East Creek Corridor Plan
East Creek Watershed
Addison and Rutland Counties, Vermont
May 25, 2011

Prepared by:

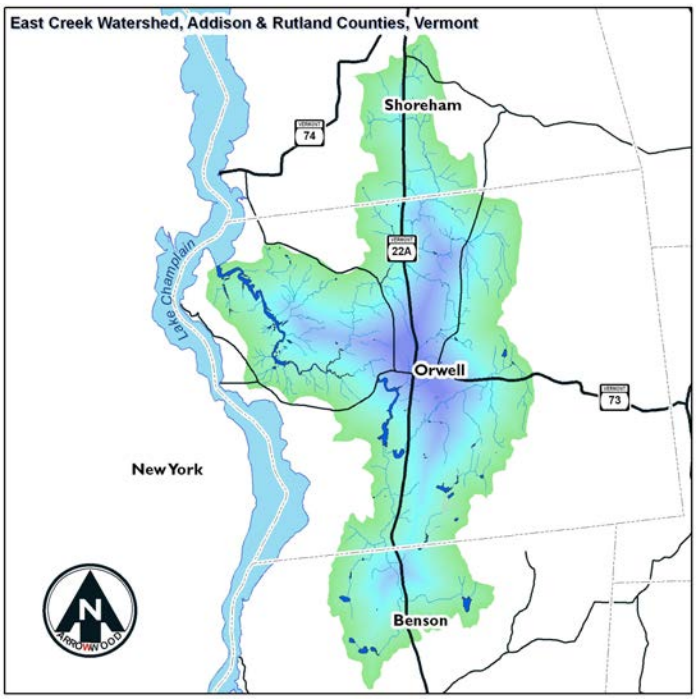
Dori Barton
Principal/Wetlands Ecologist
Aaron Worthley
Ecologist/GIS Analyst

Prepared for:
Vermont Agency of Natural Resources
River Management Program

ARROWWOOD ENVIRONMENTAL
950 BERT WHITE ROAD
HUNTINGTON, VT 05462
(802 434-7276 FAX: (802) 329-2253

Executive Summary

The East Creek has a watershed size of approximately 32 square miles. The East Creek is a direct tributary to Lake Champlain. Watershed origins include the towns of Benson, Orwell, and Shoreham, as such, reaching two counties in Vermont-Addison and Rutland. The towns of Orwell, Benson, and Shoreham through their Town Plans are committed to protecting, enhancing and improving the health of the East Creek.



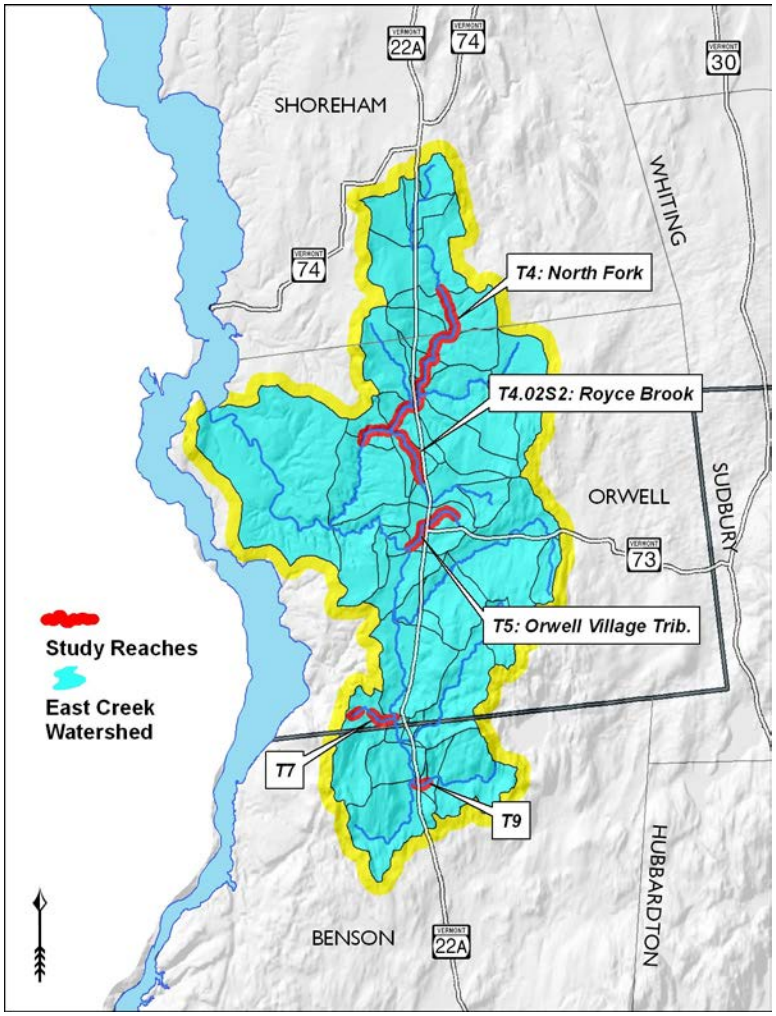
East Creek Watershed Map

In September 2009, the Vermont River Management Program extended a Request for Proposals for a Phase 1 and 2 Geomorphic Assessment of East Creek in the Lake Champlain Direct sub-basin. The Phase 1 assessments identified priority reaches for the Phase 2 assessments and were completed by Arrowwood Environmental in the winter of 2010. Phase 2 assessments were completed on 11 reaches by Arrowwood Environmental in the summer of 2010. During the winter of 2011, Arrowwood Environmental worked on the development of a community-based river corridor management plan for the East Creek Watershed.

The Corridor Plan focuses on stream reaches on the North Fork of East Creek and four of its tributaries. The study reaches are located on the following waters within the following towns:

Shoreham:	North Fork/Jones Brook (T4.08)
Orwell:	North Fork/Jones Brook (T4.02-T4.07)
	Royce Brook (T4.02S2.02)
	Orwell Village Tributary (T5.01)
	Doughty Hill Tributary (T7.01)
Benson:	Cranberry Swamp Tributary (T9.01)

The East Creek watershed is comprised of the two major forks (North and South) of the Creek with several smaller tributaries flowing into these forks, which converge just west of Old Foundry Road, and flow directly into Lake Champlain. The North Fork, also called Jones Brook, has its headwaters in the hills southeast of the village of Shoreham, Vermont. The stream meanders through agricultural lands in a relatively broad valley about Route 22A until it reaches the forests northeast of Hough Crossing. At this point, the valley becomes narrow and steeper sloped with the stream less meandering. The South Fork has its headwaters in hills southeast of Bullhead Pond in Benson, Vermont. The stream flows east towards Route 22A from Bullhead Pond through a forested landscape. As the stream turns north it enters a very broad and gently sloping valley. The stream meanders through agricultural lands and extensive wetlands, picking up flows from many tributaries as it moves through the towns of Benson and Orwell to its confluence with the North Fork. The major tributaries of both the North and South Forks of East Creek are generally small streams that meander through gently sloping, broad to very broad valleys within an agricultural setting.



East Creek Subwatershed Map

Many land uses are incompatible with the meandering and ever-changing nature of rivers and streams. Rivers and streams are often straightened, armored, dredged, bermed, or encroached upon to protect property investments or to make floodplain available for other land uses. Channel

straightening and bank armoring remove or alter natural meanders, while undersized bridges and culverts act as channel constrictions, forcing the stream to flow faster through a narrow area. These channel alterations directly affect the stream by increasing its slope and power, resulting in areas of bed and bank erosion.

Streams naturally exhibit erosion and deposition processes. When systems are not in equilibrium, the degree and rate of erosion may overwhelm the streams natural ability to transport sediment and natural depositional processes. Sedimentation and associated degradation of aquatic habitat are concerns in the East Creek and its tributaries. At the watershed scale, erosive materials present in upper sideslopes of steep valley walls, alluvial soils on exposed streambanks, and bed materials contribute to a high sediment-load system. Geomorphic instability related to the downcutting (and loss of floodplain access) of several of the study reaches have resulted in adjustment processes that are manifested largely in redistribution of the sediment loads as the river tries to regain equilibrium and establish a new floodplain.

Watershed and reach scale stressors were evaluated for each study reach including hydrologic alterations, land use and land cover changes, sediment regime stressors, channel slope and depth modifiers, boundary conditions and riparian modifiers. Changes to sediment regime and reach sensitivity to future adjustments were also evaluated. Figures and Tables were created to allow for in-depth evaluation of how each of these stressors has contributed to the current condition of the study reaches, and how that differs from the expected reference (or equilibrium) condition. Restoration and conservation techniques were developed for each reach, and a comprehensive Preliminary Project Identification and Prioritization table was created to prioritize the identified restoration and conservation strategies.

The findings of the East Creek Corridor Plan are summarized as follows:

- Historically, the East Creek watershed acted as a sediment and nutrient attenuation zone, with incoming fine sediments from upstream stored on the floodplain, and inputs of coarse sediment essentially in balance and equal to outputs of coarse sediment.
- Many sections of the watershed still act as sediment and nutrient attenuation zones.
- Portions of the watershed have largely been transformed into a sediment and nutrient source and transport zone where floodplain access is limited and sediment and nutrients

are funneled through the system to downstream receiving waters, due to the historic and ongoing adjustment processes and stressors documented in the watershed.

- The highest priority projects developed for the watershed are those that attempt to restore the sediment and nutrient attenuation assets in areas that have been converted to transport zones.
- Other recommended project types include riparian buffer and corridor enhancement to filter out excess nutrients, help stabilize streambanks, restore wetlands, and provide shade and cover to improve aquatic habitat; and replacement of undersized bridges and culverts to reduce channel constrictions, restore normal flow patterns, and improve aquatic habitat.

This Corridor Plan encourages coordination of landowner and municipal efforts to approach restoration with an eye to watershed scale dynamics. The South Lake Citizen Advisory Committee and local Conservation Commissions can play a critical role in coordinating restoration efforts, and this report aims to facilitate such coordination in a way that can help landowners understand the part their properties play within the context of the entire watershed.

TABLE OF CONTENTS

FIGURES

LIST OF TABLES

LIST OF ATTACHMENTS

East Creek Corridor Plan
East Creek Watershed
Addison and Rutland Counties, Vermont

1.0 PROJECT OVERVIEW

In September 2009, the Vermont River Management Program extended a Request for Proposals for a Phase 1 and 2 Geomorphic Assessment of East Creek in the Lake Champlain Direct sub-basin. Phase I and Phase 2 Stream Geomorphic Assessments were conducted by Arrowwood Environmental for the East Creek Watershed. The Phase 1 assessment completed steps 1-7 of the Stream Geomorphic Assessment Phase 1 Protocols using the SGAT GIS extension. The Phase 1 assessments identified priority reaches for the Phase 2 assessments. Phase 2 assessments were completed on 11 reaches by Arrowwood Environmental in the summer of 2010. During the winter of 2011, Arrowwood Environmental worked on the development of a community-based river corridor management plan for the Phase 2 assessed reaches of the East Creek watershed.

2.0 INTRODUCTION

The towns of Shoreham, Orwell and Benson through their Conservation Commissions and Planning Commissions are committed to protecting, enhancing and improving the health of the East Creek and its tributaries. The following excerpts are from Town Plans within the East Creek Watershed, and serve to summarize the goals the towns have for the Creek and its watershed and also to identify strategies to

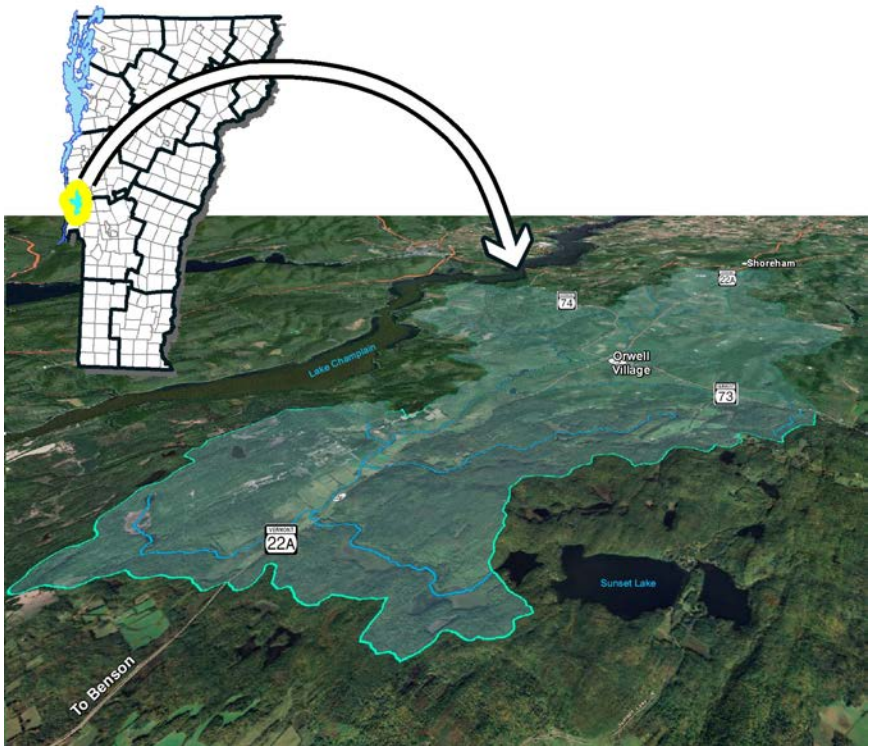


Figure 1. East Creek Watershed Map

accomplish those goals.

Orwell Town Plan: The Town of Orwell has identified Lake Champlain and East Creek as critical resources and has provided them with protective 75' buffer zones. The Town Plan sets forth the following policies related to surface water resources:

- Support the continued management of the East Creek area to provide bird nesting, breeding migration stop-over habitat.
- Protect existing high-quality riparian habitat within the town by establishing or maintaining undisturbed, naturally vegetated riparian buffers along the town's streams to protect water quality, prevent erosion, reduce the amount of pollutants entering the surface water, and provide habitat and corridors that connect habitats.
- Protect lakes, ponds, rivers and streams from encroaching development, including roads and driveways, by incorporating development setbacks and standards into the town's land use regulations that require the maintenance or establishment of naturally vegetated riparian buffers.
- Require the restoration of riparian habitat when reviewing site plans or subdivisions by designating "no mow" zones along surface waters, allowing for the natural revegetation of woody vegetation, or requiring active planting of native woody vegetation in the riparian area. (Orwell Town Plan, 2007)

Benson Town Plan: Within Benson, restoration efforts are taking place to bring back forest habitat conditions along the East Creek. The Southern Lake Champlain Valley Program of The Nature Conservancy and the Poultney-Mettowee Watershed Partnership have been working together to supply native plants grown from local seed sources for local ecological restoration and vegetative buffer plantings. Several landowners in Benson have signed up for federal cost-share programs to remove riparian areas from agriculture use. This federally funded stream bank protection program is called Partners For Wildlife.

