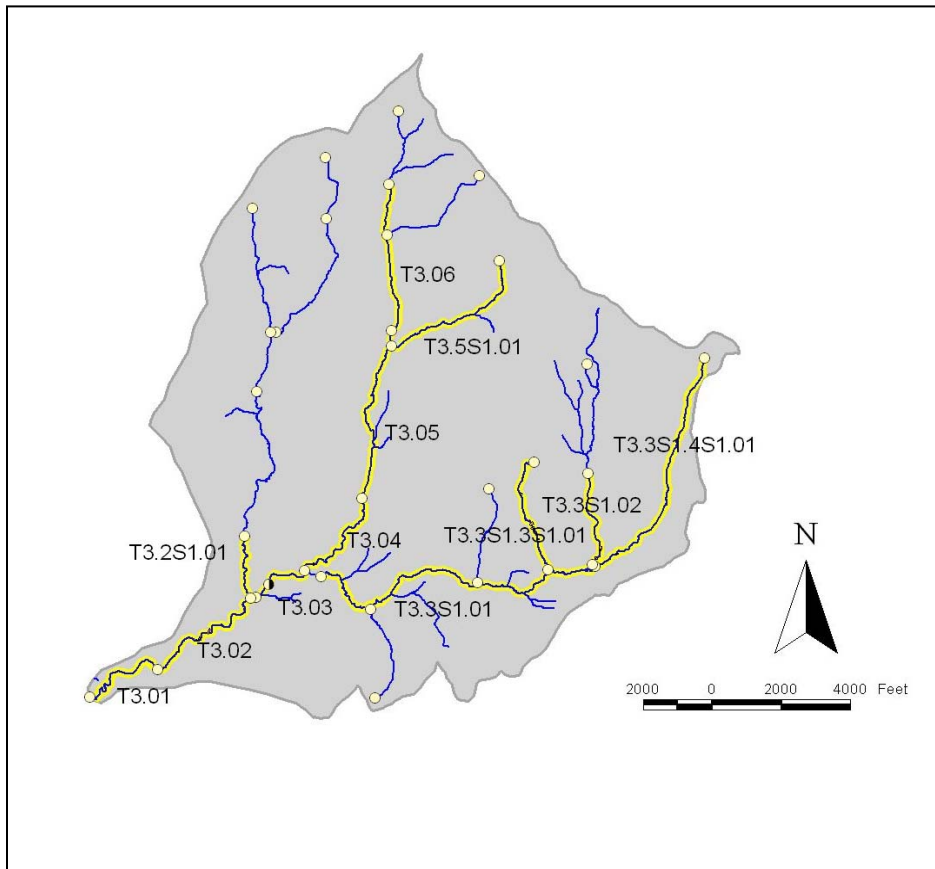


**Corridor Planning Project and  
Phase 2 Stream Geomorphic Assessment  
Wanzer Brook Watershed  
Fairfield, Franklin County, Vermont  
December 2005**



*Prepared by*

WASTE NOT Resource Solutions  
1662 Pumpkin Village Road  
Enosburg Falls, VT 05450

South Mountain Research & Consulting  
2852 South 116 Road  
Bristol, VT 05443

*Prepared under contract to*

Town of Fairfield  
Fairfield, VT

**TABLE OF CONTENTS**

**1.0 INTRODUCTION..... 1**

**2.0 BACKGROUND ..... 2**

    2.1 GEOGRAPHIC SETTING ..... 3

    2.2 REGIONAL GEOLOGIC SETTING..... 3

        2.2.1 *Bedrock Geology*..... 5

        2.2.2 *Surficial Geology*..... 5

    2.3 GEOMORPHIC SETTING ..... 5

**3.0 ASSESSMENT METHODOLOGY..... 8**

**4.0 PHASE 2 ASSESSMENT RESULTS..... 9**

    4.1 WANZER BROOK MAIN STEM (T3) ..... 9

    4.2 MAJOR TRIBUTARY REACHES TO WANZER BROOK..... 17

**5.0 SUMMARY AND DISCUSSION..... 25**

    5.1 WATERSHED AND CHANNEL STRESSORS ..... 25

    5.2 DOMINANT ADJUSTMENT PROCESSES AND REACH SENSITIVITY ..... 25

    5.3 RIVER CORRIDOR MANAGEMENT STRATEGIES ..... 28

        5.3.1 *Equilibrium – Minor Adjustment*..... 30

        5.3.2 *Unstable (Dis-equilibrium) – Moderate Departure*..... 32

        5.3.3 *Unstable (Dis-equilibrium) – Downcutting (Incising Reach)*..... 33

**6.0 ALTERNATIVES ANALYSIS..... 33**

    6.1 SITE/REACH – LEVEL MANAGEMENT ALTERNATIVES ..... 33

    6.2 WATERSHED-LEVEL MANAGEMENT STRATEGIES ..... 37

        6.2.1 *Improved Road Maintenance Practices*..... 37

        6.2.2 *Crossing Structures*..... 37

        6.2.3 *Town Planning*..... 38

**7.0 REFERENCES..... 39**

**8.0 GRANTS / RESOURCES (PARTIAL LISTING)..... 41**

**APPENDICES**

- A. Phase 2 Stream Geomorphic Assessment Results
- B. Annotated Reach-based Orthophotos
- C. Project CD



## **1.0 INTRODUCTION**

A corridor protection planning project was completed in the Summer and Fall of 2005 in the Wanzer Brook watershed, tributary to Black Creek in the Missisquoi River basin, Fairfield, Vermont. The Wanzer Brook Corridor Project has been administered through the Town of Fairfield with funding provided from the Vermont Agency of Natural Resources (VTANR) Water Quality Division under a Category 2 River Corridor Management Grant. The project manager was Brian Jerose, Partner, WASTE NOT Resource Solutions and a town resident, reporting to the Town of Fairfield Selectboard. Brian has worked with local landowners, the town highway department and other supporting agencies, and local volunteers, including town residents and the Missisquoi River Basin Association (MRBA). Brian has been assisted with geomorphic assessments and Geographic Information System services by Kristen Underwood of South Mountain Research & Consulting, Bristol, Vermont.

The principal goal of this Wanzer Brook Corridor Protection project has been to identify river corridor protection and restoration strategies to reduce erosion and sediment loading in the Wanzer Brook watershed. This goal is connected to the larger objective of reducing phosphorus and other pollutants entering the Missisquoi River and Lake Champlain. Study results have also informed landowner and community planning efforts for reducing fluvial erosion hazards and improving aquatic and riparian habitats.

In support of corridor planning, Phase 2 geomorphic and habitat assessments were completed in the Summer of 2005 on 12 reaches (7.9 river miles) of the Wanzer Brook main stem and tributaries, following protocols published by the Vermont Agency of Natural Resources (VTANR, 2005). Objectives of the Phase 2 geomorphic assessments were to:

- determine the geomorphic condition of targeted reaches, and identify active vertical and lateral adjustment processes;
- identify current and historic channel and watershed stressors; and
- evaluate the sensitivity of reaches to future channel and watershed stressors given their current geomorphic condition and inherent vulnerability (e.g., valley setting, slope, streambed and streambank sediments, vegetative buffer conditions);
- support selection, prioritization and design of riparian restoration and conservation projects that are geomorphically-compatible and therefore more effective and sustainable.

This summary report has been prepared by WASTE NOT Resource Solutions (WNRS) and South Mountain Research & Consulting (SMRC) under contract to the Town of Fairfield.



## 2.0 BACKGROUND

Corridor planning and Phase 2 stream geomorphic assessments were undertaken in the Wanzer Brook watershed to provide a geologic and geomorphic context for the streambank erosion and water quality issues documented in the river over the past several years.

The State of Vermont has listed the Wanzer Brook as impaired for aquatic life support uses as a result of agricultural runoff (VTDEC WQD, 2004a). A portion of receiving river, Black Creek, from its confluence with the Missisquoi River upstream past the Wanzer Brook confluence to the village of East Fairfield has also been listed as a priority surface water in need of further assessment due to sediment, nutrient, and *E. coli* impacts from agricultural runoff which have possibly impaired the Black Creek for contact recreation uses, aquatic life support uses, and aesthetics (VTDEC WQD, 2004b).

Long-term water quality monitoring at the mouth of the Missisquoi River has identified elevated phosphorous levels and sedimentation (VTDEC WQD, 2005). Phosphorous loading from the Missisquoi River to Lake Champlain and phosphorus levels in the Missisquoi Bay area of Lake Champlain continue to exceed target levels outlined in the Lake Champlain Phosphorous TMDL (LCBP, 2005). In addition to certain agricultural and urban land use practices, eroding streambanks have been identified as a contributing nonpoint source of phosphorus in rivers and streams of Vermont (VTANR, 2001; DeWolfe *et al.*, 2004).



## **2.1 Geographic Setting**

The Wanzer Brook drains a 7.2-square-mile area of land located in Fairfield and Sheldon townships of Franklin County in northwestern Vermont. All but the northern extent (headwaters) of the watershed is located in Fairfield township. Wanzer Brook flows into the Black Creek, which in turn flows to the Missisquoi River and to Missisquoi Bay on Lake Champlain (Figures 1a and 1b). The Wanzer Brook watershed is approximately 54% forested, 36% in agriculture, and 4% developed, while the remaining land cover is water and wetlands (NRPC, draft 2005).

## **2.2 Regional Geologic Setting**

The Wanzer Brook watershed is located in the Champlain Valley physiographic province (Thompson & Sorenson, 2000; Dennis, 1964), the broad north-south trending valley which surrounds Lake Champlain and extends into portions of Vermont, New York and Quebec. The watershed is located in the higher-elevation area of the Champlain Valley in the foothills near the boundary with the Green Mountain physiographic province to the east. There is debate as to the position of the boundary between these two provinces, and some publications have described the general location of the Wanzer Brook watershed to be within the Green Mountain province (Stewart, 1974).

In recent geologic time (from 20,000 to 13,200 years before present) this landscape was occupied by advancing and retreating glaciers, with ice up to a mile or more in thickness above the present land surface in the Champlain Valley (Stewart & MacClintock, 1969). Glacial tills now blanket much of the bedrock-controlled slopes and headwaters of the watershed (Doll, 1970).

As the global climate warmed and the glaciers receded, a large fresh-water lake inundated the Champlain Valley. At its highest stage, Lake Vermont's shoreline extended into the Wanzer Brook watershed (Stewart & MacClintock, 1969; Doll, 1970). A deposit of lake sands are mapped amidst the till-covered slopes in the mid-portion of the watershed (Cannon, 1964; Doll, 1970).

Lake Vermont waters receded in stages as natural dams in southern Vermont and New York gave way. From approximately 12,800 to 10,200 years before present, marine waters filled the valley from the St. Lawrence Seaway as the rate of rise in ocean water levels far exceeded the rate of rise, or isostatic rebound, of the land surface now relieved of its glacial burden (Stewart and MacClintock, 1969; Cronin, 1977; Wagner, 1972; Connally and Calkin, 1972). The maximum elevation of these brackish waters is believed to have extended into the present-day Black Creek valley as far upstream as East Fairfield. A marine delta deposit was mapped along the northeast margin of the Black Creek valley at the approximate position of today's Wanzer Brook confluence (Wagner, 1972).

Champlain Sea waters had receded from the Champlain Valley by approximately 10,000 years before present, as the rate of land rise began to outpace the rate of sea-level rise. River systems, including the Wanzer Brook and Black Creek, then went to work moving sediments left in the wake of the glaciers, and further eroding the foothills of the Green Mountains. The surrounding landscape continues in this erosion/deposition phase today.



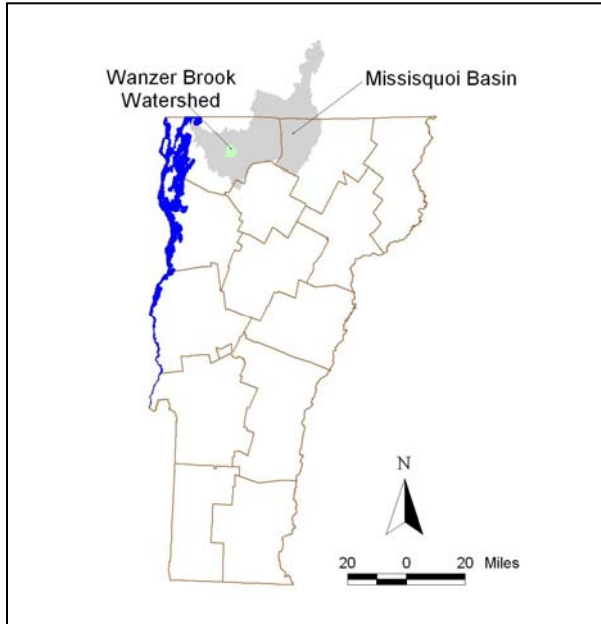
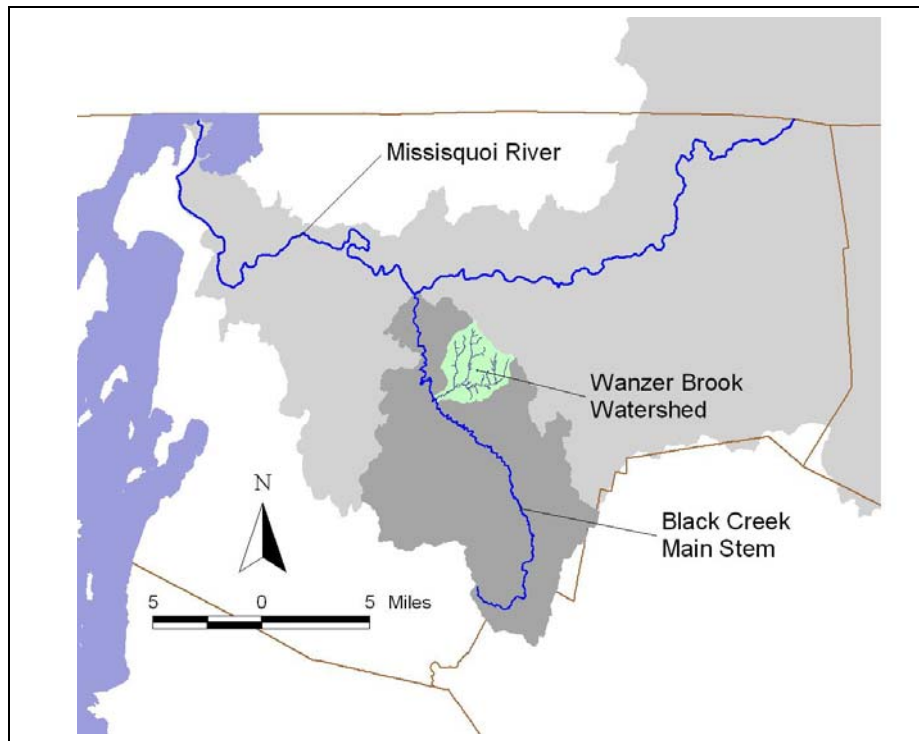


Figure 1a. (left) Location of Wanzer Brook Watershed within Missisquoi Basin and Vermont.

