

STILLHOUSE CREEK STREAM RESTORATION – Project # 363
Second Annual Monitoring Report –Final
January 2009



Submitted to:



North Carolina Department of
Environment and Natural Resources
Ecosystem Enhancement Program
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Raleigh, NC 27699-1652

Designed by:

United States Department of Agriculture
Natural Resources Conservation Services (NRCS)

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Second Annual Monitoring Report –Final

CONDUCTED FOR THE NORTH CAROLINA DEPARTMENT OF ENVIRONMENT
AND NATURAL RESOURCES

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I. Executive Summary/Project Abstract

Located in the historic district of Hillsborough, North Carolina, the Stillhouse Creek stream restoration project was designed and built through the combined efforts of the North Carolina Ecosystem Enhancement Program (NCEEP, formerly North Carolina Wetlands Restoration Program), the Orange County Soil and Water Conservation District (SWCD), Natural Resources Conservation Service (NRCS), and Orange County. It restores 1,210 feet of Stillhouse Creek from south of Margaret Lane to its confluence with the Eno River. The area placed under conservation easement occupies 2.09 acres in USGS HUC 03020201030020 (NCDWQ Neuse River Subbasin 03-04-01). Construction was completed during March 2006.

Qualitative evaluation was conducted by RJG&A on 1 May 2008. The last 2008 visit to the Stillhouse Creek site was on 20 October.

The 2008 evaluation and monitoring of the Stillhouse Creek stream restoration site indicates that the project has met all its design goals after the second post-construction growing season.

Qualitative evidence of bankfull flow was observed during the August 2008 data collection. The crest gauge indicated that at least one more bankfull event had occurred in 2008. NC CRONOS indicate that bankfull events may have occurred in 2008 after rainfall events on March 4, July 5, August 28, September 6, and September 26 (NC CRONOS 2009). The project, therefore, has met its hydrologic goals for 2008.

The four vegetation monitoring plots were monitored during August 2008. The second annual vegetation monitoring results indicate that the Stillhouse Creek Stream Restoration Project has exceeded its vegetation restoration goal of 320 stems per acre by 14 percent (planted woody stem average = 364 per acre) and 384 percent (all woody stem average = 1,548).

II. Project Background

2.1. Project Objectives

RJG&A has never received a full copy of the restoration plan, but according to the brief description in the 2005 Erosion and Sediment Control Plan, the Stillhouse Creek Restoration Project was designed to achieve the following goals and objectives:

- Reduce stream bank erosion and prevent downcutting by restoring degraded, incised stream to stable, referenced condition
- Prevent stream erosion from continuing to threaten existing building foundation located near the head of the stream by implementing natural stream design restoration
- Improve retention of nutrients by restoring woody vegetation to riparian buffer
- Increase environmental education opportunities within a park setting

- Improve wildlife habitat within the conservation easement area and in-stream
- Enhance habitat for wetland dependent plants and animals by use of shallow wetland habitat areas in the floodplain
- Improve water quality by providing temporary stormwater storage in shallow wetland habitat areas in the floodplain
- Improve aesthetics of stream corridor

2.2. Structure, Restoration Type, and Approach

According to the Erosion and Sediment Control Plan for the Stillhouse Creek Stream Restoration Project, the following changes were made to the creek (NRCS 2003). A priority 2 stream restoration approach was on the upper 235 feet of Stillhouse Creek to restore the degraded, incised channel to a stable channel with a floodplain in a confined valley. A priority 1 stream restoration was used on the next 400 foot reach (stationing 235-635). A new channel was constructed in this reach to restore the pattern, profile, and dimension. A priority 4 stream enhancement 1 approach was used for the third reach (stationing 635-855) to enhance existing stream features, including the stabilization of eroding stream banks. A priority 3 stream restoration was used for the final 345 feet (stationing 855-1200) to construct a bankfull bench in a confined valley.