Shoreham Town Plan: Farming has historically been the single most important land use activity in Shoreham. Shoreham's tillable land is relatively flat and very productive, and the climate is favorable for a variety of agricultural uses. The agricultural community has made a commitment to farming, which is reflected in the working landscape. This commitment has resulted in the maintenance of a "critical mass" of agricultural activity and land-use that helps

attract and sustain the necessary support industries associated with farming. The community expresses a shared commitment to the preservation of its natural resources as expressed in the goals and actions outlined in the town plan.

Goals:

1. Assure continued recognition and conservation of Shoreham's Natural Resources.
2. Preserve and improve the condition of our surface and ground-water resources.

Actions:

1. Plan workshops to increase public awareness and appreciation of our agricultural soils, surface waters, and natural resources, and their importance in our daily life.
2. Encourage limited development along lakes and rivers, using sound conservation practices (such as buffer zones and erosion control), to preserve the health of the waters and to protect surface waters from phosphorous runoff.
3. Require the use of sustainable forestry management practices on Town-owned wooded areas.
4. Educate residents about phosphorous and control of non-point phosphorous pollution.

3.0 BACKGROUND WATERSHED INFORMATION

3.1 GEOGRAPHIC SETTING

The East Creek Watershed has a watershed size of approximately 32 square miles. The East Creek drains directly to southern Lake Champlain. Watershed origins include the towns of Shoreham, Orwell and Benson, as such, reaching two counties in Vermont-Addison and Rutland. The main branch of the East Creek (South Fork) is approximately 13 miles long, from its headwaters in Benson to its mouth at Lake Champlain in the town of Orwell. The North Fork of East Creek is approximately 10 miles long, from its headwaters in Shoreham to its confluence with the main branch in the town of Orwell.

For the purpose of geomorphic assessment and corridor planning, the East Creek has been divided into 'reaches,' eleven of which fall within the scope of this Corridor Plan. A reach is a section of stream with similar characteristics; this determination is primarily based on physical characteristics such as slope, sinuosity, dominant bed material, bed form, and valley confinement. The Corridor Plan focuses on stream reaches on the North Fork of East Creek and four of its tributaries. The study reaches are located on the following waters within the following towns:

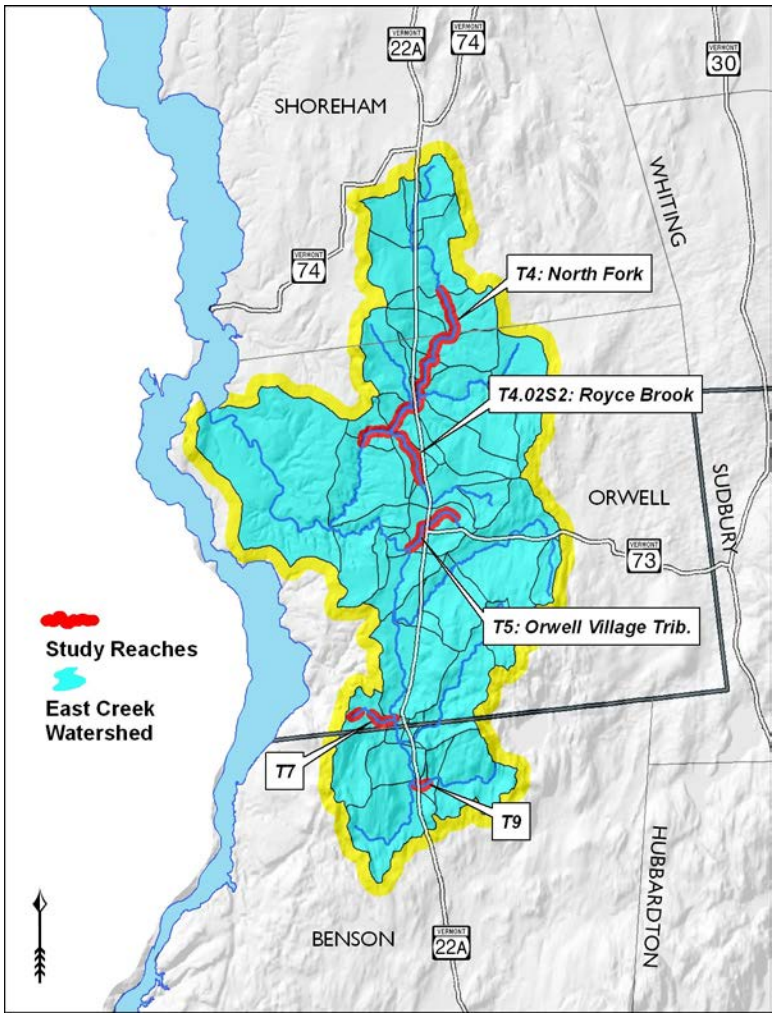


Figure 2. East Creek Subwatershed Map

Shoreham: North Fork/Jones Brook (T4.08)
Orwell: North Fork/Jones Brook (T4.02-T4.07)
Royce Brook (T4.02S2.02)
Orwell Village Tributary (T5.01)
Doughty Hill Tributary (T7.01)
Benson: Cranberry Swamp Tributary (T9.01)

3.1.1 Land Use History and Current General Characteristics

The East Creek watershed is predominately a rural agricultural area. The dominant watershed land cover/land use along the main branch of the Creek is forest with sub-dominant landuse consisting of fields and crops. The dominant watershed land cover/landuse along the North Fork is field and crop. The dominant watershed landuse along the major tributaries is forest with sub-

dominant landuse consisting of fields and crops, with the exception of Royce Brook and Orwell Village Tributary which are dominated by field and crops.

Figure 3. Orwell Village, 1939 (UVM Landscape Change Program)

Figure 4. Shoreham, 1951 (UVM Landscape Change Program)

3.2 GEOLOGIC SETTING

The East Creek is located within the Champlain Valley biophysical region. This region is often referred to as the "banana belt" for its relatively warm and dry conditions, and is characterized by excellent agricultural soils. The soils are comprised of fine clay deposited by post-glacial lakes and seas, sands deposited by post-glacial rivers, and limestone deposited by eroded outcrops. The Champlain valley consists of Ordovician limestones, dolomites and shales. (Thompson and Sorenson, 2000)

Upon retreat of the glaciers roughly 10,000 years ago, lowland portions of the watershed were flooded by the Glacial Lake Vermont, and then with sea water from the Champlain Sea. This flooding resulted in areas of lake bottom (sands and silts) and glacial outwash (gravels and sands) sediments especially prevalent today in the lower elevations of the watershed. (Thompson and Sorenson, 2000)

Table 1. East Creek Geology and Soils Summary for Phase 2 Assessed Reaches

Reach ID	Geologic materials			Valley side slopes		Soil Properties	
	Dominant	% Dom	Sub-Dominant	Left	Right	Erodibility	Erodibility (%)
T4.02 North Fork	Glacial Lake	100	None	Hilly	Hilly	Very Severe	100
T4.02 S2.02 Royce Brook	Glacial Lake	100	None	Hilly	Steep	Severe	52
T4.03	Glacial Lake	100	None	Hilly	Steep	Moderate	46
T4.04	Glacial Lake	100	None	Very Steep	Steep	Moderate	42
T4.05	Glacial Lake	98	Till	Steep	Steep	Severe	64
T4.06	Till	60	Glacial Lake	Hilly	Steep	Severe	65
T4.07	Glacial Lake	100	None	Hilly	Very Steep	Slight	13
T4.08	Glacial Lake	100	None	Steep	Steep	Moderate	27
T5.01 Orwell Village Trib.	Glacial Lake	100	None	Very Steep	Hilly	Moderate	48
T7.01 Doughty Hill Trib.	Glacial Lake	94	Till	Steep	Very Steep	Severe	58
T9.01 Cranberry Swamp Trib.	Glacial Lake	58	Other	Very Steep	Extremely Steep	Moderate	36

3.3 FLUVIAL GEOMORPHIC SETTING

The East Creek watershed is comprised of the two major forks (North and South) of the Creek with several smaller tributaries flowing into these forks, which converge just west of Old Foundry Road, and flow directly into Lake Champlain. The North Fork, also called Jones Brook, has its headwaters in the hills southeast of the village of Shoreham, Vermont. The stream meanders through agricultural lands in a relatively broad valley about Route 22A until it reaches the forests northeast of Hough Crossing. At this point, the valley becomes narrow and steeper sloped with the stream less meandering. The South Fork has its headwaters in hills southeast of Bullhead Pond in Benson, Vermont. The stream flows east towards Route 22A from Bullhead

Pond through a forested landscape. As the stream turns north it enters a very broad and gently sloping valley. The stream meanders through agricultural lands and extensive wetlands, picking up flows from many tributaries as it moves through the towns of Benson and Orwell to its confluence with the North Fork. The major tributaries of both the North and South Forks of East Creek are generally small streams that meander through gently sloping, broad to very broad valleys within an agricultural setting.

The East Creek watershed was divided into 36 reaches during the Phase 1 assessment; 11 reaches had Phase 2 assessments completed. The reaches assessed in this study of the East Creek watershed are found in a variety of topographic terrains including very broad, gently sloping valleys and narrowly confined steep bedrock valleys. Variations in topography and slope influence the channel morphologies that would be expected under undisturbed (i.e. reference) conditions. Each reach was determined based upon physical characteristics such as slope, sinuosity, valley confinement, and hydrologic characteristics. The data collected in the Phase 1 assessments provide an overview of the general physical characteristics of a watershed. Maps, aerial pictures, and historic information are combined with field interpretations to produce reference stream typing, stream impact ratings, and provisional geomorphic condition evaluations (VANR Phase 1 Handbook, May 2009). Phase 1 data describe what one would expect the river system to look like in a natural state with no human influences.

Table 2 briefly summarizes the results of the Phase 1 assessment of the Phase 2 study reaches. Further detailed descriptions of the reaches, with associated Phase 1 and 2 observations, are found in Section 5 of this report along with individual reach maps depicting Phase 2 segment delineations in the attachment.

Table 2. Phase 1 Summary Data for Phase 2 Assessed Reaches

Reach ID	Drainage Area (sq mi)	Valley width (ft)	Valley Type	Channel width (ft)	Channel Slope (%)	Sinuosity	Reference Stream Type	Channel Bedform
T4.02 North Fork	11.4	167	NW	38.2	1.57	1.15	F3	Step-Pool
T4.02S2.02 Royce Brook	1.2	210	VB	14.2	0.76	1.26	E5	Plane Bed
T4.03	9.7	190	NW	35.6	0.14	1.25	E5	Plane Bed
T4.04	8.4	305	BD	33.4	024	1.28	E5	Plane Bed
T4.05	4.9	250	BD	26.4	0.30	1.32	E5	Plane Bed
T4.06	4.9	148	NW	26.2	0.38	1.32	E5	Plane Bed
T4.07	4.6	425	VB	25.7	0.10	1.24	E5	Plane Bed
T4.08	3.6	240	VB	22.9	0.15	1.37	E5	Plane Bed
T5.01 Orwell Village Trib	0.7	983	VB	11.4	1.57	1.05	E5	Plane Bed
T7.01 Doughty Hill Trib.	1.1	970	VB	13.8	4.28	1.02	E5	Plane Bed
T9.01 Cranberry Swamp Trib.	1.5	675	VB	15.7	2.95	1.32	Cb3	Step-Pool

The most common reference stream type in the East Creek assessed reaches is the E stream type, plane bed system (Rosgen 1994) with well developed floodplains. The channels are dominated by sand substrates. This channel type is typically associated with low gradient and highly meandering channels, in broad valleys. These stream types are slightly entrenched with low width-depth ratios. The E stream type is considered a highly stable system, provided the floodplain and the low channel width/depth ratios are maintained. They are sensitive to disturbance and can rapidly adjust to other stream types in relatively short time periods. (Rosgen and Sylvey, 1996)

The C stream type, assigned to the Cranberry Swamp Tributary, are generally lower gradient streams that are also slightly entrenched, but have moderate to high width-depth ratios. These streams are more often characterized by riffle-pool sequences (Rosgen 1994) dominated by gravel/cobble substrates. This channel type is typically found in broad alluvial valleys and is noted for its meandering nature. Channels have characteristic point bars and broad, well defined floodplains to reduce energy during flood events. The C stream type is dependent upon the

stability of streambanks, and can be significantly altered and de-stabilized by changes in bank stability. (Rosgen and Sylvey, 1996)

The F channel type step-pool system, assigned to one of the lower reaches of the North Fork, is generally dominated by gravel/cobble substrates. These stream types are entrenched with high width-depth ratios and sinuosity. This channel type is found in a variety of valley types, where the width of the valley floor accommodates both the channel and a floodplain. "F" stream channels can develop very high bank erosion rates while providing for very high sediment supply and storage capacities. The F channel is often observed to be working towards re-establishment of a functional floodplain. (Rosgen 1994, Rosgen and Sylvey, 1996)

3.4 HYDROLOGY

The USGS does not maintain a flow gage in the East Creek watershed, and historical flood data is limited. Anecdotal information regarding a recent flood event of the East Creek was acquired from a local resident in Orwell, Vermont.

On January 18, 2006, rain fell all day in an area oriented southwest to northeast across Addison, Chittenden and Washington Counties in Vermont. The snow cover absorbed much of the rainfall during the day, then runoff increased significantly in the afternoon. Widespread flooding began in the afternoon. Roadside ditches and culverts clogged with snow, and prevented roads from draining. Small streams and creeks quickly rose to bankfull. By later in the evening, runoff entered the mainstem river channels and caused significant rises. (NOAA, National Weather Service, Monthly Report of River/Flood Conditions, January 2006).

According to an East Creek watershed resident, the January 2006 flood event produced 10" of rainfall resulting in flooding within the watershed. In addition to North Cross Road at the confluence of the north and south forks (Reach M07), Old Stage Road flooded along the South Fork (Reach M06). Flooding was observed over the banks of the South Fork at the Cranberry Swamp Tributary confluence (Reach M09), as well as over Route 22A (south of the Route 73 intersection) by the Orwell Village Tributary (Reach T5).

Figure 5. Flooding of the South Fork (M07) at North Cross Road, January 18, 2006 (Photo provided by David Fedor-Cunningham)

3.5 ECOLOGIC SETTING

East Creek flows north, draining a low-lying part of the Champlain Valley. Mt. Independence borders the west bank of the river mouth. Other small, steep hills separate the river valley from Lake Champlain. Near the mouth of the creek, the adjacent lands form a natural emergent marsh. The area contains Vermont's largest narrow-leafed cattail marsh. Approximately 400 acres of land along East Creek is part of a state-owned Wildlife Management Area. (Orwell Town Plan, 2007)

The State of Vermont has dammed the South Fork of East Creek with three impoundments, which provides waterfowl habitat in the low-lying lands adjacent to the creek. Agricultural runoff carries nutrients into the water, causing profuse aquatic plant growth including pondweed, bur-reed, narrow-leafed arrowhead, narrow-leafed cattail, bulrush, reed, sedge, duckweed, smartweed and the invasive purple loosestrife. (Orwell Town Plan, 2007)

The southern headwaters of East Creek (South Fork) originate from the hills east of Bullhead Pond, travel east through forested land, and then north through extensive flatlands dominated by broad floodplains and wetlands, now often functioning as agricultural land, and wind to southern Lake Champlain. The northern headwaters for East Creek (North Fork/Jones Brook) originate in

the rolling hills just southeast of the Village of Shoreham and quickly meet the valley farmland. The small tributaries to East Creek generally originate in low elevation hills (all less than 1,000 ft), descend through wooded confined valleys, wind through flat valley farmland and converge with the main forks of the Creek on its journey to Lake Champlain. Hills in the watershed include Hardigan Hill, Barnhum Hill, Blueberry Hill, Bishop Hill, and Doughty Hill.

