Black Creek
Corridor Plan

Franklin County
April 2009

Prepared for:
Missisquoi River Basin Association
2839 VT Route 105
East Berkshire, VT 05447

Prepared by:
The Johnson Company, Inc.
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Montpelier, VT 05602

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April 13, 2009

Ms. Cynthia Scott
Missisquoi River Basin Association
2839 VT Route 105
East Berkshire, Vermont 05447

Re: Black Creek Corridor Plan
Franklin County, Vermont
JCO Project No. 3-1313-3

Dear Ms. Scott:

The Johnson Company is pleased to present the following Black Creek Corridor Plan to the Missisquoi River Basin Association (MRBA).

Should you have any questions or require additional assistance, please do not hesitate to contact The Johnson Company at (802) 229-4600. Thank you for the opportunity to be of assistance to the MRBA on this project.

Sincerely,
THE JOHNSON COMPANY, INC.

By: _____
Adam Robtoy
Project Scientist

cc: Staci Pomeroy, VT RMP

Reviewed by: JSG

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EXECUTIVE SUMMARY

Black Creek is a large tributary of the Missisquoi River and drains approximately 120 square miles. The watershed extends from its confluence with the Missisquoi just north of Sheldon village south to the Bakersfield town line. Black Creek flows through the towns of Sheldon and Fairfield with small portions of its tributaries also located in St. Albans, Bakersfield, and Swanton. This River Corridor Plan focuses on the mainstem reaches, as well as two main tributaries, Dead Creek and Fairfield River. The project study area is shown on Figure 1.

Development of this Plan was a collaborative effort between The Johnson Company, Missisquoi River Basin Association (MRBA), and Vermont Rivers Management Program (RMP). Funding for the project was provided through a grant from RMP to MRBA. Improving water quality in the Black Creek is part of the larger effort to restore and sustain water quality in the Missisquoi River watershed and Lake Champlain. Phase 1 fluvial geomorphic assessments were conducted on 89 reaches within the watershed in 2005 by Northwest Regional Planning Commission. Phase 2 assessments were conducted on 17 of these 89 reaches in 2008 by The Johnson Company.

The Corridor Planning Process involves the integration of fluvial geomorphic assessment data, and the goals and objectives of the state and local community to formulate scientifically sound and ecologically beneficial river restoration and conservation projects that will not only improve water quality, but also improve the community's relationship with the river. The RMP has instituted a phased corridor planning process. Phase 1 geomorphic assessments are conducted on a watershed scale using maps, aerial photos, and observations of the river from roads and bridges. This Phase identifies river reaches where further study is warranted. Phase 2 assessments are based on data collected in the river and analyses of these data using the principles of fluvial geomorphology. The Corridor Plan uses the results of the Phase 1 and Phase 2 assessments to identify potential restoration projects.

Fluvial geomorphology is the study of rivers and the geologic processes that determine the form of rivers and their river valleys. It is fundamental to understanding the effects rivers have on the surrounding landscape and human developments within this landscape and the effects that human development has on river systems. Studies have shown that rivers work to achieve an equilibrium condition where the processes of bank erosion and bank formation are in balance. The study of fluvial geomorpology utilizes data such as channel width and depth, floodplain characteristics, and bed and bank conditions to evaluate how streams have deviated from their equilibrium condition, and to predict what adjustments are likely to occur in the future as the river works to re-establish equilibrium.

The Phase 2 assessment results indicated a large amount of stream channel adjustment occurring in portions of the watershed. Significant historic channel alterations including straightening, dredging, ditching, and floodplain development were noted. These channel alterations, in

conjunction with agricultural land use and growing residential and commercial development in the watershed, have caused an increase in stream flows and sediment load. Additionally, some of the assessed reaches have undergone some degree of channel incision, or downcutting, where the stream erodes into its bed and the stream no longer has complete access to its floodplain during high flow events. The incision, coupled with a lack of adequate woody riparian vegetation, has led to a reduction in sediment and nutrient storage capacity, and an increase in nutrient inputs. The goals of the River Corridor Planning process are to identify restoration and conservation projects which can help restore balance to the river system, and reduce the impact of these stressors.

Watershed and reach scale stressors were evaluated for each 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 condition differs from the expected equilibrium condition. Appropriate restoration and conservation techniques were developed for each reach, and a comprehensive Project and Practices Summary Table was created to prioritize the identified restoration and conservation strategies.

In summary, the findings of this Corridor Plan are as follows:

- Historically, most of the Black Creek watershed acted as a sediment and nutrient attenuation zone, where incoming fine sediments from upstream were stored on the floodplain, and inputs of coarse sediment were essentially in balance and equal to outputs of coarse sediment.
- Due to the historic and ongoing adjustment processes and stressors documented in the watershed, it has lost some of its nutrient attenuation function, and largely been transformed into a sediment and nutrient source zone due to land use changes, erosion, and decreased riparian habitat.
- Despite the high increase of stream flow and sediment inputs, most of the watershed has experienced only minor incision and still has access to its floodplain.
- The highest priority projects for the watershed are those that attempt to restore the nutrient attenuation assets which once dominated the system including riparian buffer establishment and removal of floodplain encroachments.
- Other recommended project types include replacement of undersized bridges and culverts to reduce channel constrictions, restore normal flow patterns, and improve aquatic habitat, and river corridor protection to retain floodplain access.

Overall, the Black Creek watershed is still largely undeveloped and provides significant opportunities for river corridor restoration. Obviously, there is a large amount of human investment within the river corridor, primarily in agricultural land, but also in homes,

businesses, and infrastructure, but the goals of this and other river corridor plans is to find areas within the watershed where a balance can be reached between these human investments and the health and wellbeing of river systems. Some of the larger scale active restoration projects may require conversion of considerable acres of agricultural land to floodplain and buffer; however, considerable strides may also be made through implementation of relatively narrow buffer strips and other agricultural best management practices. A complete list of recommended projects for the study area is included in Table 22 at the end of this report along with maps showing the various project areas which are included as Figures 16 through 32.

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1.0 INTRODUCTION AND PROJECT OVERVIEW

Black Creek is a large tributary of the Missisquoi River and drains approximately 65 square miles. The watershed extends from its confluence with the Missisquoi just north of Sheldon village south to the Bakersfield town line. Black Creek flows through the towns of Sheldon and Fairfield with small portions of its tributaries also located in St. Albans, Bakersfield, and Swanton. This River Corridor Plan focuses on the mainstem reaches, as well as two main tributaries, Dead Creek and Fairfield River. The project study area is shown on Figure 1.

Development of this Plan was a collaborative effort between The Johnson Company, Missisquoi River Basin Association (MRBA), and Vermont Rivers Management Program (RMP). Funding for the project was provided through a grant from RMP to MRBA. The Corridor Planning Process involves the integration of fluvial geomorphic assessment data, and the goals and objectives of the State and local community to formulate scientifically sound and ecologically beneficial river restoration and conservation projects that will not only improve water quality, but also improve the community's relationship with the river. To facilitate these goals, RMP has developed a River Corridor Planning Guide to aid in the identification and development of river restoration and conservation projects. References to this guide will be made throughout this report, and a complete copy is available online at http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_restoration.htm.

The main goal of the Vermont River Management Program is to manage toward, protect, and restore the fluvial geomorphic equilibrium condition of Vermont rivers by resolving conflicts between human investments and river dynamics in the most economically and ecologically sustainable manner (VT ANR 2007). The objectives are fluvial erosion hazard mitigation, sediment and nutrient load reduction and attenuation, and aquatic and riparian habitat protection and restoration. Improving water quality in the Black Creek is also part of the larger effort to restore and sustain water quality in the Missisquoi River watershed and Lake Champlain.

Legend

Reach/Segment Break

Phase 2 Assessed Reaches

M01 Black Reach Labels: Reach fully assessed in Phase 2 Anlaysis

T2.02C Grey Reach Labels: Reach not fully assessed in Phase 2 Anlaysis

Sheldon Springs

Sheldon Junction

Sheldon

St Rocks

Fairfield Pond

Fairfield Station

Fox Hill

Fairfield

M01

M02

T2.02C

T2.02B

T2.02A

T2.01A

T2.01B

M03A

M03B

M04A

M04B

T4.01

T4.03

T4.04A

T4.04B

T4.05A

T4.05B

Quebec

VT

NY

NH

Feet

0 1,500 3,000 6,000

Figure 1a: Site Location Map
Black Creek Watershed
Mouth Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date:

Scale: 1" = 3000' Project: 3-1313-3

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Legend

Reach/Segment Break

Phase 2 Assessed Reaches

M06 Black Reach Labels: Reach fully assessed in Phase 2 Anlaysis

M6T6.01 Grey Reach Labels: Reach not fully assessed in Phase 2 Anlaysis

M05A

M05B

M06

M07

M6T6.01

M08

M09A

M09B

M9T8.1S1.02

M9T8.1S1.01

M9T8.01

Fairfield Station

East Fairfield

Black Creek

Meadow Brook

Elm Brook

Pine Hill

Fox Hill

Wintergreen Mountain

Metcalf Pond

APPROXIMATE BOUNDARY

F A I R F I E L D

B A K E R S F

Quebec

VT

NY

NH

Feet

0 1,500 3,000 6,000

Figure 1b: Site Location Map
Black Creek Watershed
Head Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date:

Scale: 1" = 3000' Project: 3-1313-3

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2.0 BACKGROUND INFORMATION

2.1 GEOGRAPHIC SETTING

2.1.1 Watershed Description

The Black Creek watershed lies primarily within the towns of Sheldon and Fairfield with small portions in Swanton, St. Albans, and Bakersfield encompassing approximately 120 square miles. The watershed elevation ranges from approximately 100 feet above mean sea level at the confluence of Black Creek and the Missisquoi River to 200 feet above mean sea level at the southern end of the stream near the Fairfield/Bakersfield town line. Black Creek is part of the larger Missisquoi River basin and empties into the Missisquoi just north of Sheldon village. Locations of the seventeen stream reaches included in this Corridor Plan (approximately 29 linear miles) are shown on Figures 1a and 1b above. Two additional reaches originally slated for study, M6T6.01, and M9T8.1S1.01, could not be assessed due to limited property access, and the presence of multiple bedrock gorges and beaver dams.

2.1.2 Political Jurisdictions

The entire study area lies within Franklin County, Vermont in the towns of Sheldon, Fairfield, Swanton, St. Albans, and Bakersfield. Nearly all lands within the watershed are privately owned with the exception of Town and State owned roads, bridges, and culverts.

2.1.3 Land Use History and Current General Characteristics

Black Creek lies within Franklin County, one of the most intense agricultural areas of Vermont. The first inhabitants of the area were likely Native Americans who were utilizing the Missisquoi River and surrounding lands for hundreds of years before the first European settlers arrived in the late 1700s. Archealogical evidence suggests that Native Americans had an established settlement in what is now the Town of Swanton as early as 800 B.C. (Swanton Chamber of Commerce, 2005). From the time the first European settlers moved into the region, agricultural activities began to dominate the region. Like many other areas of the State, much of the forested land had been cleared by the late nineteenth century to accommodate the wool industry and other agricultural activities. Beginning in the early twentieth century, much of the

forestland began to return and dairy farming expanded to become the dominant agricultural activity. Currently, a large portion of the Black Creek watershed is occupied by dairy-related agricultural fields and farms. Sparse residential development is also present with an increasing number of homes and subdivisions built in the last few decades. Several roads and an abandoned elevated railroad bed run along portions of the mainstem. This land use evolution has been documented as an ongoing source of the hydrological changes which have taken place in many Vermont watersheds and will be discussed in more detail in Section 4.

2.2 GEOLOGIC SETTING

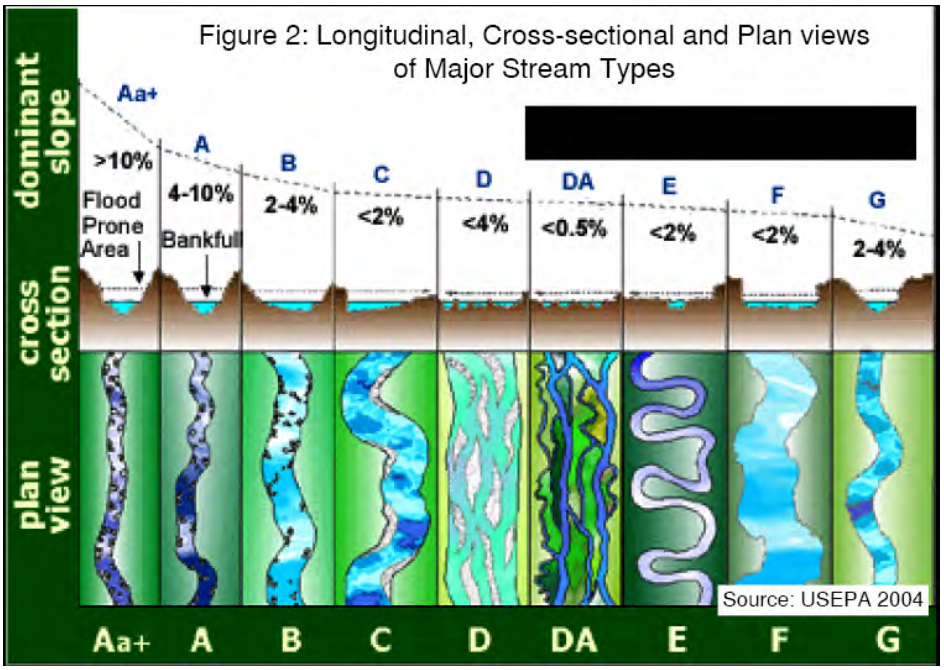
Black Creek watershed is located to the west of the Green Mountain province in higher elevation areas of the Champlain Valley province that surrounds Lake Champlain. The study area, like all of Vermont, was covered by glaciers as recently as 10,000 years ago. These glaciers left exposed bedrock along the ridge tops and deposited glacial till at lower elevations. This bedrock and till comprise a majority of the valley walls within the watershed while a majority of the river corridor is comprised of less cohesive, silts, clays and sands. Bedrock in the study area is dominated by shales and slates that were deposited as sedimentary mudstones in an ancient sea 450 to 550 million years old. Smaller occurrences of limestones, dolomites, and quartzites are present. The topography of the Black Creek watershed reflects the alignment of the underlying bedrock, draining generally to the north and bounded by erosion-resistant quartzite at the foothills of the Green Mountain Province to the east and dolomites along the north-northeast trending Champlain Thrust fault to the west (Doll, 1961).

The surficial geology reflects glacial and post-glacial depositional events in the area and is dominated by glacial till intermixed with deposits of recent alluvium, gravel, and sand (Stewart and MacClintock, 1970). Soils in the study area are dominated by deep, moderately to poorly drained silt and clay loams predominantly associated with the following series: Massena, Lyons, Munson, Buxton, Windsor, and Missisquoi (USDA SCS, 1976).

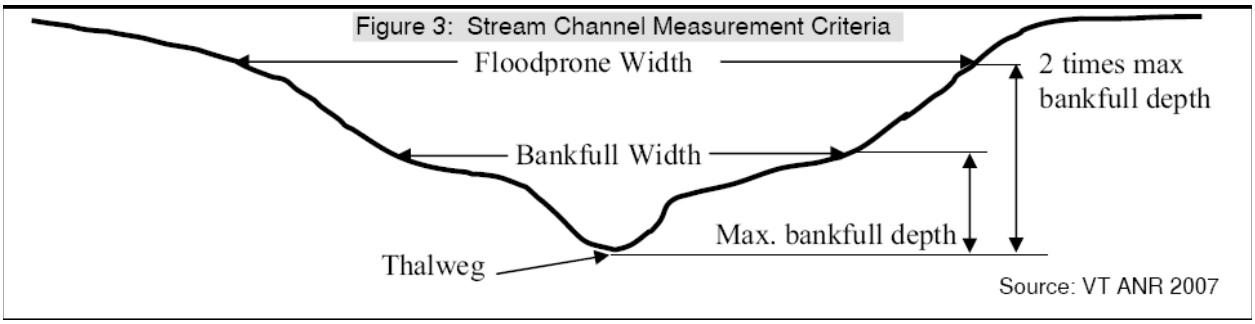
2.3 GEOMORPHIC SETTING

The watershed was divided into 89 reaches during Phase 1 assessment; 17 reaches had Phase Two assessments completed in the summer of 2008 and are the focus of this corridor plan. Each reach was delineated based on physical characteristics such as slope, sinuosity, valley confinement, and hydrologic characteristics determined by remote sensing techniques in the Phase 1 geomorphic assessment. The locations of the assessed reaches are shown on Figures 1a and 1b. The following is a summary of the Phase 1 Geomorphic results which describe the expected, or reference, condition for the study area. These data describe what one would expect the river system to look like in its natural state with no anthropogenic influences.

Channel slopes for the study area reported in the Phase 1 assessment ranged from 0.01% (M09) to 1.88% (T4.05) with most reaches having slopes less than 0.5%. Relatively large valley widths were reported for all studied reaches ranging from just over 400 to more than 3,000 feet. Reference bankfull widths ranged from 19 to 82 feet. Based on the Phase 1 data, 9 of the 17 studied reaches have an E reference stream types characterized by slopes of less than 2%, moderate to high sinuosity, and substrate ranging from sand to boulder. The remaining 8 reaches were characterized as C-type streams. Figure 2 below shows the characteristics of various stream types (A through G) and how they appear in plan and cross section views (US EPA 2004).



Stream typing involves classifying reaches based on combinations of physical parameters such as valley landform, channel dimensions, slope, sediment supply, and bed forms, which indicate the fluvial processes at work in a river reach. Streams are placed into different stream types based on their entrenchment, width to depth ratio, sinuosity, channel slope, substrate size, and bed features (VT ANR 2007). The first stream type descriptor is a capital letter (A through G) that describes the entrenchment ratio (equal to floodprone width divided by bankfull width) and width to depth ratio (equal to bankfull width divided by average depth). Figure 3 below shows how each of these ratios is measured (VT ANR 2007).



The second descriptor is a number (1 through 6) used to describe the dominant bed substrate in decreasing order: 1 – bedrock; 2 – boulder; 3 – cobble; 4 – gravel; 5 – sand; and 6 -

silt. The third descriptor is a lower case letter which describes the channel slope: a = slope >4%; b = slope 2-4%; and C = slope <2%, though this descriptor is only used if the channel slope falls outside the normal range typically found for that stream type (shown in the Figure 2 above). The fourth and final descriptor describes the bedform of the reach. The most common of these is riffle-pool, but other bedforms include step-pool, plane bed, dune-ripple, and braided. When combined these four descriptors convey a great deal of information about how the stream reach looks. Table 1 below summarizes the Phase 1 data for the seventeen studied reaches. All of the study area reaches were classified as E or C stream types, which are common in Vermont. It is important to note that these stream types are the reference, or expected types for the study area and may not reflect the current conditions. The objective of the Phase 2 and corridor planning processes is to identify what types of stressors are impacting each reach, how these stressors change the existing stream type and other parameters, and use this information to identify restoration and conservation projects that can aid in returning the river system to its equilibrium state. More detailed descriptions and maps of the study area are located in Section 5 of this report.

Table 1: Black Creek Phase 1 Reference Stream Data								
Reach ID	Reach Length (miles)	Valley Type	Valley Width (ft)	Channel Width (ft)	Channel Slope (%)	Sinuosity	Reference Stream Type	Bedform
M01	15,541	Broad	600	81.9	0.17	1.1	E	Dune-Ripple
M02	4,564	Very Broad	1,317	79.8	0.09	1.2	E	Dune-Ripple
M03	23,871	Very Broad	696	61.5	0.03	1.4	E	Dune-Ripple
M04	5,286	Very Broad	3,500	49.6	0.04	1.3	E	Dune-Ripple
M05	14,993	Very Broad	1,541	76.8	0.03	1.9	C	Dune-Ripple
M06	7,534	Broad	654	73.2	0.05	1.4	C	Dune-Ripple
M07	10,963	Broad	488	65.7	0.32	1.3	E	Dune-Ripple
M08	5,710	Very Broad	470	34.0	0.3	1.1	E	Dune-Ripple
M09	14,789	Broad	541	58.6	0.01	1.4	E	Dune-Ripple
T2.01	5,051	Broad	444	53.0	0.95	1.5	E	Dune-Ripple
T2.02	7,876	Narrow	166	52.4	1.1	1.1	C	Riffle-Pool
T4.01	3,238	Very Broad	972	49.0	0.15	1.4	C	Plane bed
T4.03	3,131	Narrow	95	64.0	0.83	1.04	C	Step-Pool
T4.04	6,657	Narrow	80	46.8	0.5	1.2	B	Step-Pool
T4.05	4,421	Broad	290	42.2	1.9	1.1	C	Step-Pool
M9T8.01	5,012	Very Broad	547	29.1	1.1	1.3	C	Dune-Ripple
M9T8.1S1.02	4,966	Very Broad	428	19.7	1.5	1.4	C	Riffle-Pool

2.4 HYDROLOGY

The United States Geological Survey (USGS) maintains a Vermont Streamstats website, which computes flow and basin characteristics for Sites without permanent gauges (http://water.usgs.gov/osw/streamstats/Vermont.html). A copy of the USGS Streamstats printout for Black Creek is presented in Figure 4 below as an example.

Figure 4:
Streamstats Ungaged Site Report

Date: Mon Mar 30 2009 14:01:17
Site Location: Vermont
NAD83 Latitude: 44.8948 (44 53 41)
NAD83 Longitude: -72.9438 (-72 56 37)
NAD27 Latitude: 44.8948 (44 53 41)
NAD27 Longitude: -72.9442 (-72 56 39)
Drainage Area: 120 mi2

Peak Flow Basin Characteristics

100% Statewide Peak Flow (120 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	120	0.211	850
Percent Lakes and Ponds (percent)	1.08	0	6.86
Percentage of Basin Above 1200 ft (percent)	4.85	0	100
Geographic Factor for VT (dimensionless)	254015.6	-87	296194

Streamflow Statistics

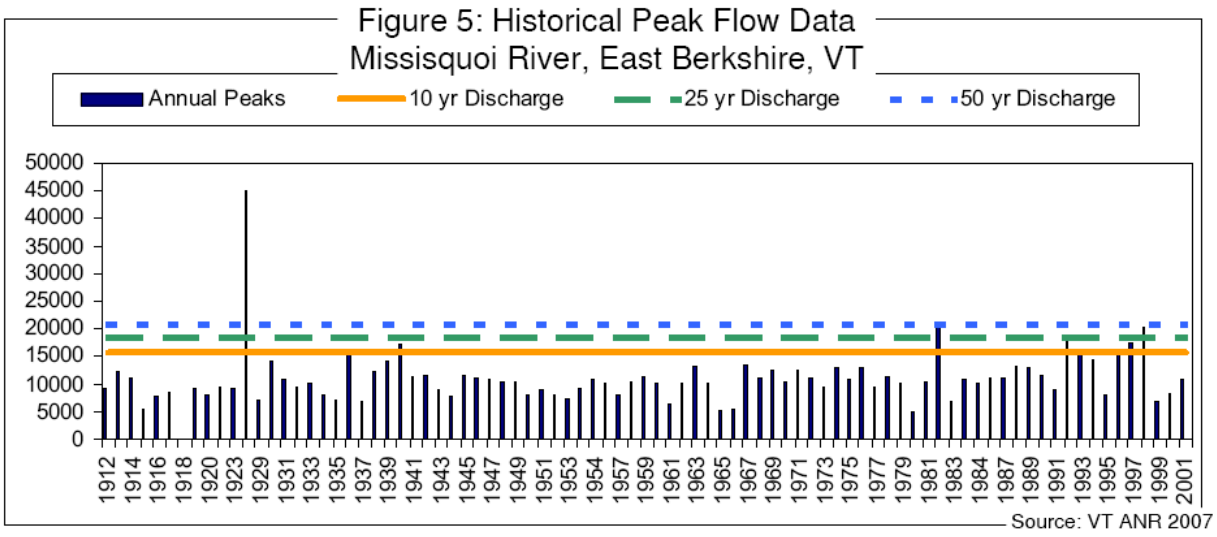
Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
PK2	2230	42	1.4	1150	4330
PK5	3150	40	2.3	1640	6020
PK10	3760	41	3.2	1950	7260
PK25	4480	42	4.6	2300	8700
PK50	4990	43	5.5	2550	9750
PK100	5500	44	6.3	2720	11100
PK500	6670	49	7.6	3070	14500

Source: USGS 2009

The Basin Characteristics Table shows the drainage area (120 square miles) as well as other hydrologic data. The Streamflow Statistics Table shows the water flow in cubic feet per second (one cubic foot is equal to 7.5 gallons) for different streamflow events. PK2 refers to a 2-

year flow event while PK100 refers to a 100-year flood event. The flood event numbers equal the statistical likelihood that the event will happen in any given year. For example on average there is a 1 in 2 chance that a PK2 flow event will occur in any year, while there is a 1 in 100 chance of a PK100 flow event occurring. While not directly used at this stage in the corridor planning process, this USGS flow information can be useful in a variety of ways from delineating floodplains to designing proper bridge widths.

The nearest USGS gages for the study area are on the Missisquoi in Swanton, VT and East Berkshire, VT. Annual peak recordings began at the Swanton gage in 1990 and show annual highs above the 10 year discharge in 1996 and 2006. Data for the East Berkshire gage goes back to 1912, and recorded the highest water levels in 1927, when many locations across Vermont were flooded, and lesser high flow events in excess of 25 year discharge in 1982, 1992, 1997, and 1998. A summary of peak annual flows for the East Berkshire gage is shown in Figure 5 below. The flow values along the Y-axis are shown in cubic feet per second (the same units as the Streamstats Table above). While this data represents a much larger watershed than that for Black Creek, it shows that several large flow events have occurred in the region over the last 20 years. Frequent flooding has been reported in the Black Creek over the last 15 years. In 2002 alone, overbank flooding was reported to have occurred 13 times (Dubois & King, 2005).



2.5 ECOLOGICAL SETTING

The study area includes a variety of aquatic and upland habitat types which are dominated by agricultural crop and pasture land, but also includes forest, riparian wetland complexes, and beaver ponds. The primary aquatic habitat consists of a plane-bed sandy to silty substrate community which is largely a result of active river management and corresponding geomorphic changes. Human land use, primarily conversion of forest and wetlands to agricultural land, have diminished the habitat diversity of the watershed and reduced the amount of riparian forest and wetland communities which, under natural conditions, would be the dominant ecological communities. The higher elevation tributaries of Black Creek are less intensely managed for agriculture and support deer wintering habitat and one or more rare, threatened, or endangered species (Vermont Fish and Wildlife, 1997). A majority of the studied reaches had habitat assessment ratings of fair to poor based on the Vermont Agency of Natural Resources Stream Geomorphic Assessment Protocols.

3.0 METHODOLOGY

3.1 FLUVIAL GEOMORPHIC ASSESSMENT PROTOCOLS

All of the Phase 2 geomorphic assessments conducted in 2008 were performed in accordance with the most recent available Vermont Agency of Natural Resources (VT ANR) Stream Geomorphic Assessment Protocols. A copy of these protocols is available on the VT ANR Rivers Management Website at http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassess.htm. These protocols were designed to provide a sound, consistent, scientifically based data gathering and analysis system to obtain information about the physical processes ongoing within river systems. The protocols are divided into three phases. A Phase 1 assessment is completed primarily using remote sensing tools such as topographic maps, aerial photographs, GIS technology, and windshield surveys to predict the physical condition of streams in their natural, or equilibrium, state without human influences, and also document what human related impacts are ongoing within the watershed.

Phase 2 assessments are field-based and provide more detailed information, including physical measurements such as channel width and depth, and floodplain and substrate characteristics, to detail what levels of adjustment are occurring within the stream system and predict what future adjustments may occur. The Phase 2 assessment results form the basis for development of river corridor plans. A more detailed Phase 3 assessment involves detailed survey work and is used prior to implementation of larger scale active restoration projects.

A Phase 1 assessment of the entire Black Creek watershed was completed by Northwest Regional Planning Commission in 2005. A subset of 19 reaches were selected for Phase 2 assessment during 2008 and completed by The Johnson Company, Inc. Two of the 19 reaches could not be assessed due to limited property access and the presence of bedrock gorges and multiple beaver dams, resulting in the 17 reaches included in this corridor plan. All of the Phase 2 assessed reaches are shown on Figures 1a and 1b.

The Phase 2 assessment results indicated some areas with a large degree of stream adjustment occurring within the Black Creek watershed. Significant historic channel alterations were noted, which included straightening, berming, ditching, and lack of riparian buffers. Despite these channel alterations, relatively little channel incision, or downcutting, has occurred, likely due to the naturally low stream gradient, cohesive bed and bank material, and the presence of bedrock grade controls throughout the watershed. Nearly all the assessed reaches still have access to their floodplain and frequently overtop their banks. Significant channel encroachments and intensive agricultural land use have resulted in an increase in sediment and nutrients within the stream channel, a lack of storage capacity, and a decrease in water quality and aquatic habitat. The causes and consequences of these adjustment processes are discussed in more detail in Sections 4 and 5 of this Corridor Plan.

3.2 QUALITY ASSURANCE AND QUALITY CONTROL

A thorough QA review was performed by The Johnson Company in 2008 and 2009 and

all of the data were reviewed by VT ANR following collection. All of the collected data are stored in the DMS and available to the public through RMP's Data Management System (DMS) located at https://anrnode.anr.state.vt.us/ssl/sga/security/frmLogin.cfm, username: public, password: public.

4.0 DEPARTURE ANALYSIS AND STRESSOR IDENTIFICATION

Section 4 describes the results of the Phase 1 and 2 assessments for the Black Creek watershed. A variety of maps and tables including Stressor, Departure and Sensitivity Maps are included to show watershed and reach scale stressors and how they interact and affect the watershed as a whole. The data, tables, and maps described in Section 4 will be used to identify restoration and conservation techniques on a reach scale-basis (described in Section 5) that meet the goals and objectives of reducing fluvial erosion hazards, increasing sediment and nutrient attenuation sites, and improving aquatic and riparian habitat.

4.1 DEPARTURE ANALYSIS

4.1.1 Hydrologic Regime Stressors

The hydrologic regime may be defined as the timing, volume, and duration of flow events throughout the year, and over time it may be influenced by many factors including climate, soils, geology, groundwater inputs, watershed land cover and use, connectivity of the stream to riparian and floodplain networks, and valley and stream morphology (VT ANR, 2007). Hydrologic regime is characterized by the input and manipulation of water at the watershed scale (i.e. dams, large land use changes, ect.) and should not be confused with channel hydraulics which deals with the energy and flows on a smaller, reach-wide scale (i.e. bridges, culverts). When the hydrologic regime of a watershed is impacted, the stream will often undergo a series of predictable adjustments which can result in significant changes in sediment loading and flow patterns downstream (VT ANR, 2007). An example of this is a large dam which impounds water and periodically releases it into the river system. The large pulses of water released from the dam will affect the stream channel and surrounding riparian lands differently than the more constant flow changes which occur in a natural system. Because dams are typically managed in

a way that results in high flows occurring more frequently than they would naturally, the stream bed and banks are subjected to an increased frequency of highly erosive energy. The River Stressor ID Table, Table 2, summarizes the stressors that were identified in the Black Creek Watershed. These stressors and conditions are contributing to increased or decreased flow, sediment load, channel slope, power, and boundary resistance at both the watershed and reach scales. The red descriptor in each cell describes the overall stressor while the parameters listed below show which factors are contributing to or indicative of that stressor. For example, buffer widths less than 25 feet contribute to decreased boundary resistance while widths greater that 25 feet help resist erosion and contribute to increased boundary resistance. More detailed descriptions of these stressors and contributing factors are provided in each appropriate Section below. Figures 6 through 9 depict the major hydrologic stressors identified within the study area.

4.1.1.1 Historic Impacts

One of the most significant hydrologic stressors for most watersheds in Vermont is the large scale deforestation that occurred in the 19th century. As the state was settled much of the forest was cut for timber and the land cleared for agriculture. Where today Vermont is approximately 80% forestland and 20% open, in the late 19th and early 20th century it was only 20% forested and 80% open. The effect of those land use changes are still being seen today. With much of the land cleared higher intensity flash floods were more common and carried with them a large amount of sediment down into the valleys. This sediment built up in the river systems and raised the bed elevation of many streams. Many of these streams are now in the process of eroding down through the built-up sediment and losing access to their floodplain in the process. This process is increased through channel management techniques such as channelization, dredging, and ditching (VT ANR 2007). The effects of deforestation in Black Creek are not currently as pronounced as in other areas, probably due to the naturally low slope of the valley and the prevalence of bedrock grade controls and cohesive silts and clays which reduced the amount of historic erosion, sediment buildup.

