, 1986 (see Table A-1).

Tight meander bends at the location of yellow-highlighted circles would be expected to exhibit excess erosion, and potential for neck cutoffs. Restoration along the outside of these meander bends would not be advised given the high potential for lateral and/or vertical undermining of the structures during continued erosion. Similarly, buffer plantings along the outside of these undersized meander bends should be cautioned as investments in the corridor and along the bank may be compromised by the continuing erosion.

Table A-1. Radius of Curvature Calculations, Reach M16, Lewis Creek.

Reach	Width _{bkfl} (feet)	Source	Radius of Curvature		
			Williams Eq. 33	Range, Williams (SD)	
			Radius of Curvature Predicted (ft)	Low (ft)	High (ft)
				-0.35	+0.55
M16	60.6	Phase 1 (regime)	129	84	200
	44.0	Cross Section (XS-1)	90	59	140
	68.6	Cross Section (XS-2)	148	96	230
	56.3	Cross Section (XS-3)	119	77	184
	42.0	2001 Phase 2	86	56	133
	42	Low	86	56	133
	69	High	148	96	230
	54	Average	114	74	177

Reach	Width _{bkfl} (meters)	Source	Radius of Curvature		
			Williams Eq. 33	Range, Williams (SD)	
			Belt Width Predicted (ft)	Low (ft)	High (ft)
				-0.35	+0.55
M16	18	Phase 1 (regime)	39	26	61
	13	Cross Section (XS-1)	27	18	43
	21	Cross Section (XS-2)	45	29	70
	17	Cross Section (XS-3)	36	24	56
	13	2001 Phase 2	26	17	40
	13	Low	26	17	40
	21	High	45	29	70
	17	Average	35	23	54

From Williams, 1986; *Journal of Hydrology*, 88 (147-164).

Equation 33: Radius of curvature, $R_c = 1.3 \cdot W^{1.12}$ (in feet); applicable Width (W) range (4.9 to 7,000 feet); 79 data points, worldwide; Sample correlation coefficient of 0.97; Standard Deviation of -35 % to +55 %.

Starksboro B25L5S – Reach M15, Segment B – Padua and Cobble Creek Nursery

Landowners: Padua, John & Patricia
Street Address: 991 Tyler Bridge Road, Starksboro
Mailing Address: 991 Tyler Bridge Rd, Bristol VT 05443

12/7/2007 – 12:00 Noon Meeting with John Padua
Attending: Kristen Underwood, Marty Illick
Reference Corridor Plan, Table 27, Project 10

Background

The Paduas own land along the southwest side of Lewis Creek in the towns of Monkton and Starksboro (Figure 1). A parcel north of the Tyler Bridge Road was acquired circa 1999; the western boundary of this recently-created lot is not depicted by the (somewhat outdated) parcel boundaries on Figure 1. Padua lands include approximately 1,900 feet of frontage along the Lewis Creek including the vicinity of the Hollow Brook confluence. The Lewis Creek corridor (Phase 1) on Padua lands is partly forested and partly agricultural. The Padua's operate Cobble Creek Nursery – a wholesale tree and shrub nursery that includes both container stock and field stock. Tyler Bridge Road crosses the Lewis Creek between separate parcels of Padua land. Nursery stock is maintained on both sides of the road along the Lewis Creek left-bank floodplain. No structures are present in the Padua corridor, except for incidental sheds associated with the nursery operations. The Padua house, accessed from Tyler Bridge Road, is on a knoll which is elevated approximately 25 feet above the Lewis Creek and located just south of the left-bank corridor along the Creek.

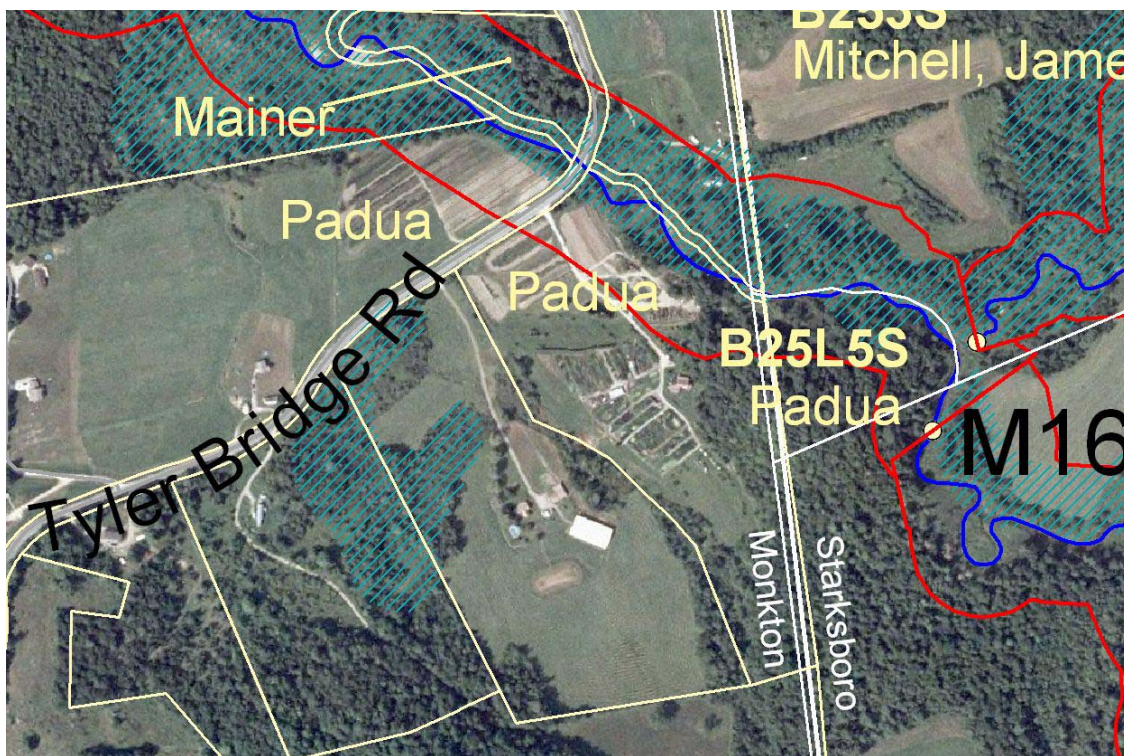


Figure 1. Padua property, Tyler Bridge Road, Monkton, Starksboro, VT (2003 NAIP base image; red line indicates Phase 1 corridor [SGAT v.4.50]; turquoise hatched lines depict NWI wetlands; white lines are Monkton and Starksboro approximate parcel boundaries [not current]).

River Corridor Constraints

(bridges, roads, buildings, agricultural structures and land uses)

- Current constraints:

There are minor structures (semi-permanent sheds) associated with the nursery currently located within the Lewis Creek corridor on Padua lands. The Tyler Bridge Road crosses the Lewis Creek corridor between Padua parcels; a bridge crossing conveys the road over Lewis Creek. The span of the bridge (62 feet) is slightly wider than the reference bankfull width (55.5 feet) and measured bankfull width (57.3 feet) of the channel (SMRC, 2007).

- Land uses and long-term commitments within the corridor:
(e.g., farming practices, public access, lands carrying easements)

Approximately 3.8 acres of tree / shrub nursery container and field stock are located within the Lewis Creek corridor (GIS estimate). The northern Padua parcel, according to John Padua, is a permitted building lot; the likely building envelope is located on the highest ground straddling the Phase 1 corridor (see Figure 2).

Current Concerns of the Landowner

(e.g., flooding losses, erosion, upstream land uses, etc.)

John Padua noted that they are strong supporters of efforts to protect river health and water quality. In the 1980s, family members used to catch 16- to 19-inch brown trout. Today, they notice increased sedimentation in the Creek, and area fishing is reportedly not as prolific as it once was.

They have observed beaver activity periodically. On occasion, the beavers have dropped large trees in the river, which have then locally altered the flow patterns and lead to some increased streambank erosion. In the past, they have paid to have beavers trapped and removed from the area, due to loss of nursery stock by beaver harvesting.

There have been two moderate flood events in the time that they have lived along the Creek; one approximately 10 years ago; and a second in January 2006. No major erosion losses were incurred by the Padua's.

Their past interest in possible conservation options (through VLT) was tempered by the fact that conservation agreements tended to limit or prevent horticultural activities (e.g., removal of top soil) within close proximity to the river. Their nursery operations depend on the ability to grow trees and shrubs in the organically-rich, well-drained floodplain soils – and remove the topsoil (e.g., dig up young trees/shrubs supporting the root ball with native soils). We discussed that conservation options through other programs (e.g., VT River Conservancy, USDA CRP program) may now allow for more flexibility in that regard, provided that their nursery operations (or other future plans for their lands) can accommodate an adjusting river and no structures in the corridor.

Kristen Underwood brought up the small gully erosion occurring along the left-bank of the Lewis Creek immediately upstream of the Tyler Bridge Road. John Padua noted that this small channel has begun to widen and deepen considerably in the last couple of years. He surmises that it is related to tributary drainage that has been diverted from a driveway culvert site on neighboring lands to the southwest owned by the Frye's. He and the Frye's have noted that the Frye driveway culvert has become blocked with sediment and debris, and a portion of the drainage from an intermittent tributary that previously drained to the northwest to a Tyler Bridge Road culvert and ditch along the western boundary of the northern Padua parcel, instead now is diverted to the Padua nursery lands. This diverted flow is picked up by drainage patterns within the nursery and is ultimately delivered to the small channel which joins the Lewis Creek just upstream of the Tyler Bridge Road (Figure 2).

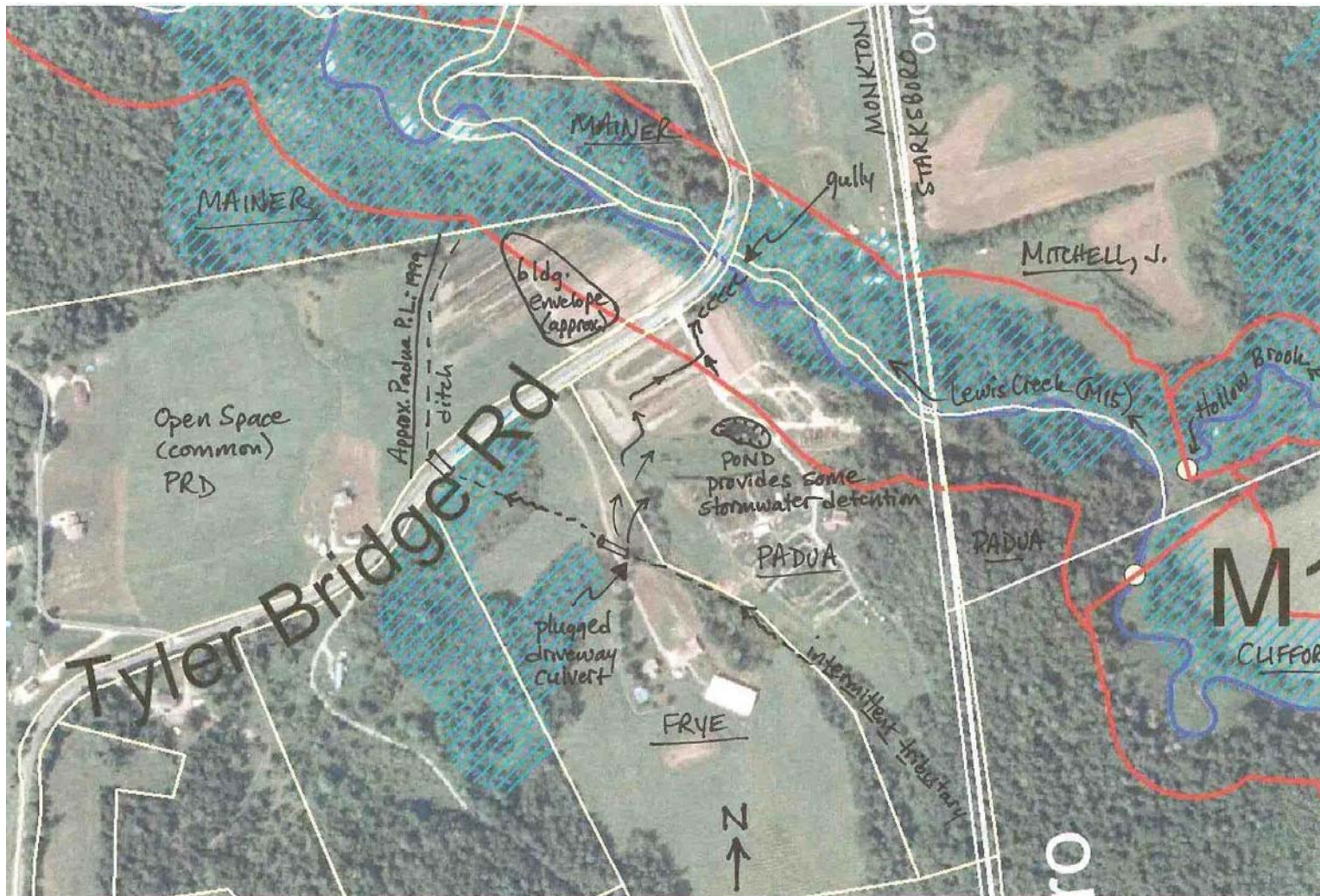


Figure 2. Drainage features in vicinity of Padua property (notes from 3 Dec 2007 meeting w/ John Padua – not field-verified). (2003 NAIP base image; red line indicates Phase 1 corridor [SGAT v.4.50]; turquoise hatched lines depict NWI wetlands; white lines are Monkton and Starksboro approximate parcel boundaries [not current]).

We discussed that changes to local drainage patterns may have increased flows to this small channel to a degree that may have exceeded thresholds for erosion – contributing to the head cuts and development of gully erosion noted in this small channel. Mr. Padua stated that they irrigate only minimally at the nursery – typically during very dry conditions. During those times, much of the irrigation water is absorbed at the tree sites, and little runoff is produced. The upper fields (at the southern extent of the nursery) drain to the north, and a small pond provides some detention of flows. John Padua will contact Pete Lossmann at NRCS to see if a USDA program might be available for technical and financial assistance to resolve this drainage issue. We advised that River Corridors Program or other funding might also be available for local match, or for related efforts on non-agricultural lands (e.g., at the Frye culvert).

River Corridor Alternatives Acceptable to Landowner

(Based upon geomorphic data, corridor constraints, and local needs.)

John Padua stated that he and his wife would be open to hearing more about possible conservation options, and would like to review a copy of the corridor plan. They would also be open to discussing possible opportunities for technical and funding assistance through either the NRCS or River Corridors Program to resolve the stormwater drainage issues on their property and the neighboring Frye property to reduce the gully erosion along the southeast side of Tyler Bridge Road. The Padua's would like to preserve the potential for developing a building on the northern Monkton parcel.

Monkton 219-1 – Reach M15, Segment B – Carrico

Landowners: Carrico, Tony & Renee
Street Address: 2668 Gilman Road, Monkton
Mailing Address: 2668 Gilman Road, Hinesburg VT 05461

11/19/2007 – 4:00 PM Meeting with Tony & Renee Carrico
Attending: Kristen Underwood, Marty Illick
Reference Corridor Plan, Table 27, Project 11

Background

Kristen Underwood and Marty Illick met with Tony & Renee Carrico and walked the property including the abandoned Lewis Creek meander below the house.

The Carrico's acquired the property in 2006; they own approximately 11 acres of land. The house, accessed from Gilman Road, is on a terrace which is elevated approximately 25 to 30 feet above the Lewis Creek floodplain. A small field at the northern extent of the property has traditionally been in hay, which is cut each year by a nearby landowner.

The Lewis Creek corridor on Carrico lands is a combination of forest cover and wetland vegetation. No structures are present in the Carrico corridor and agricultural land uses have not encroached significantly within the corridor in the last several decades. An abandoned meander of the Lewis Creek trends through the Carrico lands. Based on review of annual flights of the Lewis Creek valley maintained at NRCS offices in Middlebury, VT, the avulsion that resulted in this meander cutoff occurred beginning in 1994, and by 1995 most of the flow of the Lewis Creek was occurring in the new planform of the channel. Prior to the avulsion, this meander was migrating to the north and east and the high, eroding bank was within approximately 50 feet of the house (then owned by Kerrigan). In 1990, NRCS participated in a bank stabilization project at this site which involved rip-rap at the toe of the slope and plantings of willows and dogwood shrubs and tree saplings along the bank.