3.5.1 DISTRIBUTION OF INSTREAM, RIPARIAN AND WETLAND HABITATS

Some 1,932 acres of wetland have been mapped in the East Creek watershed, and another 2,467 acres of soil likely to support wetlands exist. Many of these wetlands are located within the Creek and smaller stream valleys and are critical to providing floodwater retention as well as wildlife habitat and a myriad of other functions.

There are no major lakes or ponds within the watershed. Occasional small natural and man-made ponds are scattered throughout the watershed, but generally, the larger surface water features tend to be wetlands with varying levels of beaver influence.

3.5.2 AQUATIC LIFE

The Biomonitoring and Aquatic Studies Section of the Vermont Department of Environmental Conservation has conducted fish biomonitoring assays in three locations within the first reach of the main branch (Reach M01) on East Creek. The last assessment was conducted in October 1993. The following table provides a summary of the sampling results for the three locations.

Table 3: Fish Diversity Summary for Biomonitoring Sites in Reach M01 (Main Branch at the Mouth)

Fish Species	Species Presence		
	Site #560000000008	Site #560000000023	Site #560000000042
Black Crappie		X	X
Bluegill	X	X	X
Chain Pickerel	X	X	X
Golden Shiner	X	X	X
Largemouth Bass	X	X	X
Mudminnow		X	
Pumpkinseed	X	X	
Yellow Perch	X	X	X
Tessellated Darter			X

3.5.3 UNIQUE PLANT and ANIMAL COMMUNITIES

The Nongame and Natural Heritage Program of the Vermont Department of Fish and Wildlife maintains a digital database of recorded/observed unique plant and animal communities throughout the State of Vermont. The following table provides a summary of the recorded species and communities within the East Creek watershed.

Figure 6. Eastern Ratsnake in East Creek Watershed (9/22/2010)

Table 4: Rare and Unique Plant and Animal Communities in East Creek Watershed

Reach ID	Recorded Plant and Animal Species/Communities
M01 Main Branch of East Creek at the Mouth	Blackchin Shiner (observed in 1938) Red-headed woodpecker (East Creek Marsh) Osprey (East Creek Marsh) Least Bittern (Cattail Marsh) Lake Cress (*Neobeckia aquatica*) Eastern Rat Snake Northern Harrier Common Moorhen Cat-tail Sedge (*Carex typhina*) False Hop Sedge (*Carex lupuliformis*) Green Dragon (*Arisaema dracontium*) Grey's Sedge (*Carex grayi*)
M02	Sweet Joe-Pye Weed (*Eupatorium pupureum*)
M03	Giant Floater
M05	Eastern Ratsnake
M08	Peregrine Falcon Tall cinquefoil (*Potentilla arguta*) Nodding stickseed (*Hackelia deflexa*) Glaucous bluegrass (*Poa glauca*) Four-leaved Milkweed (*Asclepias quadrifolia*)
M09	Hitchcock's sedge (*Carex hitchcockiana*) Allegheny crowfoot (*Ranunculus allegheniensis*) Handsome sedge (*Carex Formosa*) Sprout muhly (*Muhlenbergia sylvatica*) Fragrant sumac (*Rhus aromatica*) Tall cinquefoil (*Potentilla arguta*) Dry Oak Hickory Hophornbeam Forest (0.5 mile south of Cranberry Swamp)
T4.01 North Fork	Indiana Bat: Roost Trees Green Dragon (*Arisaema dracontium*) Hairy Sedge (*Carex trichocarpa*) Wild Senna (*Senna hebecarpa*)
T4.02S2.03 Royce Brook	Hairy honeysuckle (*Lonicera hirsuta*)
T4.03	Upland Sandpiper
T4.04	Golden Seal (Partridge Woods)
T4.04S2.02 Pepper Brook	Indiana Bat: Roost trees
T4.08	Upland Sandpiper
T5.01 Orwell Village Tributary	Hairy honeysuckle (*Lonicera hirsuta*)
T7.01 Doughty Hill Tributary	Eastern Ratsnake False cyperus (*Carex pseudocyperus*) Rose pogonia (*Pogonia ophioglossoides*) Alder Swamp
T8.03 Stacy Brook	Drooping bluegrass (*Poa saltuensis*) Broad Beech Fern (*Phegopteris hexagonoptera*) Squaw-root (*Conopholis Americana*) Hairy honeysuckle (*Lonicera hirsuta*)
T9.01 Cranberry Swamp Trib.	American ginseng (*Panax quinquefolius*) Peregrine Falcon (Benson Ledge)
T9.03	Calcareous Red-Maple-Tamarack Swamp (Pond Woods WMA) Poor Fens (Cranberry Swamp, spectacular area) Eastern Ratsnake Great Blue Heron (Walker Swamp) Nest sites Fragrant Sumac (*Rhus aromatica*) Four-leaved Milkweed (*Asclepias quadrifolia*)

While deer wintering yards are not generally characterized as unique or rare, they are considered critical wildlife habitat. The Vermont Department of Fish and Wildlife developed a digital map of deer wintering habitat. Deer wintering habitat generally consists of south facing, conifer woods (i.e. Hemlock trees).

White-tailed deer are found throughout the East Creek watershed and there are roughly 1,663 acres of mapped deer winter habitat within the watershed, which is most certainly an underestimate of the actual total. With the exception of main branch Reach M01, the mapped yards are located directly along the Creek. The presence of these mapped habitats indicates that the riparian buffers in these locations, when in tact, serve not only an important function for the Creek but also for the wildlife in the surrounding area.

Some mammals present in the upland portions of the watershed include red and grey fox, coyote, fisher, bobcat, and many smaller mammals. In the wetlands and riparian zones, mink, river otter, beaver, muskrat, Eastern Ratsnake and others join the mix.

4.0 METHODS

4.1 FLUVIAL GEOMORPHIC AND HABITAT ASSESSMENT PROTOCOLS

In an effort to provide a sound basis for decision-making and project prioritization and implementation, the Vermont Agency of Natural Resources (VTANR) has developed protocols for conducting geomorphic assessments of rivers. The results of these assessments provide the scientific background to inform planning in a manner that incorporates an overall view of watershed dynamics as well as the reach-scale dynamics that have been a primary focal point of project planning in the past. Incorporating upstream and downstream dynamics in the planning process can help increase the effectiveness of implemented projects by addressing the sources of river instability that are largely responsible for erosion conflicts, increased sediment and nutrient loading, and reduced river habitat quality (VTANR, 2009). Trainings have been held to provide consultants, regional planning commissions, and watershed groups with the knowledge and tools necessary to make accurate and consistent assessments of Vermont's rivers.

The stream geomorphic assessments are divided into three phases. A Phase 1 assessment is a preliminary analysis of the condition of the stream through remote data sources such as aerial photographs, maps, and 'windshield survey' data collection. Phase 2 involves rapid assessment fieldwork to inform a more detailed analysis of what adjustment processes are taking place and to predict how the river will continue to evolve in the future. Phase 3 involves detailed fieldwork for the identification and implementation of management and restoration projects.

4.1.1 PHASE 1 AND PHASE 2 ASSESSMENTS

Phase I and Phase 2 Stream Geomorphic Assessments were conducted by Arrowwood Environmental, LLC for the East Creek Watershed. The Phase 1 assessment completed steps 1-7 of the Stream Geomorphic Assessment Phase 1 Protocols using the SGAT GIS extension. The Phase I assessment was completed on 36 reaches and completed in June 2010. The Phase 1 assessment identified priority reaches for the Phase 2 assessments. Phase 1 assessment results are presented in Phase 1 Stream Geomorphic Assessment: Executive Summary report (AE, 2010). The Phase 2 assessment completed steps 1-7 of the Stream Geomorphic Assessment Phase 2 Protocols using the SGAT GIS extension. Phase 2 assessments were completed on 11 reaches by Arrowwood Environmental in 2010 and are summarized in the following sections.

4.2 QA/QC SUMMARY REPORT

Arrowwood Environmental (AE) conducted the Phase 2 assessment in compliance with the Vermont DEC River Management Program. The Microsoft Access Phase 2 database was submitted to Shannon Pytlik of the River Management Program for a QA review in October 2010. Photos were taken at each study cross-section and problem areas. Photos were digitally provided for the QA review on an attached CD. Based on QA comments from Ms. Pytlik, AE finalized the DMS database for the East Creek watershed in November 2010.

4.3 PHASE 2 RESULTS

The Phase 2 Rapid Stream Assessment is a detailed protocol for gathering data about the stream channel and riparian corridor. One of the products of the Phase 2 assessment is the determination of existing stream type. The stream type describes general physical characteristics of the channel

and the fluvial processes going on in the assessed reach. Stream typing in the field provides an opportunity to verify the provisional reference stream type made during the Phase 1 assessment and to identify where the existing stream type has departed from the reference stream type. (VANR Phase 2 Handbook, May 2009).

Measurements of channel dimensions were made using a depth rod, a measuring tape, a hand-held tape ruler, and a hand level. Channel dimensions were measured at cross over (riffle) locations, and conducted at least one cross-section per stream segment. The cross section data was entered in the Vermont Agency of Natural Resources, Phase 2 Stream Geomorphic Assessment Database.

Table 5 summarizes the existing channel conditions, including entrenchment ratio, width/depth ratio, incision ratio, sinuosity, sediment storage types, stream types, bed material and bed form for the Phase 2 study reaches.

Figure 7. Phase 2 cross section location

Table 5. East Creek Phase 2 Channel Summary Data

Segment ID	Entrenchment Ratio	Width/ Depth Ratio	Incision Ratio	Sediment Storage Types	Phase 2 Stream Type	Bed Material	Bed Form
Reach T4.02 North Fork	A: 1.1 B: 1.2	A: 14.8 B: 25.7	A: 1.0 B: 1.0	A: Point, side, diagonal B: Island	A: F B: F	A: Bedrock B: Cobble	A: Plane bed B: Step-Pool
Reach T4.02S2.02 Royce Brook	11.5	13.1	1.0	--	E	Silt	Plane bed
Reach T4.03 North Fork	NA	NA	NA	--	NA	Silt	Plane bed
Reach T4.04 North Fork	4.9	8.5	1.4	--	E	Silt	Plane bed
Reach T4.05 North Fork	8.4	18.4	1.6	--	E	Silt	Plane bed
Reach T4.06 North Fork	8.9	11.8	1.4	--	E	Silt	Plane bed
Reach T4.07 North Fork	14.3	9.7	1.0	--	E	Silt	Plane bed
Reach T4.08 North Fork	11.7	20.7	1.0	--	E	Silt	Plane bed
Reach T5.01 Orwell Village Tributary	A: 30 B: 1.2 C: NA	A: 15.0 B: 10.0 NA:	A:1.0 B: 2.8 NA:	A: -- B: -- C: NA	A: E B: G C: NA	A: Silt B: Silt C: NA	A: Plane bed B: Plane bed C: NA
Reach T7.01 Doughty Hill Tributary	A: 90 B: 50 C: NA	A: 6.4 B: 4.0 C: NA	A: 1.0 B: 1.0 C: NA	A: Mid B: -- C: NA	A: E B: E C: NA	A: Silt B: Silt C: NA	A: Plane bed B: Plane bed C: NA
Reach T9.01 Cranberry Swamp Tributary	A: NA B: 21.9	A: NA B: 21.1	A: NA B: 1.0	A:NA B: Point, Side	A:NA B: C	A:NA B: Gravel	A:NA B: Step-Pool

Table 6. Sediment Regime Types in East Creek Watershed

Sediment Regime	Stage of Channel Evolution / Geomorphic Condition	Common Existing Stream Type	Delimiting criteria related to Sediment supply, transport, and storage	Natural Valley Type
Transport	**Stage I or V Good-Ref**	**A1, A2, B1, B2, G1, G2, G3, F1, F2, F3**	**Bedrock gorge= yes**	**NC, SC, NW**
	Stage I or V	**A3, B3, B4**	**Incision ratio <1.3**	**NC, SC, NW**
Fine Source and Transport & Coarse Deposition	Stage II-IV Fair-Poor	E3, E4, E5 C3, C4, C5, B3c, B4c, B5c, F3, F4, F5	Bank armor < 50% W/d > 30 Incision ratio ≥ 1.3	NW, BD, VB
	Stage II-IV Fair-Poor	D3, D4, D5	Bank armor < 50% Incision ratio ≥ 1.3	NW, BD, VB
Coarse Equilibrium (in = out) & Fine Deposition	Stage I or V Fair-Good-Ref	D3, D4, D5	Incision ratio < 1.3	NW, BD, VB
	Stage I or V Fair-Good-Ref	C2, C3, E3	W/d < 30 Incision ratio < 1.3	NW, BD, VB
	Stage I or V Fair-Good-Ref	C4, C5 E4, E5	W/d > 30 Incision ratio < 1.3	NW, BD, VB

Phase 2 work assessed all reaches of the East Creek as being at Stage I to III of channel evolution (Table 8). Schumm (1977 and 1984) has described five stages of channel evolution (F-stage model) for reaches such as those found in the study area, where the stream has a bed and banks that are sufficiently erodible to be shaped by the stream over time, paraphrased from the SGA protocols (VTANR 2009, Appendix C) as follows:

I. **Stable** – in regime, reference to good condition. Insignificant to minimal adjustment; planform is moderate to highly sinuous.

II. **Incision** – Fair to poor condition, major to extreme channel degradation. High flow events are contained in the channel, and channel slope is typically increased.