Figure 1b. (below) Location of Wanzer Brook Watershed within Black Creek watershed and Missisquoi Basin, Franklin County, VT.



### 2.2.1 Bedrock Geology

In general, the bedrock geology of the Wanzer Brook watershed consists of greywacke with some phyllite of the Pinnacle Formation of Cambrian age (Dennis, 1964; Stewart, 1974). Greywacke is a poorly-sorted sandstone that has been intensively folded and transformed by pressure and temperature during mountain-building events. Phyllites are also a metamorphic rock – finer grained and highly foliated.



Figure 2. (T3.02) Channel-spanning bedrock downstream of the Wanzer Road crossing of Wanzer Brook main stem.

The characteristics and properties of the underlying bedrock geology of the watershed influence the Wanzer Brook in many ways. The greywackes and phyllites are part of a northeast-southwest trending upward fold of rocks called the Enosburg Anticlinorium (Dennis, 1964). These rock types are somewhat resistant to erosion and form the high relief in the watershed most prominently seen as Leach Hill and Sheldon Hill.

Surface exposures of bedrock influence the channel position and profile in the watershed. Bedrock exposures along the valley walls control the lateral position of the river channel. Locations of channel-spanning bedrock offer vertical grade control, preventing possible downward erosion of the channel in response to regional or local stressors (at least over the 10- to 100-year time spans on which this study is focused). Within the study area there are several exposures of bedrock grade controls, offering stability to the Wanzer Brook and its tributaries (see Figure 2 and Figure 21).

### 2.2.2 Surficial Geology

Post glacial activity has influenced the surficial sediments and soil types which are present in the Wanzer Brook watershed today. Upland slopes are dominated by shallow- to moderate-thickness glacial till deposits overlying bedrock (Doll, 1970; Flynn & Joslin, 1979). Glacial tills are also revealed in the stream valleys of the Wanzer Brook main stem and tributaries, with alluvium locally present along the channel margins. Surficial geologic maps indicate isolated deposits of lake sands near the center of the Wanzer Brook watershed. These sandy sediments would be locally more erodible than surrounding till deposits, and are a governing factor in the channel adjustment processes along the Wanzer Brook and tributary corridors.

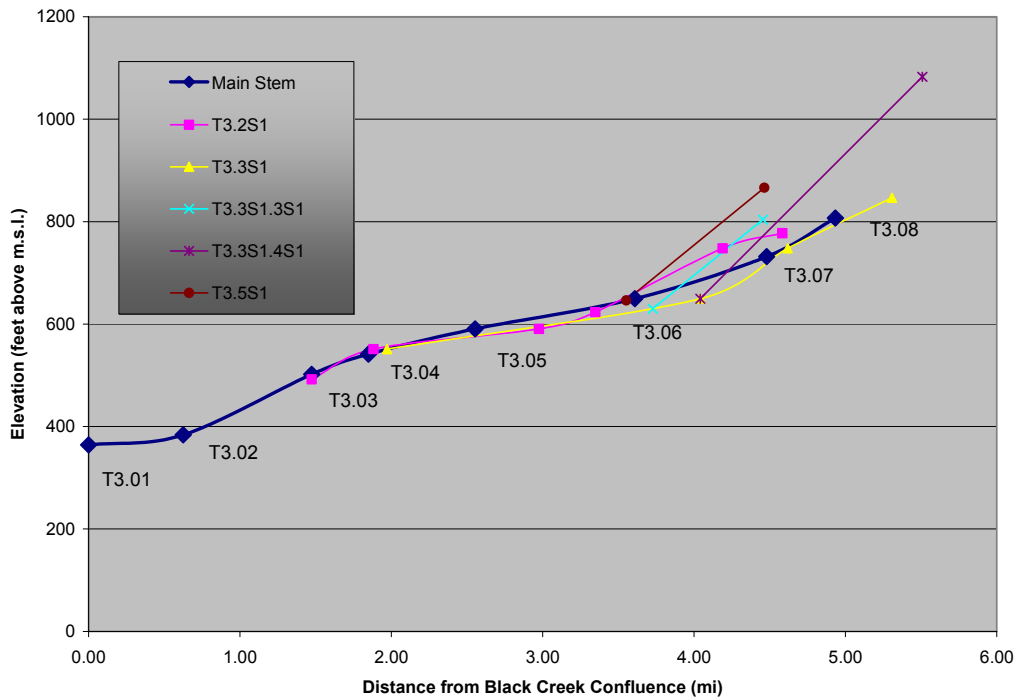
## 2.3 Geomorphic Setting

Figure 3 illustrates the Wanzer Brook main stem and its major tributaries in longitudinal profile. Generally, valley and river channel slopes become shallower as one progresses downstream toward the broad valley and confluence with the Black Creek. Elevations within the Wanzer Brook watershed range from approximately 910 feet in the northeast extent of the watershed on the western flanks of Leach Hill, and 830 feet at the northern extent of the watershed near Sheldon Hill, to 365 feet at the confluence with Black Creek. Channel gradients in the tributaries to Wanzer Brook are steep (ranging from approximately 2 to 6%). As one progresses downstream along the Wanzer Brook main stem, the drainage area increases (up to 7.2 square miles at the confluence with Black Creek), but channel gradients generally decrease (typically less than 2% decreasing to 0.6% at the downstream extent). In reach T3.02 there are several



channel-spanning exposures of bedrock, resulting in a locally steeper reach of the main stem. Downstream of this reach approaching the confluence with Black Creek (T3.01), gradients change significantly as the Wanzer Brook flows out into the broader Black Creek floodplain. An alluvial fan has developed at this location.

**Longitudinal Profile of Wanzer Brook**



*Figure 3. Longitudinal profile of Wanzer Brook main stem (Black Creek) and Principal Tributaries.*

In the Phase 1 Stream Geomorphic Assessment (NRPC, 2005), the Wanzer Brook watershed was delineated into geomorphic reaches using remote sensing methods supported by windshield surveys. Geomorphic reaches were defined based on variation in valley confinement, slope, and sinuosity. The reader is referred to the Phase 1 summary report prepared by Northwest Regional Planning Commission for details of the Phase 1 assessment.

The Wanzer Brook watershed was delineated into a total of 22 reaches (17 river miles) during the Phase 1 process. Reach lengths ranged from 1,965 feet (0.4 mile) to 10,928 feet (2.1 miles). The upstream drainage area to each reach ranged from 0.12 square miles to a maximum of 7.2 square miles (at the confluence with Black Creek).

Based on the channel and watershed stressors identified through remote sensing, windshield surveys, and limited historical research during the Phase 1 Geomorphic Assessment, 12 reaches along the Wanzer Brook main stem and tributaries were prioritized for Phase 2 Stream Geomorphic Assessments in 2005 (see Figure 4, Table 1). Symbols in Figure 4 denote the downstream reach breaks. Main-stem reaches along the Black Creek are identified with an "M". Wanzer Brook is the third major tributary to join the Black Creek proceeding upstream from the confluence with Missisquoi River. Therefore, Wanzer Brook main stem reaches were denoted with a "T3" prefix. Tributaries joining the Wanzer Brook main stem are indicated with an "S".



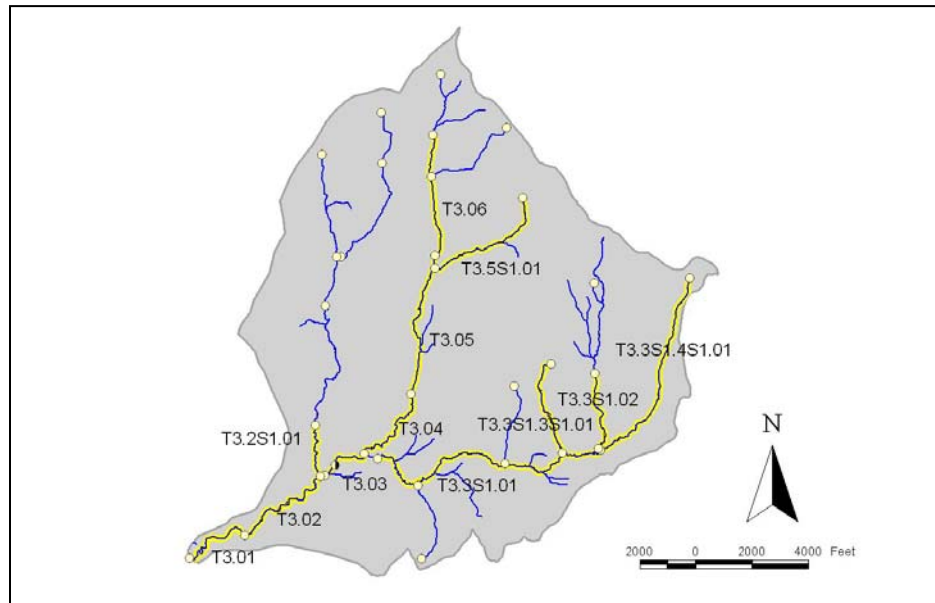


Figure 4. Location of reaches selected for Phase 2 Stream Geomorphic Assessments in Wanzer Brook watershed.

Table 1. Phase 2 Stream Geomorphic Assessment Reaches  
 Wanzer Brook (Black Creek) watershed, Fairfield, VT, 2005

Reach	Drainage Area (sq mi)	Reach Length (ft)	Length Reach Assessed	% of Reach Assessed
<b>Wanzer Brook main stem</b>				
T3.01	7.2	3,298	3,298	100%
T3.02	7.1	4,486	4,486	100%
T3.03	5.1	1,977	1,977	100%
T3.04	2.3	3,721	3,721	100%
T3.05	2.1	5,570	5,570	100%
T3.06	0.9	4,601	2450	53%
<b>Tributaries</b>				
T3.2S1.01	1.7	2,154	2,154	100%
T3.3S1.01	2.5	10,928	10,928	100%
T3.3S1.02	0.8	3,048	1220	40%
T3.3S1.3S1.01	0.2	3,842	2992	78%
T3.3S1.4S1.01	0.3	7,743	1040	13%
T3.5S1.01	0.5	4,818	1950	40%

Seven of the 12 reaches were targeted as major reaches for investigation: five reaches on the main stem of the Wanzer Brook (T3.01 through T3.05), and the downstream portions of two principal tributaries (T3.2S1.01 and T3.3S1.01). These reaches were expected to exhibit channel adjustments given past and current channel and watershed disturbances provisionally identified during Phase 1 Stream Geomorphic Assessments (NRPC, draft 2005). Also, willing landowners and potential restoration and conservation projects had been identified along these major reaches. For five of the 12 reaches (T3.06, T3.3S1.02, T3.3S1.3S1.01, T3.3S1.4S1.01, and T3.5S1.01), only a portion of the reach was assessed – typically, those portions in current



agricultural or residential use, as opposed to forested cover (see Table 1 for lengths assessed). These minor reaches were located upstream of the major reaches, and/or as feeder tributaries along the length of the major reaches. They were assessed to provide a context for the major reaches assessed: to understand the possible contributions of sediment and nutrients to the major reaches generated by land use choices and/or geomorphic adjustments, and to identify locations of potential grade controls.

Table 2. Phase 1 Stream Geomorphic Assessment (Step 8) Stream and Watershed Impact Ratings for Selected Major and Minor Reaches Wanzer Brook (Black Creek) watershed, Fairfield, VT (NRPC, draft 2005)

Reach	Phase 1 Impact Scores
<b>Wanzer Brook main stem</b>	
T3.01	16
T3.02	13
T3.03	11
T3.04	7
T3.05	12
T3.06	3
<b>Tributaries</b>	
T3.2S1.01	7
T3.3S1.01	16
T3.3S1.02	5
T3.3S1.3S1.01	4
T3.3S1.4S1.01	3
T3.5S1.01	3

### 3.0 ASSESSMENT METHODOLOGY

Geomorphic and habitat assessments were completed on 12 reaches (7.9 river miles) along portions of the Wanzer Brook main stem and tributaries (see Figure 4, Table 1). Phase 2 Stream Geomorphic Assessment protocols are field procedures for geomorphic and habitat assessment. Reach-specific and cross-section data gathered during Phase 2 identify the present geomorphic condition of the river reach and the dominant process(es) of adjustment (i.e., degradation, widening, aggradation and/or planform adjustment). Phase 2 results, along with Phase 1 assessment results, define the natural and human disturbances to the watershed and channel over time and the composite response or adjustment of the channel to these stressors. Reference is made to VTANR Stream Geomorphic Assessment protocols (VTANR, 2005) for the specific assessment methods.