Table 2: River Stressor ID Table - Black Creek

River Segment ID	Watershed Scale Stressors		Reach Scale Stressors	
	Hydrologic (Figures 6, 7, 8, and 9)	Sediment Load (Figures 7, 8, 9, and 10)	Stream Power (Figures 11 and 12)	Boundary Resistance (Figure 13)
M01	**Increased Flows** Stormwater Inputs/mile = >2<=5 (Moderate) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Hay/Crop Tile Drains and Field Ditches	**Increased Load** Crop land use = watershed = >5%<=10% (Moderate) Crop land use = subwatershed = >=10<20% (High) P2 corridor dominant = Hay/Crop Deposition Features/mile = <2 (Low) Erosion Features = Moderate Mass Failures = 1	**Increased Stream Power - Slope** Straightening = >20% **Increased Stream Power - Depth** Stormwater Inputs/mile = >2<=5 (moderate) **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** No Significant Impacts	**Increased Boundary Resistance** Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank erosion = L = >5<=20%, R = >5<=20%
M02	**Increased Flows** Stormwater Inputs/mile = >2<=5 (Moderate) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) P2 corridor dominant = Hay/Crop Tile Drains and Field Ditches	**Increased Load** Crop land use = watershed = >5%<=10% (Moderate) Crop land use = subwatershed = >5%<=10% (Moderate) P2 corridor dominant = Hay/Crop Deposition Features/mile = <2 (Low) Erosion Features = Moderate	**Increased Stream Power - Slope** Straightening = >5<=20% **Increased Stream Power - Depth** Stormwater Inputs/mile = >2<=5 **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** No Significant Impacts	**Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank Cohesive = No Bank erosion = L = >5<=20%, R = >5<=20%
M03A	**Increased Flows** Stormwater Inputs/mile = <=2 (Low) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) P2 corridor dominant = Crop Tile Drains and Field Ditches	**Increased Load** Crop land use = watershed = >5%<=10% (Moderate) Crop land use = subwatershed = >=10<20% (High) Deposition Features/mile = <2 (Low) Erosion Features = Low/Moderate P2 corridor dominant = Crop	**Increased Stream Power - Slope** Straightening = >20% Encroachments = Low **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** No Significant Impacts	**Increased Boundary Resistance** Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank armoring = L = Moderate, R = Moderate Bank erosion = L = >5<=20%, R = <5%
M03B	**Increased Flows** Stormwater Inputs/mile = >2<=5 (Moderate) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) P2 corridor dominant = Crop/pasture Tile Drains and Field Ditches	**Increased Load** Crop land use = watershed = >5%<=10% (Moderate) Crop land use = subwatershed = >=10<20% (High) Deposition Features/mile = >2<=5 (Moderate) Erosion Features = Moderate/High P2 corridor dominant = Crop/pasture	**Increased Stream Power - Slope** Straightening = >5<=20% Encroachments = Low **Increased Stream Power - Depth** Berms/roads = >5<=20% (Moderate) Stormwater Inputs/mile = >2<=5 (moderate) **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** No Significant Impacts	**Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank Cohesive = No Bank erosion = L = >20%, R = >5<=20% Bank armoring = L = Moderate, R = Low
M04A	**Increased Flows** Stormwater Inputs/mile = <=2 (Low) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Crop/Pasture Field ditches and tile drain	**Increased Load** Crop land use = watershed = >5%<=10% (Moderate) Crop land use = subwatershed = >=10<20% (High) P2 corridor dominant = Crop/Pasture Deposition Features/mile = <2 (Low) Erosion Features = Moderate	**Increased Stream Power - Slope** Straightening = >5<=20% **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** No Significant Impacts	**Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank Cohesive = No Bank erosion = L = >5<=20%, R = >5<=20% Bank armoring = L = Low, R = Moderate

The River Stressor ID Table shows the various stressors and conditions which are contributing to increased or decreased flow, sediment load, channel slope, power, and boundary resistance at both the watershed and reach scales.
The red descriptor in each cell describes the overall stressor, while the parameters listed below describe what factors are contributing to or indicative of that stressor (i.e. reduced buffer widths cause decreased boundary resistance, while increased buffer widths increase boundary resistance and help resist bank erosion). More detailed desriptions of these stressors are provided in the appropriate text section of the report.
L and R refers to left and right side of channel when looking downstream

Table 2: River Stressor ID Table - Black Creek

River Segment ID	Watershed Scale Stressors		Reach Scale Stressors	
	Hydrologic (Figures 6, 7, 8, and 9)	Sediment Load (Figures 7, 8, 9, and 10)	Stream Power (Figures 11 and 12)	Boundary Resistance (Figure 13)
M04B	**Increased Flows** Stormwater Inputs/mile = >2<=5 (Moderate) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Crop/Pasture Field ditches and tile drain	**Increased Load** Crop land use = watershed = >5%<=10% (Moderate) Crop land use = subwatershed = >=10<20% (High) P2 corridor dominant = Crop/Pasture Deposition Features/mile = >5 (High) Erosion Features = High	**Increased Stream Power - Slope** No Significant Impacts **Increased Stream Power - Depth** Stormwater Inputs/mile = >2<=5 (moderate) **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** Deposition Features/mile = >5 (High)	**Increased Boundary Resistance** Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank armoring = L = Moderate, R = Moderate Bank erosion = L = >20%, R = >20%
M05A	**Increased Flows** Stormwater Inputs/mile = >5 (High) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Crop/Hay Field ditches and tile drain	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = >=5<10% (Moderate) Deposition Features/mile = <2 (Low) Erosion Features = Low/Moderate Mass Failures = 1	**Increased Stream Power - Slope** Straightening = >20% Encroachments = High **Increased Stream Power - Depth** Berms/roads = >20% (High) Stormwater Inputs/mile = >5 (High) **Decreased Stream Power - Slope** Beaver Dams = 2 **Decreased Stream Power - Depth** No Significant Impacts	**Increased Boundary Resistance** Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank armoring = L = Moderate, R = Moderate Bank erosion = L = <5%, R = >5<=20%
M05B	**Increased Flows** Stormwater Inputs/mile = >2<=5 (Moderate) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Crop/Hay Field ditches and tile drain	**Increased Load** Crop land use = watershed = >5%<=10% (Moderate) Crop land use = subwatershed = >=10<20% (High) Deposition Features/mile = >2<=5 (Moderate) Erosion Features = Moderate	**Increased Stream Power - Slope** Straightening = >20% Encroachments = High **Increased Stream Power - Depth** Berms/roads = >5<=20% (Moderate) Stormwater Inputs/mile = >2<=5 (Moderate) **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** No Significant Impacts	**Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank Cohesive = No Bank erosion = L = >5<=20%, R = >5<=20% Bank armoring = L = Moderate, R = Moderate
M06	**Increased Flows** Stormwater Inputs/mile = >2<=5 (Moderate) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) Field Ditches Roads and ditches	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = <5% (Low) Deposition Features/mile = >2<=5 (Moderate) Erosion Features = Moderate/High Mass Failures = One Tributary Rejuvination = yes	**Increased Stream Power - Slope** Straightening = >20% (high) **Increased Stream Power - Depth** Berms/roads = <5% (Low) Stormwater Inputs/mile = <=2 **Decreased Stream Power - Slope** GC & Constrictions/mile = <=2 (Low) Beaver Dams = 2 **Decreased Stream Power - Depth** Deposition Features/mile = >5 (High)	**Increased Boundary Resistance** Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank armoring = L = Moderate, R = Low Bank erosion = L = >20%, R = >5<=20%
M07	**Increased Flows** Stormwater Inputs/mile = <=2 (Low) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=10<20% (High) Field Ditches and Tile Drains Roads and ditches	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = >=5<10% (Mod) Erosion Features = Moderate	**Increased Stream Power - Slope** Straightening = >20% (High) Encroachments = High **Increased Stream Power - Depth** Berms/roads = >5<=20% (Moderate) **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** No Significant Impacts	**Increased Boundary Resistance** Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank armoring = L = Low, R = Moderate Bank erosion = L = >5<=20%, R = >5<=20%

The River Stressor ID Table shows the various stressors and conditions which are contributing to increased or decreased flow, sediment load, channel slope, power, and boundary resistance at both the watershed and reach scales.
The red descriptor in each cell describes the overall stressor, while the parameters listed below describe what factors are contributing to or indicative of that stressor (i.e. reduced buffer widths cause decreased boundary resistance, while increased buffer widths increase boundary resistance and help resist bank erosion). More detailed desriptions of these stressors are provided in the appropriate text section of the report.
L and R refers to left and right side of channel when looking downstream

Table 2: River Stressor ID Table - Black Creek

River Segment ID	Watershed Scale Stressors		Reach Scale Stressors	
	Hydrologic (Figures 6, 7, 8, and 9)	Sediment Load (Figures 7, 8, 9, and 10)	Stream Power (Figures 11 and 12)	Boundary Resistance (Figure 13)
M08	**Increased Flows** Stormwater Inputs/mile = <=2 (Low) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) Field Ditches and Tile Drains	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = <5% (Low)	**Increased Stream Power - Slope** Straightening = >20% (High) Encroachments = High **Increased Stream Power - Depth** Berms/roads = >5<=20% (Moderate) **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** No Significant Impacts	**Increased Boundary Resistance** Bank Cohesive = Yes R Buffer dominant = >25ft **Decreased Boundary Resistance** L Buffer dominant= <25ft Bed = smaller than coarse gravel Bank armoring = L = Low, R = Low
M09A	**Increased Flows** Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) P2 corridor dominant = Pasture/Crop	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Pasture/Crop Erosion Features = Moderate/High	**Increased Stream Power - Slope** Straightening = >5<=20% (Moderate) Encroachments = Low **Increased Stream Power - Depth** Berms/roads = >5<=20% (Moderate) **Decreased Stream Power - Slope** No Significant Impact **Decreased Stream Power - Depth** No Significant Impact	**Increased Boundary Resistance** Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank armoring = L = Low, R = Low Bank erosion = L = >20%, R = >5<=20%
M09B	**Increased Flows** Stormwater Inputs/mile = <=2 (Low) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) P2 corridor dominant = Forest/Hay Field ditches	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Forest/Hay Deposition Features/mile = >2<=5 (Moderate) Erosion Features = Low Mass Failures = 1	**Increased Stream Power - Slope** Straightening = >20% (High) Encroachments = Low **Increased Stream Power - Depth** Berms/roads = >5<=20% (Moderate) Stormwater Inputs/mile = <=2 (Low) **Decreased Stream Power - Slope** Beaver Dams = multiple **Decreased Stream Power - Depth** No Significant Impact	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness L Buffer dominant= >25ft R Buffer dominant= >25ft **Decreased Boundary Resistance** Cohesive Bank = No Bed = smaller than coarse gravel Bank erosion = L = <5%, R = >5<=20%
T2.01A	**Increased Flows** Stormwater Inputs/mile = >2<=5 (Moderate) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) Field Ditches and Tile Drains P2 corridor dominant = Hay	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = >=10<20% (High) P2 corridor dominant = Hay Deposition Features/mile = >5 (High) Erosion Features = High	**Increased Stream Power - Slope** Encroachments = Low **Increased Stream Power - Depth** Berms/roads = <5% (low) Stormwater Inputs/mile = >2<=5 (Moderate) **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** Dredging	**Increased Boundary Resistance** Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank armoring = L = Low, R = Low Bank erosion = L = >20%, R = >20%
T2.01B	**Increased Flows** Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Hay	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = >=10<20% (High) P2 corridor dominant = Hay Deposition Features/mile = >5 (High)	**Increased Stream Power - Slope** No Significant Impacts **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** GC & Constrictions/mile = >5 (High) **Decreased Stream Power - Depth** Deposition Features/mile = >2<=5 (Moderate)	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness L Buffer dominant= >25ft R Buffer dominant= >25ft Bed = larger than coarse gravel **Decreased Boundary Resistance** Bank Cohesive = No Bank armoring = L = Low, R = Moderate

The River Stressor ID Table shows the various stressors and conditions which are contributing to increased or decreased flow, sediment load, channel slope, power, and boundary resistance at both the watershed and reach scales.
The red descriptor in each cell describes the overall stressor, while the parameters listed below describe what factors are contributing to or indicative of that stressor (i.e. reduced buffer widths cause decreased boundary resistance, while increased buffer widths increase boundary resistance and help resist bank erosion). More detailed desriptions of these stressors are provided in the appropriate text section of the report.
L and R refers to left and right side of channel when looking downstream

Table 2: River Stressor ID Table - Black Creek

River Segment ID	Watershed Scale Stressors		Reach Scale Stressors	
	Hydrologic (Figures 6, 7, 8, and 9)	Sediment Load (Figures 7, 8, 9, and 10)	Stream Power (Figures 11 and 12)	Boundary Resistance (Figure 13)
T2.02A	**Increased Flows** Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low)	**Increased Load** Crop land use = watershed = >=<5<10% (Mod) Crop land use = subwatershed = >=5<10% (Mod) Deposition Features/mile = >5 (High)	**Increased Stream Power - Slope** No Significant Impacts **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** No Significant Impacts	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness L Buffer dominant= >25ft R Buffer dominant= >25ft Bed = larger than coarse gravel **Decreased Boundary Resistance** Bank Cohesive = No
T2.02B	**Increased Flows** Stormwater Inputs/mile = >2<=5 (Moderate) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) Field Ditches and Tile Drains P2 corridor dominant = Pasture/Hay	**Increased Load** Crop land use = watershed = >=<5<10% (Mod) Crop land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Pasture/Hay Deposition Features/mile = >5 (High)	**Increased Stream Power - Slope** Straightening = >20% (High) **Increased Stream Power - Depth** Stormwater Inputs/mile = >2<=5 (Moderate) **Decreased Stream Power - Slope** GC & Constrictions/mile = >2<=5 (Moderate) **Decreased Stream Power - Depth** No Significant Impacts	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness L Buffer dominant= >25ft Bed = larger than coarse gravel **Decreased Boundary Resistance** Bank Cohesive = No R Buffer dominant= <25ft Bank armoring = L = High, R = High
T2.02C	Not Assessed - Beaver Dam influence and bedrock gorge			
T4.01	**Increased Flows** Stormwater Inputs/mile = <2 (Low) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) P2 corridor dominant = Pasture/Hay Field ditches and tile drains	**Increased Load** Crop land use = watershed = >=<5<10% (Mod) Crop land use = subwatershed = <=5% (Low) P2 corridor dominant = Pasture/Hay Deposition Features/mile = >5 (High) Erosion Features = High	**Increased Stream Power - Slope** Straightening = >20% (High) **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** Deposition Features/mile = >2<=5 (Moderate)	**Increased Boundary Resistance** Bank Cohesive = Yes Bed = larger than coarse gravel **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bank erosion = L = >20%, R = >20%
T4.03	**Increased Flows** Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low)	**Increased Load** Crop land use = watershed = >=<5<10% (Mod) Crop land use = subwatershed = <=5% (Low) Erosion Featrues = Low/Moderate Deposition Features/mile = >5 (High)	**Increased Stream Power - Slope** No Significant Impacts **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** GC & Constrictions/mile = >2<=5 (Moderate) **Decreased Stream Power - Depth** Deposition Features/mile = >5 (High)	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness L Buffer dominant= >25ft R Buffer dominant= >25ft Bed = larger than coarse gravel Bank Cohesive = Yes **Decreased Boundary Resistance** No Significant Impacts
T4.04A	**Increased Flows** Stormwater Inputs/mile = <2 (Low) Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Hay/Pasture	**Increased Load** Crop land use = watershed = >=<5<10% (Mod) Crop land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Hay/Pasture Deposition Features/mile = >2<=5 (Moderate) Erosion Features = Low/Moderate	**Increased Stream Power - Slope** No Significant Impacts **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** GC & Constrictions/mile = >5 (High) **Decreased Stream Power - Depth** No Significant Impacts	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness L Buffer dominant= >25ft R Buffer dominant= >25ft Bed = larger than coarse gravel Bank Cohesive = Yes **Decreased Boundary Resistance** Bank armoring = L = Moderate, R = Low Bank erosion = L = >5<=20%, R = <5%

The River Stressor ID Table shows the various stressors and conditions which are contributing to increased or decreased flow, sediment load, channel slope, power, and boundary resistance at both the watershed and reach scales.
The red descriptor in each cell describes the overall stressor, while the parameters listed below describe what factors are contributing to or indicative of that stressor (i.e. reduced buffer widths cause decreased boundary resistance, while increased buffer widths increase boundary resistance and help resist bank erosion). More detailed desriptions of these stressors are provided in the appropriate text section of the report.
L and R refers to left and right side of channel when looking downstream

Table 2: River Stressor ID Table - Black Creek

River Segment ID	Watershed Scale Stressors		Reach Scale Stressors	
	Hydrologic (Figures 6, 7, 8, and 9)	Sediment Load (Figures 7, 8, 9, and 10)	Stream Power (Figures 11 and 12)	Boundary Resistance (Figure 13)
T4.04B	**Increased Flows** Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Hay/Forest	**Increased Load** Crop land use = watershed = >=<5<10% (Mod) Crop land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Hay/Forest Deposition Features/mile = >5 (High) Erosion Features = Moderate/High Mass Failures = 1	**Increased Stream Power - Slope** Straightening = >5<=20% (Moderate) **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** Beaver Dams = 2 **Decreased Stream Power - Depth** Gravel Mining	**Increased Boundary Resistance** Bank Cohesive = Yes Bed = larger than coarse gravel **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bank erosion = L = >20%, R = >=5<20% Bank armoring = L = Low, R = Low
T4.05A	**Increased Flows** Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) P2 corridor dominant = Crop/Pasture	**Increased Load** Crop land use = watershed = >=<5<10% (Mod) Crop land use = subwatershed = <5% (Low) P2 corridor dominant = Crop/Pasture Deposition Features/mile = >5 (High) Erosion Features = Low/Moderate	**Increased Stream Power - Slope** Straightening = >20% (High) Encroachments = Low **Increased Stream Power - Depth** Berms/roads = >20% (High) **Decreased Stream Power - Slope** GC & Constrictions/mile = >2<=5 (Moderate) **Decreased Stream Power - Depth** Deposition Features/mile = >2<=5 (Moderate)	**Increased Boundary Resistance** Bed = larger than coarse gravel **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bank Cohesive = No Bank erosion = L = >=5<20%, R = <5% Bank armoring = L = Moderate, R = Moderate
T4.05B	**Increased Flows** Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low)	**Increased Load** Crop land use = watershed = >=<5<10% (Mod) Crop land use = subwatershed = <5% (Low) Deposition Features/mile = >5 (High)	**Increased Stream Power - Slope** No Significant Impacts **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** GC & Constrictions/mile = >5 (High) **Decreased Stream Power - Depth** No Significant Impacts	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness L Buffer dominant= >25ft R Buffer dominant= >25ft Bed = larger than coarse gravel **Decreased Boundary Resistance** Bank Cohesive = No
M6T6.01	Not Assessed - No Landowner Permission			
M9T8.01A	**Increased Flows** Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) P2 corridor dominant = Hay/Forest	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = <5% (Low) P2 corridor dominant = Hay/Forest Deposition Features/mile = >5 (High) Erosion Features = Moderate	**Increased Stream Power - Slope** Straightening = >5<=20% (Moderate) **Increased Stream Power - Depth** No Significant Impacts **Decreased Stream Power - Slope** Beaver Dams = 1 **Decreased Stream Power - Depth** Deposition Features/mile = >5 (High)	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness R Buffer dominant= >25ft Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant = <25 ft Bed = smaller than coarse gravel Bank erosion = L = >20%, R = <5%
M9T8.01B	Not Assessed - Wetland/beaver activity			

The River Stressor ID Table shows the various stressors and conditions which are contributing to increased or decreased flow, sediment load, channel slope, power, and boundary resistance at both the watershed and reach scales.
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L and R refers to left and right side of channel when looking downstream

Table 2: River Stressor ID Table - Black Creek

River Segment ID	Watershed Scale Stressors		Reach Scale Stressors	
	Hydrologic (Figures 6, 7, 8, and 9)	Sediment Load (Figures 7, 8, 9, and 10)	Stream Power (Figures 11 and 12)	Boundary Resistance (Figure 13)
M9T8.01C	**Increased Flows** Urban land use = Watershed = <5% (Low) Urban Land use = subwatershed = <5% (Low) P2 corridor dominant = Crop/Forest	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = >=10<20% (High) P2 corridor dominant = Crop/Forest Deposition Features/mile = >5 (High) Erosion Features = Moderate	**Increased Stream Power - Slope** Straightening = >20% (High) Encroacments = High **Increased Stream Power - Depth** Berms/roads = >20% (High) **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** Deposition Features/mile = >5 (High)	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness L Buffer dominant= >25ft R Buffer dominant= >25ft Bed = larger than coarse gravel **Decreased Boundary Resistance** Bank Cohesive = No Bank erosion = L = >=5<20%, R = >=5<20%
M9T8.1S1.01	Not Assessed - Wetland/beaver activity and bedrock gorge			
M9T8.1S1.02A	Not Assessed - Wetland/beaver activity			
M9T8.1S1.02B	**Increased Flows** Stormwater Inputs/mile = >5 (High) Urban land use = Watershed = >=5<10% (Moderate) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Forest/Pasture Tile Drains	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = <5% (Low) P2 corridor dominant = Forest/Pasture Deposition Features/mile = >5 (High) Erosion Features = Moderate	**Increased Stream Power - Slope** No Significant Impacts **Increased Stream Power - Depth** Stormwater Inputs/mile = >5 (High) **Decreased Stream Power - Slope** No Significant Impacts **Decreased Stream Power - Depth** Deposition Features/mile = >5 (High)	**Increased Boundary Resistance** Riparian Veg./bank cohesiveness L Buffer dominant= >25ft R Buffer dominant= >25ft Bed = larger than coarse gravel Bank Cohesive = Yes **Decreased Boundary Resistance** Bank erosion = L = >=5<20%, R = >=5<20%
M9T8.1S1.02C	**Increased Flows** Urban land use = Watershed = >=5<10% (Moderate) Urban Land use = subwatershed = >=5<10% (Mod) P2 corridor dominant = Pasture	**Increased Load** Crop land use = watershed = <5% (Low) Crop land use = subwatershed = <5% (Low) P2 corridor dominant = Pasture Deposition Features/mile = >5 (High) Erosion Features = Moderate/High	**Increased Stream Power - Slope** Straightening = >20% (High) **Increased Stream Power - Depth** Berms/Roads = >5<=20% (Moderate) **Decreased Stream Power - Slope** GC & Constrictions/mile = >5 (High) **Decreased Stream Power - Depth** Deposition Features/mile = >5 (High)	**Increased Boundary Resistance** Bank Cohesive = Yes **Decreased Boundary Resistance** L Buffer dominant= <25ft R Buffer dominant= <25ft Bed = smaller than coarse gravel Bank erosion = L = >5<=20% R = >20%
M9T8.1S1.02D	Not Assessed - Wetland/beaver activity			

The River Stressor ID Table shows the various stressors and conditions which are contributing to increased or decreased flow, sediment load, channel slope, power, and boundary resistance at both the watershed and reach scales.
The red descriptor in each cell describes the overall stressor, while the parameters listed below describe what factors are contributing to or indicative of that stressor (i.e. reduced buffer widths cause decreased boundary resistance, while increased buffer widths increase boundary resistance and help resist bank erosion). More detailed desriptions of these stressors are provided in the appropriate text section of the report.
L and R refers to left and right side of channel when looking downstream

Legend

Stormwater Inputs

Stormwater Inputs/Mile

<=2

>2 <= 5

Reach/Segment Break

Phase 2 Assessed Reaches

Phase 2 Non-Assessed Reaches

Roads

M01

M02

T202.C

T2.02B

T2.02A

T2.01A

T2.01B

M03A

M03B

M04A

M04B

T4.01

T4.03

T4.04A

1

T4.04B

T4.05A

T4.05B

Match Line

BOUCHARD RD

PLEASANT

CROWE H

MAIN

BRIDGE

TH 25

CENTRAL

SHELDON WOODS RD

JOHNSON DR

SHELDON WOODS RD

NAPOLI RD

NAPOLI RD 3

POND RD

MCKENZIE RD

YATES CAMP RD

GIRARD RD

SWIZLER'S PT

CRONIN RD

POND RD

WHITE'S RD

SIMONDS RD

MADDEN RD

REYNOLDS RD

TOWN HWY 40

BARRY RD

TH 27

MENARD RD

NORTH RD

TH 28

CASTLE RD

CONNOR RD

CHURCH RD

ROUTE 36

SOUTH RD

TH 46

SOULE DR

PARK

GILBERT HILL RD

BRANON RD

PARADEE RD

WANZER RD

EMCH RD

TALCOTT RD

TIFFANY RD

NORTHROP RD

PUMPKIN VILLAGE RD

CHESTER A ARTHUR RD

Feet

0 1,250 2,500 5,000

Quebec

VT

NY

NH

Figure 6a: Hydrologic Alterations Map
Black Creek Watershed
Mouth Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date:

Scale: 1" = 2500' Project: 3-1313-3

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Legend

Stormwater Input

Stormwater Inputs/mile

<=2

>2 <= 5

> 5

Reach/Segment Break

Phase 2 Assessed Reaches

Phase 2 Non-Assessed Reaches

Roads

Match Line

M05A

M05B

M06

M07

M6T6.01

M08

M09A

M09B

M9T8.1S1.02

M9T8.1S1.01

M9T8.01

A

B

C

D

RYAN RD

SPRING HILL RD

TH 32

SHENANG RD

DODD RD

MITCHELL RD

TH 35

ROUTE 36

TH 48

BRUSO

JOHNNY BULL HILL

EGYPT RD

ELM BROOK RD

BRIDGE

SCHOOL

NEW

LAWYER RD

FAIRFIELD RD

CROSS RD

SHERMAN ST

WHITELAND DR

OLD CREAMERY DR

MILL

MOREY RD

BOOT HILL RD

WHITNEY RD

ROMAR RD

BARRYWILDE RD

LAPLAND RD

STRATTON RD

LAPLAND EXT

METCALFE POND RD

LOST NATION RD

CASSEL RD

GOATPATH RD

ROUTE 108 S

HOWRIGAN RD

TAYLOR RD

NOBLE RD

Quebec

VT

NY

NH

Feet

0 1,250 2,500 5,000

Figure 6b: Hydrologic Alterations Map
Black Creek Watershed
Head Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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4.1.1.2 Stormwater Runoff

Stormwater inputs affect the hydrologic regime by increasing the peak flow during high flow events. In addition, impervious surfaces such as roads and buildings reduce the attenuation of rainfall through infiltration and increase the rate and volume of precipitation that reaches the stream channel. The stormwater symbols depicted on Figures 6a and 6b include agricultural ditches and drainage tile inlets, as well as storm drains and other "end of pipe" inputs into the stream channel. The River Stressor ID Table breaks stormwater impacts down into three categories based on the number of stormwater inputs identified per mile of assessed stream (<=2 (low), >2<=5 (moderate), and >5 (high)). Black Creek is dominated by agricultural and forest land except for sparse residential development along the roadways. An abundance of field ditches and tile drains are present, particularly in the lower reaches M01 through M07. These ditch networks reduce the amount of precipitation which infiltrates into the ground and increases the volume and velocity of water entering the stream channel, thereby increasing flood and erosion hazards.

4.1.1.3 Dams

Dams change the hydrologic regime of a watershed by altering the timing, duration, and volume of large flow events. While many river systems throughout Vermont are influenced by dams, Black Creek is not one of them. No human constructed dams were identified within the study area with the exception of M07, where the remnants of a former dam were noted. The impacts of this dam are minimal, as it is constructed in a naturally occurring bedrock gorge. Several beaver dams were identified in the watershed. While they can influence the flow patterns of small portions of a reach, these features are generally transient and not large enough to have a significant impact on the overall hydrologic regime.

4.1.1.4 Land Use and Land Cover

As described above, land use and land cover have a significant impact on the hydrologic regime of a watershed, particularly small intensely agricultural ones such as Black Creek. Figures 7, 8, and 9 show the current land use and cover for the study area. As is evident on

Figures 7 and 9, agriculture is by far the dominant land use in the watershed, however urbanization and road density are also contributing factors to changes in hydrology. Table 2 shows the percent urbanization for each reach. Altered hydrology may be a significant stressor once urban land use reaches greater then 5% of the watershed (VT ANR, 2007). While the Black Creek watershed is a rather rural community, the urban land use within the study area is still slightly greater than 5% for many reaches. This urban and agricultural land use has caused an increase in the magnitude and duration of large flow events through increased runoff and decreased infiltration capacity. This is particularly true in agricultural lands that were converted from wetlands. As is shown in Figures 9a and 9b, a majority of the historic wetlands have been converted into agricultural land through subsurface drainage and ditching. The light green layer on Figure 9 represents significant wetlands, including swamps, bogs, and other areas normally saturated for most of the year. The dark green layer represents hydric soils, or areas where the soil is saturated for a minimum of two weeks each year, but usually dries out for a period of time in the summer months. Large areas of both types of wetlands have been converted to agricultural use. Wetlands are very important flood mitigation features, capturing excess rainfall or snowmelt and slowly releasing it into the surrounding soils. The conversion of these wetlands not only increases the magnitude and rate of runoff into the stream channel, it also increases the sediment and nutrient inputs into the system as fertilizers and topsoil are washed from the land surface. These and other sediment load stressors are discussed below.

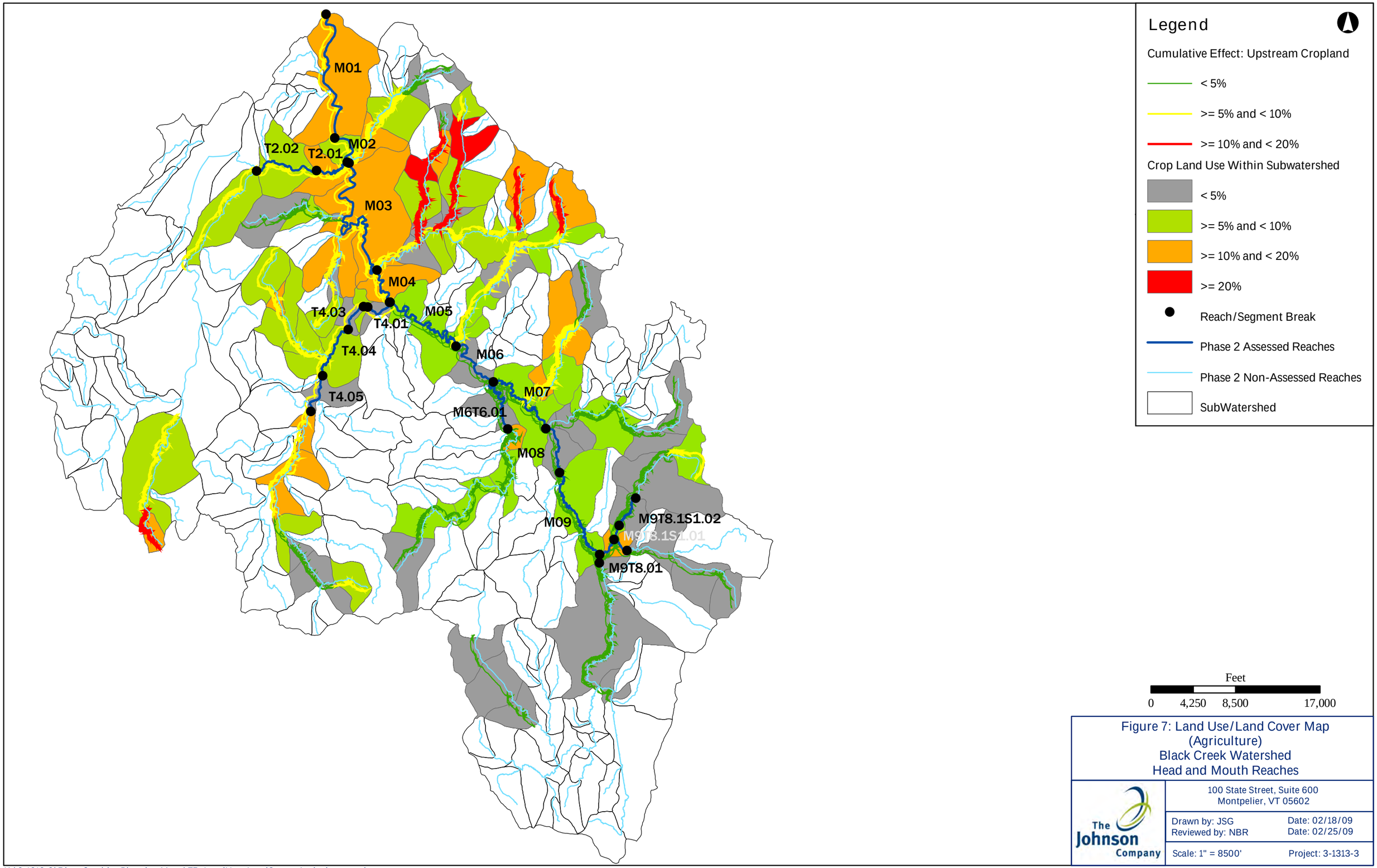

Figure 7: Land Use/Land Cover Map
(Agriculture)
Black Creek Watershed
Head and Mouth Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 8500' Project: 3-1313-3

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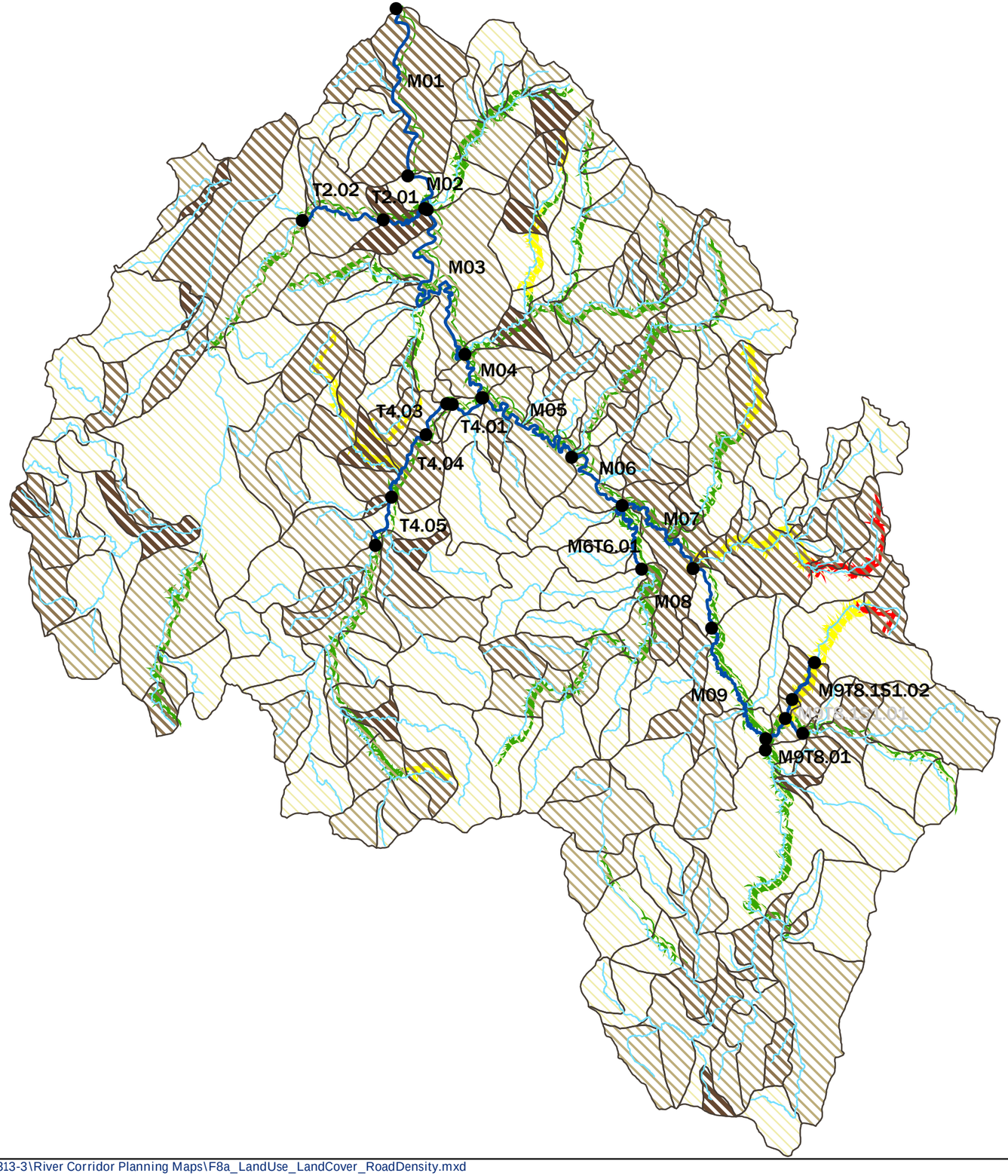

Legend

Road Density (sq.mi. road / sq.mi. subwatershed)

- 0 - 1
- 2
- 3
- 4 - 6

Cumulative Upstream Urbanization

- < 5%
- >= 5% and < 10%
- >= 10% and < 20%
- Reach Break
- Phase 2 Assessed Reaches
- Phase 2 Non-Assessed Reaches
- SubWatershed

Feet

0 4,250 8,500 17,000

Figure 8a: Land Use/Land Cover Map
(Road Density)
Black Creek Watershed
Head and Mouth Reaches

The Johnson Company
100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 8500' Project: 3-1313-3

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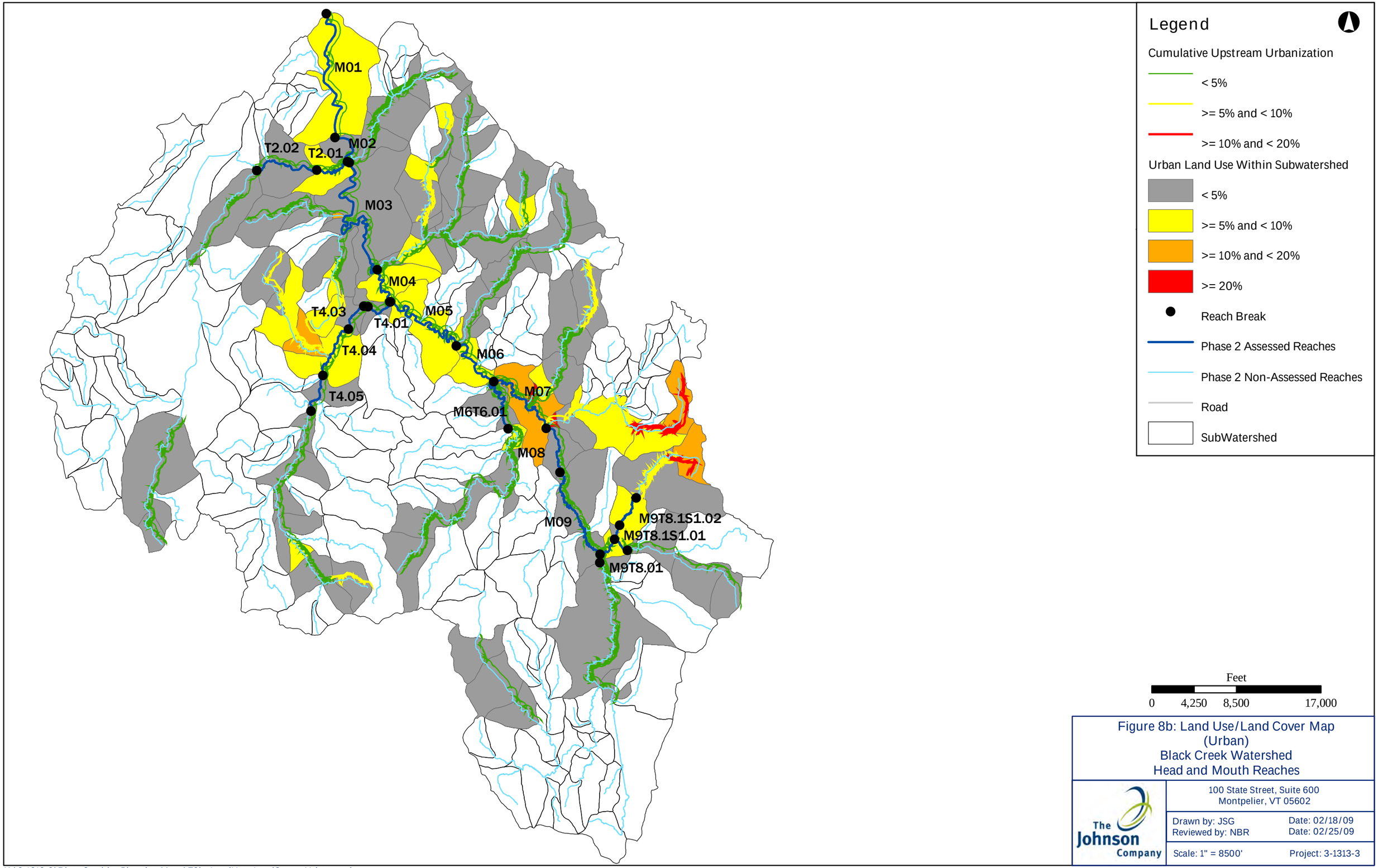

Figure 8b: Land Use/Land Cover Map (Urban)
Black Creek Watershed
Head and Mouth Reaches

The Johnson Company
100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 8500' Project: 3-1313-3

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Legend

Agricultural Land Use

Significant Wetlands

Hydric Soils

Reach/Segment Break

Phase 2 Assessed Reaches

Phase 2 Non-Assessed Reaches

Roads

M01

M02

M03A

M03B

M04A

M04B

T2.02B

T2.02A

T2.01A

T2.01B

T4.01

T4.03

T4.04A

T4.04B

T4.05A

T4.05B

Match Line

BOUCHARD RD

PLEASANT

CROWE H

MAIN

BRIDGE

TH 25

CENTRAL

SHELDON WOODS RD

JOHNSON DR

NAPOLI RD

POND RD

MCKENZIE RD

GIRARD RD

SWIZLER'S PT

CRONIN RD

WHITE'S RD

SIMONDS RD

REYNOLDS RD

MADDEN RD

MENARD RD

NORTHROP RD

TALCOTT RD

TIFFANY RD

PUMPKIN VILLAGE RD

PARADEE RD

WANZER RD

TOWN HWY 40

BARRY RD

TH 27

TH 28

NORTH RD

CASTLE RD

CONNOR RD

CHESTER A ARTHUR RD

CHURCH RD

ROUTE 36

SOUTH RD

PARK

GILBERT HILL RD

BRANON RD

BMCH RD

TH 46

Quebec

VT

NY

NH

Feet

0 1,250 2,500 5,000

Figure 9a: Land Use/Land Cover Map
(Wetlands)
Black Creek Watershed
Mouth Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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Legend

Agricultural Land Use

Significant Wetlands

Hydric Soils

Reach/Segment Break

Phase 2 Assessed Reaches

Phase 2 Non-Assessed Reaches

Roads

Match Line

M05A

M05B

M06

M07

M6T6.01

M08

M09A

M09B

M9T8.1S1.02

M9T8.1S1.01

M9T8.01

A

B

C

D

RYAN RD

SPRING HILL RD

TH 32

SHENANG RD

DODD RD

MITCHELL RD

TH 35

ROUTE 36

TH 12

BRUSO RD

JOHNNY BULL HILL RD

EGYPT RD

ELM BROOK RD

NEW

TH 48

WHITELAND DR

SHERMAN ST

OLD CREAMERY DR

FAIRFIELD RD

CROSS RD

LAWYER RD

MOREY RD

BOOT HILL RD

WHITNEY RD

ROMAR RD

BARRYWILDE RD

LAPLAND RD

LAPLAND EXT

METCALFE POND RD

CASSEL RD

LOST NATION RD

GOAT PATH RD

ROUTE 108 S

HOWRIGAN RD

TAYLOR RD

NOBLE RD

Quebec

VT

NY

NH

Feet

0 1,250 2,500 5,000

Figure 9b: Land Use / Land Cover Map
(Wetlands)
Black Creek Watershed
Head Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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4.1.2 Sediment Regime Stressors

The sediment regime is defined as the quantity, size, transport, sorting, and distribution of sediments which are influenced by the proximity of sediment sources, the hydrologic regime, as well as the valley, stream, and floodplain characteristics (VT ANR, 2007). The sediment regime may be split into two types of sediment: wash load and bed load. Wash load refers to finer grained materials which become suspended in the water column at higher flows and eventually settle out under lower flows and velocity, typically on floodplains and the inside of meander bends as flood waters recede. When these features are absent from a watershed, wash load sediments may remain suspended in the water column until they reach a larger receiving body of water. Bed load sediments are comprised of coarser materials that move during high flow events by rolling along the stream bed until they encounter areas of lesser energy. A watershed in equilibrium has a consistent pattern and movement of wash and bed loads. When this pattern is disrupted, aquatic habitat, water quality, and stream morphology are affected. (VT ANR, 2007).