III. **Widening/Migration** – Fair to poor condition, major to extreme widening and aggradation.

IV. **Stabilizing** – Fair to good condition, major reducing to minor aggradation, widening and planform adjustments

V. **Stable** – In regime, reference to good condition. Insignificant to minimal adjustment.

Table 7. Sediment Regime Reach Summary Table

Sediment Regime	Stage of Channel Evolution Geomorphic Condition	Common Existing Stream Type	Delimiting criteria related to Sediment supply, transport, and storage	Natural Valley Type
Reach T4.02 North Fork	A: Stage I: Reference B: Stage I: Reference	F1 F3	Incision ratio 1.0 W/d 14.85 Incision ratio 1.0 W/d 25.68	NC SC
Reach T4.02S2.02 Royce Brook	Stage I: Good	E5	Incision ratio 1.0 W/d 13.14	VB
Reach T4.03 North Fork	Not assessed			
Reach T4.04 North Fork	Stage III: Good	E5	Incision ratio: 1.36 W/d 8.54	VB
Reach T4.05 North Fork	Stage III: Good	E5	Incision ratio 1.59 W/d 18.45	VB
Reach T4.06 North Fork	Stage II: Good	E5	Incision ratio 1.36 W/d 11.84	BD
Reach T4.07 North Fork	Stage I: Good	E5	Incision ratio 1.0 W/d 9.66	VB
Reach T4.08 North Fork	Stage I: Good	E5	Incision ratio 1.0 W/d 20.69	VB
Reach T5.01 Orwell Village Tributary	A: Stage I: Good	E5	Incision ratio 1.0 W/d 15.00	VB
	B: Stage III: Poor	G5	Incision ratio: 2.83 W/d 9.96	VB
	C: Not assessed			
Reach T7.01 Doughty Hill Tributary	A: Stage I: Good B: Stage I: Reference	E5 E5	Incision ratio 1.0 W/d 6.41 Incision ratio 1.0 W/d 4.0	VB VB
	C: Not assessed			
	D: Stage III: Poor	F5	Incision ratio 1.0 W/d 21.17	NW
Reach T9.01 Cranberry Swamp Tributary	A: Not assessed			
	B: Stage I: Fair	C4	Incision ratio 1.0 W/d 21.05	VB

Under the existing sediment regime, which includes limited floodplain access and increased stream power in five of the assessed segments, erosion, widening, and lateral migration are likely to increase when sediment load exceeds carrying capacity in the East Creek watershed, until channel geometry changes sufficiently to decrease stream power in these segments.

4.4 REACH DESCRIPTIONS

Observations and results made during the Phase 2 study are summarized below by reach number, and reach summary reports from the Phase 2 database are included in the attachment. Field measurements and locations of other features are overlaid on 2009 aerial photos (NAIP). Reach maps are included in the attachment and were created from available GPS data and field sketches.

4.4.1 Reach T4.02: North Fork/Jones Brook

T4.02-A

Reach T4.02 is the most downstream reach of the North Fork of East Creek included in the study area. It was divided into two segments because of the change in confinement and channel bedform in the upper reach where the valley is slightly broader and the channel is a step pool form. Segment T4.02-A begins at the downstream reach break with T4.01 and extends upstream approximately 1,900'. The segment is characterized by a shale bedrock channel with a series of steep grade controls. Deposits of shale were found at point and side bar locations along the channel. There is one large pool at the upstream end of the segment which is the outlet of a large wetland to the north. While the segment has excellent buffers, there is limited large woody debris (LWD) in the segment itself (LWD/Mile=8). The segment is set in a narrow valley with steep riparian banks comprised of bedrock and evidences no sign of instability. Due to a Rapid Geomorphic Assessment (RGA) of Reference and little observable adjustment in the channel, the channel has been classified as Channel Evolution Model (CEM) stage I.

Figure 8. Bedrock Channel and large pool at upstream end of segment

T4.02-A Summary Data North Fork/Jones Brook	
Reach/Segment Length	1,893 ft
Valley Confinement	Narrowly Confined
Reference Stream Type/Bedform	F1 Planebed
Existing Stream Type/Bedform	F1 Planebed
Geomorphic Condition	Reference
Channel Evolution Stage	I
Adjustment Process	Relatively stable channel
Habitat Condition	Good
Stream Sensitivity	Low

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae Colonization

Reach Stressors

Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

T4.02-B

Segment T4.02-B has a nice step pool formation within a limestone bedrock setting. There are several nice, deep pools (Pools/Mile=28). This segment also has a nice intact forested buffer and corridor for the majority of its length. The upper 700' of this segment, both upstream and downstream of the Route 73 bridge, has a narrower buffer width in the vicinity of some residential structures. The Route 73 bridge is slightly undersized with a width only large enough to support 91% of a bankfull flow event. Scour was observed at both the upstream and downstream end of this structure. There are ledge grade controls both immediately upstream and downstream of this structure limiting any immediate channel adjustment potential from the undersized condition. Two mass failures and a short section of erosion (~125') are located just upstream of the T4.02-A segment break. The habitat condition of the segment is only Fair. Habitat conditions are reduced as a result of low flow conditions in the channel, continuous algae mats on the substrate and relative lack of large woody debris in the channel.

While the channel morphology scored low in the Rapid Habitat Assessment (RHA), F3 stream types are typically characterized by entrenched, meandering channels with high to very high width/depth ratios (WDRs) as is seen in this system (Rosgen and Silvey, 1996). Due to an RGA of Reference and little observable adjustment in the channel, the channel has been classified as CEM stage I.

Figure 9. Photos at Route 73 bridge looking downstream and representative right bank with good riparian vegetation

T4.02-B Summary Data North Fork/Jones Brook	
Reach/Segment Length	2,042 ft
Valley Confinement	Semi-Confined
Reference Stream Type/Bedform	F3 Step Pool
Existing Stream Type/Bedform	F3 Step Pool
Geomorphic Condition	Reference
Channel Evolution Stage	I
Adjustment Process	Relatively stable channel
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs

Figure 10. Photos looking downstream to the Route 73 bridge; and at a mass failure

4.4.2 Reach T4.02S2.02: Royce Brook

Royce Brook is the first major tributary to the North Fork, entering the creek just west of Hough Crossing. Reach T4.02S2.02 is the only reach of Royce Brook included in the study. The first reach of the tributary was not assessed but is characterized as a step-pool system within a steeply sloped, narrowly confined valley. By contrast, the valley setting for T4.02S2.02 is very broad with no structural encroachments in the river corridor. The reach is characterized as a shallow slope (0.76%), narrow, meandering channel with plane bed bedform. The channel exhibits E type geometry with WDR of 13.1 and entrenchment ratio (ER) of 11.5. Due to an RGA of Good and little observable adjustment in the channel, the channel has been classified as CEM stage I. The substrate is predominated by silt, interrupted by bedrock grade controls in the upstream portion of the reach. Water is slightly impounded upstream of the grade controls.

The habitat condition of the reach is only Fair due to virtually no large woody debris, substantial fine deposition throughout the channel resulting in filling of pools, and poor river bank vegetation. The reach has generally poor buffers, with the subdominant width less than 25' for both banks. This reach falls within an agricultural setting and was impacted by historic straightening, and cattle grazing. There is evidence on both banks in the downstream half of the reach of a major planting effort in the not too distant past. The project appears to have involved establishment of designated cattle watering points; relocation of pasture fencing to provide a buffer to the stream channel; and planting of shrub and tree species within the newly established buffer. At this time, the vegetation is not substantial enough to improve the habitat ranking but is expected to be so in the future. The upstream half of the reach does not appear to have been involved in the recent restoration efforts with buffers generally less than 25' and pasture fences adjacent to the channel.

There are two undersized culverts within the reach. The Brown Lane culvert is only wide enough to support 45% of a bankfull flow event. Scour was observed at the upstream and downstream end of this structure. This culvert is made of concrete sections which have separated under the roadway. Water is flowing through the sections and undermining the structure. There is a 1' freefall drop from the culvert to the water surface at the outlet. There is a large pool at the downstream end of this structure. A single watering access is now located on the upstream end of the culvert. The farm road culvert, just downstream of the T4.02.S2.03 reach break, can only

support 27% of a bankfull flow event. Scour was not observed upstream or downstream of this structure.

Figure 11. Photos at cross section and the upstream end of a bedrock grade control

T4.02S2.02 Summary Data Royce Brook	
Reach/Segment Length	5,773 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type/Bedform	E5 Plane Bed
Geomorphic Condition	Good
Channel Evolution Stage	I
Adjustment Process	Relatively stable w/ minor erosion and scour
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

Figure 12. Cattle watering access and cattle crossing point

Figure 13. Undersized culverts for a farm road and Brown Lane

4.4.3 Reach T4.03: North Fork/Jones Brook

Reach T4.03 is characterized as wetland with deep saturated muck bed material. The valley setting is narrow with no structural encroachments in the river corridor. This reach falls within an agricultural setting. The reach was not wadeable and for this reason, a cross section was not completed. The stream was observed to have an E type geometry with meandering, plane bed bedform. While there are no grade controls in this reach, flow is impounded due to a bedrock grade control at the upper end of Reach T4.02.

The habitat condition of the reach is only Fair due to virtually no large woody debris, substantial fine deposition throughout the channel resulting in filling of pools, significant substrate colonization by algae and poor river bank vegetation. The reach has a generally good buffer on the left bank, with the dominant width greater than 150'. The right bank has areas of good buffer, but a 650' section of less than 25' adjacent to a hay field. The invasive purple loosestrife was identified at the upstream end on the reach. There is little erosion in this reach with only a few short sections of slumping outer banks at the upstream end of the reach. There is an old abutment at the downstream end of the reach which is not serving as a channel constriction.

Figure 14. Old abutment on right bank and partial debris jam

T4.03 Summary Data North Fork/Jones Brook	
Reach/Segment Length	3,447 ft
Valley Confinement	Narrow
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type	Wetland
Geomorphic Condition	
Channel Evolution Stage	
Adjustment Process	
Habitat Condition	Fair
Stream Sensitivity	

* Cross section not conducted

Habitat Stressors
Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating
Tributaries
Dredging
Stormwater inputs
Headcuts

4.4.4 Reach T4.04: North Fork/Jones Brook

Reach T4.04 is a relatively short reach situated about Route 22A. The valley setting is very broad with no structural encroachments in the river corridor. This reach falls within an agricultural setting but does not evidence historic straightening or dredging. The reach is characterized as a shallow slope (0.24%), narrow, meandering channel with plane bed bedform. The channel exhibits E type geometry with WDR of 8.5 and ER of 4.9. Moderate incision was observed at the cross-section location (IR=1.4). The substrate is predominated by silt. Due to the incision and early stages of widening (RGA = "Good"), the channel has been classified as CEM stage III.

The habitat condition of the reach is only Fair due to virtually no large woody debris, substantial fine deposition throughout the channel resulting in filling of pools, significant substrate colonization by algae and poor river bank vegetation. The reach has poor buffer widths of less than 25' for more than 20% of both the right and left banks. The invasive purple loosestrife was identified throughout the reach. There is little erosion in this reach with only a few short sections of historic erosion in the middle of the reach.

There is evidence on both banks upstream of the Route 22A of a major planting effort in the not too distant past. The project appears to have involved planting of shrub and tree species within the newly established buffer. At this time, the vegetation is not substantial enough to improve the habitat ranking but is expected to be so in the future.

There are two structures (Rte 22A culvert and a farm bridge) within the reach, both of which support the bankfull flow event. Scour was observed at the upstream and downstream end of both structures. There is also an historic abutment at the downstream end of the reach. This abutment is not acting a channel constriction.

Figure 15. Old abutment on left bank and upstream view of channel from the farm bridge

T4.04 Summary Data North Fork/Jones Brook	
Reach/Segment Length	2,051 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type/Bedform	E5 Plane Bed
Geomorphic Condition	Good
Channel Evolution Stage	III
Adjustment Process	Planform changes with some erosion on outside bends
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors
Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

4.4.5 Reach T4.05: North Fork/Jones Brook

Reach T4.05 is a relatively short reach located to the east of Rte 22A. The valley setting is very broad with no structural encroachments in the river corridor. This reach falls within an agricultural setting but does not evidence historic straightening or dredging. The reach is characterized as a shallow slope (0.30%), meandering channel with plane bed bedform. The channel exhibits E type geometry with WDR of 18.4 and ER of 8.4. Moderate incision was

observed at the cross-section location (IR=1.6). The substrate is predominated by silt. Due to the incision and early stages of widening (RGA = "Good"), the channel has been classified as CEM stage III.

The habitat condition of the reach is only Fair due to virtually no large woody debris, substantial fine deposition throughout the channel resulting in filling of pools, significant substrate colonization by algae and poor river bank vegetation. The channel alternates between being dry and having ponded water along the course of the reach. The reach has good buffer widths of greater than 150' on both the right and left banks. The invasive purple loosestrife was identified throughout the reach. There is erosion on the outside bends of the channel in this reach suggesting ongoing widening of the channel.

There is evidence on both banks in the upstream section of this reach of a major planting effort in the not too distant past. The project appears to have involved planting of shrub and tree species within the buffer. At this time, the vegetation is not substantial enough to improve the habitat ranking but is expected to be so in the future.

Figure 16. Photos of pool area created by artificial rock impoundment; and pool along the outside channel bend at the toe of the valley wall

T4.05 Summary Data North Fork/Jones Brook	
Reach/Segment Length	2,054 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type/Bedform	E5 Plane Bed
Geomorphic Condition	Good
Channel Evolution Stage	III
Adjustment Process	Widening with erosion on outside bends
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

4.4.6 Reach T4.06: North Fork/Jones Brook

Reach T4.06 is a relatively short reach located to the east of Rte 22A. The valley setting is broad with no structural encroachments in the river corridor. This reach falls within an agricultural setting but does not evidence historic straightening or dredging. The reach is characterized as a shallow slope (0.38%), narrow, meandering channel with plane bed bedform. The channel exhibits E type geometry with WDR of 11.9 and ER of 8.9. Moderate incision was observed at the cross-section location (IR=1.4). The substrate is predominated by silt. Due to the historic incision and relative lack of erosion at this time, the channel has been classified as CEM stage II.

The reach starts at the downstream end with a nice, deep pool at the base of an 11' bedrock grade control. The upstream end of the reach is impounded by a beaver dam, creating a nice open water area with wetland vegetation. The habitat condition of the reach overall though, is only Fair due to virtually no large woody debris, substantial fine deposition throughout the channel resulting in filling of pools, some substrate colonization by algae and poor river bank vegetation. The channel alternates between being dry and having areas of ponded water along its course. The reach has generally good buffer widths of greater than 100' on the left bank and greater than 50' on the right bank. The invasive purple loosestrife was identified at the downstream and upstream portions of the reach. There is little erosion in this reach. A field ditch originating from a corn field was noted at the downstream end.

There is evidence on the right bank along the entire length of the reach of a major planting effort in the not too distant past. The project appears to have involved planting of shrub and tree

species within the newly established buffer. At this time, the vegetation is not substantial enough to improve the habitat ranking but is expected to be so in the future.

Figure 17. Pool downstream of grade control and dry channel downstream of beaver dam

T4.06 Summary Data North Fork/Jones Brook	
Reach/Segment Length	3,335 ft
Valley Confinement	Broad
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type/Bedform	E5 Plane Bed
Geomorphic Condition	Good
Channel Evolution Stage	II
Adjustment Process	Historic degradation with low bank erosion
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

4.4.7 Reach T4.07: North Fork/Jones Brook

Reach T4.07 is a relatively short reach located to the east of Rte 22A. The valley setting is very broad with no structural encroachments in the river corridor. This reach falls within an agricultural setting but does not evidence historic straightening or dredging. The reach is characterized as a shallow slope (0.10%), narrow, meandering channel with plane bed bedform. The channel exhibits E type geometry with WDR of 9.7 and ER of 14.3. No incision was observed at the cross-section location (IR=1.0). The

Figure 18. Channel at cross section

substrate is predominated by silt. Due to an RGA of Reference and little observable adjustment in the channel, the channel has been classified as CEM stage I.