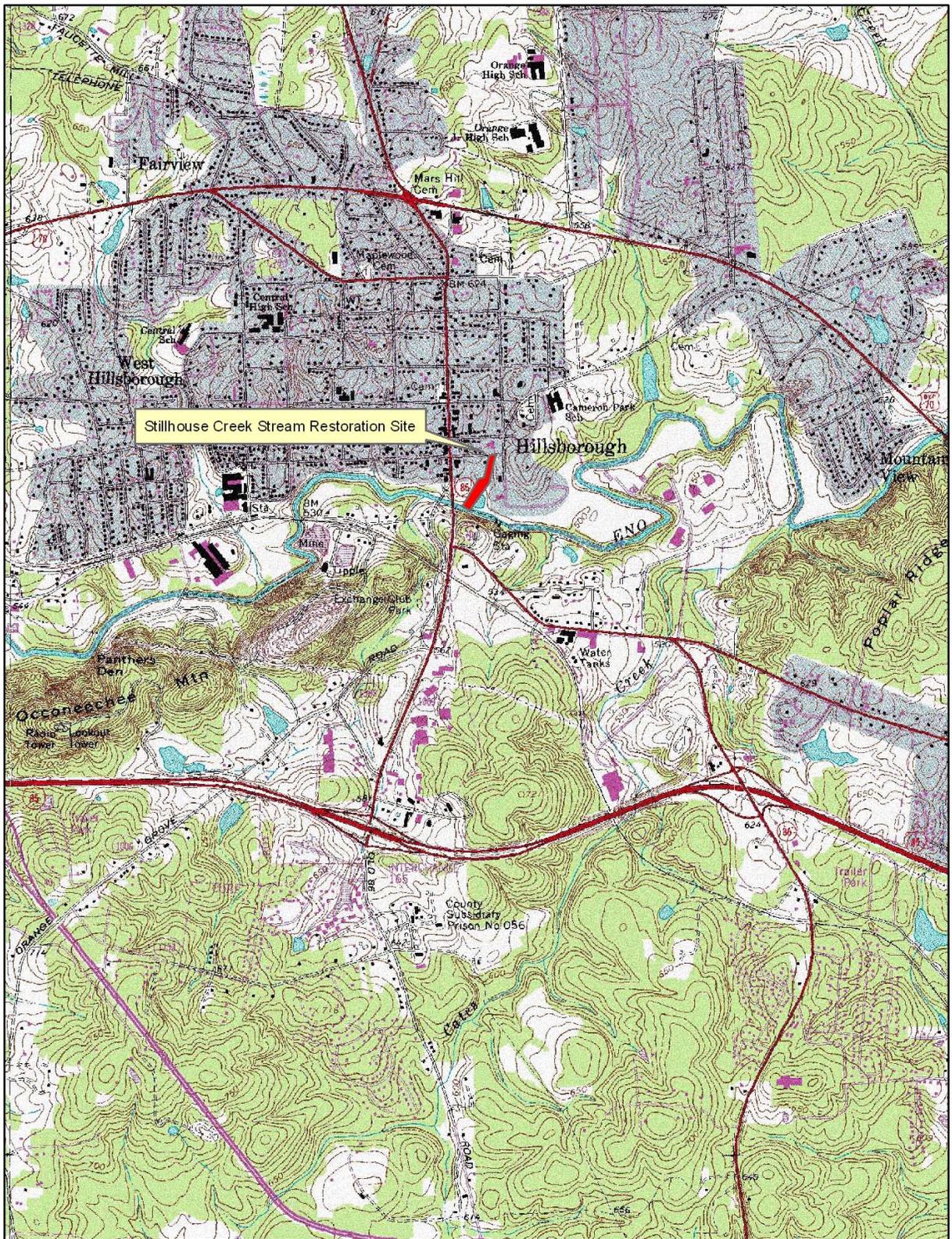
Coir fiber matting, live staking, and brush mattresses were installed to help stabilize the graded stream banks and the outside of meanders. A 20 foot wide buffer was planted with native woody and herbaceous species on both sides the upstream-most reach. The buffer width along the balance of the restoration project is between 20 and 80 feet.

2.3. Location and Setting

To get to the Stillhouse Creek restoration site from I-85, take exit 164 and head north on South Churton Street for 1.3 miles. Turn east on East Margaret Lane. The upstream boundary of the conservation easement is 0.1 mile east of the intersection, on the south side of the road. Its downstream boundary is at Stillhouse Creek's confluence with the Eno River. Figure 1 shows the general location of the project.

