



## **Sunderland Brook Tributary Report: Phase 2 Stream Geomorphic Assessment Summary**

**November 20, 2007**

### **Introduction:**

Sunderland Brook was identified for geomorphic assessment during 2005 as part of a joint UVM-VTANR research project to assess the impacts of stormwater runoff on geomorphic stability in small watersheds in Chittenden County (Fitzgerald, 2007). As part of this project, 13 stream segments along the mainstem were assessed using the Phase 2 approach of the VTANR Stream Geomorphic Assessment Protocols (SGA). The assessments were carried out by Evan Fitzgerald and the UVM field crew in August 2005. Fitzgerald Environmental Associates, LLC. was retained by the VTANR River Management Program in 2007 to complete Phase 2 assessments on 2 additional tributary reaches. The reaches were identified by VTANR for assessment due to the impacts of urbanization in the watershed, and the need to collect baseline physical data to aid in future monitoring efforts required by the Total Maximum Daily Load permitting approach adopted by the Agency. The reaches are found along the so-called “Sunnyside Trib” of Sunderland Brook, referred to as Tributary 1 (T1) in this summary.

The following is a documentation of the key geomorphic processes and adjustments occurring in Sunderland Brook Tributary 1 at the reach scale. The intent of this documentation is twofold: 1) concisely summarize the tributary settings and geomorphic processes; 2) highlight for those using the data the key steps containing important or extraordinary information. When used in conjunction with the Phase 1 and 2 data in the web-based Data Management System (DMS), and the SGA watershed mapping, this documentation also provides explanation for questions that may arise concerning discrepancies in the data. At the end of each tributary summary is a discussion of potential projects that could protect, sustain, or restore fluvial geomorphic equilibrium conditions, through the implementation of either passive or active stream corridor management strategies. Following the discussion text is Appendix 1, which summarizes QA notes and other relevant information for the Phase 1 and 2 databases. Plots for each channel cross-section measured during the Phase 2 analysis are provided in Appendix 2. Reach summary statistics and site maps are found in Appendices 3 and 4, respectively.

### **Sunderland Brook Tributary 1 (T1):**

Tributary 1 of Sunderland Brook is the only major tributary whose drainage area exceeds 10% of the watershed drainage area. It is located in the vicinity of Route 7 and the urban

area associated with I-89 Exit 16. Tributary 1 meets the mainstem in Sunny Hollow approximately 300 feet west of Route 7 at mainstem Reach M05 (see map in Appendix 4). Moving upstream, Tributary 1 extends south, crossing Route 7 and following the road for ½ mile before making a mild bend to the southeast. The channel then extends through a low-gradient zone with beaver activity before crossing Hercules Drive. Upstream of the first Hercules Drive crossing, the tributary is found in a straightened channel which makes a 90 degree bend to the east before crossing Hercules Drive again and entering the Camp Johnson military base. Segment descriptions and a project identification summary for Tributary 1 are found below.

### **T1.01-A**

#### *Segment Description:*

The downstream end of this segment is located at the confluence with the mainstem west of Route 7. The overall channel slope for the reach is 4.4%, however the lower section of the reach below the Route 7 crossing has an approximate slope of 0.5%. The field assessment indicated a different stream type (from Phase 1) in the lower reach, requiring the division of the reach into two separate segments. Segment A begins at the confluence with the mainstem, and has a channel length of 950 feet. This segment has E-type geometry (Rosgen, 1994) with sand substrate and a dune-ripple bedform (Montgomery and Buffington, 1997). Only limited incision was noted immediately downstream of the Route 7 crossing, while much of the reach had good floodplain connectivity and a sinuous planform (Figure 1). Two stormwater inputs were noted below Route 7, however they did not appear to be resulting in channel adjustments downslope.

This segment has good geomorphic stability (stage I of channel evolution), but also has a very high sensitivity to future adjustments due to the propensity of E-type channels to undergo adjustments. Good pool variability and overall cover was observed throughout the segment resulting in an RHA score of good. The segment ends approximately 200 feet upstream of the Route 7 crossing where a tributary that originates in Camp Johnson enters from the southeast.



Figure 1. Cross section in lower T1.01-A



Figure 2. Cross section in lower T1.01-B

### **T1.01-B**

#### *Segment Description:*

This segment begins 200 feet upstream of the Route 7 crossing and extends to the south along Route 7. At the segment break there is a sharp change in slope, and the channel geometry and bedform changes abruptly. This segment has B-type channel geometry with step-pool bedform. There are two significant grade controls in this segment which are controlling the migrating of adjustments along the channel network. A ledge is located near the lower segment break just upstream of a small flood chute. Upstream of this grade control, two significant flood chutes and a mass failure were noted, indicating that the channel is adjusting laterally in response to aggradation of sediment from an upstream source. Near the reach break with T1.02, an 8 foot waterfall is found that is preventing the downstream adjustments from moving upslope. A mass failure (8 feet high) is found just downstream of the waterfall on the left bank approximately 500 feet upstream of the Route 7 crossing. This failing slope may be the source of some of the sediment that has aggraded in between the grade controls.

The habitat conditions for this segment have been assessed as good overall, despite a low score for aggradation and a small wetted perimeter relative to the channel width. The geomorphic stability has been assessed as fair with a channel evolution stage of IV. The middle section of the reach is redeveloping a minor degree of sinuosity (naturally low in this setting) in response to previous aggradation and widening. The segment ends at the upstream reach break with T1.02 where there is a break in valley slope.

### **T1.02-A**

#### *Segment Description:*

The lower reach break for T1.02 is located 1,700 feet downstream of Champlain Drive. There is a mild change in slope at the reach break, however the overall slope of T1.02 decreases to 0.9%. Nearly all of the elevation loss for this reach (65 feet total) is found in the lower end. The field assessment indicated a different stream type (from Phase 1) in the lower reach, requiring the division of the reach into two separate segments. The channel slope remeasured with GIS is approximately 2.5% in the lower reach. Segment A is found from the reach break up to a sharp break in slope by Champlain Drive. This segment has B-type channel geometry with plane bedform. Numerous grade controls (ledges; Figure 3) throughout the reach are arresting adjustments caused by upslope runoff and sediment inputs. Under reference conditions we would expect a B-type channel with coarse gravel or cobble, however aggradation from two large gullies caused by concentrated stormwater runoff (Figure 4) have increased the fine sediment loading and embeddedness, resulting in the plane bedform. Aggradation and widening have moved into downstream reach T1.01.B, but a large amount of sediment is being stored in this segment.