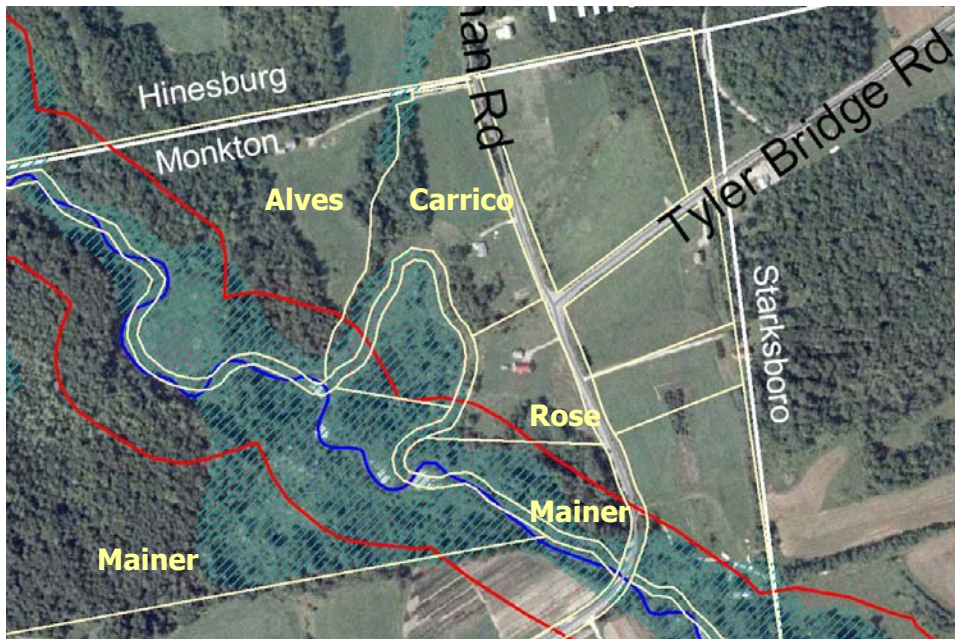


Figure 1. Carrico property, Gilman Road near the intersection with Tyler Bridge Rd. (2003 NAIP base image; red line indicates Phase 1 corridor (SGAT v.4.50); turquoise hatched lines indicate NWI wetlands)

River Corridor Constraints

(bridges, roads, buildings, agricultural structures and land uses)

- Current constraints:

There are no structures currently within the Lewis Creek corridor on Carrico lands. If the Lewis Creek were to re-occupy the abandoned meander at some time in the future, the Carrico and Rose homes would be located within the right-bank corridor of the new river planform.

- Land uses and long-term commitments within the corridor:
(e.g., farming practices, public access, lands carrying easements)

As present land owners, Tony and Renee Carrico do not foresee future encroachments within the corridor.

Current Concerns of the Landowner

(e.g., flooding losses, erosion, upstream land uses, etc.)

Tony & Renee expressed concerns about erosion along a small tributary to the Lewis Creek that flows along their southern border (see Figure 2). Waters are conveyed under Gilman Road through a culvert and flow to the southwest to the abandoned Lewis Creek meander. Upstream of the Gilman Road crossing this tributary appears to flow from the north in an unconfined, wetland-like setting; for a short section it has been apparently channelized along the Gilman Road. Downstream of the Gilman Road crossing this tributary flows in a semi-confined valley ranging from approximately 12 to 25 feet below the terrace upon which the Carrico house and the nearby Rose house are built. We observed a lateral and vertical scour hole at the downstream end of the Gilman Road culvert. The culvert outlet is elevated above the channel and water cascades into the scour pool. The valley walls of this small tributary are vegetated by herbaceous cover with the occasional shrub and deciduous tree. In an area approximately 150 ft downstream of the culvert, the banks of this tributary are eroding, and fracture lines were observed near the top of the bank along the right-bank (facing downstream).

Based on review of the USGS topographic map, this tributary channel receives drainage from an area to the north and east, between Gilman Road and Tyler Bridge Road. This area has seen increased residential development between 1948 and the 1983, based on review of historic topographic maps and aerial photographs. It is possible that increased runoff from this developed area may have contributed to increased erosion along the banks of this tributary (exacerbated by the undersized culvert). It is also possible that road ditch runoff along Gilman Road may be contributing to increased flows. A new culvert has been installed in recent weeks which diverts some road ditch runoff under Gilman Road at a location further to the north of the Carrico home to a second tributary channel that flows along the northwest border of the Carrico property.

Tony & Renee have not noticed erosion along the tall bank behind the house along the abandoned Lewis Creek meander. A healthy covering of red-osier dogwood and willows was noted along this tall bank.



Figure 2. Drainage features in vicinity of Carrico property.

Base map: 1999 1:5000 black & white orthophotograph, Vermont Mapping Program; turquoise hatched lines indicate NWI wetlands; white lines indicate Monkton parcel boundaries.

River Corridor Alternatives Acceptable to Landowner

(Based upon geomorphic data, corridor constraints, and local needs.)

Tony & Renee are open to possibilities, and would like to review a copy of the corridor plan. They would be open to hearing more about possible conservation options. Also discussed was the possibility that the Lewis Creek corridor might be expanded to include the area of the abandoned meander (see Figure 3).

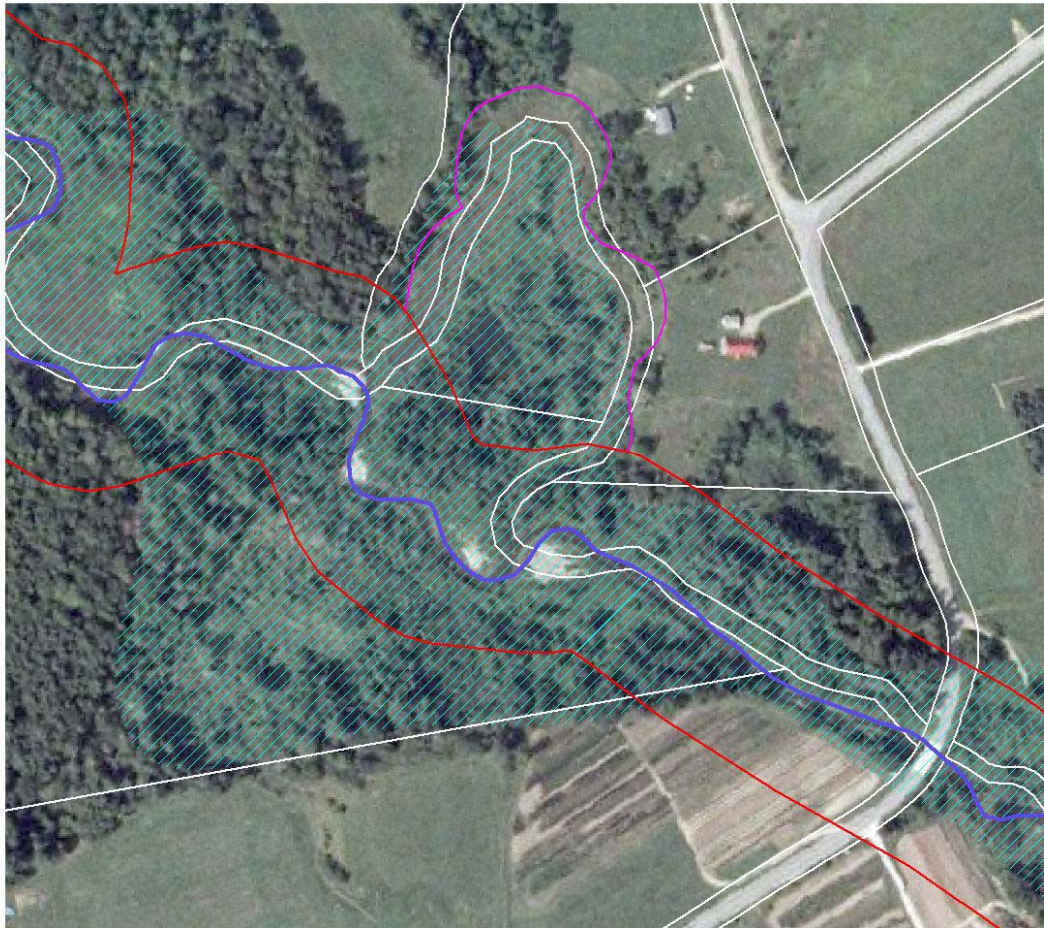


Figure 3. Potential extension of Lewis Creek corridor (in purple) to the top of the valley wall to encompass the abandoned meander.

Base map: (2003 NAIP base image; red line indicates Phase 1 corridor (SGAT v.4.50); turquoise hatched lines indicate NWI wetlands; white lines indicate Monkton parcel boundaries).

Monkton 219-3 – Reach M15, Segments B & A – Alves

Landowners: Alves, Caroline
Street Address: 2572 Gilman Road, Monkton
Mailing Address: 2572 Gilman Road, Hinesburg VT 05461

10/4/2007 – 7:00 PM Meeting with Caroline Alves
Attending: Kristen Underwood, Marty Illick, Stevie Spencer
Reference Corridor Plan, Table 27, Project 11

Background

Caroline Alves has occupied the property for approximately 19 years. The house, accessed from Gilman Road, is on a terrace which is elevated approximately 25 to 30 feet above the Lewis Creek floodplain. A small field at the northern extent of the property has traditionally been in hay, which is cut each year by a nearby landowner.

The Lewis Creek corridor on Alves lands is a combination of forest cover and wetland vegetation. Ms. Alves maintains a small garden plot on the floodplain on the inside of the Lewis Creek meander bend. No structures are present in the Alves corridor and agricultural land uses have not encroached significantly within the corridor in the last several decades.

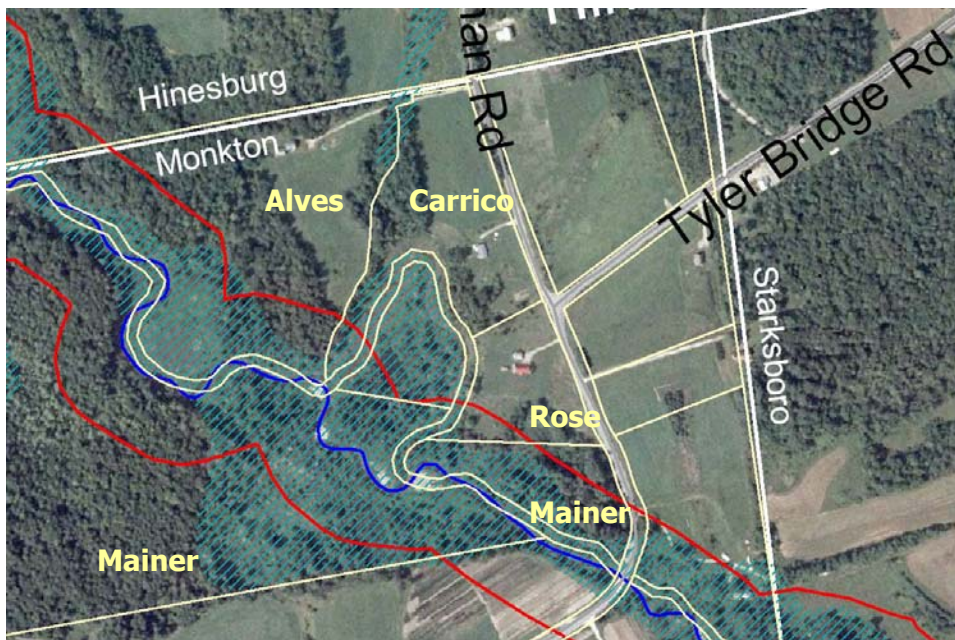


Figure 1. Carrico property, Gilman Road near the intersection with Tyler Bridge Rd. (2003 NAIP base image; red line indicates Phase 1 corridor (SGAT v.4.50); turquoise hatched lines indicate NWI wetlands)

River Corridor Constraints

(bridges, roads, buildings, agricultural structures and land uses)

- Current constraints:

There are no structures currently within the Lewis Creek corridor on Alves lands.

- Land uses and long-term commitments within the corridor:
(e.g., farming practices, public access, lands carrying easements)

As present Ms. Alves does not foresee future encroachments within the corridor.

Current Concerns of the Landowner

(e.g., flooding losses, erosion, upstream land uses, etc.)

Ms. Alves has periodically planted shrubs and trees along the high bank which forms the northwest channel boundary of the abandoned meander. This high bank has been prone to erosion and slumping.

Following abandonment of the meander of the Lewis Creek just upstream from Alves lands, Ms. Alves wonders about the location of property lines in the area, including the Alves / Carrico common line, since the deeds often reference the Lewis Creek channel (which has now moved substantially).

River Corridor Alternatives Acceptable to Landowner

(Based upon geomorphic data, corridor constraints, and local needs.)

Ms. Alves would like to review a copy of the corridor plan, and would be open to hearing more about possible conservation options. Management goals of a potential conservation project that would be important to Ms. Alves, include: control of invasive species, management to restore natural communities, preventing ATV, snowmobile and other motorized access, controlling hunting access (for safety).

Hinesburg 12-01-38.000 – Reach M15, Segment A – Lorraine

Landowner: Dexter Lorraine
 Street Address: 652 Lewis Creek Road, Hinesburg, VT 05461
 Contacts: 482-2981 (H), cdexter@accessvt.com

Description: 20 acres (approx). Residential lot accessed off Lewis Creek Road. Parcel includes approximately 800 ft of frontage along Lewis Creek.

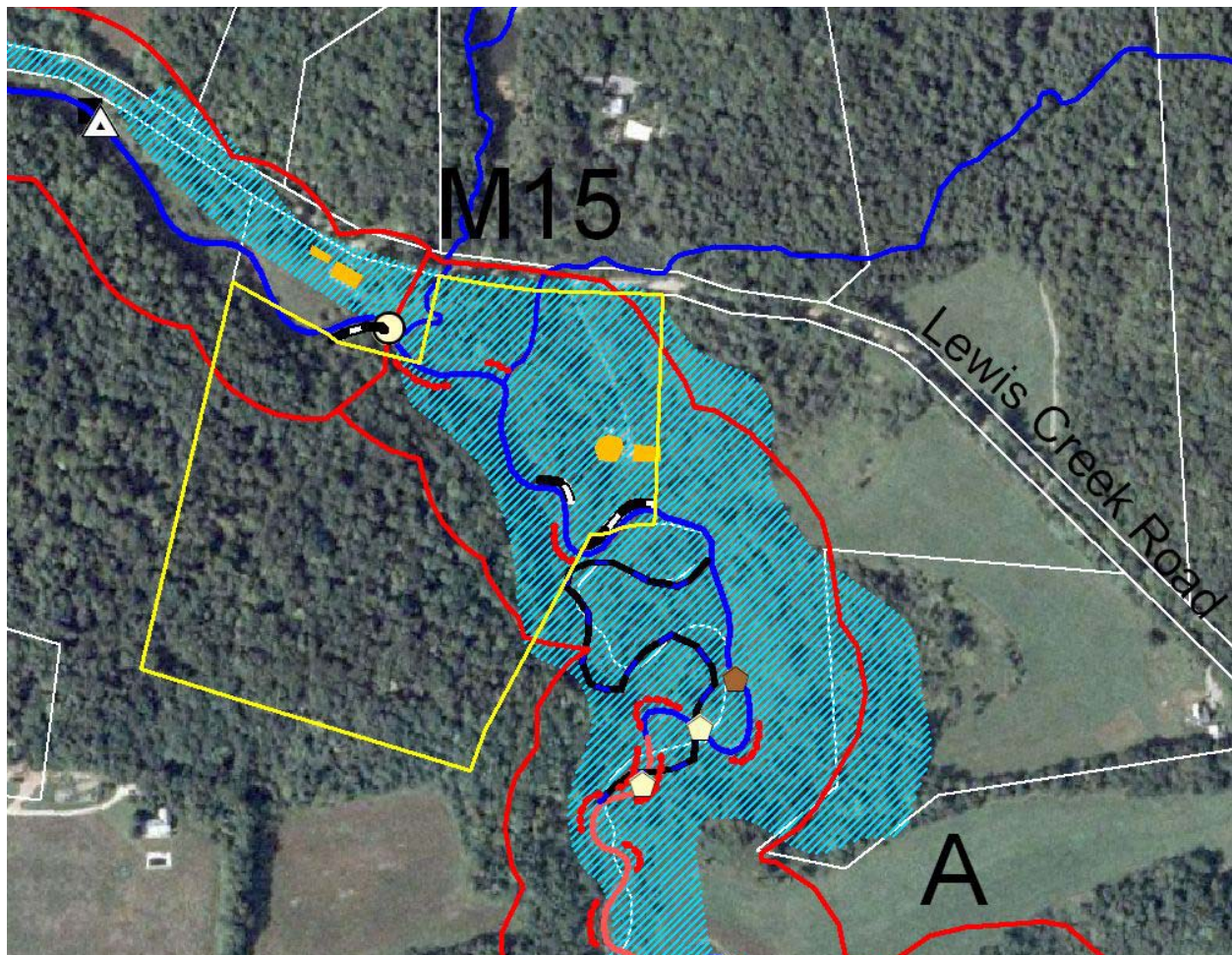


Figure 1. Phase 2 geomorphic features in vicinity of Dexter Lorraine parcel, reach M15-A, Hinesburg. Lorraine property outlined in yellow.