Stillhouse Creek's watershed is approximately 152 acres at its confluence with the Eno River. North of East Margaret Lane its watershed is approximately 75 acres. The entire watershed is within downtown Hillsborough and is almost entirely occupied by residential and commercial development.

Prior to its restoration, Stillhouse Creek traversed open lawn for most of its length across the Orange County Park. It had unstable and eroding banks throughout and an actively downcutting streambed that threatened the stability of an adjacent municipal building. A covered shelter with a stone retaining wall was built in the summer of 2007. The wall appears to have intruded upon the conservation easement. A split-rail fence was added along the easement boundary from approximately station 200 to station 700 in the fall of 2008.



2.4. History and Background

A complete copy of the Stillhouse Creek restoration plan has never been provided to RJG&A. Data in Exhibit Tables I – III are based on the Sediment and Erosion Control Plan and as-built materials that were provided by EEP (CDM 2005). Mitigation type and approach and type rely on the narrative description of the project and Rosgen (Rosgen 2007).

Exhibit Table I. Mitigation Structure and Objectives Stillhouse Creek Stream Restoration – EEP Project #363						
Reach ID*	Existing Feet	Type	Approach	Footage	Stationing	Comment
Reach 1	235	R	P2	235	00+00-02+35	Shallow pools, small meanders, and steep riffles
Reach 2	400	R	P1	400	02+35-6+35	Realigned, reconnected to floodplain
Reach 3	220	E1	P4	220	6+35-8+55	Banks stabilized
Reach 4	345	R	P3	355	8+55-12+10	Connected to floodprone area

* Reaches outlined in this table are from the Sediment and Erosion Control Plan and were not provided to RJG&A until after the draft monitoring report for monitoring year one was completed and submitted to NCEEP in November 2007. Without this information, RJG&A made its own determination about reach breaks. Analysis of the data collected in year one and subsequent monitoring years is based on the reach breaks assigned to the project in the fall of 2007.

Exhibit Table II. Activity and Reporting History Stillhouse Creek Stream Restoration - EEP Project #363		
Activity or Report	Data Collection	Completion
Restoration Plan	-	November 2005
Final Design – 90%	-	November 2005
Construction	-	March 2006
Temporary S&E mix applied	-	NA
Permanent seed mix applied	-	NA
Bare Root Planting	-	March 2006
Mitigation Plan/As-built	August 2006	December 2007
Year 1 Monitoring		December 2007
Qualitative Evaluation	June and November 2007	
Vegetation	October 2007	
Geomorphologic	November 2007	

Exhibit Table III. Project Contacts Stillhouse Creek Stream Restoration - EEP Project #363	
Designer Primary project design POC	NRCS Not Provided
Construction Contractor Construction Contractor POC	Not Provided Not Provided
Planting Contractor Planting contractor POC	Fluvial Solutions Peter Jelenevsky
Planting Source	Mellow Marsh
Monitoring Performers Monitoring POC	RJG&A 1221 Corporation Parkway, Suite 100 Raleigh, NC 27616 Mr. Sean Doig (919) 872-1174

Exhibit Table IV. Project Background - Stillhouse Creek Stream Restoration EEP Project #363	
Project County	Orange
Drainage Area	152 acres (0.24 square mile)
Drainage Impervious Cover Estimate (%)	30
Stream Order	First Order
Physiographic Region	Piedmont
Ecoregion	Carolina Slate Belt
Rosgen Classification of As-built ¹	
Reach 1	B-6
Reach 2	E-4

¹ No as-built cross-section data collected. Rosgen classification based on Year 1 monitoring cross-section data.