Figure 3. Ledge grade control in T2.02-A



Figure 4. Gully in lower T2.02-A

The habitat conditions for this segment have been assessed as fair overall, with very low scores noted for embeddedness and velocity-depth patterns. The geomorphic stability has been assessed as fair with a channel evolution stage of IIb. This stage indicates that there is significant aggradation being caused by the supply of fine sediment from the gullies, resulting in widening and lateral adjustments. The segment ends at the upstream segment break with T1.02-B where there is a sharp break in channel slope just east of Champlain Drive.

### **T1.02-B**

#### *Segment Description:*

Segment B is found from a change in slope by Champlain Drive up to the origin of Tributary 1 in Camp Johnson. This segment has E-type channel geometry with gravel-dominated substrate and riffle-pool bedform. Immediately upstream of segment break is a section of low gradient channel with a bedrock substrate - an unusual combination of features. Upstream of this area the channel enters an herbaceous-covered riparian area and becomes very narrow and slow-flowing. The discharge continues to decrease as the channel nears a large beaver dam, which impounds water for approximately 500 feet of the channel. More ponding is found upstream in the Camp Johnson Army Base (property not accessible), and by the Hampton Inn at the crossing of Mountain View Drive. The channel has been mostly straightened in the upper segment where it is surrounded by development in the corridor.

The habitat quality and geomorphic stability assessment for this segment was limited to the areas downstream of beaver ponding at Hercules Drive. The habitat conditions have been assessed as fair overall, with low scores noted for riparian buffers due to vegetation modifications in the middle and upper segment. The geomorphic stability has been assessed as good with a channel evolution stage of I. Only minor aggradation and changes in planform were noted in the areas below Hercules Drive.



Figure 5. Cross section in lower T1.02-B



Figure 6. Beaver pond in upper T1.02-B

### *Preliminary Project Identification:*

Below is a discussion of the problem areas noted during the Phase 2 assessments, and possible approaches to restoration. Due to the limited problem areas noted for T1.01-A (lowermost segment) and T1.02-B (uppermost segment), no preliminary projects are included for these segments.

#### *T1.01-B:*

- Research on small watersheds of Chittenden County has shown that high-gradient reaches in urban watersheds which have limited natural floodplain access tend to undergo vertical adjustments more readily than low-gradient reaches (Fitzgerald, 2007). A similar pattern was noted for the two high gradient segments assessed in Tributary 1. Encroachment on the corridor in this segment and upstream segment T1.02-A may be unlikely due to the steep corridor topography. Nevertheless, due to the likelihood of future adjustments in both segments, protection of the stream corridor from future encroachment is highly recommended. Adequate protection of the stream corridor (6 times the channel width) is recommended to accommodate future stream channel adjustments towards equilibrium.
- The channel adjustments noted for this segment are caused by impacts from upstream stormwater inputs and gullies. A discussion of remediation options for these impacts is found below.

#### *T1.02-A:*

- One large gully has formed below a stormwater outfall (18 inch diameter) originating from Sunderland Woods Drive. This 100 foot long gully is 17 feet wide and 5 feet deep. It has cut through the upper sand substrate, reaching a dense clay layer below. The sediment delivered to the channel from this gully is likely causing the planform changes noted in the downstream segment. The following remediation approaches should be considered for this gully: 1) installation of adequate stormwater controls for runoff from Sunderland Woods development; 2) application of rock weirs (or check dams) and side slope

- armoring in gully to prevent further export of sediment to the channel.
- A second, smaller gully is found below a stormwater ditch carrying Route 7 runoff, located south of Sunny Hollow Quick Stop. This 60 foot long gully is 7 feet wide and 3.5 feet deep. Like the larger downstream gully, it is likely exacerbating the planform changes noted in segment T1.01-B. The source of the runoff should be further investigated to determine if upslope controls along Route 7 are feasible.

### **Literature Cited:**

Fitzgerald, E. P., 2007, Linking urbanization to stream geomorphology and biotic integrity in the Lake Champlain Basin, Vermont [M.S. Thesis]: Burlington, Vermont, University of Vermont, 121 p.

Montgomery, D. R., & Buffington, J. M., 1997, Channel-reach morphology in mountain drainage basins, *Geological Society of America Bulletin*, 109(5), 596-611.

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

## APPENDIX 1

QA Notes For: **Sunderland Brook (Reaches T1.01 & T1.02)**  
Ph2 Assessment by Fitzgerald Environmental Associates, LLC.  
Data checked by Jared Carrano  
October 5, 2007

The questions raised in this Quality Assurance assessment are meant to address potential discrepancies within the data set, uncover data entry errors, or otherwise clarify and confirm those observations that might not have been expected. It is important to take into consideration how data might be viewed or interpreted by the myriad of users who are familiar with the science and protocols but may be unfamiliar with the assessed reaches. While providing notes and comments, try to anticipate the types of questions that may arise due to outliers and exceptions observed within the reach or segment. While attempting to clarify the data for those users wishing to utilize it years after collected, it's better to err on the side of making excessive comments than it is for them to be insufficient.

After reviewing the comments below, please update this document (preferably in a second color) with what steps were (or were not) taken to address the comments/questions.

### General Comments

Length of buffer where width is less than 25' has not been indexed for these reaches.  
**FIT updated and uploaded to DMS (EPF, 10/18/07)**

You have not uploaded your excel cross section worksheets to the DMS.  
**Uploaded to T1.01 location (EPF, 10/18/07)**

### Reach By Reach:

T1.01 B            Step 2.14: Your Width/Depth ratio and Entrenchment ratio would make this a C stream type.  
**The Rosgen system allows for some variance in ratios. ER is slightly outside the B-type range, but all other parameters (esp. slope) support B-type classification (EPF, 10/18/07)**

Step 5: In both your notes and narrative you say that aggradation is prevalent. There are no bars noted or steep riffles noted for this segment. What evidence do you have to support the aggradation you noted?  
**Error in data entry. Mid-channel bars were present and have been entered in DMS (EPF, 10/18/07)**

Step 7: Though you have noted that the degradation was historic; you have an incision ration of 1; making it unclear that any incision has happened. Your channel evolution stage was IV, suggesting a new floodplain has formed at a lower elevation. Does your cross-section data and plot support this? Provide comments in the “notes” to help clarify this discrepancy.

**Cross-section data supports stage IV. Additional narrative provided in step 5 for clarification (EPF, 10/18/07).**

In your comments you noted that widening was prevalent. The width of 12 in the cross-section data is similar to that of the Phase 1 width of 13. There is also no erosion noted in this segment. Is there other evidence to help support the note of prevalent widening?