- | | | | | | |
|--|----------------------|--|-----------------------|--|----------------------------|
| | Reach Break | | Beaver Dam | | Crossing Structure |
| | Segment Break | | Debris Jam | | Bankfull Constrictor (red) |
| | 1974 channel | | Mass Failure | | FPW Constrictor (yellow) |
| | 1999, 1995 channel | | Erosion | | Development in Corridor |
| | Straightened Channel | | Wetlands (NWI) | | Streambank Revetment |
| | Phase 1 Corridor | | Bedrock grade control | | Berm |
| | | | | | Ph 2 Cross Section |

Hinesburg 12-01-38.000 – Reach M15, Segm A – Lorange
November 2007 – Marty Illick telephone Interview with Dexter Lorange
Reference Corridor Plan, Table 27, Project 12

Background

In the fall of 2007, Dexter provided a brief history of the many bank stabilization projects that he organized for his very active stretch of Lewis Creek in order to protect his house and associated buildings. In the late 1990s, Partners for Wildlife (USFW) and LCA volunteers helped with planting trees and shrubs along his floodplain, which have since mostly fallen into the river. After a passive approach was tried, he installed a revetment/rip-rap project in 1999 through Partners for Wildlife. According to Dexter the revetments failed. He then installed various sections of rip-rap treatments over the next 3 to 4 years, many of which have since been outflanked or covered by active sedimentation. The most recent streambank stabilization project was installed in 2006 by John Barrows, excavating contractor (see Figure 2). Project records should be on file with the ACOE, FWD and the Town of Hinesburg. Dexter reported that in the spring of 2006, a 4-foot "sandbar" was created adjacent to the rip-rap site, and in the spring of 2007 a 20-foot "sandbar" was created. The stream continues to move laterally and is destabilizing the left bank across from his home which appears to be close to a valley wall.



Figure 2. Rip-rap armoring installed circa 2006 along right bank at Dexter Lorange property off Lewis Creek Road in Hinesburg (Segment M15-A). View downstream, 29 November 2006.

Land uses and long-term commitments within the corridor:

The Lorance parcel is in residential use. It is largely forested, except for the driveway and immediately vicinity of the house site. Wetlands (NWI) are mapped along the lower-elevation areas contiguous to the channel (Figure 1).

Mr. Lorance recalls some mention of land use restrictions associated with the portion of his parcel across the Lewis Creek, but could not recall the details. These could be identified through review of the deed.

River Corridor Constraints

Rip-rap armoring has been installed along the right bank, as described above. Also, the residential home and outbuildings are located in the right-bank corridor within 50 to 300 feet of the Lewis Creek. (Note: the present position of the Lewis Creek channel is different than depicted by the VHD line on Figure 1 – it is closer to the buildings indicated in orange). A gravel driveway leads south from Lewis Creek Road to access the home.

Current Concerns of the Landowner

Mr. Lorance is concerned by the excessive erosion / deposition in the Lewis Creek channel in close proximity to his home and associated buildings.

River Corridor Alternatives Acceptable to Landowner

Dexter said he was very interested in LCA conservation ideas and would like to be part of the M15 conservation discussion. He said he could be in email contact or attend meetings when he is in town.

Starksboro Conservation Commission

2/11/2008 – 7:30 PM Starksboro Conservation Commission special meeting
Attending: Marty Illick, Alison Wagner, Kristen Underwood, Amy Diller
Starksboro CC: Louis DuPont, Robert Turner, Jody Higgs

Following Meeting Minutes prepared by Louis DuPont, Starksboro Conservation Commission

A brief account of a presentation by Kristen Underwood and Marty Illick on the 2008 Lewis Creek Corridor Plan to Starksboro Conservation Commission members on February 11th 2008 at the Town Library.

Present: Kristen Underwood-South Mountain Research, Marty Illick—Director Lewis Creek Association, Amy Diller—Watershed Coordinator Addison County Regional Planning Commission, Alison Wagner, Jody Higgs, Robert Turner, Louis duPont

Marty spoke about the Federal Emergency Management Agency maps for Starksboro and how they are not always accurate, particularly as regards States Prison Hollow. The house of Linda Paskowitz is actually in the floodplain that was created by the 38 flood.

Marty said that the town plan's flood hazard text and the FEMA flood hazard map, which informs how insurance companies handle flood insurance for home owners, needs to be updated. Marty also said the two Lewis Creek Corridor Plan also identify management options for Starksboro's North and South Riparian parcels, and the possibilities for managing these river corridors in ways that could help to mitigate potential flood hazards downstream.

Kristen then spoke about the evolving town plan and bylaw language for protecting stream and river banks and corridors from encroaching development that is prone to flood inundation or erosion hazards. Our zoning ordinance in Starksboro currently calls for a 100 ft. setback from the stream for building, but less than 100 ft. is allowed if there is "no adverse impact". As "adverse impact" is vague and often difficult to agree upon, we have end up with structures in the fluvial erosion hazard land area. She also mentioned that a number of towns including Lincoln and Middlebury, have gone beyond the basic FEMA language of "inundation hazard" zones to include "Fluvial Erosion Hazard" zones. After the extremely damaging July flood of several years ago, Lincoln particularly knows the hazard posed by streambank and gully erosion. Linda P.'s house is at risk to erosion hazards. While the corridor plan will have town plan and bylaw guidance language, Addison County Regional Planning Commission and Amy are available to help Starksboro make town plan improvements.

Kristen also mentioned that FEMA is in the process of re-drawing the FEMA maps, but that this is a slow process. She said that if a town is proactive, it may be able to have its maps re-drawn sooner than otherwise. In order to make sure that the maps are made more accurate, and landowners are able to properly insure their investments, the Town needs to work with FEMA. The corridor plan that will be submitted to the Select Board, Planning Commission, and the CC, will help in this work. The plan will be distributed by the end of March as recommended by SCC and others.

Marty inquired about the possibility of improving the Creek's access to the flood plain in the Southern Riparian Parcel. This would likely involve some bulldozer work on the left bank (looking downstream). This work could potentially help to de-energize the downstream section with the States Prison Hollow neighborhood. If the town is interested to explore this option, LCA can pursue and get back to the SCC.

Kristen then reminded us of a couple of instances recently, where the town allowed homes to be built adjacent to the Lewis Creek. In her opinion, one was at least partially within the “fluvial erosion hazard” zone.

Amy said that she was willing to help by providing examples of recently revised Town Plans and Zoning Ordinances that dealt with riparian issues.

Robert mentioned that the upcoming Town Plan revision should also include language describing the importance of the stream corridor to our local wildlife populations for both habitat itself and as a travel corridor.

Marty added that the FEH land area only addresses instream aquatic animals such as mussels, fish and macroinvertebrates.

Louis described the effort and investment that has gone into creating and improving the towns recreation fields and pavilion. The Rec. Committee particularly, as well as the other town boards, would be very interested in any proposals that would help to protect these investments and ward off future flood damage.

Marty then suggested that a meeting with the States Prison Hollow neighborhood might be a good idea. This would increase their awareness of potential hazards. This could possibly happen after the plan has been submitted.

Review of Existing Management Plans

APPENDIX C

River Corridor Plan

Lewis Creek: Reaches M14 – M18

Hinesburg, Monkton, & Starksboro

Chittenden & Addison Counties, Vermont

March 2008

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Starksboro – Reach M17, Segment B – Town of Starksboro lands Northern Riparian Parcel (conserved)

Reference Corridor Plan, Table 27, Project 5

Reference (see Project CD) - Town of Starksboro 28 July 2003
Management Plan for the Cota Lands Conservation Parcels.

Background

The Town of Starksboro Northern Riparian Parcel is approximately 92 acres in area comprised of former Cota Farm lands north of States Prison Hollow Road. These lands were transferred to the Town of Starksboro in December of 1998, along with the Southern Riparian Parcel encompassing portions of Lewis Creek reach M19 south of States Prison Hollow Rd. These two parcels are part of a multi-acre conservation project involving the Town of Starksboro, Vermont Land Trust, and the Vermont Housing Conservation Board. The Starksboro Conservation Commission is primary steward of these lands and Lewis Creek Association partners with the Commission regarding management of the activities that pertain to the Lewis Creek.

A total of 3,200 feet of Lewis Creek frontage is estimated for this Northern Riparian Parcel. The Lewis Creek forms the western boundary of the parcel in its southern portion, and bisects the northern portion of the parcel (See Figure 1).

The 28 July 2003 Management Plan for the Cota Lands Conservation Parcels states that access to the Northern Riparian Parcel "is via a 50-foot right-of-way extending from Green Mountain Cemetery Road on the east" (Town of Starksboro, 2003).

Land uses and long-term commitments within the corridor:

Management goals for the Northern Riparian Parcel, expressed in the Town of Starksboro, 28 July 2003 *Management Plan for the Cota Lands Conservation Parcels*, include:

- "to conserve and protect the public outdoor recreational, scenic, environmental, ecological, cultural, forestry, agricultural and open space resources of the Protected Property";
- to "provide opportunities for educational activities";
- to "permit the maintenance of public trails incidental to appropriate public recreational use", and
- "to conserve wildlife habitats associated with the Protected Property for present and future generations." (p. 6)

The management plan further outlines that:

- structures are prohibited (p. 7);
- vehicular traffic is prohibited (p. 7);
- "Management will encourage vegetation buffers...by plantings as needed" (p.7).
- "Future efforts at streambank stabilization will likely be limited to planting" (p.8).
- "Since the stream channel in this area meanders in a well defined corridor, no streambank protection measures are anticipated" (p.10).

In summary, the Northern Riparian Parcel "is to be managed primarily to conserve wildlife habitat, maintain or improve water quality, provide education opportunities for local school children and adults, and for non-motorized recreation" (p. 10).

River Corridor Constraints

Historically, the Northern Riparian Parcel was part of the Cota Farm. Former hay and/or pasture use is inferred from review of 1942 and 1962 aerial photographs. Historic channelization is also inferred from

review of these photographs. At present, lands along the Lewis Creek corridor in the Northern Riparian Parcel are mostly fallow, and dominated by wetlands (NWI). Short sections of old rip-rap armoring constrain the channel planform to a limited degree. Pockets of rip-rap are being eroded and undermined by active lateral adjustments of the channel.

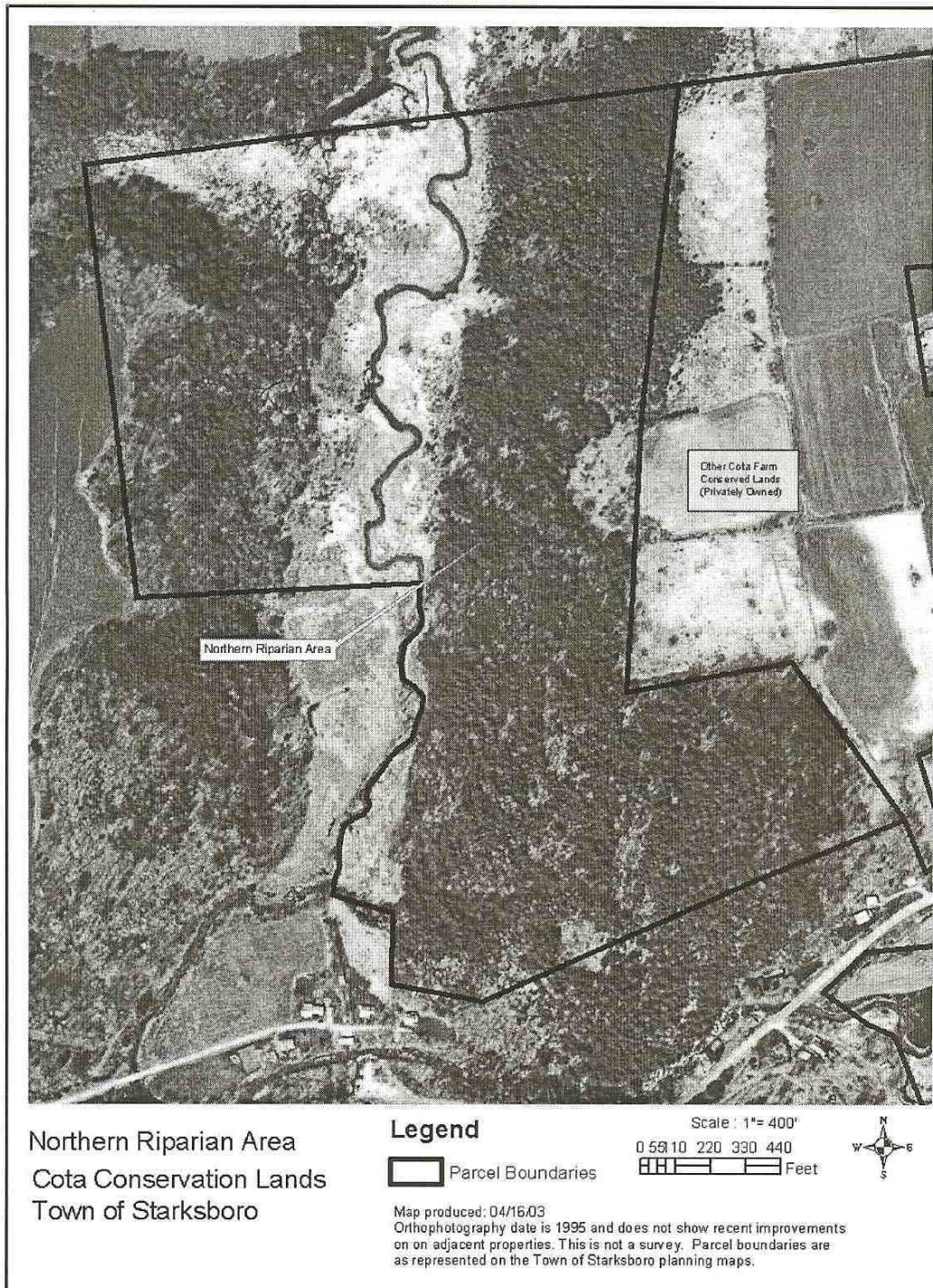


Figure 1. Location of Northern Riparian Parcel, excerpted from Town of Starksboro, 28 July 2003 Management Plan for the Cota Lands Conservation Parcels, Appendix B.

Compatibility of Town of Starksboro Lands Management Plan
with Lewis Creek Corridor Plan for reaches M14 – M18

Prevention of certain activities, as noted in the Town of Starksboro Management Plan (e.g., vehicular access, new structures) would appear to be consistent with the Corridor Plan goals of corridor protection and passive geomorphic approaches to support a return to dynamic equilibrium conditions of the Lewis Creek.

Buffer plantings and avoidance of bank stabilization techniques other than vegetative are also recommendations consistent with management goals expressed in the Lewis Creek corridor plan.

Recommendations:

- A. The long-range management plan for the Northern Riparian Parcel (and other Town of Starksboro parcels) would be strengthened by a more specific statement of purpose with regard to protection of the corridor area surrounding the Lewis Creek channel, namely:
1. Accommodating the anticipated equilibrium conditions and associated physical adjustment processes of the Lewis Creek.
 2. Minimizing, to the extent consistent with (1) above, future conflicts between the anticipated physical adjustment processes of the river and incompatible land use and other channel management activities within the Lewis Creek corridor on the parcel.
 3. Maintaining and enhancing connection of the Lewis Creek to the surrounding floodplain and channel-contiguous wetlands for protection and restoration of floodplain and wetland functions for maximum flow, sediment, and nutrient attenuation.
- B. A potential task to address Goal # 3 above would be review of the Parcel for possible wetlands restoration strategies with partner agencies / groups including the Vermont Wetlands Section, VT Fish & Wildlife, US Fish & Wildlife (Partners), VT Land Trust and Lewis Creek Association.
- C. Maintenance and protection of floodplain and wetland functions would be enhanced by the control of non-native invasive species. Small pockets of Japanese Knotweed were noted by Lewis Creek Association during September 2007 geomorphic assessments. An Invasive Species Management Plan should be developed for the Parcel.

**Hinesburg 12-01-69.100 – Reach M15, Segment A – State of Vermont lands
 Copp/Welch I (conserved)**

Landowner: State of Vermont, Agency of Natural Resources, Department of Fish & Wildlife
 Contact: Bill Crenshaw, District Wildlife Biologist, Bill.Crenshaw@state.vt.us

Description: 42.9 acres, acquired in 1995, subject to conditions of separate "Grant of Development Rights and Conservation Restrictions" from the sellers to the VT Land Trust and the Hinesburg Land Trust. Parcel includes nearly 2/3-mile of frontage along Lewis Creek.