4.1.2.1 Watershed Scale Sediment Regime Stressors

Because the sediment regime is closely linked to a stream's hydrologic characteristics, many of the same stressors discussed above will have an impact on the watershed-wide sediment regime. Many of the existing hydrologic stressors such as stormwater inputs, increased runoff from agricultural fields, and urbanization, not only cause increased flows, but also increased bed and wash loads due to lack of sediment attenuation sites and increased surface runoff. In addition, the increased flows can cause production of in-stream sediment from erosion of the stream banks and bed. As previously shown in Table 2, all of the assessed reaches have increased sediment load caused by one or more of these hydrologic stressors. Figures 10a and 10b show the sediment load indicators for the study area. The increased sediment load is evident in the number of deposition features present (particularly in Reaches T2.01, T2.02, T4.01, T4.03, T4.04, and T4.05) as well as the extensive erosion noted in many of the mainstem reaches.

Legend

Mass Failure

Steep Riffle

Bank Erosion

Deposition / mile

<=2

>2 <= 5

> 5

Reach/Segment Break

Phase 2 Assessed Reaches

Phase 2 Non-Assessed Reaches

Roads

M01

M02

T202.C

T2.02B

T2.02A

T2.01A

T2.01B

M03A

M03B

M04A

M04B

T4.01

T4.03

T4.04A

T4.04B

T4.05A

T4.05B

Match Line

Quebec

VT

NY

NH

Feet

0 1,250 2,500 5,000

Figure 10a: Sediment Load Indicators Map
Black Creek Watershed
Mouth Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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Legend

Mass Failure

Steep Riffle

Bank Erosion

Deposition / mile

<=2

>2 <= 5

> 5

Reach/Segment Break

Phase 2 Assessed Reaches

Phase 2 Non-Assessed Reaches

Roads

Match Line

M05A

M05B

M06

M07

M6T6.01

M08

M09A

M09B

M9T8.1S1.02

M9T8.1S1.01

M9T8.01

A

B

C

D

RYAN RD

SPRING HILL RD

TH 32

DODD RD

MITCHELL RD

TH 35

SHENANG RD

ROUTE 36

TH

BRUSO RD

JOHNNY BULL HILL

EGYPT RD

ELM BROOK RD

NEW

BRIDGE

SCHOOL

TH 48

WHITELAND DR

LAWYER RD

FAIRFIELD RD

CROSS RD

SHERMAN ST

OLD CREAMERY DR

MILL

MOREY RD

BOOT HILL RD

WHITNEY RD

ROMAR RD

BARRYWILDE RD

LAPLAND RD

STRATTON RD

LAPLAND EXT

METCALFE POND RD

LOST NATION RD

CASSEL RD

GOATPATH RD

ROUTE 108 S

HOWRIGAN RD

TAYLOR RD

NOBLE RD

Quebec

VT

NY

NH

Feet

0 1,250 2,500 5,000

Figure 10b: Sediment Load Indicators Map
Black Creek Watershed
Head Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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4.1.2.2 Reach Scale Sediment Regime Stressors

Just as hydrologic alterations can affect the watershed wide sediment regime, modifications to the valley, channel, floodplain, and boundary conditions at the reach scale can change the hydrology and sediment transport capacity. Reach scale stressors can affect either stream power (increase or decrease in stream channel slope or depth) or the resistance to stream power known as boundary conditions (VT ANR, 2007). Examples of human related activities which can increase stream power through slope and depth changes are channel straightening, dredging, berming, and undersized bridges and culverts. Structures such as dams and weirs can lead to a decrease in stream power. Boundary resistance is increased through armoring and placement of grade controls or decreased by removal of riparian vegetation and dredging. A summary of these reach scale stressors is shown on Table 2.

Reach scale channel slope modifiers are summarized on Figures 11a and 11b. Many of the assessed reaches within Black Creek watershed exhibit stressors related to channel slope increases including extensive straightening, and human related encroachments within the river corridor including roads, railroad berms, and development. Stressors related to decreased channel slope are also common in the watershed including multiple undersized bridges and culverts, beaver dams, and bedrock grade controls. Reach scale channel depth modifiers are shown on Figures 12a and 12b. The main stressors associated with increased channel depth are roads, corridor encroachments from the abandoned railroad bed, residential development, stormwater inputs, and bridges and culverts, all of which are common throughout the watershed. Channel depth decreases are caused by dredging, beaver dams, and an overabundance of deposition features. Those reaches with significant channel depth decreases include M04, M06, T2.01, T4.01, T4.03, M9T8.01, and M9T8.1S1.02. Many of the reaches within the watershed contain multiple stressors which are affecting both the stream slope and depth.

Legend

Slope Decreases

- Natural Grade Controls
- Beaver Dam
- Bridge or Culvert

Slope Increases

- Encroachment / Development
- Straightening
- Reach/Segment Break
- Phase 2 Assessed Reaches
- Phase 2 Non-Assessed Reaches
- Roads

M01
M02
T202.C
T2.02B
T2.02A
T2.01A
T2.01B
M03A
M03B
M04A
M04B
T4.01
T4.03
T4.04A
T4.04B
T4.05A
T4.05B

Match Line

Quebec
VT
NY
NH

Feet
0 1,250 2,500 5,000

Figure 11a: Channel Slope Modifiers Map
Black Creek Watershed
Mouth Reaches

The Johnson Company
100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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Legend

Slope Decreases

- Natural Grade Controls
- Human Constructed Grade Control
- Beaver Dam
- Bridge or Culvert

Slope Increases

- Encroachment / Development
- Straightening
- Reach/Segment Break
- Phase 2 Assessed Reaches
- Phase 2 Non-Assessed Reaches
- Roads

Match Line

M05A

M05B

M06

M6T6.01

M07

M08

M09A

M09B

M9T8.1S1.02

M9T8.1S1.01

M9T8.01

RYAN RD
SPRING HILL RD
TH 32
SHENANG RD
DODD RD
MITCHELL RD
ROUTE 36
BRUSH RD
JOHNNY BULL HILL
EGYPT RD
ELM BROOK RD
NEW
BRIDGE
SCHOOL
WHITELAW DR
TH 48
LAWYER RD
FAIRFIELD RD
CROSS RD
SHERMAN ST
OLD CREAMERY DR
MILL
MOREY RD
BOOT HILL RD
WHITNEY RD
ROMAR RD
BARRYWILDE RD
LAPLAND RD
STRATTON RD
LAPLAND EXT
METCALFE POND RD
LOST NATION RD
CASSEL RD
GOATPATH RD
ROUTE 108 S
HOWRIGAN RD
TAYLOR RD
NOBLE RD

Quebec
VT
NY
NH

Feet
0 1,250 2,500 5,000

Figure 11b: Channel Slope Modifiers Map
Black Creek Watershed
Head Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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Legend

Depth Increases

- Stormwater Input
- Bridge or Culbert
- Berm, Railroad or Road

Phase 2 Encroachment Percentage

- <5%
- >5% <=20%
- >20%

Depth Decreases

- Beaver Dam
- Dredging or Gravel Mining

Deposition / mile

- <=2
- >2 <= 5
- > 5

- Reach/Segment Break
- Phase 2 Assessed Reaches
- Phase 2 Non-Assessed Reaches
- Roads

T202.C
T2.02B
T2.02A
T2.01A
T2.01B
M01
M02
M03A
M03B
M04A
M04B
T4.01
T4.03
T4.04A
T4.04B
T4.05A
T4.05B

Match Line

Feet
0 1,250 2,500 5,000

Quebec
VT
NY
NH

Figure 12a: Channel Depth Modifiers Map
Black Creek Watershed
Mouth Reaches

The Johnson Company
100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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Match Line

M05A

M05B

M06

M6T6.01

M07

M08

M09A

M09B

M9T8.1S1.02

M9T8.1S1.01

M9T8.01

A

B

C

D

RYAN RD

SPRING HILL RD

TH 32

SHENANG RD

DODD RD

MITCHELL RD

TH 35

ROUTE 36

JOHNNY BULL HILL

ELM BROOK RD

EGYPT RD

LAWYER RD

FAIRFIELD RD

CROSS RD

TH 48

SHERMAN ST

OLD CREAMERY DR

MILL

MOREY RD

BOOT HILL RD

WHITNEY RD

ROMAR RD

BARRYWILDE RD

LAPLAND RD

STRATTON RD

LAPLAND EXT

METCALFE POND RD

LOST NATION RD

CASSEL RD

GOATPATH RD

ROUTE 108 S

HOWRIGAN RD

TAYLOR RD

NOBLE RD

Legend

Depth Increases

- Stormwater Input
- Bridge or Culbert
- Berm, Railroad or Road

Phase 2 Encroachment Percentage

- <5%
- >5% <=20%
- >20%

Depth Decreases

- Beaver Dam
- Dredging or Gravel Mining

Deposition / mile

- <=2
- >2 <= 5
- > 5

- Reach/Segment Break
- Phase 2 Assessed Reaches
- Phase 2 Non-Assessed Reaches
- Roads

Quebec

VT

NY

NH

Feet

0 1,250 2,500 5,000

Figure 12b: Channel Depth Modifiers Map
Black Creek Watershed
Head Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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In addition to the increased channel slope and depth, a significant reduction in the channel boundary resistance has occurred through a reduction in bank vegetation and buffer. Normally woody vegetation located along the stream channel will withstand some of the stream energy produced during flood events and help prevent excessive erosion and channel migration. Woody buffer vegetation will also filter out sediment and nutrients before they reach the channel and enhance aquatic habitat by moderating water temperatures and providing food and habitat structure for aquatic organisms. Decreased Boundary Conditions and Riparian Modifiers Maps are shown as Figures 13a and 13b. The decreased boundary resistance in Black Creek is caused by the lack of woody buffer along nearly every reach except T2.02, T4.03, and T4.04. Increased Boundary Conditions and Riparian Modifiers Maps are shown as Figures 13c and 13d. The naturally cohesive silt and clay soils present within many reaches act to increase boundary resistance and may explain why more widespread erosion is not present in the watershed. Natural grade controls present in M01, M07, T2.01, T2.02, T4.04, and T4.05 also help stabilize the stream channel and reduce erosion.

Legend

Dredging or Gravel Mining
Bank Armoring
Bank Erosion
Buffer less than 25 ft
Reach/Segment Break
Phase 2 Assessed Reaches
Phase 2 Non-Assessed Reaches
Roads

M01
M02
M03A
M03B
M04A
M04B
T4.01
T4.03
T4.04A
T4.04B
T4.05A
T4.05B
T2.01A
T2.01B
T2.02A
T2.02B
T202.0
1

Match Line

Quebec
VT
NY
NH

Feet
0 1,250 2,500 5,000

Figure 13a: Boundary Conditions and Riparian Modifiers Map (Decreased Boundary Resistance)
Black Creek Watershed
Mouth Reaches

The Johnson Company
100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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Legend

Dredging or Gravel Mining
Bank Armoring
Bank Erosion
Buffer less than 25 ft
Reach/Segment Break
Phase 2 Assessed Reaches
Phase 2 Non-Assessed Reaches
Roads

Match Line

M05A
M05B
M06
M6T6.01
M07
M08
M09A
M09B
M9T8.1S1.02
M9T8.1S1.01
M9T8.01
A
B
C
D

RYAN RD
SPRING HILL RD
TH 32
DODD RD
MITCHELL RD
TH 35
SHENANG RD
ROUTE 36
JOHNNY BULL HILL
EGYPT RD
ELM BROOK RD
NEW BRIDGE
SCHOOL
TH 48
LAWYER RD
FAIRFIELD RD
CROSS RD
SHERMAN ST
WHITELAND DR
OLD CREAMERY DR
MILL
MOREY RD
BOOT HILL RD
WHITNEY RD
BARRYWILDE RD
ROMAR RD
LAPLAND RD
STRATTON RD
LAPLAND EXT
METCALFE POND RD
LOST NATION RD
CASSEL RD
GOATPATH RD
ROUTE 108 S
HOWRIGAN RD
TAYLOR RD
NOBLE RD

Quebec
VT
NY
NH

Feet
0 1,250 2,500 5,000

Figure 13b: Boundary Conditions and Riparian Modifiers Map (Decreased Boundary Resistance)
Black Creek Watershed
Head Reaches

The Johnson Company

100 State Street, Suite 600
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Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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Legend

- Natural Grade Controls
- Phase 2 Cohesive Bank
- Phase 2 Coarse Bed
- Reach/Segment Break
- Phase 2 Assessed Reaches
- Phase 2 Non-Assessed Reaches
- Roads

M01
M02
M03A
M03B
M04A
M04B
T4.01
T4.03
T4.04A
T4.04B
T4.05A
T4.05B
T2.01A
T2.01B
T2.02A
T2.02B
T202.C

Match Line

Quebec
VT
NY
NH

Feet
0 1,250 2,500 5,000

Figure 13c: Boundary Conditions and Riparian Modifiers Map (Increased Boundary Resistance)
Black Creek Watershed
Mouth Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

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Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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Legend

- Natural Grade Control
- Human Constructed Grade Control
- Phase 2 Cohesive Bank
- Phase 2 Coarse Bed
- Reach/Segment Break
- Phase 2 Assessed Reaches
- Phase 2 Non-Assessed Reaches
- Roads

Match Line

M05A
M05B
M06
M07
M6T6.01
M08
M09A
M09B
M9T8.1S1.02
M9T8.1S1.01
M9T8.01
A
B
C
D

RYAN RD
SPRING HILL RD
TH 32
SHENANG RD
DODD RD
MITCHELL RD
ROUTE 36
TH 32
BRUSO RD
JOHNNY BULL HILL
EGYPT RD
ELM BROOK RD
BRIDGE
SCHOOL
NEW
TH 48
WHITELAND DR
LAWYER RD
FAIRFIELD RD
CROSS RD
SHERMAN ST
OLD CREAMERY DR
MILL
MOREY RD
BOOT HILL RD
WHITNEY RD
ROMAR RD
BARRYWILDE RD
LAPLAND RD
STRATTON RD
LAPLAND EXT
METCALFE POND RD
LOST NATION RD
CASSEL RD
GOAT PATH RD
ROUTE 105 S
HOWRIGAN RD
TAYLOR RD
NOBLE RD

Quebec
VT
NY
NH

Feet
0 1,250 2,500 5,000

Figure 13d: Boundary Conditions and Riparian Modifiers Map (Increased Boundary Resistance)
Black Creek Watershed
Head Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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4.1.3 Constraints to Sediment Transport and Attenuation

Streams in equilibrium are continuously moving sediment through the watershed from upstream to downstream. The type and amount of sediment are dictated by the size and overall slope of the watershed and the type of geologic material through which the stream flows. Understanding the transport and storage of sediment within a watershed is one of the most important aspects of river corridor restoration. Changes or modifications to watershed inputs and hydraulic geometry create disequilibrium and lead to an uneven distribution of stream power and sediment. This disequilibrium is manifested through large and small scale channel adjustments such as excessive erosion and deposition. These adjustments will continue until the stream returns itself to an equilibrium state where a balance between flow and sediment transport and attenuation is achieved (VT ANR, 2007).

Table 3, Departure Analysis Table, presents data on sediment transport and Table 4, Sediment Regime Table, shows the sediment regime for the study area and how it has changed from its reference regime. This information is presented graphically in Figures 14a and 14b along with lateral constraints present within the river corridor including roads, bridges, and homes. With the exception of T2.01B, T4.03, and T4.04A (which are located in naturally narrow portions of the valley and act as transport systems), nearly the entire watershed has historically had a coarse equilibrium and fine deposition sediment regime. This means that the stream was in balance and the sediment inputs essentially equaled the sediment outputs. Fine sediments and nutrients were stored on the floodplain during high flow events, and generally the system was in equilibrium. Currently, much of the study area has retained this function, though human encroachments and land use conversion has limited the amount of floodplain available and reduced the nutrient retention capacity of that floodplain. A few of the assessed reaches (M03B, M05, T4.01, T4.04B, and T4.05A) have been converted to a fine source and transport regime where less sediment and nutrient attenuation is occurring because the channel has lost some of its historic floodplain access. The consequence of this conversion is that sediment and nutrients are no longer retained in the watershed, but carried downstream to other reaches and

receiving bodies of water, namely the Missisquoi River and ultimately Lake Champlain. As shown in Table 3, all of the reaches have opportunities for increased sediment storage through floodplain restoration and riparian buffer implementation given the limited number of constraints from roads, bridges, homes and other development (Figures 14a and 14b). Lateral constraints are shown for the entire watershed and may be helpful for future restoration and/or town planning efforts. Implementing these measures will require conversion of some agricultural land to vegetated buffer. More information about how these altered sediment regimes play into river corridor restoration and conservation projects for the area are described in Section 5.

Table 3: Departure Analysis Table - Black Creek

	Existing Constraints Which May Limit Restoration Opportunities		Transport[1]		Attenuation (sediment/nutrient storage)[2]		
River Segment	Vertical	Lateral	Natural	Converted	Natural	Increased	Asset
M01	Natural - Bedrock Grade Control	Human - Roads, Bridges, Berms, Houses, and Agriculture					X
M02A		Human - Agriculture					X
M03A		Human - Roads, Bridges, Berms, and Agriculture					X
M03B		Human - Railroad and Agriculture		X			X
M04A		Human - Roads, Bridges, and Agriculture					X
M04B		Human - Agriculture				X	X
M05A		Human - Roads, Bridges, Railroad, and Agriculture		X			X
M05B		Human - Roads, Bridges, Houses, Railroad, and Agriculture		X			X
M06		Human - Roads, Bridges, Houses, Railroad, and Agriculture					X
M07	Natural - Bedrock Grade Controls	Human - Dam, Roads, Bridges, Railroad, and Agriculture					X
M08		Human - Railroad and Agriculture					X
M09A		Human - Roads, Bridges, Railroad, and Agriculture					X
M09B		Human - Roads, Bridges, Railroad, and Agriculture					X
T2.01A		Human - Berm and Agriculture			X	X	X
T2.01B	Natural - Bedrock Grade Control	Human - Roads, Bridges, Houses, and Agriculture	X			X	
T2.02A		Human - Agriculture				X	X
T2.02B	Natural - Bedrock Grade Controls	Human - Agriculture					X
T2.02C	Not Assessed - Beaver Dam and Bedrock Gorge						
T4.01		Human - Railroad and Agriculture		X		X	X
T4.03	Natural - Bedrock Grade Control	Human - Agriculture	X			X	
T4.04A	Natural - Bedrock Grade Controls	Human - Roads, Bridges, Houses, and Agriculture	X				
T4.04B		Human - Agriculture		X		X	X
T4.05A	Natural - Bedrock Grade Control	Human - Berms and Agriculture		X		X	X
T4.05B	Natural - Bedrock Grade Controls	Human - Agriculture				X	X
M6T6.01	Not Assessed - No Landowner Permission						
M9T8.01A		Human - Agriculture				X	X

Notes:
1 This column shows if each segment was naturally a transport reach, or has been converted from a storage to a transport reach (blank cells indicate the reach is not a transport reach)
2 These columns indicate which segments were naturally high sediment deposition areas, are currently experiencing an increase in sediment depositional features, and/or could be an asset to allow future deposition to occur

Table 3: Departure Analysis Table - Black Creek

	Existing Constraints Which May Limit Restoration Opportunities		Transport[1]		Attenuation (sediment/nutrient storage)[2]		
River Segment	Vertical	Lateral	Natural	Converted	Natural	Increased	Asset
M9T8.01B	Not Assessed - Beaver Activity and Wetlands						
M9T8.01C		Human - Berms and Agriculture				X	X
M9T8.1S1.01	Not Assessed - Bedrock Gorge and Beaver Activity						
M9T8.1S1.02A	Not Assessed - Beaver Activity						
M9T8.1S1.02B		Human - Agriculture				X	X
M9T8.1S1.02C		Human - Roads, Bridges, and Agriculture				X	X
M9T8.1S1.02D	Not Assessed - Wetland Complex and Beaver Activity						

Notes:

1 This column shows if each segment was naturally a transport reach, or has been converted from a storage to a transport reach (blank cells indicate the reach is not a transport reach)

[2] These columns indicate which segments were naturally high sediment deposition areas, are currently experiencing an increase in sediment depositional features, and/or could be an asset to allow future deposition to occur

Table 4: Sediment Regime Table - Black Creek

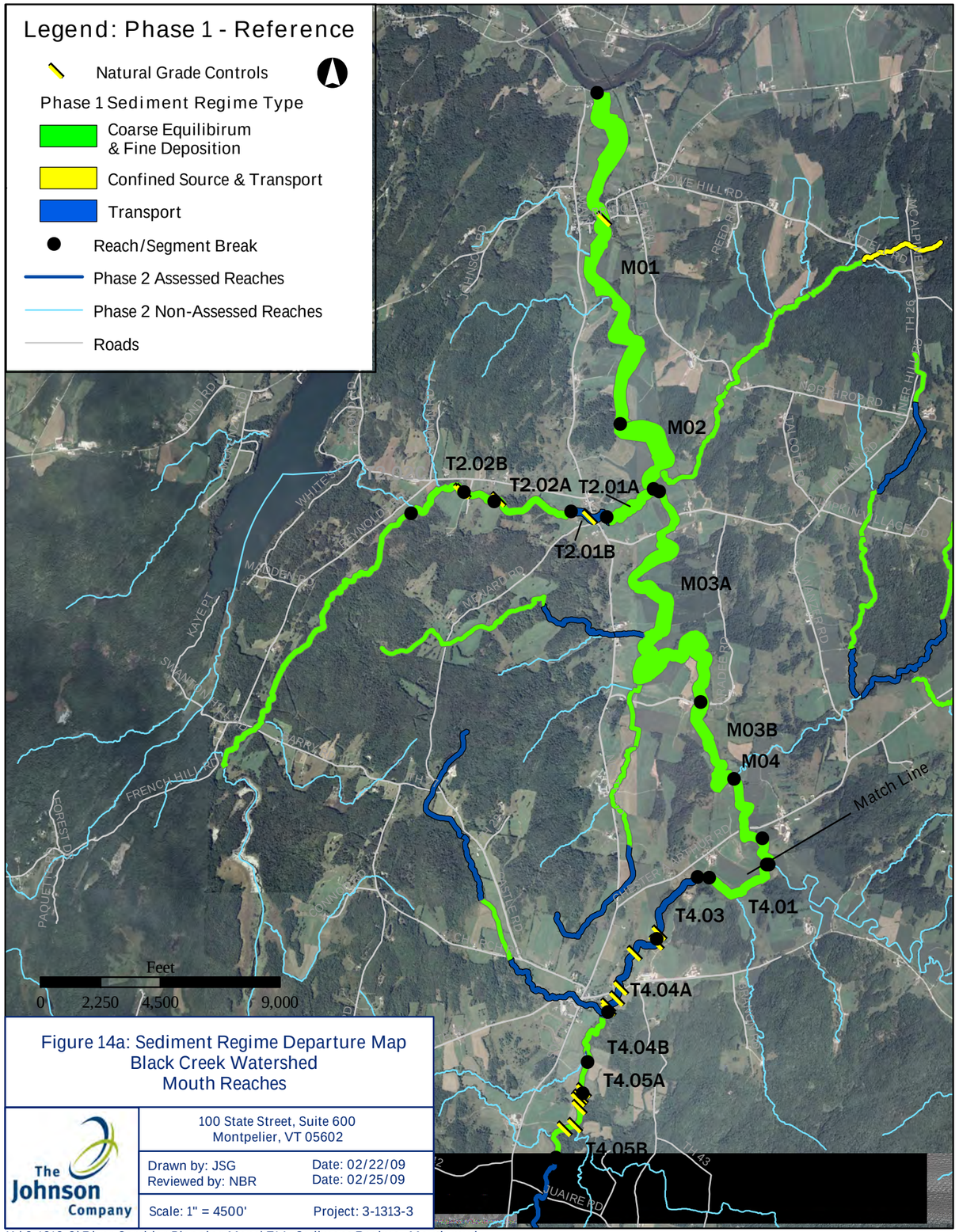
Reach ID	Reference Sediment Regime	Reference Stream Type	Stage of Channel Evolution/Geomorphic Condition	Criteria related to Sediment Supply, Transport and Storage	Existing Stream Type	Existing Sediment Regime
M01	Coarse Equilibrium & Fine Deposition	E5	I/Good	Incision Ratio = 1.2 Bank Armoring = <50% Valley Type = B Straightening = <50% W/D Ratio = 11.2	E5 - Dune-Ripple	Coarse Equilibrium & Fine Deposition
M02	Coarse Equilibrium & Fine Deposition	E5	V/Good	Incision Ratio = 1.1 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 10.5	E5-Dune-Ripple	Coarse Equilibrium & Fine Deposition
M03A	Coarse Equilibrium & Fine Deposition	E5	I/Good	Incision Ratio = 1.2 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 10.4	E6-Dune-Ripple	Coarse Equilibrium & Fine Deposition
M03B	Coarse Equilibrium & Fine Deposition	E5	IV/Fair	Incision Ratio = 1.6 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 12.5	E4 - Riffle-Pool	Fine Source & Transport and Coarse Deposition
M04A	Coarse Equilibrium & Fine Deposition	E5	I/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 9.2	E5 - Dune-Ripple	Coarse Equilibrium & Fine Deposition
M04B	Coarse Equilibrium & Fine Deposition	C4	II/Fair	Incision Ratio = 1.2 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 20.4	C4 - Riffle-Pool	Coarse Equilibrium & Fine Deposition
M05A	Coarse Equilibrium & Fine Deposition	C5	I/Good	Incision Ratio = 1.3 Bank Armoring = <50% Valley Type = VB Straightening = >50% W/D Ratio = 14.8	C5 - Dune-Ripple	Fine Source & Transport and Coarse Deposition
M05B	Coarse Equilibrium & Fine Deposition	C5	III/Fair	Incision Ratio = 1.4 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 11.4	E5 - Dune-Ripple	Fine Source & Transport and Coarse Deposition
M06	Coarse Equilibrium & Fine Deposition	E5	I/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = B Straightening = <50% W/D Ratio = 5.7	E5 - Dune-Ripple	Coarse Equilibrium & Fine Deposition
M07	Coarse Equilibrium & Fine Deposition	E5	IV/Fair	Incision Ratio = 1.2 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 11.3	E5 - Dune-Ripple	Coarse Equilibrium & Fine Deposition
M08	Coarse Equilibrium & Fine Deposition	E5	I/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 7.3	E5 - Dune-Ripple	Coarse Equilibrium & Fine Deposition
M09A	Coarse Equilibrium & Fine Deposition	E4	I/Good	Incision Ratio = 1.1 Bank Armoring = <50% Valley Type = B Straightening = <50% W/D Ratio = 10.2	E5 - Dune-Ripple	Coarse Equilibrium & Fine Deposition
M09B	Coarse Equilibrium & Fine Deposition	E4	I/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 7.9	E5 - Dune-Ripple	Coarse Equilibrium & Fine Deposition
T2.01A	Coarse Equilibrium & Fine Deposition	E5	IV/Fair	Incision Ratio = 1.2 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 10.9	E5 - Dune-Ripple	Coarse Equilibrium & Fine Deposition
T2.01B	Transport	B3	I/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = N Straightening = <50% W/D Ratio = 30.1	B3 - Step-Pool	Transport
T2.02A	Coarse Equilibrium & Fine Deposition	C2	I/Reference	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = SC Straightening = <50% W/D Ratio = 21.7	C2 - Step-Pool	Coarse Equilibrium & Fine Deposition
T2.02B	Coarse Equilibrium & Fine Deposition	C2	I/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = VB Straightening = >50% W/D Ratio = 25.4	C4 - Riffle-Pool	Coarse Equilibrium & Fine Deposition
T2.02C	Not Assessed - Bedrock Gorge and Beaver Dam Influence					
T4.01	Coarse Equilibrium & Fine Deposition	C4	III/Fair	Incision Ratio = 1.8 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 16	C4 - Plane-Bed	Fine Source & Transport and Coarse Deposition
T4.03	Transport	B3	IIb/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = N Straightening = <50% W/D Ratio = 26	B3 - Step-Pool	Transport
T4.04A	Transport	B4	I/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = N Straightening = <50% W/D Ratio = 29.5	B4 - Step-Pool	Transport
T4.04B	Coarse Equilibrium & Fine Deposition	C4	III/Fair	Incision Ratio = 1.5 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 24	C4 - Riffle-Pool	Fine Source & Transport and Coarse Deposition
T4.05A	Coarse Equilibrium & Fine Deposition	C4	IV/Good	Incision Ratio = 1.4 Bank Armoring = <50% Valley Type = VB Straightening = >50% W/D Ratio = 16.2	C4 - Plane-Bed	Fine Source & Transport and Coarse Deposition

Table 4: Sediment Regime Table - Black Creek

Reach ID	Reference Sediment Regime	Reference Stream Type	Stage of Channel Evolution/Geomorphic Condition	Criteria related to Sediment Supply, Transport and Storage	Existing Stream Type	Existing Sediment Regime
T4.05B	Coarse Equilibrium & Fine Deposition	C4	I/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = B Straightening = <50% W/D Ratio = 20	C4 - Step-Pool	Coarse Equilibrium & Fine Deposition
M6T6.01	Not Assessed - No Property Access					
M9T8.01A	Coarse Equilibrium & Fine Deposition	C4	I/Fair	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = VB Straightening = >50% W/D Ratio = 13.8	C4 - Dune-Ripple	Coarse Equilibrium & Fine Deposition
M9T8.01B	Not Assessed - Wetland and Beaver Dams					
M9T8.01C	Coarse Equilibrium & Fine Deposition	C4	I/Good	Incision Ratio = 1.2 Bank Armoring = <50% Valley Type = VB Straightening = >50% W/D Ratio = 13.7	C4 - Riffle-Pool	Coarse Equilibrium & Fine Deposition
M9T8.1S1.01	Not Assessed - Bedrock Gorge and Wetland Complex					
M9T8.1S1.02A	Not Assessed - Beaver Dams					
M9T8.1S1.02B	Coarse Equilibrium & Fine Deposition	C4	I/Good	Incision Ratio = 1.3 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 15.4	C4 - Riffle-Pool	Coarse Equilibrium & Fine Deposition
M9T8.1S1.02C	Coarse Equilibrium & Fine Deposition	C4	I/Good	Incision Ratio = 1.0 Bank Armoring = <50% Valley Type = VB Straightening = <50% W/D Ratio = 16	C4 - Riffle-Pool	Coarse Equilibrium & Fine Deposition
M9T8.1S1.02D	Not Assessed - Beaver Dams					

Legend: Phase 1 - Reference

- Natural Grade Controls
- Phase 1 Sediment Regime Type
  - Coarse Equilibirum & Fine Deposition
  - Confined Source & Transport
  - Transport
- Reach/Segment Break
- Phase 2 Assessed Reaches
- Phase 2 Non-Assessed Reaches
- Roads



Legend: Phase 2 - Existing

- Natural Grade Controls
- Lateral Constraints
- Phase 2 Sediment Regime Type
  - Coarse Equilibirum & Fine Deposition
  - Fine Source and Transport & Coarse Deposition
  - Transport
- Reach/Sgement Break
- Phase 2 Assessed Reaches
- Phase 2 Non-Assessed Reaches
- Roads

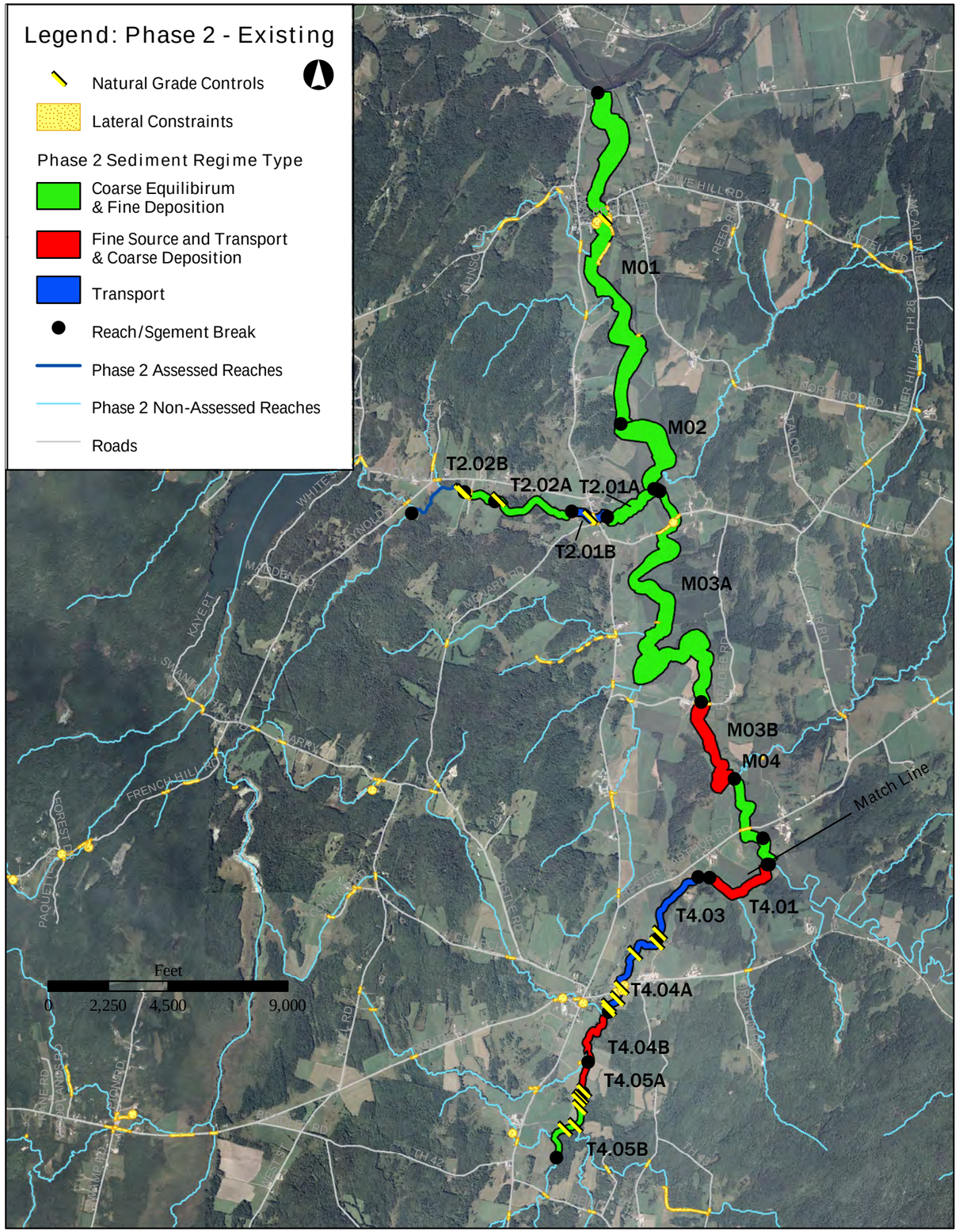


Figure 14a: Sediment Regime Departure Map
Black Creek Watershed
Mouth Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG	Date: 02/22/09
Reviewed by: NBR	Date: 02/25/09
Scale: 1" = 4500'	Project: 3-1313-3

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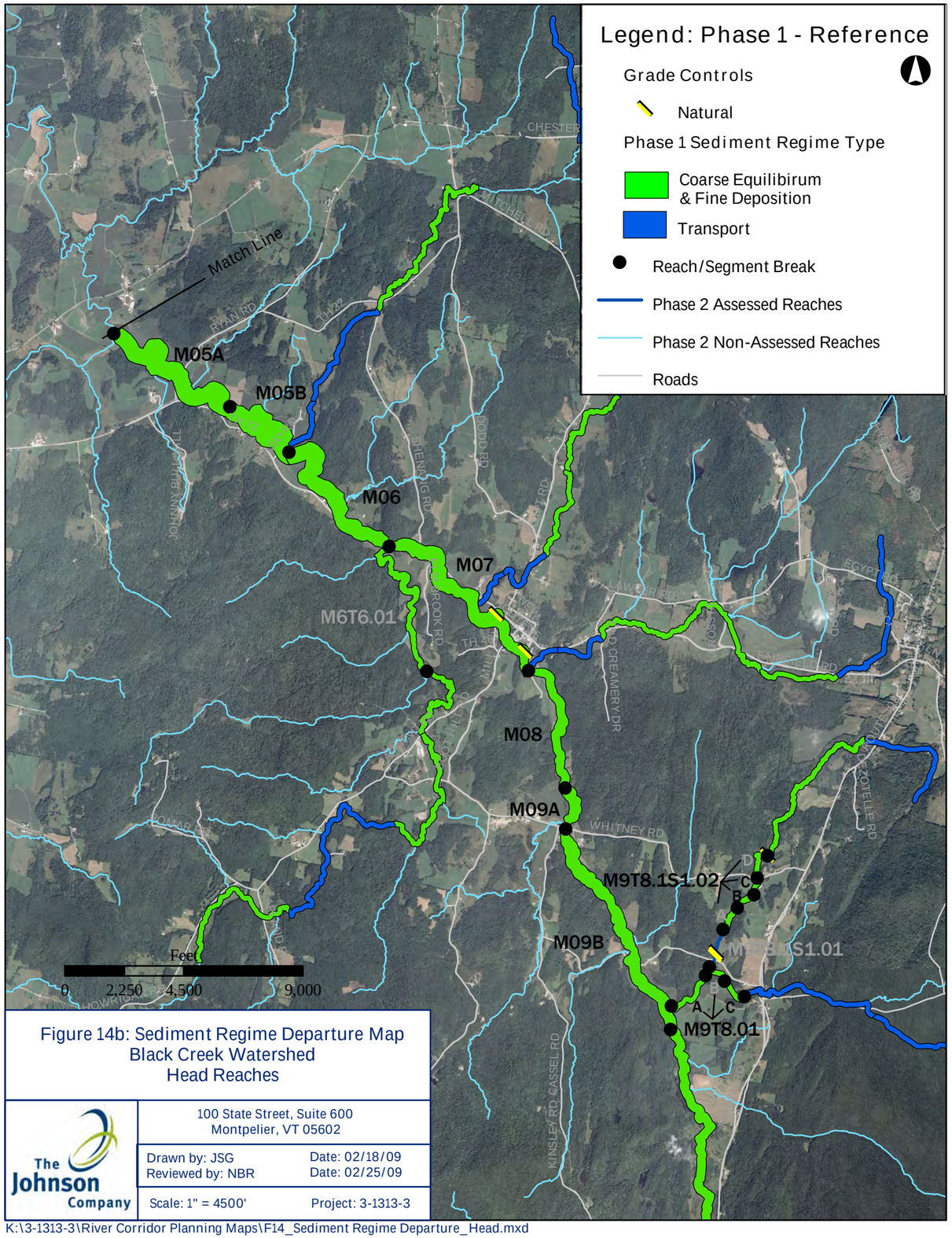

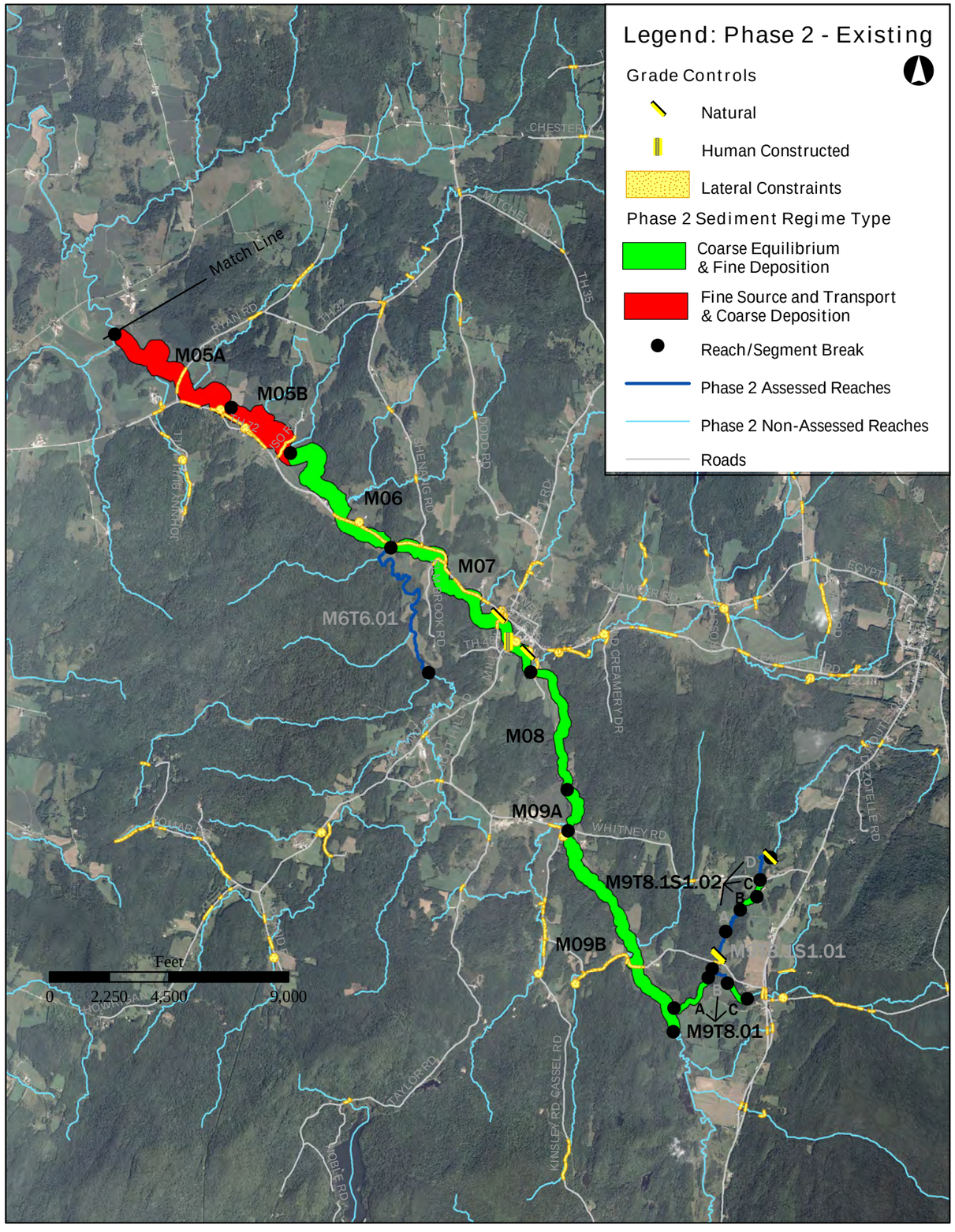

Figure 14b: Sediment Regime Departure Map
Black Creek Watershed
Head Reaches

The Johnson Company
100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 4500' Project: 3-1313-3

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4.2 SENSITIVITY ANALYSIS

Figures 15a and 15b show the predicted stream sensitivity for each reach in the study area. Stream sensitivity is defined as the likelihood that future vertical and lateral adjustments will occur including channel migration, widening, degradation, and aggradation. This sensitivity rating is based on the documented current and historic adjustment processes combined with known reference information for each reach. As is shown on Figures 15a and 15b, fourteen of the seventeen reaches have a high or very high sensitivity, meaning it is very likely that further vertical and lateral adjustments will occur.