**Narrative clarified in step 5 to indicate aggradation and planform changes are occurring (EPF, 10/18/07).**

T1.02 A A reach that has departed from a reference bedform of step or riffle-pool to plane bed should not be characterized as having a riffle type of “complete”. You should update the riffle type to either eroded or sedimented, depending on the process that likely lead to the current plane bed system.

**Updated in DMS to sedimented (EPF, 10/18/07).**

T1.02 B In your notes, you commented that there is a section of bedrock substrate. Is this a grade control? None were noted; but from both the notes and narrative sounded like could be.

**This grade control is continuous from the ledge grade control mapped in the downstream segment. It was not considered a grade control for this segment (EPF, 10/18/07).**

#### **Auto QC Comments:**

T1.01 A &  
T1.02 B

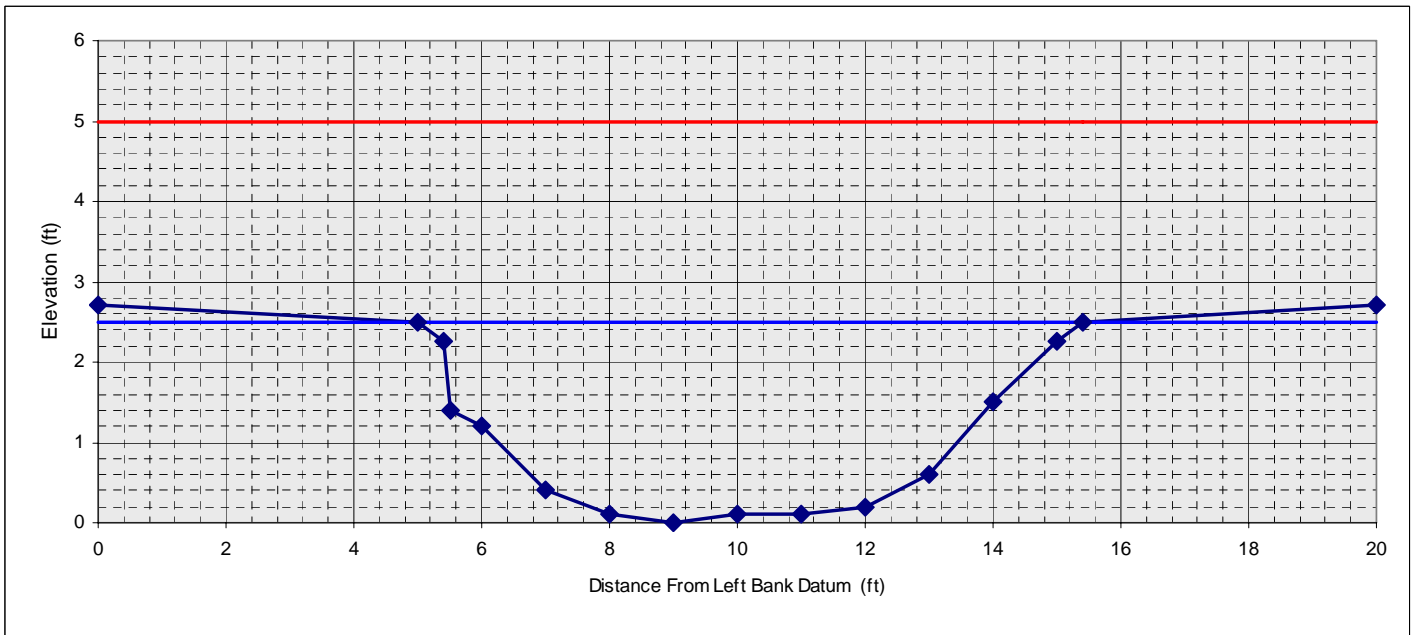
The check in X.1 is asking for an explanation for why you chose “Not Evaluated” for Avg. Largest Particle size. This is because we want people to explain why any feature that could have been evaluated was not. So when NE is selected it requires a comment to pass. If - like in this case - a channel is plane bed, then you can simply select “Not Applicable” and this will eliminate the QC flag. You do not need to select both.

**Updated in DMS (EPF, 10/18/07).**

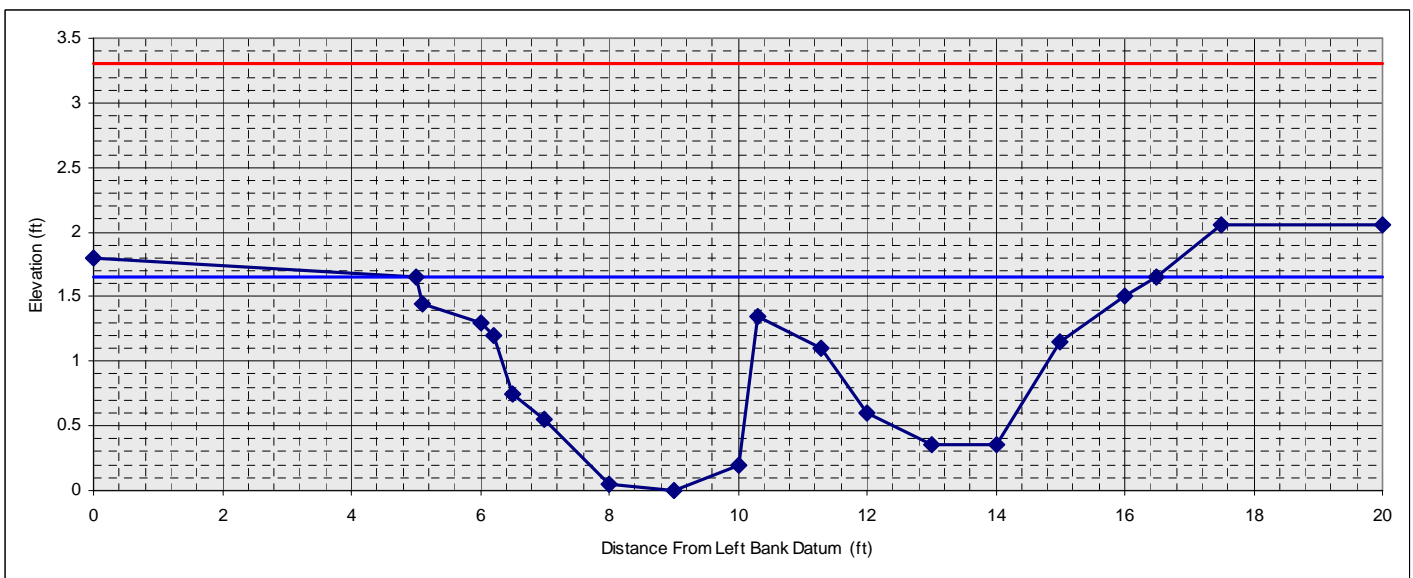
## Appendix 2

Cross-sectional plots for Sunderland Tributary reaches and segments are found below. The horizontal **blue line** represents the bankfull width and depth, and the **red line** represents the field-estimated floodprone depth and width (if visible on plot). Reaches/segments with multiple cross sections are denoted by X1, X2, etc.

