Little Bugaboo Creek Stream Restoration
2008 Final Monitoring Report
Monitoring Year Four

Ecosystem Enhancement Program Project Number 00056

Submitted to:

NCDENR-Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, NC 27699-1652

Project Designed by:

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Submitted: February 17, 2009

Ecosystem Enhancement PROGRAM

Little Bugaboo Creek Stream Restoration
2008 Final Monitoring Report
Monitoring Year Four

Ecosystem Enhancement Program Project Number 00056

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February 17, 2009

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1.0 EXECUTIVE SUMMARY/PROJECT ABSTRACT

URS Corporation (URS) was retained by the North Carolina Ecosystem Enhancement Program (EEP) to conduct stream monitoring at the Little Bugaboo Creek stream restoration project, located in Wilkes County, North Carolina. The stream monitoring effort conducted by URS in December of 2008 represents Monitoring Year (MY) Four for this project. Prior to the monitoring effort, URS received a digital As-Built drawing for the project site from EEP. In addition, URS received an As-Built/Monitoring Year One Report prepared by EarthTech (EarthTech 2005), and a Year One Monitoring Report prepared by EcoLogic Associates, P.C (EcoLogic 2006).

EEP, formerly the Wetlands Restoration Program (WRP), identified Little Bugaboo Creek and an Unnamed Tributary to Little Bugaboo Creek as potential stream restoration sites in 2002. The existing channels were actively eroding due to unlimited cattle access and lack of streamside vegetation. The design used a Priority Level II restoration approach. Little Bugaboo Creek and the Unnamed Tributary were designed as type C channels. A total of 6,230 linear feet of stream channel was restored.

Prior to restoration, the pastures adjacent to the channel consisted of fescue with sparse trees along drainages. The banks along much of the reach were vertical and supported little to no vegetation. The main channel was classified as types Bc, C, E, and F because the channel was downcutting and was eroding its banks to establish a floodplain at a lower elevation.

The Priority II restoration involved increasing the existing length and providing a floodplain. Cross vanes and rootwads were incorporated for aquatic habitat enhancement and bed and bank stability. A 50-foot riparian buffer was planted on both sides of the restored stream channel.

The Little Bugaboo Creek restoration site is in overall poor condition. The site continues to have areas of severe bank erosion, bare banks, accelerated channel widening, and associated aggradation. While the majority of the rock structures are functioning properly and providing crucial grade control, several of them are failing. These problems may be due to any number of reasons, and are likely due to a combination of several factors. In some areas, the failure of the vegetation has likely contributed to the excessive bank erosion. Overall, the bed features are in good condition with many riffles and pools. During 2008 (MY4) monitoring a large sediment plume was observed at the top of the project on Little Bugaboo Creek. It extends approximately 100 feet into the project reach. The plume can be seen on the 2008 longitudinal profile provided in Appendix B-VIII.

URS conducted 2006 (MY2) and 2007 (MY3) monitoring for the site. During both years the most serious problem with the site was the presence of beavers. Not only were the beavers destroying the streamside planted vegetation, they were also changing the nature of the channel. It appeared as if the site supported a fairly large beaver population. The number and size of the beaver dams increased dramatically between 2006 and 2007.

During 2008 (MY4) monitoring only one small beaver dam was observed. The dam is on the mainstem and appears to be inactive. It is not creating a large amount of backwater. No new stem chew was observed along either channel. It appears as if the beavers have abandoned the site since 2007 (MY3) monitoring.

The 2006 (MY3) monitoring data showed a narrowing trend when compared with the cross section data from the 2005 (MY1) Monitoring Report (EarthTech, June 2005). The cross section data for 2007 (MY3) are very similar to the 2006 (MY2) data. In general the cross sectional area, bankfull width, and width to depth ratios decreased in 2006 and have slightly increased in 2007 (MY3); however, both sets of data remain below 2005 (MY1) data. 2008 (MY4) width-to-depth ratios are remaining below 12 and

entrenchment ratios are remaining above 2.2. Due to the lack of bankfull indicators in a relatively new system, bankfull was typically placed near the top of bank for monitoring analysis.

Vegetation survival at the site is poor. According to the 2005 (MY1) Monitoring Report, five of the vegetation plots were significantly disturbed due to repair activities along Little Bugaboo Creek. The plots disturbed by channel repairs were replanted, but plantings appear to be concentrated close to the channel, leaving much of the upper floodplain/upland void of woody vegetation. The 2005 (MY1) Monitoring Report (EcoLogic 2006) found insufficient stems to fulfill US Army Corps of Engineers (USACE) requirements. The 2006 (MY2) Monitoring Report (URS 2007), the 2007 (MY3) Monitoring Report (URS 2008), and the 2008 (MY4) monitoring effort found half of the vegetation plots had insufficient stems to fulfill USACE requirements. In addition, it appears that cows from the adjacent pastures are entering the conservation easement near the crossing at the top of the project reach. The buffer area on both banks has been grazed and a cow was observed within the easement on December 16, 2008.

Herbaceous grasses and herbs dominated much of the buffer area during the 2008 (MY4) monitoring event. Common species include wiregrass (*Aristida* spp.), dogfennel (*Eupatorium capillifolium*), goldenrod (*Solidago* spp.), and bluestem (*Andropogon* spp.). In addition, fescue (*Festuca* sp.) is widespread along the fencelines to the adjoining pastures. Taxonomy follows 'Flora of the Carolinas, Virginia, Georgia, and surrounding areas' (Weakley 2007). URS recommends testing site soils, fertilizing where necessary based on soil tests, and replanting stems in areas unlikely to meet survivability requirements for mitigation credit.

2.0 PROJECT BACKGROUND

2.1 PROJECT OBJECTIVES

The main objective of the restoration project was to construct a stable meander geometry, modify the channel cross sections, and establish a floodplain at the existing stream elevation, thus restoring a stable dimension, pattern, and profile. Specific project objectives included the following:

1. Restore 4,276 linear feet of Little Bugaboo Creek and 1,954 linear feet of an Unnamed Tributary to Little Bugaboo Creek;
2. Provide a stable stream channel that neither aggrades nor degrades while maintaining its dimension, pattern, and profile with the capacity to transport its watershed's water and sediment load;
3. Improve water quality and reduce further property loss by stabilizing eroding stream banks;
4. Reconnect the stream to its floodplain or establish a new floodplain at a lower elevation;
5. Improve aquatic habitat with the use of natural material stabilization structures such as root wads, rock vanes, woody debris and a riparian buffer, and
6. Provide aesthetic value, wildlife habitat and a bank stability through the creation or enhancement of a riparian zone.

2.2 PROJECT STRUCTURE, MITIGATION TYPE, AND APPROACH

Prior to restoration, the pastures adjacent to the channel consisted of fescue with sparse trees along drainages. The banks along much of the reach were vertical and supported little to no vegetation. The main channel was classified as stream types Bc, C, E, and F stream because the channel was downcutting and was eroding its banks to establish a floodplain at a lower elevation.

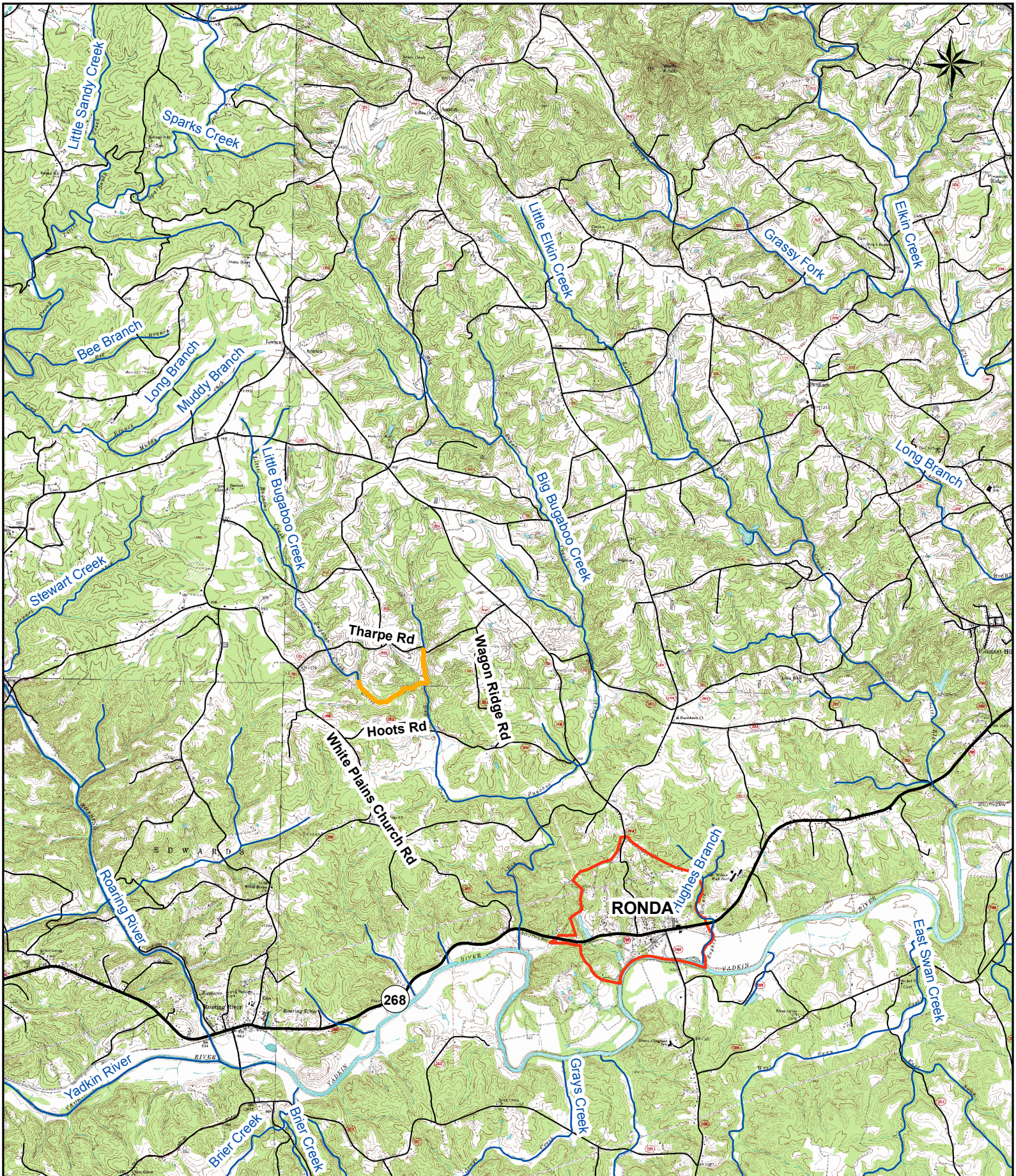
The Priority II restoration involved increasing the existing stream length and providing a floodplain. Cross vanes and rootwads were incorporated for aquatic habitat enhancement and bed and bank stability. A 50-foot riparian buffer was planted using native vegetation. Cattle were fenced from the riparian area. Little Bugaboo Creek was designed as a type C channel and the Unnamed Tributary was designed as type C and F channels. A total of 6,230 linear feet of stream channel was restored.

2.3 LOCATION AND SETTING

Little Bugaboo Creek is located on agricultural land approximately seven miles east-northeast of North Wilkesboro, just northwest of the town of Ronda in Wilkes County, North Carolina (Figure 1). The headwaters of the project originate approximately three miles to the north-northwest of the restoration site. From the headwaters, Little Bugaboo Creek flows for approximately four miles before its confluence with Big Bugaboo Creek. An Unnamed Tributary to Little Bugaboo Creek enters Little Bugaboo Creek at the end of the project site. The headwaters of the Unnamed Tributary originate approximately 1.6 miles from the restoration site. From its headwaters, the Unnamed Tributary flows for approximately 2.5 miles before the confluence with Little Bugaboo Creek.

To travel to the site from Raleigh, take I-40 West towards Greensboro. Merge onto US-421 North via Exit 188 toward Yadkinville/Wilkesboro Take the Red White and Blue Road Exit - Exit 276 toward NC-268/Mathis Farm Road. Turn right at Red White and Blue Road. Follow signs to NC-268/Roaring River. Make a right on NC-268, and then a left shortly after onto White Plains Road. The site is located between N Hoots Road and Tharpe Road. To access the mainstem, make a right onto N Hoots Road off of White Plains Road. The site can be accessed through a chicken farm on the left side of the road. To access the Unnamed Tributary, make a right on Tharpe Road from White Plains Road. The site is on the right side of the road and can be accessed through a farm gate that leads into a cattle pasture.

The project is contained within the property of five landowners. The project reach is bound to the north by Tharpe Road. Hoots Road runs south of the project reach.



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URS

Prepared For:
NC Ecosystem
Enhancement Program

Ecosystem Enhancement PROGRAM

Project:
Little Bugaboo Creek
Stream Restoration
Wilkes County, NC

Monitoring Year:
4 (2008)

Project Number:
00056

Date:
February 2009

Legend
- Project Reach
- City Boundary

Figure 1
Project Vicinity

0 0.5 1 Miles

2.4 PROJECT HISTORY AND BACKGROUND

The Little Bugaboo Creek Stream Restoration project was designed by EarthTech and constructed in the fall and winter of 2003 to 2004. The As-built/Monitoring Year 1 Report was completed by EarthTech in June 2005. 2005 (MY1) Monitoring was conducted by EcoLogic in February of 2006. 2006 (MY2) Monitoring was conducted by URS in the fall of 2006, and 2007 (MY3) Monitoring was conducted by URS. The estimated restoration length was 6,230 linear feet. This length includes 4,276 feet of Little Bugaboo Creek and 1,954 feet of an Unnamed Tributary to Little Bugaboo Creek.

Historically, a mill and dam were located approximately 150 feet below the confluence of Little Bugaboo Creek and the Unnamed Tributary. The mill dam backed up water within approximately half of the project reach. Both streams had incised down to bedrock through the alluvial sediments of the historic pond. The dam was removed near the beginning of the 20th Century. Relict dam sediments within the project reach could be attributable to the site's erosion rates.

Land use throughout the restoration site is agricultural. The primary use is cattle production and the spreading of chicken litter. Fences within the project area did not restrict cattle access to streams and drainages in the area. Cattle access to the stream and riparian areas resulted in streambank erosion prior to restoration. Continual grazing limited the ability of vegetation to reestablish itself along the majority of the reach. Additional degradation resulted from historic channelization of both reaches.

Table I: Project Mitigation Structure and Objectives Table

Little Bugaboo Creek EEP Project Number 00056						
Project Segment or Reach	**Existing Feet***	**Mitigation Type**	**Approach**	**Linear Footage****	**Stationing*****	**Comment**
Unnamed Tributary	1,892	R	PII	2,243	0+00 to 19+54	
Little Bugaboo Creek	4,478	R	PII	4,677	0+00 to 42+76	

* Existing Feet were measured from existing topography on design plans provided by EEP.
**Linear Footage is derived from the 2008 (MY4) longitudinal profile conducted by URS.
*** Stationing follows the 2005 (MY1) Monitoring Report (EcoLogic 2006).

R = Restoration
EI = Enhancement
EII = Enhancement II
S = Stabilization
PI = Priority I
PII = Priority II
PIII = Priority III
SS = Stream Bank Stabilization

Table II: Project Activity and Reporting History

Little Bugaboo Creek EEP Project Number 00056			
Activity or Report	**Scheduled Completion**	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan	April 2002	Unknown	April 2002
Construction	2003	Unknown	2003/2004
Permanent seed mix applied	2004	Unknown	2004
Live stakes and woody plants	2004	Unknown	2004
Final Walk Through	Unknown	Unknown	Unknown
As-Built Report/Mitigation Plan	2004	Unknown	June 2005
Year 1 Monitoring	October 2005	February 2006	June 2006
Year 2 Monitoring	October 2006	November 2006	January 2007
Year 3 Monitoring	October 2007	November 2007	January 2008
Year 4 Monitoring	December 2008	December 2008	December 2008
Repair and Replanting	Unknown	Ongoing – February 2009	Ongoing
Year 5 Monitoring	--	--	--

Table III: Project Contact Table

Little Bugaboo Creek EEP Project Number 00056	
Designer Primary project design POC	EarthTech of NC, Inc. 701 Corporate Center Drive, Suite 475 Raleigh, NC 27607 Bill Jenkins PE, RLA 919-854-6228
Construction Contractor Construction contractor POC	Dixie Grading and Equipment Company 5228 W US HWY 421 Wilkesboro, NC 28697 Randall Miles 336-973-7281
Planting Contractor Planting contractor POC	Carolina Environmental PO Box 1905 Mt. Airy, NC 27030 Joanne Chetham 336-320-3849
Seeding Contractor Seeding contractor POC	Carolina Environmental PO Box 1905 Mt. Airy, NC 27030 Joanne Chetham 336-320-3849
Seed Mix Sources 	 Unknown

Nursery Stock Suppliers	Unknown
Monitoring Performers – 2004 Monitoring POC	Earth Tech of North Carolina 701 Corporate Center Drive, Suite 475 Raleigh NC 27607 Ron Johnson 919-854-6210
Monitoring Performers – 2005 (MY1) Monitoring POC	EcoLogic Associates, P.C. 4321-A S. Elm-Eugene St. Greensboro, NC 27406 Kyle Hoover 336-335-1108
Monitoring Performers – 2006 (MY2) Monitoring POC	URS Corporation – North Carolina 1600 Perimeter Park Drive, Suite 400 Morrisville, NC 27560 Kathleen McKeithan 919-461-1100
Monitoring Performers – 2007 (MY3) Monitoring POC	URS Corporation – North Carolina 1600 Perimeter Park Drive, Suite 400 Morrisville, NC 27560 Kathleen McKeithan 919-461-1100
Monitoring Performers – 2008 (MY4) Monitoring POC	URS Corporation – North Carolina 1600 Perimeter Park Drive, Suite 400 Morrisville, NC 27560 Kathleen McKeithan 919-461-1100
Repair and Replanting Contractor - Unknown	Unknown