During Phase 2 assessments, specific features and present channel positions were located using a Garmin™ global positioning system (GPS) unit. Pictures were recorded with digital cameras. In accordance with protocols, specific features were digitized in ArcView® 3.x shape files, including cross section locations, grade control locations, and others. Phase 2 assessment data were entered into the online Data Management System (DMS) maintained by the Vermont Department of Environmental Conservation, Water Quality Division.

Assessments were performed under a programmatic Quality Assurance Project Plan (QAPP) generated by the Vermont Water Quality Division, River Management Section (VTDEC WQD, 2003).



## 4.0 PHASE 2 ASSESSMENT RESULTS

Phase 2 assessment results are summarized below for the Wanzer Brook main stem and tributary reaches. Detailed Phase 2 assessment results are tabulated in Appendix A, including the standard report output from the online DMS for Phase 1 & 2 Stream Geomorphic Assessment data. Major channel and geographic features are noted on orthophotograph base maps of each reach in Appendix B. Orthophotograph coverage (Vermont Mapping Program) for the watershed is dated 1995.

In the text below, left bank (LB) and right bank (RB) of the river are located facing downstream. "IR" refers to Incision Ratio (Low Bank Height / Bankfull Max Depth) and "ER" refers to Entrenchment Ratio (Flood Prone Width / Bankfull Width) (see protocols). Stream type designations are after Rosgen (1996) and Montgomery & Buffington (1997). "LWD" refers to large woody debris.

### 4.1 Wanzer Brook Main Stem (T3)

Phase 2 assessments were completed on a 4.1-mile section of the Wanzer Brook main stem extending from the upstream-most Chester A. Arthur Road crossing (T3.06) downstream to the confluence with Black Creek (T3.01) (see Figure 4). Results for the six reaches which comprise this section are summarized in Table 3.

The Wanzer Brook drains a 7.2-square mile area. This 4.5-mile long tributary joins the Black Creek (reach M03) approximately 3,000 feet downstream of the Chester A. Arthur crossing of Black Creek at Fairfield Station. Phase 2 assessments revealed greater variation in channel profile along the Wanzer Brook main stem than was apparent at the remote-sensing scale of Phase 1 assessments (NRPC, 2005). Slopes in Table 3 have been updated from the Phase 1 slopes based on re-interpretation of topographic contour mapping supported by field observations. Some reaches were segmented to reflect portions of reaches with locally steeper slopes. Other reaches were segmented based on geomorphic condition and varying degrees of channel adjustment.

**T3.06** – Reach T3.06 is located in a semi-confined, moderately-steep valley setting, which is largely forested. This area was historically cleared for pasturing and other farm uses, and some degree of channelization associated with this historic farming use is inferred. However, the reach has revegetated nicely and now has ample woody riparian buffers along the majority of both banks. At present, active pasturing is encroaching along short lengths of right bank and left bank corridors. Wetlands mapped as part of the National Wetlands Inventory (NWI) contiguous to the stream channel are identified near the upstream and downstream extents of the reach.

Assessments of the downstream half of this reach suggest good floodplain access, with minor widening and planform adjustment occurring. This reach was ranked in the Fair RGA category on the cusp with Good. Good diversity of channel morphology, presence of epifaunal substrates, minimal streambank erosion and in-stream sedimentation, and largely continuous woody buffers indicate Good habitat conditions (RHA by VTANR protocols).



**Table 3. Results of Phase 2 Geomorphic Assessments, Wanzer Brook Main Stem**

**Wanzer Brook Main Stem - Fairfield**

Reach	Segment	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq mi)	Stream Type	RHA Condition	RGA Condition	Adjustment	Stream Type Departure?	Sensitivity
T3.01	--	3,298	<i>0.6</i>	7.2	C4-PB	0.48 Fair	0.38 Fair	PF, Wid, Aggrad	No	Very High
T3.02	--	4,486	<i>2.6</i>	7.1	B4-R/P	0.62 Fair	0.51 Fair	Aggrad, Wid	No	High
T3.03	A	540	<i>1.8</i>	5.1	C4-R/P	0.58 Fair	0.59 Fair	Aggrad	No	Very High
	B	1,437	<i>2.1</i>		B4-S/P	0.59 Fair	0.51 Fair	Wid, PF, Aggrad	No	High
T3.04	--	3,721	<i>1.3</i>	2.3	C4-R/P	0.65 Good	0.66 Good	Wid (minor)	No	High
T3.05	A	2,410	<i>1.2</i>	2.1	C4-R/P	0.71 Good	0.74 Good	Aggrad (minor)	No	High
	B	3,160	<i>0.9</i>		C4-R/P	0.47 Fair	0.49 Fair	Aggrad, Wid	No	Very High
T3.06	<i>a</i>	<i>2,450</i>	<i>1.7</i>	0.9	C4-R/P	0.69 Good	0.61 Fair	PF	No	Very High

Notes: (1) (2) (3)

Abbreviations:

S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Ref = Reference  
 RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTDEC, 2005).  
 PF = Planform Adjustment; Aggrad = Aggradation; Wid = Widening; NM = Not Measured.

Notes:

- (1) Segments denoted with a small case letter in italics represent the portion of the reach which was assessed and do not represent a true segment as defined in VTANR geomorphic assessment protocols.
- (2) Channel lengths noted in italics represent the portion of the reach which was assessed, not the complete reach length. See Table x for complete reach lengths, and percentage of reach assessed.  
Slope values in italics indicate those which are updates from Phase 1 calculations: either calculated for segments delineated during Phase 2 assessments, or for portions of a reach assessed, or which were revised from Phase 1 due to error correction or field-based observations.
- (3)



**T3.05** – Proceeding downstream, reach T3.05 has experienced more intensive agricultural use surrounding the Pumpkin Village Road crossing. Variable land uses and geomorphic condition within the reach caused the Project Team to segment the reach: upstream Segment B (3,160 feet) and downstream Segment A (2,410 feet).

### ***Segment B***

This upstream half of reach T3.05 is a prior-converted wetland which has been subjected to intensive encroachments by residential and agricultural uses. Cattle are afforded direct access to the stream along much of the segment length (see Figure 5). The stream is crossed by equipment fords, animal crossings, a culvert crossing for Pumpkin Village Road and a culvert crossing for a recently-installed residential driveway. Portions of the channel and a feeder tributary (T3.5S1.01) have been historically straightened to maximize crop and pasture areas, and to facilitate installation and maintenance of the culvert crossings.



*Figure 5. T3.05-B. Cows are afforded direct access to the Wanzer Brook in pasture areas downstream of the Pumpkin Village Road crossing.*

Phase 2 assessments in T3.05-B indicate active aggradation, widening and planform adjustments (meander extension) in response to past straightening, direct pasturing, and lack of woody riparian buffers. Incision appears minor in degree ( $IR < 1.2$ ) despite past channelization. Cohesive soils may be offering erosion resistance, moderating the degree of incision. No channel-spanning bedrock was observed in the segment. Culvert crossings may offer local grade control in annual to low-magnitude flood events.

Habitat conditions are compromised by the lack of woody riparian buffers which, if present, would offer shading to the channel, as well as recruitment of large woody debris (LWD), detritus and organic material. Streambank erosion is prevalent along both banks, and vegetative cover has been reduced by grazing and hoof damage. Pools are filling with sediments derived from streambank erosion. Direct pasturing and close encroachment by croplands are likely contributing nutrients and sediments to the Wanzer Brook.

### ***Segment A***

The downstream half of Reach T3.05 is in forested land cover. Portions of the segment may have been straightened historically (decades ago) when the area was broadly deforested for pasture uses. Evidence of a possible historic equipment crossing was noted. At present, the



corridors are fully forested and the channel is not encroached upon by agriculture or development.

Assessments indicated only minor degrees of widening, aggradation and planform adjustment. Evidence for channel incision was minor (IR = 1.2). Actual sinuosity of the channel is greater than indicated by the surface water coverage (Vermont Hydrography Dataset) for this section of the Wanzer Brook (i.e. Phase 1 Step 2.6). It is likely that the heavy forest cover and the small size of the channel in this watershed location obscured the channel planform at the resolution of the 1:5000 orthophotos used for VHD development (and sinuosity calculation).

Wetlands (NWI) are mapped within the segment (see Figure 6). Sediment accumulation and LWD recruitment were noted associated with the wetland areas, suggesting that these could serve an important sediment attenuation role in the watershed, isolating downstream reaches from the sediment and nutrient impacts of streambank erosion and pasturing within upstream Segment B.



*Figure 6. T3.05-A. Wetland areas contiguous to the channel in this segment may offer important sediment and nutrient attenuation functions.*

Beaver activity is associated with the wetland areas. A recent breaching of a beaver dam appears to have resulted in a drop in local base levels of 2 to 3 feet. Recently eroded streambanks were noted associated with the breached beaver dam.

Good diversity of channel morphology, presence of epifaunal substrates, limited streambank erosion and instream sedimentation, and continuous woody buffers indicate Good habitat conditions (RHA by VTANR protocols) in T3.05-A.

**T3.04** – This reach occupies a narrow to broad valley presently in forest cover. Forested land cover along the left bank corridor is newly re-vegetating after recent logging activity. Other than recent logging, floodplain encroachments within the reach are negligible.

Phase 2 assessments indicated only minor adjustments within the reach. Stability is probably afforded by channel-spanning bedrock, extensive forested buffers, lack of current encroachments on the channel and corridor, and lack of undersized crossing structures.

Habitat conditions are on the cusp between Good and Fair. Adequate diversity of channel morphology and epifaunal substrates is available, as well as continuous forested buffers (see Figure 7). However, conditions are compromised somewhat by moderate streambank erosion and instream sedimentation, particularly in the downstream half of the reach.





*Figure 7. T3.04. Forested riparian buffers and corridors within the reach provide for recruitment of Large Woody Debris, detritus and organic matter important to aquatic habitats.*

**T3.03** – Within reach T3.03 the Wanzer Brook receives flow from a major tributary draining the southern part of the watershed along Chester A. Arthur Road (T3.3S1.01). The total upstream drainage area more than doubles within reach T3.03 from 2.3 square miles at the upstream end of the reach to 5.1 square miles at the downstream end. Thus, at reach T3.03, the Wanzer Brook integrates the stressors from channel management and watershed-level disturbances within this tributary drainage as well as those from within the upstream drainage area of the main stem (see Section 4.2 for description of T3.3S1.01 and its tributaries).

The valley setting in T3.03 narrows quite a bit and the channel gradient increases (from 1.3% in T3.04 to 2.1% in T3.03). In the downstream quarter of the reach, the valley opens up and the channel gradient then decreases to approximately 1.8%. Essentially, the downstream reach break for T3.03 should have been positioned approximately 540 feet upstream from its current position. However, the resolution of remote sensing resources during Phase 1 Stream Geomorphic Assessments (topographic map and orthophotos) was insufficient to reveal the true position of this subtle change in valley setting with greater accuracy. Thus, the reach was segmented following Phase 2 field-based assessments to capture these changes in valley setting: upstream Segment B (1,977 feet); downstream Segment A (540 feet) which constitutes a Subreach with different reference stream type.

### ***Segment B***

Segment T3.03-B is geologically incised below the surrounding terraces in a narrowly-confined valley. The time frame for this incision is likely to have been on the order of thousands of years ago. Encroachments by agriculture, silviculture, and residential uses are presently limited to a few old fords for equipment crossings. In the watershed surrounding the reach, croplands do encroach to the limits of the Phase 1 corridor (see Appendix B) in a few locations along left bank and right bank high up on the valley terraces. Within the narrowly-confined valley, the channel often impinges on the valley wall, and multiple mass failures have developed exposing glacial tills (see Figure 8).

Phase 2 assessment of Segment B revealed a narrow floodplain approximately two to three channel widths wide. The channel appears to have adequate access to this floodplain (IR = 1.2). Moderate degrees of channel aggradation, widening, and planform adjustment are evidenced by presence of multiple mid-channel bars, enlarged point and side bars, transverse bars, steep aggradational riffles, flood chutes, and leaning trees.





Figure 8. T3.03-B. Mass failure along right bank, mid-reach - approximately 60 feet high and 200 feet long – exposing glacial tills overlain by sandy soils.

Aggradation and lateral adjustments within T3.03-B appear to be driven by both in-reach streambank erosion and mass wasting as well as by water and sediment loading from tributary reach T3.3S1.01. Evidence for the latter includes the geomorphic and adjustment conditions noted during Phase 2 assessments on this tributary (see Section 4.2) and a sizeable “delta” deposit of sediments and LWD of apparent episodic (flood-related) origin at the confluence of T3.3S1.01 with Wanzer Brook.

Despite the well-developed woody riparian buffers providing ample LWD and detritus, and despite the lack of floodplain encroachments, habitat conditions have been compromised by excessive streambank erosion and sedimentation of pools.

### **Segment A**

The downstream 540 feet of reach T3.03 gradually transitions to a broader (C-R/P) valley setting of lesser gradient, similar to downstream reach T3.02. The channel has good connection to a larger floodplain in this segment. Streambank erosion and planform adjustments are less pronounced, but the segment is still showing limited signs of widening and aggradation in response to significant volumes of sediments being delivered from upstream.