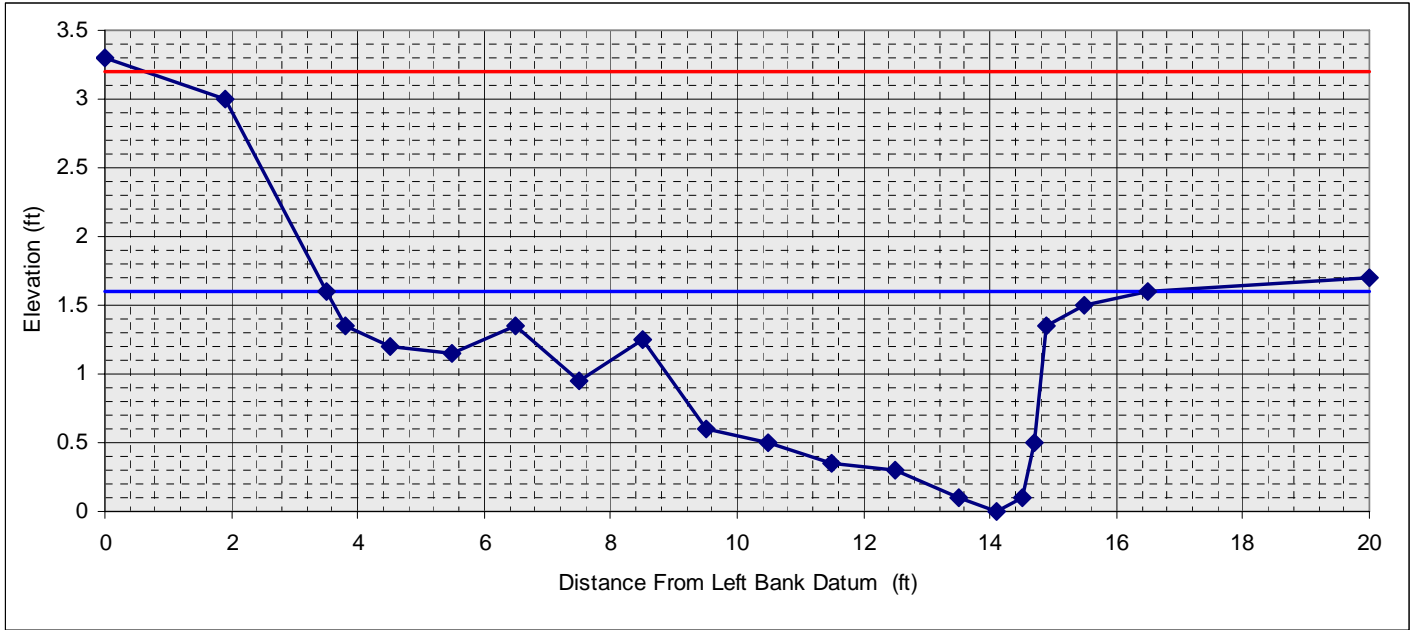
### Segment T1.01-A



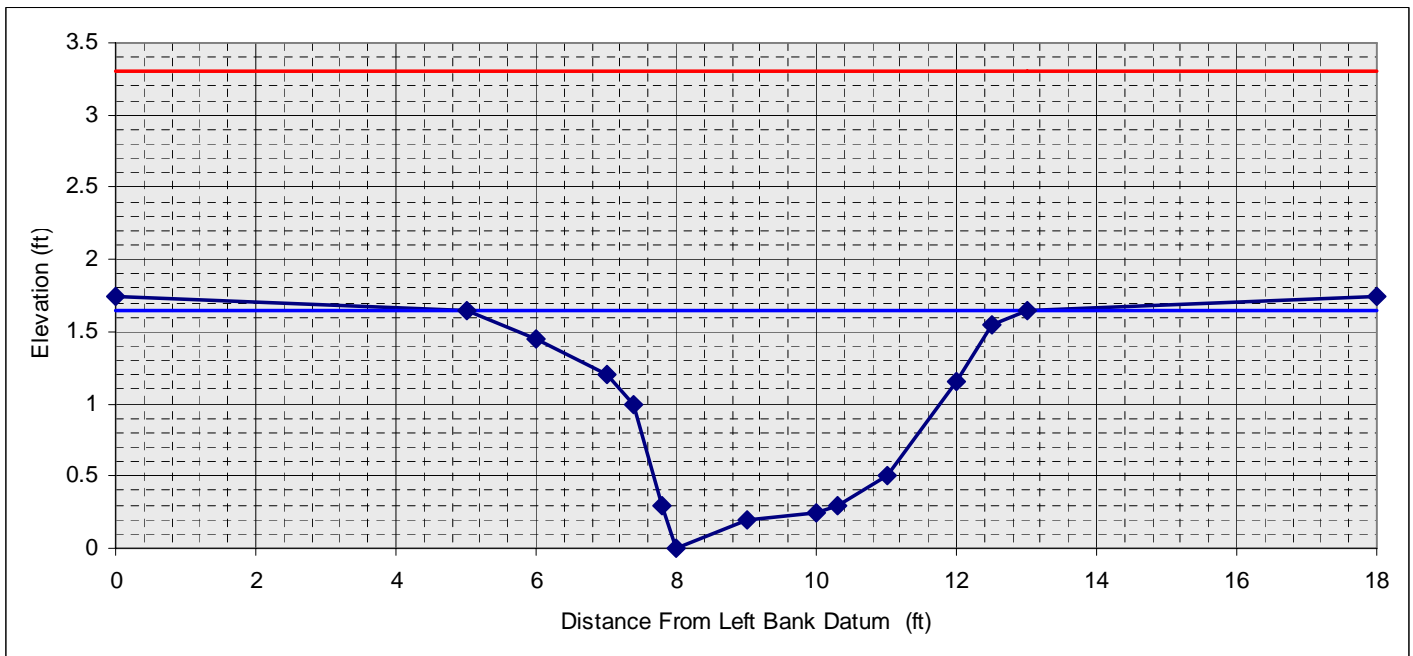
### Segment T1.01-B



### Segment T1.02-A



### Segment T1.02-B



**Appendix 3 - Phase 2 Reach Summary Statistics**

Reach/ Segment	Stream Type	Dominant Bed Material	Bedform	RHA Score	RHA Condition	RGA Score	RGA Condition	Reach Sensitivity	CEM**	CEM** Stage
T1.01-A	E	Sand	Dune-Ripple	0.83	Good	0.74	Good	High	F	I
T1.01-B	B	Cobble	Step-Pool	0.74	Good	0.61	Fair	High	F	IV
T1.02-A	B	Gravel	Plane Bed	0.59	Fair	0.50	Fair	High	D	IIb
T1.02-B	E	Gravel	Riffle-Pool	0.65	Fair	0.65	Good	High	F	I