5.0 PRELIMINARY PROJECT IDENTIFICATION

The preceding Section 4 discussed the underlying stressors and described how each reach within the study area has departed from its reference conditions. The following Section will identify appropriate types of projects for each reach in the study area by utilizing the tables, figures and data above along with the step-wise procedure for identification of river corridor restoration and conservation projects developed by VT ANR (2007). Appropriate projects were broken down into the following eight project types which are described in more detail for each reach:

1. Protect River Corridors – prevent encroachments within the river corridor to retain key functions and/or allow time for the river to adjust to equilibrium conditions on its own;

2. Plant Stream Buffers – increase bank stability and reduce sediment and nutrient inputs;

3. Stabilize Stream Banks – hard and/or soft engineering techniques to reduce/prevent erosion;

4. Arrest Head Cuts – installation of permanent grade controls to prevent further incision;

5. Remove Berms – restore floodplain access and increase sediment and nutrient storage capacity;

6. Remove or Replace Structures – replace undersized or poorly aligned bridges or culverts to reduce channel constrictions and restore equilibrium conditions

7. Restore Incised Reach – use a combination of active restoration techniques such as floodplain creation to restore equilibrium conditions;

8. Restore Aggraded Reach – use a combination of active restoration techniques such as natural channel design to restore equilibrium conditions.

For each of the assessed reaches, a Project and Practices Summary Table was created describing the types of projects which would best aid in restoring sediment and nutrient attenuation and restoring the reach to equilibrium conditions (Tables 5 – 21). Section 5.2 takes the project techniques identified at the Reach scale and prioritizes them at the watershed scale based on project type to identify which projects may be technically feasible and achieve the greatest possible benefit.

Legend

Current Adjustments

Vertical

Stream Sensitivity

Very Low

Moderate

High

Very High

Reach/Segment Break

Phase 2 Assessed Reaches

Phase 2 Non-Assessed Reaches

Roads

M01

M02

T202.C

T2.02B

T2.02A

T2.01A

T2.01B

M03A

M03B

M04A

M04B

T4.01

T4.03

T4.04A

T4.04B

T4.05A

T4.05B

Match Line

BOUCHARD RD

PLEASANT

CROWE H

MAIN

BRIDGE

CENTRAL

TH 25

SHELDON WOODS RD

JOHNSON DR

SHELDON WOODS RD

NAPOLI RD

NAPOLI RD 3

POND RD

MCKENZIE RD

YATES CAMP RD

GIRARD RD

SWIZLER'S PT

CRONIN RD

POND RD

WHITE'S RD

SIMONDS RD

MADDEN RD

MENARD RD

REYNOLDS RD

TOWN HWY 40

BARRY RD

TH 27

TH 28

CASTLE RD

CONNOR RD

CHURCH RD

ROUTE 36

SOUTH RD

NORTH RD

GILBERT HILL RD

SOULES DR

PARK

BRANON RD

CHESTER A ARTHUR RD

PUMPKIN VILLAGE RD

PARADEE RD

WANZER RD

TALCOTT RD

TIFFANY RD

NORTHROP RD

EMCH RD

TH 46

Quebec

VT

NY

NH

Feet

0 1,250 2,500 5,000

Figure 15a: Stream Sensitivity Map
Black Creek Watershed
Mouth Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

K:\3-1313-3\River Corridor Planning Maps\F15_Stream Sensitivity_Mouth.mxd

Legend

Stream Sensitivity

High

Very High

Reach/Segment Break

Phase 2 Assessed Reaches

Phase 2 Non-Assessed Reaches

Roads

Match Line

M05A

M05B

M06

M07

M08

M09A

M09B

M6T6.01

M9T8.1S1.02

M9T8.1S1.01

M9T8.01

A

B

C

D

DODD RD

MITCHELL RD

TH 35

SKINNER

RYAN RD

SPRING HILL RD

TH 32

SHENANG RD

ROUTE 36

TH 72

BRUSO RD

JOHNNY BULL HILL

EGYPT RD

ELM BROOK RD

BRIDGE

NEW SCHOOL

WHITELAND DR

TH 48

LAWYER RD

FAIRFIELD RD

CROSS RD

SHERMAN ST

OLD CREAMERY DR

MILL

MOREY RD

BOOT HILL RD

WHITNEY RD

ROMAR RD

BARRYWILDE RD

LAPLAND RD

STRATTON RD

LAPLAND EXT

METCALFE POND RD

LOST NATION RD

CASSEL RD

GOATPATH RD

ROUTE 108 S

HOWRIGAN RD

TAYLOR RD

NOBLE RD

Quebec

VT

NY

NH

Feet

0 1,250 2,500 5,000

Figure 15b: Stream Sensitivity Map
Black Creek Watershed
Head Reaches

The Johnson Company

100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: JSG Date: 02/18/09
Reviewed by: NBR Date: 02/25/09

Scale: 1" = 2500' Project: 3-1313-3

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5.1 REACH BASED PROJECT IDENTIFICATION

5.1.1 Reach M01 Description and Project Identification

Reach M01 is the furthest downstream reach in the study area and extends from the confluence with the Missisquoi River upstream for approximately 3 miles. This reach was found to be only slightly incised (incision ratio of 1.2) and still has access to its floodplain during most high flow events. The existing stream type of E5 Dune-Ripple was consistent with its reference stream type. Minor bank erosion was noted along small portions of the reach, though most of the banks were found to be relatively stable. The reach was found to be in Evolution Stage I, or Reference, with little active adjustments occurring and a rapid geomorphic score of 0.74 (good). The riparian corridor was dominated by hay and corn fields, with large areas of inadequate buffer of less than 25 feet. Sheldon Falls, a large bedrock gorge, is located in the middle of the segment. No major problems were identified with either of the assessed bridges. The habitat assessment showed fair aquatic habitat primarily due to embeddedness, lack of woody cover, and very few favorable sediment types and flow patterns.

Given the current, relatively stable condition of M01, the recommended remedial strategies are to protect the existing undeveloped river corridor to retain the reach's nutrient attenuation assets, and enhance the current buffer. The river corridor is defined as the area adjacent to the stream through which the stream would naturally meander over its lifetime to maintain equilibrium conditions. In most cases this is measured as three times the bankfull channel width on either side of the stream. As the furthest downstream reach, M01 receives all the inputs from upstream, and provides some attenuation of those inputs. Several large areas have riparian buffers of less than 25 feet, particularly upstream of Bridge Street. Buffer planting should be concentrated in these areas to reduce sediment and nutrient inputs, improve aquatic habitat, and improve bank stability. If possible, buffer establishment should be extended up the field ditches identified in the reach to reduce nutrient and sediment inputs. An aerial view of the reach is shown on Figures 16a and 16b, and descriptions of the recommended projects are shown in Table 5. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 5: Projects and Practices Table - Black Creek
Reach M01

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M01	Protect River Corridor - Reach slightly incised (1.2) but relatively stable. Protect existing corridor to retain floodplain connection and sediment attenuation zones. Corridor currently undeveloped agriculture and forest except near Bridge Street in Sheldon where bedrock gorge is also present.	Medium	Medium	55	Yes	Landowner cooperation/negotiations
M01	Plant Stream Buffer and other Ag BMPs - Large portions of reach with buffers less than 25 feet adjacent to hay and crop fields. Buffer enhancement to reduce nutrient inputs, improve aquatic habitat, and improve bank stability. Buffers should extend along field ditches as well.	High	Medium	18	Yes	Need landowner permission and planting plan, could be CREP eligible
M01	Remove Berm - Approximately 500 feet of berm located along left bank near Missisquoi confluence. Remove berm to improve floodplain connection and sediment and nutrient attenuation.	Low	Low	28	Yes	Landowner permission needed. Berm located only ~100 feet from valley wall so removal would not result in much benefit. Removal of this berm lower priority than other more extensive ones.

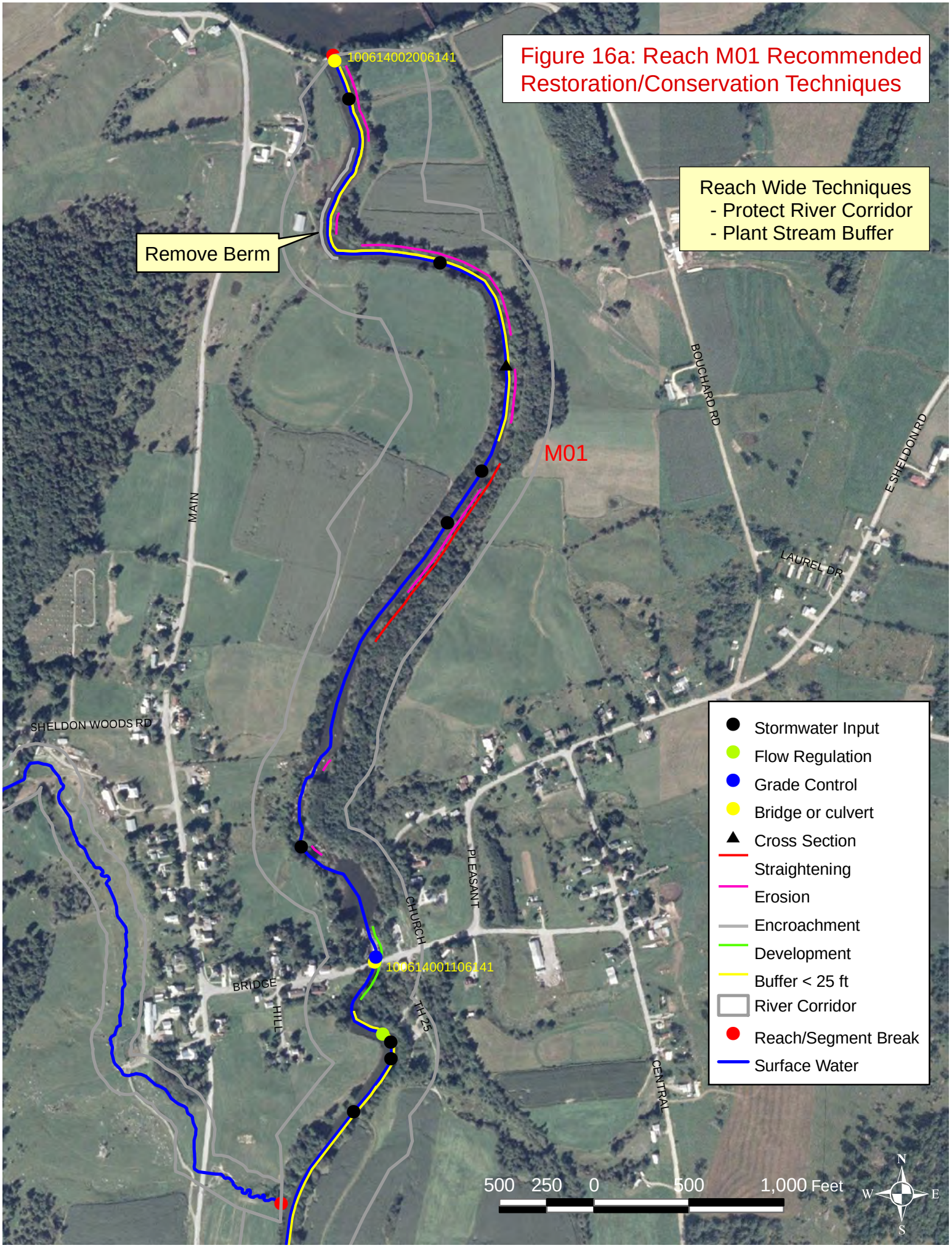


Figure 16a: Reach M01 Recommended Restoration/Conservation Techniques
Reach Wide Techniques
- Protect River Corridor
- Plant Stream Buffer
Remove Berm
100614002006141
100614001106141
M01
MAIN
BOUCHARD RD
E SHELDON RD
LAUREL DR
SHELDON WOODS RD
PLEASANT
CHURCH
BRIDGE
HILL
TH 25
CENTRAL
Stormwater Input
Flow Regulation
Grade Control
Bridge or culvert
Cross Section
Straightening
Erosion
Encroachment
Development
Buffer < 25 ft
River Corridor
Reach/Segment Break
Surface Water
500 250 0 500 1,000 Feet
N
W
E
S

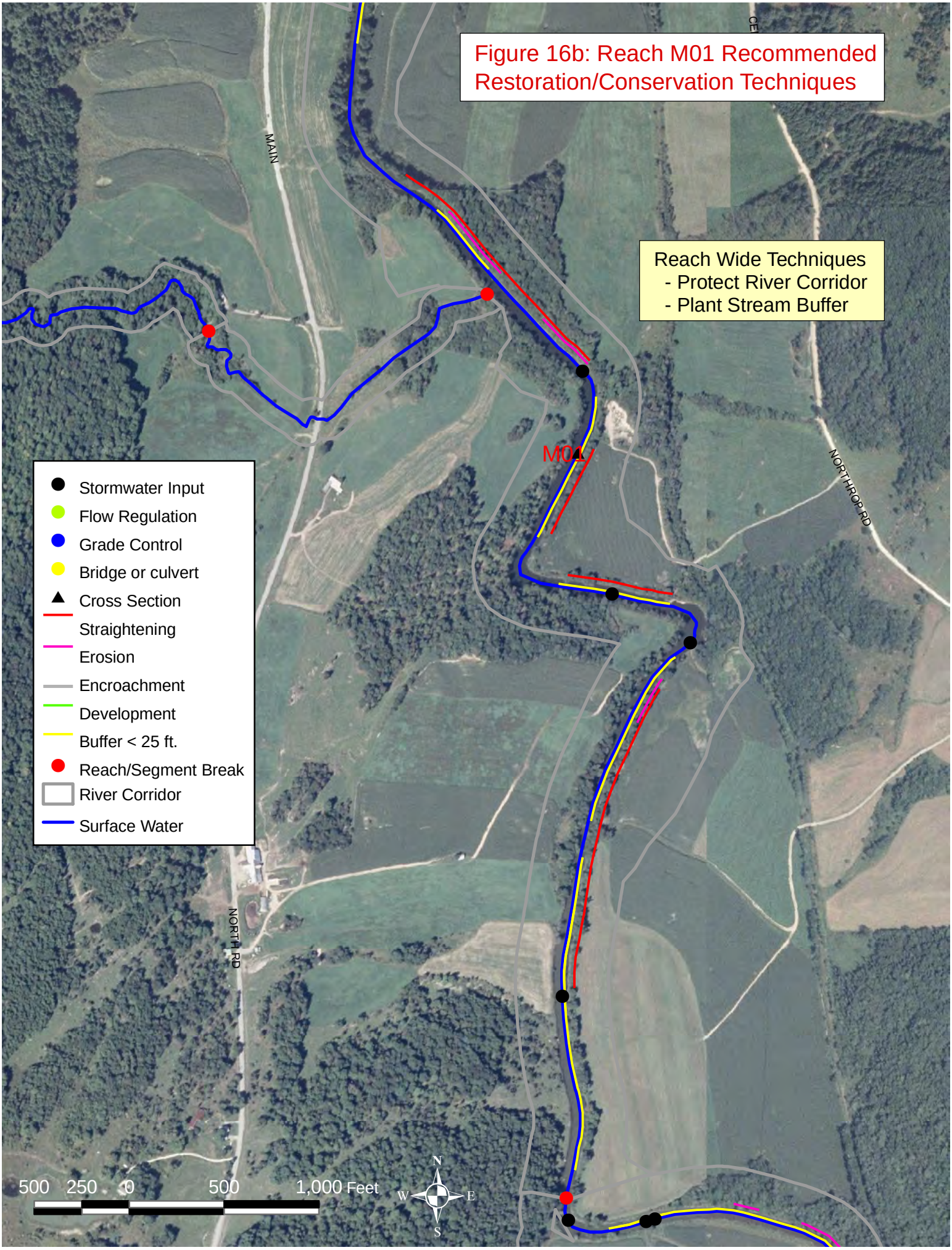


Figure 16b: Reach M01 Recommended Restoration/Conservation Techniques
Reach Wide Techniques
- Protect River Corridor
- Plant Stream Buffer
M01
MAIN
NORTHROP RD
NORTH RD
Stormwater Input
Flow Regulation
Grade Control
Bridge or culvert
Cross Section
Straightening
Erosion
Encroachment
Development
Buffer < 25 ft.
Reach/Segment Break
River Corridor
Surface Water
500 250 0 500 1,000 Feet
N
W
E
S

5.1.2 Reach M02 Description and Project Identification

Reach M02 extends from the end of reach M01 upstream for approximately 0.8 miles to the confluence with Dead Creek. This reach was found to be only slightly incised (ratio of 1.1) and still has adequate floodplain access. The existing stream type of E5 Dune-Ripple was consistent with its reference stream type. Minor bank erosion was noted along small portions of the reach, though most of the banks were found to be relatively stable. The reach was found to be in channel evolution stage V, with little active adjustments occurring and a rapid geomorphic score of 0.73 (good). The riparian corridor was dominated by a mix of hay and crop with a large area of forest on the right bank. Buffer widths were generally 0-25 feet, with approximately 1,500 feet having less than 25 foot buffers. The habitat assessment was fair primarily due to lack of woody cover, embeddedness, and very few favorable sediment types and flow patterns.

Given the current, relatively stable condition of M02, the recommended remedial strategies are to protect the existing undeveloped river corridor to retain the reach's nutrient attenuation assets, and enhance the current buffer. Several large areas have riparian buffers of less than 25 feet, particularly upstream of Bridge Street. Buffer planting should be concentrated in these areas to reduce sediment and nutrient inputs, improve aquatic habitat, and improve bank stability. Buffer establishment along the field ditches at the northern end of the reach is also important to reduce sediment and nutrient inputs. An aerial view of the reach is shown on Figure 17, and descriptions of the recommended projects are shown in Table 6. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 6: Projects and Practices Table - Black Creek
Reach M02

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M02	Protect River Corridor - Retain floodplain connection and sediment attenuation zones. Corridor currently undeveloped hay and corn fields with incision ratio of 1.1.	Medium	High	47	Yes	Landowner cooperation/negotiations
M02	Plant Stream Buffer and other Ag BMPs - Large area in downstream portion of reach with buffers less than 25 feet. Buffer enhancement should be targeted in these areas and extend along field ditches as well.	High	Medium	15	Yes	Need landowner permission and planting plan, CREP funding possible

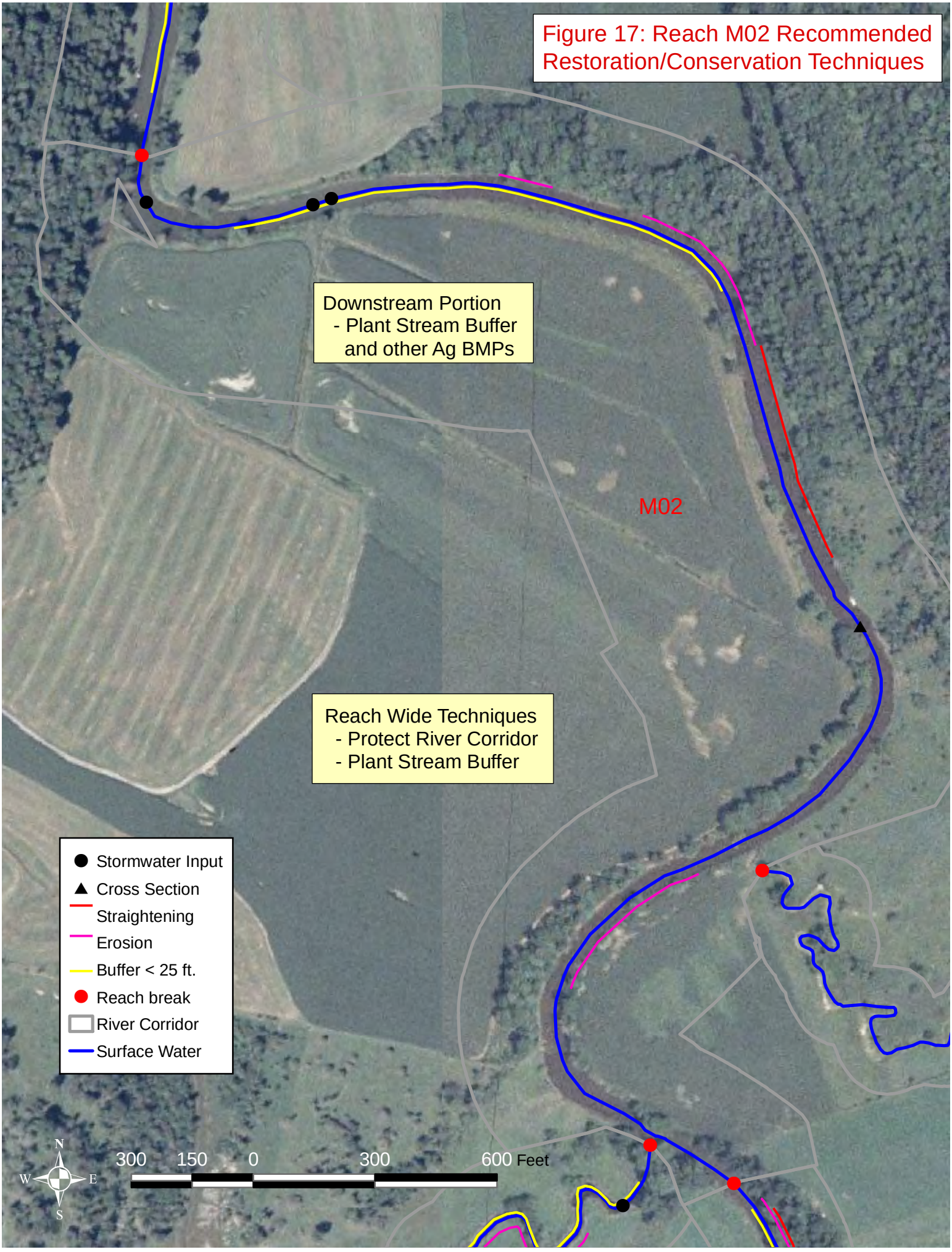


Figure 17: Reach M02 Recommended Restoration/Conservation Techniques
Downstream Portion
- Plant Stream Buffer and other Ag BMPs
M02
Reach Wide Techniques
- Protect River Corridor
- Plant Stream Buffer
Stormwater Input
Cross Section
Straightening
Erosion
Buffer < 25 ft.
Reach break
River Corridor
Surface Water
N
W
E
S
300 150 0 300 600 Feet

5.1.3 Reach M03 Description and Project Identification

Reach M03 extends upstream from the confluence with Dead Creek upstream for approximately 4.5 miles. The reach was segmented into two parts, M03A and M03B due to differences in channel dimensions and depositional features. M03A is the downstream end of the reach and extends from the confluence with Dead Creek upstream for approximately 3.5 miles. It was found to be only slightly incised (incision ratio of 1.2) and still has access to its floodplain during most high flow events. The existing stream type of E5 Dune-Ripple was consistent with its reference stream type. Minor bank erosion was noted along small portions of the reach, though most of the banks were found to be relatively stable. The segment was found to be in channel evolution stage I, or reference condition, with little active adjustments occurring and a rapid geomorphic score of 0.65 (good). The riparian corridor was dominated by a mix of corn fields and pasture, with large areas of inadequate buffer of less than 25 feet. Cows were observed in the stream channel just upstream of Pumpkin Village Road. The bridge on Paradee Road is undersized with a structure to channel width ratio of only 65%.

M03B extends from Paradee Road upstream for approximately 1 mile. This segment was highly incised (ratio of 1.6) and has lost much of its historic floodplain access. Despite the historic incision, its existing stream type of E4 Dune-Ripple was consistent with its reference type. The segment was found to be in channel evolution stage IV, as it has incised and is in the process of widening and aggrading to re-create floodplain access. The river corridor was dominated by a mix of crop, pasture, and forest with large portions having little to no riparian buffer. The abandoned elevated railroad bed runs through the upstream half of the segment and represents a major floodplain constriction.

The recommended projects for segment A are to protect the river corridor to retain the existing sediment and nutrient attenuation assets. In addition, large areas of the segment have inadequate buffer, so woody vegetation planting is also required. Cattle fencing should be included in this effort to limits animal access to the stream channel near Pumpkin Village Road.

The bridge on Paradee Road is significantly undersized and should be replaced to restore more normal flow patterns and reduce flooding and erosion hazards.

Segment M03B is highly incised (ratio of 1.6) so active floodplain restoration is recommended over corridor protection. Given the stream type and cohesive bank and bed soils, natural channel evolution would take significantly longer here than in a steeper, gravelly bedded stream which makes passive floodplain restoration a less desirable option. The active approach would involve lowering the existing bank heights with heavy equipment to re-create floodplain access and prevent future erosion of the existing stream banks. In combination with this, corridor protection and buffer establishment should be included to prevent future channel management which could impact the stream channel and establish a woody buffer to stabilize the streambanks, improve aquatic habitat, and reduce sediment and nutrient inputs. The abandoned railroad bed runs through a large portion of the stream corridor and represents a major floodplain constraint. Removing or retrofitting this berm with adequately sized culverts and/or bridges would restore the floodplain to a more normal size which could reduce flood hazards upstream and downstream of M03. Ideally all these strategies would be combined into one large project, but if that is not feasible they could be implemented separately to provide limited benefits. For example, if active floodplain restoration is not feasible, but the railroad berm could be removed or retrofitted, the stream would still regain some floodplain access and would be less likely to flood and/or erode the downstream portion of the reach. Table 7 and Figures 18a, b, and c below describe and show the locations of the recommended projects. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 7: Projects and Practices Table - Black Creek
Reach M03

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M03A	Protect River Corridor - Reach slightly incised (1.2) but relatively stable. Protect existing corridor to retain floodplain connection and sediment attenuation zones. Corridor currently undeveloped agriculture except near Pumpkin Village Road and Paradee Road.	Medium	High	41	Yes	Landowner permission.
M03A	Plant Stream Buffer and other Ag BMPs - Large area in segment with buffers less than 25 feet. Buffer enhancement should be targeted in these areas and extend up field ditches as well. Cattle fencing near Pumpkin Village Road crossing to limit cow access to stream.	High	High	6	Yes	Need landowner permission and planting plan, could be CREP eligible
M03A	Replace undersized structure - Paradee Road bridge noted as channel and floodplain constriction in phase 2 with structure/channel width ratio of 65%.	Medium	Medium	34	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. Town of Fairfield owned structure.
M03B	Restore Incised Reach - Reach no longer has complete access to floodplain (incision of 1.6), corridor protection project could be combined with active restoration (create new floodplain) to enhance sediment attenuation and reduce erosion	Medium	High	40	Yes	Should be combined with corridor protection and stream buffer planting projects, Landowner cooperation and more detailed assessment needed
M03B	Remove Berm - Approximately 800 feet of berm (railroad bed) located along left bank. Remove or retrofit berm with bridges and culverts to improve floodplain connection and sediment and nutrient attenuation.	High	High	26	Yes	Landowner permission needed. Ideally combined with floodplain restoration and buffer planting projects.
M03B	Protect River Corridor - Most of Segment is undeveloped crop, pasture, and forested. Due to high Incision ratio of 1.6 corridor protection should be done in combination with active floodplain restoration to re-establish floodplain connection and reduce future erosion.	Low as stand alone project	Low as stand alone project	56	Yes	Landowner cooperation - Should be combined with active floodplain restoration.
M03B	Plant Stream Buffer and other Ag BMPs - Large area in downstream portion of segment with buffers less than 25 feet. Buffer enhancement should be targeted in these areas and extend along field ditches as well. Ideally combined with active floodplain restoration and berm removal projects.	High	High	7	Yes	Need landowner permission and planting plan

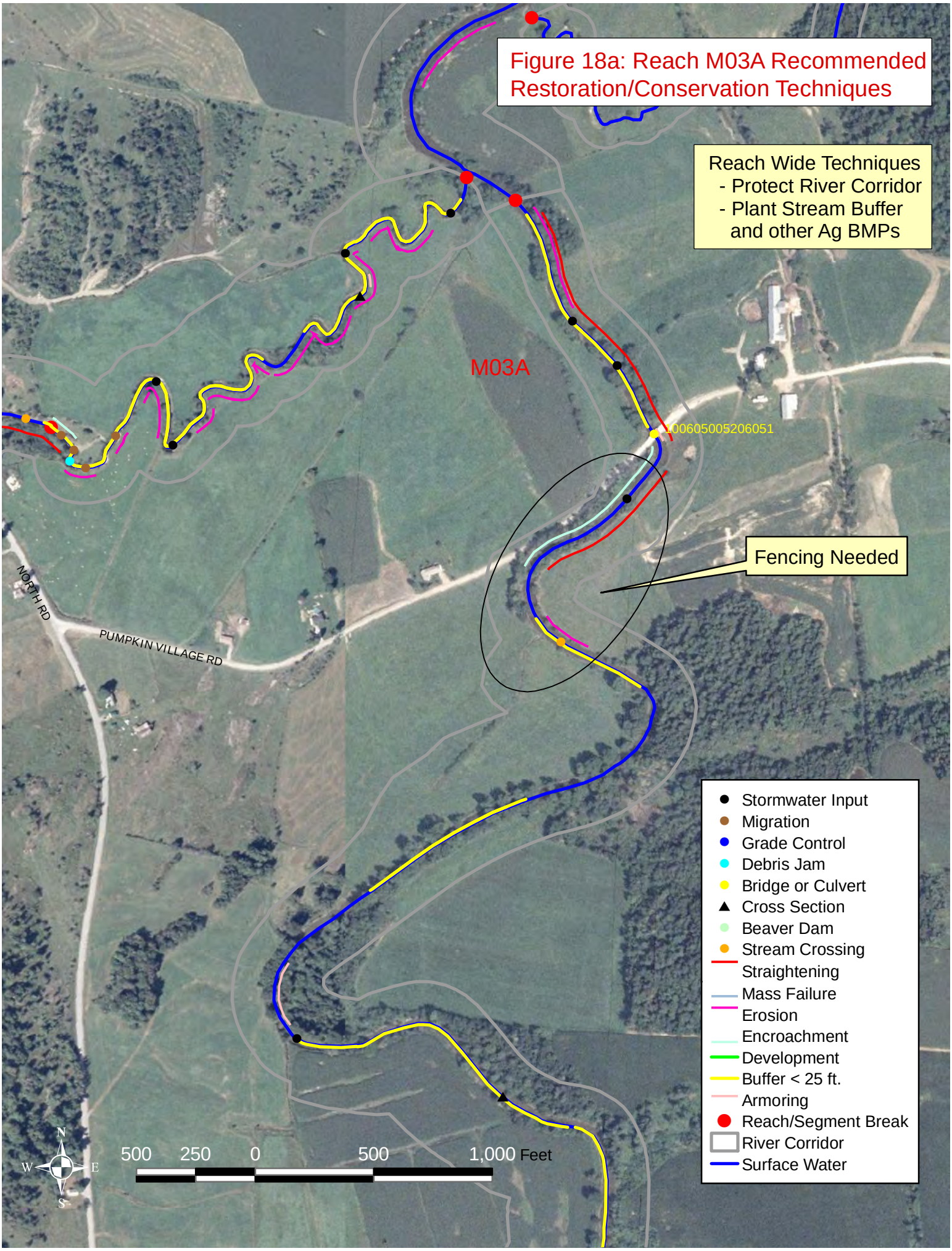


Figure 18a: Reach M03A Recommended Restoration/Conservation Techniques
Reach Wide Techniques
- Protect River Corridor
- Plant Stream Buffer and other Ag BMPs
M03A
100605005206051
Fencing Needed
NORTH RD
PUMPKIN VILLAGE RD
Stormwater Input
Migration
Grade Control
Debris Jam
Bridge or Culvert
Cross Section
Beaver Dam
Stream Crossing
Straightening
Mass Failure
Erosion
Encroachment
Development
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
N
W
E
S
500 250 0 500 1,000 Feet