Figure 19. Nice wetland along channel

The downstream start of the reach is impounded from the beaver dam observed in reach T4.06. This has resulted in a nice open water area fringed by a cattail marsh and old oxbow backwater area. The habitat condition of the reach overall though, is only Fair due to virtually no large woody debris, substantial fine deposition throughout the channel resulting in filling of pools, and poor river bank vegetation. The channel alternates between being full at the downstream section due to the beaver dam impoundment and the undersized farm road culvert (see description below) to being alternately dry, to having areas of ponded water along the mid section of the reach, to having a relatively full channel again at the upstream end of the reach as a result of a series of small beaver dams. The reach has generally good buffer widths of greater than 100' on the right bank and greater than 50' on the left bank. The invasive purple loosestrife was identified throughout the reach. There is no observable erosion in this reach.

There is evidence on both the left and right banks along the entire length of the reach of a major planting effort. The project appears to have involved planting of shrub and tree species within the newly established buffer. At this time, the vegetation is not substantial enough to improve the habitat ranking but is expected to be so in the future.

Figure 20. Planting project underway

Figure 21. Undersized farm road culvert

There is one significantly undersized culvert just upstream of the T4.06 reach break. The culvert is associated with a farm road and is only wide enough to support 14% of a bankfull flow event. The culvert appears to be inverted with evidence of flooding observed in the roadway. The culvert is impounding flow for a significant length of this reach. Scour was not observed at the upstream or downstream end of this structure.

T4.07 Summary Data North Fork/Jones Brook	
Reach/Segment Length	4095 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type/Bedform	E5 Plane Bed
Geomorphic Condition	Reference
Channel Evolution Stage	I
Adjustment Process	Relatively stable channel
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

4.4.8 Reach T4.08: North Fork/Jones Brook

Reach T4.08 is the most upstream reach of the North Fork that was included in the current study. The reach is a little over a mile long with the upstream extent just south of Brown Road. The valley setting is very broad with no structural encroachments in the river corridor. This reach falls within an agricultural setting but does not evidence historic straightening or dredging. The reach is characterized as a shallow slope (0.15%), narrow, meandering channel with plane bed bedform. The channel exhibits E type geometry with WDR of

Figure 22. Impounded area at beaver dam

20.7 and ER of 11.7. No incision was observed at the cross-section location (IR=1.0). The substrate is predominated by silt. Due to an RGA of Good and little observable adjustment in the channel, the channel has been classified as CEM stage I.

The habitat condition of the reach is only Fair due to virtually no large woody debris, substantial fine deposition throughout the channel resulting in filling of pools, and poor river bank vegetation. The channel alternates between being dry and having areas of ponded water along the course of the reach. There is a small beaver dam just upstream of the farm road culvert at the downstream end of the reach which is creating a lengthy impounded area. This impoundment has created a nice open water area fringed by wetlands. Wood ducks were observed in the open water area during the field survey. The reach has good buffer widths of generally greater than 100' on both the left bank and greater than 50' on the right bank. The invasive purple loosestrife was identified sporadically throughout the reach. There are two cattle crossings within this reach. There is no observable erosion in this reach.

There is evidence on both the left and right banks along the entire length of the reach of a major planting effort. The project appears to have involved planting of shrub and tree species within the newly established buffer. At this time, the vegetation is not substantial enough to improve the habitat ranking but is expected to be so in the future.

Figure 23. Buffer plantings in the background

There is one significantly undersized culvert just upstream of the T4.07 reach break. The culvert is associated with a farm road and is only wide enough to support 7% of a bankfull flow event. The culvert is impounding flow and likely floods across the road. Scour was not observed at the upstream or downstream end of this structure.

T4.08 Summary Data North Fork/Jones Brook	
Reach/Segment Length	6,267 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type/Bedform	E5 Plane Bed
Geomorphic Condition	Good
Channel Evolution Stage	I
Adjustment Process	Relatively stable channel
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating
Tributaries
Dredging
Stormwater inputs
Headcuts

Figure 24. Upstream cattle crossing and watering hole

Figure 25. Undersized, squashed culvert

4.4.9 Reach T5.01: Orwell Village Tributary

The Orwell Village Tributary is comprised of just one reach, T5.01. It was divided into three segments because of changes in channel dimension, stream type and bed form, buffer conditions, and lack of property access.

T5.01-A

Reach segment T5.01A begins at the confluence with the South Fork at the municipal waste water treatment plant on Sewer Plant Road, and extends upstream approximately 0.9 miles. The valley setting is very broad with some structural encroachments in the river corridor. Approximately 600' of roadway, primarily associated with the sewage treatment plant, and 250' of development is located within the river corridor. This reach falls within an agricultural setting and has evidence of significant historic straightening (approximately 1500 linear feet). The reach is characterized as a shallow slope (1.4%), narrow, relatively straight channel with plane bed

bedform. The channel exhibits E type geometry with WDR of 15 and ER of 30. No incision was observed at the cross-section location (IR=1.0). The substrate is predominated by silt. While this segment was historically altered by straightening, it is currently stable (RGA=Good), and has been classified as CEM stage I. Review of the 1960's black and white aerial photography reveals a much more sinuous channel, with multiple channel migrations present.

This segment resembles more of a wetland than a stream channel. There is little water in the channel except for areas where it transitions to cattail marsh. The habitat condition of the reach is only Fair due to virtually no large woody debris or pools, historic stream alteration, and poor river bank vegetation. The reach has poor buffer widths of less than 25' for more than 70% of both the right and left banks. The invasive purple loosestrife was identified sporadically throughout the reach. There is no observable erosion in this reach.

Figure 26. Dry channel meandering through reed canary grass and dry channel downstream of Route 73 culvert

There are three instream culverts within the segment, two of which (Rte 22A and Rte 73 crossings) support the bankfull flow event. The Rte 22A culvert is partially backwatered at the outlet. The bottom of this culvert is rotten with water flowing around and under the structure. The third culvert is associated with a farm road at the upstream segment break and is only wide enough to support 42% of a bankfull flow event. A sag in the roadway was observed possibly indicating a

Figure 27. Upstream invert of farm road culvert

subsurface break in the culvert. Scour was observed at the upstream and downstream end of this structure.

T5.01A Summary Data Orwell Village Tributary	
Reach/Segment Length	4,559 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type/Bedform	E5 Plane Bed
Geomorphic Condition	Good
Channel Evolution Stage	I
Adjustment Process	Relatively stable channel
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

T5.01-B

Subreach T5.01-B begins just upstream of the farm road at the T5.01-A segment break and extends upstream to North Orwell Road. The valley setting is very broad (slightly broader than segment A) with no structural encroachments in the river corridor. This reach falls within an agricultural setting but does not evidence historic straightening or dredging. The subreach is characterized as a moderate slope (2.6%), narrow (slightly wider than segment A), meandering channel with plane bed bedform. The channel exhibits G type geometry with WDR of 10 and ER of 1.2. Significant incision was observed throughout the segment (IR=2.8), and bank erosion was common. The substrate is predominated by silt. There appear to be significant flows moving through this segment, and with a lack of natural grade controls, the channel has responded by incising its bed. The high degree of silt in the bed substrate is likely from the ongoing bank erosion. Due to the incision with extensive erosion (RGA=Poor) the CEM has been classified as stage III. The subreach has an "extreme" sensitivity to future impacts, and will likely undergo significant lateral adjustments in the future. The subreach has undergone a stream channel departure converting this stream segment to a G (entrenched) from B (moderately entrenched).

Figure 28. Channel at cross section

This departure indicates a loss of floodplain access that is contributing to extreme stream sensitivity in this segment.

The habitat condition of this segment is only Fair due to lack of reference condition features (steps and pools) and replacement by plane bed features, poor hydrologic conditions (virtually no water in the channel), extensive scour and erosion, and poor stream buffers. The reach has poor buffer widths of less than 25' for more than 35% of the right bank. The left bank has generally good buffers of greater than 100'. The invasive purple loosestrife was identified sporadically throughout the reach.

There is one instream culvert in the segment, under North Orwell Road, that is only wide enough to support 33% of a bankfull flow event. Scour was not observed at the upstream or downstream end of this structure. This culvert has a 3' freefall drop at the outlet.

Figure 29. North Orwell Road culvert

T5.01B Summary Data Orwell Village Tributary	
Reach/Segment Length	1,571 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	B3 Step Pool
Existing Stream Type/Bedform	G5 Plane Bed
Geomorphic Condition	Poor
Channel Evolution Stage	III
Adjustment Process	Historic Degradation Widening/Planform changes
Habitat Condition	Fair
Stream Sensitivity	Extreme

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

T5.01-C

Reach segment T5.01C begins just upstream of North Orwell Road and extends approximately 900' upstream. This segment was not assessed due to lack of property access. Field observations were made from North Orwell Road and are provided here. The valley setting is very broad with structural encroachments (residential dwelling) in the river corridor of the left bank. This segment is characterized as marsh wetland with generally good buffers on the left bank. The right bank appears to have an approximately 200' length with buffer less than 25'. The wetland serves as the headwaters to the overall reach.

T5.01C Summary Data
Orwell Village Tributary

Reach/Segment Length	**912 ft**
Valley Confinement	
Reference Stream Type/Bedform	
Existing Stream Type/Bedform	
Geomorphic Condition	
Channel Evolution Stage	
Adjustment Process	
Habitat Condition	
Stream Sensitivity	

***Not assessed due to lack of access**

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

4.4.10 Reach T7.01: Doughty Hill Tributary

The Doughty Hill Tributary is comprised of one reach, T7.01. It was divided into four segments because of the change in valley width, confinement, and stream type and channel bedform.

T7.01-A

Segment T7.01-A begins at the downstream confluence with South Fork reach M06 and extends upstream approximately 900'. The valley setting is very broad with no structural encroachments in the river corridor. This reach falls within an agricultural setting and has evidence of significant historic straightening (approximately 500 linear feet). The reach segment is characterized as a shallow slope (1.5%), narrow (5' bankfull width), low sinuosity channel with plane bed bedform. The channel exhibits E type geometry with WDR of 6.4 and ER of 90. Incision was not observed at the cross section and bank erosion was not present. Due to the lack of incision or erosion and widening (RGA=Good) the CEM has been classified as stage I.

The habitat condition of this segment is only Fair due to virtually no large woody debris cover, substantial fine deposition throughout the channel resulting in filling of pools, and poor river bank vegetation. The channel alternates between being dry and having areas of ponded water along the course of the reach. The reach has generally good buffer widths of greater than 100' for both the right and left banks. The invasive purple loosestrife was identified throughout the downstream half of the segment.

.

Figure 30. Photos at the cross section

T7.01A Summary Data Doughty Hill Tributary	
Reach/Segment Length	1,001 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type/Bedform	E5 Plane Bed
Geomorphic Condition	Good
Channel Evolution Stage	I
Adjustment Process	Relatively stable channel
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts
Berms

T7.01-B

Segment T7.01-B begins at the T7.01-A segment break and extends upstream approximately 720' upstream of the Old Stage Road crossing. The valley setting is very broad (although quite a lot narrower than segment T7.01-A) with approximately 140' of development encroachments in the river corridor. This reach falls within an agricultural setting but has no evidence of historic straightening. The reach segment is characterized as a shallow slope (0.9%), narrow (5' bankfull width), and low sinuosity channel with plane bed bedform. The channel exhibits E type geometry with WDR of 4 and ER of 50. Incision was not observed at the cross section and bank erosion was not present. Due to the lack of incision or erosion and widening (RGA=Reference) the CEM has been classified as stage I.

The stream channel, which is generally dry, comes in and out of wetland marsh areas. The stream corridor on both banks upstream of the Old Stage Road crossing is managed by the current property owners as grassland bird habitat. The overall habitat condition of this segment is only Fair due to virtually no large woody debris cover, poor hydrologic conditions, absence of pools and substantial fine deposition throughout the channel, and poor river bank vegetation. The channel alternates between being dry and having areas of ponded water along the course of the reach. The reach has generally poor buffer widths of less than 50' and in many places less than 25' for both the right and left banks. The invasive purple loosestrife was identified just upstream of the Old Stage Road culvert. There is very little erosion present within this segment.

Figure 31. Channel at the cross section

Figure 32. Outlet of Old Stage Road culvert

There are two instream culverts in the segment, one under Old Stage Road and one associated

with a farm field, that are both wide enough to support a bankfull flow event. Scour was observed at the downstream end of the Old Stage Road structure.

T7.01B Summary Data Doughty Hill Tributary	
Reach/Segment Length	1,531 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	E5 Plane Bed
Existing Stream Type/Bedform	E5 Plane Bed
Geomorphic Condition	Reference
Channel Evolution Stage	I
Adjustment Process	Relatively stable channel
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

T7.01-C

Segment T7.01-C begins at the downstream segment break with T7.01-B and extends upstream 1450' through a cattail marsh. This segment was not assessed due wetland conditions and lack of a clearly defined channel. Field observations were made from the adjoining agricultural fields. The valley setting is very broad with no structural encroachments in the river corridor. This segment is characterized as marsh wetland with generally good buffers and good buffer vegetation on the right bank. The left bank has an approximately 600 linear foot distance of buffer less than 25' with poor streambank vegetation. Two field ditches were observed in this segment. The invasive purple loosestrife was identified at the downstream end of the segment.

T7.01C Summary Data Doughty Hill Tributary	
Reach/Segment Length	1,450 ft
Valley Confinement	
Reference Stream Type	
Existing Stream Type	Wetland
Geomorphic Condition	
Channel Evolution Stage	
Adjustment Process	
Habitat Condition	
Stream Sensitivity	

*X-section not conducted due to wetland conditions.

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts
Berms

T7.01-D

Subreach T7.01-D begins at the downstream segment break with T7.01-C and extends upstream approximately 775'. This subreach is the headwaters for the Doughty Hill Tributary. The valley setting is narrow with no structural encroachments in the river corridor. This reach falls within a forested landscape. The reach is characterized as a steep slope (9%), wide (16' bankfull width as compared to downstream segments), and low sinuosity channel with step-pool bedform. The channel exhibits F type geometry with WDR of 21.2 and ER of 1.3. Incision was not observed at the cross section (IR=1), and bank erosion was not common (~80' section on the left bank). The substrate is predominated by sand. The high degree of sand in the bed substrate is likely sourced from multiple stream inputs from the upslope watershed.

Figure 33. Channel at cross section

Due to the channel aggradation and widening (RGA=Poor) the CEM has been classified as stage III. The segment has an "extreme" sensitivity to future impacts, and will likely undergo significant lateral adjustments in the future. The segment has undergone a stream channel departure converting this stream segment to an F (moderate to high width/depth ratio) from an A (low width/depth ratio). This departure indicates an over-widening of the channel.