\*\* CEM = Channel Evolution Model

Mean:	0.70	0.63
Max:	0.83	0.74
Min:	0.59	0.50

Project: **Sunderland Brook**  
 Stream: **Sunderland South Tributary 1**  
 Organization: **UVM-ENSC-285**  
 Segment Length (ft): **950**

**Phase 2 Segment Summary** page 1 of 2  
 Reach # **T1.01** Segment: **A**  
 Observers: **EPF, SPP** Why Not assessed:  
 Segment Location: **Sunnyhollow above and below Route 7 crossing.**

November 20, 2007 SGAT Version: 4.56  
 Completion Date: **July 2, 2007**  
 Rain: **No**

**QC Status - Staff: Provisional Consultant: Passed**

Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms height	0	0
Roads height	0	0
Railroads height	0	0
Improved Paths height	0	0
Development	0	0

1.4 Adjacent Side **Left** **Right**

Hillside Slope **Very Steep** **Very Steep**

Continuous w/ **Never** **Never**

W/in 1 Bankfill **Sometimes** **Sometimes**

Texture **Not Evalua** **Not Evalua**

1.5 Valley Features

Valley Width (ft) **200**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **no**

Step 2. Stream Channel

2.1 Bankfull Width **10**

2.2 Max Depth (ft) **2.50**

2.3 Mean Depth (ft) **1.56**

2.4 Floodprone Width (ft) **90**

Notes:  
 Below Route 7 crossing the channel is close to reference conditions for a slow winder E-type. Some scour below culvert and changes in planform indicate that the culvert is undersized. slope changes significantly at

Step 2. (Contued)

2.5 Aband. Floodpln **2.50** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **6.67**

2.7 Entrenchment Ratio **8.65**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Not Applicable**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0%
Boulder	0%
Cobble	0%
Coarse Gravel	5%
Fine Gravel	8%
Sand	87%
Silt and smaller	0%

Silt/Clay Present? **Yes**

Detritus **15 %**

# Large Woody **64**

2.13 Average Largest Particle on

Bed **N/A**

Bar **N/A**

2.14 Stream Type

Stream Type: **E**

Bed Material: **Sand**

Subclass Slope: **None**

Bed Form: **Dune-Ripple**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

**E 5 Non Dune-Ripple**

3.3 old	Amount	Mean Height
Failures	<b>None</b>	<b>0.00</b>
Gullies	<b>None</b>	<b>0.00</b>

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Undercut**

Bank Texture **Left** **Right**

Upper

Material Type **Sand** **Sand**

Consistency **Non-cohesive** **Non-cohesive**

Lower

Material Type **Silt** **Silt**

Consistency **Non-cohesive** **Non-cohesive**

Bank Erosion **Left** **Right**

Erosion Length (ft) **30** **18**

Erosion Height (ft) **3.00** **3.00**

Revetmt. Type **Rip-Rap** **None**

Revetmt. Length (ft) **32** **0**

Near Bank Veg. Type **Left** **Right**

Dominant **Herbaceous** **Herbaceous**

Sub-dominant **Shrubs/Saplin** **Shrubs/Saplin**

Bank Canopy **Left** **Right**

Canopy % **51-75** **51-75**

Mid-Channel Canopy **Closed**

3.2 Riparian Buffer

Buffer Width **Left** **Right**

Dominant **51-100** **>100**

Sub-dominant **26-50** **26-50**

W less than 25 **0** **0**

Buffer Veg. Type **Left** **Right**

Dominant **Shrubs/Saplin** **Shrubs/Saplin**

Sub-dominant **Mixed Trees** **Mixed Trees**

3.3 Riparian Corridor

Corridor Land **Left** **Right**

Dominant **Shrubs/Saplin** **Shrubs/Saplin**

Sub-dominant **Commercial** **Commercial**

Mass Failures **11** **0**

Height **6** **0**

Gullies **0** **0**

Height **0** **0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Low**

4.4 # of Debris Jams **5**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch	<b>0</b>	Road Ditch	<b>1</b>
Other	<b>0</b>	Tile Drain	<b>0</b>
Overland Flow	<b>0</b>	Urb Strm Wtr Pipe	<b>1</b>

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
<b>2</b>	<b>6</b>	<b>0</b>
Diagonal	Delta	Island
<b>0</b>	<b>0</b>	<b>0</b>

5.2 Other Features **Braiding**

Flood	Neck Cutoff	Avulsion
<b>1</b>	<b>0</b>	<b>0</b>

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
<b>0</b>	<b>0</b>	<b>No</b>

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **120**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Sunderland Brook**  
 Stream: **Sunderland South Tributary 1**  
 Organization: **UVM-ENSC-285**  
 Segment Length (ft): **950**

Phase 2 Segment Summary  
 Reach # **T1.01**  
 Observers: **EPF, SPP**  
 Segment: **A**  
 Segment Location: **Sunnyhollow above and below Route 7 crossing.**

page 2 of 2  
 Completion Date: **July 2, 2007**  
 Rain: **No**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
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Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	<b>14</b>	<b>None</b>	<b>No</b>
7.2 Channel Aggradation	<b>15</b>	<b>None</b>	<b>No</b>
7.3 Widening Channel	<b>16</b>		<b>No</b>
7.4 Change in Planform	<b>14</b>		<b>No</b>

Total Score **59**

Geomorphic Rating **0.7375**

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Culvert	4.00	Yes	No	Yes	Yes

Problem Scour Below, Alignment

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	16
6.2 Pool Substrate	16
6.3 Pool Variability	15
6.4 Sediment Deposition	17
6.5 Channel Flow Status	17
6.6 Channel Alteration	16
6.7 Channel Sinuosity	13
6.8 Bank Stability	Left: 8 Right: 8
6.9 Bank Vegetation Protection	Left: 10 Right: 10
6.10 Riparian Vegetation Zone Width	Left: 10 Right: 10

Total Score 166

Habitat Rating 0.83

Habitat Stream Condition **Good**

Narrative:

Minor changes in planform by road crossing and minor incision.