Table IV: Project Background Table

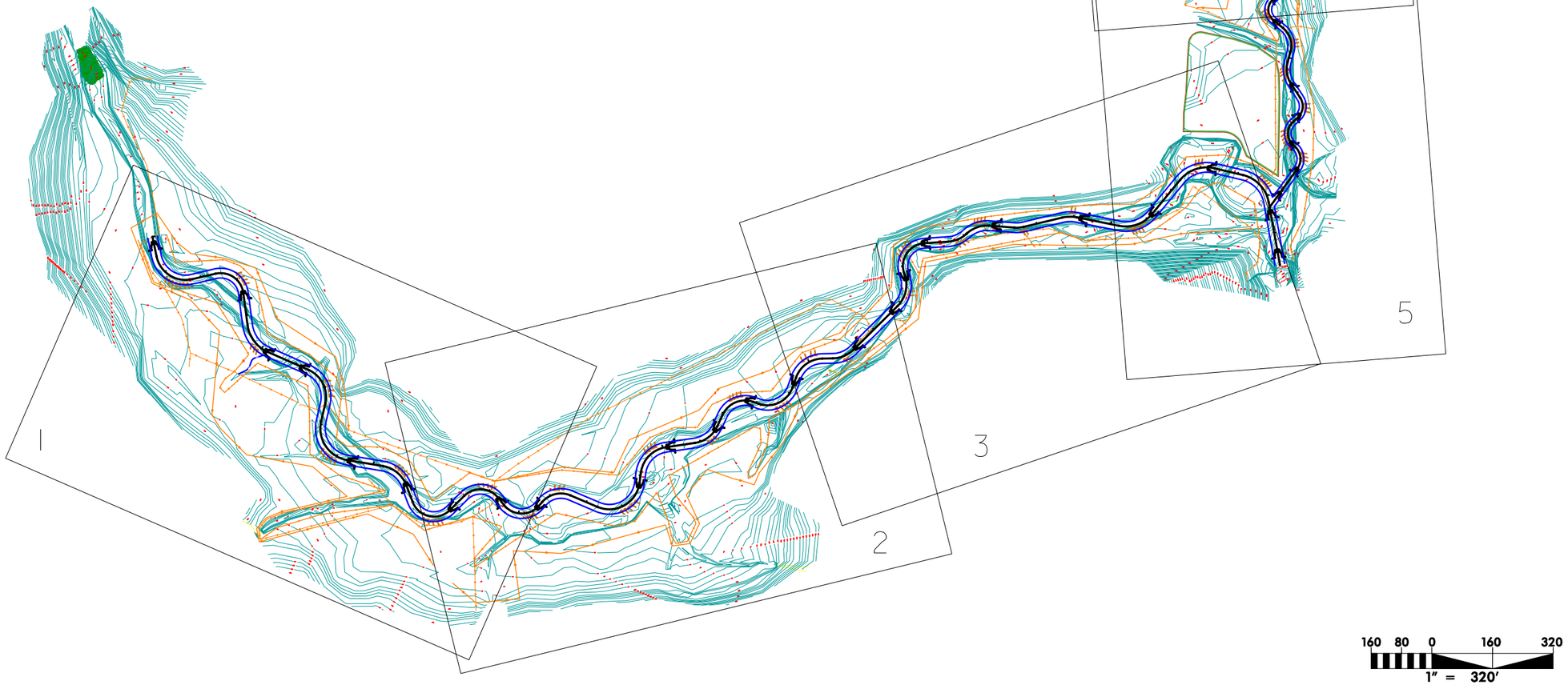
Little Bugaboo Creek EEP Project Number 00056	
Project County	Wilkes County
Drainage Area Little Bugaboo	3.45 square miles
 Unnamed Tributary	1.4 square miles
Drainage impervious cover estimate (%)	2
Stream Order Little Bugaboo	3rd
 Unnamed Tributary	3rd
Physiographic Region	Piedmont/Foothills
Ecoregion	Northern Inner Piedmont (45e)
Rosgen Classification of As-Built	C

Dominant soil types	Chewacla and Rion
Reference site ID	Basin Creek
USGS HUC for Project and Reference	03040101
NCDWQ Sub-basin for Project and Reference	05050001
NCDWQ classification for Project and Reference	03-07-01 – Project
Any portion of any project segment 303d listed?	No
Any portion of any project segment upstream of a 303d listed segment?	No
Reasons for 303d listing or stressor	NA
% of project easement fenced	100%

2.5 MONITORING PLAN VIEW

See Figure 2 for Monitoring Plan View.

Veg Plots			Photo Points		
ID	Northing	Easting	ID	Northing	Easting
9	915332	1414444	655	917481.3	1416889
8	915589.8	1414222	657	917200.1	1416993
10	915207.1	1414512	670	916874.1	1416935
11	915122.6	1414617	673	916737.4	1416889
12	915063	1414755	676	916563.6	1416971
13	915037.7	1414879	679	916406.3	1416998
14	915070.8	1414991	681	916355.9	1416999
15	915031.9	1415095	687	916153	1417029
17	915339.3	1415648	693	915956.5	1417054
16	915271.5	1415568	745	915923.2	1416982
18	915487.6	1415860	741	915860	1417048
21	915760.4	1416504	703	915544.2	1414237
19	915884.5	1416806	706	915232.6	1414449
21	915822.1	1416922	718	915308.9	1415522
7	916335	1417003	723	915407.5	1415713
6	916548.7	1416925	728	915606.3	1416020
5	916744.3	1416905	661	917038.5	1416952
4	916948.1	1416931	667	916938.3	1416877
2	917144.6	1416954			
3	917273.8	1416986			
1	917346.9	1416918			



160 80 0 160 320

1" = 320'

BASE MAP IS DESIGN PLANS PROVIDED BY EEP.

REVISIONS

NO.	DATE

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PROJECT: LITTLE BUGABOO STREAM RESTORATION 2008 MONITORING REPORT

TITLE: KEY PLAN

CLIENT: NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

Ecosystem Enhancement Program

FIGURE 2

DATE: DEC 2008

TECHNICIAN: EHJ

CHECKED BY: KM

MONITORING YEAR 4

EEP PROJECT NO. 00056

SHEET NO. 0

BEGIN CONSTRUCTION
SREV 10+00.00

PERMANENT CONSERVATION EASEMENT

CROSS SECTION 3

C-1
C-2
C-3
C-4
C-5
C-6
C-7
C-8

VP8
VP9
VP10
VP11
VP12
VP13

P703
P706

EXISTING CROSSING

CROSS SECTION 4

CROSS SECTION #1
CROSS SECTION #2
CROSS SECTION #3

℄ STREAM (SREV)

MATCH LINE - STA 23+85

REPLACE 48" CMP
48" CMP
INV: 117.08'

LEGEND

CROSS VANE*
* See Detail on Plan Sheet C-8

ROOT WAD*
* See Detail on Plan Sheet C-8

NOTE: Structure placement on Plan Sheets are for location only. Actual placement shall be directed by Resident Engineer.

VEGETATION PLOTS

PHOTO POINTS

40 30 0 40 80
1" = 80'

BASE MAP IS DESIGN PLANS PROVIDED BY EEP.

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PROJECT: LITTLE BUCABOO STREAM RESTORATION 2008 MONITORING REPORT

TITLE: MONITORING PLAN VIEW

CLIENT: NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

Ecosystem Enhancement Program

FIGURE 2

DATE: DEC 2008

TECHNICIAN: EHJ

CHECKED BY: KM

MONITORING YEAR 4

EEP PROJECT NO. 00056

SHEET NO. 1

MATCH LINE - STA 23+85

MATCH LINE - STA 36+10

PERMANENT CONSERVATION EASEMENT

℄ STREAM (SREV)

VPI4

VPI5

VPI6

VPI7

P718

P723

CROSS SECTION 5

C-9

C-10

C-11

C-12

C-13

C-14

C-15

C-16

C-17

N 24° 25' 25.5" E
130.000

S 66° 56' 14.5" E
77.383

N 7° 44' 29.2" E
28.193

N 81° 37' 41.9" E
17.086

N 24° 47' 48.0" E
33.132

S 10° 41' 58.9" E
15.573

N 88° 55' 30.7" E
27.684

N 86° 15' 38.0" E
21.828

REALIGN DRAINAGE SWALE
SEE DETAIL A

STEP-POOL OUTFALL
SEE DETAIL

DIRT PATH IMPROVEMENTS
SEE DETAIL

CHANNEL PLUG (TYP.)
SEE DETAIL

CLEANOUT DITCH TO DAYLIGHT
FROM PROPOSED PIPE INVERT

APPROXIMATELY 30' HEAD DITCH

EXISTING WETLAND AREA

MIN.EL.1111.0

MIN.EL.1111.50

MIN.EL.1117.0

MIN.EL.1118.0

INV.1114.5

INV.1115.5

INV.1108.5

INV.1108.0

28" 18" RCP

40" 18" RCP

LEGEND

CROSS VANE*

* See Detail on Plan Sheet C-8

ROOT WAD*

* See Detail on Plan Sheet C-8

NOTE: Structure placement on Plan Sheets are for location only. Actual placement shall be directed by Resident Engineer.

VEGETATION PLOTS

PHOTO POINTS

40 30 0 40 80

1" = 80'

BASE MAP IS DESIGN PLANS PROVIDED BY EEP.

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Ecosystem Enhancement Program

FIGURE 2

DATE: DEC 2008

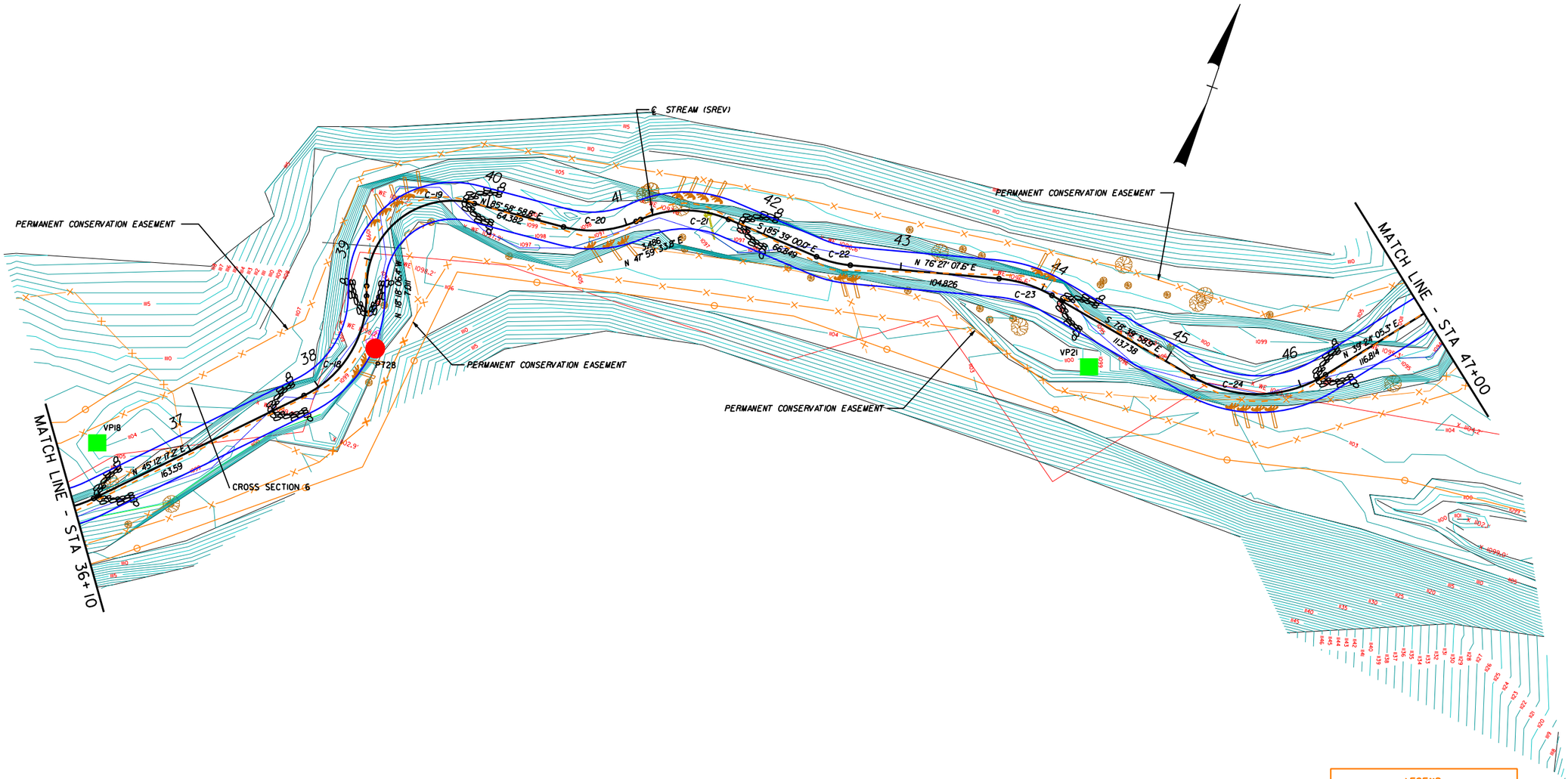
TECHNICIAN: EHJ

CHECKED BY: KM

MONITORING YEAR 4

EEP PROJECT NO. 00056

SHEET NO. 2



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TITLE: MONITORING PLAN VIEW

CLIENT: NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

Ecosystem Enhancement

FIGURE 2

DATE: DEC 2008

TECHNICIAN: EHJ

CHECKED BY: KM

MONITORING YEAR 4

EEP PROJECT NO. 00056

SHEET NO. 3

BEGIN CONSTRUCTION
TRIB 10+00.00

MATCH LINE - TRIB- STA 21+00

ARMOR LEFT BANK WITH
CLASS B STONE

℄ STREAM (TRIBUTARY)

PERMANENT CONSERVATION EASEMENT

MAINTAIN TREE

PERMANENT CONSERVATION EASEMENT

CROSS SECTION 1

CROSS SECTION 2

VP1
VP2
VP3
VP4
VP5

P657
P661
P667
P673

LEGEND

CROSS VANE*
* See Detail on Plan Sheet C-8

ROOT WAD*
* See Detail on Plan Sheet C-8

NOTE: Structure placement on Plan Sheets are for location only. Actual placement shall be directed by Resident Engineer.

VEGETATION PLOTS

PHOTO POINTS

40 30 0 40 80
1" = 80'

BASE MAP IS DESIGN PLANS PROVIDED BY EEP.

REVISIONS

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PROJECT: LITTLE BUGABOO
STREAM RESTORATION
2008 MONITORING REPORT

TITLE: MONITORING PLAN VIEW

CLIENT: NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

Ecosystem Enhancement Program

FIGURE 2

DATE: DEC 2008

TECHNICIAN: EHJ

CHECKED BY: KM

MONITORING YEAR 4

EEP PROJECT NO. 00056

SHEET NO. 4

LEGEND	
CROSS VANE* * See Detail on Plan Sheet C-8	
ROOT WAD* * See Detail on Plan Sheet C-8	

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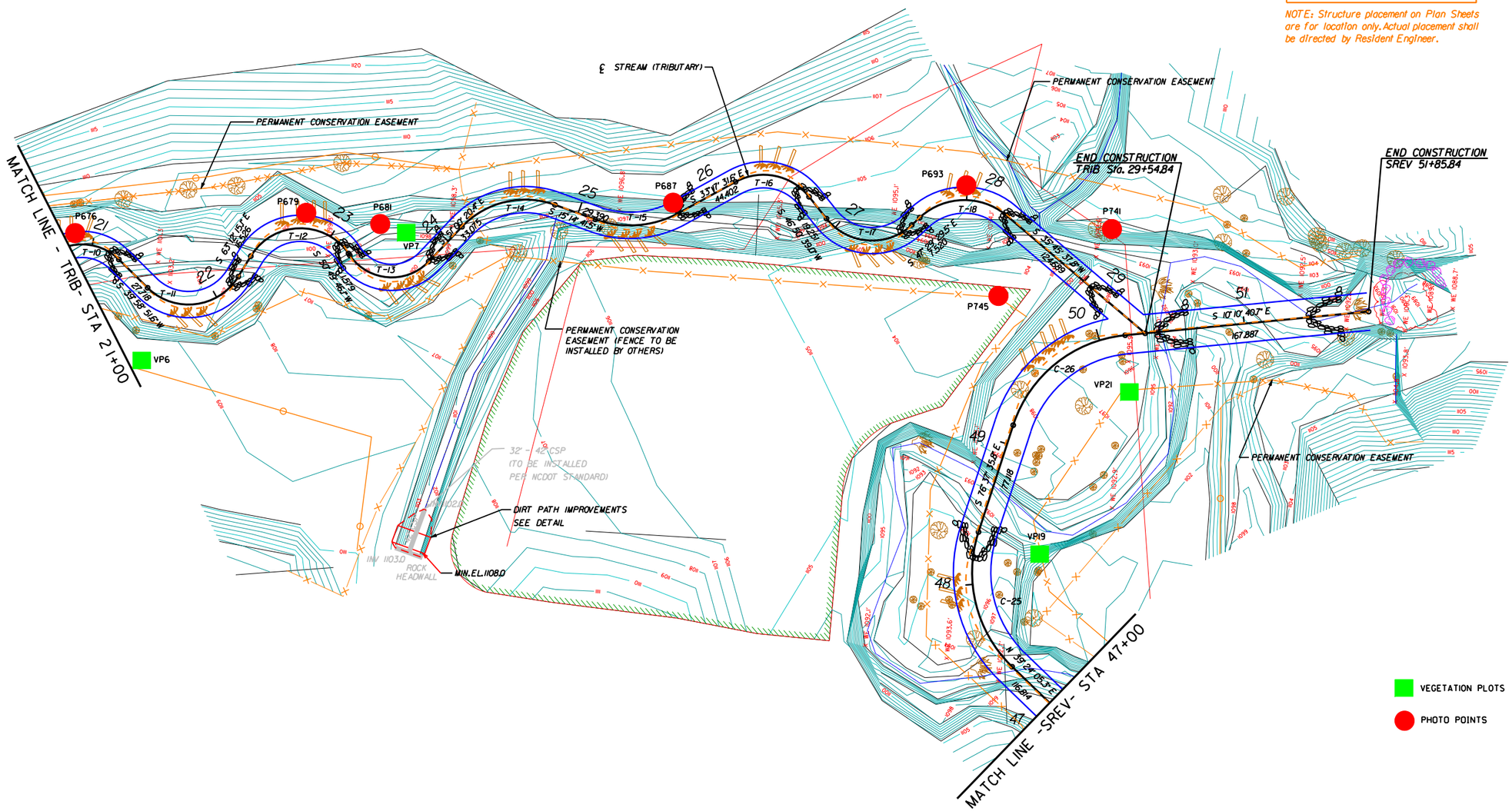

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CLIENT: NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

Ecosystem Enhancement Program

FIGURE 2

DATE: DEC 2008

TECHNICIAN: EHJ

CHECKED BY: KM

MONITORING YEAR 4

EEP PROJECT NO. 00056

SHEET NO. 5

3.0 PROJECT CONDITION AND MONITORING RESULTS

3.1 VEGETATION ASSESSMENT

3.1.1 VEGETATION PROBLEM AREAS

No Vegetative Problem Areas were identified during 2005 (MY1) Monitoring. Notes provided on the Vegetative Problem Areas Plan View were as follows:

- No significant vegetation problems were noted on the intact banks or in the easement corridor, though eroded banks will obviously need replanting when stream repairs are made.