This subreach is located within a nicely forested setting with good buffers and streambank vegetation. The overall habitat condition of this segment is only Fair due to poor hydrologic conditions (high percentage of exposed substrate), absence of pools and substantial fine deposition throughout the channel.

T7.01D Summary Data Doughty Hill Tributary	
Reach/Segment Length	776 ft
Valley Confinement	Narrow
Reference Stream Type/Bedform	A4 Step-Pool
Existing Stream Type/Bedform	F5 Step Pool
Geomorphic Condition	Poor
Channel Evolution Stage	III
Adjustment Process	Channel is overwidened/some erosion
Habitat Condition	Fair
Stream Sensitivity	Extreme

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors

Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

4.4.11 Reach T9.01: Cranberry Swamp Tributary

Reach T9.01 is the most downstream reach of the Cranberry Swamp Tributary included in the study area. It was divided into two segments due to impounded conditions in segment T9.01-A.

T9.01-A

Segment T9.01-A begins at the confluence with South Fork reach M09 and extends upstream approximately 600'. This segment is impounded by a beaver dam. This segment was not assessed due to open water conditions. Field observations were made from the adjoining upland fields. The left bank of this segment has good buffers and streambank vegetation. The left bank has generally poor buffers of less than 25' with poor streambank vegetation. A debris pile consisting of lumber was identified on the left bank just downstream of the T9.01-B segment break. The invasive purple loosestrife was observed on the left bank in the area of the debris pile.

T9.01A Summary Data Cranberry Swamp Tributary		Habitat Stressors	Reach Stressors
Reach/Segment Length	607 ft		Poor Buffers
Valley Confinement			Erosion
Reference Stream Type		Invasive Plants	Mass Failures
Existing Stream Type		Dump Sites	Encroachments
Geomorphic Condition		Animal Crossings	Straightening
Channel Evolution Stage		Dredging	Revetments
Adjustment Process		Poor Stream Bank Vegetation	Constrictions
			Rejuvenating Tributaries
Habitat Condition			Dredging
Stream Sensitivity		Algae	Stormwater inputs
*Impounded Segment		Colonization	Headcuts

T9.01-B

Segment T9.01-B begins at the T9.01-A segment break and extends 880' upstream of the Rte 22A crossing. The valley setting is very broad with significant structural encroachments in the river corridor, approximately 706 linear feet of development. The reach is characterized as a steep slope (4.6%), wide (16' bankfull channel), and moderate sinuosity channel with step-pool bedform. The channel exhibits C type geometry with WDR of 21.1 and ER of 21.1. Incision was not observed at the cross section (IR=1), and bank erosion was not common (~100' section on the left bank and 62' section on the right bank). The substrate is predominated by gravel, with a high percentage of sand. The high degree of sand in the bed substrate is likely sourced from the upstream beaver dams. Due to the relative channel stability (RGA=Good), with only a few areas of erosion, the CEM has been classified as stage I.

Figure 34. Channel at cross section

Figure 35. Poor buffers at downstream end of segment

This upper section of the segment is generally located within a nicely forested setting with good step pool formation, good buffers and good streambank vegetation. The overall habitat condition of this segment is only Fair due to river corridor encroachments and poor buffers in the downstream portion of the segment. The invasive purple loosestrife was identified at the downstream end of the segment. Of concern is a new clear cut at the upstream end of the reach. Extensive excavation of the valley wall has occurred in this location as well as a stream excavation and installation of what appears to be an undersized culvert. The stream was not accessed in this location due to difficult access conditions.

Figure 36. Private culvert with 12" freefall

There are two instream culverts in the segment, one under Rte 22A and one associated with a private driveway off of Perch Pond Road. Neither culvert is wide enough to support a bankfull flow event. The culvert associated with the private drive was observed from a distance and determined to be of poor alignment to the stream. This culvert appears to have a 12" freefall at the outlet. The Rte 22A culvert is wide enough to support 50% of a bankfull event. This arch culvert is 8' wide and has a 2' freefall with plunge pool at the outlet.

T9.01B Summary Data Cranberry Swamp Tributary	
Reach/Segment Length	1,188 ft
Valley Confinement	Very Broad
Reference Stream Type/Bedform	C3b Step Pool
Existing Stream Type/Bedform	C4b Step Pool
Geomorphic Condition	Good
Channel Evolution Stage	I
Adjustment Process	Some erosion
Habitat Condition	Fair
Stream Sensitivity	High

Habitat Stressors

Invasive Plants
Dump Sites
Animal Crossings
Dredging
Poor Stream Bank Vegetation
Algae
Colonization

Reach Stressors
Poor Buffers
Erosion
Mass Failures
Encroachments
Straightening
Revetments
Constrictions
Rejuvenating Tributaries
Dredging
Stormwater inputs
Headcuts

5.0 DEPARTURE ANALYSIS AND STRESSOR IDENFICATION

Detailed discussion provided in the attachment.

6.0 PRELIMINARY PROJECT IDENTIFICATION AND PRIORITIZATION

The preceding departure and sensitivity analysis provides the watershed and reach scale background to guide prioritization and selection of projects in a manner that maximizes their effectiveness and reduces the likelihood of failure, specifically by assessing the underlying causes of channel instability. With the information from these maps and tables, a step-wise process has been conducted to identify the following actions, in order of priority, in a manner designed to facilitate restoration of the stream to equilibrium conditions (VTANR 2010):

Step 6.1. Protect River Corridors
Step 6.2. Plant Stream Buffers
Step 6.3. Stabilize Stream Banks
Step 6.4. Arrest head cuts and nick points
Step 6.5. Remove Berms and other constraints to flood and sediment load attenuation
Step 6.6. Remove/Replace Structures (e.g. undersized culverts, constrictions, low dams)
Step 6.7. Restore Incised Reaches
Step 6.8. Restore Aggraded Reaches

As indicated in Section 5.2 of this report, the high to extreme sensitivity of most of the reaches in the East Creek study area indicates that passive geomorphic projects is generally an appropriate

management alternative. This places a very high priority, throughout the study area, on the first two items identified in the stepwise procedure above.

6.1 SITE-LEVEL PROJECT IDENTIFICATION

The site-level projects developed for the assessed reaches of the East Creek watershed are provided below in Table 8. The project strategy and priority for each project are listed by project number and reach/segment. A total of 32 projects were identified to promote the restoration or protection of channel stability and aquatic habitat. The table summarizes key information for each project, including the site stressors and constraints, project strategy, priority, and potential partners.

The project locations identified for the study area are included on maps in the attachment. The 33 projects are further broken down by category as follows: Ten active geomorphic restoration projects; twenty-two passive geomorphic restoration projects.

This Corridor Plan encourages coordination of landowner and municipal efforts to approach restoration with an eye to watershed scale dynamics. The South Lake Citizen Advisory Committee and local conservation commissions can play a critical role in coordinating restoration efforts, and this report aims to facilitate such coordination in a way that can help landowners understand the part their properties play within the context of the entire watershed.

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T4.02S2.02 #1 Royce Brook Orwell *Starting at the downstream reach break with T4.02S2.01 and extending upstream approximately 700'*	Passive Restoration Buffer Plantings/Restrict livestock access from channel	The first ~700' of this reach has experienced recent pasturing by livestock which has resulted in eroded banks and lack of streambank vegetation.	Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover. Create a buffer between the pasture and the channel.	Low	Mod	Reduce thermal loading to stream; reduce sediment loading to stream; improve aquatic habitat	VTDEC; Landowner; NRCS, US F&W
T4.02S2.02 #2 Royce Brook Orwell *Brown Lane Crossing*	Active Restoration Structure Retrofit/ Replacement	**B**rown Lane culvert is undersized-width is only 45%of the bankfull channel width. The culvert is cracked and water is not conveyed through the structure. This culvert also has a 12" freefall drop at the outlet with large downstream plunge-pool.	Replace the culvert with a new structure (culvert or bridge) which is adequately sized and located.	High	High	Increase capacity to handle bankfull event; Provision of AOP; Restore natural hydrology of the stream	VTDEC; NRCS; FF&W; Town of Orwell
T4.02S2.02 #3 Royce Brook Orwell *Farm Trail Crossing approximately 400' downstream from T4.02S2.03 reach break*	Active Restoration Structure Retrofit/ Replacement	Farm Trail culvert is significantly undersized-width is only 27% of the bankfull channel width.	Replace the culvert with a new structure (culvert or bridge) which is adequately sized.	Mod	Low	Restore full AOP; Increase capacity to handle bankfull event	VTDEC; Landowner

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T4.02S2.02 #4 Royce Brook Orwell From the Farm Trail Crossing (project #3) extending downstream approximately 1000'	Passive Restoration Buffer Planting/Relocate Livestock Fencing	For this 1000' stretch, the stream has poor buffers of generally less than 25'. Greater than 50% of this stretch has been historically straightened. Some of the adjoining fields are used for pasture with fencing in close proximity to the stream. The remaining fields are used for hay production.	Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover. Increase the buffer width between the hay field and the channel. Relocate the pasture fencing to provide a wider buffer.	Mod	Mod	Reduce thermal loading to stream; improve aquatic habitat; allow for reestablishment of natural planform	VTDEC; Landowner; NRCS
T4.02S2.02 #4 Royce Brook Orwell *Entire reach, both right and left banks*	Passive Restoration Corridor Conservation	This reach is generally quite sinuous, with the exception of ~500' in the upstream portion. This reach has been identified as a natural attenuation site and an easement would help to mitigate sediments transported from upstream reaches.	Corridor protection will enable sediment that is transported from upstream reaches to settle out before entering transport reach T4.04. It will also allow for natural planform to develop in the straightened upper portion of the reach.	Mod	Mod	Reduce sediment to downstream reaches; allow for reestablishment of natural planform	VRC; VTDEC; Landowner
T4.03 #1 North Fork Orwell *Entire reach, both right and left banks*	Passive Restoration Corridor Conservation	This short reach is a natural attenuation site and an easement would help to mitigate the sediment passing through upstream transport converted reaches T4.04, T4.05, and T4.06.	Corridor protection will enable sediment that is transported from upstream reaches T4.04, T4.05, and T4.06 above will settle out in developing meanders.	High	High	Reduce sediment to downstream reaches	VRC; VTDEC; Landowner

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T4.03 #2 North Fork Orwell *Approximately 885' upstream of the T4.02 reach break*	Passive Restoration Buffer Plantings	There is approximately 650' linear of poor buffer <25' on the right bank. The adjoining field is used for hay production.	Plant a wider riparian buffer with native woody vegetation. Increase the buffer width between the hay field and the channel on the right bank.	Mod	High	Reduce thermal loading to stream; improve aquatic habitat	VTDEC; Landowner; NRCS
T4.04 #1 North Fork Orwell *Just upstream of Rte 22A culvert extending to just downstream of the farm road bridge*	Passive Restoration Buffer Plantings	There is approximately 750' linear of poor buffer <25' on both the right and left banks. The adjoining landuses are residential and agricultural. There is evidence of a planting project on both banks; the plantings are not doing well in this area.	Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover, especially in areas where existing plantings are not doing well. Plantings should be set back from the bank as this reach is in CEM III, widening. Increase the buffer width between the adjoining landuses and the channel.	Mod	High	Reduce thermal loading to stream; improve aquatic habitat	VTDEC; Landowner; NRCS
T4.05 #1 North Fork Orwell *Approximately 550' downstream of the upstream reach break with T4.06*	Active Restoration Removal of Rock Impoundment	There is a pile of rock stacked across the channel creating an impoundment of the channel.	Remove rock from the channel to restore natural channel flow.	Low	Mod	Restoration of natural channel flow	Landowner; Volunteers

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T4.06 #1 North Fork Orwell *Approximately 1,000' upstream of the T4.05 reach break*	Passive Restoration Relocate Pasture Fencing	There is an active planting project underway in this reach having also included moving sections of fences away from the channel. There is remaining an approximately 350' section left to relocate away from the right bank.	Relocate approximately 350' section of fencing to create a wider buffer to the stream channel.	Low	Low	Reduce thermal and nutrient loading to the stream	VTDEC; Landowner; NRCS
T4.07 #1 North Fork Orwell *Entire reach, right and left banks*	Passive Restoration Corridor Conservation	This reach is quite sinuous and has been identified as a natural attenuation site and an easement would help to mitigate sediments transported from upstream reaches before entering transport reach T4.04.	Corridor protection will enable sediment that is transported from upstream reaches to settle out before entering reach T4.04.	High	High	Reduce sediment to downstream reaches	VRC; VTDEC; Landowner
T4.07 #2 North Fork Orwell *Approximately 375' upstream of the T4.06 reach break*	Active Restoration Structure Replacement	Significantly undersized culvert associated with a farm road that is only wide enough to support 14% of a bankfull flow event. The culvert appears to be inverted with evidence of flooding observed in the roadway. The culvert is impounding flow for a significant length of this reach. Scour was not observed at the upstream or downstream end of this structure.	Replace the culvert with a new structure (culvert or bridge) which is adequately sized.	Mod	Mod	Provision of AOP; Increase capacity to handle bankfull event; Restore natural hydrology of the stream	VTDEC; Landowner; NRCS; US F&W

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T4.08 #1 **North Fork** **Shoreham** *Entire reach, right and left banks*	Passive Restoration Corridor Conservation	This reach is quite sinuous and has been identified as a natural attenuation site and an easement would help to mitigate the sediment transported from upstream reaches which appear to have poor buffers.	Corridor protection will enable sediment that is transported from upstream reaches to settle out in developing meanders.	High	High	Reduce sediment to downstream reaches	VRC; VTDEC; Landowner
T4.08 #2 **North Fork** **Shoreham** *Approximately 230' upstream of the T4.07 reach break*	Active Restoration Structure Replacement	Significantly undersized culvert associated with a farm road that is only wide enough to support 7% of a bankfull flow event. The culvert is impounding flow. Scour was not observed at the upstream or downstream end of this structure.	Replace the culvert with a new structure (culvert or bridge) which is adequately sized.	Mod	Low	Increase capacity to handle bankfulll flow event; Provision of AOP; Restore natural hydrology of the stream	VTDEC; Landowner; NRCS; US F&W
T4.08 #3 **North Fork** **Shoreham** *Just downstream of the Brown Road culvert at the T4.09 reach break*	Passive Restoration Restrict livestock access to channel	There is a cattle crossing and watering hole at the upstream extent of this reach. The cattle have open access to the channel for a distance of approximately 135'. As a result, there is no vegetation on the stream banks.	Establish a defined crossing point and off-stream watering location. Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover. Create a buffer between the pasture and the channel.	Low	High	Reduce thermal loading to stream; reduce sediment and nutrient loading to stream; improve aquatic habitat	VTDEC; Landowner; NRCS, US F&W