Project: **Sunderland Brook**  
 Stream: **Sunderland South Tributary 1**  
 Organization: **UVM-ENSC-285**  
 Segment Length (ft): **950**

**Phase 2 Segment Summary** page 1 of 2  
 Reach # **T1.01** Segment: **B**  
 Observers: **EPF, SPP** Why Not assessed:  
 Segment Location: **Along Sunny Hollow above the Rt. 7 crossing.**

November 20, 2007 SGAT Version: 4.56  
 Completion Date: **July 2, 2007**  
 Rain: **No**

**QC Status - Staff: Provisional Consultant: Passed**

Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	672	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side Left Right

Hillside Slope **Very Steep** **Very Steep**

Continuous w/ **Sometimes** **Sometimes**

W/in 1 Bankfill **Always** **Always**

Texture **Mixed** **Mixed**

1.5 Valley Features

Valley Width (ft) **40**

Width Determination **Measured**

Confinement Type **Semi-confined**

Rock Gorge? **No**

Human-caused Change? **no**

Notes:  
 Short segment with two grade controls which are keeping adjustments from moving up and downslope. In between grade controls aggradation and changes in planform are prevalent.

Step 2. (Contued)

2.5 Aband. Floodpln	<b>1.65</b>	ft.
Human Elev Floodpln	<b>0.00</b>	ft.
2.6 Width/Depth Ratio	<b>14.37</b>	
2.7 Entrenchment Ratio	<b>2.91</b>	
2.8 Incision Ratio	<b>1.00</b>	
Human Elevated Inc Rat	<b>0.00</b>	
2.9 Sinuosity	<b>Low</b>	
2.10 Riffles Type	<b>Complete</b>	
2.11 Riffle/Step Spacing (ft)	<b>50</b>	
2.12 Substrate Composition		
Bedrock	<b>27%</b>	
Boulder	<b>4%</b>	
Cobble	<b>29%</b>	
Coarse Gravel	<b>16%</b>	
Fine Gravel	<b>15%</b>	
Sand	<b>9%</b>	
Silt and smaller	<b>0%</b>	
Silt/Clay Present?	<b>Yes</b>	
Detritus	<b>5 %</b>	
# Large Woody	<b>16</b>	
2.13 Average Largest Particle on		
Bed	<b>8.0</b>	<b>inches</b>
Bar	<b>2.5</b>	<b>inches</b>
2.14 Stream Type		
Stream Type:	<b>B</b>	
Bed Material:	<b>Cobble</b>	
Subclass Slope:	<b>a</b>	
Bed Form:	<b>Step-Pool</b>	
Field Measured Slope:		
2.15 Reference Stream Type		
(if different from Phase 1)		
3.3 old	Amount	Mean Height
Failures	<b>None</b>	<b>0.00</b>
Gullies	<b>None</b>	<b>0.00</b>

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Moderate**

Bank Texture Left Right

Upper

Material Type **Sand** **Sand**

Consistency **Non-cohesive** **Non-cohesive**

Lower

Material Type **Boulder/Cobbl** **Boulder/Cobbl**

Consistency **Non-cohesive** **Non-cohesive**

Bank Erosion Left Right

Erosion Length (ft) **0** **0**

Erosion Height (ft) **0.00** **0.00**

Revetmt. Type **Rip-Rap** **None**

Revetmt. Length (ft) **19** **0**

Near Bank Veg. Type Left Right

Dominant **Deciduous** **Deciduous**

Sub-dominant **Coniferous** **Coniferous**

Bank Canopy Left Right

Canopy % **76-100** **76-100**

Mid-Channel Canopy **Closed**

3.2 Riparian Buffer

Buffer Width Left Right

Dominant **26-50** **>100**

Sub-dominant **0-25** **None**

W less than 25 **71** **0**

Buffer Veg. Type Left Right

Dominant **Mixed Trees** **Mixed Trees**

Sub-dominant **Herbaceous** **Coniferous**

3.3 Riparian Corridor

Corridor Land Left Right

Dominant **Forest** **Forest**

Sub-dominant **Commercial** **None**

Mass Failures **10** **0**

Height **8** **0**

Gullies **0** **0**

Height **0** **0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **None**

4.2 Adjacent Wetlands **None**

4.3 Flow Status **Low**

4.4 # of Debris Jams **1**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch **0** Road Ditch **0**

Other **0** Tile Drain **0**

Overland Flow **0** Urb Strm Wtr Pipe **1**

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
<b>2</b>	<b>0</b>	<b>0</b>
Diagonal	Delta	Island
<b>0</b>	<b>0</b>	<b>0</b>

5.2 Other Features Braiding

Flood	Neck Cutoff	Avulsion	
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
<b>0</b>	<b>0</b>	<b>No</b>

5.4 Stream Ford or Animal **No**

5.5 Straightening **None**

Straightening Length: **0**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Sunderland Brook**  
 Stream: **Sunderland South Tributary 1**  
 Organization: **UVM-ENSC-285**  
 Segment Length (ft): **950**

Phase 2 Segment Summary  
 Reach # **T1.01**  
 Observers: **EPF, SPP**  
 Segment: **B**  
 Segment Location: **Along Sunny Hollow above the Rt. 7 crossing.**

page 2 of 2  
 Completion Date: **July 2, 2007**  
 Rain: **No**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Ledge	Mid-segment	4.00	4.00	Yes	
Waterfall	Mid-segment	8.00	7.00	Yes	

4.8 Channel Constrictions **None**

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**

	Score	STD	Historic
7.1 Channel Degradation	<b>13</b>	<b>None</b>	<b>Yes</b>
7.2 Channel Aggradation	<b>11</b>	<b>None</b>	<b>No</b>
7.3 Widening Channel	<b>13</b>		<b>No</b>
7.4 Change in Planform	<b>12</b>		<b>No</b>

Total Score **49**

Geomorphic Rating **0.6125**

Channel Evolution Model **F**

Channel Evolution Stage **IV**

Geomorphic Condition **Fair**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	13
6.2 Embeddedness	16
6.3 Velocity/Depth Patterns	14
6.4 Sediment Deposition	12
6.5 Channel Flow Status	9
6.6 Channel Alteration	14
6.7 Frequency of Riffles/Steps	17
6.8 Bank Stability	Left: 8 Right: 8
6.9 Bank Vegetation Protection	Left: 9 Right: 9
6.10 Riparian Vegetation Zone Width	Left: 8 Right: 10
Total Score	147
Habitat Rating	0.735
Habitat Stream Condition	<b>Good</b>

Narrative:

Aggradation is high in between the two grade controls. See section 5 for further narrative.