- Vegetation problems were assessed without an as-built species list or planting plan, thus species survival and mortality rates could not be evaluated.

- Scattered but widespread occurrences of emerging Chinese privet (*Ligustrum sinense*) and multiflora rose (*Rosa multiflora*) were noted throughout the corridor, which will become problematic if not treated. Adjacent areas are infested with Chinese privet, so this will likely be a recurring management challenge.

Twenty-two Vegetative Problem Areas were found at the Little Bugaboo site during the 2006 (MY2) monitoring. Twenty-five Vegetative Problem Areas were found at the Little Bugaboo site during the 2007 (MY3) monitoring. Sixteen Vegetative Problem areas were noted at the Little Bugaboo site during the 2008 (MY4) monitoring.

Major issues included bare banks as a result of erosion and scour and poor survivability. Additionally, Chinese privet is populating the streambanks and floodplain. Herbaceous grasses and herbs dominated much of the buffer area during the 2008 (MY4) monitoring event. Thick mats of herbaceous vegetation were observed outside of the stream banks. Common species include wiregrass, dogfennel, goldenrod, and bluestem. It is likely that the presence and density of the above-mentioned native herbs is to blame for size and survivability issues. The small planted stems are not successfully competing for space, light, and nutrients. The Vegetative Problem Areas Tables are located in Appendix A-I. Vegetative Problem Area Photos are located in Appendix A-II.

3.1.2 VEGETATION CURRENT CONDITION PLAN VIEW

See Appendix A-III for the Vegetation Current Condition Plan View.

3.2 STREAM ASSESSMENT

3.2.1 PROCEDURAL ITEMS

3.2.1.1 Morphometric Criteria

Dimension and profile were sampled at a rate per the 2003 USACE Stream Mitigation Guidelines as follows:

Dimension: Six permanent cross sections were surveyed. Two are located on the Unnamed Tributary (one riffle and one pool) and four are located on Little Bugaboo Creek (two riffles and two pools). At the instruction of the EEP Project Manager, URS surveyed the cross-sections established by EcoLogic for the 2005 (MY1) Monitoring Report. The cross section numbers and locations do not correspond to the As-

Built cross sections established by EarthTech. The survey includes points measured at all breaks in slope, including edges of channel, top of bank, any bankfull indicators, and thalweg.

Profile: A longitudinal profile survey was performed on the entire project reach (6,921 linear feet). 4,677 linear feet were surveyed on Little Bugaboo Creek and 2,243 linear feet were surveyed on the Unnamed Tributary. Survey points include measurements taken in the thalweg at the beginning of each stream feature such as riffle and pool, as well as the maximum pool depth, and top of bank.

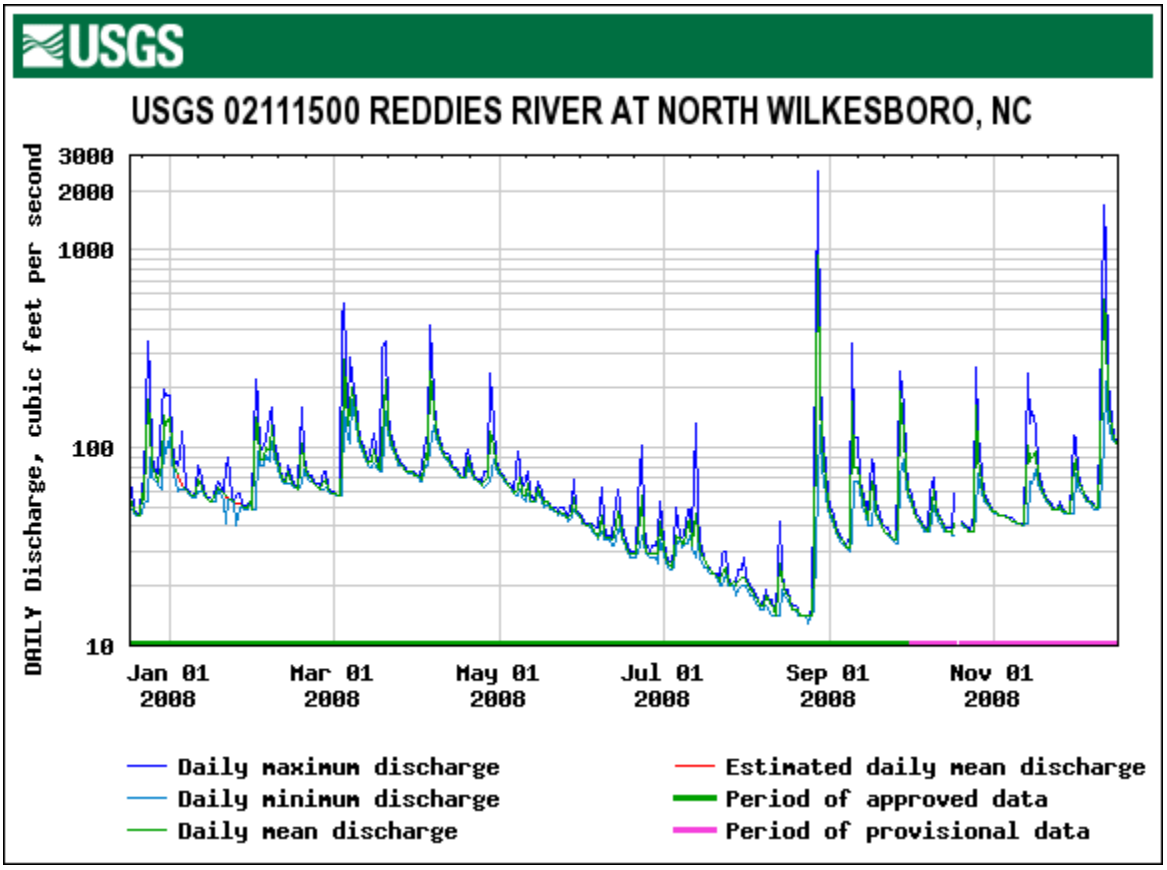
3.2.1.2 Hydrologic Criteria

No crest gages are installed at this site to document bankfull events. Therefore, potential occurrence was extrapolated based on US Geological Survey (USGS) stream gage discharge data for the Roaring River near Roaring River, NC (USGS 2008). The USGS gage plot is shown below (Figure 3). The gage is located less than five miles from the project site and has a drainage area of 128 square miles. An estimate of the number of bankfull events in 2008 was made by comparing the stream discharges from the USGS data in cubic feet per second (cfs) against the bankfull discharge estimated from the drainage area on the Rural Piedmont Regional Curve. According to the regional curve, a bankfull event occurs on a stream with a 128 square mile drainage area when the discharge is about 2,500 cfs. This discharge was exceeded in August and November of 2008. Little Bugaboo Creek is in close proximity to the Roaring River. Therefore, it is likely that the project site also experienced two bankfull events during 2008.

Table V: Verification of Bankfull Events

Little Bugaboo Creek EEP Project Number 00056		
Date of Data Collection	**Date of Occurrence**	**Method**
12/2/07	January 2007	USGS Stream Gage Discharge
12/17/08	August 2008	USGS Stream Gage Discharge
12/17/08	November 2008	USGS Stream Gage Discharge

Figure 3: USGS Stream Gage Discharge Data



3.2.2 STREAM PROBLEM AREAS

There were 35 Stream Problem Areas identified on Little Bugaboo Creek in 2005. In 2006, 40 Stream Problem Areas were identified, in 2007 34 Stream Problem Areas were identified, and in 2008 17 Stream Problem Areas were identified. The most notable change between 2007 and 2008 was the absence of beaver dams and recent beaver activity at the site. In 2007, four beaver dams were documented on the mainstem and five beaver dams were documented on the Unnamed Tributary. During 2008, there were no dams remaining on the Unamed Tributary and only one small, inactive dam on the mainstem. It appears as if the beavers have abandoned the site. The Stream Problem Areas Plan View, tables, and photographs are located in Appendices B-I, B-II, and B-III respectively.

As discussed in the 2006 (MY2) and 2007 (MY3) reports, there are several areas not captured by the cross sections where the channel size is increasing laterally. Bank erosion in the form of mass wasting, sloughing, and scour exists in Little Bugaboo Creek and the Unnamed Tributary. Underlying causes of erosional problems are difficult to determine at this stage since URS was not involved with the design, construction, or follow-up maintenance phases of this project. Immediate causes are attributed to easily erodible, sandy substrate that dominates the streambank soils. Insufficient vegetative protection has likely contributed to erosion problems as well. Ultimate causes for the erosion problems may be attributed to problems with the project design and/or the implementation of the design during construction activities.

The problem areas attributed to improper design and/or construction are likely caused by constructed channel dimensions. The Unnamed Tributary design calls for a floodprone width of 170, yet the channel As-Built floodprone width ranges from 60-75. Likewise, the entrenchment ratio was designed at 9 but was built at 3 to 3.8. The mainstem design calls for a floodprone width of 255, but it was built to 100. The entrenchment ratio was designed at 9.9 but was built to 3 to 3.5. This suggests the channel is not able to dissipate enough energy by accessing its floodplain, and is eroding its banks as a result.

URS agrees with the underlying causes of erosion stated in the 2005 As-Built/Monitoring Year 1 Report provided by EarthTech. The report attributes the instability of Little Bugaboo Creek and the Unnamed Tributary to lack of vegetation/poor survival, the inner berm was not constructed according to the plans for typical cross sections, and overland flow/drainageways entering the stream channel. It appears that the problems experienced by the system immediately following construction have allowed for a continual decline in the system's stability.

3.2.3 FIXED PHOTO STATION PHOTOS

Stream Photo Station Photos are located in Appendix B-IV.

3.2.4 STABILITY ASSESSMENT

Table VI: Categorical Stream Feature Visual Stability Assessment (% Functioning)

Little Bugaboo Creek EEP Project Number 00056						
Feature	**Initial***	**MY-01****	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffle	100	N/A	92	44	94	
B. Pool	100	N/A	87	54	89	
C. Thalweg	100	N/A	88	22	92	
D. Meanders	100	N/A	67	34	51	
E. Bed General	100	N/A	98	88	95	
F. Bank Condition	100	N/A	86	83	93	
G. Vanes / J Hooks	100	N/A	82	79	92	
H. Wads and Boulders	100	N/A	75	75	81	
Unnamed Tributary EEP Project Number 00056						
Feature	**Initial***	**MY-01****	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffle	100	N/A	96	71	100	
B. Pool	100	N/A	91	90	100	
C. Thalweg	100	N/A	100	100	100	
D. Meanders	100	N/A	67	76	83	
E. Bed General	100	N/A	100	88	100	
F. Bank Condition	100	N/A	91	66	85	
G. Vanes / J Hooks	100	N/A	95	82	97	
H. Wads and Boulders	100	N/A	89	89	100	

* It is assumed that all were 100 percent functional upon completion of construction.
** No stability data are presented in the previous report.

3.2.5 QUANTITATIVE MEASURES TABLES (MORPHOLOGY AND HYDROLOGY)

Table VII: Baseline Morphology and Hydraulic Summary

Little Bugaboo Creek EEP Project Number 00056																		
Parameter	**USGS Gage Data**			**Regional Curve Interval**			**Pre-Existing Condition**			**Project Reference Stream**			**Design**			**As-built**		
Dimension	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
BF Width (ft)	--	--	--	12	40	23	26	35.5	30.75	20	21.5	20.75	--	--	25.8	20.3	44	28.8
Floodprone Width (ft)	--	--	--	--	--	--	--	--	90	--	--	130	--	--	255	87.5	100	100
BF Cross Sectional Area (ft^2)	--	--	--	27	100	51	54	87.7	70.85	40.9	42.8	41.85	--	--	55.7	53.9	67.5	60.1
BF Mean Depth (ft)	--	--	--	1.5	3.3	2.4	1.9	2.9	2.4	2	2	2	--	--	2.15	1.4	3.2	2.2
BF Max Depth (ft)	--	--	--	--	--	--	2.7	4.1	3.4	2.5	2.7	2.6	--	--	3.5	3.6	4.6	4.1
Width/Depth Ratio	--	--	--	--	--	--	8.8	17.4	13.1	9.8	10.8	10.3	--	--	12	12	32.6	12.6
Entrenchment Ratio	--	--	--	--	--	--	--	--	2.7	--	--	65	--	--	9.9	3.1	3.5	3.3
Bank Height Ratio	--	--	--	--	--	--	1.9	4.5	2.8	1.0	1.0	1.0	--	--	--	--	--	--
Wetted Perimeter (ft)	--	--	--	--	--	--	29.8	41.3	35.55	24	25.5	24.75	--	--	30.1	32.7	46.8	33.3
Hydraulic radius (ft)	--	--	--	--	--	--	1.812	2.123	1.993	1.704	1.678	1.691	--	--	1.850	1.3	2.0	1.9
Pattern																		
Channel Beltwidth (ft)	--	--	--	--	--	--	36	140	88	31	44	37.5	NA	NA	NA	63	122	92.5
Radius of Curvature (ft)	--	--	--	--	--	--	62	234	148	42	63	52.5	72.9	102.9	87.9	60	110	85
Meander Wavelength (ft)	--	--	--	--	--	--	133	590	361.5	185	260	222.5	196	366	281	206	366	286
Meander Width Ratio	--	--	--	--	--	--	4.4	19.3	11.85	8.9	12.6	10.75	6.5	12.2	9.35	7.2	12.7	9.9

Table VII: Baseline Morphology and Hydraulic Summary (cont.)

Little Bugaboo Creek EEP Project Number 00056																		
Parameter	**USGS Gage Data**			**Regional Curve Interval**			**Pre-Existing Condition**			**Project Reference Stream**			**Design**			**As-built**		
Dimension	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Profile																		
Riffle Length (ft)	--	--	--	--	--	--	--	--	--	23	78	50.5	--	--	--	3	91	47
Riffle Slope (ft/ft)	--	--	--	--	--	--	--	--	--	0.02	0.02	0.02	--	--	0.01	0.00	0.20	0.10
Pool Length (ft)	--	--	--	--	--	--	--	--	--	8	32	20	--	--	--	47	94	70.5
Pool Spacing (ft)	--	--	--	--	--	--	57	287	172	98	180	139	106	217	161.5	121	127	124
Substrate																		
d50 (mm)	--	--	--	--	--	--	--	--	0.25	--	--	3	--	--	--	0.25	11.3	5.8
d84 (mm)	--	--	--	--	--	--	--	--	23	--	--	50	--	--	--	1	64	32.5
Additional Reach Parameters																		
Valley Length (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3420
Channel Length (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4276
Sinuosity	--	--	--	--	--	--	--	--	1.3	--	--	1.1	--	--	1.2	--	--	1.3
Water Surface Slope (ft/ft)	--	--	--	--	--	--	--	--	0.00	--	--	0.01	--	--	0.01	0.00	0.01	0.01
BF Slope (ft/ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--		0.00	0.01	0.00
Rosgen Classification	--	--	--	--	--	--	--	--	Bc, C, E, F	--	--	E4	--	--	C	--	--	C

Table VII: Baseline Morphology and Hydraulic Summary (cont.)

Unnamed Tributary EEP Project Number 00056																		
Parameter	**USGS Gage Data**			**Regional Curve Interval**			**Pre-Existing Condition**			**Project Reference Stream**			**Design**			**As-built**		
Dimension	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
BF Width (ft)	--	--	--	7.5	30	16.5	17.5	18	17.75	29.5	36.9	33.2	--	--	18	14.8	31	18.6
Floodprone Width (ft)	--	--	--	--	--	--	--	--	38	--	--	329	--	--	170	61	75	68.0
BF Cross Sectional Area (ft^2)	--	--	--	13	50	26	21.2	21.9	21.55	64.9	71.9	68.4	--	--	27	22.1	34.4	30.9
BF Mean Depth (ft)	--	--	--	1.0	2.6	1.8	1.2	1.2	1.2	1.9	2.2	2.05	--	--	1.5	1.1	2.3	1.4
BF Max Depth (ft)	--	--	--	--	--	--	2.2	2.3	2.25	3	3.2	3.1	--	--	2.1	2.64	3.8	3.1
Width/Depth Ratio	--	--	--	--	--	--	14.4	14.8	14.6	13.4	19.4	16.4	--	--	12	11.2	17.2	14.2
Entrenchment Ratio	--	--	--	--	--	--	1.8	2.5	2.15	--	--	8.9	--	--	9.4	3.47	3.8	3.6
Bank Height Ratio	--	--	--	--	--	--	1.9	4.5	2.8	1.0	1.0	1.0	--	--	--	--	--	--
Wetted Perimeter (ft)	--	--	--	--	--	--	19.9	20.4	20.15	33.3	41.3	37.3	--	--	21	19.4	33.2	21.3
Hydraulic radius (ft)	--	--	--	--	--	--	1.07	1.07	1.07	1.95	1.74	1.84	--	--	1.29	1.0	1.8	1.2
Pattern																		
Channel Beltwidth (ft)	--	--	--	--	--	--	26	74	50	59	75	67	--	--	--	40	131	59.5
Radius of Curvature (ft)	--	--	--	--	--	--	27	98	62.5	40.1	69.3	54.7	1.8	3.7	2.8	--	--	--
Meander Wavelength (ft)	--	--	--	--	--	--	87	355	221	--	--	350	129	224	176.5	130	204	175
Meander Width Ratio	--	--	--	--	--	--	4.9	19.9	12.4	--	--	10.5	9	12	10.5	7.01	11.00	9.43

Table VII: Baseline Morphology and Hydraulic Summary (cont.)