This segment is also contiguous with the confluence of T3.2S1.01 at the upstream extent of T3.02. There is an isolated broader-valley, gentler-gradient setting at this confluence which likely serves an important flow and sediment attenuation role for the Wanzer Brook as well as the T3.2S1.01 tributary. The area is utilized for low-density, low-frequency (late in the year) pasturing by the current landowner. Herbaceous cover dominates the area, but it does not appear at all overgrazed.

Habitat conditions are compromised in the segment by the degree of sedimentation and the lack of woody riparian buffers which, if present, would offer shading, detritus and organic material.

**T3.02** – Within reach T3.02 the Wanzer Brook receives flow from a major tributary draining the north and northwestern part of the watershed (T3.2S1.01). The upstream drainage area increases from 5.1 square miles at the upstream end of reach T3.02 to 7.1 square miles at the downstream end. With the exception of a localized, broader-valley setting at the upstream end of the reach near this confluence, reach T3.02 flows through a semi-confined to narrow valley of relatively steep gradient (2.6%, or B stream type). The upstream third of the reach has historically been utilized for low-density, low-frequency pasture, and tree buffers are largely absent. The downstream two-thirds below the Wanzer Road crossing is well-forested and slightly



steeper in gradient. Encroachments on the channel and corridor are minimal. Multiple exposures of channel-spanning bedrock are present mid-reach.

Substantial aggradation and widening are indicated by the prevalence of enlarged point and side bars, mid-channel bars, transverse bars, leaning trees, bifurcated flows, and a width/depth ratio greater than 40. In select locations where the channel has impinged on the valley walls, mass wasting of the channel margins has contributed additional sediments and LWD to the channel. Enhanced sediment production and delivery within the reach and from upstream reaches appears to have reduced the sediment transport capacity of reach T3.02.

Evidence of incision within the reach is minor to moderate, and the channel is adequately connected to its narrow floodplain. Vertical stability is probably afforded by the presence of channel-spanning bedrock. Roughness elements of the forested floodplain may also moderate erosive energies of the channel during bankfull and flood flows. At the Wanzer Road crossing, historic wooden cribbing is present directly under the bridge span between abutments, perpendicular to the channel. This cribbing may serve as a vertical grade control under annual and low-magnitude flood events.

Habitat conditions within T3.02 have been compromised somewhat by streambank erosion, mass wasting, lack of buffers, and less than optimal streambank vegetative protection (particularly in the upstream third). On the plus side, continuous forested buffers, active recruitment of LWD, abundant epifaunal substrates and morphological diversity in the lower two-thirds of the reach have contributed favorably to instream and riparian habitat conditions.

**T3.01** – Reach T3.01 is the downstream-most reach of the Wanzer Brook main stem near the confluence with Black Creek. Here the Wanzer Brook is emerging from the semi-confined valley geologically incised below forested and agricultural plains and flowing out onto the broader Black Creek floodplain which itself was formed from silt/clay deposits of glacial Lake Vermont and the Champlain Sea. The channel gradient decreases substantially (from 2.6% in T3.02 to 0.6% in T3.01). The sediment transport capacity of the Wanzer Brook drops significantly and an alluvial fan has developed over the last several 1000 years.

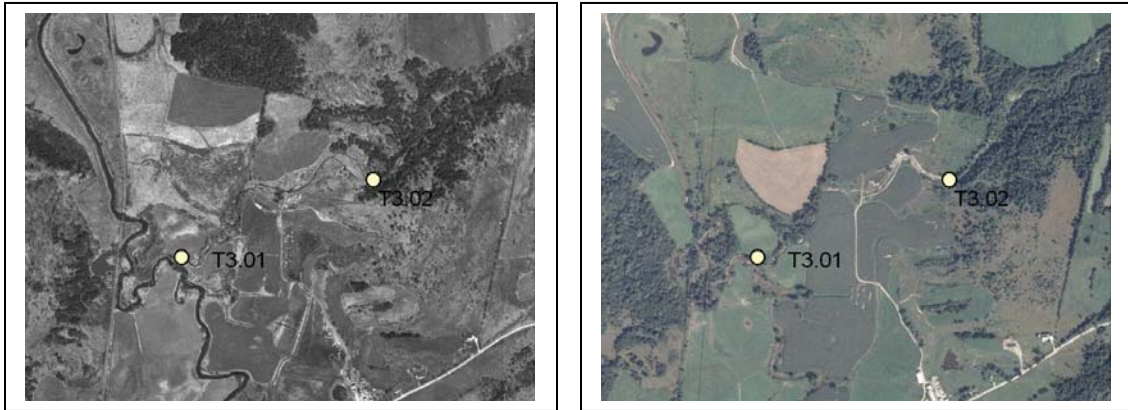
Agricultural land uses along T3.01 have encroached on the channel and corridor to increasing extents in recent years. Cropping in the valley has intensified and previously forested tracts of land are in the process of being converted to agricultural use (see Figure 9). In the process of land clearing, large cobbles and boulders (from Wanzer Brook alluvial fan deposits and/or delta deposits in a Champlain Sea interval) have been removed from the fields and used to armor the Wanzer Brook and create berms along the top of stream banks (see Figure 10). Comparison of historic aerial photographs reveals that reach T3.01 has had highly variable planform over the years, as a result of active channelization, dredging, berming, and the channel's subsequent lateral and vertical adjustments to intensive management. The Brook is presently forded in two locations, where the channel is observed to be locally overwidened and flow is bifurcated at low stage. At least two separate locations of current gravel extraction from enlarged point bars were observed during field reconnaissance.

Despite the long history of intensive channel management along T3.01, the channel appears to have some access to its floodplain, exhibiting only moderate signs of channel incision ( $IR = 1.5$ ). Cohesive silt/clay soils of the Black Creek valley, which underlie the alluvial fan deposits, may be moderating channel-downcutting. It is more likely that the potential for channel incision driven by channelization and berming has been offset by the aggradational and widening processes dominating the reach in this alluvial fan setting of reduced sediment transport capacity.



December 2005

Backwater effects of annual flooding in the Black Creek valley also control the local base level of reach T3.01 and are likely governing flow and sediment transport dynamics in the Wanzer Brook to some degree. Further survey-level assessments, historical research, and flow and sediment transport modeling would be necessary to confirm the complex response of the channel in this location to local, downstream and upstream stressors.



(a)

(b)

Figure 9. T3.01. (a) 1995 orthophoto base. (b) 2003 color aerial imagery. Riparian corridor along reach T3.01 has seen significant encroachment by cropping uses in the past 10 years. Forested areas north of the T3.02 downstream reach break have been cleared and are in the process of being converted to cropland.



Figure 10. T3.01. View upstream. Boulders / cobbles removed from newly-cleared fields have been used to armor the streambanks (picture right is left bank). Active gravel extraction from enlarged point bars (picture left). Overwidened stream channel at equipment ford sites (picture center).

Habitat conditions within T3.01 are impaired due to the lack of buffers, overwidened channel dimensions and lack of pool/riffle diversity associated with the plane bed morphology, and the degree of streambank erosion and sedimentation.



## 4.2 Major Tributary Reaches to Wanzer Brook

Two major tributaries to the Wanzer Brook main stem are discussed in the sections below: T3.2S1.01 and T3.3S1.01. Portions of additional tributaries to T3.3S1.01 were also assessed to understand the possible contributions of sediment and nutrients to the major reaches as generated by land use choices and/or geomorphic adjustments, and to identify locations of potential grade controls. Results for tributary reaches are summarized in Table 4.

**T3.2S1.01** – This is the downstream-most reach of a major tributary draining the north and northwestern portions of the Wanzer Brook watershed. It joins the Wanzer Brook main stem at the upstream end of reach T3.02. Reach T3.2S1.01 flows from a broad-valley, lesser-gradient setting at its upstream extent, downstream through a semi-confined to narrow, steeper-gradient valley to join the Wanzer Brook in a broader valley setting of lesser gradient. The considerable variability in valley setting led the Project Team to segment the reach to identify an 800-foot Subreach of B-stream type in the mid-portion of the reach (Segment B identified on maps in Appendix B). The downstream Segment A and upstream Segment C surrounding this subreach had similar characteristics to one another, and were classified as a C stream type.

Floodplain encroachments within the reach are fairly limited to an equipment ford and farm road crossing at the upstream extent (see Figure 11) and low-frequency (late-season), low-density direct pasturing by cows. Croplands extend close to the corridor along the top of the valley walls. Tile drains were observed elevated above the channel mid-way up the right valley wall in upstream Segment C. Within the Segment B Subreach, the channel often meets the valley wall and mass wasting is active. Sediments derived from these mass failures have created localized aggradation and planform adjustments. Several steep aggradational riffles were evident. One brief section of channel-spanning bedrock is present mid-segment.



*Figure 11. T3.2S1.01. View to the southeast. Active equipment ford at upstream extent of reach. Farm road providing access to this crossing also conveys stormwater runoff directly to the channel from fields to the west and northwest of the channel. Fine sediments (silts, clays, and fine sands) have accumulated in the channel coincident with the ford crossing.*

Trees are sparse within the narrow stream valley, and this lack of woody buffer has probably contributed to the degree of streambank erosion, widening, and aggradation noted within the reach. Floodplain access is reduced in mid-reach Segment B, but optimal in the upstream Segment C and downstream Segment A.

Habitat conditions have been compromised by lack of woody buffers and sedimentation from in-reach streambank erosion and mass wasting.



**Table 4. Results of Phase 2 Geomorphic Assessments, Select Wanzer Brook Tributaries**

**Tributaries to Wanzer Brook - Fairfield**

Reach	Segment	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq mi)	Stream Type	RHA Condition	RGA Condition	Adjustment	Stream Type Departure?	Sensitivity
T3.2S1.01	A	270	<i>1.8</i>	1.70	C4-R/P	0.61 Fair	0.58 Fair	Aggrad	No	Very High
	B	800	<i>3.9</i>		B4-S/P	0.66 Good	0.54 Fair	PF, Aggrad, Wid	No	High
	C	1,084	<i>1.8</i>		<i>has characteristics of Segment A.</i>					
T3.3S1.01	--	10,928	<i>0.53</i>	2.5	C4-R/P	0.53 Fair	0.50 Fair	Wid, Aggrad, PF	No	Very High
T3.3S1.02	<i>a</i>	<i>1,220</i>	<i>2.7</i>	0.8	C4b-S/P	0.73 Good	0.69 Good	None	No	High
T3.3S1.3S1.01	<i>a</i>	<i>2,992</i>	<i>5.3</i>	0.2	A4-S/P	0.56 Fair	0.51 Fair	Deg, Wid, Aggrad, PF	No	Very High
T3.3S1.4S1.01	<i>a</i>	<i>1,040</i>	<i>4.7</i>	0.3	A4-S/P	0.55 Fair	0.56 Fair	Aggrad, Wid, PF	No	Very High
T3.5S1.01	<i>a</i>	<i>1,950</i>	<i>3.2</i>	0.5	B4-R/P	0.54 Fair	0.59 Fair	Wid, Deg (historic)	No	High

Notes: (1) (2) (3)

Abbreviations:

S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Ref = Reference  
 RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTDEC, 2005).  
 PF = Planform Adjustment; Aggrad = Aggradation; Wid = Widening; NM = Not Measured.

Notes:

- (1) Segments denoted with a small case letter in italics represent the portion of the reach which was assessed and do not represent a true segment as defined in VTANR geomorphic assessment protocols.
- (2) Channel lengths noted in italics represent the portion of the reach which was assessed, not the complete reach length. See Table x for complete reach lengths, and percentage of reach assessed.  
 Slope values in italics indicate those which are updates from Phase 1 calculations: either calculated for segments delineated during Phase 2 assessments, or for portions of a reach assessed, or which were revised from Phase 1 due to error correction or field-based observations.





### **Section E**

The upstream fifth of Reach T3.3S1.01 extends from approximately 500 feet upstream of the Dodd Road crossing downstream to the Boomhower / Magnan property line. The topographic setting indicates a C stream type in a narrow to broad valley. Dairy cattle have been directly pastured along Section E for several years, and buffers are absent. Incision, widening, aggradation and planform adjustments are active through this portion of the channel, as evidenced by a series of steep riffles, steep undercut banks, fractures along tops of banks with slump-block failure, prevalence of mid-channel bars, transverse bars, and bifurcated flow, flood chutes, and meander extension. Local landowners report that headcuts migrated upstream from the recently (2003) restored wetland in Section D where the channel bed elevation was lowered to some degree. Channel incision subsequently led to active widening and streambank erosion. Fencelines have been repeatedly undermined and lateral channel migration has encroached on a culvert crossing which provides pasture access in feeder tributary, T3.3S1.3S1.01.

Other stressors within Section E of T3.3S1.01 include removal of forested buffers along the channel, direct access by cattle, and possible enhanced flows and sediment loading from upstream sources including road runoff along Chester A. Arthur Road (see results for T3.3S1.02 and T3.3S1.4S1.01 in Table 4 and Appendix A). Pasture along T3.3S1.3S1.01 has also been overgrazed in past years, contributing sediment and nutrient runoff to T3.3S1.01.

Direct pasturing along Section E was observed during Phase 2 assessment work, with associated high turbidity and fecal matter in the stream. Grasses are closely-cropped and hoof damage was contributing to streambank erosion. The landowner has signed up with USDA for cost-sharing assistance through the EQIP program. During the last year, nutrient loading to Wanzer Brook has been reduced through the construction of a covered barnyard for dairy cows in an area close to the channel that was previously prone to runoff. As part of the project they will also be establishing a single stream crossing point for animals heading to pasture, and excluding livestock from the brook.