Project: **Sunderland Brook**  
 Stream: **Sunderland South Tributary 1**  
 Organization: **UVM-ENSC-285**  
 Segment Length (ft): **1,700**

**Phase 2 Segment Summary** page 1 of 2  
 Reach # **T1.02** Segment: **A**  
 Observers: **EPF, SPP** Why Not assessed:  
 Segment Location: **Alongside Rt 7 coming out of Sunny Hollow. Segment upstream ending point east of**

November 20, 2007 SGAT Version: 4.56  
 Completion Date: **July 2, 2007**  
 Rain: **No**

**QC Status - Staff: Provisional Consultant: Passed**

Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms height	0	0
Roads height	619	0
Railroads height	0	0
Improved Paths height	0	0
Development	0	0

1.4 Adjacent Side **Left** **Right**

Hillside Slope **Very Steep** **Very Steep**

Continuous w/ **Sometimes** **Sometimes**

W/in 1 Bankfill **Sometimes** **Sometimes**

Texture **Mixed** **Mixed**

1.5 Valley Features

Valley Width (ft) **50**

Width Determination **Measured**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **no**

Step 2. Stream Channel

2.1 Bankfull Width **13**

2.2 Max Depth (ft) **1.65**

2.3 Mean Depth (ft) **0.77**

2.4 Floodprone Width (ft) **25**

Notes:  
 Many grade controls throughout the reach that are arresting adjustments caused by upslope runoff and sediment inputs. Reference conditions would be a B-type channel with coarse gravel or cobble

Step 2. (Contued)

2.5 Aband. Floodpln **1.65** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **16.88**

2.7 Entrenchment Ratio **1.88**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Sedimented**

2.11 Riffle/Step Spacing (ft) **60**

2.12 Substrate Composition

Bedrock	0%
Boulder	0%
Cobble	25%
Coarse Gravel	23%
Fine Gravel	20%
Sand	33%
Silt and smaller	0%

Silt/Clay Present? **Yes**

Detritus **10** %

# Large Woody **66**

2.13 Average Largest Particle on

Bed	<b>7.0</b>	<b>inches</b>
Bar	<b>1.5</b>	<b>inches</b>

2.14 Stream Type

Stream Type: **B**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

**B 4 Non Riffle-Pool**

3.3 old	Amount	Mean Height
Failures	<b>None</b>	<b>0.00</b>
Gullies	<b>None</b>	<b>0.00</b>

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Undercut**

Bank Texture **Left** **Right**

Upper

Material Type **Mix** **Mix**

Consistency **Non-cohesive** **Non-cohesive**

Lower

Material Type **Boulder/Cobbl** **Boulder/Cobbl**

Consistency **Cohesive** **Cohesive**

Bank Erosion **Left** **Right**

Erosion Length (ft) **40** **65**

Erosion Height (ft) **3.00** **2.00**

Revetmt. Type **None** **None**

Revetmt. Length (ft) **0** **0**

Near Bank Veg. Type **Left** **Right**

Dominant **Deciduous** **Deciduous**

Sub-dominant **Shrubs/Saplin** **Shrubs/Saplin**

Bank Canopy **Left** **Right**

Canopy % **76-100** **76-100**

Mid-Channel Canopy **Closed**

3.2 Riparian Buffer

Buffer Width **Left** **Right**

Dominant **51-100** **>100**

Sub-dominant **26-50** **None**

W less than 25 **0** **0**

Buffer Veg. Type **Left** **Right**

Dominant **Mixed Trees** **Mixed Trees**

Sub-dominant **Shrubs/Saplin** **Shrubs/Saplin**

3.3 Riparian Corridor

Corridor Land **Left** **Right**

Dominant **Forest** **Forest**

Sub-dominant **Commercial** **None**

Mass Failures **48** **0**

Height **9** **0**

Gullies **0** **0**

Height **0** **0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Minimal**

4.3 Flow Status **Low**

4.4 # of Debris Jams **5**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch	<b>0</b>	Road Ditch	<b>1</b>
Other	<b>0</b>	Tile Drain	<b>0</b>
Overland Flow	<b>0</b>	Urb Strm Wtr Pipe	<b>1</b>

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
<b>2</b>	<b>5</b>	<b>4</b>

Diagonal	Delta	Island
<b>0</b>	<b>0</b>	<b>0</b>

5.2 Other Features **Braiding**

Flood	Neck Cutoff	Avulsion
<b>0</b>	<b>0</b>	<b>0</b>

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
<b>1</b>	<b>0</b>	<b>No</b>

5.4 Stream Ford or Animal **No**

5.5 Straightening **None**

Straightening Length: **0**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Sunderland Brook**  
 Stream: **Sunderland South Tributary 1**  
 Organization: **UVM-ENSC-285**  
 Segment Length (ft): **1,700**

Phase 2 Segment Summary  
 Reach # **T1.02**  
 Observers: **EPF, SPP**

page 2 of 2  
 Segment: **A**

November 20, 2007  
 Completion Date: **July 2, 2007**  
 Rain: **No**

Segment Location: **Alongside Rt 7 coming out of Sunny Hollow. Segment upstream ending point east of**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Ledge	Mid-segment	3.00	2.00	No	
Ledge	Mid-segment	4.00	3.00	No	
Ledge	Mid-segment	3.00	2.00	No	
Ledge	Mid-segment	7.00	7.00	Yes	
Ledge	Mid-segment	2.00	2.00	Yes	
Ledge	Mid-segment	9.00	8.00	No	

4.8 Channel Constrictions **None**

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
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Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**

	Score	STD	Historic
7.1 Channel Degradation	<b>12</b>	<b>None</b>	<b>Yes</b>
7.2 Channel Aggradation	<b>8</b>	<b>None</b>	<b>No</b>
7.3 Widening Channel	<b>10</b>		
7.4 Change in Planform	<b>10</b>		<b>No</b>
Total Score		<b>40</b>	
Geomorphic Rating		<b>0.5</b>	
Channel Evolution Model		<b>D</b>	
Channel Evolution Stage		<b>IIb</b>	
Geomorphic Condition		<b>Fair</b>	
Stream Sensitivity		<b>High</b>	

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score	
6.1 Epifaunal Substrate - Available Cover	16	
6.2 Embeddedness	3	
6.3 Velocity/Depth Patterns	8	
6.4 Sediment Deposition	6	
6.5 Channel Flow Status	9	
6.6 Channel Alteration	15	
6.7 Frequency of Riffles/Steps	15	
6.8 Bank Stability	Left: 6 Right: 6	
6.9 Bank Vegetation Protection	Left: 9 Right: 9	
6.10 Riparian Vegetation Zone Width	Left: 6 Right: 9	
Total Score		117
Habitat Rating		0.585
Habitat Stream Condition		<b>Fair</b>

Narrative:

Aggradation and widening due to sediment loading from gullies. See section 5 for additional narrative.