Unnamed Tributary EEP Project Number 00056																		
Parameter	**USGS Gage Data**			**Regional Curve Interval**			**Pre-Existing Condition**			**Project Reference Stream**			**Design**			**As-built**		
Dimension	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Profile																		
Riffle Length (ft)	--	--	--	--	--	--	--	--	--	10	245	127.5	--	--	--	22	28	25
Riffle Slope (ft/ft)	--	--	--	--	--	--	--	--	--	--	--	0.02	--	--	0.02	0.00	0.20	0.10
Pool Length (ft)	--	--	--	--	--	--	--	--	--	8	32	20	--	--	--	47	94	70.5
Pool Spacing (ft)	--	--	--	--	--	--	33	176	104.5	271	334	302.5	64	166	115.0	121	127	124
Substrate																		
d50 (mm)	--	--	--	--	--	--	--	--	5	--	--	58	--	--	--	0.5	5.7	3.1
d84 (mm)	--	--	--	--	--	--	--	--	23	--	--	180	--	--	--	8	32	20
Additional Reach Parameters																		
Valley Length (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1603
Channel Length (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1954
Sinuosity	--	--	--	--	--	--	--	--	1.2	--	--	--	--	--	1.3	--	--	1.2
Water Surface Slope (ft/ft)	--	--	--	--	--	--	--	--	0.01	--	--	0.014	--	--	0.01	--	--	0.01
BF Slope (ft/ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.01
Rosgen Classification	--	--	--	--	--	--	--	--	C and F	--	--	C4	--	--	C and F	--	--	C

Table VIII: Morphology and Hydraulic Monitoring Summary

Little Bugaboo Creek EEP Project Number 00056																				
Parameter	Cross Section 3 Riffle					Cross Section 4 Pool					Cross Section 5 Pool					Cross Section 6 Riffle				
Dimension	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	27.1	19.3	22.4	20.8		20.6	14.0	22.6	22.5		31.3	27.3	19.0	17.3		17.8	13.3	13.2	15.7	
Floodprone Width (ft)	91.3	91	80.5	95		68.8	49.3	>50	>50		52.8	>50	>55	>55		39	45.0	38	45	
BF Cross Sectional Area (ft^2)	63.2	45.7	51.3	60.5		34	21.6	42.4	41.7		47	31	39.2	42.1		20.6	23.1	21.0	23.5	
BF Mean Depth	2.3	2.4	2.3	2.9		1.7	1.5	1.9	1.9		1.5	1.1	2.1	2.4		1.2	1.7	1.6	1.5	
BF Max Depth	4.7	4.2	3.2	4.4		3.7	2.6	2.9	3.7		5	4.4	4.6	4.5		2.4	2.5	2.2	2.3	
Width/Depth Ratio	11.6	8.2	9.7	7.2		12.5	9.1	12.0	12.2		20.8	24.1	9.2	7.2		15.5	7.7	8.3	10.5	
Entrenchment Ratio	3.4	4.7	3.6	4.6		3.3	3.5	>2.2	>2.2		1.7	>1.8	>2.9	3.2		2.2	3.4	2.9	2.9	
Bank Height Ratio	--	1.0	1.4	1.0		--	1.0	1.0	1.0		--	1.4	1.0	1.0		--	1.0	1.0	1.0	
Wetted Perimeter (ft)	30	21.8	24.2	24.0		22.9	15.8	24.3	25.0		36.2	32.4	24.1	22.5		19.3	14.8	15.3	17.6	
Hydraulic radius (ft)	2.1	2.1	2.1	2.5		1.5	1.4	1.7	1.7		1.3	1.0	1.6	1.9		1.1	1.6	1.4	1.3	
Substrate																				
d50 (mm)	5	6	7	1.8		0.29	13	1.1	9.9		0.29	0.94	0.69	0.2		21.13	48	46	6.9	
d84 (mm)	15	64	18	18		2.33	59	1.7	37		2	48	30	11		54.5	130	90	31	

Table VIII: Morphology and Hydraulic Monitoring Summary (cont.)

Little Bugaboo Creek EEP Project Number 00056															
Parameter	**MY1**			**MY2**			**MY3**			**MY4**			**MY5**		
Pattern	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
Channel Beltwidth (ft)	16	115	70	--	--	--	55	250	110	30	130	87			
Radius of Curvature (ft)	42	121	72	--	--	--	50	218	128	25	93	57			
Meander Wavelength (ft)	105	210	163	--	--	--	175	435	286	200	360	258			
Meander Width Ratio	3.8	11.6	7.4	--	--	--	2.2	10.2	4.5	0.7	3.1	2.0			
Profile															
Riffle Length (ft)	13.8	48.5	29.1	10.0	128.0	55	11	97	39	1.3	32.5	18.8			
Riffle Slope (ft/ft)	0.007	0.034	0.015	0.002	0.026	0.012	0.000	0.021	0.011	0.000	0.150	0.048			
Pool Length (ft)	9.23	94.6	44.5	16.0	131.0	45	37	219	80	9.7	85.5	39.9			
Pool Spacing (ft)	16.2	175.3	80.5	43.0	347.0	120	37	522	127	24	289	98			
Additional Reach Parameters															
Valley Length (ft)	--	--	2975	--	--	2975	--	--	2975	--	--	2975			
Channel Length (ft)	--	--	4293	--	--	4232	--	--	5018	--	--	4677			
Sinuosity	--	--	1.4	--	--	1.4	--	--	1.7	--	--	1.6			
Water Surface Slope (ft/ft)	--	--	0.57	--	--	0.0055	--	--	0.0047	--	--	0.0053			
BF Slope (ft/ft)	--	--	0.53	--	--	0.0056	--	--	0.0047	--	--	0.0053			
Rosgen Classification	--	--	B	--	--	E4	--	--	E4	--	--	E4			

Table VIII: Morphology and Hydraulic Monitoring Summary (cont.)

Unnamed Tributary EEP Project Number 00056										
Parameter	Cross Section 1 Pool					Cross Section 2 Riffle				
Dimension	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	23.5	13.8	15.1	14.6		18.8	17.4	14.8	12.6	
Floodprone Width (ft)	52	>42.7	>47	>45		32.4	>81.0	>50	>51	
BF Cross Sectional Area (ft^2)	38.3	23.3	25.5	29.3		30.7	30.5	26.9	28.0	
BF Mean Depth	1.6	1.7	1.7	2.0		1.6	1.8	1.8	2.2	
BF Max Depth	3.8	3.5	3.7	3.5		3.2	3.2	3.1	3.5	
Width/Depth Ratio	14.4	8.2	9.0	7.3		11.5	9.9	8.2	5.7	
Entrenchment Ratio	2.2	>3.1	>3.1	3.1		1.7	>4.7	>3.4	4.0	
Bank Height Ratio	--	1.0	1.0	1.0		--	1.0	1.0	1.0	
Wetted Perimeter (ft)	25.7	17.5	18.2	18.9		20.7	19.6	17.8	15.3	
Hydraulic radius (ft)	1.5	1.3	1.4	1.6		1.5	1.6	1.5	1.8	
Substrate										
d50 (mm)	0.2	12	0.38	8.9		23.4	22	55	7.1	
d84 (mm)	0.7	68	90	45		51.3	68	100	34	

Table VIII: Morphology and Hydraulic Monitoring Summary (cont.)

Unnamed Tributary EEP Project Number 00056															
Parameter	**MY1**			**MY2**			**MY3**			**MY4**			**MY5**		
Pattern	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
Channel Beltwidth (ft)	25	132	47	--	--	--	24	240	36	40	160	61			
Radius of Curvature (ft)	20	92	48.5	--	--	--	38	110	66	30	98	49			
Meander Wavelength (ft)	75	230	100	--	--	--	140	320	187	130	200	164			
Meander Width Ratio	3.9	12.2	5.3	--	--	--	2.6	7.4	2.4	3.2	12.7	5.0			
Profile															
Riffle Length (ft)	12.3	36.9	22	3	70	28	23	84	48	4.2	103.8	38.4			
Riffle Slope (ft/ft)	0.001	0.058	0.024	0.006	0.067	0.021	0.000	0.032	0.016	0.000	0.092	0.022			
Pool Length (ft)	15.8	66.8	32.2	15	43	28	17	41	29	9.7	59.3	28.0			
Pool Spacing (ft)	15.8	130.2	56.1	31	196	95	10	240	72	11.0	129.7	58.3			
Additional Reach Parameters															
Valley Length (ft)	--	--	1585	--	--	1585	--	--	1585	--	--	1585			
Channel Length (ft)	--	--	2013	--	--	1925	--	--	2074	--	--	2244			
Sinuosity	--	--	1.3	--	--	1.2	--	--	1.31	--	--	1.4			
Water Surface Slope (ft/ft)	--	--	1.11	--	--		--	--	0.011	--	--	0.01			
BF Slope (ft/ft)	--	--	0.011	--	--	0.011	--	--	0.012	--	--	0.01			
Rosgen Classification	--	--	B/C	--	--	E4	--	--	E4	--	--	E4			

4.0 METHODOLOGY SECTION

As of December 1, 2008, all monitoring methodologies follow the most current templates and guidelines provided by EEP (EEP 2006). Photographs were taken at high resolution using aSealife EcoShot 6.0 megapixel digital camera. GPS location information was collected in 2006 (MY2) using a Trimble Geo XT handheld mapping grade GPS unit. GPS locations were collected on both banks of each cross section and on all four corners of each vegetation plot. Stream and vegetation problem areas were noted in the field on As-Built Plan Sheets. Permanent photo station photographs were taken from locations marked in the 2005 (MY1) Monitoring Report, prepared by EcoLogic Associates.

4.1 STREAM METHODOLOGY

The methods used to generate the data in this report are standard fluvial geomorphology techniques as described in *Applied River Morphology* (Rosgen 1996) and related publications from US Forest Service and the interagency Stream Mitigation Guidelines (USACE 2003). URS' field morphological survey was conducted using a Nikon DTM-420 Total Station and the data were analyzed and displayed using the Reference Reach Spreadsheet, Version 4.1T (Mecklenburg 2006). Pebble counts were conducted by sampling a total of 100 pebbles from the feature of the cross section (riffle or pool). According to the most recent guidance issued in Rosgen courses, the pebble count was concentrated within the wetted perimeter of the channel and did not include the banks. The exact pebble count methodology used in previous monitoring periods (prior to 2006, MY2) is not known, so it is unknown if the results are comparable.

Photographs were taken at each cross section. A photo was taken from the left bank towards the right bank, and from the right bank towards the left bank.

4.2 VEGETATION METHODOLOGY

According to 2005 As-Built/Year One Monitoring Report, 16 permanent vegetation plots were established at the site, using metal conduit to mark their locations in the field. During the initial site assessment in 2006, none of the As-built vegetation plots were located. However, URS did observe 21 permanent vegetation plots that were established by EcoLogic Associates, using white PVC piping at the upstream outside corner of each plot to mark their locations in the field. At the time of the 2006 (MY1) Report, EcoLogic did not have historic project documentation. EcoLogic established 21 new vegetation plots and six new cross sections in 2005 (MY1). The locations of the vegetation plots and cross sections are different than those presented in the 2005 As-Built/Year One Monitoring Report. Since EarthTech's vegetation plots and cross sections were not located during URS' 2006 initial site visit, the plots and cross sections established by EcoLogic in 2006 (MY1) were used.

Vegetation monitoring methods followed the 2006 CVS-EEP Protocol for Recording Vegetation (Lee, *et al.* 2006). Per the protocol (http://cvs.bio.unc.edu/methods.htm), 14 vegetation plots are required for the site. URS inventoried EcoLogic plots 1, 2, 4, 6, 7, 8, 11, 12, 13, 14, 15, 16, 19, and 21. Vegetation plot photographs and GPS locations were collected at the southwest corner of each vegetation plot in 2006 (MY2). Vegetation monitoring plots were re-marked in the field by replacing all old flagging with new flagging. Each vegetation plot was marked by EcoLogic in 2005 with a four-foot PVC pipe at the upstream, outside corner. The remaining three corners were marked with steel conduit. URS placed orange flagging at the southwest corner of each vegetation plot and blue flagging at the remaining corners. The orientation of the plot was marked on the CVS-EEP data sheet if the PVC was not in the southwest corner (the origin of the plot). Planted stems were flagged in white. Volunteer/natural regeneration stems were inventoried, but not flagged. Monitoring taxonomy follows 'Flora of the Carolinas, Virginia, Georgia, and surrounding areas' (Weakley 2007). Stem height was measured with a

folding one-meter rule. Diameter at breast height and decimeter height were measured with calipers. The X,Y coordinates relative to the southwest corner (origin) of each stem in the plot were recorded in 2006. The results of the stem counts are summarized in Appendix A-I. Vegetation plot photos are located in Appendix A-IV.

5.0 REFERENCES

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Appendices

Appendix A: Vegetation Raw Data

Appendix A-I: Vegetation Survey Data Tables

Table A1: Vegetation Metadata

Report Prepared By	Susan Shelingoski
Date Prepared	12/18/2008 11:41
database name	BigWarrior_Bugaboo_Silas_Snow Database.mdb
database location	P:\Jobs3\31825348_Monitoring\Veg\2008 DATABASES
computer name	RDUXPL160
file size	57245696
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
ALL Stems by Plot and spp	A matrix of the count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	56
project Name	Little Bugaboo Creek
Description	Stream Restoration
River Basin	Yadkin-Pee Dee
length(ft)	6,920
stream-to-edge width (ft)	15
area (sq m)	4.8 acres
Required Plots (calculated)	14
Sampled Plots	14

Table A2: Vegetation Vigor by Species

	Species	4	3	2	1	0	Missing	Unknown
	Alnus serrulata	11					2	
	Aronia arbutifolia					2		
	Betula nigra	2						
	Callicarpa americana	3					3	
	Cornus racemosa	17						
	Fraxinus pennsylvanica	22	3			2	2	
	Juglans nigra	7						
	Nyssa sylvatica	9					3	
	Quercus alba	12						
	Rhus glabra	3					1	
	Salix nigra	3						
	Sambucus canadensis	12		1	1	1		
	Rhus copallinum	2						
	Ilex opaca						1	
	Liriodendron tulipifera	1	1					
	Platanus occidentalis	51	3	1		1	1	
	Prunus	7	1				1	
	Acer negundo	5	7					
TOT:	**18**	**167**	**15**	**2**	**1**	**6**	**14**	

Table A3: Vegetation Damage by Species

	Species	All Damage Categories	(no damage)	Beaver	Deer	Diseased	Vine Strangulation
	Acer negundo	12	12				
	Alnus serrulata	13	13				
	Aronia arbutifolia	2	2				
	Betula nigra	2	2				
	Callicarpa americana	6	6				
	Cornus racemosa	18	18				
	Fraxinus pennsylvanica	29	27	2			
	Ilex opaca	1	1				
	Juglans nigra	7	7				
	Liriodendron tulipifera	2	2				
	Nyssa sylvatica	12	12				
	Platanus occidentalis	57	54	1	1	1	
	Prunus	9	9				
	Quercus alba	12	12				
	Rhus copallinum	2	2				
	Rhus glabra	4	4				
	Salix nigra	3	3				
	Sambucus canadensis	15	13				2
TOT:	**18**	**206**	**199**	**3**	**1**	**1**	**2**

Table A4: Vegetation Damage by Plot

	plot	All Damage Categories	(no damage)	Beaver	Deer	Diseased	Vine Strangulation
	056-01-0001-year:4	26	26				
	056-01-0002-year:4	44	44				
	056-01-0004-year:4	8	7				1
	056-01-0006-year:4	12	12				
	056-01-0007-year:4	16	16				
	056-01-0008-year:4	5	5				
	056-01-0011-year:4	22	22				
	056-01-0012-year:4	10	9			1	
	056-01-0013-year:4	8	8				
	056-01-0014-year:4	10	9		1		
	056-01-0015-year:4	6	6				
	056-01-0016-year:4	2	2				
	056-01-0019-year:4	6	6				
	056-01-0021-year:4	31	27	3			1
TOT:	**14**	**206**	**199**	**3**	**1**	**1**	**2**

Table A5: Stem Count by Plot and Species

	Species	Total Planted Stems	# plots	avg# stems	plot 056-01-0001-year:4	plot 056-01-0002-year:4	plot 056-01-0004-year:4	plot 056-01-0006-year:4	plot 056-01-0007-year:4	plot 056-01-0008-year:4	plot 056-01-0011-year:4	plot 056-01-0012-year:4	plot 056-01-0013-year:4	plot 056-01-0014-year:4	plot 056-01-0015-year:4	plot 056-01-0016-year:4	plot 056-01-0019-year:4	plot 056-01-0021-year:4
	Acer negundo	12	1	12														12
	Alnus serrulata	11	5	2.2	4				3		1		2	1				
	Betula nigra	2	2	1									1					1
	Callicarpa americana	3	2	1.5	2						1							
	Cornus racemosa	17	2	8.5		16						1						
	Fraxinus pennsylvanica	25	10	2.5		6	4	2	2	1	1	1	3	2				3
	Juglans nigra	7	3	2.33		5					1	1						
	Liriodendron tulipifera	2	2	1				1										1
	Nyssa sylvatica	9	4	2.25		3		3									2	1
	Platanus occidentalis	55	13	4.23	13	7	1	4	8	3	4	1		4	2	2	1	5
	Prunus	8	4	2								3		1	3			1
	Quercus alba	12	5	2.4	7	1					2	1	1					
	Rhus copallinum	2	2	1										1	1			
	Rhus glabra	3	2	1.5			1				2							
	Salix nigra	3	1	3					3									
	Sambucus canadensis	14	5	2.8		3	1				7	1						2
TOT:	**16**	**185**	**16**		**26**	**41**	**7**	**10**	**16**	**4**	**19**	**9**	**7**	**9**	**6**	**2**	**3**	**26**