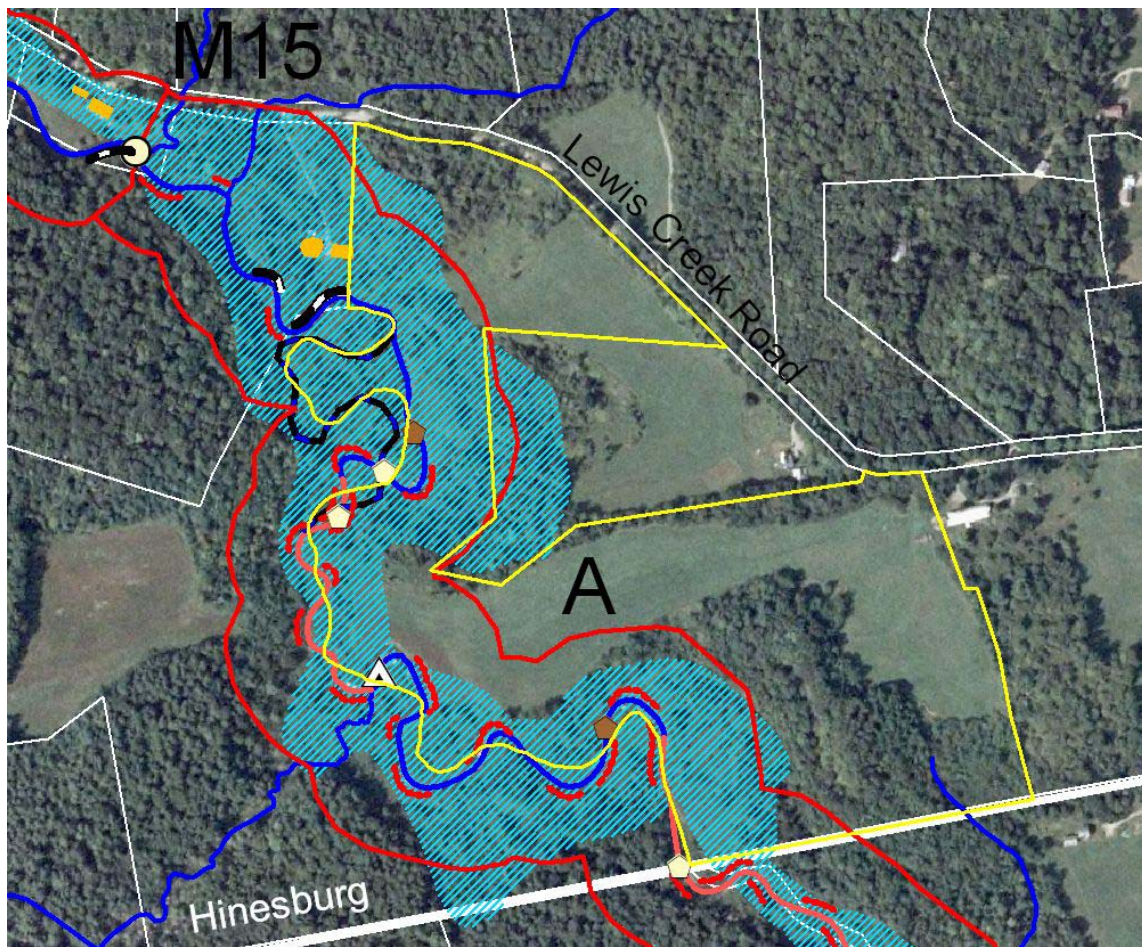


Figure 1. Phase 2 geomorphic features in vicinity of Copp/Welch I conserved parcel, reach M15-A, Hinesburg. *Copp/Welch I property outlined in yellow.*

- | | | |
|------------------------|-------------------------|----------------------------|
| ○ Reach Break | ■ Beaver Dam | ☒ Crossing Structure |
| ◐ Segment Break | ◑ Debris Jam | Bankfull Constrictor (red) |
| — 1974 channel | — Mass Failure | FPW Constrictor (yellow) |
| — 1999, 1995 channel | — Erosion | ■ Development in Corridor |
| — Straightened Channel | ▨ Wetlands (NWI) | — Streambank Revetment |
| □ Phase 1 Corridor | ■ Bedrock grade control | — Berm |
| | | △ Ph 2 Cross Section |

Hinesburg 12-01-69.100 – Reach M15, Segm A – State of Vermont lands
Copp/Welch I

Reference Corridor Plan, Table 27, Project 11

Reference (see Project CD) - VTANR Dept of Fish & Wildlife *Interim Stewardship Plan: Baldwin, Copp/Welch I, Fisher, Lande, and Copp/Welch II Parcels Addition to Lewis Creek Streambank*, prepared by Bill Crenshaw, District Wildlife Biologist, February 2002.

Review of DFW Interim Stewardship Plan

The above plan identifies the Copp/Welch I parcel (42.9 acres) as one of several parcels comprising the "Lewis Creek Streambank", acquired by the State of Vermont through sale or donation. The interim stewardship plan is in place to govern management of these lands, until a long-range management plan is developed for the Lewis Creek Streambank by DFW and the Hinesburg Land Trust.

The interim stewardship plan identifies a riparian buffer (minimal width of 100 feet) along the Lewis Creek as a "potential sensitive feature".

Prohibited activities under the interim stewardship include:

- "ground disturbing activities",
- "Construction of new roads",
- "erection of new structures...parking lots or other infrastructure",
- "recreational use of ...ATVs...[or] snowmobiles."

Activities permitted under the interim stewardship plan include:

- "Planting of trees along riparian areas" and
- "Stabilizing of eroded streambank along Lewis Creek".

Compatibility of DFW Interim Stewardship Plan with Lewis Creek Corridor Plan for reaches M14 – M18

Prevention of certain activities noted above would appear to be consistent with the Corridor Plan goals of corridor protection and passive geomorphic approaches to support a return to dynamic equilibrium conditions of the Lewis Creek. Buffer plantings are also consistent with management goals expressed in the Lewis Creek corridor plan.

However, structural stabilization of eroding streambanks would not be advised under the Lewis Creek corridor plan, where the main objective is to permit unconstrained lateral adjustments of the river channel as the river regains a more balanced planform, profile and dimensions.

Recommendations:

A. The long-range management plan for Copp/Welch I parcel would be strengthened by a more specific statement of purpose with regard to protection of the corridor area surrounding the Lewis Creek channel, namely:

1. Accommodating the anticipated equilibrium conditions and associated physical adjustment processes of the Lewis Creek.
2. Minimizing, to the extent consistent with (1) above, future conflicts between the anticipated physical adjustment processes of the river and incompatible land use and other channel management

activities within the Lewis Creek corridor on the parcel.

3. Maintaining and enhancing connection of the Lewis Creek to the surrounding floodplain and channel-contiguous wetlands for protection and restoration of floodplain and wetland functions for maximum flow, sediment, and nutrient attenuation.

B. A potential task to address Goal #3 above would be review of the Parcel for possible wetlands restoration strategies with partner agencies / groups including the Vermont Wetlands Section, VT Fish & Wildlife, US Fish & Wildlife (Partners), VT Land Trust and Lewis Creek Association.

C. Consistent with Goals 1 & 2, it would be important to clarify in the Management Plan for Copp/Welch I that the permitted activity - "Stabilizing of eroded streambank along Lewis Creek" – should prioritize vegetative and bioengineered methods over structural elements such as rip-rap. The Lewis Creek reach along which the Copp/Welch I parcel is located (M15-A) is undergoing substantial lateral adjustment, and receives high sediment loads from upstream reaches and tributaries. Propensity for lateral channel adjustments is enhanced near the downstream end of the segment, where the channel enters a natural (bedrock-controlled) valley choke point. Bank stabilization efforts will have a high likelihood of failure in such a laterally adjusting reach experiencing high rates of deposition.

Exceptions may be warranted where a pre-existing "human-placed structure [is] at high risk and not taking action may result in increased risk of erosion, to not only the structure, but lands that would provide the opportunity to establish a buffer." (p.46, Section 6, *River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects*, VTANR, 11 July 2007 draft). At the downstream extent of segment M15-A there is a residential home with outbuildings located within 50 feet of the right bank of Lewis Creek (see Outreach Appendix B). Substantial rip-rap armoring was installed along the right bank of the Lewis Creek on this private property immediately downstream of the Copp/Welch I parcel in 2006.

D. Maintenance and protection of floodplain and wetland functions would be enhanced by the control of non-native invasive species. An Invasive Species Management Plan should be developed for the Parcel.

TOWN OF STARKSBORO
MANAGEMENT PLAN FOR THE COTA LANDS CONSERVATION PARCELS

July 28, 2003

This management plan for the former Cota Farm in Starksboro has been duly adopted by the Selectboard of the Town of Starksboro as of this _____ day of _____, 2003

In The Presence Of:

TOWN OF STARKSBORO

Witness

By: _____
Alice Dubenetsky

William Coon

Glynda McKinnon

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1. INTRODUCTION AND PURPOSE

This document describes management, use, and anticipated improvements to all of the town-owned property acquired as part of the “Cota Farm” project. The Cota Farm project was a joint effort by the Vermont Land Trust, the Town of Starksboro, the Vermont Housing Conservation Board, townspeople and landowners to protect 776 acres of farmland, forest, and riparian area. The project resulted in the town’s acquisition of two so-called riparian areas along Lewis Creek, a parcel used as a municipal recreational field (ball field), and a gravel pit. The project was completed with the transfer of conserved properties to the Town on December 14, 1998.

According to the Grant of Development Rights and Conservation Restrictions (Grant)¹, a management plan is required for the ball field and riparian areas and the management plan must:

- Provide for the use and management of the Protected Property in a fashion which is not inconsistent with the Purposes of this Grant; and
- Be designed to protect riparian and wildlife habitat, scenic, ecological, cultural and open space values; and
- Be designed to provide reasonable public access to recreational values; and
- Be prepared in consultation with the Lewis Creek Association (LCA); and
- Otherwise be consistent with the terms and conditions of the Grant.

There is no formal requirement for a management plan for the gravel pit; however, the town has obtained an amended Act 250 permit to operate the pit. The extraction and reclamation plan has been incorporated into this management plan as Appendix C.

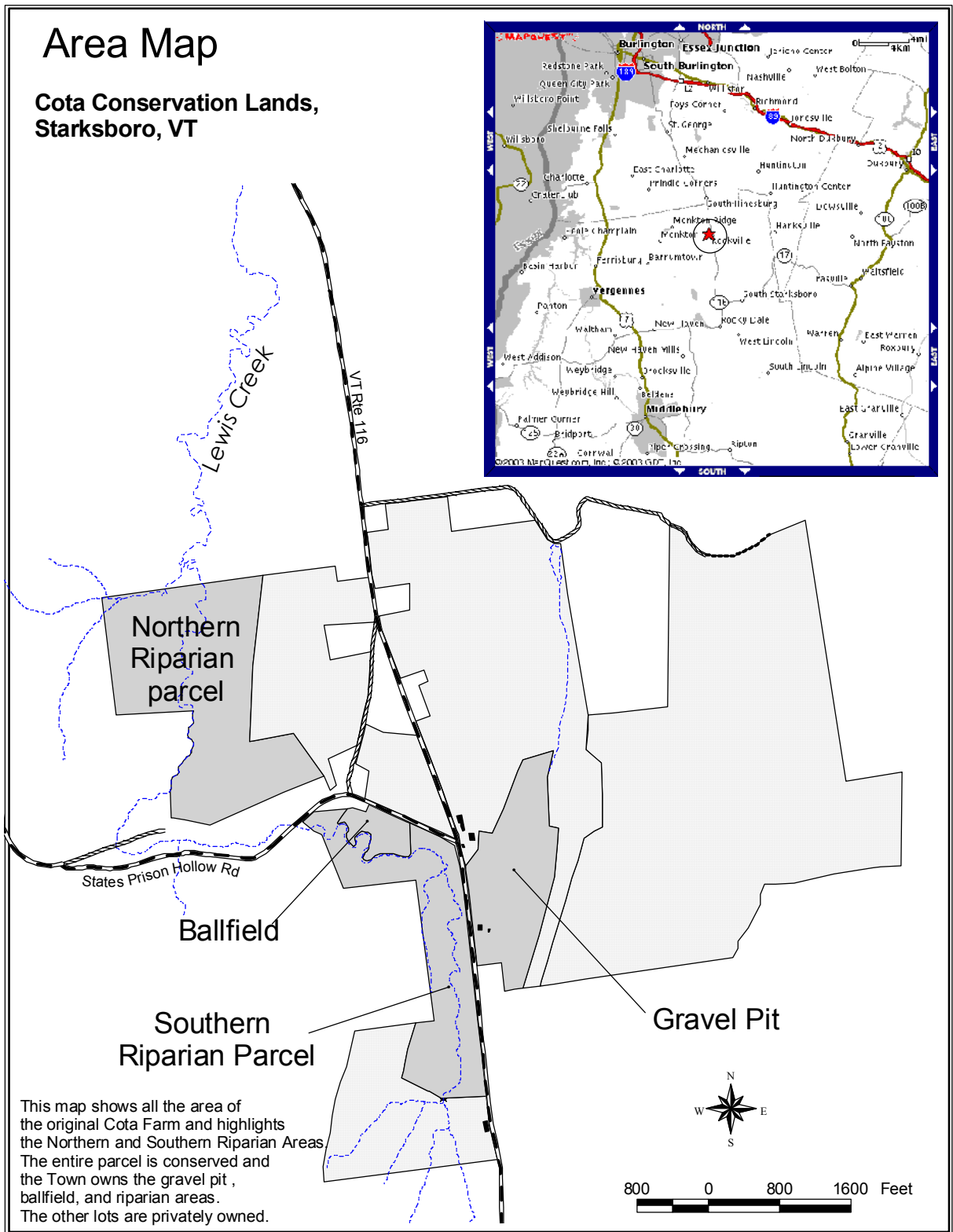
The Town Clerk, Town of Starksboro Selectboard and the Starksboro Conservation Commission are the primary local contacts. Stewardship of the property rests principally with the Conservation Commission, though the local recreation committee will supervise improvements to the ball fields. The Lewis Creek Association has been and will continue to be an active participant in any activities that directly affect Lewis Creek and are partners in the management of this property.

2. PROPERTY DESCRIPTION

That portion of the original Cota Farm covered by this plan, the town-owned lots, consists of 4 “parcels” encompassing 200 acres in Starksboro, Vermont (Figure 1). The property straddles nearly 2 miles of Lewis Creek, encompassing pasture, woodland, and wetlands. It is bisected by State’s Prison Hollow Road and VT Rte. 116 and is further described below.

¹ The Grant for each property is included in its entirety in Appendix A.

Figure 1. Map of the Cota Farm Project showing the town owned parcels.



1. Southern Riparian Parcel

Located to the south of the Ball Field Parcel and State's Prison Hollow Road, this 63-acre parcel consists mainly of abandoned pastureland, most of it in the active floodplain of the Creek. The vegetation includes, overgrown fields, tall brush, and scrubby hardwood trees. In addition to a mile of Lewis Creek frontage, a small open-water wetland follows the base of a slope along the western boundary. In general, there is little topographic relief to the entire parcel, except along the southeastern edge where it grades steeply up to meet VT Rte. 116. This parcel has 1100 feet of frontage on Rte. 116 and 3000 feet along State Prison Hollow Road. (See Southern Riparian map in Appendix B)

2. Ball Field Parcel

The Ball Field Parcel is approximately 7.5 acres and lies northerly of the Southern Riparian Parcel and southerly of State's Prison Hollow Road. It has had a long history of use as a recreational field prior to its acquisition by the Town, but always with some doubt as to the permanence of this arrangement with prior landowners. The land is in the floodplain (and adjacent to) Lewis Creek. The nearly the entire area is mowed grass, with the exception of a brushy riparian buffer along the Creek edge, and a graveled drive and parking area. (See Ball Field map in Appendix B). Presently, the grassed area includes two rough baseball fields with pole and wire backstops and a small (3'x3') equipment storage shed. During the fall, the mowed area is used for soccer. The parcel has roughly 540 feet of road frontage and 160 feet of Creek frontage. This area also provides easy access to Lewis Creek for fishing, hiking, and other recreational activities.