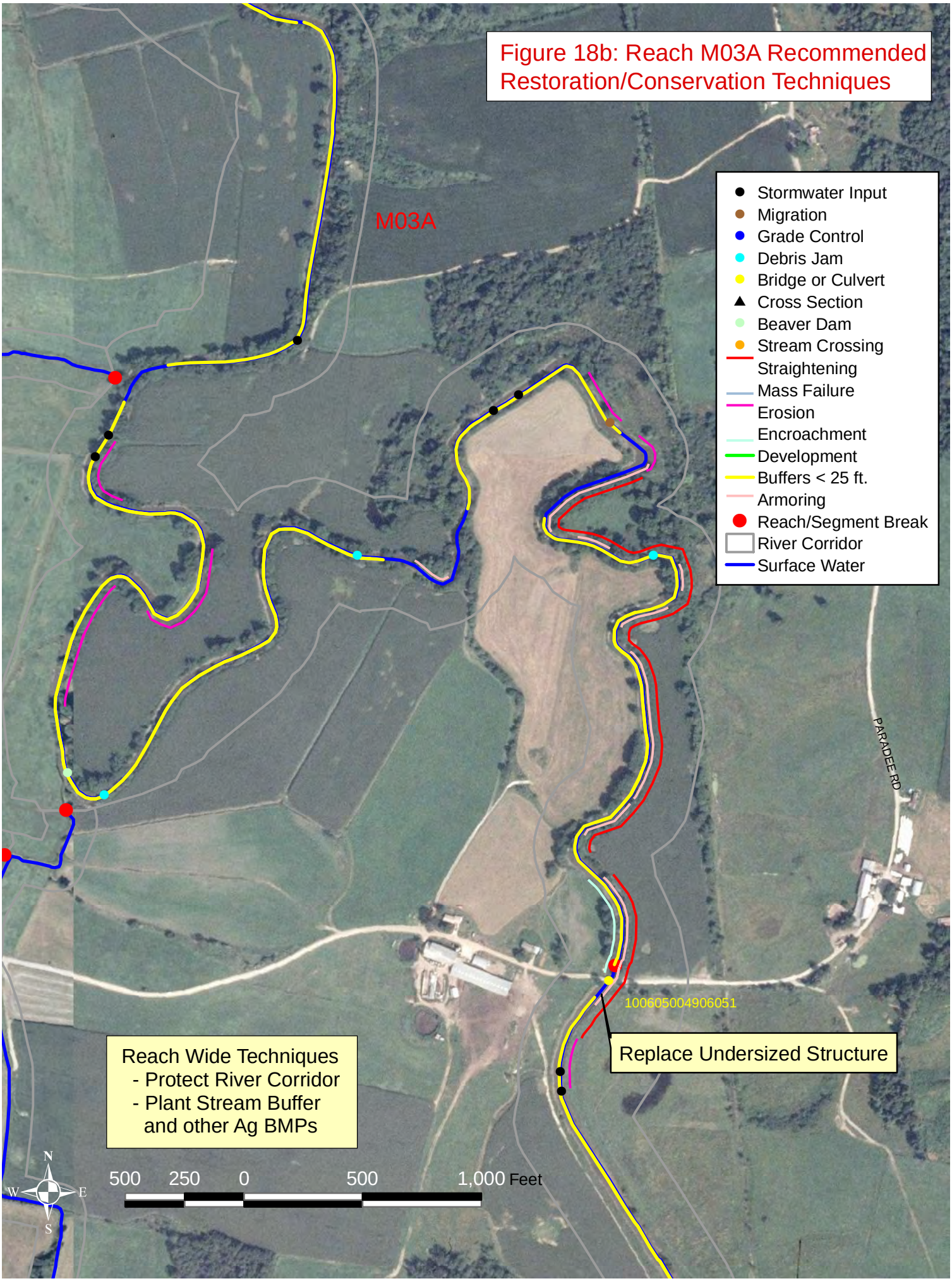


Figure 18b: Reach M03A Recommended Restoration/Conservation Techniques
M03A
Stormwater Input
Migration
Grade Control
Debris Jam
Bridge or Culvert
Cross Section
Beaver Dam
Stream Crossing
Straightening
Mass Failure
Erosion
Encroachment
Development
Buffers < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
PARADEE RD
100605004906051
Replace Undersized Structure
Reach Wide Techniques
- Protect River Corridor
- Plant Stream Buffer and other Ag BMPs
N
W
E
S
500 250 0 500 1,000 Feet

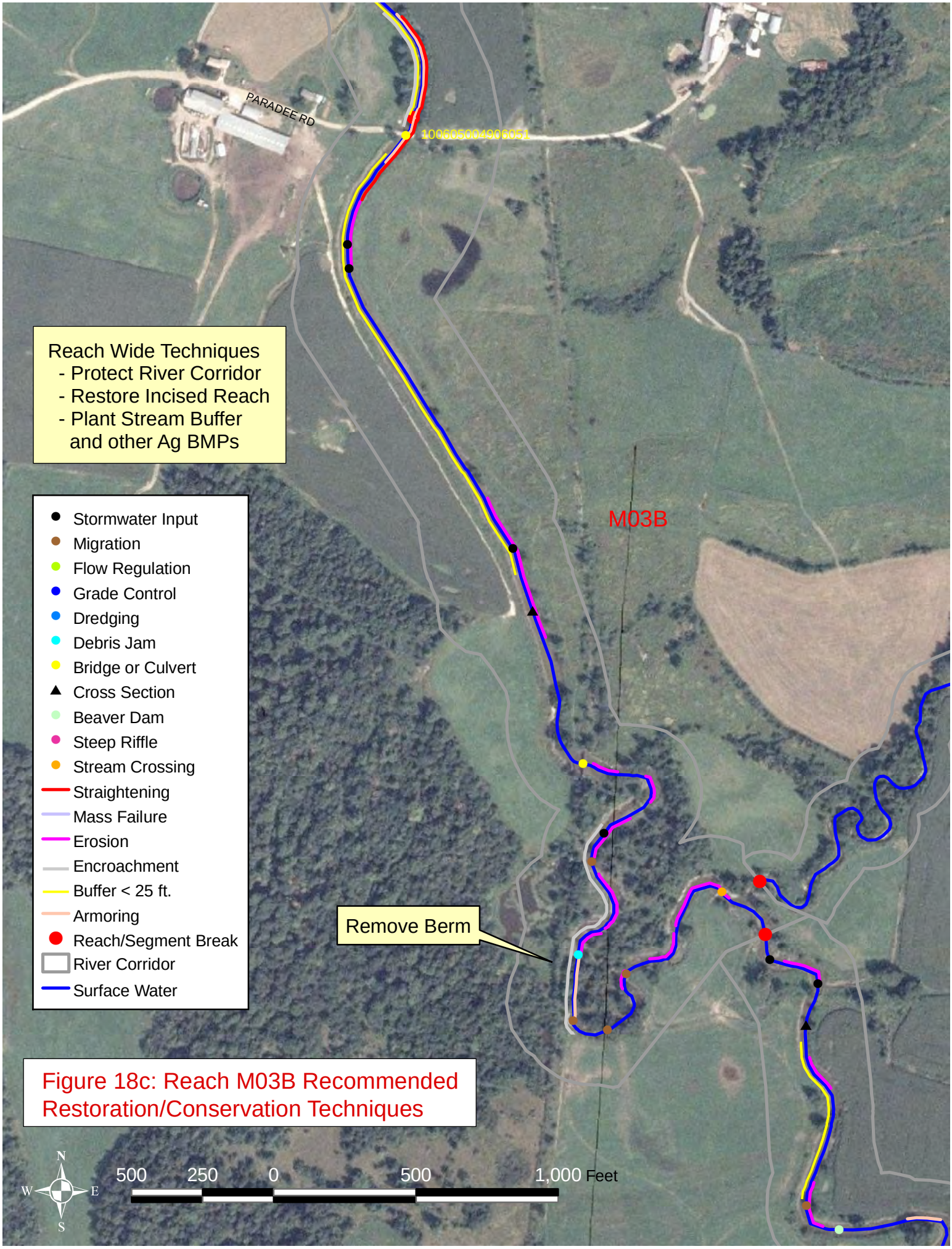


Figure 18c: Reach M03B Recommended Restoration/Conservation Techniques

5.1.4 Reach M04 Description and Project Identification

Reach M04 extends from the end of M03 upstream for approximately one mile, crossing Chester A. Arthur Road midway. The reach was segmented into M04A and M04B due to differences in channel dimensions and sediment types. M04A is the downstream end of the reach and extends to approximately 1,000 feet south of Chester Arthur Road. This segment was found to be relatively stable with an incision ratio of 1.0. The existing stream type of E5 Dune-Ripple was consistent with its reference stream type. Minor bank erosion was noted along small portions of the reach, though most of the banks were found to be relatively stable. The segment was found to be in channel evolution stage I, or reference condition, with little active adjustments occurring and a rapid geomorphic score of 0.80 (good). The riparian corridor was dominated by a mix of corn fields and pasture, with large areas of inadequate buffer of less than 25 feet. The bridge on Chester A. Arthur Road is adequately sized with a structure to channel width ratio of only 180%. Despite the geomorphic stability, the aquatic habitat was relatively poor due to a lack of woody cover and coarse grained sediment deposition.

M04B is the upstream portion of the reach and is approximately ¼ mile long. It was slightly incised (ratio of 1.2) but still has access to its floodplain during most high flow events. Due to an increase in coarse sediment and more distinct riffles and pools, this segment was classified as a C4 – riffle-pool stream. The segment was found to be in channel evolution stage II, due to the historic incision, though only minor bank erosion was observed. Similar to segment A, the riparian corridor was dominated by a mix of corn fields and pasture, with large areas of inadequate buffers less than 25 feet.

The recommended remedial/conservation strategies for both M04A and M04B are to protect the existing river corridor to preserve the sediment and nutrient retention functions of the reach. A lack of adequate buffer dominates the reach so buffer planting is a high priority. If possible the planted buffers should extend up the field ditches to reduce sediment and nutrient inputs into the stream channel.

Lack of buffers along Reach M04.

Table 8 and Figure 19 below describe and show the locations of the recommended projects. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 8: Projects and Practices Table - Black Creek
Reach M04

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M04A	Protect River Corridor - River corridor dominated by crop and pasture with buffers less than 25 feet. Reach relatively stable with good floodplain access. Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Medium	High	43	Yes	Landowner cooperation needed.
M04A	Plant Stream Buffer and other Ag BMPs- Majority of river corridor dominated by crop and pasture with large areas of buffers less than 25 feet. If possible, buffers planting should extend up field ditches to limit sediment and nutrient inputs.	High	High	3	Yes	Landowner cooperation required. Could be CREP eligible
M04B	Protect River Corridor - River corridor dominated by crop and pasture with buffers less than 25 feet. Segment slightly incised (ratio of1.2), but otherwise relatively stable with good floodplain access. Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Medium	High	42	Yes	Landowner cooperation needed.
M04B	Plant Stream Buffer and other Ag BMPs- Majority of river corridor dominated by crop and pasture with large areas of buffers less than 25 feet. If possible, buffers planting should extend up field ditches to limit sediment and nutrient inputs.	High	High	4	Yes	Landowner cooperation required. Could be CREP eligible

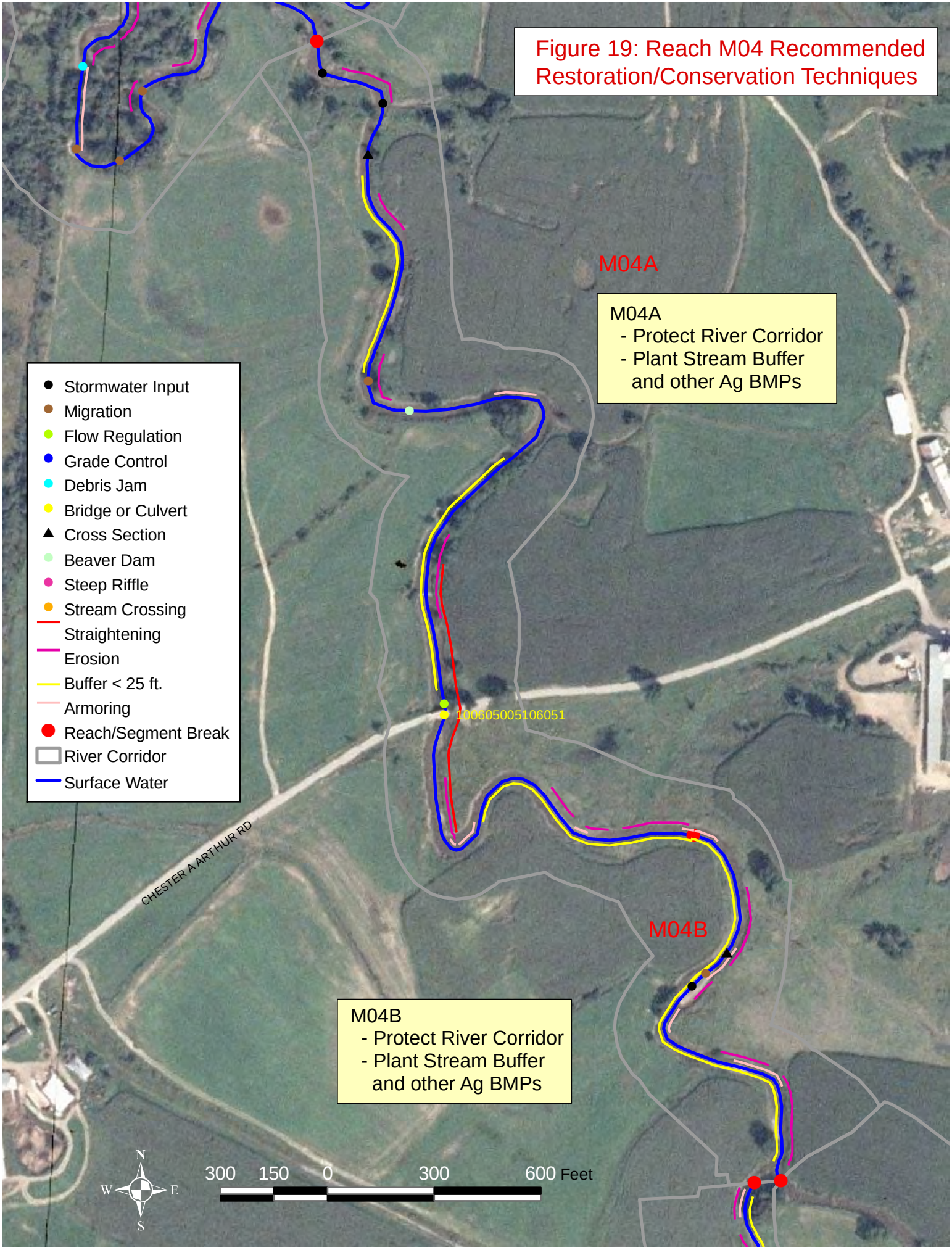


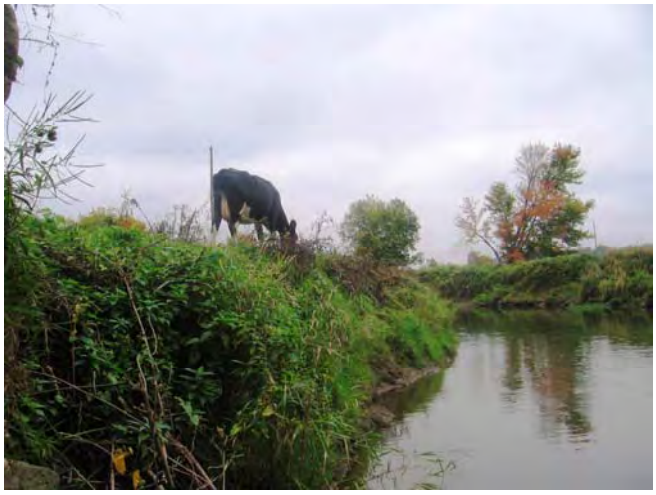
Figure 19: Reach M04 Recommended Restoration/Conservation Techniques
M04A
M04A
- Protect River Corridor
- Plant Stream Buffer and other Ag BMPs
Stormwater Input
Migration
Flow Regulation
Grade Control
Debris Jam
Bridge or Culvert
Cross Section
Beaver Dam
Steep Riffle
Stream Crossing
Straightening
Erosion
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
100605005106051
CHESTER A ARTHUR RD
M04B
M04B
- Protect River Corridor
- Plant Stream Buffer and other Ag BMPs
N
W
E
S
300 150 0 300 600 Feet

5.1.5 Reach M05 Description and Project Identification

Reach M05 extends from the end of M04 at the confluence with Fairfield River upstream for approximately three miles to Bruso Road. The reach was segmented into M05A and M05B due to flow status changes and channel encroachments. M05A is the downstream portion of the reach and extends from the confluence with Fairfield River to approximately 1,000 feet south of Ryan Road. It was found to be relatively stable, despite being slightly incised with an incision ratio of 1.3. Documented flooding in M05, suggests that despite the measured incision, the stream regularly floods over its banks. The reach was classified as a C5 Dune-Ripple, consistent with its reference type and in Evolution Stage I. The riparian corridor was dominated by a mix of corn, hay, and pasture with large areas of buffers less than 25 feet. Cows were observed in the stream channel near the segment break between M05A and M05B. The abandoned railroad bed runs along a large portion of the segment and represents a major floodplain constriction. Other constrictions noted include the bridge on Ryan Road, which had a structure to channel width ratio of 95%, and a private bridge located just downstream which had a structure to channel width ratio of 66%. The rapid habitat assessment score was 0.63 (fair).

M05B is the upstream portion of the reach and extends to just south of Bruso Road. It was found to less stable than segment A with an incision ratio of 1.3, and active widening and planform adjustments. Documented flooding in M05 suggests that despite the measured incision, the stream regularly floods over its banks. The reach was classified as an E5 Dune-Ripple, consistent with its reference type and in Evolution Stage III (widening). The riparian corridor was dominated by a mix of corn and hay with large areas of buffers less than 25 feet. The abandoned rail bed runs along a significant portion of the river corridor, though it is less of a constriction than in segment A as it is close to the natural valley wall. The bridge on Bruso Road, and a private bridge located upstream were identified as channel and floodplain constrictions within the segment. The structures had structure to channel width ratios of 94% and 75% respectively.

Recommended projects for Reach M05 include corridor protection, buffer planting/cattle exclusion, berm removal, and replacement of undersized structures. Documented flooding in this reach indicates that the stream regularly accesses the floodplain. Corridor protection would protect this important asset by limiting development and channel management. More importantly the elevated railroad bed which runs along a large portion of the segment is a significant floodplain constriction. Removal of this berm, or retrofitting the existing berm by adding bridges or adequately sized culverts would significantly improve the flow regime and sediment and nutrient retention functions of the reach. These actions are not needed in segment B because the berm runs along the natural valley wall. The entire reach suffers from a lack of adequate buffer. Tree and buffer planting should be implemented to reduce sediment and nutrient inputs. Cattle fencing is needed to limit cows access to the stream channel mid-reach.



Finally, four undersized bridges were identified in the reach; two private structures and two town owned structures on Ryan Road and Bruso Road. Replacement of these structures combined with the other techniques described above would improve the flow and sediment regimes of the reach. Table 9 and Figures 20a and 20b below describe and show the locations of the recommended projects. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 9: Projects and Practices Table - Black Creek
Reach M05

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M05A	Protect River Corridor - River corridor dominated by crop and pasture with buffers less than 25 feet. Reach relatively stable with good floodplain access, though segment is slightly incised (ratio of 1.3). Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Medium	High	44	Yes	Landowner cooperation needed.
M05A	Plant Stream Buffer, cattle fencing, and other Ag BMPs- Majority of river corridor dominated by crop and pasture with large areas of buffers less than 25 feet. If possible, buffers planting should extend up field ditches to limit sediment and nutrient inputs. Cows observed in stream near segment break, fencing and proper cattle crossings should be part of buffer projects.	High	High	1	Yes	Landowner cooperation required. Could be CREP eligible
M05A	Remove Berm - Approximately 2,000 feet of berm (railroad bed) located along left bank limits floodplain access. Remove or retrofit berm with bridges/culverts to improve floodplain connection and sediment and nutrient attenuation.	High	High	21	Yes	Landowner permission needed. Berm removal in segment B not as important as berm runs close to valley wall there.
M05A	Replace undersized structures - Ryan Road bridge noted as channel and floodplain constriction in phase 2 with structure/channel width ratio of 95%. Private bridge located ~1,000 feet downstream of Ryan Road also noted as constriction with structure/channel width ratio of 66%.	Medium	Medium	36	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. One structure owned by Town of Fairfield, other privately owned structure.
M05B	Protect River Corridor - River corridor dominated by crop and hay with buffers less than 25 feet. Reach relatively stable with good floodplain access, though segment is slightly incised (ratio of 1.3). Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Medium	High	45	Yes	Landowner cooperation needed.
M05B	Plant Stream Buffer and other Ag BMPs- Majority of river corridor dominated by crop and hay with large areas of buffers less than 25 feet. If possible, buffers planting should extend up field ditches to limit sediment and nutrient inputs.	High	High	2	Yes	Landowner cooperation required. Could be CREP eligible
M05B	Replace undersized structures - Bruso Road bridge noted as channel and floodplain constriction in phase 2 with structure/channel width ratio of 94%. Private bridge located upstream near farm also noted as constriction with structure/channel width ratio of 75%.	Medium	Medium	37	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. One structure owned by Town of Fairfield, other privately owned structure.

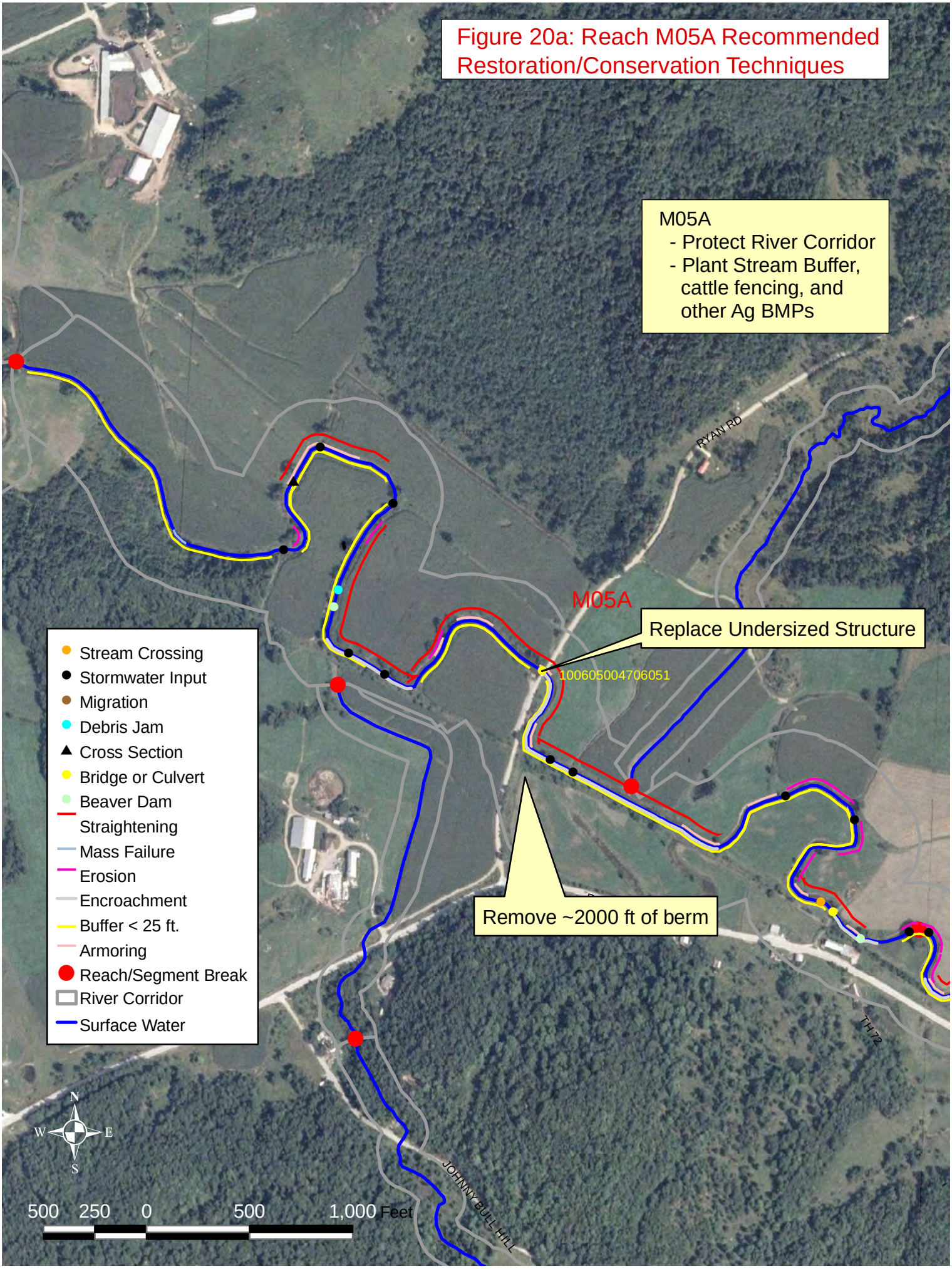


Figure 20a: Reach M05A Recommended Restoration/Conservation Techniques
M05A
- Protect River Corridor
- Plant Stream Buffer, cattle fencing, and other Ag BMPs
RYAN RD
M05A
Replace Undersized Structure
100605004706051
Remove ~2000 ft of berm
Stream Crossing
Stormwater Input
Migration
Debris Jam
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Mass Failure
Erosion
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
N
W
E
S
500 250 0 500 1,000 Feet
TH 72
JOHNNY BULL HILL

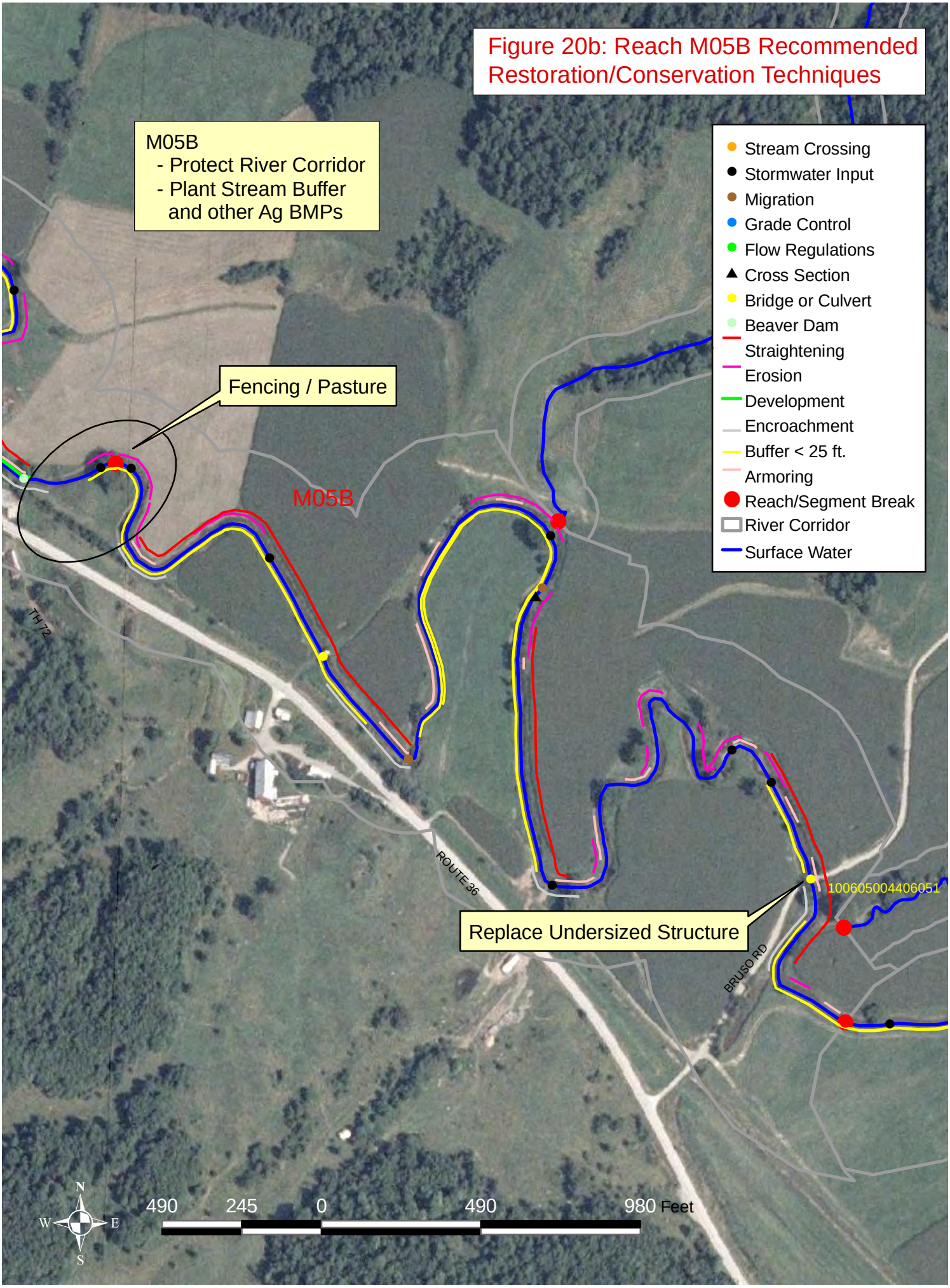


Figure 20b: Reach M05B Recommended Restoration/Conservation Techniques
M05B
- Protect River Corridor
- Plant Stream Buffer and other Ag BMPs
Fencing / Pasture
M05B
Replace Undersized Structure
100605004406051
TH 72
ROUTE 36
BRUSO RD
Stream Crossing
Stormwater Input
Migration
Grade Control
Flow Regulations
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Erosion
Development
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
N
W
E
S
490
245
0
490
980 Feet

5.1.6 Reach M06 Description and Project Identification

Reach M06 extends from just south of Bruso Road to approximately 1,000 feet south of route 36. This reach was found to be relatively stable with an incision ratio of 1.0. The reach was classified as an E5 Dune-Ripple, consistent with its reference type and in channel evolution stage I. Relatively minor erosion was noted. The riparian corridor was dominated by a mix of hay and pasture with large areas of inadequate buffers less than 25 feet. The rapid habitat assessment score was 0.59 (fair) mainly due to a lack of available cover and favorable sediment and flow patterns. The abandoned elevated rail bed runs along the river corridor for a large portion of the reach and represents a major floodplain constriction. The bridge crossing Route 36 was adequately sized (structure to channel width ratio of 218%), though rather poorly aligned.

As is the case with most of the other downstream reaches, the recommended project types for M06 include corridor protection, buffer planting, and removal/retrofitting of the elevated railroad bed. The reach currently serves as a sediment and nutrient attenuation zone so protecting these functions is important to both the reach and the watershed as a whole. Those portions of the rail bed which constrict the floodplain should be removed or retrofitted with bridges and/or adequately sized culverts to allow floodwaters to move freely onto and off of the floodplain. In addition, most of the reach lacks sufficient buffer between the stream channel and agricultural, lands. Buffer widths of at least 25 to 50 feet should be established throughout to reduce excess sediment and nutrient inputs. Table 10 and Figure 21 below describe and show the locations of the recommended projects. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 10: Projects and Practices Table - Black Creek
Reach M06

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M06	Protect River Corridor - River corridor dominated by hay and pasture with significant buffers less than 25 feet. Reach relatively stable with good floodplain access (incision of 1.0). Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Medium	High	49	Yes	Landowner cooperation needed.
M06	Plant Stream Buffer and other Ag BMPs- Majority of river corridor dominated by hay and pasture with large areas of buffers less than 25 feet. If possible, buffers planting should extend up field ditches to limit sediment and nutrient inputs.	High	High	9	Yes	Landowner cooperation required. Could be CREP eligible
M06	Remove Berm - Approximately 500 feet of berm (railroad bed) located along left bank just above Route 36 limits historic floodplain access. Berm also present downstream of road, but not as close to channel. Remove or retrofit berm with bridges/culverts to improve floodplain connection and sediment and nutrient attenuation.	High	High	24	Yes	Landowner permission needed.

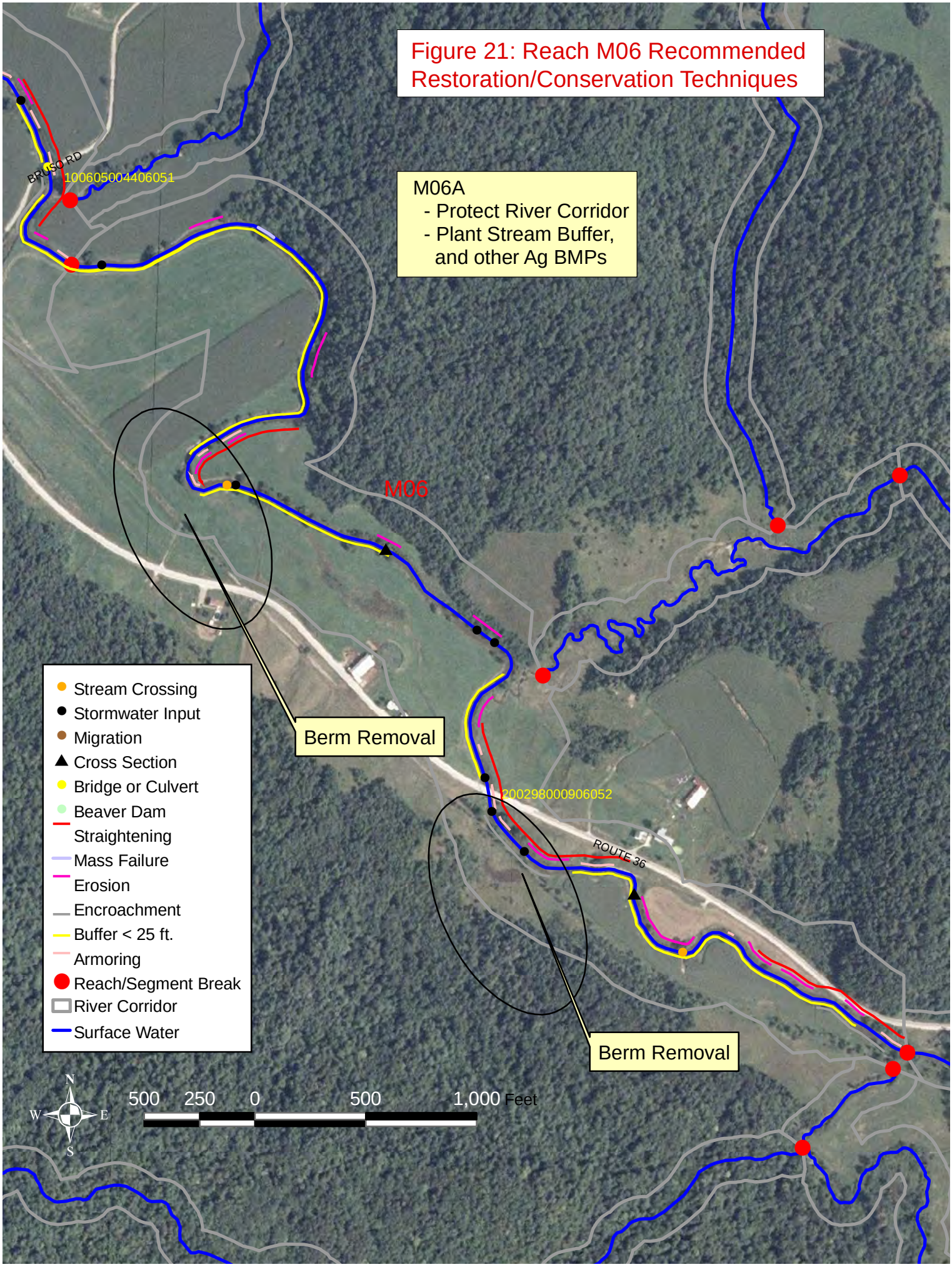


Figure 21: Reach M06 Recommended Restoration/Conservation Techniques
M06A
- Protect River Corridor
- Plant Stream Buffer, and other Ag BMPs
BRUSO RD
100605004406051
M06
Berm Removal
200298000906052
ROUTE 36
Berm Removal
Stream Crossing
Stormwater Input
Migration
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Mass Failure
Erosion
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
N
W
E
S
500 250 0 500 1,000 Feet

5.1.7 Reach M07 Description and Project Identification

Reach M07 extends from the confluence with Elm Brook upstream for approximately two miles to the village of East Fairfield. The reach was found to be slightly incised (ratio of 1.2) with minor active widening and aggradation. The existing stream type of E5 Dune-Ripple was consistent with its reference type. Moderate bank erosion was noted, mostly on the outside of meander bends. The riparian corridor was dominated by a mix of hay and forest, with large areas of inadequate buffers less than 25 feet. The abandoned elevated rail bed runs within the river corridor in the upstream half of the reach and represents a major floodplain constriction. The upstream portion of the reach near East Fairfield village is dominated by two large bedrock gorges and could not be assessed. Remnants of old concrete dams were present in these gorges, though their impact on the channel dynamics is rather minimal given their location inside natural bedrock constrictions. Five bridges cross the channel within the reach. Two of these are for the former railroad, and the remainder are town owned structures. Two of them, the railroad bridge at the downstream end of reach, and Elm Brook Road bridge, were identified as channel and floodplain constrictions with structure to channel width ratios of 53% and 87% respectively.

Given the current conditions of M07, the recommended remedial strategies are to protect the existing river corridor, implement adequate riparian buffers, replace the undersized bridges, and remove or retrofit the elevated rail bed. The reach currently has good floodplain access, though portions of the floodplain are limited by Route 36 on one side and the rail bed on the other. The rail bed in the downstream end of the reach should be removed, lowered, or retrofitted with bridges and/or adequately sized culverts to restore the lost floodplain access. In addition, the two undersized bridges should be replaced with newer structures with adequate widths. Increasing the buffer widths along the agricultural fields is also an important strategy here. An aerial view of the reach is shown on Figures 22a and 22b, and descriptions of the recommended projects are shown in Table 11.

Table 11: Projects and Practices Table - Black Creek
Reach M07

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M07	Protect River Corridor - River corridor dominated by mix of hay and forest with large areas of buffers less than 25 feet. Reach relatively stable with good floodplain access (incision of 1.2). Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Medium	High	48	Yes	Landowner cooperation needed.
M07	Plant Stream Buffer and other Ag BMPs- Majority of river corridor dominated by hay with large areas of buffers less than 25 feet. If possible, buffers planting should extend up field ditches to limit sediment and nutrient inputs.	High	High	8	Yes	Landowner cooperation required. Could be CREP eligible
M07	Remove Berm - Approximately 1,000 feet of berm (railroad bed) located along left bank in downstream end of reach limits historic floodplain access. Remove or retrofit berm with bridges/culverts to improve floodplain connection and sediment and nutrient attenuation.	High	High	22	Yes	Landowner permission needed.
M07	Replace undersized structures - Elm Brook Road bridge noted as channel and floodplain constriction in phase 2 with structure/channel width ratio of 53%. Railroad bridge located near downstream reach break also noted as constriction with structure/channel width ratio of 87%.	Medium	Medium	35	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. One structure owned by Town of Fairfield, other privately owned structure.