Because of the intensively disturbed nature of the channel in Section E, bankfull features were obscured, and Phase 2 cross sections yielded inconclusive results with regard to the degree of entrenchment and incision. Pending data analysis of a Phase 3 (survey-level) assessment conducted by VTDEC in the Fall of 2005, Section E may exhibit such degrees of incision and associated stream type departure that segmentation will be warranted.

### **Section D**

Section D extends downstream from the Boomhower / Magnan line to the Ryan Road crossing. This portion of the T3.3S1.01 channel flows through a broad valley of lesser gradient than Section E. Wetlands (NWI) are mapped along this section. Along the right-bank corridor and to the north of the channel is cropland; to the south is forested land. The corridor directly along the channel is currently fallow, and is associated with a recent wetland restoration project. A historically straightened section of channel in prior-converted wetlands has been restored to regime-based channel dimensions, profile and planform (see Figure 13).

This project was completed in 2003 (a collaborative project between Partners for Wildlife (Chris Smith), NRCS (Kathy Hakey), ACOE). During Phase 2 assessments in 2005, the Project Team noted some limited meander extension, and subtle development of riffle / pool bedforms.



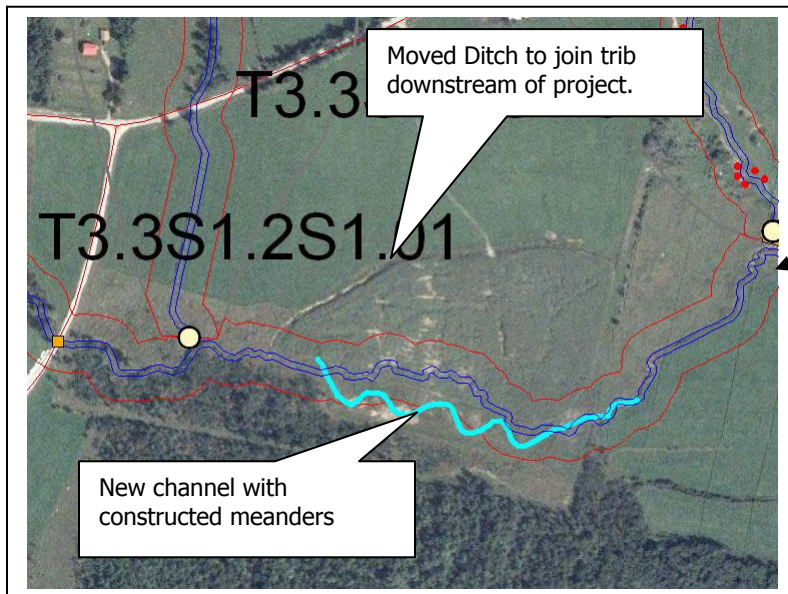
Sediments had recently been deposited on the regraded floodplain surface immediately surrounding the channel. Sedimentation by fines was also noted, and may be related to the active streambank failures in upstream Section E. Two prominent field ditches draining to this Section are also contributing fine sediments, as evidenced by small "delta" deposits at their confluences with the Wanzer Brook tributary.



Figure 13. T3.3S1.01.  
Wetlands restoration project  
on Magnan property.  
(a) 1995 prior to restoration.  
(b) 2003 post restoration.

(a)

1995 ortho



(b)

2003 ortho



### Section C

Section C of T3.3S1.01 extends from the Ryan Road crossing downstream to the Gavin Ryan property. The valley is narrower and steeper along this portion of the channel, suggesting a C-narrow reference stream type. Hayfields encroach on the left and right corridors, but development is negligible within this section, save for the undersized Ryan Road box culvert crossing. Historic straightening is suggested by the long linear stretches of channel more than 20 times channel width in length, and by anecdotal evidence. Occasional patches of rip-rap (field stone) are present along both banks. A large crushed metal tank is present along right bank at the apparent upstream end of this historic straightening/armoring project. There are piles of field stone at this location, which is accessible from Chester A. Arthur Road.

Despite intensive channelization and armoring, the channel has maintained limited access to its floodplain (IR ~ 1.5 based on a quick cross section mid-section). Incision may have been moderated by presence of cohesive soils within the channel margins. Shrub and tree buffers may have offered stability to the channel as well. Along the channel is a closed canopy of shrub / tree buffer varying in width from 5 to 50 feet on either bank (Figure 14). Along this mostly continuous buffer, there is an occasional patch of absent buffer.

The channel appears transport-dominated, punctuated by the occasional pocket of aggrading and overwidened channel (mid-channel bars, enlarged point bars) with local access to incipient floodplains forming at a lower elevation. Debris jams formed by recruitment of LWD seem to be contributing to these localized areas of meander extension and floodplain building.



*Figure 14. T3.3S1.01 – Section C. "Alder Way" downstream of the Ryan Road crossing. Previously channelized section bordered by hayfields and lined by 5 to 50-foot shrub/tree buffers. Section is beginning to create some sinuosity and build a new floodplain through meander extension, facilitated by recruitment of LWD and debris jams.*

### Section B

Section B consists of the portion of T3.3S1.01 flowing through the Gavin Ryan farm. The channel flows through a very broad valley setting of lesser gradient than upstream Section C. Direct pasturing by cows is permitted upstream of the Chester A. Arthur Road crossing. Tile drainage from adjacent fields discharges directly to the stream in a few spots. Recently installed (2005) fencing has now excluded cows from the channel downstream of the road crossing, although two animal crossings have been retained (engineered by NRCS). Prior to establishment of the downstream fencing, the reach had essentially no undisturbed buffer along either bank; vegetation in near-bank areas consists of close-cropped (grazed) grasses, with occasional shrubs. Substantial bank erosion from hoof damage had been evident downstream of the road crossing. Fecal matter was observed in the stream channel.



December 2005

The channel maintains good access to its floodplain throughout the Section (IR = 1.0 at cross section mid-Section). Localized channel widening and planform adjustments were evident with moderate aggradation. Fine sediment has accumulated in the channel. Moderate turbidity of the water was observed during field assessments, which cleared noticeably as the Project Team moved upstream of the direct-pasture area into Section C. Meander extension was frequent, and brief sections of braided and avulsed channel were noted near the upstream end of section.

Local instability was noted at the Chester A. Arthur road crossing. Significant lateral and some vertical scour was noted at the downstream end of this box culvert. The current structure was installed in 2002, following a wash-out in the 2001 floods. The former structure was narrower than the current structure, and it is possible that evidence of lateral scour associated with the crossing is related more to the past undersized culvert crossing. Channel overwidening local to the structure may also be, in part, a result of cattle access; cows frequently cross in this location, and one of the new engineered cattle crossings was installed at this location (Figure 15). Sediment has built up within the box culvert structure itself since its installation.



Figure 15. T3.3S1.01 – Section B. NRCS-engineered cattle crossing approximately 75 feet downstream of Chester A. Arthur Road crossing – installed August 2005.

### Section A

During reach delineations in the Phase 1 Stream Geomorphic Assessment, a 650-foot length of channel at the downstream extent of Reach T3.3S1.01 was apparently missed, resulting in an “orphan”, non-delineated segment (Figure 16). This appears to be an artifact of the remote-sensing scale limitations, or may be a result of a Stream Geomorphic Assessment Tool (SGAT) software “bug”.

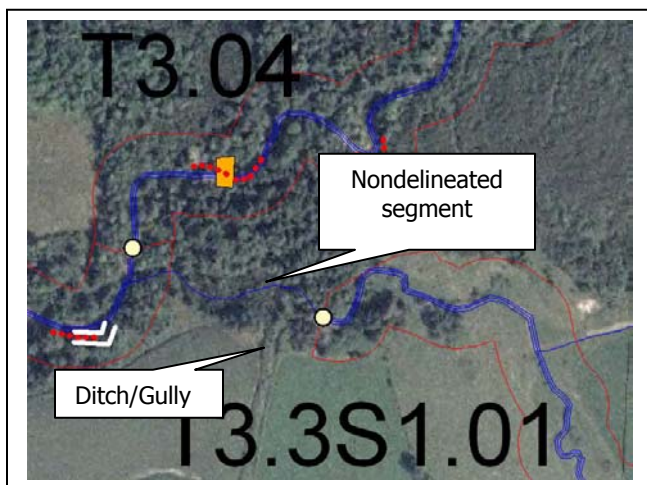


Figure 16. T3.3S1.01. Location of ditch and gully erosion draining to non-delineated downstream segment of reach.



Within this non-delineated segment of T3.3S1.01 where the tributary joins the Wanzer Brook main stem, the Project Team observed a sizeable "delta" deposit of sediments and LWD of apparent episodic (flood-related) origin.

Approximately 500 feet upstream from the confluence, a debris flow was noted at the bottom of a substantial erosional gully in the left valley wall (see Figure 17). The Project Team walked upstream in the gully and came to the adjacent corn field where an agricultural ditch with standing water was observed terminating at the top of the gully.

This drainage ditch / gully serves as a point source of significant quantities of sediment and nutrients to the Wanzer Brook tributary. Debris flows and sediment originating in the gully have contributed to a localized reduction of sediment transport capacity along the Wanzer Brook tributary (T3.3S1.01). Given that this ditch/intermittent tributary is receiving barnyard and cropland runoff from upstream farms, there are likely nutrient contributions as well.

The non-delineated segment of T3.3S1.01 exhibits a C stream type with narrow valley confinement. No direct pasturing was evident. There is a relatively undisturbed, revegetating riparian buffer with select trees and shrubs in a fallow pasture near the upstream extent. A full canopy cover and mixed-tree forested buffer is present along the downstream end approaching the confluence with T3.03.



*Figure 17. Erosional gully at the terminus of a field ditch trending northeast through corn fields northwest of Chester A. Arthur Road. Debris flow extends to the confluence with T3.3S1.01, approximately 500 feet upstream of that tributary's confluence with Wanzer Brook main stem.*

## **5.0 Summary and Discussion**

Phase 1 and Phase 2 assessment results have begun to characterize the watershed and channel stressors to the Wanzer Brook watershed over time, and the spatial and temporal variability in adjustment processes which together have resulted in the present day geomorphic conditions. These interpretations can be used by watershed stakeholders to identify possible consequences of land use and watershed management decisions on future geomorphic condition of the river to improve water quality and aquatic habitats and to minimize erosion and flooding hazards.

### **5.1 Watershed and Channel Stressors**

Various watershed-scale and channel-level disturbances have served as stressors to the Wanzer Brook and its tributaries (Table 5). These stressors have been identified through direct observation, limited historical research, anecdotal accounts from landowners and local citizens, as well as remote sensing. This list is not comprehensive, but it begins to characterize the degree of natural and human disturbances to the watershed, that have caused variable and overlapping adjustment responses in the channel.

Generally speaking, reaches in broader valley settings with lesser gradients, have been more closely encroached upon by residential and agricultural land uses. These reaches/segments are showing evidence of multiple reach-scale and site-scale disturbances including channelization, dredging, berming, armoring, gravel extraction undersized crossing structures, fords, direct pasturing and tile/ditch drainage. Reaches/segments most impacted would include: T3.01, T3.02, T3.05-B, T3.3S1.01, and T3.5S1.01.

### **5.2 Dominant Adjustment Processes and Reach Sensitivity**

The Wanzer Brook and tributary channels are responding to stressors through adjustment of their dimension, planform, and profile. Adjustments have occurred to varying degrees, as dependent on multiple factors (including channel sediment types, vegetative cover type and density, presence of grade controls, etc.). Rapid Geomorphic Assessment scores of the assessed reaches ranged from Fair to Good (scores of 0.47 to 0.74), indicating minor to moderate adjustment. None of the reaches was identified to be in Reference (stable) condition. None of the reaches was identified to have undergone adjustment severe enough to constitute a stream type departure. One possible exception to this is the upstream-most portion of reach T3.3S1.01 near the Boomhower Farm just downstream of the Dodd Road crossing (pending analysis of Phase 3 , survey-level, geomorphic assessments).

The relative magnitude of channel adjustment processes, together with the topographic, geologic, and vegetative setting define the sensitivity of a given reach or segment to continuing and future stresses. Generally speaking, those channels with steeper gradients in confined valleys carrying coarser sediment loads (boulders, cobbles) and showing good vertical grade controls (e.g., channel-spanning bedrock) are considered to be most stable and least sensitive to vertical and lateral adjustments that may present conflicts with human investments in the corridor. In contrast, the more sensitive reaches (High, Very High, or Extreme), susceptible to future adjustments in response to current and future channel and watershed stressors, include the low- to moderate-gradient (less than 2%) channels dominated by gravels or sands, and absent of grade controls.