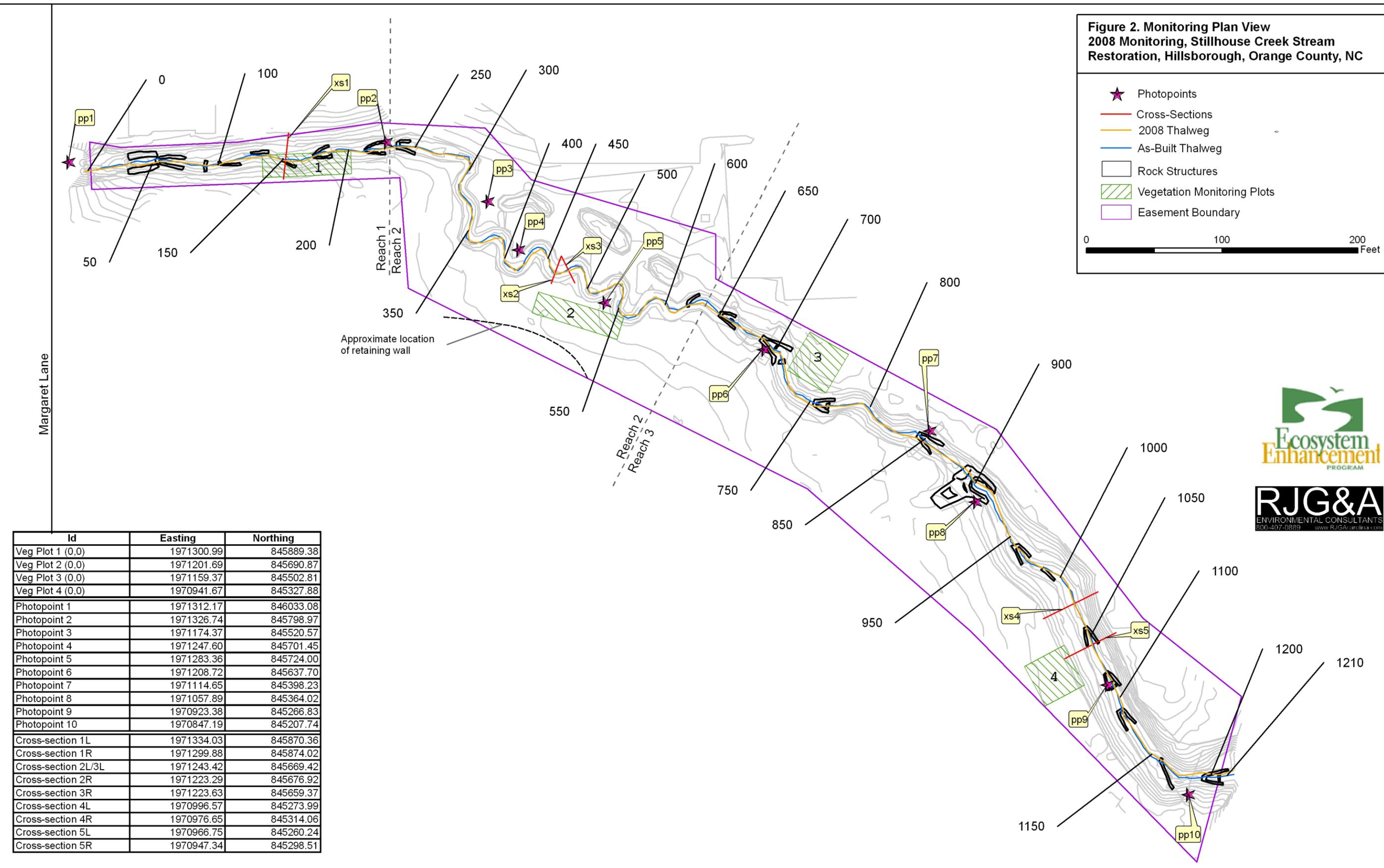
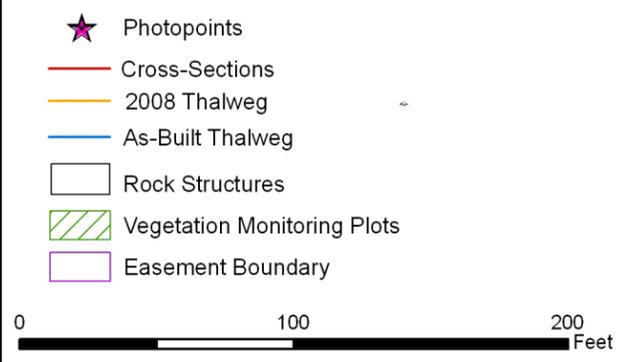
Exhibit Table IV. Project Background - Stillhouse Creek Stream Restoration EEP Project #363	
	Reach 3 C-4
Dominant Soil Types	
	Reach 1 Georgeville-Urban land complex
	Reach 2 Georgeville-Urban land complex
	Reach 3 Georgeville-Urban land complex and Congaree fine sandy loam
Reference Site ID ²	Upper Reach: UT to Caraway Creek (Randolph County) and UT to N. Fork New River (Ashe County); Lower Reach: Silas Creek (Forsyth County)
USGS HUC for Project and Reference	03020201030020, NA
NCDWQ Sub-basin for Project and Reference	03-04-01, NA
NCDWQ Classification for Project and Reference	C - NSW
Any portion of the project segment 303d listed?	No
Any portion of the project segment upstream of a 303d listed segment?	No – not in NCDWQ 03-04-01
Reasons for 303d Listing or Stressor	NA
% of Project Easement Fenced	0%