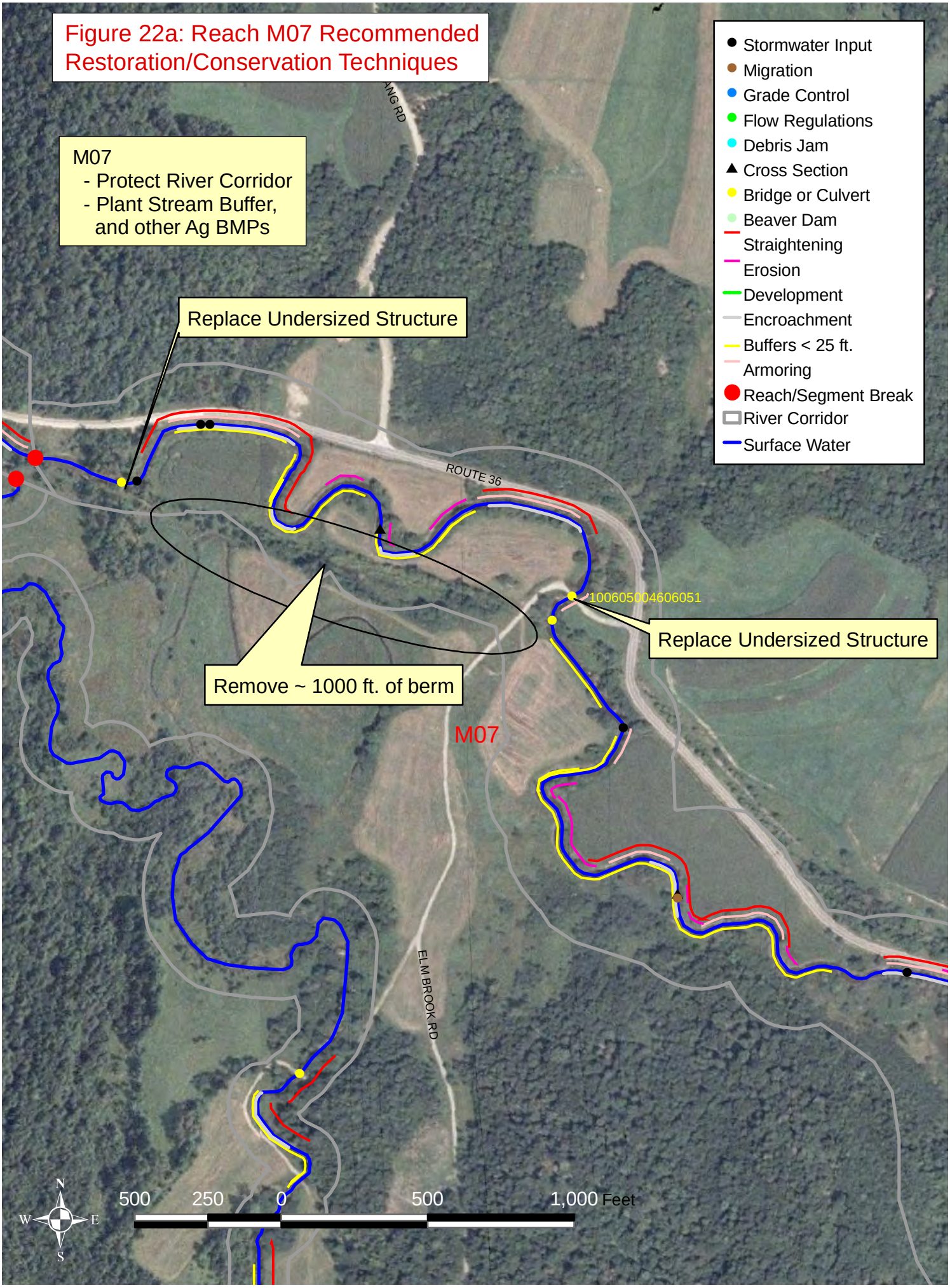


Figure 22a: Reach M07 Recommended Restoration/Conservation Techniques
M07
- Protect River Corridor
- Plant Stream Buffer, and other Ag BMPs
Replace Undersized Structure
Remove ~ 1000 ft. of berm
Replace Undersized Structure
100605004606051
M07
ROUTE 36
ELM BROOK RD
Stormwater Input
Migration
Grade Control
Flow Regulations
Debris Jam
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Erosion
Development
Encroachment
Buffers < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
N
W
E
S
500
250
0
500
1,000 Feet

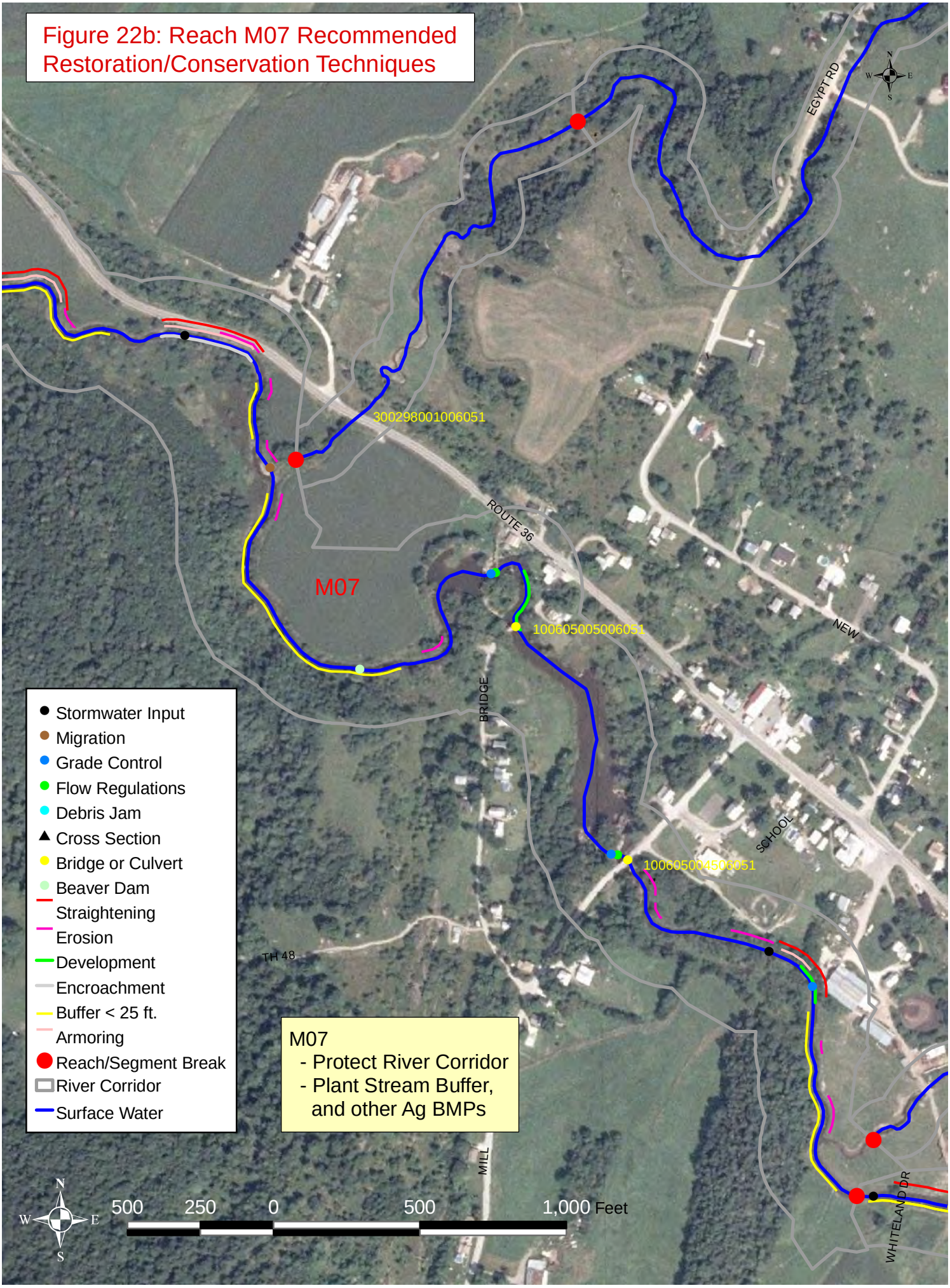


Figure 22b: Reach M07 Recommended Restoration/Conservation Techniques
EGYPT RD
300298001006051
ROUTE 36
M07
100605005006051
BRIDGE
NEW
SCHOOL
100605004506051
TH 48
MILL
WHITELAND DR
Stormwater Input
Migration
Grade Control
Flow Regulations
Debris Jam
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Erosion
Development
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
M07
- Protect River Corridor
- Plant Stream Buffer, and other Ag BMPs
N
W
E
S
500 250 0 500 1,000 Feet

5.1.8 Reach M08 Description and Project Identification

Reach M08 extends from the upstream end of M07 upstream for approximately 1.1 miles. The reach was found to be relatively stable, despite heavy encroachment from the abandoned rail bed, which runs within the river corridor for the entire reach. It was not incised (ratio of 1.0) and is in channel evolution stage I. The existing stream type of E5 – Dune-Ripple was consistent with its reference type. The riparian corridor was dominated by a mix of pasture and forest, with little fencing to prevent cows access to the stream channel. Two sets of culverts were identified near the downstream end of the reach, one on the abandoned railbed, the other on a nearby private crossing. While the combined widths of both sets of culverts are adequate for the size of the stream channel, both represent a flood hazard due to the likelihood of debris jams blocking their entrances. The rapid habitat assessment score was 0.64 (good), indicating favorable aquatic habitat.

The recommended project types for M08 are very similar to those for M07. The abandoned railroad bed should be removed or retrofitted with bridges and/or adequately sized culverts to increase the size of available floodplain. The existing river corridor should be protected from development and/or channel management to retain the sediment and nutrient attenuation functions of the reach. Fencing and dedicated cattle crossing sites need to be implemented to limit the cows access to the stream channel and buffer strips need to be established along the pastures. Replacement of the two undersized culverts is also needed. An aerial view of the reach is shown on Figure 23, and descriptions of the recommended projects are shown in Table 12. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 12: Projects and Practices Table - Black Creek
Reach M08

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M08	Protect River Corridor - River corridor dominated by mix of pasture and forest with large areas of buffers less than 25 feet. Reach relatively stable with good floodplain access (incision of 1.0). Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Medium	High	52	Yes	Landowner cooperation needed.
M08	Plant Stream Buffer and cattle fencing - Majority of river corridor dominated by pasture with large areas of buffers less than 25 feet. Several areas with cows in stream, fencing and dedicated crossings needed to reduce erosion and limit nutrient inputs.	High	Medium	16	Yes	Landowner cooperation required. Could be CREP eligible
M08	Remove Berm - Railroad bed runs within corridor for most of reach and limits historic floodplain access. Remove or retrofit berm with bridges/culverts to improve floodplain connection and sediment and nutrient attenuation.	High	High	25	Yes	Landowner permission needed.
M08	Replace undersized structures - Two culverts located near upstream end of reach. Abandoned railbed has 3 culverts, private crossing has 2. Replacement with bridge or arch would improve flow, limit flooding/erosioin hazards, limit debris jam potential, and improve aquatic habitat.	Medium	Medium	32	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. Both structures privately owned.

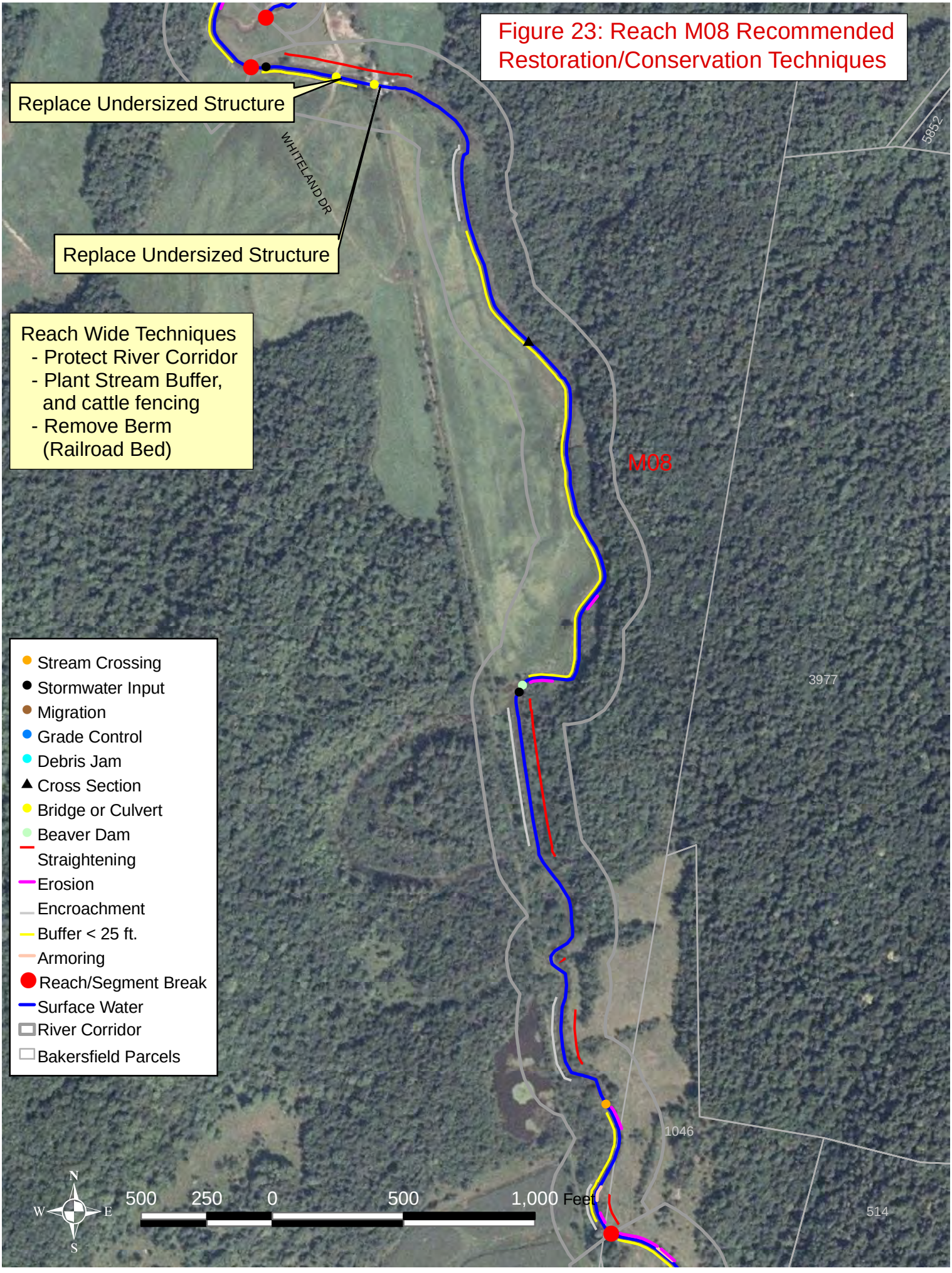


Figure 23: Reach M08 Recommended Restoration/Conservation Techniques
Replace Undersized Structure
Replace Undersized Structure
WHITELAND DR
Reach Wide Techniques
- Protect River Corridor
- Plant Stream Buffer, and cattle fencing
- Remove Berm (Railroad Bed)
M08
5852
3977
1046
514
Stream Crossing
Stormwater Input
Migration
Grade Control
Debris Jam
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Erosion
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
Surface Water
River Corridor
Bakersfield Parcels
N
W
E
S
500
250
0
500
1,000 Feet

5.1.9 Reach M09 Description and Project Identification

Reach M09 extends from the upstream end of M08 upstream for approximately 2.8 miles to just south of the confluence with M9T8.01. It was segmented into two parts, M09A and M09B due to land use differences. M09A extends from the downstream end of the reach upstream for approximately 0.5 miles to Whitney Road. The segment was relatively stable with very little incision (ratio of 1.1) and minor planform adjustments. The existing stream type of E5 Dune-Ripple was consistent with its reference type. The riparian corridor was dominated by pasture with extensive erosion and little to no existing buffers. Cows were observed within the stream channel throughout the reach. The habitat assessment showed relatively poor aquatic habitat primarily due to a lack of adequate woody cover and few favorable sediment types and flow patterns.

M09B is the downstream end of the reach and extends from Whitney Road upstream for approximately 2.3 miles to just south of M9T8.01. This segment was also relatively stable with no incision or other major ongoing adjustments. The existing stream type of E5 Dune-Ripple was consistent with its reference type. The riparian corridor was dominated by a mix of forest and hay fields with little to no buffer between the fields and stream channel (though only minor erosion was noted). Multiple beaver dams were noted throughout the reach. Like much of the other main stem reaches, the abandoned rail bed runs through portions of the river corridor and represents a major floodplain constriction. The culvert crossing Lost Nation Road is severely undersized and represents a major channel and floodplain constriction.

Given the relative stable condition of M09A, the recommended remedial strategies are to protect the existing undeveloped river corridor to retain the reach's nutrient attenuation assets, and enhance the riparian buffer to increase those assets. Cattle fencing and improved stream crossing structures should also be incorporated to reduce nutrient inputs into the stream. Corridor protection and buffer enhancement are also important in Segment B. Removal or retrofitting of the railroad berm should also be done where it encroaches upon the floodplain to enhance the sediment and nutrient retention potential of the reach. The culverts that cross Lost Nation Road are severely undersized and should be replaced with a bridge or arch to reduce flood hazards around the road. An aerial view of the reach is shown on Figures 24a, b, and c, and descriptions of the recommended projects are shown in Table 13. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 13: Projects and Practices Table - Black Creek
Reach M09

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M09A	Protect River Corridor - River corridor dominated by mix of pasture and forest with large areas of buffers less than 25 feet. Reach relatively stable with good floodplain access (incision of 1.1). Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Medium	High	50	Yes	Landowner cooperation needed.
M09A	Plant Stream Buffer and cattle fencing - Majority of river corridor dominated by pasture with large areas of buffers less than 25 feet. Several areas with cows in stream, fencing and dedicated crossings needed to reduce erosion and limit nutrient inputs.	High	High	11	Yes	Landowner cooperation required. Could be CREP eligible
M09B	Protect River Corridor - River corridor dominated by mix of hay and forest with large areas of buffers less than 25 feet. Reach relatively stable with good floodplain access (incision of 1.1). Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Medium	High	51	Yes	Landowner cooperation needed.
M09B	Remove Berm - Railroad bed runs within corridor for large areas upstream and downstream of Lost Nation Road and limits historic floodplain access. Remove or retrofit berm with bridges/culverts to improve floodplain connection and sediment and nutrient attenuation.	High	High	23	Yes	Landowner permission needed.
M09B	Plant Stream Buffer and other Ag BMPs- Large portion of river corridor dominated by hay with large areas of buffers less than 25 feet. If possible, buffers planting should extend up field ditches to limit sediment and nutrient inputs.	High	High	12	Yes	Landowner cooperation required. Could be CREP eligible
M09B	Replace undersized structure - Culvert crossing Lost Nation Road highly undersized with structure to channel width of 27%. Replacement with bridge or arch would improve flow, limit flooding/erosioin hazards, limit debris jam potential, and improve aquatic habitat.	Medium	High	30	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. Town of Bakersfield owned structure.

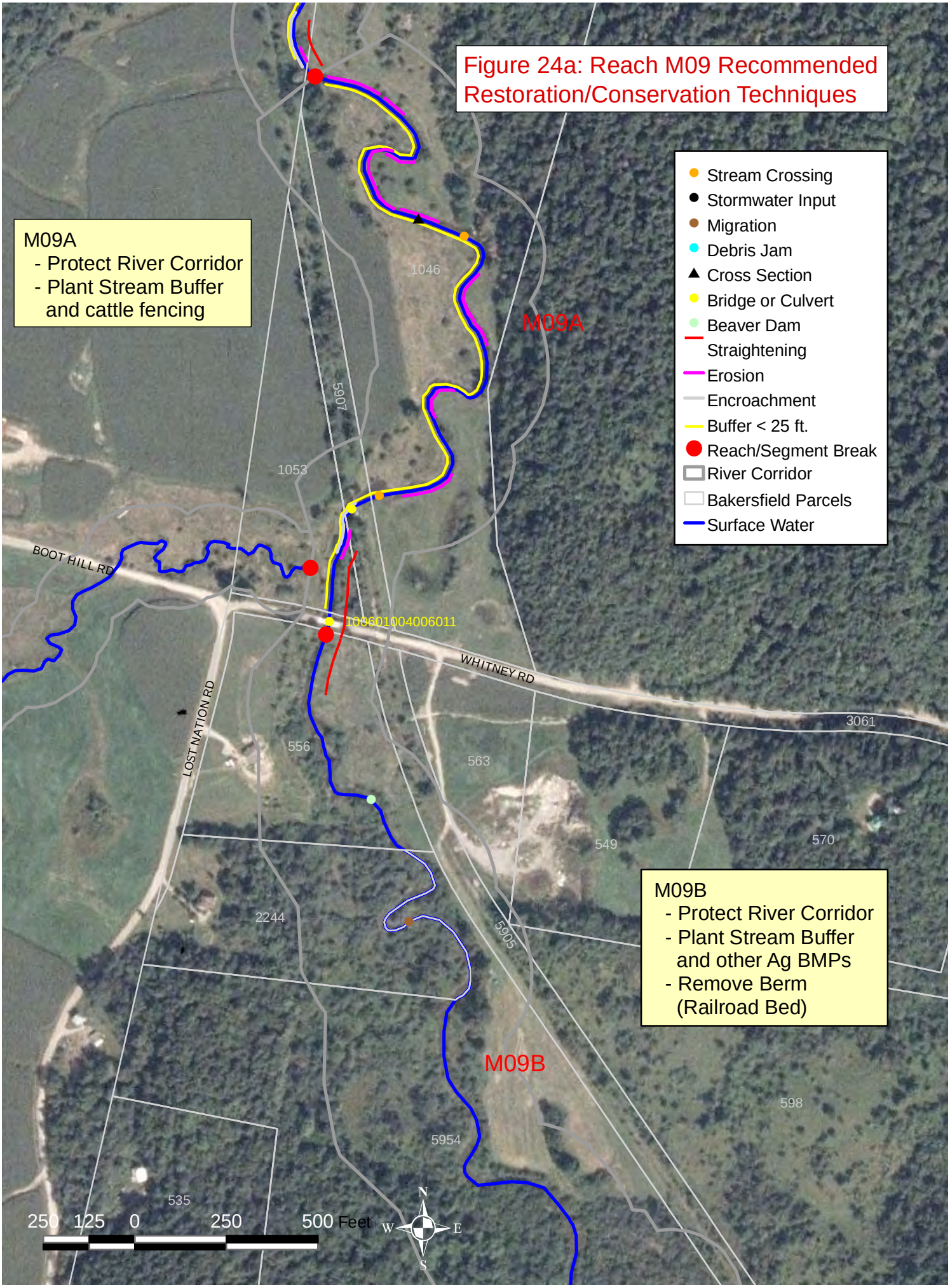


Figure 24a: Reach M09 Recommended Restoration/Conservation Techniques
M09A
- Protect River Corridor
- Plant Stream Buffer and cattle fencing
M09B
- Protect River Corridor
- Plant Stream Buffer and other Ag BMPs
- Remove Berm (Railroad Bed)
Stream Crossing
Stormwater Input
Migration
Debris Jam
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Erosion
Encroachment
Buffer < 25 ft.
Reach/Segment Break
River Corridor
Bakersfield Parcels
Surface Water
M09A
M09B
1046
1053
5907
BOOT HILL RD
WHITNEY RD
LOST NATION RD
1006010004006011
3061
556
563
549
570
2244
5905
598
5954
535
250 125 0 250 500 Feet
N
W
E
S

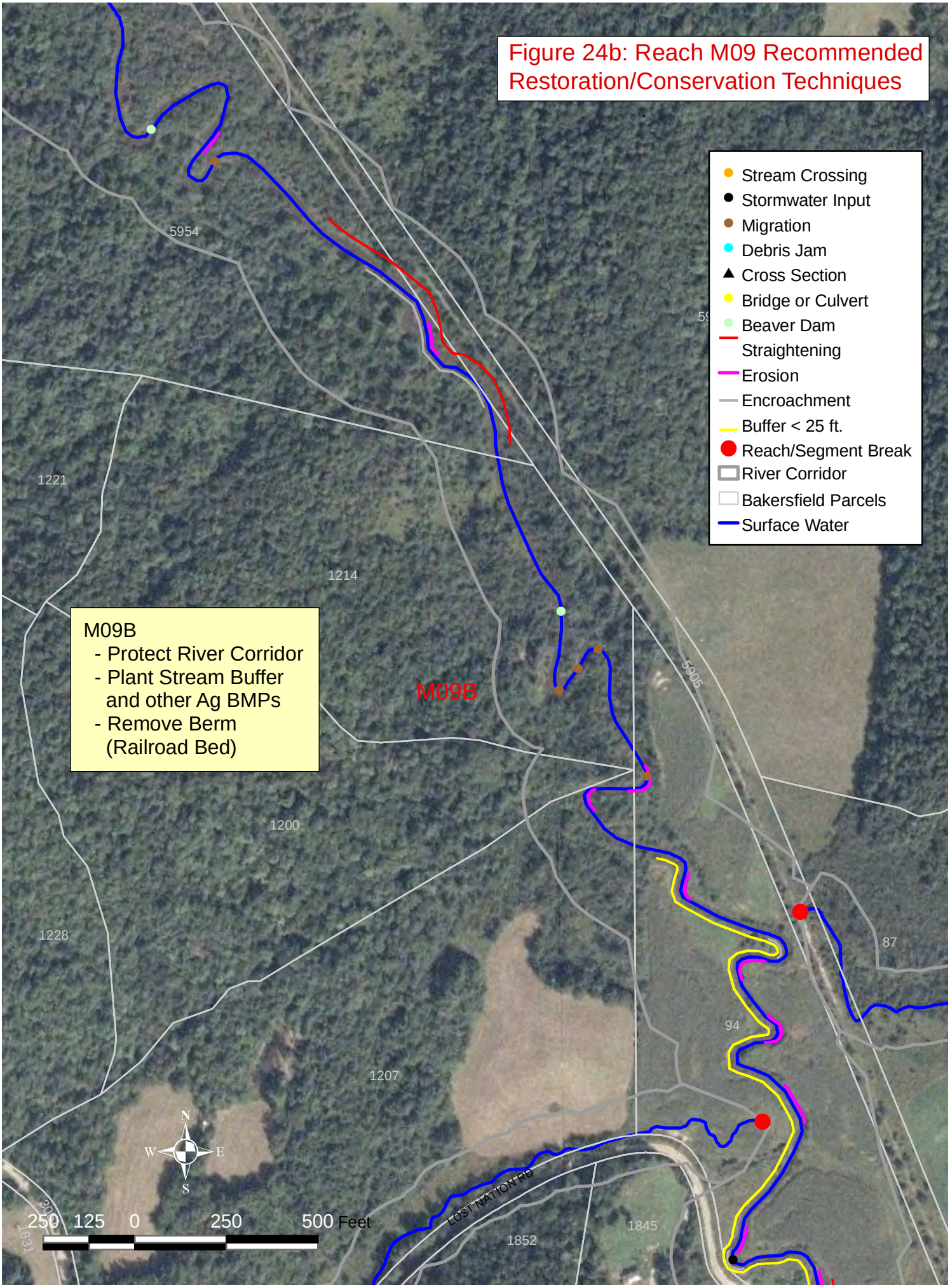


Figure 24b: Reach M09 Recommended Restoration/Conservation Techniques
Stream Crossing
Stormwater Input
Migration
Debris Jam
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Erosion
Encroachment
Buffer < 25 ft.
Reach/Segment Break
River Corridor
Bakersfield Parcels
Surface Water
M09B
- Protect River Corridor
- Plant Stream Buffer and other Ag BMPs
- Remove Berm (Railroad Bed)
M09B
5954
1221
1214
1200
1228
1207
5905
87
94
1845
1852
LOST NATION RD
N
W
E
S
250 125 0 250 500 Feet

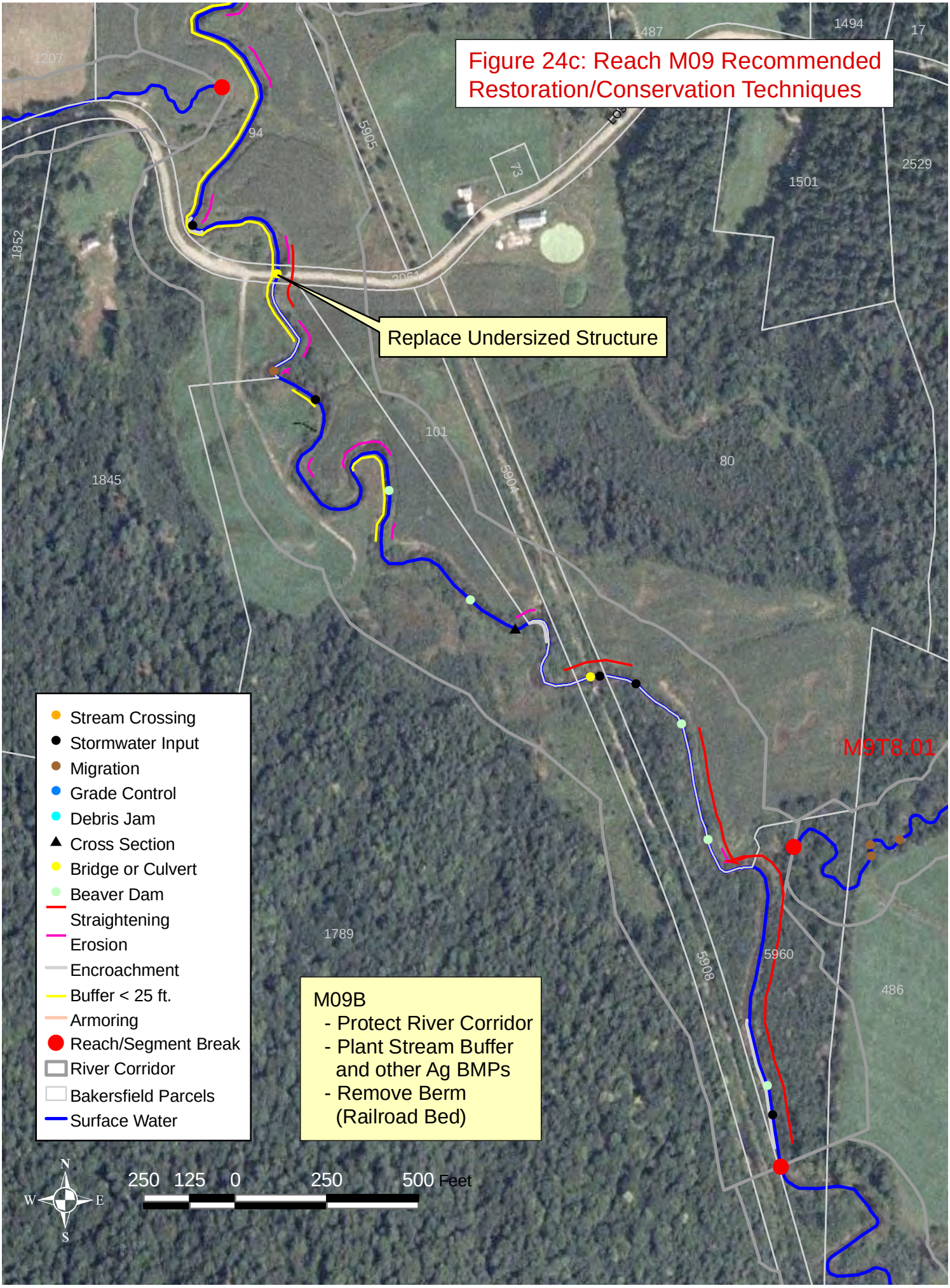


Figure 24c: Reach M09 Recommended Restoration/Conservation Techniques
Replace Undersized Structure
M9T8.01
M09B
- Protect River Corridor
- Plant Stream Buffer and other Ag BMPs
- Remove Berm (Railroad Bed)
Stream Crossing
Stormwater Input
Migration
Grade Control
Debris Jam
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Erosion
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Bakersfield Parcels
Surface Water
N
W
E
S
250 125 0 250 500 Feet
1207
1487
1494
17
2529
1501
1852
1845
1789
5960
5908
5904
5905
486
80
101
94
73

5.1.10 Reach T2.01 Description and Project Identification

Reach T2.01 extends from its confluence with Black Creek north of Pumpkin Village Road upstream for approximately 1 mile. The reach was segmented into T2.01A and T2.01B due to differences in the channel dimensions and boundary conditions. Segment A is the downstream end of the reach and is approximately 0.7 miles long. The segment was classified as an E5 Dune-Ripple, consistent with its reference stream type, though due to minor historic channel degradation and active widening and aggradation it is in Evolution Stage IV (Widening). Only minor incision was noted (ratio of 1.2) and no active head cuts were observed. A significant amount of bank erosion was observed. The riparian corridor was dominated by hay fields with little to no buffer. The habitat assessment showed relatively poor aquatic habitat conditions. T2.01B is the upstream portion of the reach and extends to approximately 0.2 miles upstream of the North Road crossing. This segment was naturally steeper and more confined, and was classified as a B3 – Step-pool system. It was relatively stable with no active adjustment processes. The riparian corridor was dominated by a mix of hay fields and residential development with buffers ranging from 26 to 50 feet in width. The habitat assessment showed good aquatic habitat. The culvert crossing North Road is severely undersized with a structure width to channel width ratio of only 21%.

Given the current condition of T2.01A, the recommended remedial strategies are to protect the existing undeveloped corridor to retain the attenuation assets of the reach and enhance the riparian buffer. Buffer establishment is needed to reduce sediment and nutrient inputs and stabilize the numerous eroding streambanks. Segment B is naturally a transport system located in a narrow portion of the valley so corridor protection is less important here. The culvert crossing North Road should be replaced with an adequately sized bridge or arch. Table 14 and Figure 25 below describe and show the locations of the recommended projects.

Table 14: Projects and Practices Table - Black Creek
Reach T2.01

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
T2.01A	Protect River Corridor - River corridor dominated by hay fields with large areas of buffers less than 25 feet. Reach actively widening and aggrading with good floodplain access (incision of 1.2). Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	High	High	46	Yes	Landowner cooperation needed.
T2.01A	Plant Stream Buffer and other Ag BMPs- River corridor dominated by hay with large areas of buffers less than 25 feet. If possible, buffers planting should extend up field ditches to limit sediment and nutrient inputs.	High	High	10	Yes	Landowner cooperation required. Could be CREP eligible
T2.01B	Protect River Corridor - River corridor dominated by mix of residential and hay with buffers between 26 and 50. Reach naturally a transport B-type stream, so corridor protection less important here than in sediment attenuation areas.	Medium	Low	65	Yes	Landowner cooperation needed.
T2.01B	Replace undersized structure - Culvert crossing North Road highly undersized with structure to channel width of 21%. Replacement with bridge or arch would improve flow, limit flooding/erosioin hazards, limit debris jam potential, and improve aquatic habitat.	High	High	29	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. Town of Fairfield owned structure.

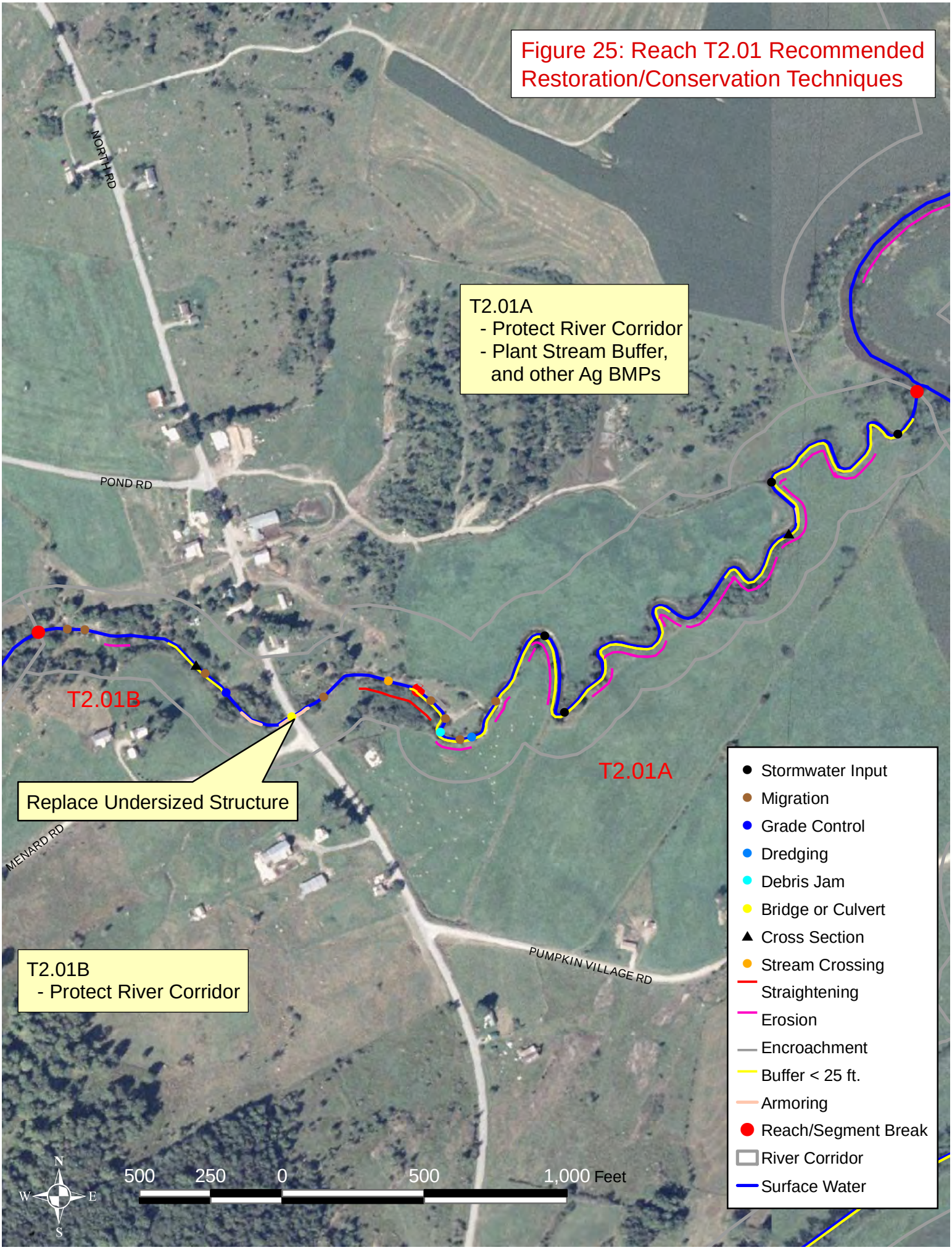


Figure 25: Reach T2.01 Recommended Restoration/Conservation Techniques
T2.01A
- Protect River Corridor
- Plant Stream Buffer, and other Ag BMPs
T2.01B
T2.01A
Replace Undersized Structure
T2.01B
- Protect River Corridor
NORTH RD
POND RD
MENARD RD
PUMPKIN VILLAGE RD
Stormwater Input
Migration
Grade Control
Dredging
Debris Jam
Bridge or Culvert
Cross Section
Stream Crossing
Straightening
Erosion
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
N
W
E
S
500 250 0 500 1,000 Feet

5.1.11 Reach T2.02 Description and Project Identification

Reach T2.02 extends from the end of T2.01 upstream for approximately 1.5 miles. The reach was segmented into T2.02A, T2.02B, and T2.02C due to differences in the channel dimensions and streambank and boundary conditions. T2.02A is the downstream end of the reach and is approximately 0.7 miles long. The segment was classified as a C3 – Riffle-Pool, consistent with its reference stream type, and overall the reach was stable and in reference condition. No erosion or other adjustments were noted. The riparian corridor was dominated by forest with buffers greater than 100 feet. The habitat assessment showed excellent aquatic habitat.