3. Northern Riparian Parcel

Northerly of State's Prison Hollow Road, this 92-acre parcel encompasses a diversity of habitats. The southernmost section is a steep, dry, rocky knob that supports a pole-timber and small sawtimber-sized forest of oaks, hemlock, and northern hardwoods (on different slopes and aspects). Steep ledge outcrops define the southern face, some 200 feet above State Prison Hollow Road and Lewis Creek. Towards the north and west this land drops off to the Creek and includes overgrown pasture on the upper slopes, mixed hardwoods and hemlocks on the moderately steep, westerly grade to the Creek, and areas of emergent wetlands in places immediately along the Creek. Westerly of the Creek, the land is mostly wooded. Soils are richer and support a higher sugar maple component. In addition to supporting a wide range of plant species and a variety of wildlife habitats, the parcel forms an important wildlife corridor along the Creek between open, agricultural lands on either side. Access to this parcel is via a 50-foot right-of-way extending from Green Mountain Cemetery Road on the east. The parcel lacks town road frontage but includes approximately 3200' of frontage along Lewis Creek. (See Northern Riparian Parcel map in Appendix B.)

Gravel Pit Parcel

The Gravel Pit Parcel is on the east side of VT Rte. 116 and is, not surprisingly, the most disturbed by recent human activity. The previous owners operated this area for commercial gravel extraction. Close to 75% of the parcel area has had the topsoil and overburden removed (stockpiled). The previous extraction plan divided the area into 4 "phases," according to the Act 250 permit. Each phase required certain steps towards reclamation before the next phase could be entered. Extraction and reclamation was completed for the first phase, that area closest to the southern boundary and Rte. 116. In this area,

remaining slopes have been seeded and stabilized. Operations were active in phases 2 and 3 when the previous owner declared bankruptcy and the Town acquired this property with the burden to reclaim these areas. As of the writing of this plan, an amended Act 250 permit has been obtained by the Town based on a revised extraction and reclamation plan. This plan is included in Appendix C. Currently, the Town is extracting from the original phase 4 area and is ahead of the reclamation schedule suggested in the current plan.

The Parcel includes the following improvements:

- A 40' x 60', 1-story metal building currently used as the Town Fire House
- A 14' x 20', 1 story wood frame building housing previously used truck scale equipment
- An in-ground truck scale.

Other Natural Features

This section describes the natural features of the riparian areas. The ball field and gravel pit contain few “natural” areas and few natural features not previously noted.

Mammals

The two riparian parcels provide a diversity of habitat for wildlife. A 1998 wildlife habitat assessment (Morse and Morse Wildlife Consultants) confirmed signs of white tail deer, beaver, mink, muskrat, raccoon, river otter, coyote, and red fox. The report suggests a very high probability for the existence of fisher, weasel, bobcat, and bear activity on this land. (This report is available at the Starksboro Town Office.)

Vegetation

A vegetation survey of both parcels of land on December 6 and December 7 of 1999 revealed the following:

- Hardwood Trees and Shrubs: alder, apple, ash, basswood, black birch, box, elder, butternut, dogwood, elm, hawthorn, hickory, maple, muscle wood, oak, white birch, willow, yellow birch
- Conifers: hemlock, juniper, larch, white cedar
- Plants: agrimony, black-eyed Susan, black raspberry, cattails, celandine, chick weed, chicory, ferns, forget-me-nots, golden rod, grape vine, horsetail plant, Jerusalem artichoke, mint, moneywort, mullein, nanny berry, nightshade, Queen Anne's lace, sedges, self heal, smart weed, soapwort, spiny cucumber, St. John's wort, thistle, vervain, Virginia creeper, water willow, wild clematis, wild geranium, yellow dock, yellow rocket.

No rare, threatened, or endangered species are known to occur, but no exhaustive inventory has been undertaken.

Lewis Creek Habitat

The nearly 2 miles of Lewis Creek frontage can be viewed as part of the “middle reaches” of Lewis Creek. A few miles to the south are the pristine headwaters, but this middle section runs through valley farmland and is technically judged “impaired.” Regular water quality sampling (including one site on the ball field) frequently record high coliform and phosphorous counts. A recent hydrologic study has evaluated the stability of the stream channel and has made recommendations for riparian zone management. Stream channel movement is a prevalent feature for this reach and any physical improvements must consider the likelihood of periodic flooding, deposition, and channel relocation.

While the aquatic habitat along this section of the Creek lacks some of the structure and streambank shading for ideal game fish conditions, the brown trout (wild and stocked) are common. The northern parcel has better habitat and is below the Millhouse Falls, increasing the chances that steelhead and smallmouth bass from Lake Champlain and lower reaches might migrate this far upstream. Non-game species present include white suchia, common shiner, blacknose and longnose dace.

Birds

The wide range of habitat of the two parcels is able to support many different species of birds. The tangled shrubby meadows may attract species such as meadowlarks, sparrows, bobolinks, bluebirds, cardinals, and thrashers. The marshy areas and the creek itself may be home to ducks, herons, and blackbirds. There is ample brush to provide shelter for indigo buntings, catbirds, kingfishers, and finches. The woods and their border habitats are potential habitat for many species, including turkey, vireos, warblers, woodpeckers, and juncos. The vegetation survey revealed several very good food sources for birds such as ample wild grapevines, scattered fruit trees, and various berries.

Natural communities

Most of the lower-elevation riparian area (North and South parcels) is influenced by Lewis Creek. Open meadows along the Creek are generally wet and seasonally inundated. The long-term tendency of this area would likely be a sedge meadow. The west-sloping corridor along Rte. 116 tends toward mesic red oak-northern hardwood forest, but soils have been compacted and vegetation altered by years of grazing.

The Northern Riparian Parcel along the Creek includes areas of sedge meadows and shallow emergent marsh. The forested areas of this parcel are diverse and include northern hardwood forest, small areas of rich northern hardwood forest, hemlock-northern hardwood forest, and mesic red oak-northern hardwood forest. Since virtually all of the forested area has seen agricultural use in the last century, the vegetative composition in some areas is transitional.

3. GOALS OF THE MANAGEMENT PLAN

This management plan is intended to:

- Provide public documentation of the purposes of these parcels;
- Provide for the use and management of the Protected Property in a fashion that is not inconsistent with the Purposes of the Conservation Easement(s) applying to the various Parcels; and
- Comply with the existing Vermont Land Trust and Vermont Housing and Conservation Board easements:
 - Primary Purpose: Consistent with the goals set forth in 10 V.S.A. §6301, the Management Plan is designed to protect both the Ball field and the Riparian sections of the Property.
 - The Plan is designed to conserve and protect the public outdoor recreational, scenic, cultural and open space resources of the Ball field section of the Protected Property and to prevent the use or development of the Ball field section of the Protected Property for any purpose or in any manner that would adversely affect these resources.
 - The Plan is designed to conserve wildlife habitats and riparian values associated with the Northern and Southern Riparian Sections of the Protected Property for present and future generations and to prevent the use or development of the Protected Property for any purpose or in any manner that would adversely affect these resources.
 - Secondary purposes:
 - For the Ball field:
 - to provide opportunities for educational activities, and
 - permit the construction and maintenance of public trails and structures incidental to appropriate public recreational use; and
 - For the Riparian areas:
 - to conserve and protect the public outdoor recreational, scenic, environmental, ecological, cultural, forestry, agricultural and open space resources of the Protected Property; and
 - provide opportunities for educational activities, and
 - permit the maintenance of public trails incidental to appropriate public recreational use.
 - to conserve wildlife habitats associated with the Protected Property for present and future generations.

4. MANAGEMENT ISSUES

All Parcels

- While the area is rich in natural diversity, there are no particularly sensitive areas requiring protection. There is no history of inappropriate use of these lands, and there are no plans for restricting access or posting the property. External boundaries are generally well marked. Subdivision lines for the gravel pit, southern riparian parcel, and northern riparian parcel have all been surveyed. These lines are internal to the original Cota Farm property and separate town-owned lands from other conserved lands.
- The Conservation Commission, in partnership with the Lewis Creek Association (LCA) will monitor the property for illegal activities, such as dumping, prohibited uses of the property, and damage to permanent and existing structures. Signs describing appropriate and prohibited activities will be installed at public access points. In the event of inappropriate or prohibited activities, we will attempt to educate the public about the Town's responsibilities through the Town and LCA newsletters, neighborhood meetings, or contacts with individuals. Where appropriate, the state police will be involved in enforcement against prohibited activities. Neighbors of the property will be informed of the management plan process through letters and invitations to meetings.
- Physical improvements and structures will be prohibited except as outlined in the Grant and this Management Plan.
- No vehicular traffic is permitted except in designated parking areas. Bicycle access may be permitted on future approved trails, and mowing equipment is used on the Ball field in season. Construction equipment necessary to install riprap, to grade or improve drainage on the ball fields, or to construct approved structures will be permitted strictly as needed for the duration of each project. The Town and LCA have cooperated with the Vermont Agency of Natural Resources and Federal Fish and Wildlife officials (Partners for Wildlife).
- While low-impact uses (hunting, fishing, skiing, snow shoeing, hiking) are encouraged, intensive uses with negative resource impacts are prohibited. For all areas except the gravel pit, low-impact recreational uses are encouraged. We have sponsored hikes in both riparian parcels and are in the preliminary stages of planning for a recreational trail on the southern parcel. The reclaimed area of the gravel pit may, in future plans be considered for a variety of trails, possibly including motorized recreational use.
- Harvesting of native plant species is prohibited and introduction of non-native species is prohibited.
- Management will encourage vegetation buffers by locating recreation areas appropriately, and by plantings as needed.

A hydrologic study was undertaken (in cooperation with the State of VT, UVM, and the Lewis Creek Association) to better understand the management of the flood plain. The results of this study suggest:

- The stream channel in the vicinity of the ball fields and southern riparian area should be allowed to meander and establish equilibrium. Stream armor (rip-rap) has been installed along the Lewis Creek immediately adjacent to active recreational fields. This treatment should

protect the field from further erosion. No further stream armor is planned; rather any further improvements will be specifically allow the Creek access to its historical flood plain.

- Vegetative streamside buffers should be restored. In each of the last 3 years, planting of trees along the riparian buffer has been accomplished using students and volunteers labor and funding from the Partners For Wildlife Program. These kinds of activities are likely to continue, as funding and labor are available.
- Future efforts at streambank stabilization will likely be limited to planting. Some plantings may be specifically designed to improve fish habitat.

Additional studies are contemplated that may refine the scope management along the Creek. The Conservation Commission and the Lewis Creek Association will continue to collaborate with the USDA Natural Resource Conservation Service, the US Fish and Wildlife Service (Partners for Wildlife), and the State Agency of Natural Resources. The Conservation Commission will also be an active participant in the current effort to create a Basin Plan for the entire Otter Creek (including Lewis Creek) basin. There is interest in using this opportunity to craft a plan for the entire length of Lewis Creek in Starksboro.

Ball Field Parcel

Obviously, this parcel already sees and will continue to see the greatest level of recreational use. For this reason it requires the greatest attention to management. The Conservation Commission, the Starksboro Sports and Recreation Committee, the Lewis Creek Association, and others have been working cooperatively to address the needs. There are 2 primary objectives: maintaining and improving the area for public recreation and protecting the adjacent creek from impacts from this use. The two objectives are not incompatible, but both objectives need to be considered in any anticipated management.

Since its acquisition by the Town, there is renewed interest in making improvements that will enhance its recreational value. Over the last few years, the graveled access and parking area was expanded to improve parking and riprap was installed along a portion of the Creek where playing fields were being eroded. Vegetative plantings intended to fortify the streamside buffer and enhance wildlife use have been made each of the last 3 years. These efforts have been coordinated by the LCA and have received assistance from the Partners For Wildlife program and NRCS. Elementary school children, boy scouts, and other volunteers have participated in the planting. All but a narrow strip on one shore of the Creek adjacent to the parking area is vegetated. This remaining area has historically been left open to provide access to the fire department for water. Working with the fire department, we expect to install a dry hydrant some distance back from the stream (20-30'). This will maintain access to the water, but will allow us to revegetate this remaining strip of riparian buffer along the parking area.

The Starksboro Sports and Recreation Committee has received a LWCF grant to construct a 24 x 40, one-story picnic pavilion, make minor improvements to the graveled drive and parking, and rebuild the baseball backstops. Construction is expected for fall 2003.

Additional plans for the Ball Field include the possibility of other modest structures that support the permitted uses, such as:

- replacing the small, existing equipment storage structure;
- bleachers;
- regrading or reseeding the fields;

- a small kiosk for notices and informational literature;
- concession stand
- a small, low-impact bridge that would provide access to a possible future trail on the west side of Lewis Creek.

The Ball Field area map in the Appendix outlines a building envelope adjacent to parking area and pavilion to contain additional anticipated structures. This area defines a stream buffer of no less than 50 feet and generally encompasses the area now improved with gravel parking along with some adjacent grassed area. It is our intent to locate all permanent structures within this area, with the understanding that certain minor structures (including bleachers and backstops) may be constructed closer to the ball fields. Also, the dry hydrant may have its access closer than 50 feet from the creek.

In general, use of pesticides and fertilizers on the Ball Field is discouraged and temporary facilities (such as portable toilets, lighting) may be installed on the Ball Field Parcel.

The Easement permits the use of the Ball Field recreational areas for concerts, fairs, or community celebrations. While no events of this type are currently contemplated, it is reasonable to anticipate interest in these activities as the facilities improve. Requests for uses of this type will be addressed by the Town Selectboard on a case-by-case basis. Use for overnight camping is not permitted.

The Conservation Commission, in partnership with the Lewis Creek Association (LCA) will monitor the property for illegal activities, such as dumping, prohibited uses of the property, and damage to structures. Signs describing appropriate and prohibited activities will be installed at public access points. In the event of inappropriate or prohibited activities, we will attempt to educate the public about the Town's responsibilities through the Town and LCA newsletters, neighborhood meetings, or contacts with individuals. Where appropriate, the state police will be involved in enforcement against prohibited activities.

Southern Riparian Parcel

This parcel is also to be managed primarily to conserve wildlife habitat, maintain or improve water quality, provide education opportunities for local school children and adults, and for non-motorized recreation. All of these events currently take place and are being encouraged by the Conservation Commission.

The Starksboro Conservation Commission is currently in the planning stages for a walking trail beginning at the parking area on the adjacent Ball Field parcel and proceeding along the east side of Lewis Creek. The design of this trail will conform to the Grant provisions, specifically paragraph III(3):

- The location, use and construction of such trail is consistent with the Purposes of this Grant, and are otherwise consistent with the Management Plans.
- The trail shall be located at least 50 feet away from the bank of Lewis Creek as it exists on the date of this Grant, and as it may for time-to-time change its course.
- The surface of the trail may be improved with stone or gravel, but the trail shall not be paved.

- Use of the trail for non-motorized, mechanical recreation such as bicycling may be permitted in the discretion of Grantor, but no such use shall be permitted elsewhere on the protected Property.
- A plan describing the location, construction, maintenance and use of the trail is submitted to Grantees for their approval prior to trail clearing, which approval shall not be unreasonably withheld or conditioned, provided the plan fulfills the requirements of this paragraph III(3).
- No additional improvements are currently contemplated for this parcel; however, this plan recognizes interests expressed in the public process leading to this plan to extend the proposed to be a loop trail along the west side of the Creek. This extension may or may not include a low-tech, low-impact bridge across the Creek in the vicinity of the ball field. There is also interest in exploring the long-term prospects for extending this trail off the protected property and linking it to Starksboro Village.

The proposed location of this trail has been shown on the map (appendix B). The trail is expected to be little more than a trail through the brush in most places. It will provide an opportunity for exploration adjacent to (but not directly along) Lewis Creek and will provide an alternative for pedestrian use of this section of Rte. 116. Biking on the trail will not be prohibited. Equestrian use of the trail will be discouraged by signage. The trail construction will conform to generally accepted trail construction guidelines to assure stability and durability. Further construction and management details will be submitted to VLT for approval before any clearing or trail construction begins.

We anticipate that this trail may result in an increase in undesirable uses such as off-trail bicycle use, ATV use, litter, etc. The Conservation Commission will discourage motorized use by signs, narrow trail design, and if necessary, barriers to motorized access. Off-trail biking may be self-controlling due to the excessively brushy nature of the area. In general, litter and any inappropriate uses will need to be addressed through a process of patrolling, enforcement, on-site signage, and public education. Signage explaining appropriate uses will be placed at both ends of the trail

Northern Riparian Parcel

This parcel is to be managed primarily to conserve wildlife habitat, maintain or improve water quality, provide education opportunities for local school children and adults, and for non-motorized recreation. Management objectives for this parcel are similar to those for the Starksboro Municipal Forest. Therefore, we have proposed to the town that this parcel be added to the Town Forest, and managed as an “ecological reserve”, in accordance with the Starksboro Town Forest Management Plan. The objectives for such ecological reserves include education; protection and enhancement of forest health including water quality, site productivity, and native biological diversity; and identification and protection of cultural resources. No forest management will be practiced on this parcel apart from the control of invasive exotic species. Since the stream channel in this area meanders in a well defined corridor, no streambank protection measures are anticipated. Existing logging roads may be cleared of brush occasionally to enhance non-motorized access. A copy of the Starksboro Town Forest Plan is on file in the Town Office.