**Table 5. Summary of Watershed and Channel Stressors in Study Area Reaches / Segments.  
 Wanzer Brook Watershed, 2005 Stream Geomorphic Assessment.**

	T3.01		T3.02		T3.03		T3.04		T3.05		T3.06		T3.2S1.01			T3.3S1.01		T3.3S1.02		T3.3S1.3S1.01		T3.3S1.4S1.01		T3.5S1.01			
			A	B			A	B					A	B	C												
<b>Stressors</b>	Wanzer Main Stem											Wanzer tributaries															
<b>Watershed</b>																											
Deforestation in 1800s																											
Road Networks (1700s, 1800s)		√							√								√	√	√	√					√		
Flood events (1927, 1938, 1984, 1997, 2000)																											
<b>Channel - Reach Scale</b>																											
Channelization / Straightening	√					√ (H)			√								√	√	√						√		
Dredging	√																									√	
Berming	√																									√	
Bank Armoring	√	√																								√	
Floodplain Encroachment	√																√ (m)									√	
Loss of Forested Buffers	√	√											√	√	√						√	√				√	
Impoundment (dam)																										√	
<b>Channel - Site Scale</b>																											
Gravel extraction	√																										
Undersized Crossing Structure		√							√												√	√				√	
Ford	√	√			√	√			√				√		√		√	√	√		√	√			√	√	
Cattle in Stream		√ (m)											√ (m)		√		√	√	√		√	√			√	√	
Tile drains/ ditches to reach															√		√	√	√		√	√			√	√	

Notes: √ = existing stressor; √ (H) = historic stressor; √ (m) = minor condition



Sensitivities of the Wanzer Brook reaches and segments as defined in VTANR protocols (2005) are presented in Figure 18. Each of the assessed reaches was classified in either the High or Very High sensitivity class.

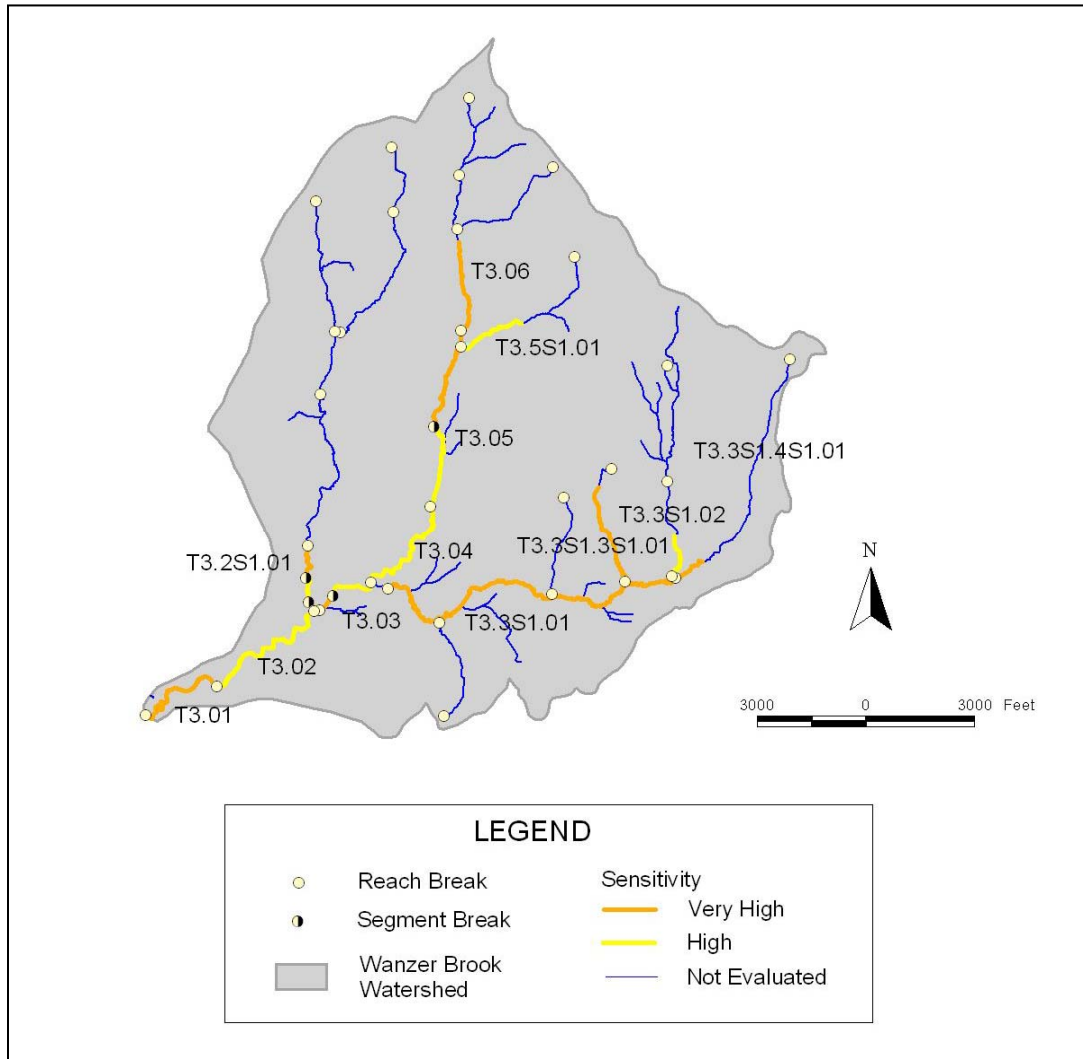


Figure 18. Reach / Segment Sensitivity,  
 Wanzer Brook Watershed, 2005 Stream Geomorphic Assessments.

The subtle variability of sensitivity among the study area reaches is a function of the geomorphic condition (degree of active adjustment / stream type departure), itself a function of geologic boundary conditions (e.g., presence of vertical bedrock grade controls) and vegetative (buffer) boundary conditions, as well as valley and channel topography.

Generally speaking, those reaches which were classified as Very High sensitivity are located along the broader, less steep valleys of the Wanzer Brook river network, where agricultural and residential land uses have encroached more noticeably (Figure 19).



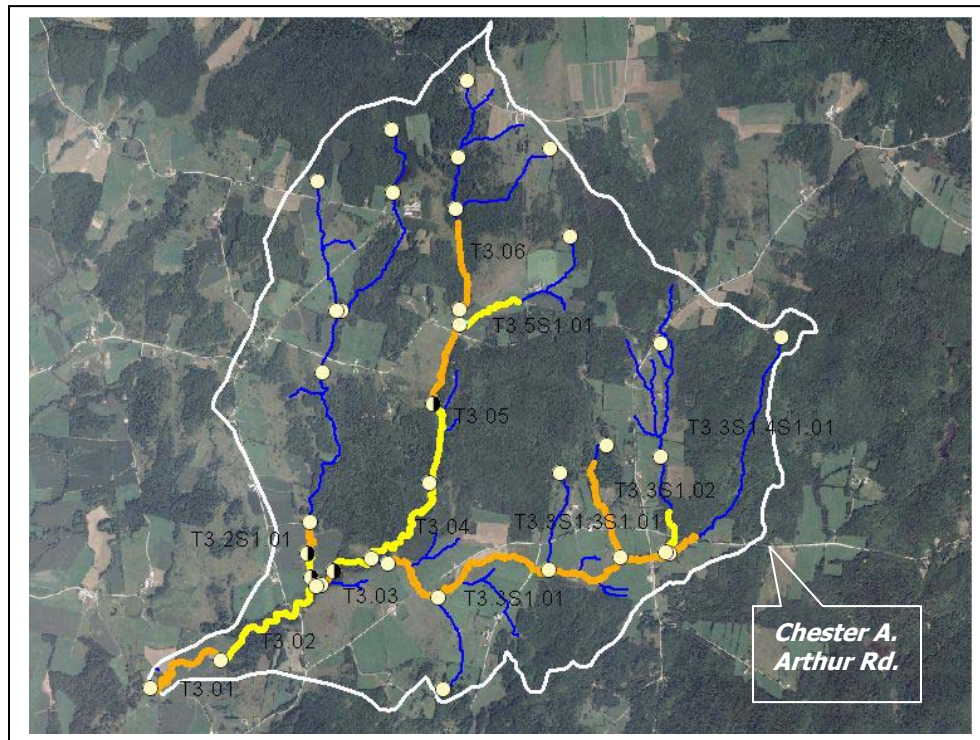


Figure 19. Assigned reach /segment sensitivity (following VTDEC, 2005) in Wanzer Brook watershed (outlined in white) on base map of 2003 NAIP color aerial imagery. (See Figure 18 legend).

Following current guidance from VTDEC (2005), both categories of Sensitivity assigned to Wanzer Brook reaches/segments would indicate the same magnitude of riparian corridor based on the meander belt width approach: a six-times-channel-width belt width centered around a meander center line.

### 5.3 River Corridor Management Strategies

Landowners, Fairfield community members, and resource agencies, including Missisquoi River Basin Association, the Natural Resources Conservation Service, US Fish & Wildlife, and Vermont Agency of Natural Resources, can use geomorphic data to inform future management strategies for the river corridor. For a given reach or segment, the active adjustment processes, degree of departure from reference, and sensitivity ranking will define the short-term compatibility and long-term sustainability of various restoration or conservation options and future land use or channel management activities. VTDEC River Management Section has developed guidelines for classifying reaches / segments into potential management approaches based on geomorphic characteristics (VTDEC, 2005):

- Equilibrium – Stable Reference (Conservation Reach)
- Equilibrium – Minor Adjustment (Eroding Banks, High Recovery Reach)
- Unstable – Moderate Departure (Moderately Unstable Reach)
- Unstable – Downcutting (Incising Reach)
- Unstable – Severe Departure (Highly Unstable Reach)



None of the assessed Wanzer Brook reaches/segments were noted in the extreme categories on either end of the spectrum: Equilibrium-Reference category or Unstable-Severe Departure category. The study area reaches / segments have been classified into the remaining categories in the sections below, and potential management strategies have been outlined, based on active or passive geomorphic approaches.

Active geomorphic approaches are typically appropriate for Unstable reaches exhibiting active bed degradation and/or a severe departure from reference condition. Certain moderately unstable reaches can also be candidates for active-geomorphic solutions, particularly where infrastructure may be at risk or where such active approaches are strategic in the protection of upstream stable or reference reaches. Active approaches are also relevant when there is a desire among stakeholders to accelerate the river's return to a more balanced condition. Cost of active approaches and their risk of failure is typically much higher than other alternatives.

A passive geomorphic approach involves long-term management and preservation of a belt-width derived river corridor. Phase 2 data collected in this project (including bankfull width measurements, and sensitivity classifications) can be used to generate a corridor. (Note: the reach-based orthophotos in Appendix B depict the Phase 1 Appendix E corridor; reference VTANR protocols, 2005; this is slightly wider than the corridor that would be based on field data and Sensitivity determinations).

Within the belt-width derived river corridor, the channel is allowed to adjust unimpeded to a more sinuous, meandering planform closer to regime conditions. During ongoing adjustments, the river will re-establish greater floodplain access and adjust channel dimensions for optimum conveyance of its water and sediment loads. Generally speaking, the river can achieve a sustainable and balanced planform, profile and channel geometry more successfully and much more cheaply than humans engaged in a series of active channel restoration projects. Floodplain access for the river can be maintained and enhanced by protecting the corridors from development and floodplain filling, and refraining from channel management activities that tend to cause the channel to become disconnected with its floodplain (e.g., channelization, dredging, berming). Generally, passive approaches to channel and floodplain restoration and conservation are most appropriate for reaches / segments in the following stream condition categories (VTDEC RMS, 2005):

- Equilibrium – Stable Reference - where conservation of the corridor can serve to protect stream equilibrium conditions and ecological processes within the riparian corridor.
- Equilibrium – Eroding Banks – High Recovery Reach where restoring channel boundary conditions (vegetation, to increase roughness elements
- Unstable – Moderate Departure.

**Preservation of sediment attenuation areas** along the river network is an important element in the passive geomorphic approach. Several wetland areas and valley settings contiguous to the Wanzer Brook channel were identified during Phase 2 assessments for the potential role they could serve in sediment and nutrient attenuation. With the willingness of landowners, these sites may be good candidates for conservation, particularly where existing land uses do not appear to be in conflict with channel adjustment processes.

Within the belt-width defined corridor approach to passive geomorphic restoration, **enhancement of forested riparian buffer areas** along the channel margins should also be pursued. Buffers serve to improve water quality through filtering and nutrient uptake (Figure 20). Forested buffers offer roughness elements to the channel margins and near bank areas,



helping to dissipate the erosive energies of flood waters and contributing to greater flow and sediment attenuation in the floodplain. Thus, buffers will help to restore and maintain dynamic equilibrium of the channel by increasing resistance to shear stresses along the channel boundaries. Tree buffers will provide the additional benefits of organic matter, detritus, and LWD to aquatic and riparian habitats. Connectivity of buffer areas from reach to reach along a river network also provides for wildlife corridors, thereby supporting mammalian terrestrial habitats.



Figure 20. T3.5S1.01. Direct sediment and nutrient runoff from corn fields adjacent to Wanzer Brook tributaries.

Establishment of wider buffers will help to filter sediments and take up nutrients to improve water quality in the receiving channels.

### 5.3.1 Equilibrium – Minor Adjustment

Tributary	Reach	Segment	Stream Type	RGA Condition	Sensitivity
Wanzer Bk M.S.	T3.04		C4-R/P	0.66 Good	High
Wanzer Bk M.S.	T3.05	A	C4-R/P	0.74 Good	High
Wanzer Bk M.S.	T3.06		C4-R/P	0.61 Fair	Very High
Unnamed	T3.3S1.02		C4b-S/P	0.69 Good	High

The above four reaches are Equilibrium-Minor-Adjustment reaches, undergoing relatively minor widening and aggradation, with some limited planform adjustment. While T3.06 was rated in the Fair category for Rapid Geomorphic Assessment, this reach is on the cusp with the Good category, and exhibits generally minor degree of adjustment. Channel stressors are minor in extent and degree in these Equilibrium-Minor Adjustment reaches. Two of the reaches have channel-spanning bedrock which affords stability to the reach/segment (T3.04 and T3.3S1.02). All four reaches/segments have well-developed forested riparian buffers which increase the channel's resistance to erosion. All four reaches/segments have established wetland areas contiguous to a portion of the stream channel which can offer flow and sediment attenuation (National Wetlands Inventory mapping).