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T5.01-A #1 Orwell Village Tributary *Approximately 475' upstream of confluence with the South Fork extending upstream to T5.01B*	Passive Restoration Corridor Conservation	This segment has been historically straightened and has poor buffers. There are some corridor encroachments to be excluded. The surrounding landuse is primarily agriculture. The segment has been identified as a natural attenuation site and an easement would help to mitigate the sediment transported from the upstream segment that has been converted to a transport reach.	Corridor protection will enable sediment that is transported from upstream reaches to settle out in developing meanders.	High	High	Reduce sediment to downstream reaches; Reduce thermal loading to stream; improve aquatic habitat; allow for reestablishment of natural planform	VRC; VTDEC; Landowner
T5.01-A #2 Orwell Village Tributary *Rte 22A stream crossing*	Active Restoration Structure Replacement	The Rte 22A culvert is wide enough to support 100% of the bankfull flow event but is partially backwatered at the outlet. The bottom of this culvert is rotten with water flowing around and under the structure.	Replace the culvert with a new structure (culvert or bridge) which is at least the same size.	Low	Low	Restore structural integrity of the culvert and road	Town of Orwell

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T5.01-A #3 Orwell Village Tributary *Farm road crossing at the T5.01A and T5.01B segment break*	Active Restoration Structure Replacement	Undersized culvert associated with a farm road that is only wide enough to support 42% of a bankfull flow event. A sag in the roadway was observed possibly indicating a subsurface break in the culvert. Scour was observed at the upstream and downstream end of this structure.	Replace the culvert with a new structure (culvert or bridge) which is adequately sized.	Mod	Low	Increase capacity to handle bankfull flow event; stabilize structure and the roadway; Restore full AOP	VTDEC; Landowner
T5.01-A #4 Orwell Village Tributary *Approximately 900' upstream of the confluence with M04 extending upstream to the T5.01B segment break*	Passive Restoration Buffer Planting	Approximately 70% of this stream segment (both banks) has poor buffers of less than 25'. This stretch has evidence of significant historic channel straightening. The right corridor landuse is hay production. The left corridor landuse is a mix of hay and pasture. The section of pasture (just downstream of the Rte 73 crossing) has less than 5' buffer to the stream channel.	Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover. Increase the buffer width between the adjoining landuses and the channel.	High	Mod	Reduce thermal and nutrient loading to stream; allow for natural planform to develop; improve aquatic habitat	VTDEC; Landowner; NRCS

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T5.01-A #5 Orwell Village Tributary *Approximately 1400' upstream of the confluence with M04 extending to the Rte 73 crossing*	Passive Restoration Relocate pasture fencing	The left corridor landuse is a mix of hay and pasture. The 600' section of pasture (just downstream of the Rte 73 crossing on the left bank) has less than 5' buffer to the stream channel.	Increase the buffer width between the adjoining landuses and the channel. Relocate pasture fences to create a wider buffer width to the channel on the left bank.	Mod	Mod	Reduce thermal and nutrient loading to stream; improve aquatic habitat	VTDEC; Landowner; NRCS
T5.01-B #1 Orwell Village Tributary *North Orwell Road crossing at the upstream segment break with T5.01C*	Active Restoration Structure Replacement	Undersized culvert wide enough to support only 33% of the bankfull storm event. Scour was not observed at the upstream or downstream end of this structure. This culvert has a 3' freefall drop at the outlet.	Replace the culvert with a new structure (culvert or bridge) which is adequately sized.	High	High	Provision of AOP; Increase capacity to handle bankfull event; Restore natural hydrology of the stream	VTDEC; Landowner; NRCS; US F&W
T5.01-C #1 Orwell Village Tributary *The entire length of the segment, which starts just upstream of the North Orwell Road crossing*	Passive Restoration Buffer Plantings	This reach was assessed from North Orwell Road. The buffer on the left bank appears to be <25' for the ~900' length of the segment. The stream channel appears to have been straightened for the entire length of the segment. The adjoining landuse is residential for the left bank and agricultural for the right bank.	Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover. Increase the buffer width between the adjoining landuses and the channel.	Mod	Mod	Reduce thermal loading to stream; allow for natural planform to develop; improve aquatic habitat	VTDEC; Landowner; NRCS

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T7.01A #1 Doughty Hill Tributary *Approximately 500' upstream of the confluence with M06.*	Passive Restoration Buffer Plantings	Approximately 500' of the downstream portion of this segment shows evidence of historic straightening. Just upstream of this straightened section there is a distance of approximately ~290' of poor buffer <25' on the left bank. The adjoining landuse is in hay production.	Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover. Increase the buffer width between the adjoining hay field and the channel.	Mod	Mod	Reduce thermal loading to stream; allow for natural planform to develop; improve aquatic habitat	VTDEC; Landowner; NRCS
T7.01A #2 Doughty Hill Tributary *Entire segment, both right and left banks*	Passive Restoration Corridor Conservation	Approximately 500' of the downstream portion of this segment shows evidence of historic straightening. This segment has been identified as a natural attenuation site and an easement would help to mitigate the sediment transported from upstream segments that have poor buffers and erosion.	Corridor protection will enable sediment that is transported from upstream reaches to settle out in developing meanders.	High	High	Reduce sediment to downstream reaches; allow natural planform to develop; improve aquatic habitat	VRC; VTDEC; Landowner

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T7.01B#1 Doughty Hill Tributary *Entire segment, both right and left banks*	Passive Restoration Corridor Conservation	The current landowners of the upstream portion of this segment (northwest of Old Stage Road) are managing the corridor for grassland bird habitat. This segment has been identified as a natural attenuation site and an easement would help to mitigate the sediment transported from the upstream transport segment.	Corridor protection will enable sediment that is transported from upstream reaches to settle out.	High	High	Reduce sediment to downstream reaches	VRC; VTDEC; Landowner
T7.01C #1 Doughty Hill Tributary *Approximately 220' upstream of the T7.01B segment break*	Passive Restoration Buffer Plantings	There is approximately 550' of poor buffer <25' on the left bank. The remaining buffer width is generally less than 50' to the T7.01D segment break. The adjoining landuse on the left bank is hay.	Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover. Increase the buffer width between the adjoining landuses and the channel.	Mod	Mod	Reduce thermal loading to stream; improve aquatic habitat	VTDEC; Landowner; NRCS
T9.01A #1 Cranberry Swamp Tributary *Entire segment, right and left banks.*	Passive Restoration Corridor Conservation	This reach is quite sinuous and has been identified as a natural attenuation site and an easement would help to mitigate the sediment transported from upstream segments which have erosion, poor buffers and corridor encroachments	Corridor protection will enable sediment that is transported from upstream reaches to settle out in developing meanders.	High	High	Reduce sediment to downstream reaches	VRC; VTDEC; Landowner

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T9.01A #2 Cranberry Swamp Tributary *Approximately 330' downstream of the Rte 22A crossing*	Passive Restoration Buffer Plantings	There is ~150'along the left bank that has poor buffer <25'. The adjoining landuse is residential.	Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover. Increase the buffer width between the adjoining landuses and the channel.	Mod	Mod	Reduce thermal loading to stream; improve aquatic habitat	VTDEC; Landowner; NRCS
T9.01A #3 Cranberry Swamp Tributary Left bank just downstream of the T9.01-B segment break.	Passive Restoration Dump Site Cleanup	A debris pile consisting of lumber debris was identified on the left bank.	Remove debris from river corridor.	Low	Low	Improve river corridor habitat conditions	Landowner; volunteers
T9.01B #1 Cranberry Swamp Tributary *Starting at the downstream segment break with T9.01A and extending to Rte 22A*	Passive Restoration Buffer Plantings	There is approximately 270' of poor buffer <25' on the left bank downstream of the Rte 22A crossing. The adjoining landuse is residential.	Plant a wider riparian buffer with native woody vegetation in areas lacking canopy cover. Increase the buffer width between the adjoining landuses and the channel.	Mod	Mod	Reduce thermal loading to stream; improve aquatic habitat	VTDEC; Landowner; NRCS
T9.01B #2 Cranberry Swamp Tributary *Rte 22A stream crossing*	Active Restoration Replace/Retrofit Structure	The Rte 22A culvert is wide enough to support 50% of a bankfull event. This arch culvert is 8' wide and has a 2' freefall with plunge pool at the outlet.	Replace the culvert with a new structure (culvert or bridge) which is adequately sized. Or, retrofit structure to provide AOP	High	Mod	Restore full AOP; Increase capacity to handle bankfull flow event	VTDEC; Landowner

Table 8. Preliminary Project Identification and Prioritization for East Creek Watershed							
Reach/Segment, Project ID, Stream Name, Town & Location	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project Description**	**Hazard Mitigation Priority**	**Ecological Benefits Priority**	**Project Benefits**	**Potential Partners**
T9.01B #3 Cranberry Swamp Tributary *1st Private driveway off of Perch Pond Road; ~650 upsteam of Rte 22A crossing*	Active Restoration Structure Replacement	The culvert associated with the private drive was observed from a distance and determined to be of poor alignment to the stream. This culvert appears to have a 12" freefall at the outlet.	Replace the culvert with a new structure (culvert or bridge) which is adequately sized and aligned to the stream.	High	High	Restore full AOP; Increase capacity of structure to handle bankfull event	VTDEC; Landowner

6.2 WATERSHED STRATEGIES

6.2.1 Floodplain and River Corridor Planning and Protection

Several strategies can be used by state agencies and municipalities to reduce human conflicts with the river. The first strategy, planning and zoning to minimize future encroachment, includes tools such as corridor-based zoning ordinances, participation in the National Flood Insurance Program, and fluvial erosion hazard protection areas.

The towns of Orwell, Benson and Shoreham all have local zoning regulations and a town plan. Within the local zoning ordinance, the Town of Orwell has established a Flood Hazard Overlay District and a Shoreland Overlay District. These districts effectively prohibit new dwellings within the Flood Hazard zone and establish a 75' setback from East Creek for any new development. The Town of Benson has established a Floodplain Overlay District within its local zoning regulations, which encompasses the lands shown as the A zone on the latest Flood Insurance Rate Map (FIRM) for the Town. The town has a separate freestanding Flood Hazard Area Zoning Bylaw. The town also has a Lake Shore District that establishes a 75' setback for the Hubbardton River and the shore of Lake Champlain and a specified list of lakes and ponds within the district. East Creek is not provided a setback in the Benson zoning regulations. The Town of Shoreham has adopted within its zoning regulation a Flood Hazard Area Regulation which applies to all lands identified on the latest FIRM for the town. Development within the flood hazard area is subject to conditional use review by the Zoning Board of Adjustment. East Creek is not provided a setback in the Shoreham zoning regulations.

The National Flood Insurance Program (NFIP) was created by Congress through the National Flood Insurance Act of 1968. It enables property owners in participating communities to purchase insurance protection against flood related losses (inundation hazards). The insurance provides an alternative to disaster assistance by covering damage repairs to buildings and their contents. Participation in the NFIP is based on an agreement between the Federal Government and local communities that states the Federal Government will make flood insurance available if a community adopts and enforces a floodplain management ordinance to reduce flood risks to new construction in Special Flood Hazard Areas (SFHA). The SFHAs and other risk premium

zones that affect participating communities are depicted on Flood Insurance Rate Maps. The Mitigation Division within the Federal Emergency Management Agency manages the NFIP, and oversees the floodplain management and mapping components of the Program (http://www.fema.gov/business/nfip/). As described above, the towns of Orwell, Benson and Shoreham all participate in the NFIP.

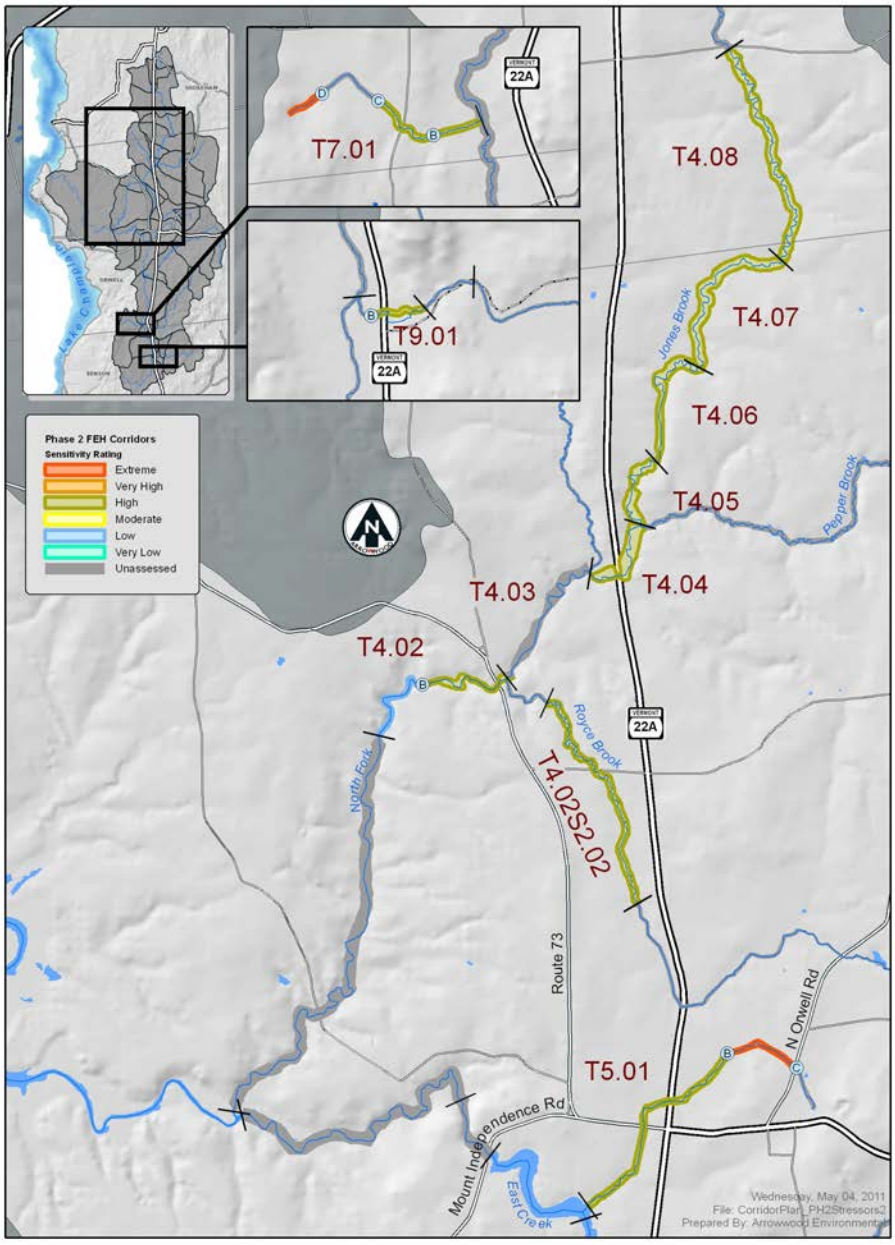


Figure 37. East Creek Draft FEH Protection Areas Map

Mapping of Fluvial erosion hazard (FEH) protection areas uses the geomorphic data collected in Phases I and II to rate the erosion hazards in the zone along the Creek based on the predicted movement of the river (http://www.anr.state.vt.us/cleanandclear/rivstrm.htm). Mapping of FEH protection areas was completed for East Creek by Arrowwood Environmental in the spring of 2011. The RMP has not yet conducted a formal QA review of the data and therefore, the map is still in draft form. Upon approval, the East Creek

FEH Protection Areas map can be made available to the towns in the Project Area. In each town, corridor-based municipal zoning ordinances can be considered as a means to limit encroachment and landuse conflicts within the FEH zones identified.