T2.02B is the middle of the reach and is approximately 0.3 miles long. This segment has been historically straightened and intensely managed for agriculture. Despite this, only minor aggradation was noted and the stream still has good floodplain access. The C4-Riffle-Pool stream type was consistent with its reference type. The riparian corridor was dominated by pasture and hayfields with little to no buffer along the right bank. Cows were observed in the stream channel throughout the segment. The new bridge crossing Jettie Drive was found to be highly undersized with a structure to channel width ratio of 60%. T2.02C was dominated by beaver dams and several bedrock gorges and could not be fully assessed.

Both T2.02A and T2.02B are currently relatively stable, so the river corridor should be protected to prevent development and channel management, and retain the reaches sediment and nutrient retention functions. Buffer planting and cattle fencing are needed along the right bank in segment B to limits cows access to the stream, reduce sediment and nutrient inputs, and improve bank stability. In addition, the bridge on Jettie Drive is undersized. This appeared to be a relatively new structure so replacement in the short term is probably unlikely, though a wider structure would reduce future flood and erosion hazards and improve the flow regime of the stream. Table 15 and Figure 26 below describe and show the locations of the recommended projects. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 15: Projects and Practices Table - Black Creek
Reach T2.02

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
T2.02A	Protect River Corridor - River corridor dominated by forest. Segment stable. Corridor protection to limit channel management and protect sediment and nutrient attenuation assets.	Low	Low	62	Yes	Landowner cooperation needed.
T2.02B	Protect River Corridor - River corridor dominated by mix of pasture and hay with no buffer on righ side. Segment currently stable with good floodplain access. Corridor protection to limit channel management and protect existing sediment and nutrient attenuation assets.	Medium	Medium	59	Yes	Landowner cooperation needed.
T2.02B	Plant Stream Buffer and cattle fencing - Majority of river corridor dominated by pasture with large areas of buffers less than 25 feet on right. Several areas with cows in stream, fencing and dedicated crossings needed to reduce erosion and limit nutrient inputs.	High	Medium	19	Yes	Landowner cooperation required. Could be CREP eligible
T2.02B	Replace undersized structure - Bridge crossing Jettie Drive undersized with structure to channel width of 60%. Replacement with wider structure to improve flow, limit flooding/erosioin hazards, limit debris jam potential, and improve aquatic habitat.	Medium	Medium	38	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. Town of Fairfield owned structure.

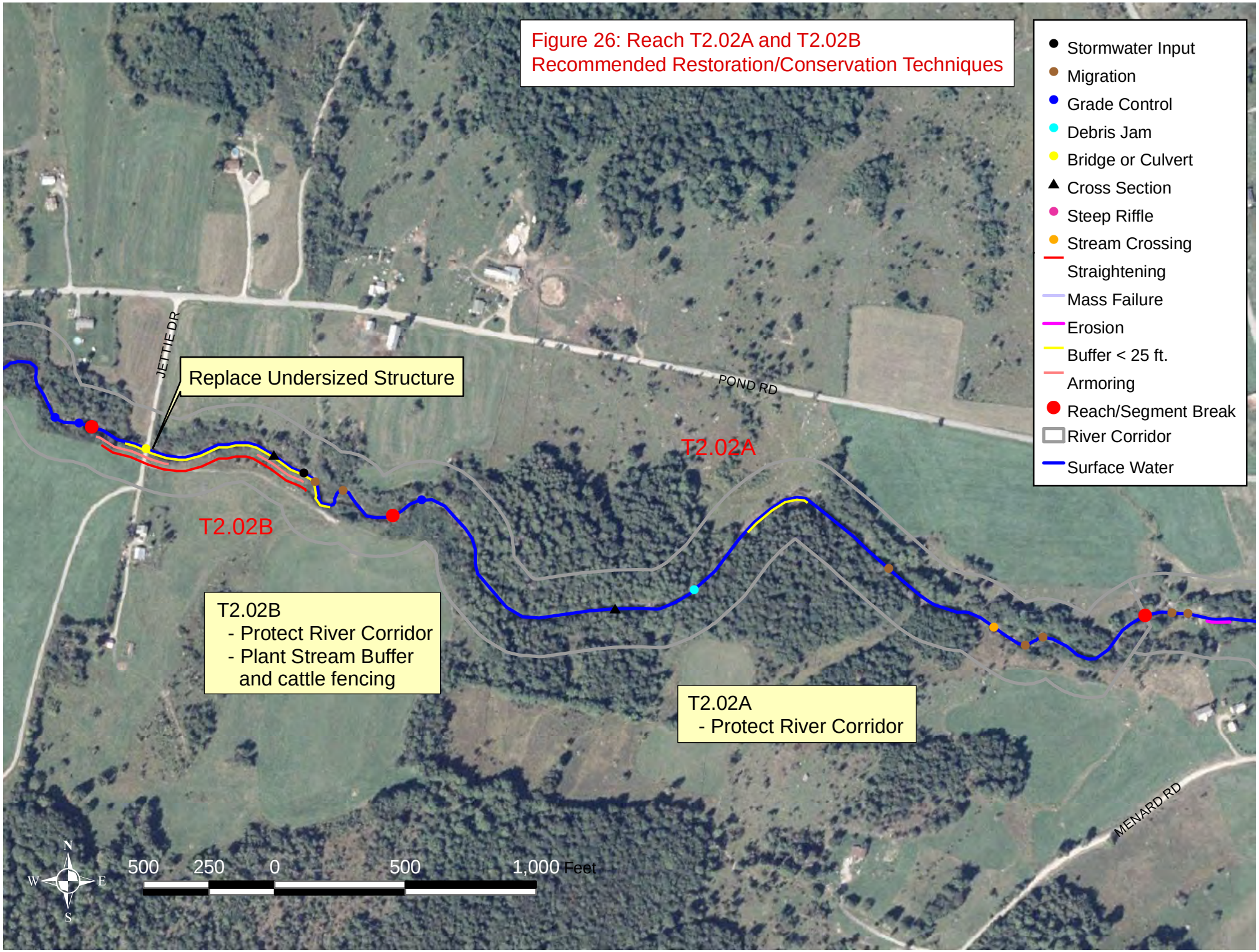


Figure 26: Reach T2.02A and T2.02B
Recommended Restoration/Conservation Techniques
Stormwater Input
Migration
Grade Control
Debris Jam
Bridge or Culvert
Cross Section
Steep Riffle
Stream Crossing
Straightening
Mass Failure
Erosion
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
JETTIE DR
POND RD
Replace Undersized Structure
T2.02A
T2.02B
T2.02B
- Protect River Corridor
- Plant Stream Buffer and cattle fencing
T2.02A
- Protect River Corridor
MENARD RD
N
W
E
S
500 250 0 500 1,000 Feet

5.1.12 Reach T4.01 Description and Project Identification

Reach T4.01 extends from its confluence with Black Creek upstream for approximately 0.6 miles to where the valley becomes narrower and steeper. This reach was found to be highly incised with an incision ratio of 1.8 due to historic straightening, extensive agricultural activities, and other channel management techniques, and has only limited floodplain access. Despite the incision, the phase 2 stream type of C4 – Plane bed was consistent with its reference type, though it lacked the expected riffle pool sequences common with C type streams. Extensive erosion was noted along both banks as the stream attempts to widen and create new floodplain access at a lower elevation (channel evolution stage III). The riparian corridor was dominated by a mix of pasture and hay fields with little to no buffer. The habitat assessment showed relatively poor aquatic habitat due to a lack of woody cover, channel alterations, and very few favorable sediment types and flow patterns. The bridge crossing the abandoned rail bed located at the lower end of the reach was adequately sized with a structure to channel width ratio of 227%.

Given the high incision ratio in T4.01, active floodplain restoration is the most appropriate technique. This would involve lowering the existing bank heights to allow the stream to flood more frequently resulting in less erosion and an increase in sediment and nutrient retention. In combination with this, corridor protection and buffer establishment should be conducted to reduce nutrient inputs. If active restoration is not possible, buffer planting could still be initiated here, though careful thought should be given to the location of plantings to prevent loss due to bank erosion. Table 16 and Figure 27 below describe and show the locations of the recommended projects.

Table 16: Projects and Practices Table - Black Creek
Reach T4.01

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
T4.01	Restore Incised Reach - Reach no longer has complete access to floodplain (incision of 1.8), corridor protection project could be combined with active restoration (create new floodplain) to enhance sediment attenuation and reduce erosion	High	High	39	Yes	Should be combined with corridor protection and stream buffer planting projects, Landowner cooperation and more detailed assessment needed
T4.01	Protect River Corridor - Most of Reach is undeveloped pasture and hay. Due to high Incision ratio of 1.8 corridor protection should be done in combination with active floodplain restoration to re-establish floodplain connection and reduce future erosion.	Low as stand alone project	Low as stand alone project	57	Yes	Landowner cooperation - Should be combined with active floodplain restoration and buffer establishment.
T4.01	Plant Stream Buffer - Majority of river corridor dominated by pasture and hay with large areas of buffers less than 25 feet. Buffer planting needed to reduce erosion and limit nutrient inputs.	High	Medium	13	Yes	Landowner cooperation required. Could be CREP eligible. Ideally combined with active floodplain restoration project.

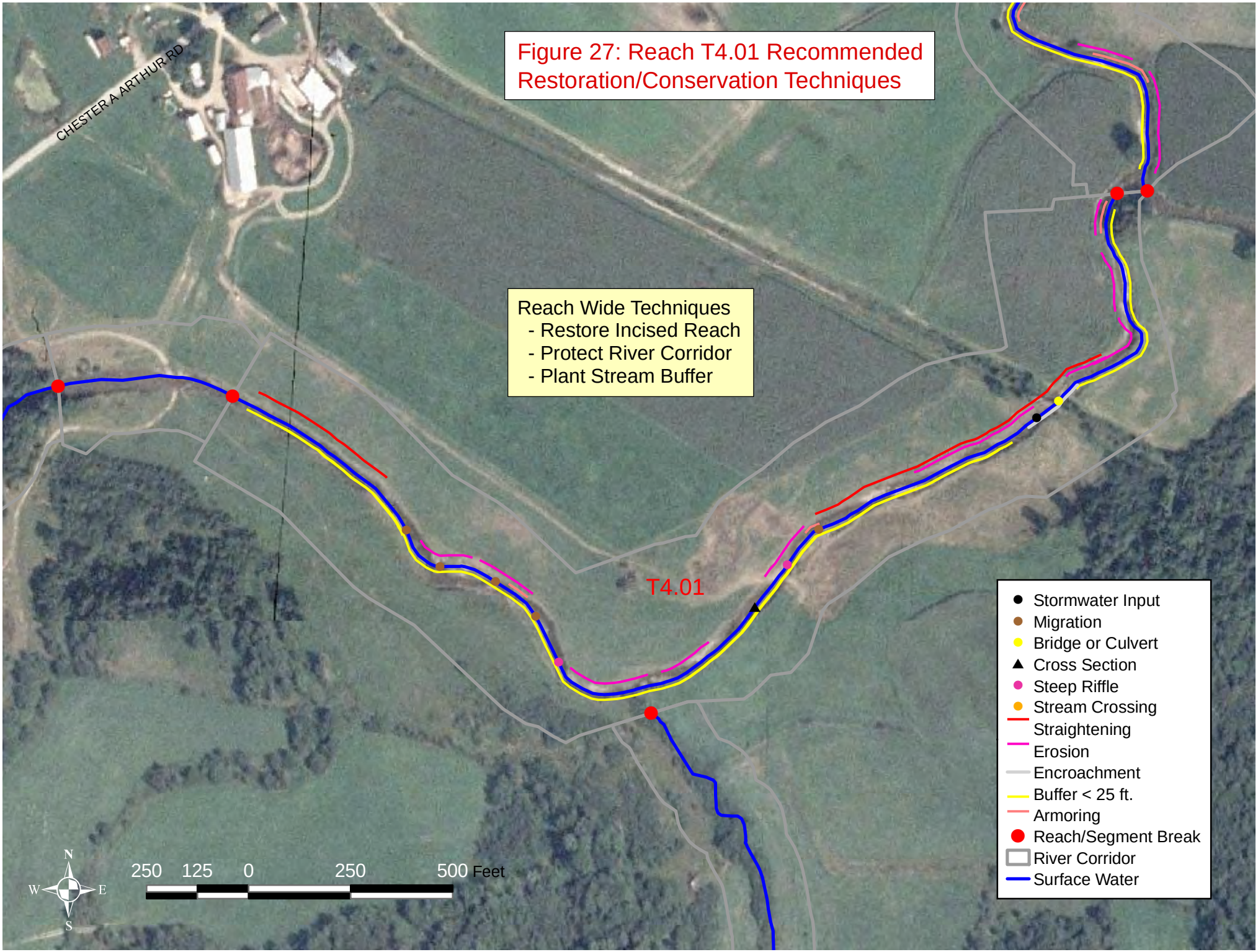


Figure 27: Reach T4.01 Recommended Restoration/Conservation Techniques
CHESTER A ARTHUR RD
Reach Wide Techniques
- Restore Incised Reach
- Protect River Corridor
- Plant Stream Buffer
T4.01
Stormwater Input
Migration
Bridge or Culvert
Cross Section
Steep Riffle
Stream Crossing
Straightening
Erosion
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
N
W
E
S
250 125 0 250 500 Feet

5.1.13 Reach T4.03 Description and Project Identification

Reach T4.03 extends from the end of T4.02 (a very short reach not assessed during this project) upstream for approximately 0.6 miles. This reach was found to be relatively stable with little ongoing adjustments. It is located in a naturally narrow and steeper portion of the valley and was classified as a B3 – step-pool type stream. No erosion or other significant problems were noted. The riparian corridor was dominated by forest with no human impacts near the stream channel. The rapid habitat assessment showed relatively good aquatic habitat.

Given the location of T4.03 and relative stability there are no recommended projects. The reach is currently stable and undeveloped. This should be maintained through corridor protection, though because this reach is naturally a transport type environment, preference should be given to protecting those areas in other reaches that can improve or retain needed sediment and nutrient retention. An aerial view of the reach is shown on Figure 28, and descriptions of the recommended projects are shown in Table 17. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 17: Projects and Practices Table - Black Creek
Reach T4.03

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
T4.03	Protect River Corridor - Reach is undeveloped forest. Reach stable with little adjustments. Reach located in narrow, steeper portion of valley acts a transport system. Corridor protection less important here than in attenuation areas.	Low	Low	66	Yes	Landowner cooperation

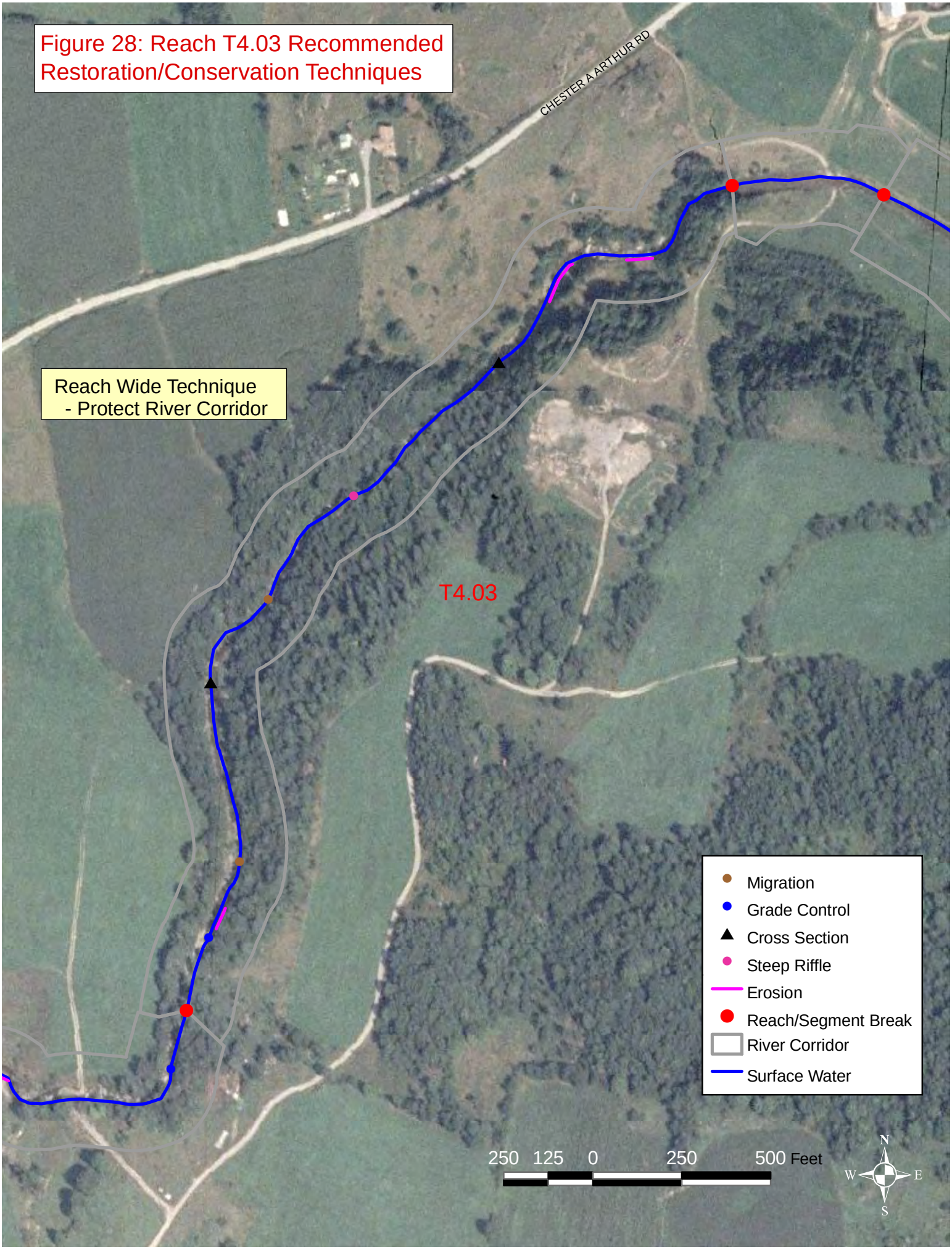


Figure 28: Reach T4.03 Recommended Restoration/Conservation Techniques
CHESTER A ARTHUR RD
Reach Wide Technique
- Protect River Corridor
T4.03
Migration
Grade Control
Cross Section
Steep Riffle
Erosion
Reach/Segment Break
River Corridor
Surface Water
250 125 0 250 500 Feet
N
W
E
S

5.1.14 Reach T4.04 Description and Project Identification

Reach T4.04 extends from the upstream end of T4.03 upstream for approximately 1.3 miles. The reach was segmented into two parts, T4.04A and T4.04B, due to differences in valley width and slope. T4.04A is the downstream end of the reach and is approximately 0.8 miles long. It is located in a naturally narrow, steeper portion of the valley, and is characterized as a B4-step-pool stream type, consistent with its reference type. Overall, the reach was relatively stable with no incision or other adjustment processes noted. Several bedrock grade controls and gorges were noted throughout the reach. The riparian corridor was dominated by a mix of pasture, hay, and forest with narrow buffer widths ranging from 25 to 100 feet. A few areas of inadequate buffer were noted, though tree plantings had recently been done to address these areas. The bridge crossing Route 36 was found to be adequately sized with a structure to channel width ratio of 165%.

T4.04B is the upstream portion of the reach and is approximately 0.5 miles long. It was moderately incised (ratio of 1.4) with active widening and aggradation (channel evolution stage III). This segment is located in a broader, shallower portion of the valley and was classified as a C4 – riffle-pool stream, consistent with its reference type. Moderate bank erosion was noted on the outside of meander bends and cows were noted in the stream channel in the upper portion of the segment. The riparian corridor was dominated by forest on the right and a mix of hay and pasture on the left with buffers ranging from 0 to 50 feet.

Given the location of T4.04 and relative stability, there are no recommended projects. The reach is currently stable and undeveloped. This should be maintained through corridor protection, though because this reach is naturally a transport type environment, preference should be given to protecting those areas in other reaches that can improve or retain needed sediment and nutrient retention. T4.04B is less stable and naturally a sediment and nutrient attenuation zone, so protecting the river corridor here is more important than downstream. Segment B is moderately incised and in the process of widening and aggrading to re-establish floodplain

connection. The existing undeveloped corridor should be protected to allow these functions to continue. In addition, buffers should be established between the hay and pasture on the left bank and the stream channel. Fencing is needed in the pasture to limit the cows access to the stream channel. An aerial view of the reach is shown on Figure 29, and descriptions of the recommended projects are shown in Table 18. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 18: Projects and Practices Table - Black Creek
Reach T4.04

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
T4.04A	Protect River Corridor - Reach is mix of hay and pasture with 25 - 50 foot buffers. Reach stable with little adjustments. Reach located in narrow, steeper portion of valley acts a transport system with multiple grade controls. Corridor protection less important here than in attenuation areas.	Lohw	Low	64	Yes	Landowner cooperation
T4.04B	Protect River Corridor - River corridor dominated by mix of hay fields and forest. Reach actively widening and aggrading to restore floodplain access (incision of 1.4). Corridor protection to allow channel adjustments to continue, limit channel management, and protect sediment and nutrient attenuation assets.	Medium	Medium	54	Yes	Landowner cooperation needed.
T4.04B	Plant Stream Buffer and cattle fencing - Majority of river corridor dominated by hay and pasture on left with ~800 feet of buffers less than 25 feet. Cows in stream in upstream portion of segment, fencing needed to reduce erosion and limit nutrient inputs.	High	Medium	20	Yes	Landowner cooperation required. Could be CREP eligible

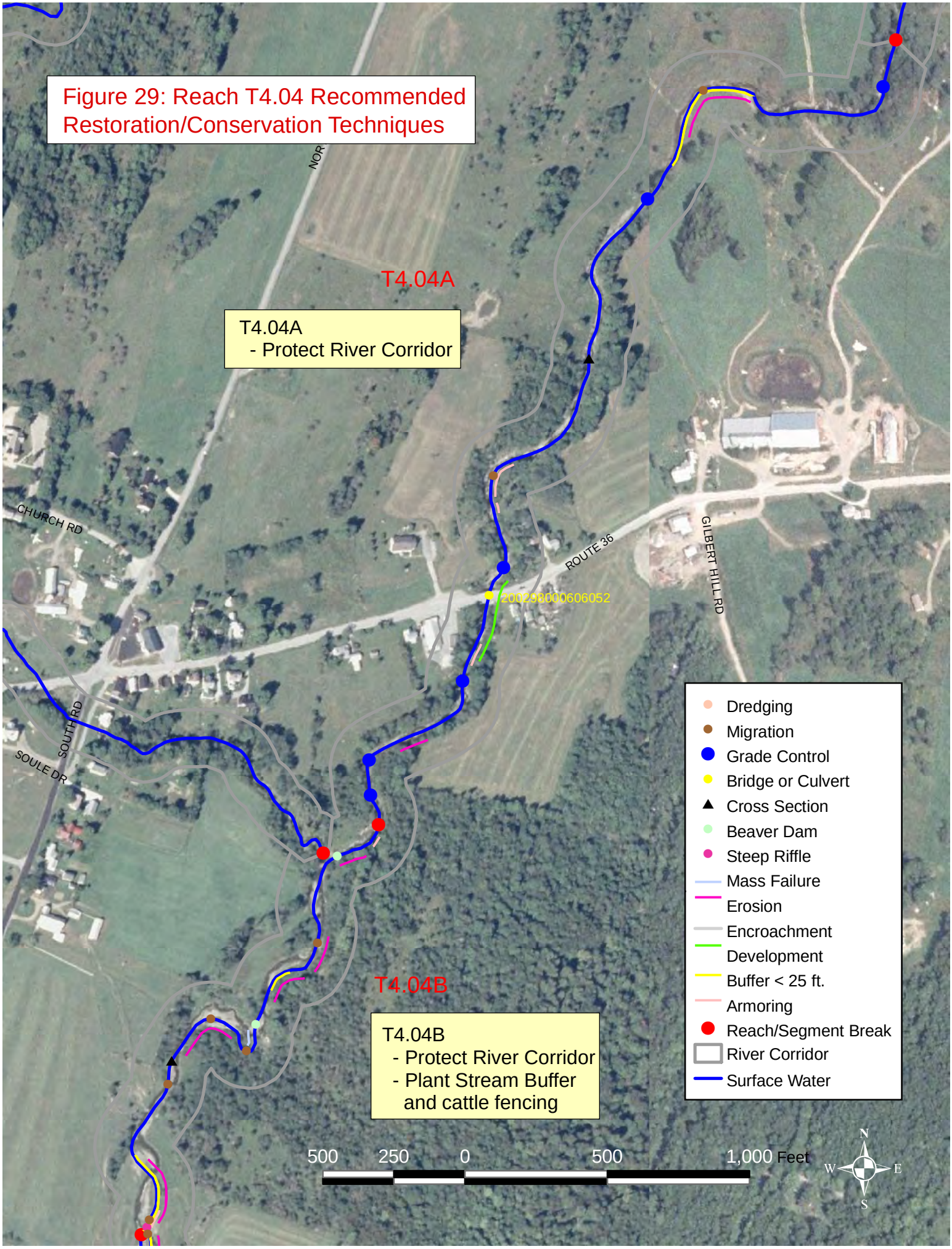


Figure 29: Reach T4.04 Recommended Restoration/Conservation Techniques
T4.04A
T4.04A
- Protect River Corridor
T4.04B
T4.04B
- Protect River Corridor
- Plant Stream Buffer and cattle fencing
CHURCH RD
ROUTE 36
GILBERT HILL RD
SOUTH RD
SOULE DR
200298000606052
Dredging
Migration
Grade Control
Bridge or Culvert
Cross Section
Beaver Dam
Steep Riffle
Mass Failure
Erosion
Encroachment
Development
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
500 250 0 500 1,000 Feet
N
W
E
S

5.1.15 Reach T4.05 Description and Project Identification

Reach T4.05 extends from the end of T4.04 upstream for approximately 0.8 miles. The Reach was segmented into T4.05A and T4.05B due to differences in valley width and corridor land use. T4.05A is the downstream portion of the reach and is approximately 0.25 miles long. It was moderately incised (ratio of 1.4) with minor widening and planform adjustments (channel evolution stage IV). The existing stream type (C4 – plane-bed) was consistent with its reference type, but lacked distinct riffles and pools as would be expected with this type of system. The riparian corridor was dominated by a mix of corn and pasture with little to no buffers. Cows were observed in the stream channel throughout the segment. A small berm runs along the left bank for approximately 600 feet, protecting the adjacent cornfield from flooding.

T4.05B was less developed and located in a narrow portion of the valley. It was relatively stable with no major adjustments noted. The riparian corridor was dominated by forest and shrub/sapling. Several bedrock grade controls were observed scattered throughout the reach.

Recommended project types for segment A include river corridor protection, buffer planting and fencing, and removal of the berm along the left bank. The stream is currently moderately incised, but still has floodplain access during most high flow events. The existing river corridor should be protected to retain the sediment and nutrient retention capacity of this area. Removal of the berm along the left side would enhance these functions. To reduce nutrient inputs and improve aquatic habitat, buffers should be established along with fencing to limits the cows' access to the stream channel. Segment B is relatively stable with little ongoing adjustments. This should be maintained through corridor protection, though because this reach is naturally a transport type environment, preference should be given to protecting those areas in other reaches that can improve or retain needed sediment and nutrient retention. Table 19 and Figure 30 below describe and show the locations of the recommended projects. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 19: Projects and Practices Table - Black Creek
Reach T4.05

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
T4.05A	Protect River Corridor - Reach is mix of crop and pasture with little to no buffers. Reach moderately incised (ratio of 1.4) minor widening and planform adjustments. Corridor protection to allow for future channel adjustments to continue and protect sediment and nutrient attenuation assets.	Medium	Medium	53	Yes	Landowner cooperation
T4.05A	Remove Berm - Approximately 600 feet of berm located along left bank corn field. Remove berm to improve floodplain connection and sediment and nutrient attenuation.	Medium	Medium	27	Yes	Landowner permission needed.
T4.05A	Plant Stream Buffer and cattle fencing - Majority of river corridor dominated by corn and pasture little to no buffers. Cows in stream throughout, fencing needed to reduce erosion and limit nutrient inputs.	High	High	5	Yes	Landowner cooperation required. Could be CREP eligible
T4.05B	Protect River Corridor - Reach is mostly undeveloped forest. Reach stable with little adjustments. Reach located in narrow, steeper portion of valley acts a transport system. Corridor protection less important here than in attenuation areas.	Low	Low	67	Yes	Landowner cooperation

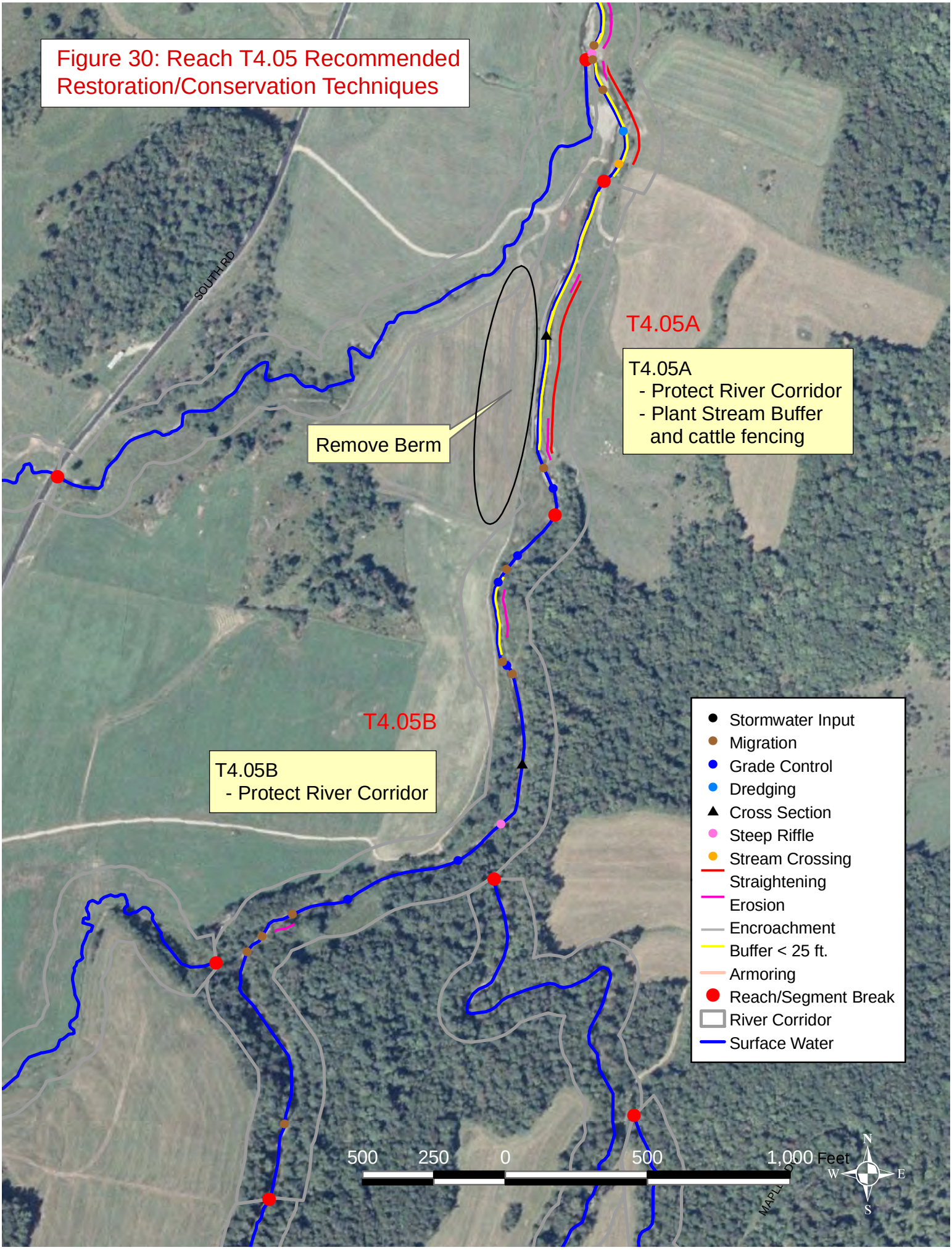


Figure 30: Reach T4.05 Recommended Restoration/Conservation Techniques
SOUTH RD
T4.05A
T4.05A
- Protect River Corridor
- Plant Stream Buffer and cattle fencing
Remove Berm
T4.05B
T4.05B
- Protect River Corridor
Stormwater Input
Migration
Grade Control
Dredging
Cross Section
Steep Riffle
Stream Crossing
Straightening
Erosion
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Surface Water
500 250 0 500 1,000 Feet
N
W
E
S

5.1.16 Reach M9T8.01 Description and Project Identification

Reach M9T8.01 extends from its confluence with Black Creek in M09 upstream for approximately one mile. The reach was segmented into M9T8.01A, M9T8.01B, and M9T8.01C based on channel dimensions and the presence of grade controls. M9T8.01A is the downstream portion of the reach and is approximately 0.5 miles long. It was not incised (ratio of 1.0) and generally stable with minor planform adjustments (channel evolution stage I). The riparian corridor was dominated by forest on the right and a mix of hay and corn on the left. Approximately 600 feet along the left bank had inadequate buffers of less than 25 feet. The existing stream type (C4) was consistent with its reference type.

Segment B was not assessed due to the presence of bedrock grade controls and multiple beaver dams and ponds. Segment C is the upstream portion of the reach and is approximately 0.2 miles long. It was relatively stable with only minor incision (ratio of 1.2) and aggradation. The existing stream type of C4 – riffle-pool was consistent with its reference type. The riparian corridor was dominated by forest and corn fields with buffers ranging from 25 to 100 feet.