Table A6: Vegetation Problem Areas

Little Bugaboo Creek EEP Project Number 00056				
Feature #	**Feature/Issue**	**Station # / Range**	**Probable Cause**	**Photo #**
VPA1	Poor survivability	0+00 to 5+60	Thick herbaceous vegetation	VPA1
VPA4	Bare bank	10+40 to 11+90	Scour	VPA4
VPA12	Bare bank	38+80	Scour	VPA12
VPA13	Bare bank	40+60	Beaver damage	VPA13
VPA14	Bare bank	61+60	Scour	VPA14
VPA15	Invasive/exotic plant	10+10	Chinese privet	VPA15
VPA16	Poor survivability	3+20	Beaver damage	VPA16
VPA17	Poor survivability	7+00	Beaver damage	VPA17
Little Bugaboo Creek EEP Project Number 00056				
UTVPA1	Bare bank	0+15	Scour	UTVPA1
UTVPA2	Bare bank	1+90 to 3+10	Scour	UTVPA2
UTVPA3	Bare bank	7+20 to 7+40	Scour	UTVPA3
UTVPA4	Bare bank	14+70 to 14+80	Scour	UTVPA4
UTVPA5	Poor survivability	15+05 to 20+00	Beaver damage	UTVPA5
UTVPA6	Invasive/exotic plant	16+00 to 16+80	Chinese privet	UTVPA6
UTVPA7	Invasive/exotic plant	18+60 to 18+90	Chinese privet	UTVPA7
UTVPA9	Invasive/exotic plant	8+90 to 9+40	Chinese privet	UTVPA9

Appendix A-II: Vegetation Problem Area Photos


VPA1 facing upstream (12/16/08)


VPA4 facing downstream (12/16/08)


VPA12 facing left bank (12/15/08)


VPA13 facing downstream (12/15/08)


VPA 14 facing left bank (12/15/08)


VPA15 facing left bank (9/4/08)

VPA16 facing upstream (12/16/08)

VPA17 facing downstream (12/16/08)


UTVPA1 facing downstream (12/15/08)


UTVPA2 facing downstream (12/15/08)


UTVPA3 facing right bank (9/4/08)


UTVPA4 facing left bank, upstream (9/4/08)


UTVPA5 on right bank (12/15/08)

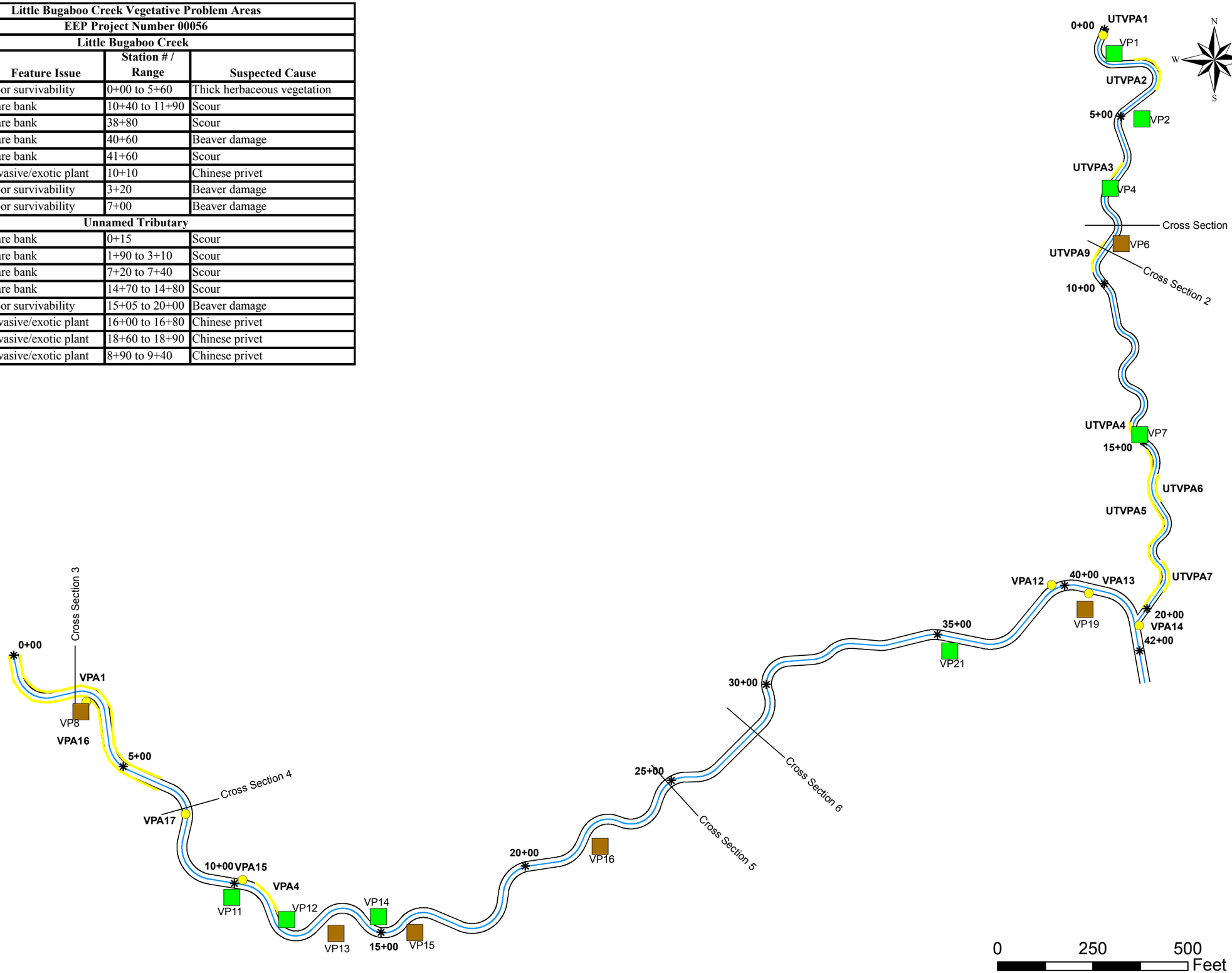

UTVPA6 on left bank (12/15/08)


UTVPA7 on left bank (12/15/08)


UTVPA9 on left bank (12/15/08)

Appendix A-III: Vegetation Current Condition Plan View

Little Bugaboo Creek Vegetative Problem Areas			
EEP Project Number 00056			
Little Bugaboo Creek			
Feature #	**Feature Issue**	**Station # / Range**	**Suspected Cause**
VPA1	Poor survivability	0+00 to 5+60	Thick herbaceous vegetation
VPA4	Bare bank	10+40 to 11+90	Scour
VPA12	Bare bank	38+80	Scour
VPA13	Bare bank	40+60	Beaver damage
VPA14	Bare bank	41+60	Scour
VPA15	Invasive/exotic plant	10+10	Chinese privet
VPA16	Poor survivability	3+20	Beaver damage
VPA17	Poor survivability	7+00	Beaver damage
Unnamed Tributary			
UTVPA1	Bare bank	0+15	Scour
UTVPA2	Bare bank	1+90 to 3+10	Scour
UTVPA3	Bare bank	7+20 to 7+40	Scour
UTVPA4	Bare bank	14+70 to 14+80	Scour
UTVPA5	Poor survivability	15+05 to 20+00	Beaver damage
UTVPA6	Invasive/exotic plant	16+00 to 16+80	Chinese privet
UTVPA7	Invasive/exotic plant	18+60 to 18+90	Chinese privet
UTVPA9	Invasive/exotic plant	8+90 to 9+40	Chinese privet



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Prepared For:
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Enhancement Program

Ecosystem Enhancement PROGRAM

Project:
Little Bugaboo Creek
Stream Restoration
Wilkes County, NC

Monitoring Year:
4 (2008)

Project Number:
00056

Date:
February 2009

Legend
- Problem Area Concern
- Problem Area Concern
- Stations
- Cross Sections
- As-built Centerline
- As-built Streambank
- Vegetation Plot Meeting Success Criteria
- Vegetation Plot Not Meeting Success Criteria

Vegetation
Current Condition
Plan View

Appendix A-IV: Vegetation Monitoring Plot Photos


VP1


VP2


VP4


VP6


VP7


VP8


VP11


VP12


VP13


VP14


VP15


VP16

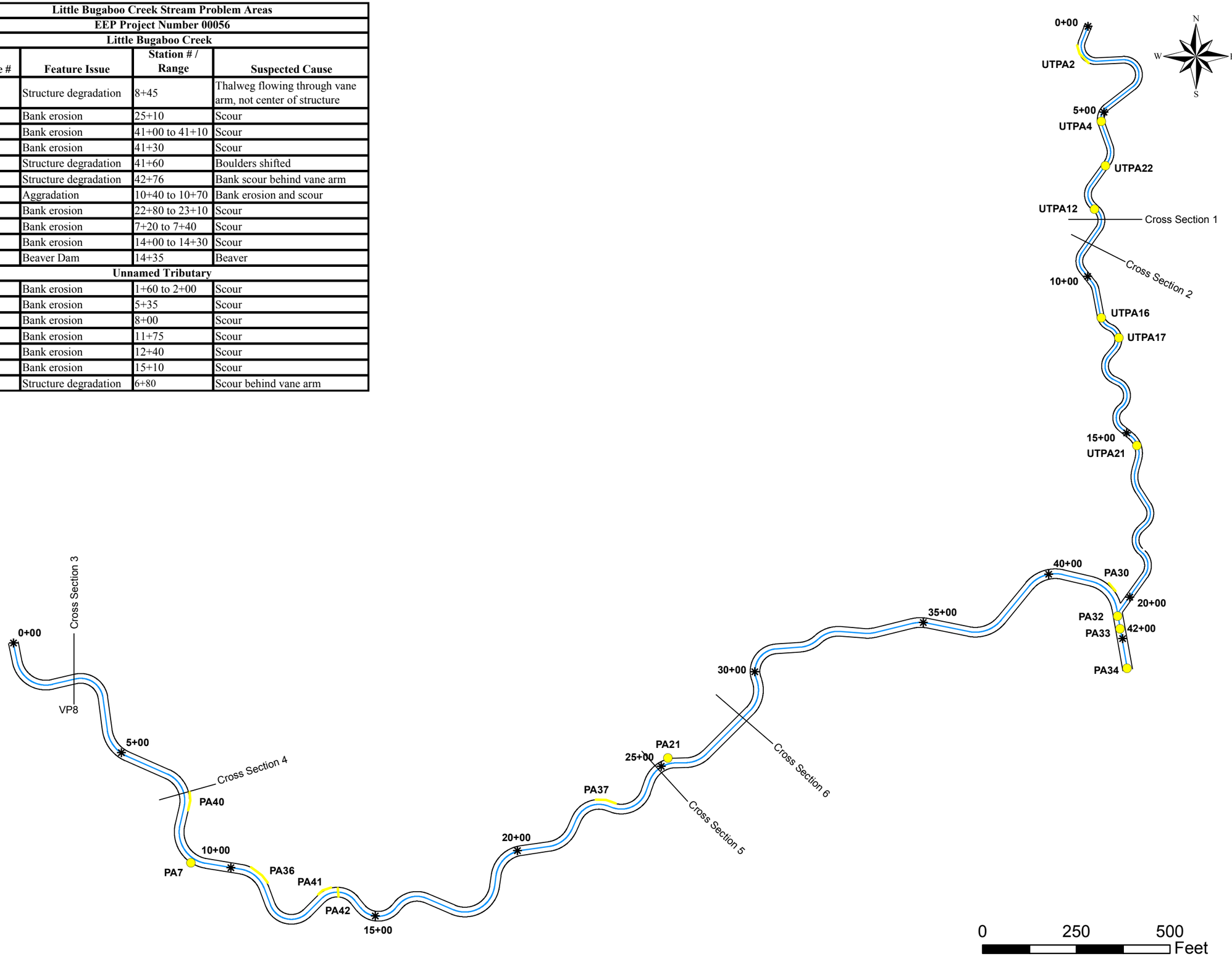
VP19

VP21

Appendix B: Geomorphic Raw Data

Appendix B-I: Stream Current Condition Plan View

Little Bugaboo Creek Stream Problem Areas			
EEP Project Number 00056			
Little Bugaboo Creek			
Feature #	**Feature Issue**	**Station # / Range**	**Suspected Cause**
PA7	Structure degradation	8+45	Thalweg flowing through vane arm, not center of structure
PA21	Bank erosion	25+10	Scour
PA30	Bank erosion	41+00 to 41+10	Scour
PA32	Bank erosion	41+30	Scour
PA33	Structure degradation	41+60	Boulders shifted
PA34	Structure degradation	42+76	Bank scour behind vane arm
PA36	Aggradation	10+40 to 10+70	Bank erosion and scour
PA37	Bank erosion	22+80 to 23+10	Scour
PA40	Bank erosion	7+20 to 7+40	Scour
PA41	Bank erosion	14+00 to 14+30	Scour
PA42	Beaver Dam	14+35	Beaver
Unnamed Tributary			
UTPA2	Bank erosion	1+60 to 2+00	Scour
UTPA4	Bank erosion	5+35	Scour
UTPA12	Bank erosion	8+00	Scour
UTPA16	Bank erosion	11+75	Scour
UTPA17	Bank erosion	12+40	Scour
UTPA21	Bank erosion	15+10	Scour
UTPA22	Structure degradation	6+80	Scour behind vane arm



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Enhancement Program

Project:
Little Bugaboo Creek
Stream Restoration
Wilkes County, NC

Monitoring Year:
4 (2008)

Project Number:
00056

Date:
February 2009

Legend
- Problem Area Concern
- Problem Area Concern
- Stations
- Cross Sections
- As-built Centerline
- As-built Streambank

Stream
Current Condition
Plan View

Appendix B-II: Stream Problem Areas Data Table

Table B1: Stream Problem Areas

Little Bugaboo Creek EEP Project Number 00056				
Feature #	**Feature/Issue**	**Station # / Range**	**Probable Cause**	**Photo #**
PA7	Structure degradation	8+45	Thalweg flowing through vane arm, not center of structure	PA7
PA21	Bank erosion	25+10	Scour	PA21
PA30	Bank erosion	41+00 to 41+10	Scour	PA30
PA32	Bank erosion	41+30	Scour	PA32
PA33	Structure degradation	41+60	Boulders shifted	PA33
PA34	Structure degradation	42+76	Bank scour behind vane arm	PA34
PA36	Aggradation	10+40 to 10+70	Bank erosion and scour	PA36
PA37	Bank erosion	22+80 to 23+10	Scour	PA37
PA40	Bank erosion	7+20 to 7+40	Scour	PA40
PA41	Bank erosion	14+00 to 14+30	Scour	PA41
PA42	Beaver dam	14+35	Beaver	PA42
Unnamed Tributary EEP Project Number 00056				
UTPA2	Bank erosion	1+60 to 2+00	Scour	UTPA2
UTPA4	Bank erosion	5+35	Scour	UTPA4
UTPA12	Bank erosion	8+00	Scour	UTPA12
UTPA16	Bank erosion	11+75	Scour	UTPA16
UTPA17	Bank erosion	12+40	Scour	UTPA17
UTPA21	Bank erosion	15+10	Scour	UTPA21
UTPA22	Structure degradation	6+80	Scour behind vane arm	UTPA22

Appendix B-III: Representative Stream Problem Area Photos

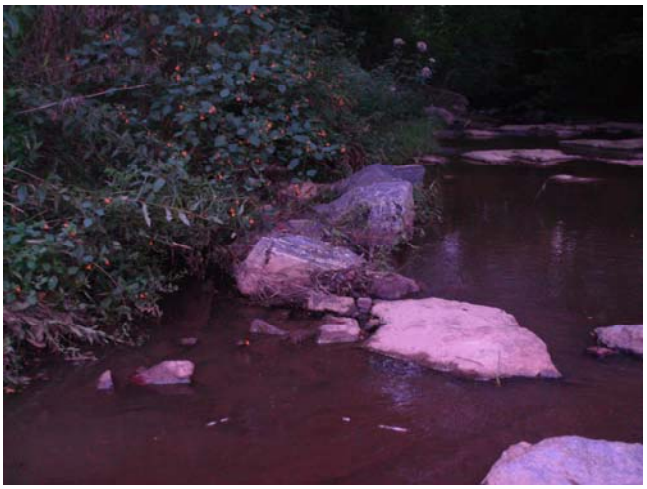

PA7 facing downstream


PA21 facing upstream


PA30 facing upstream


PA32 facing downstream


PA33 facing downstream


PA34 facing downstream (9/4/08)


PA36 facing downstream


PA37 facing left bank, downstream


PA40 facing upstream


PA41 facing left bank


PA42 facing upstream


UTPA2 facing downstream


UTPA4 facing right bank


UTPA12 facing downstream


UTPA16 facing downstream


UTPA17 facing downstream


UTPA21 facing downstream

UTPA22 facing downstream

Appendix B-IV: Stream Photo Station Photos


P655 facing downstream


P657 facing upstream


P661 facing downstream


P667 facing upstream


P673 facing downstream


P676 facing downstream


P679 facing downstream


P681 facing upstream


P687 facing downstream


P693 facing downstream


P741 facing downstream


P745 facing upstream


P703 facing downstream


P706 facing upstream


P718 facing downstream


P723 facing upstream


P728 facing upstream

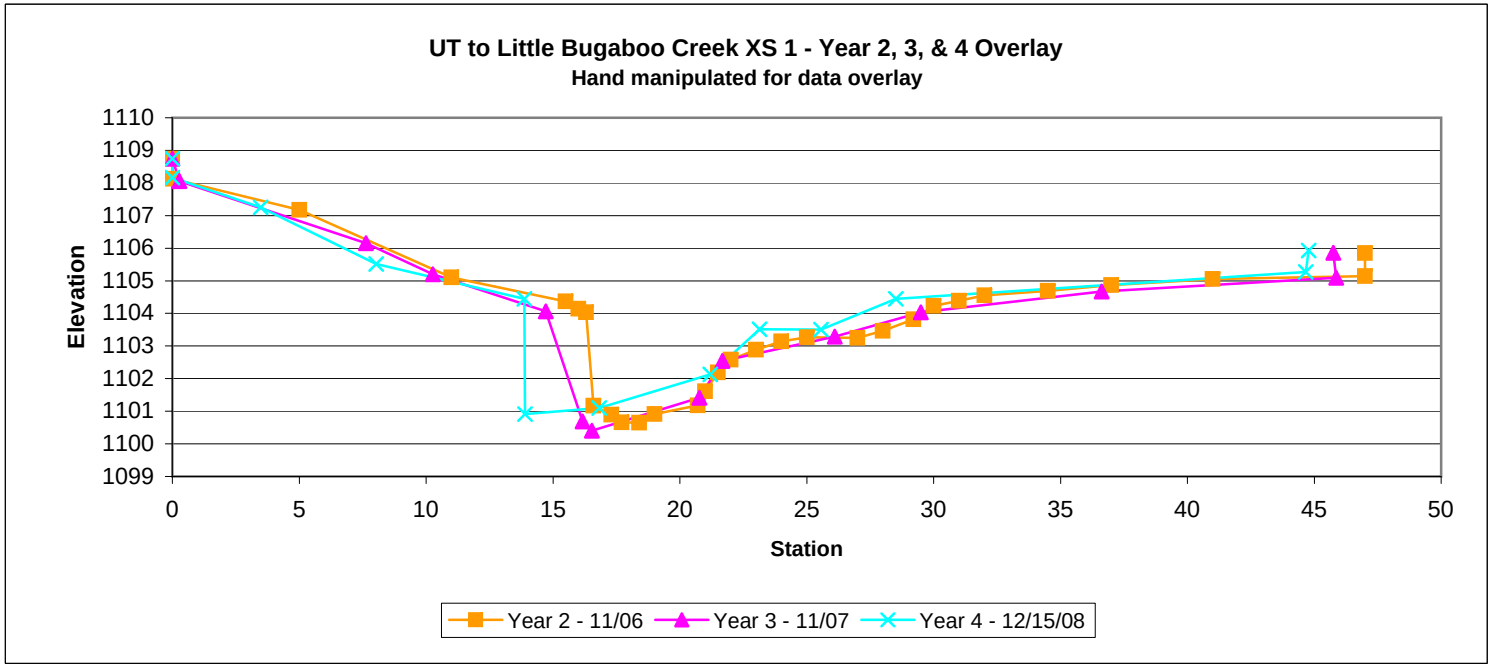
Appendix B-V: Visual Morphological Stability Assessment Table