Gravel Pit

Currently this parcel serves two primary functions. Approximately 8,000 cubic yards of gravel is extracted annually for town use and the metal building on the floor of the pit houses the Town Fire Department. In the short term, the Town anticipates moving the recycling containers to this site from the town garage. This will involve construction of temporary wooden structures (no foundations) for steps and minor sitework for a parking area. These improvements will not be visible from Rte. 116. The only additional activities anticipated within the time frame of this plan are those associated with the continued extraction and reclamation of the pit areas. Ideas that have been mentioned for possible future uses include: additional town buildings associated with road maintenance, a commuter parking lot, and recreational trails.

The gravel pit map in Appendix B outlines a preliminary building envelope. The restrictive covenants on this property require the designation of this building envelope “on the floor of the gravel pit once the finished grade has been achieved.” Since the finished grade on the pit floor may well be defined only after the bulk of the remaining gravel has been removed, this current designation is deemed “preliminary” and intended to represent the area that will contain any structures built over the life of this plan. Modifications to this building envelope will require the approval of the Vermont Land Trust.

Contact Information

As mentioned, the primary steward of these parcels is the Town of Starksboro Conservation Commission. Since membership on the Commission fluctuates, all contact should be initiated with the Starksboro Town Clerk (Cheryl Estey 453-2639). The Clerk will contact the appropriate individuals as necessary.

5. MANAGEMENT PLAN APPROVAL AND UPDATE PROCESS

This plan represents the culmination of the following process:

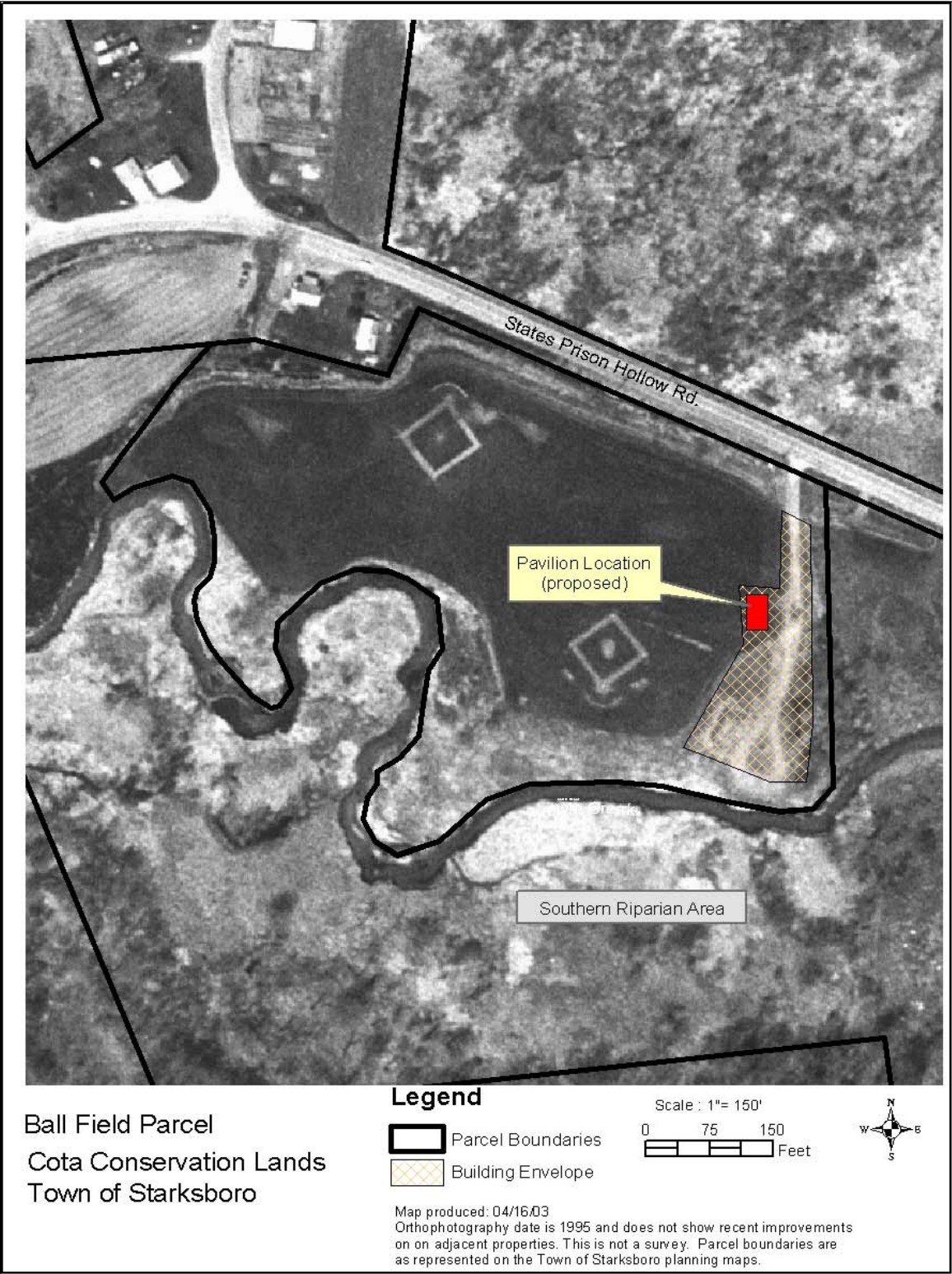
- Field data collection by various parties and the integration of information from subsequent analysis and reports.
- Solicitation of input from the general public through announcement of the planning effort in the town newsletter and at other town events.
- Review of plan drafts by members of the Conservation Commission, Selectboard, Planning Commission, Sports and Recreation Committee, and the Lewis Creek Association.
- Review of plan drafts by abutters, neighbors and other stakeholders.
- Final approval by the Selectboard.

This Management Plan shall be reviewed and updated after the first 3 years, 6 years, and 10 years. It shall be reviewed and updated at least every 10 years subsequent to this initial 10-year period. Conflicts arising out of this plan and the proposed use of the protected property shall be addressed first by private negotiations between the Conservation Commission and the conflicted party or between the conflicted party and the selectboard. Issues of a general public use nature shall be resolved in a public forum that may or may not result in revisions to this plan.

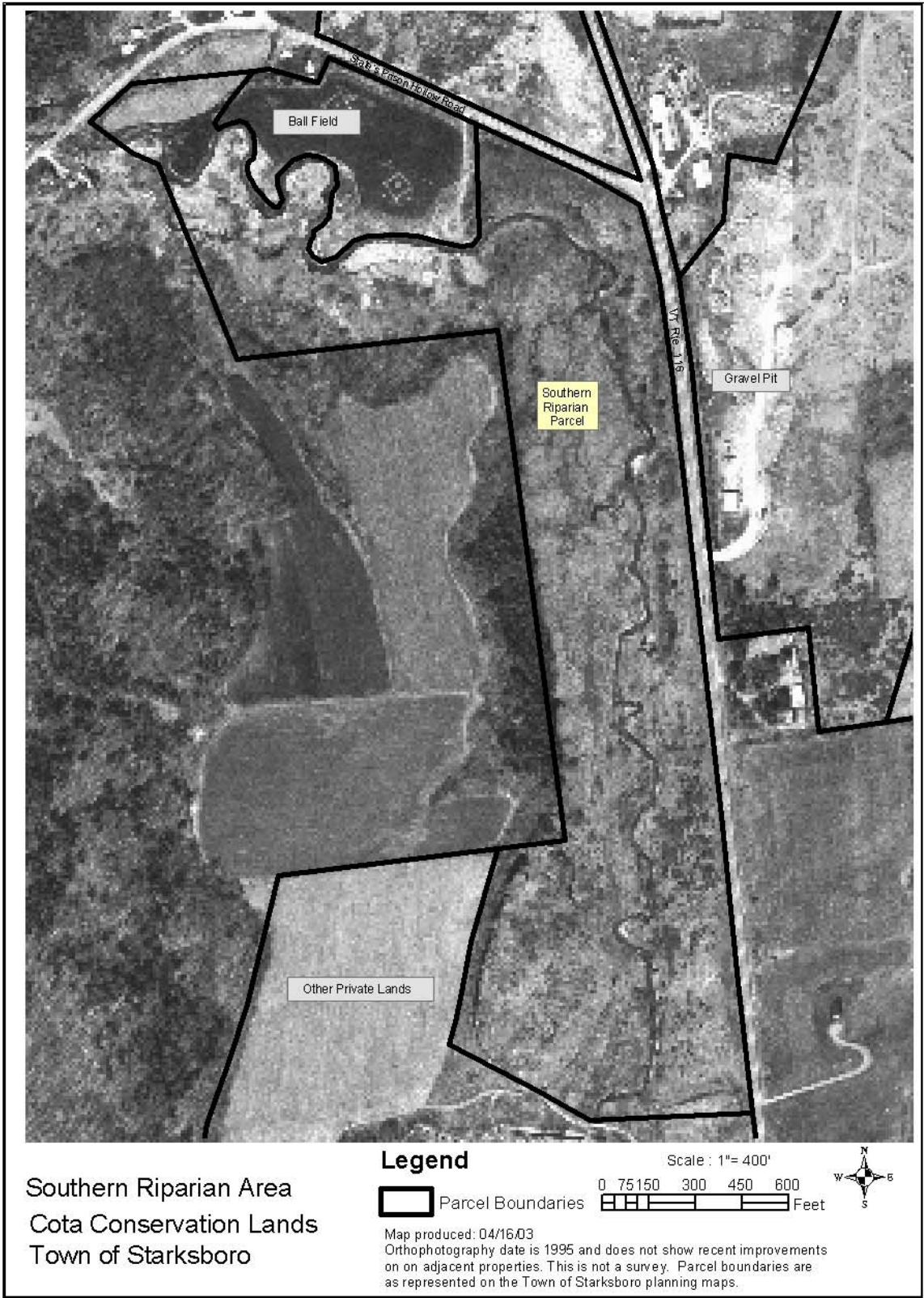
Appendix A. Copies of the Easements, Grants of Development Rights, Conservation Restrictions and Restrictive Covenants for the Protected Parcels

Appendix B. Maps of the Protected Parcels showing all existing roads, trails and structures and proposed trails and structures

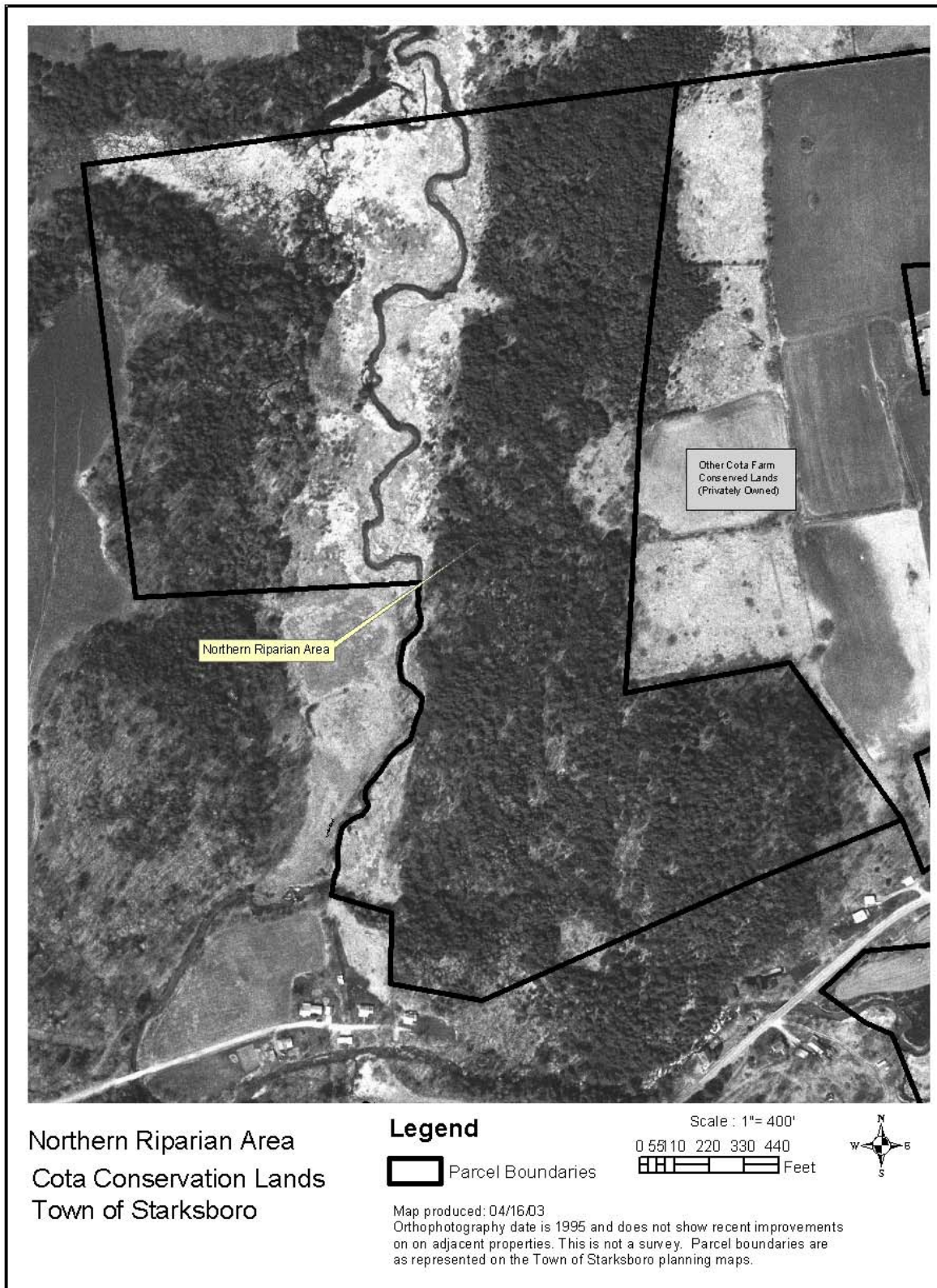
Ball Field



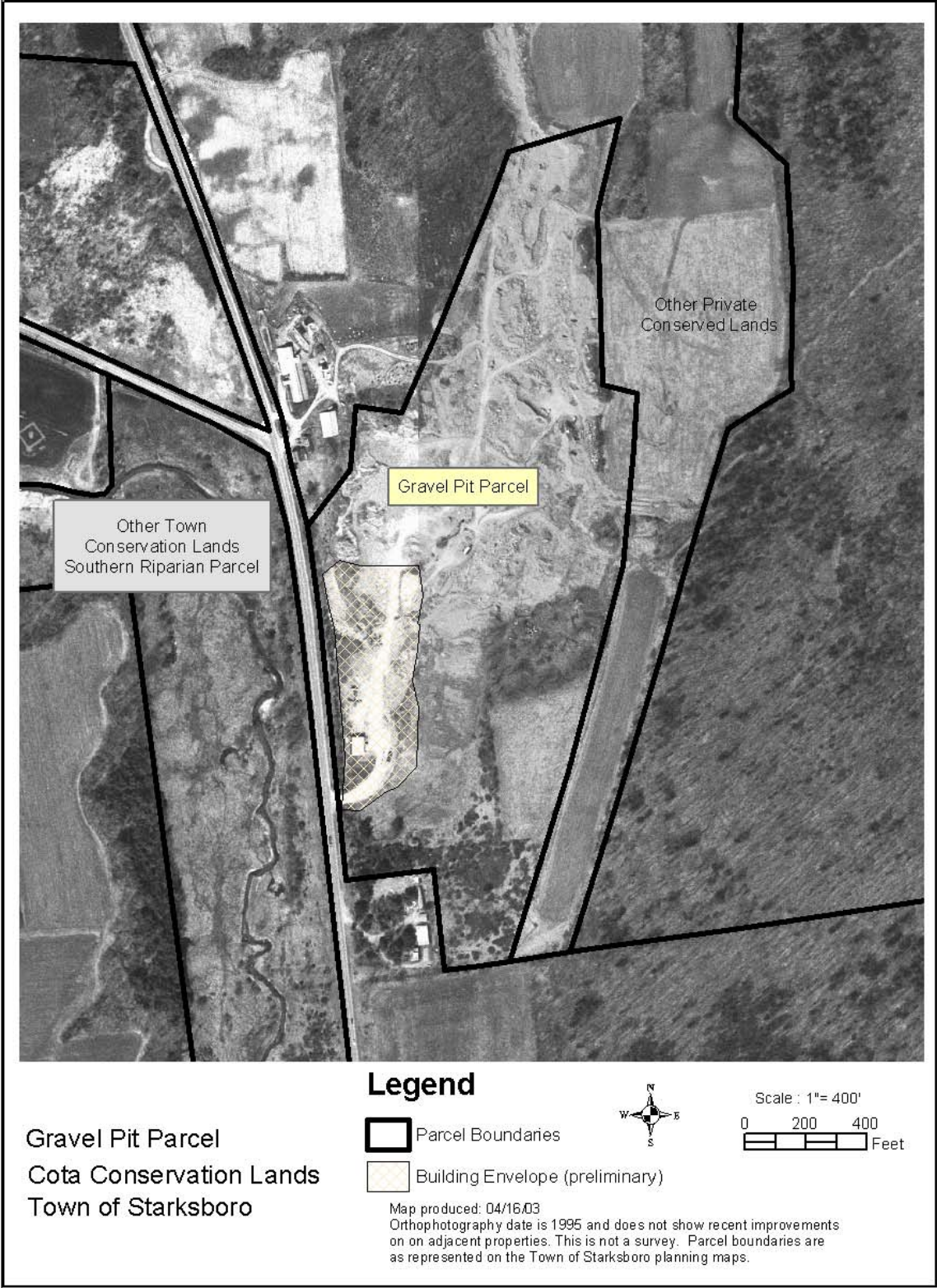
Southern Riparian Area



Northern Riparian Area



Gravel Pit



Appendix C. Act 250 Extraction and Reclamation Plan for the Gravel Pit Parcel

Appendix D. Photographs of the Protected Parcels

Northern Riparian Area looking northerly from States Prison Hollow Rd.