6.2.2 Buffer Establishment and Protection

Stream buffer planting is a high priority in sensitive reaches that are vertically stable. The study reaches for East Creek are in Stages I, II or III of channel evolution, with the reaches in Stages II and III actively adjusting. Stream buffer plantings have been recommended in the following reaches: T4.03, T4.04, T4.02S202, T5.01A, T7.01A and C, and T9.01A and B. Due to the instability of reach T4.04 (Stage III of channel evolution); planting of vegetation on the immediate stream banks is not a high project priority. Plantings within the corridor, set back from the streambanks, are a high priority in this reach. The remaining reaches are relatively stable (Stage I of channel evolution) with varying amounts of erosion and poor stream buffers. Planting of streambanks and buffers is a high priority in these reaches.

The following table prioritizes the recommended buffer planting projects:

Table 9: Buffer Planting Prioritization

Reach ID	Stream Sensitivity	Stage of Channel Evolution	Sediment and Runoff Potential from Adjoining Landuses	Opportunity to Increase Buffer Connectivity	Project Ranking
T4.03	NA	NA	High	High	2
T4.04	High	III	Mod	High	6
T4.02S2.02	High	I	High	Mod	3
T5.01A	Extreme	I	High	Mod	4
T5.01C	NA	NA	High	Mod	6
T7.01A	High	I	Mod	High	5
T7.01C	NA	NA	High	High	1
T9.01A	NA	NA	Mod	Low	8
T9.01B	High	I	Low	Mod	7

Locations of invasive plant species were inventoried and mapped for all but one reach segment, T7.01D, of the study reaches. Locations of species populations identified during the field

assessments are included on the reach field maps. Invasive plant species removal and/or control are difficult tasks. There are various methods of control and possibly eradication including chemical treatments, biological and mechanical or manual removal. Any option likely involves multiple treatments over many years. This topic is included in the method of planting stream buffers because ideally the invasive species treatment would involve a step of planting native species in treatment areas. The Nature Conservancy and the Natural Resources Conservation Service are good resources for projects contemplating invasive species control and/or removal.

6.2.3 Road-Stream Crossing Retrofits and Replacements

Bridges and culverts improperly sized at a stream crossing often modify natural channel dimensions and disrupt hydrology and sediment transport. Structures which are incompatible with stream geomorphology may fail due to excessive erosion around the structure and/or lead to disequilibrium in the reach. Undersized bridges and culverts can also prevent fish and wildlife movement resulting in loss of resident populations. A significant number of the bridges and culverts in the study reaches are currently undersized and causing various problems such as upstream deposition, excessive erosion, downstream bed degradation, and aquatic organism passage (AOP) problems. As these structures come up for replacement at the municipal level, it is important to resize them to accommodate the expected discharge and sediment loads and to place them in proper alignment with the stream channel. (VTANR, 2010)

Summary data for all structures in the study reaches was entered into the online DMS. In order to make use of the VTANR culvert screening tools for structure prioritization, Table 10 summarizes data collected for 15 crossings in the study reaches. There are nine (9) undersized bridges and culverts in the study area serving as constrictions of the stream channel. The final column of the table includes a prioritization of structures for replacement or retrofit based on a review of the following three criteria: structure width in relation to bankfull channel width; aquatic organism passage (culverts only); and geomorphic compatibility (culverts only). Removing or replacing structures is a high priority for structures no longer in use or structures that contribute to a significant increase in erosion hazard or structures likely to result in channel avulsion during a storm event. Evaluation of impacts of structure removal (including potential bank instability or channel bed elevation changes) upon corridor development and/or land use is recommended prior to project initiation.

Table 10: Bridge and Culvert Summary Data Table

Segment ID	MapID	TOWN	Stream	Type	Road Name	Bankfull Width Percent	AOP Coarse Screen	AOP Geomorphic Compatibility	AOP Priority	Project Priority
T4.02B		Orwell	North Fork	Bridge	Route 73	91	--	--	--	Low
T4.02S2.02		Orwell	Royce Brook	Culvert	Farm Road	27	Reduced AOP	Mostly Compatible	LLL	Moderate
T4.02S2.02		Orwell	Royce Brook	Culvert	Brown Lane	45	No AOP	Mostly Compatible	MLL	High
T4.04		Orwell	North Fork	Bridge	Farm Road	233	--	--	--	Low
T4.04		Orwell	North Fork	Culvert	Route 22A	283	--	Fully Compatible	HHH	Low
T4.07		Orwell	North Fork	Culvert	Farm Road	14	Reduced AOP	Partially Compatible	LLL	Moderate
T4.08		Orwell	North Fork	Culvert	Farm Road	7	Reduced AOP	Mostly Compatible	LLL	Moderate
T5.01A		Orwell	Orwell Village Trib.	Culvert	Farm Road	42	Reduced AOP	Mostly Compatible	MLL	Moderate
T5.01A		Orwell	Orwell Village Trib.	Culvert	Route 22A	100	--	Mostly Compatible	HHH	Low
T5.01A		Orwell	Orwell Village Trib.	Culvert	Route 73	183	Reduced AOP	Mostly Compatible	HHH	Low
T5.01B		Orwell	Orwell Village Trib.	Culvert	No. Orwell Road	33	No AOP	Mostly Compatible	LLL	High
T7.01B		Orwell	Doughty Hill Trib.	Culvert	No Road	100	Reduced AOP	Fully Compatible	HHH	Low
T7.01B		Orwell	Doughty Hill Trib	Culvert	Old Stage Road	300	Reduced AOP	Mostly Compatible	HHH	Low
T9.01B		Benson	Cranberry Swamp	Culvert	Private Drive	6	No AOP	Mostly Incompatible	LLL	High
T9.01B		Benson	Cranberry Swamp	Culvert	Route 22A	50	No AOP	Mostly Compatible	MLL	Moderate

Eight structures were identified during the Phase 2 field assessments as priority projects for repair or replacement. These priority structures are located in T4.02S2.02 (Brown Lane culvert and a farm road culvert), T4.07 (farm road culvert), T4.08 (farm road culvert), T5.01A (farm road culvert), T5.01B (North Orwell Road culvert), and T9.01B (Private Drive off of Perch Pond Road and Route 22A culvert). Figure 38 presents the problem structures with the watershed study area based on percentage less than bankfull.

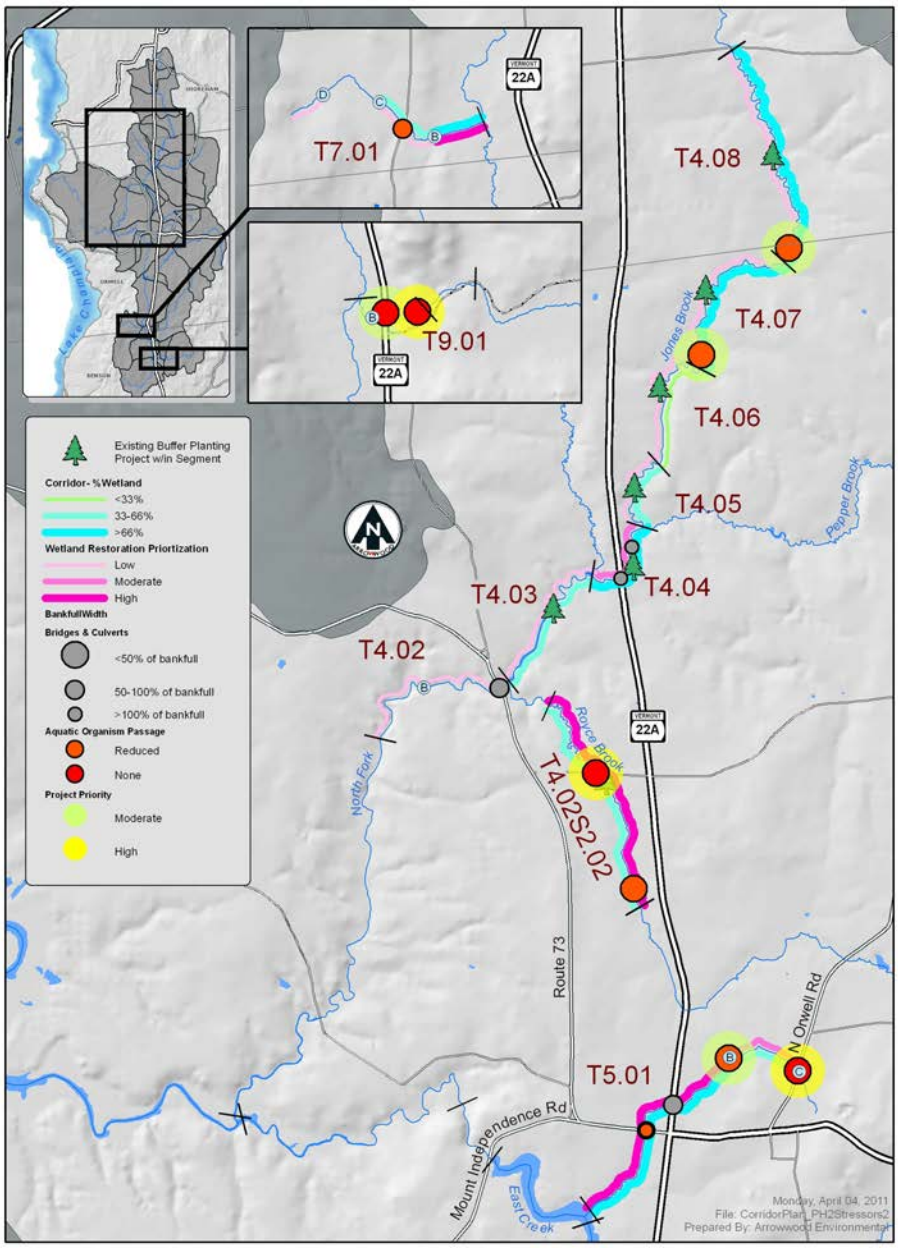


Figure 38. Problem Structures and Wetland Restoration Potential Map

6.2.4 Wetland Restoration

Wetlands have an important role in protecting the water quality of our rivers and lakes. Vermont has lost an estimated 35 percent of our wetlands since colonial times, with a corresponding decrease in water quality protection. However, in certain cases it is possible to restore impaired wetlands, bringing back their water quality protection function.

The following table provides a prioritization for potential wetland restoration projects within the East Creek study area. Within the table is presented the acres of potential wetland restoration area on a reach basis. This area was derived from the combination of hydric soils (NRCS soil survey data) and/or National Wetland Inventory mapped wetlands. Also presented in the table, is the presence or absence of a buffer planting project (as identified in the Phase 2 field survey) for each segment. For the purposes of ranking the potential restoration sites, areas with active planting projects were considered low priority for additional restoration at this time.

Table 11. Wetland Restoration Project Prioritization Table

Segment ID	Corridor Acreage	Potential Wetland Restoration Area (Acres)	Presence of Active Planting Project	Wetland Restoration Project Ranking
T4.02A North Fork	8.5	0	No	--
T4.02B	10.2	0	No	--
T4.02 S2.02 Royce Brook	23.8	11.4	Yes (downstream 2/3's of reach)	**High (upstream 1/3 of reach; ~4 acres)**
T4.03	17	9.1	Yes	Low
T4.04	10.9	7.5	Yes (upstream of Rte 22A)	Mod (downstream of Rte 22A; ~1.8 acres)
T4.05	8.8	3.0	Yes	Low
T4.06	14.7	4.8	Yes	Low
T4.07	18.1	17.16	Yes	Low
T4.08	25.5	18.64	Yes	Low
T5.01A Orwell Village Trib.	20.6	15.7	No	**High**
T5.01B	7.1	2.7	No	Mod
T7.01A Doughty Hill Trib.	4	3.4	No	**High**
T7.01B	6.9	3.5	No	Low
T7.01D	3.5	0	No	Low
T9.01B	5.4	1.7	No	Low

As Table 11 shows, Reaches T5.01A, T7.01A and T4.02.02 have the greatest potential acreage identified for potential wetland restoration and do not have buffer planting projects underway. Given the importance of these reaches as sediment and nutrient attenuation assets for the entire watershed, wetland restoration is both a watershed and reach priority for these reaches. The map presented as Figure 49 (previous section) displays the wetland restoration ranking on a reach basis for the study area.

7.0 RECOMMENDATIONS FOR CORRIDOR PLAN UPDATES

It is recommended that periodic East Creek Corridor Plan updates be made, preferably at least every five years. These updates could include:

- Assessment of management strategies in light of project implementation
- Identification of additional reach and watershed scale management options
- Identification of public outreach and education efforts

8.0 LITERATURE CITED

Arrowwood Environmental, 2010. Phase 1 Stream Geomorphic Assessment: East Creek. Executive Summary.

Benson Town Plan, 2004.

Fedor-Cunningham, David. Personal Communication regarding 2006 Flood Event. March, 2011.

Leopold, L.B. 1994. A View of the River. Cambridge, MA.: Harvard University Press.

Orwell Town Plan, 2007.

Rosgen, D.L. and H.L. Silvey. 1996. Applied River Morphology. Wildland Hydrology Books, Fort Collins, CO

Rosgen, D. L. 1994. A classification of natural rivers. *Catena*, 22(3), 169 - 199.

Schumm, S.A. 1977. The fluvial system. John Wiley and Sons, New York.

Schumm, S.A. 1984. Incised Channels: Morphology, Dynamics and Control. Water Resources Publication (ISBN-0918334-53-5), Littleton, CO.

Thompson, Elizabeth and Eric Sorenson. 2000. Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont. The Nature Conservancy and the Vermont Department of Fish and Wildlife.

University of Vermont, Landscape Change Program. 2010. Photographs: LS25261_000.jpg; LS16397_000.jpg. http://www.uvm.edu/landscape

VT DEC-RMP 2003. Alternatives for River Corridor Management: Toward resolving river and land-use conflicts in an economically and ecologically sustainable manner. Vermont Department of Environmental Conservation River Management Program Position Paper. http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_managementAlternatives.pdf

VTANR 2009. Vermont Agency of Natural Resources Protocol Handbooks. Vermont Agency of Natural Resources. http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm

VTANR 2010. Vermont Agency of Natural Resources River Corridor Planning Guide: To Identify and Develop River Corridor Protection and Restoration Projects. http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rivercorridorguide.pdf