Table B2: Visual Morphological Stability Assessment

Little Bugaboo Creek EEP Project Number 00056						
Feature Category	Metric (per As-built and reference baselines)	(# stable) Number performing as Intended	Total Number per As-Built	Total number/feet in unstable state	% perform in stable condition	Feature perform. Mean or total
A. Riffles	Present?	24	27	N/A	89	
	Armor stable (no displacement)?	25	27	N/A	93	
	Facet grade appears stable?	27	27	N/A	100	
	Minimal evidence of embedding/fining?	25	27	N/A	93	
	Length appropriate?	25	27	N/A	93	
						94
B. Pools	Present (not subject to severe aggrad. or migration)?	44	49	N/A	90	
	Sufficiently deep (max pool D:mean Bkf >1.6)	44	49	N/A	90	
	Length appropriate?	44	49	N/A	88	
						89
C. Thalweg	Upstream of meander bend (run/inflection) centering?	45	49	N/A	92	
	Downstream of meander (glide/inflection) centering?	45	49	N/A	92	
						92
D. Meanders	Outer bend in state of limited/controlled erosion?	25	49	N/A	51	
	Of those eroding, # w/concomitant point bar formation?	25	49	N/A	51	
	Apparent Rc within spec?	25	49	N/A	51	
	Sufficient floodplain access and relief?	25	49	N/A	51	
						51
E. Bed General	General channel bed aggradation areas (bar formation)	4076	4276	8/200	95	
	Channel bed degradation–areas of increasing downcutting/headcutting?	4076	4276	8/200	95	
						95
F. Bank	Actively eroding, wasting, or slumping bank	7952	8552	12/600	93	
						93
G. Vanes	Free of back or arm scour?	16	19	N/A	84	
	Height appropriate?	19	19	N/A	100	
	Angle and geometry appear appropriate?	19	19	N/A	100	
	Free of piping or other structural failures?	16	19	N/A	84	
						92
H. Wads/ Boulders	Free of scour?	20	26	N/A	77	
	Footing stable?	22	26	N/A	85	
						81

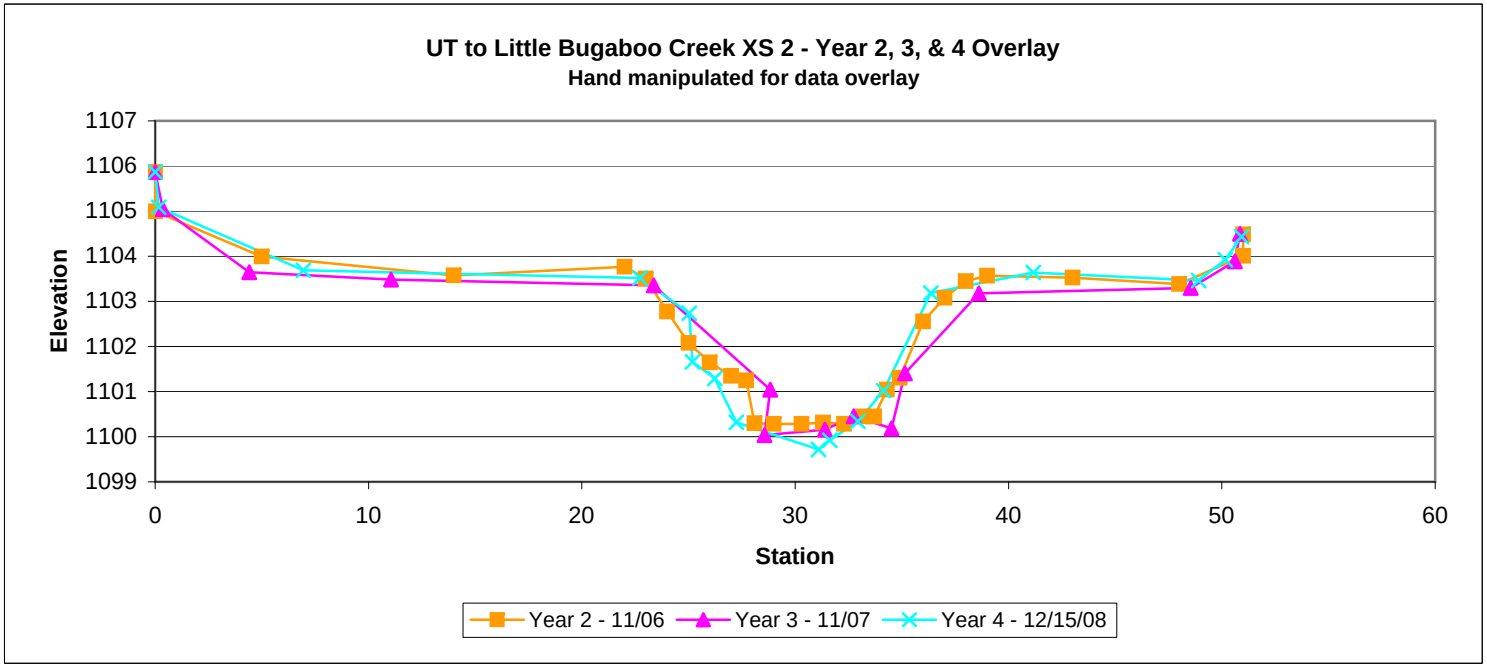
Unnamed Tributary EEP Project Number 00056						
Feature Category	Metric (per As-built and reference baselines)	(# stable) Number performing as Intended	Total Number per As-Built	Total number/feet in unstable state	% perform in stable condition	Feature perform. Mean or total
A. Riffles	Present?	20	12	N/A	100	
	Armor stable (no displacement)?	20	12	N/A	100	
	Facet grade appears stable?	20	12	N/A	100	
	Minimal evidence of embedding/fining?	20	12	N/A	100	
	Length appropriate?	20	12	N/A	100	
						100
B. Pools	Present (not subject to severe aggrad. or migration)?	30	30	N/A	100	
	Sufficiently deep (max pool D:mean Bkf >1.6)	30	30	N/A	100	
	Length appropriate?	30	30	N/A	100	
						100
C. Thalweg	Upstream of meander bend (run/inflection) centering?	9	9	N/A	100	
	Downstream of meander (glide/inflection) centering?	9	9	N/A	100	
						100
D. Meanders	Outer bend in state of limited/controlled erosion?	11	16	N/A	69	
	Of those eroding, # w/concomitant point bar formation?	14	16	N/A	88	
	Apparent Rc within spec?	12	16	N/A	75	
	Sufficient floodplain access and relief?	16	16	N/A	100	
						83
E. Bed General	General channel bed aggradation areas (bar formation)	2243	1954	0	100	
	Channel bed degradation–areas of increasing downcutting/headcutting?	2243	1954	0	100	
						100
F. Bank	Actively eroding, wasting, or slumping bank	3308	3908	10/600	85	
						85
G. Vanes	Free of back or arm scour?	15	16	N/A	94	
	Height appropriate?	16	16	N/A	100	
	Angle and geometry appear appropriate?	16	16	N/A	100	
	Free of piping or other structural failures?	15	16	N/A	94	
						97
H. Wads/ Boulders	Free of scour?	18	18	N/A	100	
	Footing stable?	18	18	N/A	100	
						100