Project: **Sunderland Brook**  
 Stream: **Sunderland South Tributary 1**  
 Organization: **UVM-ENSC-285**  
 Segment Length (ft): **5,488**

**Phase 2 Segment Summary** page 1 of 2  
 Reach # **T1.02** Segment: **B**  
 Observers: **EPF, SPP** Why Not assessed:  
 Segment Location: **From just east of Champlain Drive up to the fence at Camp Johnson at the stream crossing**

November 20, 2007 SGAT Version: 4.56  
 Completion Date: **July 2, 2007**  
 Rain: **No**

**QC Status - Staff: Provisional Consultant: Passed**

Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms height	0	0
Roads height	0	0
Railroads height	0	0
Improved Paths height	0	0
Development	0	1,514

1.4 Adjacent Side Left Right

Hillside Slope **Hilly** **Hilly**

Continuous w/ W/in 1 Bankfill **Never** **Never**

Texture **Not Evalua** **Not Evalua**

1.5 Valley Features

Valley Width (ft) **670**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **no**

Step 2. Stream Channel

2.1 Bankfull Width **8**

2.2 Max Depth (ft) **1.65**

2.3 Mean Depth (ft) **0.85**

2.4 Floodprone Width (ft) **90**

Notes:  
 Immediately upstream of segment break is a section of low gradient channel with a bedrock substrate. The channel moves upstream into an herbaceously covered and becomes very narrow and slow flowing. The

Step 2. (Contued)

2.5 Aband. Floodpln **1.65** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **9.41**

2.7 Entrenchment Ratio **11.25**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Not Applicable**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0%
Boulder	0%
Cobble	1%
Coarse Gravel	13%
Fine Gravel	50%
Sand	36%
Silt and smaller	0%

Silt/Clay Present? **Yes**

Detritus **29** %

# Large Woody **7**

2.13 Average Largest Particle on

Bed **N/A**

Bar **N/A**

2.14 Stream Type

Stream Type: **E**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	<b>None</b>	<b>0.00</b>
Gullies	<b>None</b>	<b>0.00</b>

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture Left Right

Upper

Material Type **Silt** **Silt**

Consistency **Non-cohesive** **Non-cohesive**

Lower

Material Type **Mix** **Mix**

Consistency **Cohesive** **Cohesive**

Bank Erosion Left Right

Erosion Length (ft) **0** **0**

Erosion Height (ft) **0.00** **0.00**

Revetmt. Type **None** **None**

Revetmt. Length (ft) **0** **0**

Near Bank Veg. Type Left Right

Dominant **Herbaceous** **Herbaceous**

Sub-dominant **Shrubs/Saplin** **Shrubs/Saplin**

Bank Canopy Left Right

Canopy % **1-25** **1-25**

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width Left Right

Dominant **51-100** **51-100**

Sub-dominant **>100** **0-25**

W less than 25 **0** **551**

Buffer Veg. Type Left Right

Dominant **Herbaceous** **Herbaceous**

Sub-dominant **Shrubs/Saplin** **Shrubs/Saplin**

3.3 Riparian Corridor

Corridor Land Left Right

Dominant **Shrubs/Saplin** **Shrubs/Saplin**

Sub-dominant **Commercial** **Commercial**

Mass Failures **0** **0**

Height **0** **0**

Gullies **0** **0**

Height **0** **0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Minimal**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Low**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch	<b>0</b>	Road Ditch	<b>2</b>
Other	<b>0</b>	Tile Drain	<b>0</b>
Overland Flow	<b>0</b>	Urb Strm Wtr Pipe	<b>1</b>

4.9 # of Beaver Dams **1**

Affected Length (ft) **500**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
<b>0</b>	<b>5</b>	<b>0</b>
Diagonal	Delta	Island
<b>0</b>	<b>0</b>	<b>0</b>

5.2 Other Features Braiding

Flood	Neck Cutoff	Avulsion
<b>0</b>	<b>0</b>	<b>0</b>

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
<b>0</b>	<b>0</b>	<b>No</b>

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,464**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **Sunderland Brook** Phase 2 Segment Summary page 2 of 2 November 20, 2007  
 Stream: **Sunderland South Tributary 1** Reach # **T1.02** Segment: **B** Completion Date: **July 2, 2007**  
 Organization: **UVM-ENSC-285** Observers: **EPF, SPP** Rain: **No**  
 Segment Length (ft): **5,488** Segment Location: **From just east of Champlain Drive up to the fence at Camp Johnson at the stream crossing**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
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Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	<b>11</b>	<b>None</b>	<b>No</b>
7.2 Channel Aggradation	<b>13</b>	<b>None</b>	<b>No</b>
7.3 Widening Channel	<b>15</b>		<b>No</b>
7.4 Change in Planform	<b>13</b>		<b>No</b>

Total Score **52**

Geomorphic Rating **0.65**

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Culvert	3.00	Yes	No	Yes	Yes
	Problem	Scour	Above		
Culvert	1.50	Yes	No	Yes	Yes
	Problem	None			

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	12
6.2 Pool Substrate	14
6.3 Pool Variability	11
6.4 Sediment Deposition	12
6.5 Channel Flow Status	12
6.6 Channel Alteration	11
6.7 Channel Sinuosity	11
6.8 Bank Stability	Left: 8 Right: 8
6.9 Bank Vegetation Protection	Left: 6 Right: 6
6.10 Riparian Vegetation Zone Width	Left: 9 Right: 9

Total Score 129

Habitat Rating 0.645

Habitat Stream Condition **Fair**





Narrative:

In lower portion of segment bedrock substrate prevents adjustment processes. Above only minor degradation and change in planform occurring before ponding of the beaver dam.

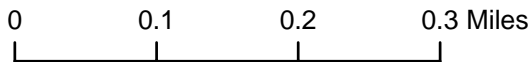
## **Appendix 4**

### **Watershed and Reach Maps**



-  Sunderland Bk Subwatersheds
-  Cross Section Locations
-  Segment Breaks
-  Sunderland Bk Surface Waters

### Sunderland Bk Tributary Map



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