Instabilities in all four Equilibrium-Minor Adjustment reaches are localized, isolated from downstream unstable reaches by bedrock grade controls (Figure 21). These are High Recovery



December 2005

Reaches, maintaining good floodplain access, where restoration of erosion resistance in channel boundaries (bed and banks) can accelerate a return to dynamic equilibrium. Strategically, investing in recovery of these upper watershed reaches will prevent localized instabilities from migrating upstream or downstream to generate more network-wide imbalances, and will relieve some of the compounded stresses on downstream reaches.

Channel and corridor management strategies appropriate to Equilibrium-Minor Adjustment reaches may include:

- Conservation to maintain floodplain access, and flow and sediment attenuation functions of floodplains and contiguous wetlands;
- Private and municipal planning strategies to prevent placement of infrastructure within the corridor;
- Indirect treatment of streambank erosion (and nutrient contributions) - e.g., exclusion of cattle;
- Enhancement and maintenance of forested buffers to improve streambank and corridor erosion resistance, provide for sediment and nutrient buffering and filtration;
- Replacement of undersized crossing structures;
- Removal of infrastructure from the stream corridor.

Typically, these are passive geomorphic approaches, meaning that none of the recommended approaches involves directly altering the channel dimensions, profile, or planform to re-establish dynamic equilibrium to the channel. Rather, the above measures would facilitate the channel's natural process of lateral and vertical adjustments to move toward a pseudo-equilibrium state under the current sediment and flow regime.

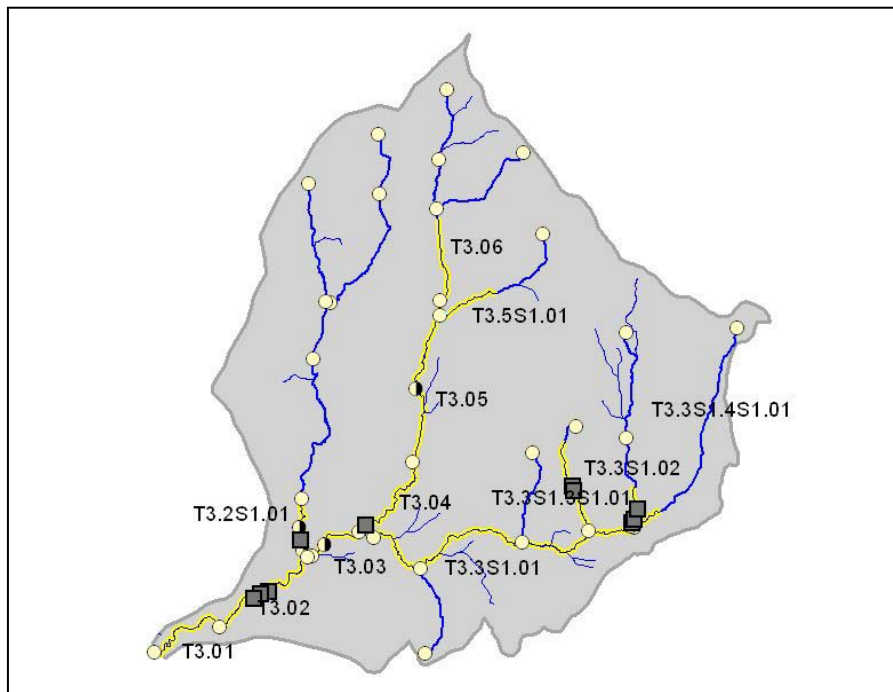


Figure 21. Location of bedrock grade controls (gray squares) identified along assessed portions of reaches (highlighted), Wanzer Brook watershed.



**5.3.2 Unstable (Dis-equilibrium) – Moderate Departure**

Tributary	Reach	Segment	Stream Type	RGA Condition	Sensitivity
Wanzer Bk M.S.	T3.01		C4-PB	0.38 Fair	Very High
Wanzer Bk M.S.	T3.02		B4-R/P	0.51 Fair	High
Wanzer Bk M.S.	T3.03	A	C4-R/P	0.59 Fair	Very High
Wanzer Bk M.S.	T3.03	B	B4-S/P	0.51 Fair	High
Wanzer Bk M.S.	T3.05	B	C4-R/P	0.49 Fair	Very High
Unnamed	T3.2S1.01	A	C4-R/P	0.58 Fair	Very High
Unnamed	T3.2S1.01	B	B4-S/P	0.54 Fair	High
Unnamed	T3.2S1.01	C	<i>has characteristics of Segment A.</i>		
Unnamed	T3.3S1.01		C4-R/P	0.50 Fair	Very High
Unnamed	T3.3S1.3S1.01		A4-S/P	0.51 Fair	Very High
Unnamed	T3.3S1.4S1.01		A4-S/P	0.56 Fair	Very High
Unnamed	T3.5S1.01		B4-R/P	0.59 Fair	High

The majority of reaches/segments assessed in the Wanzer Brook watershed in the Summer of 2005 indicate a moderate degree of channel adjustment in response to current and past channel management and watershed-level stressors. Reaches/segments in this category tend to have been subjected to stressors directly (see Table 5), particularly the main stem reaches T3.01, T3.02, and T3.05-B, as well as the tributaries to T3.05-B (T3.5S1.01) and T3.03 (T3.3S1.01, T3.2S1.01, T3.3S1.3S1.01, and T3.3S1.4S1.01). Adjustment processes are moderated in the watershed by the prevalence of cohesive soils, frequent channel-spanning bedrock grade controls (T3.02, T3.2S1.01-B, T3.3S1.02, and T3.3S1.3S1.01), and presence of occasional sections of forested riparian buffers (T3.02, T3.03, T3.3S1.01, T3.3S1.3S1.01, T3.3S1.4S1.01). For the most part, intensive channel management (channelization, dredging, armoring, berming) has not resulted in major incision (or channel downcutting). Instead, given the moderating forces listed above, channels have adjusted laterally in response to these stressors.

Channel and corridor management strategies appropriate to Unstable-Moderate Departure reaches include, both active geomorphic approaches:

- Restore floodplain connection along a historically incised channel or bermed/armored channel;

and passive geomorphic approaches (or a combination of both):

- Conservation to maintain floodplain access, and flow and sediment attenuation functions of floodplains and contiguous wetlands;
- Private and municipal planning strategies to prevent placement of infrastructure within the corridor;
- Indirect treatment streambank erosion (and nutrient contributions) - e.g., exclusion of cattle;
- Indirect treatment of channel bedform (increase roughness and restore channel bed morphology) through introduction of LWD or larger bed material;
- Enhancement and maintenance of forested buffers to improve streambank and corridor erosion resistance, reduce width/depth ratios, and provide for sediment and nutrient buffering and filtration;
- Replacement of undersized crossing structures;
- Removal of infrastructure from the stream corridor.



**5.3.3 Unstable (Dis-equilibrium) – Downcutting (Incising Reach)**

Tributary	Reach	Segment	Stream Type	RGA Condition	Sensitivity
Unnamed	T3.3S1.01		C4-R/P	0.50 Fair	Very High

The upstream fifth of reach T3.3S1.01 appears to indicate active channel degradation, accompanied by widening and planform adjustments. This portion of the channel has direct pasturing. Hoof damage and lack of woody riparian buffers along the streambanks are contributing to the lateral adjustments. The culvert crossing of Dodd Road may be serving as a local grade control; however, culverts are transient grade controls, subject to washing out in a large flood event. Phase 3 assessments conducted by VTDEC will provide confirmation of adjustment processes and the degree of floodplain connection in this part of the reach.

Active restoration may be warranted in this upstream section of T3.3S1.01, assuming that Phase 3 and further research bears out that proposed restoration designs would be sustainable (i.e., no uncontrolled stressors adding to incision / aggradation). Active geomorphic designs may include installation of grade control structures to arrest channel incision, lowering of stream bank elevations in discrete sections to reconnect the channel with a floodplain, stabilization of streambanks with hard (armoring) or soft treatments (tree revetments for current deflection), and re-establishment of woody buffers. Longterm sustainability of restoration designs will be improved by certain land use changes within the corridor upstream and downstream of the site. Such measures should include: (1) exclusion of cattle from the stream; (2) improved road maintenance practices to reduce sediment and stormwater runoff to the channel upstream of the restoration project; (3) possible replacement of undersized crossing structures; (4) enhancement of sediment and flow attenuation upstream of the project. Care should also be taken to adequately link the Boomhower restoration project with channel profile, planform, and dimension constraints of the downstream wetland restoration project on the Magnan property.

**6.0 ALTERNATIVES ANALYSIS****6.1 Site/Reach – Level Management Alternatives**

Based upon the stream conditions summarized in Sections 4 and 5, the Project Team conducted an Alternatives Analysis to identify discrete site-level and reach-level projects which could be most effective at reducing sediment and nutrient loading to the Wanzer Brook watershed. Potential geomorphically-informed restoration and conservation projects were identified, and classified into Passive or Active approaches based on geomorphic condition. Select conceptual designs were developed (for 1 October 2005 application to the follow-on Category III grant which was subsequently received by the Town of Fairfield). Technically-feasible projects were then prioritized based on gross measures of cost (low, medium, high), landowner approval, and the extent to which each project addressed the primary objective of sediment and nutrient reduction in the watershed in the short-term.

Results of the Alternatives Analysis are summarized in Table 6. Select projects noted with an asterisk in Table 6 are those for which preliminary funding has already been secured through Category III grant funding from the River Management Section (Governor's Clean & Clear Action program).



**Table 6. Alternatives Analysis: Site and Reach-Level Management, Wanzer Brook watershed.**

Project Type	Reach / Segment & Stream Condition	Site Description	Project Description / Objectives	Landowner Approval	Objectives Addressed short-term (ST) long-term (LT)	Cost	Priority	Potential Partners
<b>Active Geomorphic Alternatives</b>								
Arrest Headcuts / Bed Degradation	Tributary Ditch to T3.3S1.01 Unstable - Downcutting	<b>Ryan / Magnan Farms</b> intermittent stream/field ditch in which headcutting near the confluence with T3.3S1.01 has produced substantial sediment/nutrient loading.	Stabilize headcut and divert upstream barnyard runoff to constructed wetland for nutrient treatment and flow/sediment attenuation.	secured; enrolled in EQIP 10/2005	SED ATT; NUTR REDUC (ST)	High	High **	NRCS (EQIP); engin. consultant; VT Ag Ag
Arrest Headcuts / Bed Degradation	T3.3S1.01 Unstable - Downcutting	Upstream 1/5 of reach at <b>Boomhower Farm</b> which has exhibited active incision in recent years	Stabilize headcut; provide for vertical grade controls; re-establish floodplain connection; exclude cattle from the stream channel; reestablish vegetated buffers; address upstream hydrologic and sediment loading sources (mitigate road runoff; re-establish buffers; protect corridor).	secured; enrolled in EQIP 10/2005	SED ATT; NUTR REDUC; Accelerate return to Equilibrium channel (ST)	High	High **	NRCS (EQIP); VTRMS; VT Ag Ag

Note: Double asterisk (\*\*) in Priority column indicates project has already received implementation funding as part of a Category III River Corridor Grant (FY2006) awarded to the Town of Fairfield.

Abbreviations: SED ATT = Sediment Attenuation; NUT RED = Nutrient Reduction; ST = Short-term; LT = Long-term



**Table 6. (Continued) Alternatives Analysis: Site and Reach-Level Management, Wanzer Brook watershed.**

Project Type	Reach / Segment & Stream Condition	Site Description	Project Description / Objectives	Landowner Approval	Objectives Addressed short-term (ST) long-term (LT)	Cost	Priority	Potential Partners
<b>Passive Geomorphic Alternatives</b>								
Restore Boundary Conditions	T3.2S1.01 Unstable - Moderate Departure	<b>Tiffany Farm</b> - Reach which is actively adjusting its planform and impinging on adjacent valley walls, possibly in response to increased hydrologic pressure from up-watershed logging; absence of woody buffers from historic low-frequency pasturing; and increased stormwater and sediment contributions from a farm road and ford.	Replace stream ford with a geomorphically compatible crossing structure; re-route and attenuate stormwater runoff along farm road through alternative grades, alignment, and by using turnouts or other sediment and flow attenuation practices.	secured; enrolled in EQIP 10/2005	SED ATT; NUTR REDUC (ST)	Mod	High **	NRCS (EQIP); VT Ag Ag
			Increase buffer widths along cropped corridors (CREP) at top of valley walls; reestablish woody buffers along channel margins (CREP; Partners). Protect the corridor from future development/encroachments. Corridor easement supplemental to existing VT Land Trust agreement for Tiffany Farm.	secured; enrolled in EQIP 10/2005;	SED ATT; NUTR REDUC; Accelerate return to Equilibrium channel (LT)	Mod	High **	NRCS (EQIP); USF&W; VLT; VTRMS; VT Ag Ag
Restore Boundary Conditions	T3.3S1.01 Section B Unstable - Moderate Departure	<b>Ryan Farm</b> upstream of Chester A. Arthur Road. Direct pasturing by cows is contributing nutrients and sediments to the channel.	Increase buffer widths along pasture corridors, and exclude cattle from the stream (CREP); reestablish woody buffers along channel margins (CREP & Partners).	likely; other Farm locations enrolled in CREP 10/2005	SED ATT; NUTR REDUC (ST)	Low	High	NRCS (EQIP); USF&W; VT Ag Ag

Note: Double asterisk (\*\*) in Priority column indicates project has already received implementation funding as part of a Category III River Corridor Grant (FY2006) awarded to the Town of Fairfield.