Ballfield looking westerly from the parking area



Southern Riparian area looking northwesterly from Rte.116.



Gravel Pit looking northerly from the base of the pit area.-



Appendix E. Other References

For guidance and information on riparian corridor management for water quality, the following additional resources should be explored:

- Reports on reaches M17 (southern riparian area) and M19 (northern riparian area) on file at the Starksboro town office.
- Vermont Agency of Natural Resources, Appendix E—River Corridor Delineation Process of the Vermont Stream Geomorphic Assessment Manual.
- Lewis Creek Association

Resources

**APPENDIX D
River Corridor Plan
Lewis Creek: Reaches M14 – M18**

**Hinesburg, Monkton, & Starksboro
Chittenden & Addison Counties, Vermont**

February 2008

GRANTS / RESOURCES

Northern Vermont Resource Conservation and Development Council
617 Comstock Road, Suite 2
Berlin VT 05602-8498
<http://www.anr.state.vt.us/cleanandclear/broads.htm>

Vermont Better Back Roads Grants

Up to \$7,000 with 25% local match

VT Department of Housing & Community Affairs
National Life Building, 6th Floor, Drawer 20
Montpelier, VT 05620
<http://www.dhca.state.vt.us/Planning/MPG.htm>

Vermont Municipal Planning Grants

Single town: \$15,000

Consortium (Multiple towns): \$25,000

VT Department of Environmental Conservation
River Corridor Management Section
103 South Main St./ West Bldg.
Waterbury, VT 05761-0403
<http://www.anr.state.vt.us/dec/waterq/rivers.htm>

Vermont River Corridor Restoration & Protection Grants

http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_2008RiverCorridorGrantRFP.pdf

Clean and Clear Water Action Plan

Available FY2008 to watershed groups and municipalities statewide

Category I: Project Identification (\$100,000 FY2006)

Category II: Project Development (\$300,000 FY2006)

Category III: Project Implementation (\$850,000 FY2006)

Vermont Watershed Grants

http://www.anr.state.vt.us/dec/waterq/lakes/html/lp_watershedgrants.htm

Mini-grants: \$200 to \$1000

Grants: \$1,000 to \$6,000

Nonpoint Source Management Grants

EPA - Clean Water Act Section 319

Rick Hopkins rick.hopkins@state.vt.us

802-241-3769

PUBLICATIONS

Geomorphic Assessment and Corridor Delineation

Managing Toward Stream Equilibrium. VT DEC River Management Program, 2006.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_ManagingTowardStreamEquilibrium.pdf

River Corridor Protection as a Restoration Tool. VT DEC River Management Program, 2006.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_CorridorProtectionasRestoration.pdf

Conservation of River Corridor Lands. VT DEC River Management Program, 2006.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_MunicipalIncentives%20.pdf

Municipal Guide to Fluvial Erosion Hazard Mitigation. VT DEC River Management Program, 2006.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_municipalguide.pdf

River Corridor Protection and Management: Fact Sheet #1. VT DEC River Management Program, 2005. http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rcprotectmanagefactsheet.pdf

Defining River Corridors: Fact Sheet #2. VT DEC River Management Program, 2005.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_definingrcfactsheet.pdf

Alternatives for River Corridor Management: Vermont DEC River Management Program Position Paper. VT DEC River Management Program, 18 April 2003.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_mngmntalternatives.pdf

Procedure on ANR Floodway Determinations in Act 250 Proceedings
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_floodwayprocedure.pdf

Vermont Agency of Natural Resources Technical Guidance for Determining Floodway Limits Pursuant to Act 250 Criterion 1(D) 2/21/03
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_floodwaytechguidance.pdf

Buffers

VTANR Riparian Buffer Guidance – Adopted 20 January 2005
<http://www.anr.state.vt.us/site/html/buff/buffer-final-2005.pdf>

VTANR Riparian Buffers and Corridors Technical Papers, 2005
<http://www.anr.state.vt.us/site/html/buff/buffer-tech-final.pdf>

Sources of Native Plant Materials in Vermont. Compiled by Erin Hanley. VT DEC Water Quality. Report #209. 2005.
http://www.anr.state.vt.us/dec/waterq/wetlands/docs/wl_nativeplants.pdf

Water Quality

Citizen Water Quality Monitoring Program: 2004 Final Report. Addison County Riverwatch Collaborative. 2005.
See interactive map hosted at Addison County Regional Planning Commission web site that allows historic water quality data to be downloaded for a given sampling site.
<http://207.136.225.66/acrcw/wqsitegraphsave.php>

State of the Lake: Lake Champlain in 2005--A Snapshot for Citizens. Lake Champlain Basin Program, 2005. Available at: http://www.lcbp.org/PDFs/sol_web.pdf

Lake Champlain Long-term Monitoring – Tributary Station Summary Statistics. VT DEC Water Quality Division, 2006.
http://www.anr.state.vt.us/dec/waterq/cfm/champlain/tribstats_results.cfm

Beavers

Best Management Practices for Resolving Human-Beaver Conflicts in Vermont. Vermont Fish and Wildlife Department. Vermont DEC. Revised 2004.

http://www.anr.state.vt.us/FW/FWHOME/library/factsheets/Fish_and_Wildlife/Best_Management_Practices_for_Human-Beaver_Conflicts.pdf

CONTACTS

Conservation

Hinesburg Area Land Trust

Lake Champlain Land Trust – <http://www.lclt.org/>
One Main Street, Burlington, VT 05401
Chris Boget: (802) 862-4150

Middlebury Area Land Trust - <http://www.maltvt.org/>
211 Maple St., Suite 27A, Middlebury, VT 05753
Robin Scheu, Interim Director: (802) 388-1007

The Nature Conservancy of Vermont -
<http://nature.org/wherewework/northamerica/states/vermont/>
27 State Street, Montpelier, VT 05602-2934
(802) 229-4425

Vermont Land Trust - <http://www.vlt.org/>
Champlain Valley Office
P.O. Box 850, Richmond, VT 05477
Bob Linck, Allen Karnatz, Co-Directors: (802) 434-3079

Vermont River Conservancy - <http://www.vermontriverconservancy.org/>
29 Main Street, Suite 11, Montpelier, VT 05602
Steve Libby, Executive Director: (802) 229-0820

Stream Permits

To find out about stream-crossing structures or gravel extraction permits, see the VT DEC website, under River Management and Permits. <http://www.vtwaterquality.org/rivers.htm>.

Contact Chris Brunelle, Stream Alteration Engineer with questions:
(802) 879-5631 or chris.brunelle@state.vt.us

Restoration

USDA Natural Resources Conservation Service – <http://www.vt.nrcs.usda.gov/>

Bill Forbes, District Conservationist, NRCS Rutland County
William.Forbes@vt.usda.gov
(802) 775-8034 x14

US Fish and Wildlife Service /Partners for Wildlife - <http://www.fws.gov>

Chris Smith
Chris_E_Smith@fws.gov
(802)-872-0629 x 20

Flood Hazard Management

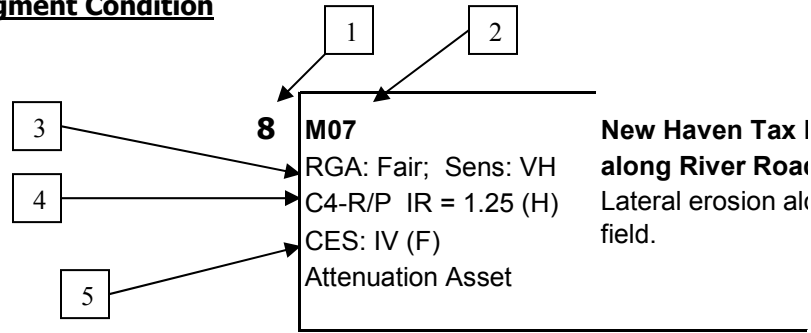
To manage risks of inundation and fluvial erosion during flooding, several publications and resources are available for homeowners as well as towns at the VT River Management Section web page:

http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_floodhazard.htm

ABBREVIATIONS

Table 27 of the Lewis Creek Corridor Plan (Section 6.1) identifies river management opportunities along corridor reaches of the Lewis Creek (reaches M14 – M18). Phase 1 and 2 Stream Geomorphic Assessment data were analyzed to identify management strategies that could support the river’s return to a more balanced condition, thereby reducing erosion hazards and improving water quality and riparian habitats over the long term. The following abbreviations were used in Table 27.

Reach / Segment Condition



1. Sequential project number
2. Geomorphic Reach Number
3. Geomorphic Condition (following VTANR protocols)

RGA = Rapid Geomorphic Assessment (Reference, Good, Fair, or Poor condition)

Sens = Sensitivity
 Ext = Extreme
 VH = Very High
 H = High
 M = Moderate
 L = Low
 VL = Very Low

4. Stream Type / Incision Ratio

Stream Type (after Rosgen, 1996 and Montgomery & Buffington, 1997)
 Casc = cascade
 S/P = step/ pool
 R/P = riffle/pool
 D/R = dune/ripple
 PB = plane bed

Incision Ratio (following VTANR protocols)
 IR = Incision Ratio
 HEF = Human-elevated floodplain
 RAF = recently abandoned floodplain
 (H) = historic
 (A) = active

5. Channel Evolution Stage / Model

Channel Evolution Stage and model (F-stage or D-stage) following VTANR protocols, Appendix C.

Site Description / Project Description

LB Left bank, facing downstream
 RB Right bank, facing downstream
 US Upstream
 DS Downstream

Objectives Addressed

AV Avoidance
 FP Floodplain Access
 SA Sediment Attenuation
 NA Nutrient Attenuation
 FA Flow Attenuation
 SR Sediment Reduction
 NR Nutrient Reduction
 EQ Equilibrium condition, support or accelerate return
 BS Bank Stabilization
 EC Ecologic
 - lt long term
 - st short term

Potential Partners - Programs

<u>Organization</u>	<u>Program</u>	<u>Description</u>
NVRCDC	BBR	Northern Vermont Resource Conservation and Development Council <i>Better Backroads Grant Program</i>
USDA NRCS	AMA CRP EQIP WHIP WRP	US Department of Agriculture, Natural Resources Conservation Service <i>Agricultural Management Assistance</i> <i>Conservation Reserve Program</i> <i>Environmental Quality Incentives Program</i> <i>Wildlife Habitat Incentives Program</i> <i>Wetlands Reserve Program</i>
USFW	Partners	US Fish & Wildlife Program <i>Partners for Fish & Wildlife Program</i>
VTAA	CREP BMPs ICM	Vermont Agency of Agriculture <i>Conservation Reserve Enhancement Program</i> <i>Best Management Practices (cost-share program)</i> <i>Integrated Crop Management (cost-share program)</i>
VTDEC WQD	RMS WS	Vermont Department of Environmental Conservation, Water Quality Division <i>River Management Section (River Corridor Grants – Clean & Clear Action Program)</i> <i>Wetlands Section (Wetland Restoration Grants – Clean & Clear Action Program)</i>
VTDEC FED	DSH	Vermont Department of Environmental Conservation, Facilities Engineering Division <i>Dam Safety & Hydrology Section</i>
Vtrans		Vermont Department of Transportation
VRC		Vermont River Conservancy

Zoning Analysis

**APPENDIX E
River Corridor Plan
Lewis Creek: Reaches M14 – M18**

**Hinesburg, Monkton, & Starksboro
Chittenden & Addison Counties, Vermont**

April 2008

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E.1 Intro

A zoning analysis has been conducted to evaluate the possible impacts on development potential in the three corridor towns resulting from measures taken to protect the Lewis Creek M14-M18 corridor from future development. This analysis has utilized the Addison Community Buildout Analysis software.

The area of the Lewis Creek M14-M18 Corridor represents a small percentage of the total area in each town (Table 1) – ranging from 0.2 to 0.6 %. A total of 38 parcels intersect the corridor in the three towns. Two of these parcels (in Starksboro and Hinesburg) are already conserved.

Table 1. Lewis Creek M14-M18 Corridor Area in Starksboro, Monkton, and Hinesburg

Town	Reaches	Status	Description	Total Town Area (ac)	Corridor Area (ac)	Percent of Town by Area	No. of Parcels
Starksboro	M18, M17, M16, M15 (partial)			29,155	174	0.6%	
		Conserved	Northern Riparian Parcel		22	0.1%	1
		Not Conserved			152	0.5%	17
Monkton	M15 (partial)			23,212	44	0.2%	
		Conserved			0	0.0%	0
		Not Conserved			44	0.2%	9
Hinesburg	M15 (partial), M14			23,212	70	0.3%	
		Conserved	Copp/Welch-I		19	0.1%	1
		Not Conserved			51	0.2%	10

E.2 Existing Zoning in Lewis Creek Corridor

E.2.1 Starksboro

The Lewis Creek corridor (reaches M18, M17, M16 and part of M15) in Starksboro is located within the zoning district identified as *Agricultural, Scenic and Rural Residential (ASRR)* (reference Land Use Map dated June 1999 prepared by Addison County Regional Planning Commission and contained in 4 August 2003 Starksboro Town Plan). The stated purpose of the ASSR district is to “provide an incentive for development to occur on the smallest possible lot size in order to preserve the remainder of the land for agriculture and its scenic beauty” (Section 1.7.4).

Current zoning regulations (adopted 15 June 2006) require a minimum lot size of **25 acres** for new development in the ASRR district (see Section 1.6). Section 1.8.1 of the Starksboro zoning regulations

allows for a slightly higher development density in this district if minimum acreages are set aside for no development:

Building Lot Size (acres)	Minimum "Set Aside" acres	Minimum total acres
1	9	10
Up to 2	13	15
Up to 3	17	20

Excerpted from Section 1.8.1 of Starksboro Zoning Regulations, adopted 15 June 2006

Planned Residential Developments are also permitted under current Starksboro zoning regulations "to cluster development in order to preserve the Town's natural resources, agricultural land, and visual landscape" (Section 4.11). Regulations allow the Development Review Board to permit an "increase by 25% in the maximum density requirements for homes in the ... Agricultural, Scenic and Rural Residential Corridor."

E.2.2 Monkton

The Lewis Creek corridor (portion of reach M15) in Monkton is located within the zoning district identified as *Rural Agricultural District – 5 (RA-5)* (reference Zoning Map dated May 1977 contained in current zoning regulations – no date provided). The lot area minimum in this district is **5 acres** (page 8-A).

A recently-updated Town Plan for Monkton (adopted September 2007) contains a map of proposed Land Use Districts which identifies this area as a Low Density Agricultural District (LDAD). The updated Town Plan also discusses that future zoning regulation revisions should include incentives for clustered development and Planned Unit Districts "to achieve the Town's goal of maintaining as much open and wooded land as possible" (page 55).

E.2.3 Hinesburg

The Lewis Creek corridor (part of reach M15 and reach M14) in Hinesburg is located within the zoning district identified as *Agricultural (AG)* (reference Zoning Map on file at the Town of Hinesburg offices). The minimum lot size in this district is **2 acres**; a maximum lot coverage of 20% is specified in Hinesburg zoning regulations (September 19, 2005).

Planned Unit Developments (PUDs) and/or Planned Residential Developments (PRDs) are permitted in Hinesburg's Agricultural district to meet several objectives, including to "...accommodate new development in a manner that...protects significant natural, cultural and scenic features."