Appendix B-VI: Cross Section Photos and Plots



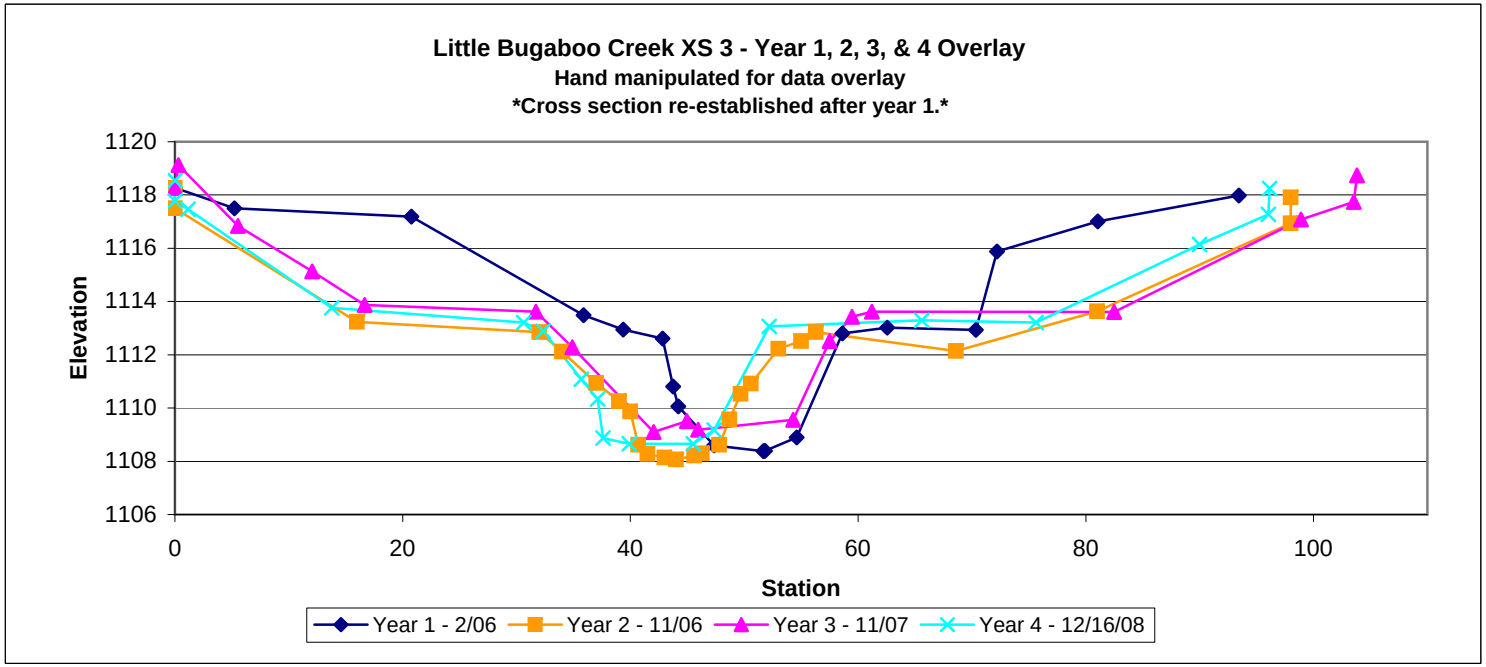
Facing Left Bank

Facing Right Bank



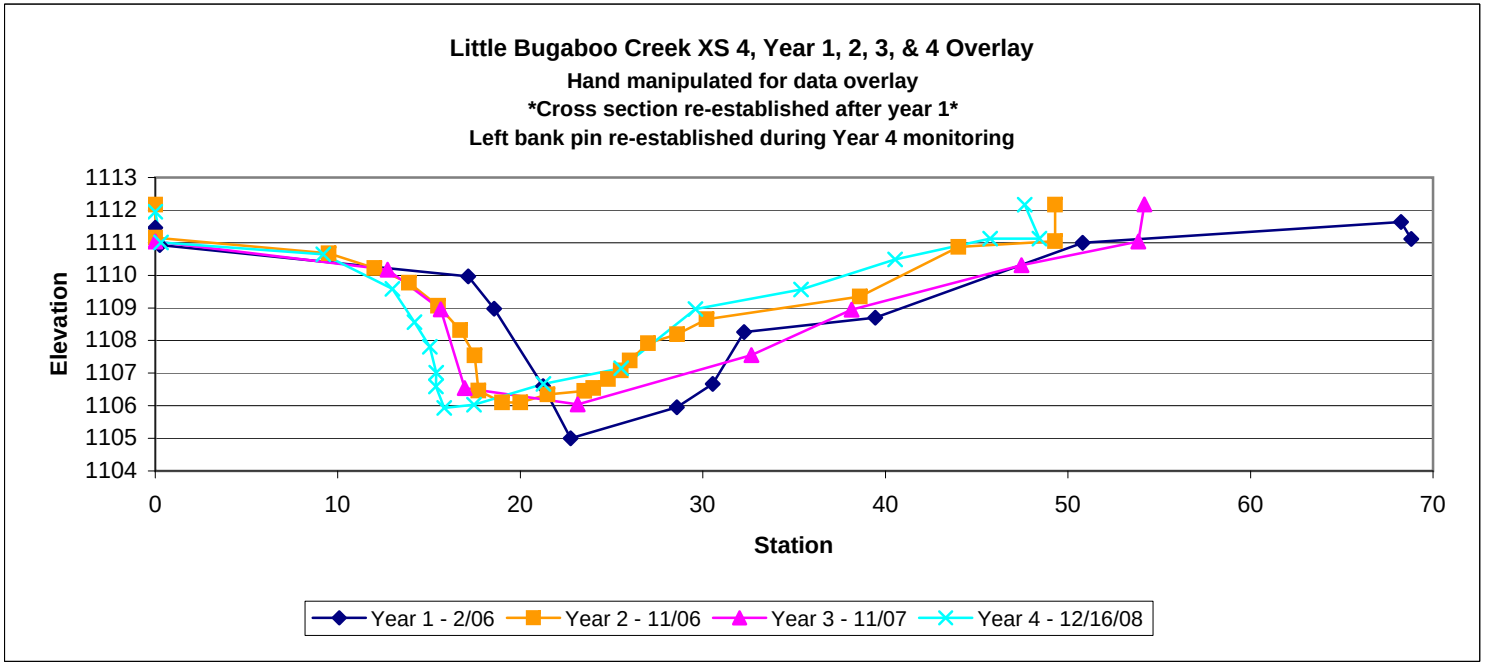
Facing Left Bank

Facing Right Bank



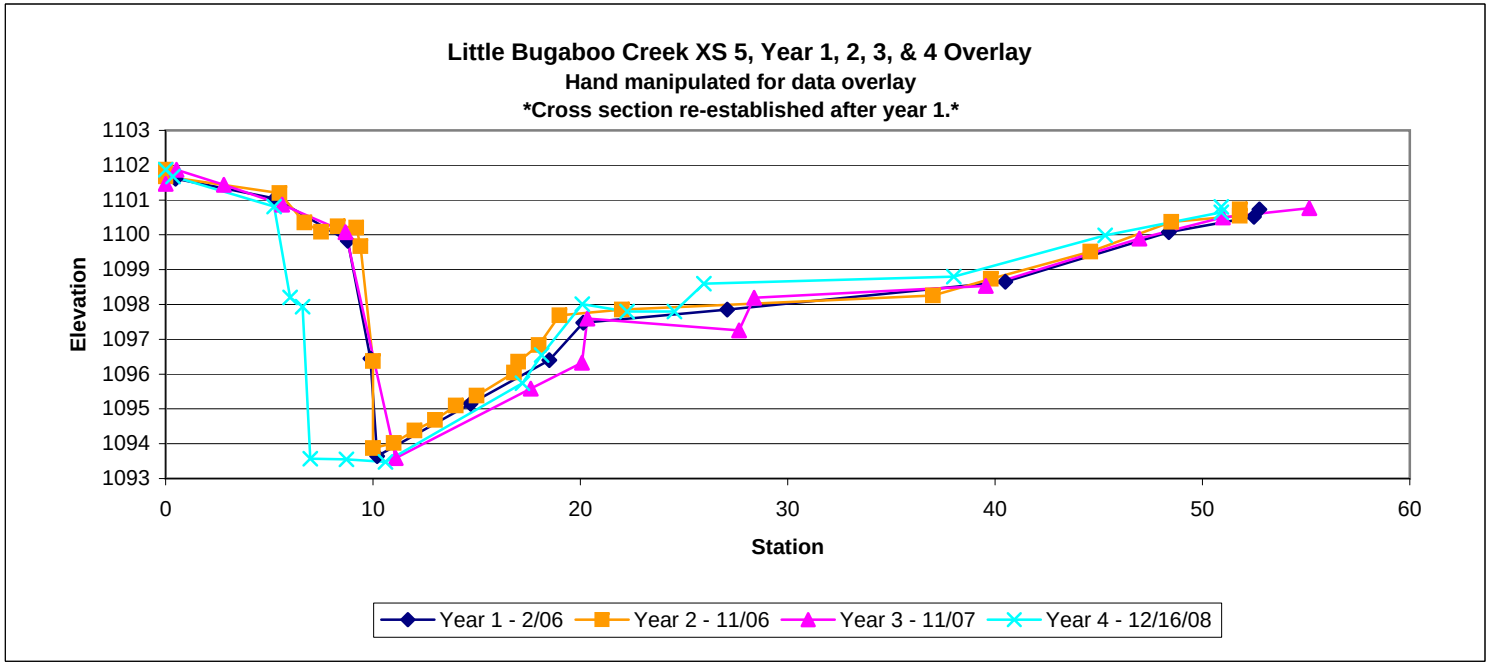
Facing Left Bank

Facing Right Bank



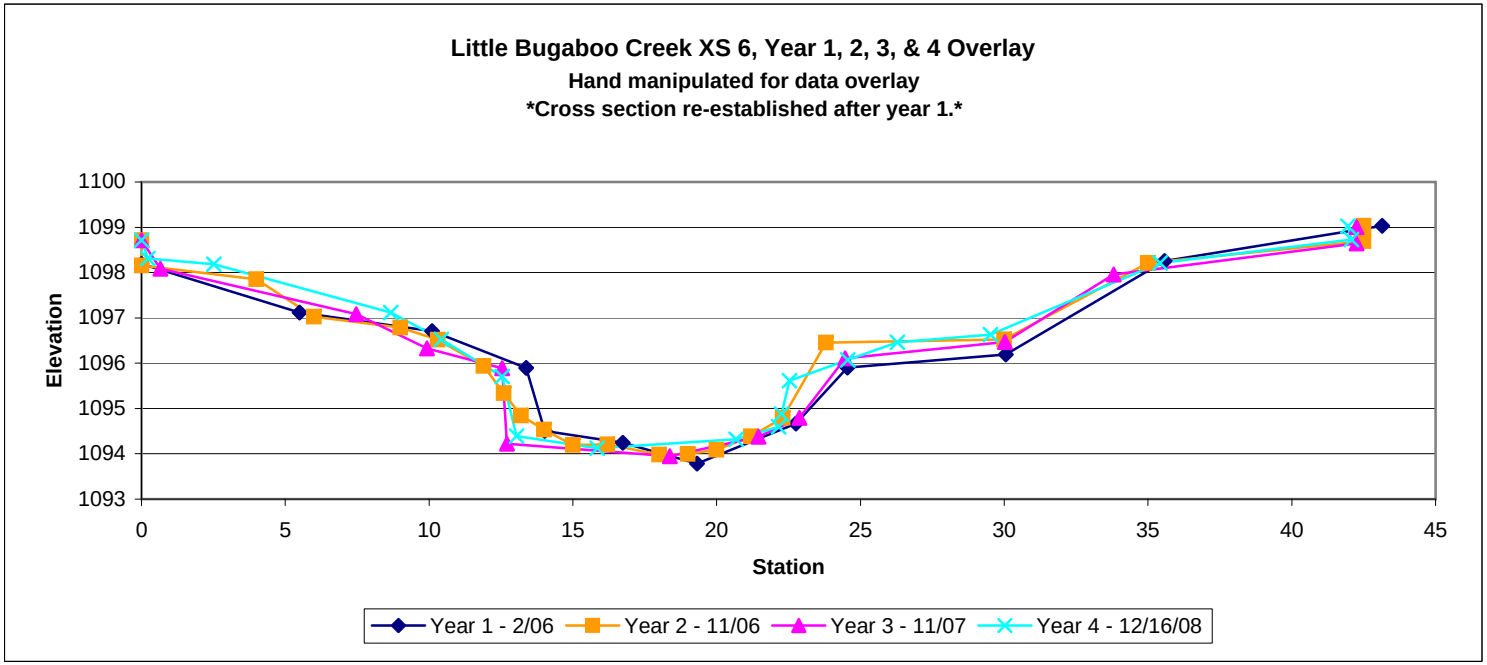
Facing Left Bank

Facing Right Bank



Facing Left Bank

Facing Right Bank



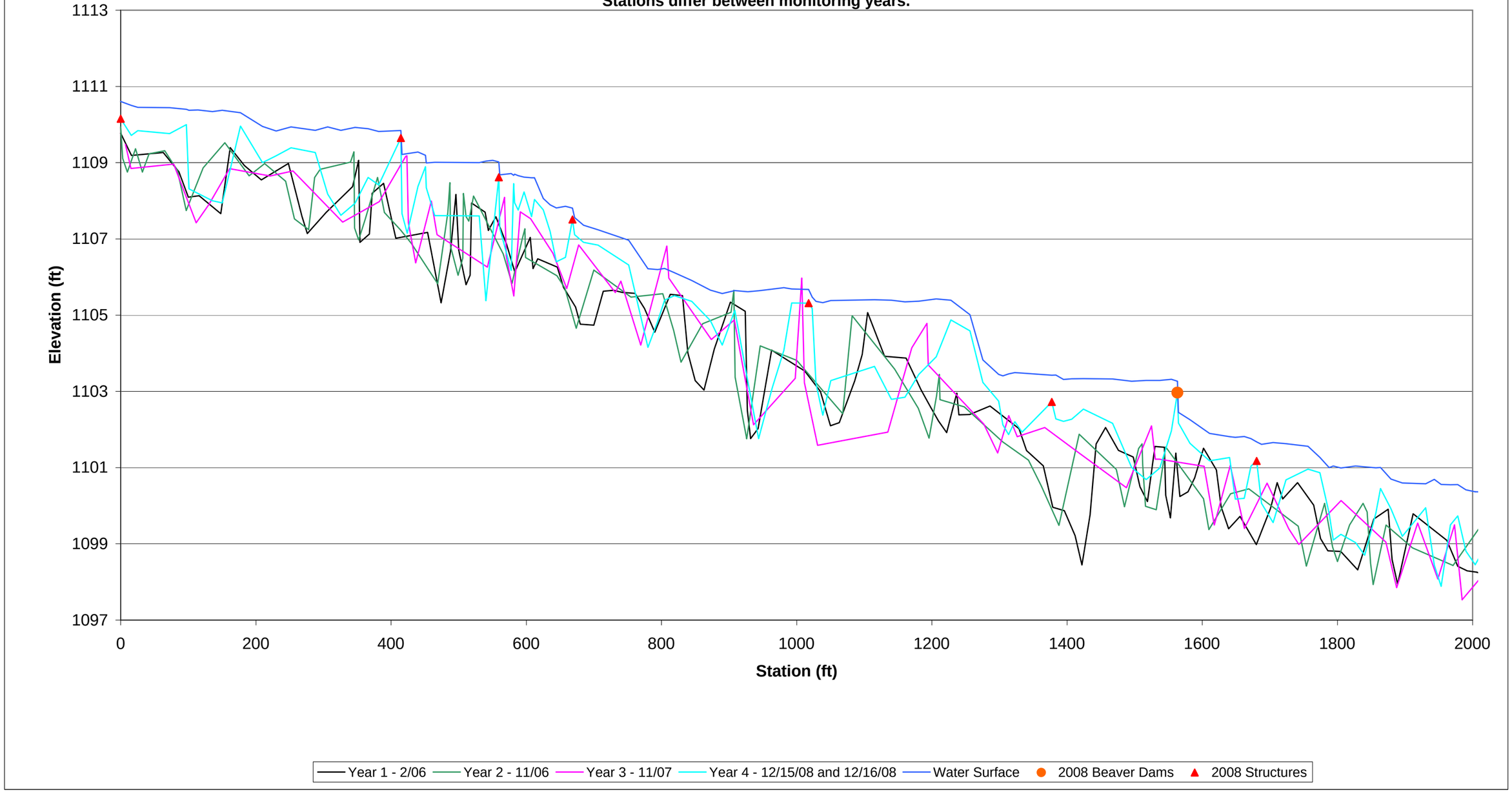
Facing Left Bank

Facing Right Bank

Appendix B-VII: Longitudinal Plot

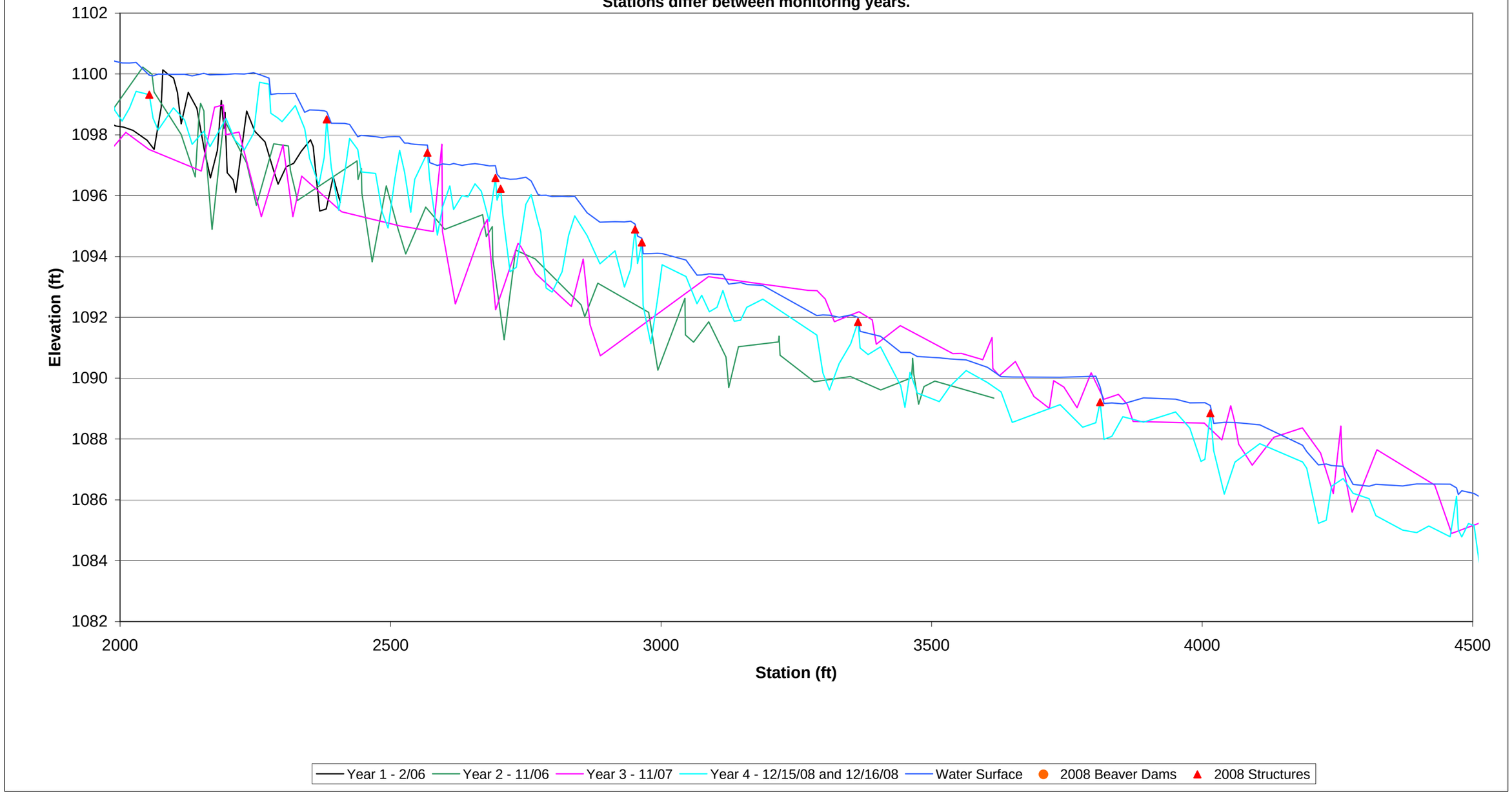
Little Bugaboo Creek - Year 1, 2, 3, & 4 Overlay (0-2000)

Hand manipulated for data overlay.
Stations differ between monitoring years.



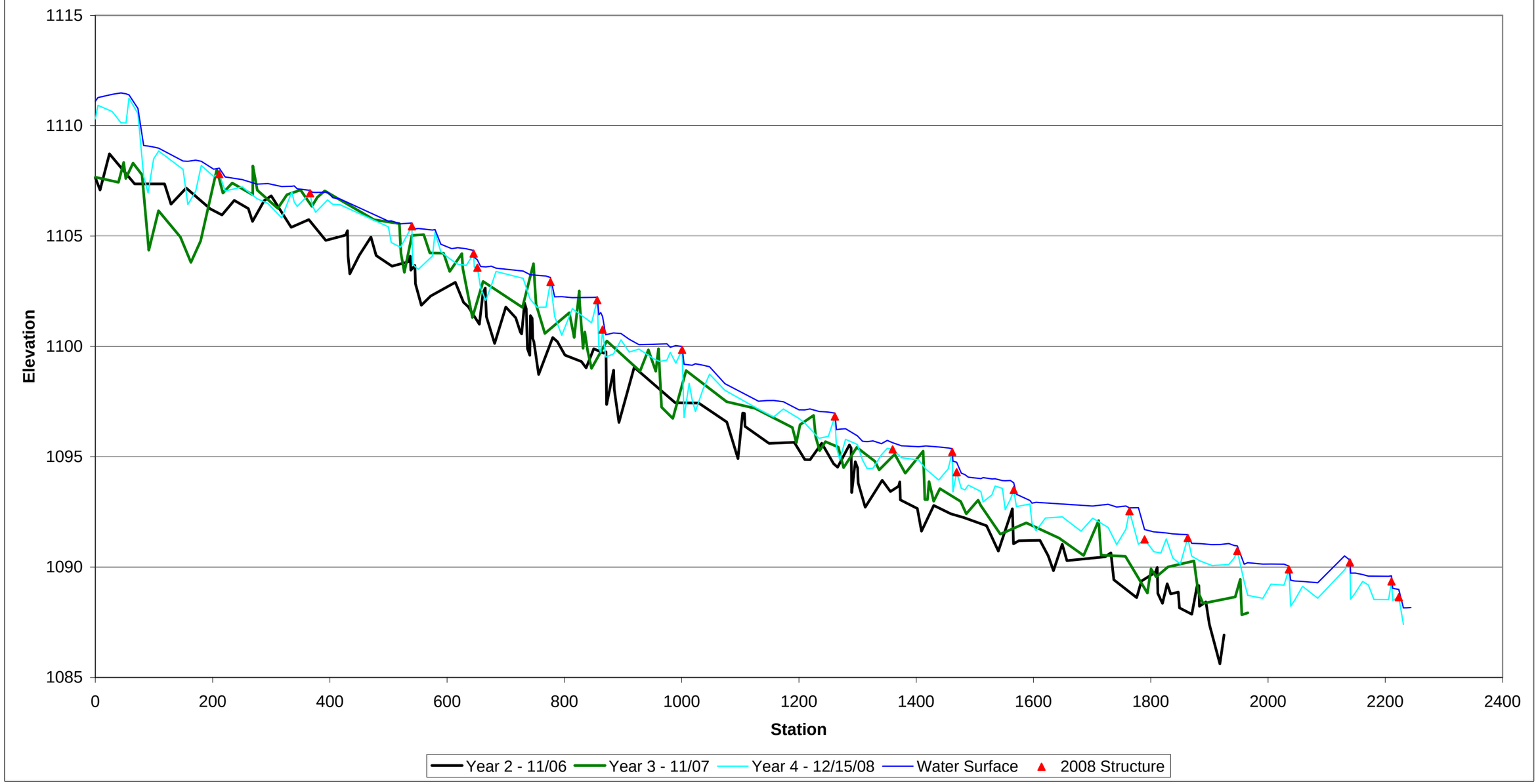
Little Bugaboo Creek - Year 1, 2, 3, & 4 Overlay (2000-4500)

Hand manipulated for data overlay.
Stations differ between monitoring years.



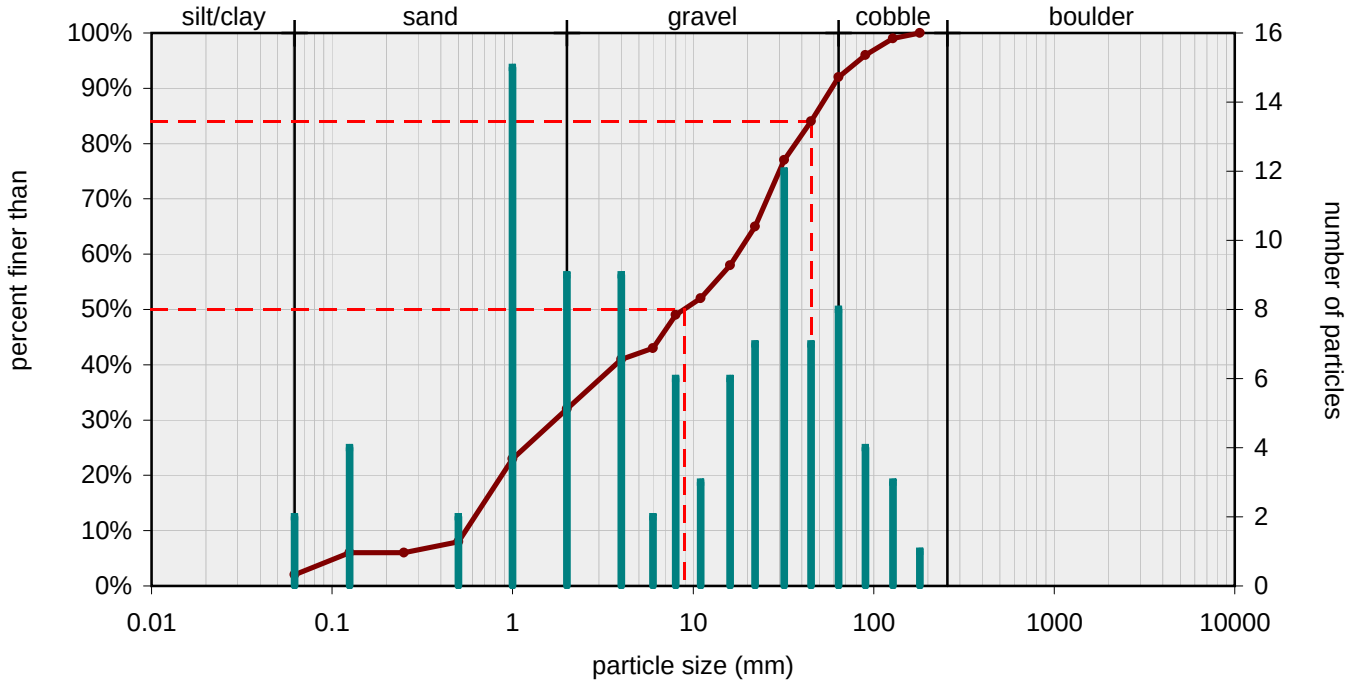
UT to Little Bugaboo Creek - Year 2, 3, & 4 Overlay