Abbreviations: SED ATT = Sediment Attenuation; NUT RED = Nutrient Reduction; ST = Short-term; LT = Long-term



**Table 6. (Continued) Alternatives Analysis: Site and Reach-Level Management, Wanzer Brook watershed.**

Project Type	Reach / Segment & Stream Condition	Site Description	Project Description / Objectives	Landowner Approval	Objectives Addressed short-term (ST) long-term (LT)	Cost	Priority	Potential Partners
<b>Active Geomorphic Alternatives</b>								
Restore Boundary Conditions	T3.05-B Unstable - Moderate Departure	<b>Riley Farm</b> downstream of Pumpkin Village Road. Direct pasturing by cows is contributing nutrients and sediments to the channel, and is contributing to active channel widening, aggradation, planform adjustments.	Increase buffer widths along pasture corridors, and exclude cattle from the stream (CREP); reestablish woody buffers along channel margins (CREP & Partners).	unknown	SED ATT; NUTR REDUC (ST) Accelerate return to Equilibrium channel (LT)	Low	High	NRCS (EQIP); VT Ag Ag; USF&W
Restore Boundary Conditions	T3.05-B T3.5S1.01 Unstable - Moderate Departure	<b>Callan Farm</b> upstream of Pumpkin Village Road. Recent installation of a residential driveway and culvert crossing has encroached upon the floodplain and compromised a prior-converted wetland area contiguous to the channel that could serve sediment/nutrient and flow attenuation functions.	Restore wetland functions and habitats; (Partners); relocate the driveway; take measures for beaver management.	likely; other Farm portions enrolled in CREP/EQIP a/o 10/2005	SED ATT; NUTR REDUC Accelerate return to Equilibrium channel (LT)	High	High **	NRCS (EQIP); USF&W; VT Ag Ag
Restore Boundary Conditions; Protect Equilibrium & Ecological Processes	T3.04, T3.05-A, T3.06, T3.3S1.02 Equilibrium - Minor Adjustment	Wetland areas contiguous to channel - property owner determinations not yet made.	Conduct functional assessments of wetland areas. Conserve wetland functions and habitats which serve a nutrient and sediment reduction role for the Wanzer Brook and tributaries.	unknown	SED ATT; NUTR REDUC Preserve geomorphic equilibrium of channel (LT)	Mod	Mod	VTRMS; wetlands specialist; USF&W; VT Ag Ag; VLT; other land trusts.

Note: Double asterisk (\*\*) in Priority column indicates project has already received implementation funding as part of a Category III River Corridor Grant (FY2006) awarded to the Town of Fairfield.

Abbreviations: SED ATT = Sediment Attenuation; NUT RED = Nutrient Reduction; ST = Short-term; LT = Long-term



## 6.2 Watershed-Level Management Strategies

Through Phase 2 assessment work and project development activities under the current Category II grant, several watershed-level management alternatives were identified that should be undertaken to achieve nutrient / sediment reductions, reduce potential for future fluvial erosion hazards, and restore and conserve riparian habitats.

### 6.2.1 Improved Road Maintenance Practices to Mitigate Stormwater / Sediment Impacts

Several stormwater runoff / road maintenance concerns were identified in specific locations upstream of proposed restoration or conservation projects. Each site likely contributes significant volumes of sediment to receiving streams, based on observations during Phase 2 assessments and Category II grant project scoping; neighboring property owners; and town officials. If unaddressed, these sediment sources will continue to impact downstream sites, and potentially influence geomorphic adjustments and the success of restoration/conservation projects.

Road maintenance practices to mitigate for stormwater and sediment runoff to the Wanzer Brook and tributaries may include: stabilization of road surfaces (different gravel materials), improvement of roadside ditches (excavation, stone lining and/or seeding and mulching), alternative grading practices (turnouts, check-basins); re-orientation of culvert crossings; and protection of culvert headers. Project sites include:

<u>Reach</u>	<u>Road</u>
T3.05 and T3.5S1.01	Pumpkin Village Road
T3.3S1.02	Chester A. Arthur Road
T3.3S1.4S1.01	Chester A. Arthur Road
T3.02	Wanzer Road

During site visits for Category II grant project scoping, preliminary designs and cost-estimates for the above project sites were developed by Brian Jerosse, grant manager, Jim Smith, a retired AOT engineer, who consults with northern Vermont towns on road, bridge and transportation projects, Rodney Judd, Town Road Supervisor, and Gavin Ryan, Selectboard member. Jim Smith would provide supervision during future project construction to ensure the integrity of the installed structures and practices. Grants are available from the Better Back Roads program (see Section 8.0). Likely partners would include the Town of Fairfield, the Better Back Roads program, and possibly the Northwest Regional Planning Commission.

### 6.2.2 Crossing Structures

Undersized or improperly sited bridge and culvert crossing structures were identified as contributors to localized channel instabilities in the Wanzer Brook watershed. Many of these concerns will be addressed within the context of site-level or reach-level restoration/conservation projects outlined in Section 6.1. Beyond this, the Town could establish ordinances or identify zoning requirements which would ensure adherence to proper siting and design practices for future development. Potential funding sources to support public planning and development of such ordinances for crossing structures include: Better Back Roads grants, Municipal Planning Grants (VT Department of Housing and Community Affairs), or Vermont Watershed Grants (see Section 8.0).



The geomorphic context should be considered when designing new and rehabilitated structures.

- New or replacement bridges and culverts should ideally have openings which pass the bankfull width to flood-prone-width without constriction. Bankfull widths and flood-prone widths have been measured for the assessed reaches during this Phase 2 assessment and are available to the Town for future crossing structure designs.
- Bridges and culverts should be designed to cross the river without creating channel approaches at an angle to structures. Such sharp angles can lead to undermining of fill materials and structural components.
- The historic channel migration pattern of the river should be considered when installing new or replacement crossing structures, and when constructing new roads, driveways, and buildings. Corridor protection strategies that prevent or limit placement of infrastructure within the corridor will protect structures from future erosion and flood losses.

### **6.2.3 Town Planning**

The present degree of residential / commercial development along the Wanzer Brook and its tributaries is currently low in most of the reaches. This condition presents landowners and the Fairfield community with a strategic opportunity to engage in a proactive planning process that supports the river's ability to seek a post-disturbance equilibrium condition. Planning strategies can ensure that new development does not encroach on the river corridor, reduce the sediment and flow attenuation functions of the floodplain area, and place infrastructure at risk of fluvial erosion losses.

Phase 2 geomorphic data can be used to define a corridor overlay district for town planning purposes. Currently, funding and technical resources are available to the town for such planning processes through the Governor's Clean and Clear Action program. Under the current Category III River Corridor grant funding (FY2006) received by the Town, funds have been earmarked for bringing together a working group to review the possible role of a corridor overlay district in town planning and to develop a viable draft ordinance for public review.



## 7.0 REFERENCES

- Cannon, William F., 1964. *The Pleistocene Geology of the Enosburg Falls Quadrangle, Vermont*. Vermont Geological Survey Open File Report No. 1964-1.
- Connally, G. Gordon, 1970. *Surficial Geology of the Brandon-Ticonderoga 15-Minute Quadrangles, Vermont*. Vermont Geological Survey: Studies in Vermont Geology No. 2.
- Connally, G. Gordon and Parker E. Calkin, 1972, *Woodfordian Glacial History of the Champlain Lowland, Burlington to Brandon, Vermont*. New England Intercollegiate Geological Conference, 64<sup>th</sup> Annual Meeting Guidebook for Field Trips in Vermont, pp. 389-397.
- Cronin, C. M., 1977, *Late-Wisconsin Marine Environments of the Champlain Valley (New York, Quebec)*. Quaternary Research 7: 238-253.
- Dennis, John G., 1964. The Geology of the Enosburg Area, Vermont. Vermont Geological Survey Bulletin No. 23, Vermont Development Department, Montpelier, VT.
- DeWolfe, Matthew N., W. Cully Hession, Mary C. Watzin, 2004. *Sediment and Phosphorus Loads from Streambank Erosion in Vermont, USA*. In Critical Transitions in Water and Environmental Resources Management.
- Doll, Charles G., Ed., 1970. *Surficial Geologic Map of Vermont*. Waterbury, VT: Vermont Geological Survey.
- Flynn, Dennis J. and Robert V. Joslin, 1979. Soil Survey of Frankling County, Vermont. USDA, Natural Resources Conservation Service.
- Lake Champlain Basin Program, 2005, *State of the Lake: Lake Champlain in 2005--A Snapshot for Citizens*. Available at: [http://www.lcbp.org/PDFs/sol\\_web.pdf](http://www.lcbp.org/PDFs/sol_web.pdf)
- Montgomery, D. R. and J. M. Buffington, 1997, Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin, v.109, no. 5, p. 596-611.
- National Agricultural Imagery Program (NAIP), 2003, TIFF ortho images obtained from Vermont Center for Geographic Information.  
<http://www.vcgi.org/dataware/products/metadata/naip2003.htm#Technical%20Doc>
- Northwest Regional Planning Commission, draft 2005, Phase 1 Stream Geomorphic Assessment: Missisquoi Basin.
- Olson, Scott A., 2002, Flow-Frequency Characteristics of Vermont Streams. USGS Water-Resources Investigations Report 02-4238.
- Rosgen, D., 1996, Applied Fluvial Morphology. Wildland Hydrology Books, Pagosa Springs, Co.
- Stewart, David P., 1974, *Geology for Environmental Planning in the Milton – St. Albans Region, Vermont*. Vermont Geological Survey Environmental Geology No. 5. Monpelier, VT: Water Resources Department.
- Stewart, David P. and Paul MacClintock, 1969, *The Surficial Geology and Pleistocene History of Vermont*. Vermont Geological Survey Bulletin No. 31.
- Thompson, Elizabeth H. and Eric R. Sorenson, 2000. Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont. Hanover, NH: University Press of New England.



- VT Agency of Natural Resources, 2005, Stream Geomorphic Assessment Protocol Handbooks, Remote Sensing and Field Surveys Techniques for Conducting Watershed and Reach Level Assessments. Available at [http://www.vtwaterquality.org/rivers/htm/rv\\_geoassesspro.htm](http://www.vtwaterquality.org/rivers/htm/rv_geoassesspro.htm)
- VT Agency of Natural Resources, 2001a, The Streamside Sentinel, published by the Vermont Agency of Natural Resources, Division of Water Quality, Waterbury, VT.
- VT DEC River Management Program, 2005 (26 October draft), *Using geomorphic assessment data to guide the development of River Corridor Management Plans to achieve: Fluvial Erosion Hazard (FEH) Mitigation, Sediment and Nutrient Load Reduction, and Ecological-based River Corridor Conservation.*
- VT DEC Water Quality Division, 2005, Lake Champlain Long-term Monitoring – Tributary Station Summary Statistics available at: [http://www.anr.state.vt.us/dec/waterq/cfm/champlain/tribstats\\_results.cfm](http://www.anr.state.vt.us/dec/waterq/cfm/champlain/tribstats_results.cfm)
- VT DEC Water Quality Division, 2004a, *State of Vermont 2004 303(d) List of Waters. Part A – Impaired Surface Waters in Need of TMDL.*
- VT DEC Water Quality Division, 2004b, *State of Vermont 2004 List of Priority Surface Waters Outside the Scope of Clean Water Act Section 303(d): Part C – Surface Waters in Need of Further Assessment.*
- VT DEC Water Quality Division, 30 July 2003 (v. 1.0), Programmatic Quality Assurance Plan for Stream Geomorphic Assessment Protocols.  
[http://www.vtwaterquality.org/rivers/docs/assessmenthandbooks/rv\\_sgaquappsigned.pdf](http://www.vtwaterquality.org/rivers/docs/assessmenthandbooks/rv_sgaquappsigned.pdf)
- VT DEC Water Quality Division, 2001, *Vermont Regional Hydraulic Geometry Curves: 2001 Provisional.*
- Wagner, W. Philip, 1972, Ice Margins and Water Levels in Northwestern Vermont. New England Intercollegiate Geological Conference, 64<sup>th</sup> Annual Meeting Guidebook for Field Trips in Vermont, pp. 319-342.



## 8.0 GRANTS / RESOURCES (partial listing)

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

### **Vermont Better Back Roads Grants**

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

---

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

### **Vermont Municipal Planning Grants**

Single town: \$15,000  
Consortium (Multiple towns): \$25,000

---

VT Department of Environmental Conservation  
River Corridor Management Section  
103 South Main St./ West Bldg.  
Waterbury, VT 05761-0403

### **Vermont River Corridor Restoration & Protection Grants**

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

Clean and Clear Water Action Plan  
Available FY2006. to Lake Champlain Basin watersheds  
Category I: Project Identification: \$100,000  
Category II: Project Development: \$300,000  
Category III: Project Implementation: \$850,000

### **Vermont Watershed Grants**

[http://www.anr.state.vt.us/dec/waterq/lakes/htm/lp\\_watershedgrants.htm](http://www.anr.state.vt.us/dec/waterq/lakes/htm/lp_watershedgrants.htm)

Mini-grants: \$200 to \$1000  
Grants: \$1,000 and higher

### **Nonpoint Source Management Grants**

EPA - Clean Water Act Section 319  
Rick Hopkins [rick.hopkins@state.vt.us](mailto:rick.hopkins@state.vt.us)  
802-241-3769



## **APPENDIX A**

### **Phase 2 Stream Geomorphic Assessment Results**



## **APPENDIX B**

### **Annotated Reach-based Orthophotos**



## **APPENDIX C**

### **Project CD**