E.2.4 Flood Hazard Area (FEMA-FIRM)

In each of the three towns, the Flood Hazard Area designated by FEMA Flood Insurance Rating Maps overlaps with the river corridor defined in this plan. Zoning regulations in each town contain the minimum standard protections for properties located within the Special Flood Hazard Area, including elevating new or substantially-improved structures above the base flood elevation (or flood proofing the structure as certified by a registered professional engineer or architect).

New development or substantial improvement to existing development within the special flood hazard area is subject to a conditional use permit by the Zoning Board of Adjustment (Starksboro, Monkton) or Development Review Board (Hinesburg). (A more recently-adopted town plan for Monkton notes that Conditional Use review will be carried out by the Development Review Board).

E.3 Existing Development

At present, only a few residential, commercial and agricultural buildings are located within the Lewis Creek corridor along reaches M18 through M14 (see Table 2). The locations of these structures are digitized in orange on the reach maps contained in Appendix A of this corridor plan.

Table 2. Development within the Lewis Creek M14–M18 Corridor.

Reach/Segment	Buildings / Development
M18	LB house and outbuildings – upstream end; RB Bed & Breakfast, former mill buildings – upstream end; RB shed – downstream end
M17-C	RB houses (5) & outbuildings
M17-B	None
M17-A	None
M16	None
M15-B	RB house
M15-A	RB house and outbuildings
M14	RB house and outbuildings – upstream end RB houses (2) & outbuildings – downstream end

Note: RB = Right Bank; LB = Left Bank

Under parcel configurations depicted on the most-recent, available, digital parcels for Starksboro, Monkton, and Hinesburg, only 5 parcels are wholly contained within the Lewis Creek M14-M18 Corridor (see Table 3). However, these parcels appear to be each fully built out, and no new structures could be located on these parcels under current zoning (see Section E.2).

Table 3. Parcels Wholly Contained Within Lewis Creek M14–M18 Corridor.

Reach/Segment	Town	Parcel ID	Approx. Size (ac)	Buildings / Development
M17-C	Starksboro	(see App B, p 3) C2391N	1.8	RB, 2 houses & outbuildings
		C2392S	0.5	RB, 1 house & outbuildings
		C2393N	0.4	RB, 1 house & outbuildings
M14	Hinesburg	(see App B, p 6) 12-01-39.000	2.0	RB house and outbuildings
		12-01-34.000	2.3	RB houses (2) & outbuildings

Note: RB = Right Bank; LB = Left Bank

E.4 Future Development

To evaluate future development in the area of the Lewis Creek M14-M18 corridor and the potential impact of development restrictions within the corridor, a basic build out was performed for each of the three towns: Starksboro, Monkton, and Hinesburg. Build outs were performed with the assistance of Amy Diller, Watershed Planner with the Addison County Regional Planning Commission, using version 2 of the *Addison Community Buildout Analysis* software, (ACBOA, an extension to ArcView® 3.x). Build out results are intended for planning purposes only – for application at a regional scale (e.g., town-wide, watershed wide). Build out results should not be evaluated at the parcel or sub-parcel level. Please refer to the documentation of the ACBOA for details of the software operations and build out procedures.

The basic build out analysis for each town utilized current zoning boundaries and minimum lot sizes for each district under present zoning. Two development-constraining layers were considered in each town:

- 1) the M14-M18 Lewis Creek corridor (depicted in red on Figure 1); and
- 2) the FEMA-FIRM floodway (depicted in a hatched blue pattern on Figure 1). Digitized Flood Hazard Areas were obtained for the corridor towns from Addison County Regional Planning Commission. The Flood Hazard Area designated by FEMA Flood Insurance Rating Maps overlaps (intersects) approximately 224 acres (78 %) of the total Lewis Creek M14-M18 Corridor area (Table 4).

Table 4. Aerial Extent of FEMA-FIRM floodway mapped in Lewis Creek corridor

	Total Area (acres)
Lewis Creek M14-M18 Corridor	289
Mapped Floodway (FEMA-FIRM) within the Corridor	224

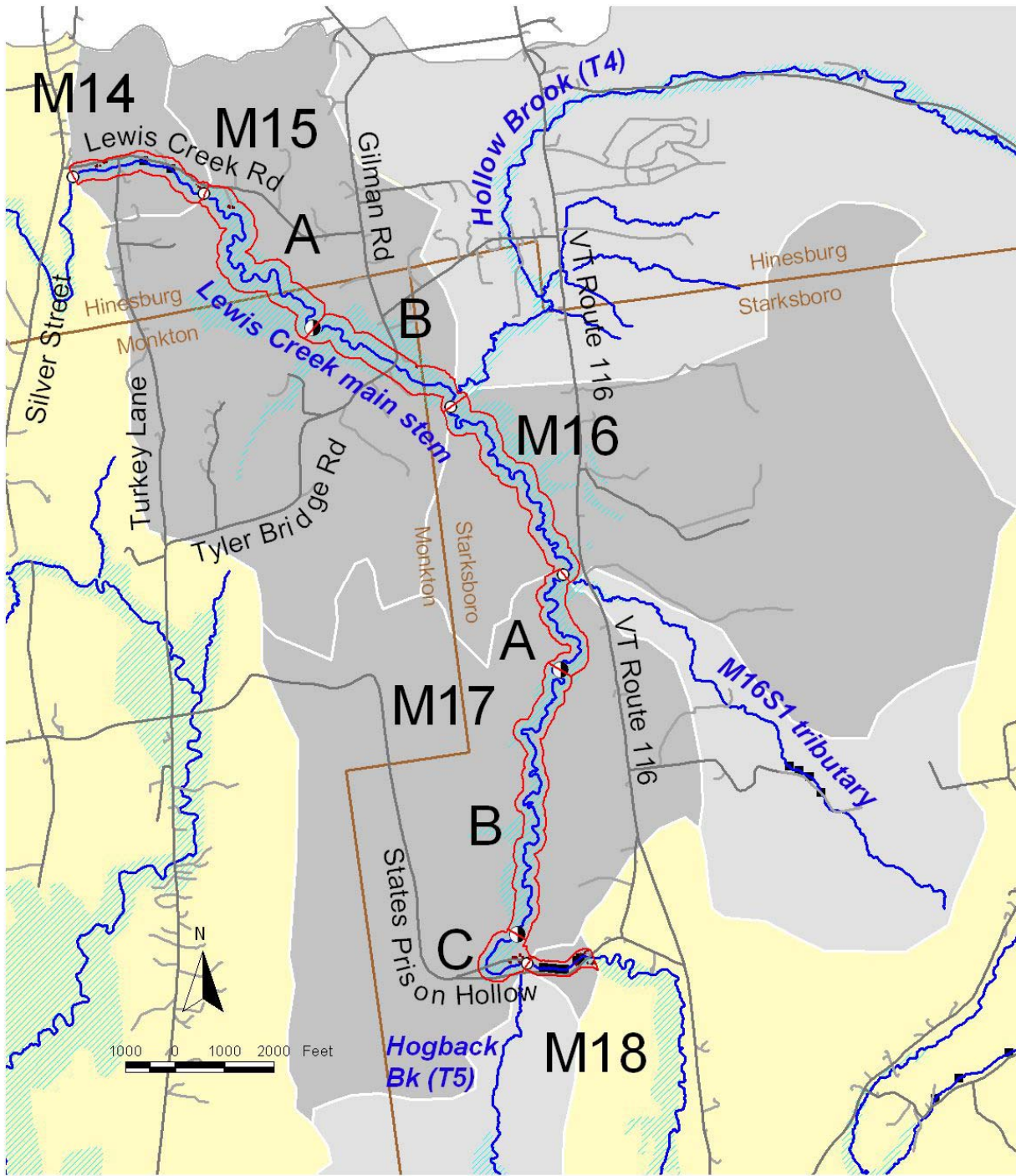


Figure 1. FEMA-FIRM floodway (blue hatched pattern) versus Lewis Creek M14-M18 Corridor (outlined in red); towns of Starksboro, Monkton, Hinesburg, Addison & Chittenden Counties, VT.

The build out did not address other constraints that may limit development including limiting soil conditions (e.g., poorly-drained), wetlands, stream buffers or setbacks (other than the M14-M18 corridor), steep slopes, Prime Ag and Statewide soils, etc.

Five scenarios were run for each town:

1. Basic Build out – considering only zoning districts, current parcel mapping, and existing structures (E911 records)
2. Remove Flood – a Basic Build out (no natural resource constraints) – no structures permitted in the FEMA-FIRM floodway (for all waterways available in town), and the floodway area was not counted toward density-requirements of the underlying zoning district.
3. Remove Flood & Corridor - a Basic Build out (no natural resource constraints) – no structures permitted in the FEMA-FIRM floodway or the M14-M18 Lewis Creek corridor, and neither area was counted toward density-requirements of the underlying zoning district.
4. Remove Flood / Count Toward Density – a Basic Build out (no natural resource constraints) – no structures permitted in the FEMA-FIRM floodway (all waterways available in town), but the floodway area could count toward density-requirements of the underlying zoning district.
5. Remove Flood & Corridor / Count Toward Density - a Basic Build out (no natural resource constraints) – no structures permitted in the FEMA-FIRM floodway or the M14-M18 Lewis Creek corridor, but both areas could count toward density-requirements of the underlying zoning district.

Scenarios 4 and 5, which allow the parcel area located within the FEMA-FIRM floodway or M14-M18 corridor to be counted toward density requirements of the underlying zoning district, more closely represent real conditions than Scenarios 2 and 3. It should be noted that while the ACBOA allows density to be relocated in a general sense, this analysis did not apply parcel-specific density bonus arrangements (PUDs, PRDs) permitted under zoning regulations for Starksboro, Monkton, or Hinesburg.

With respect to the FEMA-FIRM floodway, it could be argued that Scenarios 2 through 5 are more conservative than reality – since Special Flood Hazard Area regulations in each town do not prohibit development within the floodway. Rather, residential or nonresidential development is permitted as a conditional use if it can be established that structures are elevated above the base flood elevation or adequately flood-proofed. However, this approach was of interest since avoidance of development in these areas at risk of inundation flooding would represent a public value in terms of flood hazard mitigation, water quality improvements, and riparian habitat continuity. The Build out results for these scenarios can help to quantify the potential impact on development potential within the town, should stricter regulations be adopted for these FEMA-FIRM floodways.

Build out results for each town are summarized in Table 5. To quantify the potential impacts of development restrictions within the Lewis Creek M14-M18 corridor, one should focus on the difference in Potential Units (POTUNIT) between Scenarios 4 and 5 in each town (Table 5). Potential Units represent the total number of units possible if development occurs to the fullest extent allowed under current zoning.

Table 5. Build out Results

	BUILDOUT VERSION 2	EXISTUNIT	GFUNIT	NODEVUNIT	DENLSTUNIT	DENRELUNIT	DEVUNIT	POTUNIT
	Starksboro Totals							
1	Basic BO	754	99	0	0	0	963	1062
2	Remove Flood	754	101	27	0	0	915	1016
3	Remove Flood & Corridor	754	100	55	0	0	872	972
4	Remove Flood with area used in density calculation	754	101	0	0	9	959	1069
5	Remove Flood & Corridor with area used in density calculation	754	100	0	0	26	943	1069
	Monkton Totals							
1	Basic Buildout	626	95	4	0	0	3283	3378
2	Remove Flood	626	79	79	0	0	3180	3259
3	Remove Flood and Corridor	626	77	119	0	0	3117	3194
4	Remove Flood with area used in density calculation	626	79	4	9	56	3218	3353
5	Remove Flood and Corridor with area used in density calculation	626	77	4	9	91	3183	3351
	Hinesburg Totals							
1	Basic Buildout	1682	128	0	0	0	8883	9011
2	Remove Flood	1682	132	674	0	0	8179	8311
3	Remove Flood & Corridor	1682	132	674	0	0	8179	8311
4	Remove Flood with area used in density calculation	1682	132	0	21	556	8308	8996
5	Remove Flood & Corridor with area used in density calculation	1682	132	0	21	556	8308	8996

Table 5. Build out Results (Continued)

	BUILDOUT VERSION 2	NODEVACRE	BUILTACRE	GFACRE	UNDMINACRE	DENLSTACRE	DENRELACRE	DEVACRE
	Starksboro Totals							
1	Basic BO	0	3291	275	282	0	0	6011
2	Remove Flood	470	3242	259	280	0	0	5591
3	Remove Flood & Corridor	887	3161	247	272	0	0	5264
4	Remove Flood with area used in density calculation	0	3291	282	282	0	102	5915
5	Remove Flood & Corridor with area used in density calucation	0	3291	286	284	0	251	5770
	Monkton Totals							
1	Basic Buildout	124	2108	180	858	0	0	15916
2	Remove Flood	2244	2011	109	363	0	0	14388
3	Remove Flood and Corridor	2545	2002	104	334	0	0	14125
4	Remove Flood with area used in density calculation	124	2127	122	913	294	1010	14556
5	Remove Flood and Corridor with area used in density calculation	124	2127	127	916	294	1223	14349
	Hinesburg Totals							
1	Basic Buildout	0	3114	80	54	0	0	21054
2	Remove Flood	1260	3086	86	54	0	0	19825
3	Remove Flood & Corridor	1260	3086	86	54	0	0	19825
4	Remove Flood with area used in density calculation	0	3125	113	54	30	1053	20002
5	Remove Flood & Corridor with area used in density calculation	0	3125	113	54	30	1053	20002

▪ **Starksboro**

- There was no apparent reduction in Potential Units when the M14-M18 Lewis Creek corridor was effectively removed from development – provided that the corridor area could count towards density requirements of the underlying *Agricultural, Scenic and Rural Residential* zoning district.
- In an unexpected finding, the Potential Units available (1069) under Scenarios 4 & 5 (with floodways and corridor removed from development) was slightly higher than the Potential Units available (1062) under the Basic Build out (Scenario 1) with no constraints to development considered. According to Kevin Behm of the ACRPC, this result may be related to an artifact of the software and they are reviewing the Build out results in more detail.

▪ **Monkton**

- There was an apparent reduction of 2 Potential Units (from 3353 to 3351) when the M14-M18 Lewis Creek corridor was effectively removed from development – provided that the corridor area could count towards density requirements of the underlying *Rural Agricultural District – 5* zoning district. Two units represents less than 0.1% of the total Potential Units (3378) estimated under the Basic Build out under current zoning. A “no-development” condition for both the floodway and corridor results in a reduction of only 27 units (or 0.7% of the total Potential Units estimated under Basic Buildout).

▪ **Hinesburg**

- There was no apparent reduction in Potential Units (8996) when the M14-M18 Lewis Creek corridor was effectively removed from development – provided that the corridor area could count towards density requirements of the underlying *Agricultural* zoning district. A “no-development” condition for both the floodway and corridor results in a reduction of only 15 units (or less than 0.1% of the total Potential Units [9011] estimated under Basic Buildout).

E.5 Other Natural Constraints to Development within the Corridor

Other natural constraints to development that would apply to the lands within the Lewis Creek M14-M18 Corridor were not considered in the above Build outs. Thus, “loss” of potential development units due to protection of the M14-M18 Lewis Creek corridor is probably overstated in the above analysis.

For example, wetlands are mapped (National Wetlands Inventory) cover a significant aerial extent of the corridor – approximately 42% (Table 6).

Table 6. Aerial Extent of NWI mapped wetlands in Lewis Creek corridor

	Total Area (acres)
Lewis Creek M14-M18 Corridor	289
NWI mapped wetlands within the Corridor	121

The actual area of wetlands (or potential wetlands) within the corridor may even be greater than indicated in Table 6, due to the fact that:

- 1) wetland areas previously converted to agricultural use are typically not mapped on the NWI coverage (e.g., on Clifford farm, reach M16, Starksboro; and Hansen Farm, reach M17-B, Starksboro); and
- 2) NWI maps depict Class I and II wetlands only. There may be additional areas of Class III wetlands within the corridor. It is likely that some portion of these additional wetland areas would further limit development, even if only due to their association with soils unsuitable for on-site septic disposal.

E.6 Existing Conserved Lands within the Corridor

“Loss” of potential development units due to protection of the Lewis Creek M14-M18 Corridor is probably overstated for the towns of Hinesburg and Starksboro, since the Lewis Creek M14-M18 corridor in these two towns contains lands that are already conserved:

- Hinesburg, reach M15-A – Copp/Welch I –
19 acres this conserved parcel are contained within the corridor;
- Starksboro, reach M17-C, -B – Town of Starksboro Northern Riparian Parcel –
22 acres of this conserved parcel are contained within the corridor.

E.7 REFERENCES

Starksboro Zoning Regulations, adopted March 1993, as amended July 6, 2006.

Monkton Zoning Regulations (current, no date provided); Monkton Development Plan, adopted September 2007.

Hinesburg Zoning Regulations, adopted November 7, 1972, as amended September 19, 2005.