Hand manipulated for data overlay



Appendix B-VIII: Pebble Count Frequency Distribution Plots

Bed Surface Pebble Count, UT to Little Bugaboo Creek

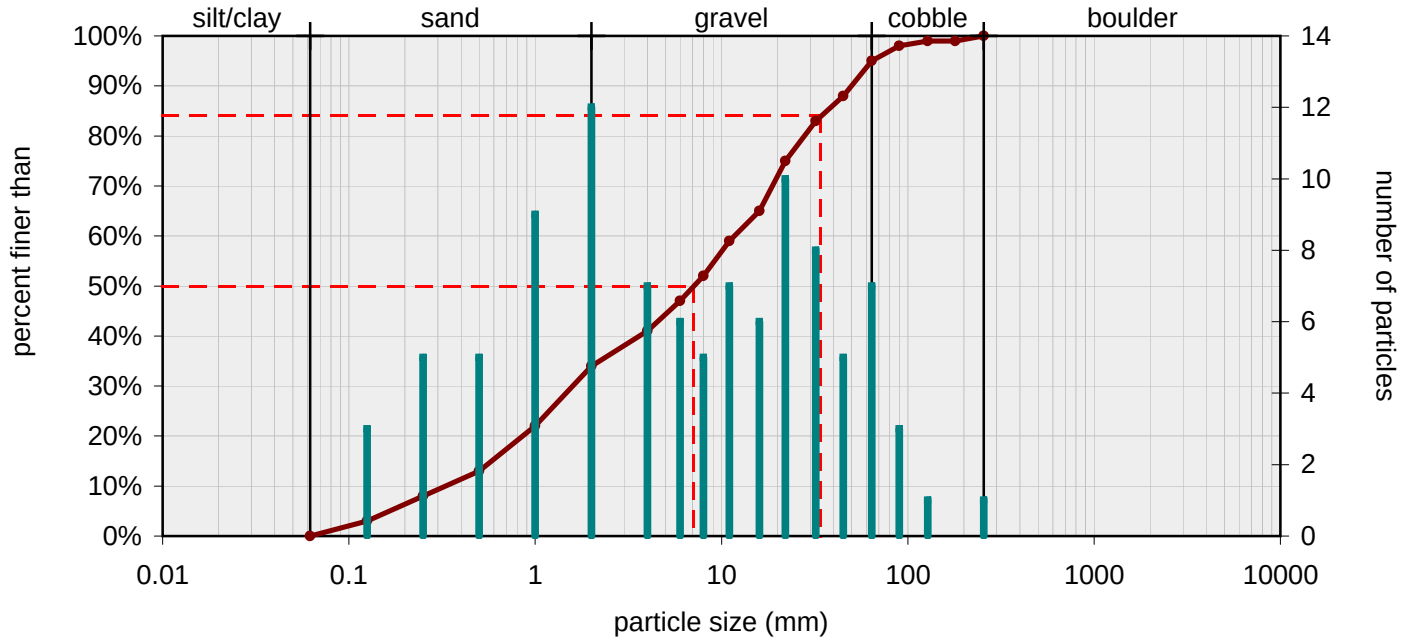


Size (mm)	
D16	0.72
D35	2.5
D50	8.9
D65	22
D84	45
D95	83

Size Distribution	
mean	5.7
dispersion	8.7
skewness	-0.14

Type	
silt/clay	2%
sand	30%
gravel	60%
cobble	8%
boulder	0%

Riffle Surface Pebble Count, UT to Little Bugaboo Creek

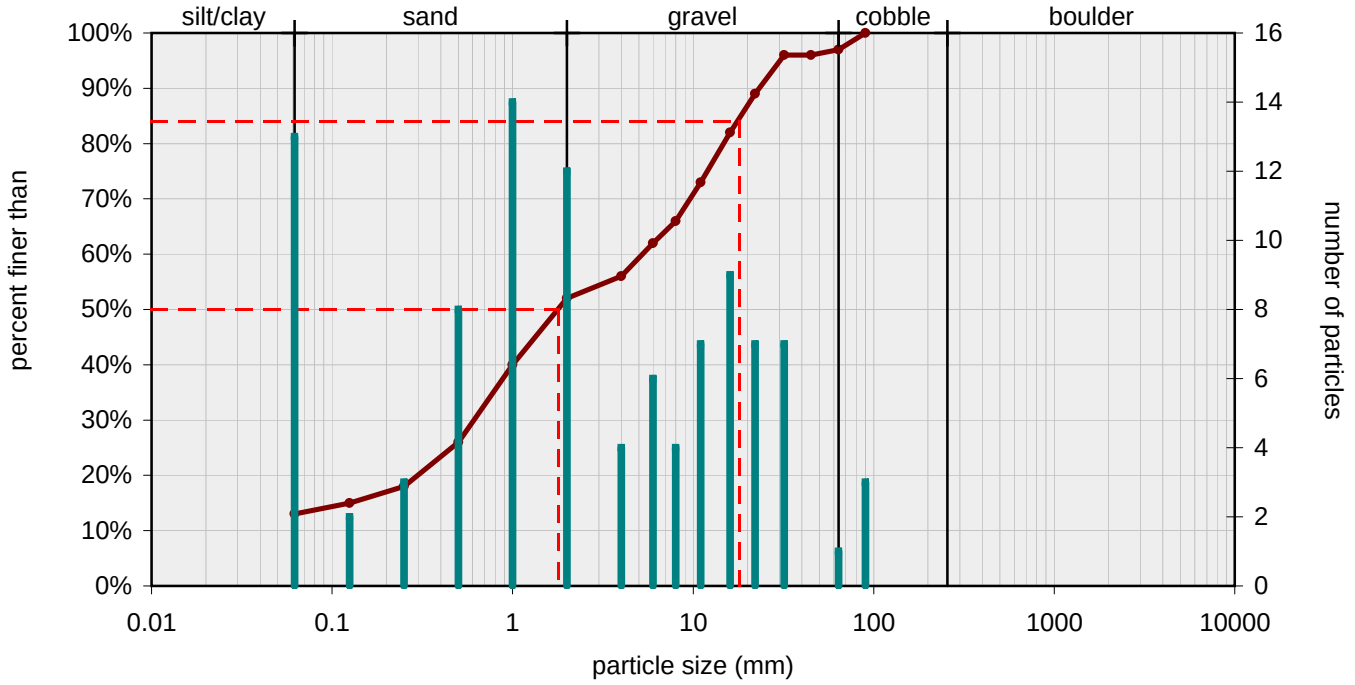


Size (mm)		
D16	0.63	3.4
D35	2.2	12
D50	7.1	17
D65	16	20
D84	34	29
D95	64	39

Size Distribution	
mean	4.6
dispersion	8.0
skewness	-0.14

Type	
silt/clay	0%
sand	34%
gravel	61%
cobble	5%
boulder	0%

Riffle Surface Pebble Count, Little Bugaboo Creek

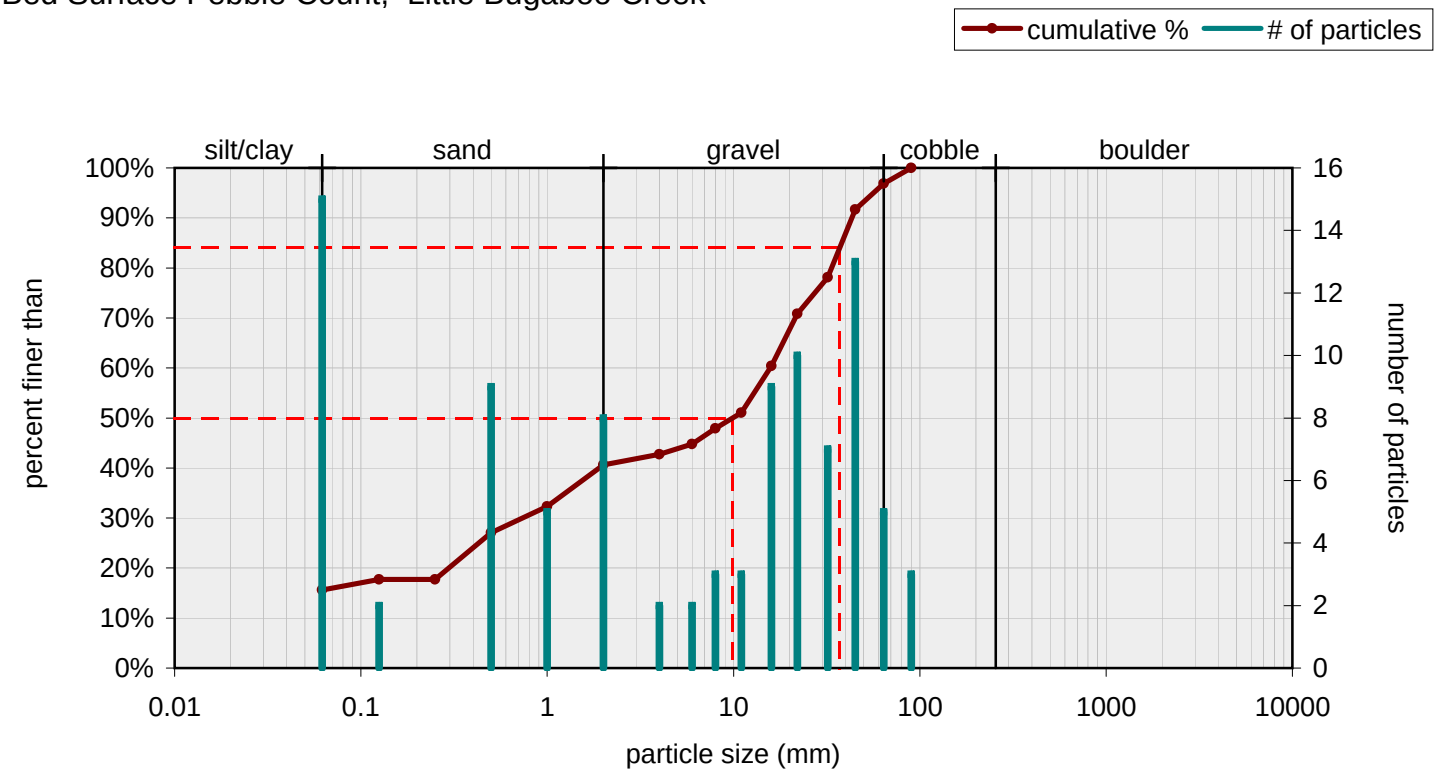


Size (mm)	
D16	0.16
D35	0.78
D50	1.8
D65	7.4
D84	18
D95	30

Size Distribution	
mean	1.7
dispersion	10.6
skewness	-0.02

Type	
silt/clay	13%
sand	39%
gravel	45%
cobble	3%
boulder	0%

Bed Surface Pebble Count, Little Bugaboo Creek

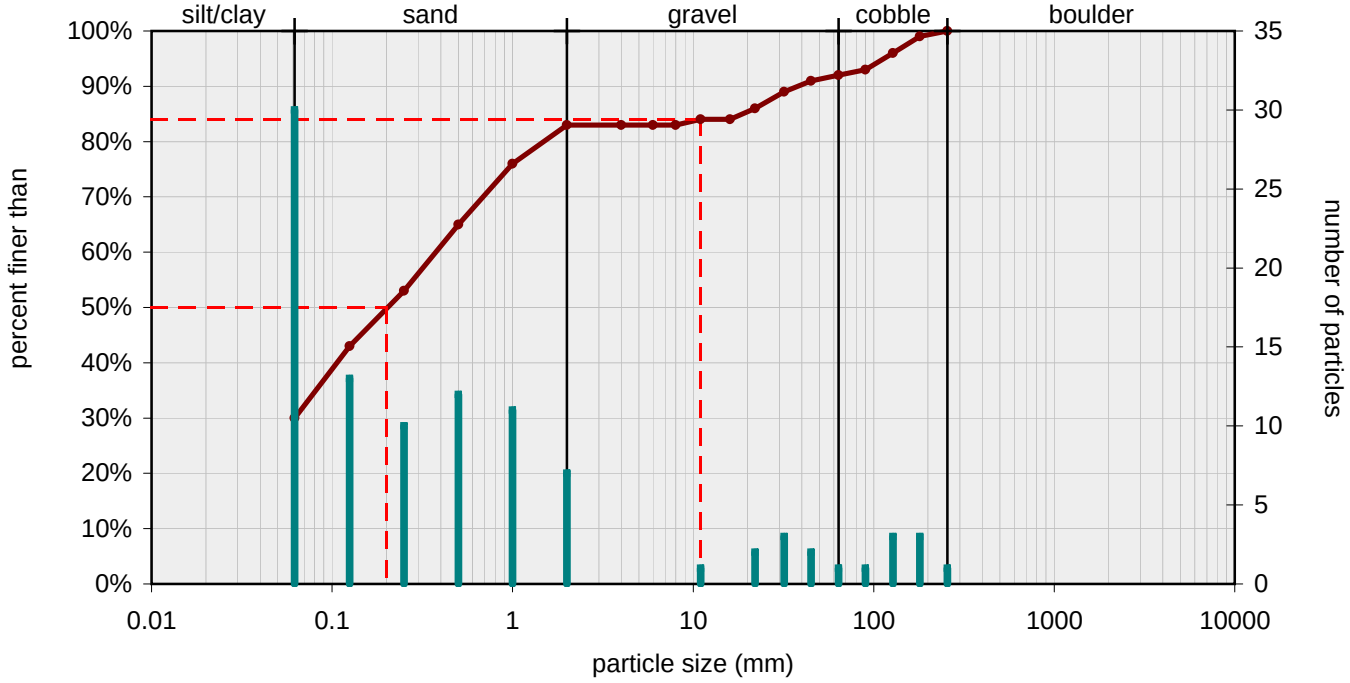


Size (mm)		
D16	0.07	3.4
D35	1.3	12
D50	9.9	17
D65	18	20
D84	37	29
D95	56	39

Size Distribution	
mean	1.6
dispersion	72.6
skewness	-0.48

Type	
silt/clay	16%
sand	25%
gravel	56%
cobble	3%
boulder	0%

Bed Surface Pebble Count, Little Bugaboo Creek

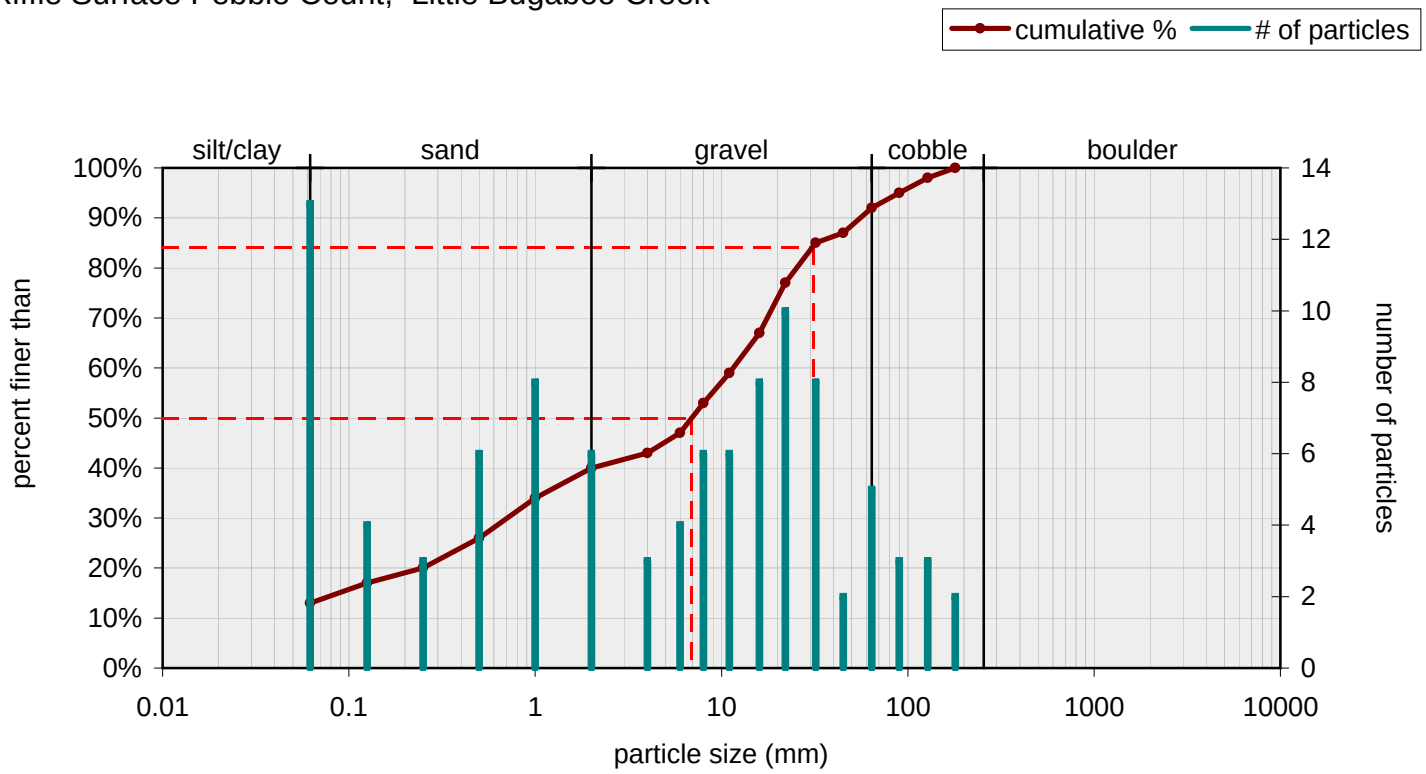


Size (mm)	
D16	0.062
D35	0.081
D50	0.2
D65	0.5
D84	11
D95	110

Size Distribution	
mean	0.8
dispersion	29.1
skewness	0.41

Type	
silt/clay	30%
sand	53%
gravel	9%
cobble	8%
boulder	0%

Riffle Surface Pebble Count, Little Bugaboo Creek



Size (mm)		
D16	0.1	3.4
D35	1.1	12
D50	6.9	17
D65	15	20
D84	31	29
D95	90	39

Size Distribution	
mean	1.8
dispersion	36.7
skewness	-0.38

Type	
silt/clay	13%
sand	27%
gravel	52%
cobble	8%
boulder	0%