Given the current relatively stable condition of M9T8.01, the recommended project types include corridor protection and buffer enhancement. The reach serves as important sediment and nutrient attenuation and wildlife habitat area. Corridor protection is needed to retain these assets. Buffer enhancement is needed in segment A where approximately 600 feet along the right bank has little to no buffer between the stream channel and the corn field. An aerial view of the reach is shown on Figure 31, and descriptions of the recommended projects are shown in Table 20. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 20: Projects and Practices Table - Black Creek
Reach M9T8.01

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M9T8.01A	Protect River Corridor - Segment is mix of hay and crop on left and forest on right. Reach not incised (ratio of 1.0) but undergoing planform adjustments. Corridor protection to allow for future channel adjustments to continue and protect sediment and nutrient attenuation assets.	Medium	Medium	60	Yes	Landowner cooperation
M9T8.01A	Plant Stream Buffer - Segment dominated by mix of hay and crop on left with ~600 feet of little to no buffer mid-segment. Buffer establishment needed to reduct sediment and nutrient inputs.	High	Medium	17	Yes	Landowner permission needed. Could be CREP eligible.
M9T8.01C	Protect River Corridor - Reach is mostly undeveloped forest. Reach stable with little adjustments. Corridor protection needed to retain attenuation assets.	Low	Low	63	Yes	Landowner cooperation

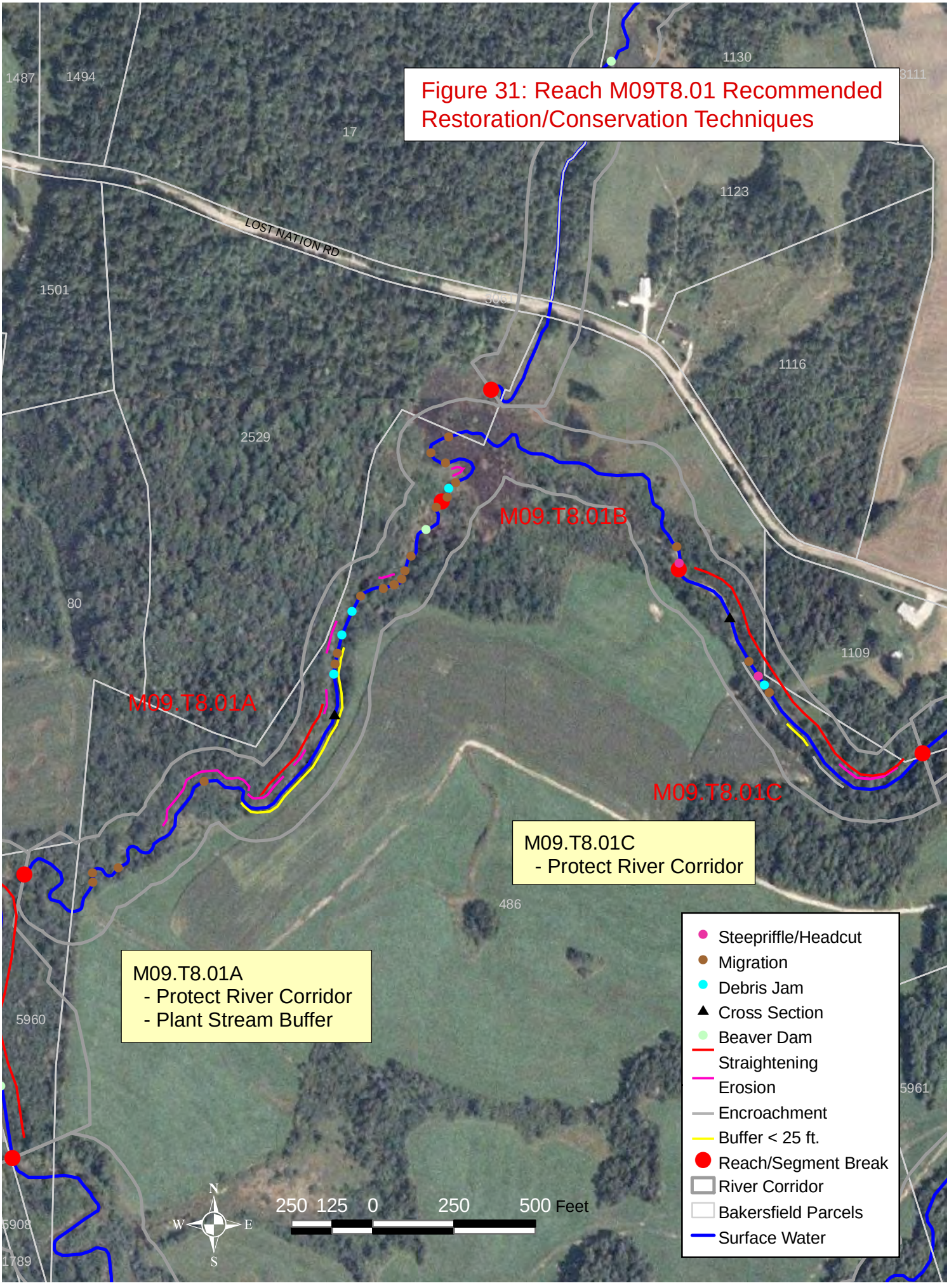


Figure 31: Reach M09T8.01 Recommended Restoration/Conservation Techniques
LOST NATION RD
M09.T8.01A
M09.T8.01B
M09.T8.01C
M09.T8.01C
- Protect River Corridor
M09.T8.01A
- Protect River Corridor
- Plant Stream Buffer
Steepriffle/Headcut
Migration
Debris Jam
Cross Section
Beaver Dam
Straightening
Erosion
Encroachment
Buffer < 25 ft.
Reach/Segment Break
River Corridor
Bakersfield Parcels
Surface Water
N
W
E
S
250 125 0 250 500 Feet
1487
1494
17
1130
3111
1123
1501
1116
2529
80
1109
486
5960
5961
5908
1789

5.1.17 Reach M9T8.1S1.02 Description and Project Identification

Reach M9T8.1S1.02 extends from the end of M9T8.1S1.01 upstream for approximately 1 mile. The reach was segmented into four parts, segments A, B, C, and D due to differences in corridor land use and presence of bedrock grade controls. Segment A was not fully assessed, as was the case with M9T8.1S1.01, due to significant beaver activity and multiple bedrock grade controls. Segment B was found to be relatively stable, despite slight incision (ratio of 1.2). Its C4-riffle-pool stream type was consistent with its reference type. Several bedrock grade controls and waterfalls were noted throughout the reach. The riparian corridor was dominated by forest. M9T8.1S1.02C extends from the end of segment B upstream to just above the culvert on Whitney Road. This segment was also relatively stable with no major adjustment processes, despite significant impacts related to agricultural activity. The riparian corridor was dominated by pasture with no fencing or buffers present. Cows were observed in the stream channel throughout the segment. The culvert crossing Whitney Road was significantly undersized with a structure to channel width ratio of 25%. Segment D was not assessed due to significant beaver activity and multiple bedrock grade controls and waterfalls.

Given the current relatively stable condition of this reach, the recommended project types include corridor protection and buffer enhancement. The reach serves as important sediment and nutrient attenuation and wildlife habitat areas. Corridor protection is needed to retain these assets. Buffer enhancement and fencing is needed in segment C where approximately 800 feet along both banks have little to no buffer or fencing to limit the cows access to the stream channel. Two undersized culverts were also noted in the area. The first is in reach M9T8.1S1.01, which was not fully assessed due to extensive beaver activity. The culvert crossing Lost Nation Road is severely undersized with a structure to channel width ratio of 60%. The culvert on Whitney Road in M9T8.1S1.02C is also undersized with a structure to channel width ratio of 25%. An aerial view of the reach is shown on Figure 32, and descriptions of the recommended projects are shown in Table 21. A prioritized list of all identified projects for the watershed is shown in Table 22.

Table 21: Projects and Practices Table - Black Creek
Reach M9T8.1S1.02

River Segment	Restoration/Conservation Technique	Reach Priority	Watershed Priority	Table 22 Project Number	Completed Independent of other Practices	Next Steps/Project Notes
M9T8.1S1.01	Replace undersized structure - Culvert crossing Lost Nation Road highly undersized with structure to channel width of 60%. Replacement with bridge or arch would improve flow, limit flooding/erosioin hazards, limit debris jam potential, and improve aquatic habitat. Remainder of reach not assessed due to bedrock gorges and beaver activity.	Medium	Medium	33	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. Town of Fairfield owned structure.
M9T8.1S1.02B	Protect River Corridor - Segment is mostly forested. Reach slightly incised (ratio of 1.2) but little ongoing adjustments. Corridor protection to allow for future channel adjustments to continue and protect sediment and nutrient attenuation assets.	Low	Low	61	Yes	Landowner cooperation
M9T8.1S1.02C	Protect River Corridor - Reach is dominated by pasture with no buffer or fencing. Reach not currently incised or experiencing other adjustments. Corridor protection to allow for future channel adjustments and protect existing sediment and nutrient attenuation assets. Should be combined with buffer establishment and fencing project to reduce nutrient inputs.	Medium	Medium	58	Yes	Landowner cooperation
M9T8.1S1.02C	Plant Stream Buffer and cattle fencing - Majority of river corridor dominated by pasture with no buffers. Cows in stream throughout, fencing needed to reduce erosion and limit nutrient inputs.	High	Medium	14	Yes	Landowner cooperation required. Could be CREP eligible
M9T8.1S1.02C	Replace undersized structure - Culvert crossing Whitney Road highly undersized with structure to channel width of 25%. Replacement with bridge or arch would improve flow, limit flooding/erosioin hazards, limit debris jam potential, and improve aquatic habitat	Medium	High	31	Yes	More detailed bridge and culvert assessments needed to determine if replacement warranted. Town of Sheldon owned structure.

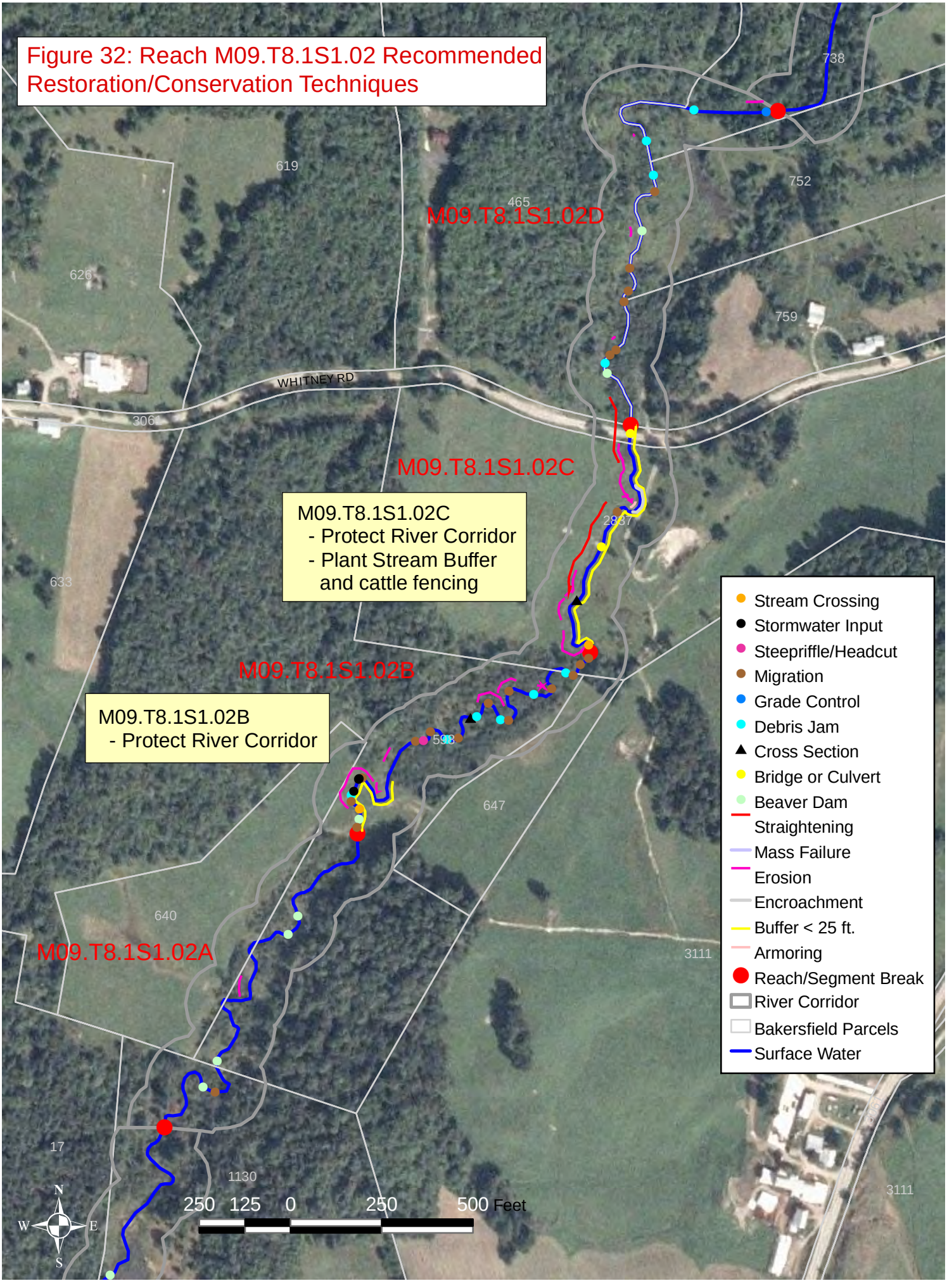


Figure 32: Reach M09.T8.1S1.02 Recommended Restoration/Conservation Techniques
M09.T8.1S1.02D
M09.T8.1S1.02C
M09.T8.1S1.02C
- Protect River Corridor
- Plant Stream Buffer and cattle fencing
M09.T8.1S1.02B
M09.T8.1S1.02B
- Protect River Corridor
M09.T8.1S1.02A
WHITNEY RD
738
619
752
465
626
759
3061
633
647
640
3111
17
1130
Stream Crossing
Stormwater Input
Steepriffle/Headcut
Migration
Grade Control
Debris Jam
Cross Section
Bridge or Culvert
Beaver Dam
Straightening
Mass Failure
Erosion
Encroachment
Buffer < 25 ft.
Armoring
Reach/Segment Break
River Corridor
Bakersfield Parcels
Surface Water
N
W
E
S
250 125 0 250 500 Feet

5.2 PROJECT PRIORITIZATION

Historically, most of the study area acted as a sediment and nutrient attenuation zone, where incoming fine sediments from upstream were stored on the floodplain, and inputs of coarse sediment slowly moved through the watershed, essentially equal to outputs of coarse sediment. Most of the studied reaches still retain this function, though land use conversion and lack of riparian buffer has greatly increased the nutrient inputs into the system and reduced its nutrient storage capacity. In addition, human encroachments including roads and berms have reduced the size of the available floodplain. A few of the reaches have 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. Given these stressors, and current and predicted future adjustments, the highest priority projects are those that attempt to restore the nutrient attenuation assets which once dominated the system. These include berm removal, riparian buffer enhancement to filter out excess nutrients, help stabilize streambanks, and provide shade, cover, and overall improvements to aquatic habitat, and replacement of undersized bridges and culverts to reduce channel constrictions and restore normal flow patterns. Overall, the Black Creek watershed is still largely undeveloped and provides significant opportunities for river corridor restoration. Obviously, there is a large amount of human investment within the river corridor, primarily in agricultural land, but also in homes, businesses, and infrastructure but the goals of this and other river corridor plans is to find areas within the watershed where a balance can be reached between these human investments and the health and wellbeing of river systems. Some of the larger scale active restoration projects may require conversion of considerable acres of agricultural land to floodplain and buffer; however, considerable strides may also be made through implementation of relatively narrow buffer strips and other agricultural best management practices. Table 22 lists potential projects in the Black Creek watershed in order of recommended priority by project type. It is important to note that this Table is an ever-evolving document in which current priorities can change over time. For the purposes of this Plan, projects were prioritized first upon overall benefit to the watershed (sediment and nutrient attenuation, habitat improvement, and re-

establishment of geomorphic equilibrium). For similar types of projects in different reaches and/or segments, priority was given to those that provide the maximum benefits (including nutrient retention, erosion prevention, and/or habitat improvement depending on the type of project). As an example for corridor protection projects, priority was given to non-forested segments over forested ones, since protecting these areas would lead to a larger increase in sediment and nutrient storage and habitat improvement. In addition, these areas are more susceptible to future channel management and alteration so protecting them should receive higher priority. For buffer enhancement type projects, priority was given to crop land over hay fields (these areas tend to contribute greater quantities of sediment and nutrients during runoff events) and reaches with longer stretches of un-buffered lands were given priority over shorter ones.

Table 22: Corridor Planning Project and Strategy Summary Table Black Creek - Franklin County, VT

Project # (Figure #)	Project Type	Reach/Segment Condition-Sensitivity	Site Description including Stressors and Constraints	Project or Strategy Description	Technical Feasibility & Priority	Other Social Benefits	Cost	Land Use Conversion & Landowner Commitment	Potential Partner Commitments
1 (20a)	Buffer Enhancement/ Cattle Exclusion and other BMPs	M05A - Good - High	Segment relatively stable with slight incision (1.3). Corridor dominated by Crop and Hay with little to no buffer and cows in stream near segment break.	Tree/buffer planting project to reduce nutrient inputs, fencing and appropriate cow crossing needed, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting/fencing design and installation, possible CREP payments	crop, hay, and pasture to buffer	VT RMP, NRCS, F&W, MRBA
2 (20b)	Buffer Enhancement and other BMPs	M05B - Fair - Very High	Segment relatively stable with slight incision (1.3). Corridor dominated by Crop and Hay with little to no buffer.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	crop and hay to buffer	VT RMP, NRCS, F&W, MRBA
3 (19)	Buffer Enhancement and other BMPs	M04A - Good - High	Segment relatively stable with no major adjustments. Corridor dominated by Crop and pasture with little to no buffer.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	crop and pasture to buffer	VT RMP, NRCS, F&W, MRBA
4 (19)	Buffer Enhancement and other BMPs	M04B - Fair - Very High	Segment relatively stable with minor incision (1.2). Corridor dominated by Crop and pasture with little to no buffer.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	crop and pasture to buffer	VT RMP, NRCS, F&W, MRBA
5 (30)	Buffer Enhancement/ Cattle Exclusion and other BMPs	T4.05 A - Good - High	Segment relatively stable with slight incision (1.3). Corridor dominated by Crop and Hay with little to no buffer and cows in stream.	Tree/buffer planting project to reduce nutrient inputs, fencing and appropriate cow crossing needed, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting/fencing design and installation, possible CREP payments	crop, hay, and pasture to buffer	VT RMP, NRCS, F&W, MRBA

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6 (18a and 18b)	Buffer Enhancement/ Cattle Exclusion and other BMPs	M03A - Good - High	Segment relatively stable with slight incision (1.2). Corridor dominated by Crop and pasture with little to no buffer and cows in stream.	Tree/buffer planting project to reduce nutrient inputs, fencing and appropriate cow crossing needed, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting/fencing design and installation, possible CREP payments	crop, hay, and pasture to buffer	VT RMP, NRCS, F&W, MRBA
7 (18a and 18b)	Buffer Enhancement and other BMPs	M03B - Fair - Very High	Segment highly incised (1.6). Corridor dominated by Crop and pasture with little to no buffers. Ideally combined with active floodplain restoration (project #40) and berm removal (project #26).	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	crop, and pasture to buffer	VT RMP, NRCS, F&W, MRBA
8 (22a and 22b)	Buffer Enhancement and other BMPs	M07 - Fair - Very High	Segment relatively stable with slight incision (1.2). Corridor dominated by hay with large areas of little to no buffer.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	hay to buffer	VT RMP, NRCS, F&W, MRBA
9 (21)	Buffer Enhancement and other BMPs	M06 - Good - High	Segment relatively stable with no incision (1.0). Corridor dominated by hay with large areas of little to no buffer.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	hay to buffer	VT RMP, NRCS, F&W, MRBA
10 (25)	Buffer Enhancement and other BMPs	T2.01A - Fair - Very High	Segment relatively stable with slight incision (1.2). Corridor dominated by hay with large areas of little to no buffer.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	hay to buffer	VT RMP, NRCS, F&W, MRBA

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11 (24a and 24b)	Buffer Enhancement/ Cattle Exclusion and other BMPs	M09A - Good - High	Segment relatively stable with slight incision (1.1). Corridor dominated by pasture with little to no buffer and cows in stream.	Tree/buffer planting project to reduce nutrient inputs, fencing and appropriate cow crossing needed, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting/fencing design and installation, possible CREP payments	pasture to buffer	VT RMP, NRCS, F&W, MRBA
12 (24b and 24c)	Buffer Enhancement and other BMPs	M09B - Good - High	Segment relatively stable with no incision (1.0). Corridor dominated by hay with large areas of little to no buffer.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	hay to buffer	VT RMP, NRCS, F&W, MRBA
13 (27)	Buffer Enhancement and other BMPs	T4.01 - Fair - Very High	Segment highly incised (1.8), but otherwise relatively stable. Corridor dominated by hay and pasture with large areas of little to no buffer. Ideally combined with active floodplain restoration (project #39) to restore floodplain access and reduce future erosion hazards.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; medium watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	hay and pasture to buffer	VT RMP, NRCS, F&W, MRBA
14 (32)	Buffer Enhancement/ Cattle Exclusion and other BMPs	M9T8.1S1.02C - Good - High	Segment relatively stable with no incision (1.0). Corridor dominated by pasture with little to no buffer and cows in stream.	Tree/buffer planting project to reduce nutrient inputs, fencing and appropriate cow crossing needed, buffers needed along field ditches as well.	Feasible; medium watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting/fencing design and installation, possible CREP payments	pasture to buffer	VT RMP, NRCS, F&W, MRBA
15 (17)	Buffer Enhancement and other BMPs	M02 - Good - High	Segment relatively stable with slight incision (1.1). Corridor dominated by hay and crop with large areas along left bank of little to no buffer.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; medium watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	hay and crop to buffer	VT RMP, NRCS, F&W, MRBA

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16 (23)	Buffer Enhancement/ Cattle Exclusion and other BMPs	M08 - Good - High	Segment relatively stable with no incision (1.0). Corridor dominated by pasture with little to no buffer in downstream half and cows in stream.	Tree/buffer planting project to reduce nutrient inputs, fencing and appropriate cow crossing needed, buffers needed along field ditches as well.	Feasible; medium watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting/fencing design and installation, possible CREP payments	pasture to buffer	VT RMP, NRCS, F&W, MRBA
17 (31)	Buffer Enhancement and other BMPs	M9T8.01A - Fair - Very High	Segment relatively stable with no incision (1.0). Corridor dominated by hay and crop with ~600 feet of along left bank of little to no buffer mid-segment.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; medium watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	hay and crop to buffer	VT RMP, NRCS, F&W, MRBA
18 (16a and 16b)	Buffer Enhancement and other BMPs	M01 - Good - High	Segment relatively stable with no incision (1.0). Corridor dominated by hay and crop with areas of less than 25 foot buffers scattered throughout.	Tree/buffer planting project to reduce nutrient inputs, buffers needed along field ditches as well.	Feasible; medium watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting design and installation, possible CREP payments	hay and crop to buffer	VT RMP, NRCS, F&W, MRBA
19 (26)	Buffer Enhancement/ Cattle Exclusion and other BMPs	T2.02B - Good - High	Segment relatively stable with no incision (1.0). Corridor dominated by pasture and hay with little to no buffer on right side and cows in stream.	Tree/buffer planting project to reduce nutrient inputs, fencing and appropriate cow crossing needed, buffers needed along field ditches as well.	Feasible; medium watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting/fencing design and installation, possible CREP payments	pasture to buffer	VT RMP, NRCS, F&W, MRBA
20 (29)	Buffer Enhancement/ Cattle Exclusion and other BMPs	T4.04B - Fair - Very High	Segment moderately incised (1.5) but otherwise relatively stable. Corridor dominated by pasture and hay with ~800 of little to no buffer on left side and cows in stream.	Tree/buffer planting project to reduce nutrient inputs, fencing and appropriate cow crossing needed, buffers needed along field ditches as well.	Feasible; medium watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, reduce nutrient inputs, improve water quality	Planting/fencing design and installation, possible CREP payments	hay and pasture to buffer	VT RMP, NRCS, F&W, MRBA

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21 (20a)	Berm Removal	M05A - Good - High	Abandoned railbed runs through corridor mid-segment and acts as floodplain constriction. Segment dominated by crop and pasture, but relatively stable. Ideally combined with buffer and fencing installation (project #1).	Remove or retrofit rail bed to re-establish lost floodplain connection.	Feasible; high watershed priority	Possible demonstration project for other reaches, reduce nutrient inputs, re-establish floodplain connection	design/permitting costs, landowner negotiations, construction/demo costs	None	VT RMP, NRCS, F&W, MRBA
22 (22a)	Berm Removal	M07 - Fair - Very High	Abandoned railbed runs through corridor mid-segment and acts as floodplain constriction (~1,000 feet). Segment dominated by hay, but relatively stable. Ideally combined with buffer and fencing installation (project #8).	Remove or retrofit rail bed to re-establish lost floodplain connection.	Feasible; high watershed priority	Possible demonstration project for other reaches, reduce nutrient inputs, re-establish floodplain connection	design/permitting costs, landowner negotiations, construction/demo costs	None	VT RMP, NRCS, F&W, MRBA
23 (24a and 24b)	Berm Removal	M09B - Good - High	Abandoned railbed runs through portions of corridor and acts as floodplain constriction. Segment dominated by hayand forest, but relatively stable.	Remove or retrofit rail bed to re-establish lost floodplain connection.	Feasible; high watershed priority	Possible demonstration project for other reaches, reduce nutrient inputs, re-establish floodplain connection	design/permitting costs, landowner negotiations, construction/demo costs	None	VT RMP, NRCS, F&W, MRBA
24 (21)	Berm Removal	M06 - Good - High	Abandoned railbed runs through portions of corridor (~500 feet) and acts as floodplain constriction. Segment dominated by hay and pasture, but relatively stable.	Remove or retrofit rail bed to re-establish lost floodplain connection.	Feasible; high watershed priority	Possible demonstration project for other reaches, reduce nutrient inputs, re-establish floodplain connection	design/permitting costs, landowner negotiations, construction/demo costs	None	VT RMP, NRCS, F&W, MRBA
25 (23)	Berm Removal	M08 - Good - High	Abandoned railbed runs through portions of corridor (~800 feet) and acts as floodplain constriction. Segment dominated by forest and pasture, but relatively stable.	Remove or retrofit rail bed to re-establish lost floodplain connection.	Feasible; high watershed priority	Possible demonstration project for other reaches, reduce nutrient inputs, re-establish floodplain connection	design/permitting costs, landowner negotiations, construction/demo costs	None	VT RMP, NRCS, F&W, MRBA

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26 (18c)	Berm Removal	M03B - Fair - Very High	Abandoned railbed runs through portions of downstream corridor (~800 feet) and acts as floodplain constriction. Segment dominated by forest and pasture and highly incised. Ideally combined with floodplain restoration (project #40) and buffer establishment (project #7).	Remove or retrofit rail bed to re-establish lost floodplain connection.	Feasible; high watershed priority	Possible demonstration project for other reaches, reduce nutrient inputs, re-establish floodplain connection	design/permitting costs, landowner negotiations, construction/demo costs	None	VT RMP, NRCS, F&W, MRBA
27 (30)	Berm Removal	T4.05A - Good - High	Approximately 600 feet of berm located along left bank along corn field. Reach moderately incised (1.4) and dominated by mix of corn and pasture. Ideally combined with buffer planting project (#5).	Remove berm to re-establish lost floodplain connection.	Feasible; medium watershed priority	Possible demonstration project for other reaches, reduce nutrient inputs, re-establish floodplain connection	design/permitting costs, landowner negotiations, construction/demo costs	None	VT RMP, NRCS, F&W, MRBA
28 (16a)	Berm Removal	M01 - Good - High	Approximately 500 feet of berm located along left bank near Missisquoi confluence. Reach slightly incised (1.2) and dominated by mix of hay and crop.	Remove berm to re-establish lost floodplain connection.	Feasible; low watershed priority	Possible demonstration project for other reaches, reduce nutrient inputs, re-establish floodplain connection	design/permitting costs, landowner negotiations, construction/demo costs	None	VT RMP, NRCS, F&W, MRBA
29 (25)	Replace Undersized Structure	T2.01B - Good - Moderate	Segment relatively stable with no major adjustments. Corridor dominated by mix of forest and hay with residential development along road. Culvert crossing North Road highly undersized with structure width/channel width ratio of 21%.	Replace undersized structure with adequately sized one, ideally replace culvert with bridge or arch.	Feasible, river corridor mostly undeveloped, Town owned structure, overall high watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA, Town of Fairfield
30 (24c)	Replace Undersized Structure	M09B - Good - High	Segment relatively stable with no major adjustments. Corridor dominated by mix of forest and hay. Culvert crossing Lost Nation Road highly undersized with structure width/channel width ratio of 27%.	Replace undersized structure with adequately sized one, ideally replace culvert with bridge or arch.	Feasible, river corridor mostly undeveloped, Town owned structure, overall high watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA, Town of Fairfield

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31 (32)	Replace Undersized Structure	M9T8.1S1.02C - Good - High	Segment relatively stable with no major adjustments. Corridor dominated by pasture. Culvert crossing Whitney Road highly undersized with structure width/channel width ratio of 25%.	Replace undersized structure with adequately sized one, ideally replace culvert with bridge or arch.	Feasible, river corridor mostly undeveloped, Town owned structure, overall high watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA, Town of Fairfield
32 (23)	Replace Undersized Structure	M08 - Good - High	Segment relatively stable with no major adjustments. Corridor dominated by pasture. Culverts crossing on abandoned rail bed and private crossing both undersized.	Replace undersized structures with adequately sized ones, ideally replace culvert with bridge or arch.	Feasible, river corridor mostly undeveloped, privately owned structures, overall medium watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA
33 (32)	Replace Undersized Structure	M9T8.1S1.01	Culvert crossing Lost Nation Road highly undersized with structure to channel width ratio of 60%. Remainder of reach not assessed due to multiple bedrock gorges.	Replace undersized structure with adequately sized one, ideally replace culvert with bridge or arch structure.	Feasible, river corridor mostly undeveloped, Town owned structure, overall medium watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA, Town of Fairfield
34 (18b)	Replace Undersized Structure	M03A - Fair - Very High	Bridge crossing Paradee Road undersized with structure width/channel width ratio of 65%.	Replace undersized structure with adequately sized one.	Feasible, river corridor mostly undeveloped, Town owned structure, overall medium watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA, Town of Fairfield
35 (22a)	Replace Undersized Structure	M07 - Fair - Very High	Bridge crossing Elm Brook Road undersized with structure width/channel width ratio of 53%. Railroad bridge located near downstrem reach break also undersized with structure/channel width ratio of 87%.	Replace undersized structures with adequately sized one.	Feasible, river corridor mostly undeveloped, Town owned structure, overall medium watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA, Town of Fairfield

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36 (20a)	Replace Undersized Structure	M05A - Good - High	Bridge crossing Ryan Road undersized with structure width/channel width ratio of 95%. Private bridge located ~1,000 feet downstream also undersized with structure/channel width ratio of 66%.	Replace undersized structures with adequately sized one.	Feasible, river corridor mostly undeveloped, Town owned structure, overall medium watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA, Town of Fairfield
37 (20b)	Replace Undersized Structure	M05B - Fair - Very High	Bridge crossing Bruso Road undersized with structure width/channel width ratio of 94%. Private bridge located upstream near farm also undersized with structure/channel width ratio of 75%.	Replace undersized structures with adequately sized one.	Feasible, river corridor mostly undeveloped, Town owned structure, overall medium watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA, Town of Fairfield
38 (26)	Replace Undersized Structure	T2.02B - Good - High	Bridge crossing Jettie Drive undersized with structure width/channel width ratio of 60%.	Replace undersized structure with adequately sized one.	Feasible, river corridor mostly undeveloped, Town owned structure, overall medium watershed priority	Aquatic habitat improvement, possible demonstration project for other reaches, reduce erosion associated with undersized structures	Design/permitting costs, construction costs	None	VT RMP, NRCS, F&W, MRBA, Town of Fairfield
39 (27)	Restore Incised Reach	T4.01 - Fair - High	Highly incised reach (ratio of 1.8). Increased flows and load due to historic land use activities and encroachments. Corridor currently mostly undeveloped hay and pasture. Bedrock grade control located upstream	Active floodplain resotration to restore sediment/nutrient retention function and reduce future erosion hazards. Ideally combined with river corridor protection and buffer enhancement (see project #s 13 and 57).	Feasible; river corridor undeveloped, high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, sediment and nutrient retention	Design/permitting costs, construction costs, possible easement transactions and buffer planting costs	Feasible; river corridor mostly undeveloped, high watershed priority	VT RMP, NRCS, F&W, MRBA
40 (18c)	Restore Incised Reach	M03B - Fair - Very High	Highly incised reach (ratio of 1.6). Increased flows and load due to historic land use activities and encroachments. Corridor currently mostly undeveloped hay and pasture.	Active floodplain resotration to restore sediment/nutrient retention function and reduce future erosion hazards. Ideally combined with river corridor protection and buffer enhancement (see project #s 7 and 56).	Feasible; river corridor undeveloped, high watershed priority	Wildlife habitat improvement, possible demonstration project for other reaches, sediment and nutrient retention	Design/permitting costs, construction costs, possible easement transactions and buffer planting costs	Feasible; river corridor mostly undeveloped, high watershed priority	VT RMP, NRCS, F&W, MRBA

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41 (18a and 18b)	Corridor Protection	M03A - Fair - Very High	Reach slightly incised (1.2) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #6).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
42 (19)	Corridor Protection	M04B - Fair - Very High	Reach slightly incised (1.2) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #4).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
43 (19)	Corridor Protection	M04A - Good - High	Reach not incised (1.0) and relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #3).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
44 (20a)	Corridor Protection	M05A - Good - High	Reach slightly incised (1.3) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #1) and berm removal (#21).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
45 (20b)	Corridor Protection	M05B - Fair - Very High	Reach slightly incised (1.4) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #2).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA

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Project # (Figure #)	Project Type	Reach/Segment Condition-Sensitivity	Site Description including Stressors and Constraints	Project or Strategy Description	Technical Feasibility & Priority	Other Social Benefits	Cost	Land Use Conversion & Landowner Commitment	Potential Partner Commitments
46 (25)	Corridor Protection	T2.01A - Fair - Very High	Reach slightly incised (1.2) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #10).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
47 (17)	Corridor Protection	M02 - Good - High	Reach slightly incised (1.1) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #15).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
48 (22a and 22b)	Corridor Protection	M07 - Fair - Very High	Reach slightly incised (1.2) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #8) and berm removal (project #22).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
49 (21)	Corridor Protection	M06 - Good - High	Reach not incised (1.0) and relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #9) and berm removal (project #24).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
50 (24a and 24b)	Corridor Protection	M09A - Good - High	Reach slightly incised (1.1) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #11).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA

Table 22: Corridor Planning Project and Strategy Summary Table Black Creek - Franklin County, VT

Project # (Figure #)	Project Type	Reach/Segment Condition-Sensitivity	Site Description including Stressors and Constraints	Project or Strategy Description	Technical Feasibility & Priority	Other Social Benefits	Cost	Land Use Conversion & Landowner Commitment	Potential Partner Commitments
51 (24c)	Corridor Protection	M09B - Good - High	Reach slightly incised (1.1) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #12) and berm removal (project #23).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
52 (23)	Corridor Protection	M08 - Good - High	Reach not incised (1.0) and relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #16) and berm removal (project #25).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, high watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
53 (30)	Corridor Protection	T4.05A - Good - High	Reach slightly incised (1.4) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural land. Ideally combined with buffer enhancement (project #5) and berm removal (project #27).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, medium watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
54 (29)	Corridor Protection	T4.04B - Fair - Very High	Reach slightly incised (1.4) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural and forest land. Ideally combined with buffer enhancement (project #20).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, medium watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
55 (16a and 16b)	Corridor Protection	M01 - Good - High	Reach slightly incised (1.2) but otherwise relatively stable. Corridor protection needed to retain sediment and nutrient attenuation function. Corridor currently undeveloped agricultural and forest land. Ideally combined with buffer enhancement (project #18) and berm removal (#28).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, medium watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA

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Project # (Figure #)	Project Type	Reach/Segment Condition-Sensitivity	Site Description including Stressors and Constraints	Project or Strategy Description	Technical Feasibility & Priority	Other Social Benefits	Cost	Land Use Conversion & Landowner Commitment	Potential Partner Commitments
56 (18c)	Corridor Protection	M03B - Fair - Very High	Reach highly incised (1.6) but otherwise relatively stable. Corridor protection needed to retain nutrient attenuation function. Corridor currently undeveloped agricultural and forest land. Ideally combined with active floodplain restoration (project #40) buffer enhancement (project #7) and berm removal (#26).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, medium watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
57 (27)	Corridor Protection	T4.01 - Fair - High	Reach highly incised (1.8) but otherwise relatively stable. Corridor protection needed to retain nutrient attenuation function. Corridor currently undeveloped agricultural and forest land. Ideally combined with active floodplain restoration (project #39) and buffer enhancement (project #13).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, medium watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
58 (32)	Corridor Protection	M9T8.1S1.02C - Good - High	Reach not incised (1.0) and relatively stable. Corridor protection needed to retain nutrient attenuation function. Corridor currently undeveloped agricultural and forest land. Ideally combined with buffer enhancement (project #14).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, medium watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
59 (26)	Corridor Protection	T2.02B - Good - High	Reach not incised (1.0) and relatively stable. Corridor protection needed to retain nutrient attenuation function. Corridor currently undeveloped agricultural and forest land. Ideally combined with buffer enhancement (project #19).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, medium watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA
60 (31)	Corridor Protection	M9T8.01A - Fair - Very High	Reach not incised (1.0) and relatively stable. Corridor protection needed to retain nutrient attenuation function. Corridor currently undeveloped agricultural and forest land. Ideally combined with buffer enhancement (project #17).	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, medium watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	Ag and forest land to buffer	VT RMP, NRCS, F&W, MRBA

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Project # (Figure #)	Project Type	Reach/Segment Condition-Sensitivity	Site Description including Stressors and Constraints	Project or Strategy Description	Technical Feasibility & Priority	Other Social Benefits	Cost	Land Use Conversion & Landowner Commitment	Potential Partner Commitments
61 (32)	Corridor Protection	M9T8.1S1.02B - Good - High	Reach slightly incised (1.2) but otherwise relatively stable. Corridor protection needed to retain nutrient attenuation function. Corridor currently undeveloped forest land.	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, low watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	None	VT RMP, NRCS, F&W, MRBA
62 (26)	Corridor Protection	T2.02A - Reference - Low	Reach stable. Corridor protection needed to retain nutrient attenuation function. Corridor currently undeveloped forest land.	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, low watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	None	VT RMP, NRCS, F&W, MRBA
63 (31)	Corridor Protection	M9T8.01C - Good - High	Reach stable. Corridor protection needed to retain nutrient attenuation function. Corridor currently undeveloped forest land.	Protect existing river corridor to prevent channel management and retain sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, low watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	None	VT RMP, NRCS, F&W, MRBA
64 (29)	Corridor Protection	T4.04A - Good - Moderate	Reach stable. Corridor protection needed to limit channel management. Segment naturally transport system with limited attenuation capacity. Corridor currently undeveloped forest land.	Protect existing river corridor to prevent channel management and retain limited sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, low watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	None	VT RMP, NRCS, F&W, MRBA
65 (25)	Corridor Protection	T2.01B - Good - Moderate	Reach stable. Corridor protection needed to limit channel management. Segment naturally transport system with limited attenuation capacity. Corridor currently undeveloped forest land.	Protect existing river corridor to prevent channel management and retain limited sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, low watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	None	VT RMP, NRCS, F&W, MRBA

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Project # (Figure #)	Project Type	Reach/Segment Condition-Sensitivity	Site Description including Stressors and Constraints	Project or Strategy Description	Technical Feasibility & Priority	Other Social Benefits	Cost	Land Use Conversion & Landowner Commitment	Potential Partner Commitments
66 (28)	Corridor Protection	T4.03 - Good - Moderate	Reach stable. Corridor protection needed to limit channel management. Segment naturally transport system with limited attenuation capacity. Corridor currently undeveloped forest land.	Protect existing river corridor to prevent channel management and retain limited sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, low watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	None	VT RMP, NRCS, F&W, MRBA
67 (30)	Corridor Protection	T4.05B - Good - High	Reach stable. Corridor protection needed to limit channel management. Segment naturally transport system with limited attenuation capacity. Corridor currently undeveloped forest land.	Protect existing river corridor to prevent channel management and retain limited sediment and nutrient attenuation function.	Feasible, river corridor undeveloped forest and ag land, low watershed priority	Possible wildlife habitat improvement, possible demonstration project for other reaches, retain sediment and nutrient retention	Possible easement transaction costs	None	VT RMP, NRCS, F&W, MRBA

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