2.5. Monitoring Plan View

See Figure 2 for Monitoring Plan View.

² No ID numbers provided by design firm, therefore reference site names included in this table.

Figure 2. Monitoring Plan View
2008 Monitoring, Stillhouse Creek Stream
Restoration, Hillsborough, Orange County, NC



Id	Easting	Northing
Veg Plot 1 (0,0)	1971300.99	845889.38
Veg Plot 2 (0,0)	1971201.69	845690.87
Veg Plot 3 (0,0)	1971159.37	845502.81
Veg Plot 4 (0,0)	1970941.67	845327.88
Photopoint 1	1971312.17	846033.08
Photopoint 2	1971326.74	845798.97
Photopoint 3	1971174.37	845520.57
Photopoint 4	1971247.60	845701.45
Photopoint 5	1971283.36	845724.00
Photopoint 6	1971208.72	845637.70
Photopoint 7	1971114.65	845398.23
Photopoint 8	1971057.89	845364.02
Photopoint 9	1970923.38	845266.83
Photopoint 10	1970847.19	845207.74
Cross-section 1L	1971334.03	845870.36
Cross-section 1R	1971299.88	845874.02
Cross-section 2L/3L	1971243.42	845669.42
Cross-section 2R	1971223.29	845676.92
Cross-section 3R	1971223.63	845659.37
Cross-section 4L	1970996.57	845273.99
Cross-section 4R	1970976.65	845314.06
Cross-section 5L	1970966.75	845260.24
Cross-section 5R	1970947.34	845298.51



III. Project Conditions and Monitoring Results

The site was initially evaluated on 1 May 2008 and was generally functioning as designed. Low flows due to the 2007-2008 drought had caused aggradation in some places in the stream channel and vegetation had rooted. These problems had resolved themselves by the time the site was visited in August 2008 for geomorphic and vegetation monitoring. The site was again qualitatively assessed on 28 October 2008.

3.1. Vegetation Assessment

No as-built vegetation monitoring plots were established and RJG&A installed four representative vegetation monitoring plots in November 2007. These plots were monitored in August 2008 pursuant to the EEP/CVS vegetation monitoring protocol. The average live, planted woody stem density for all plots was nine individuals per plot (364 stems per acre). This exceeds the required 320 stems per acre by 14 percent. The survival rate for planted woody vegetation in Reach 1 is excellent and consisted principally of silky dogwood (*Cornus amomum*), wax myrtle (*Morella cerifera*) and elderberry (*Sambucus canadensis*). The streambanks of Reach 2 are dominated by black willow (*Salix nigra*) and silky dogwood (*Cornus amomum*). On the floodplain the planted vegetation consists primarily of sycamore (*Platanus occidentalis*), green ash (*Fraxinus pennsylvanica*), and tulip poplar (*Liriodendron tulipifera*). The planted vegetation in Reach 3 includes silky dogwood (*Cornus amomum*), black willow (*Salix nigra*), and green ash (*Fraxinus pennsylvanica*) and survival of planted stems is high.

The most abundant volunteer species counted in all plots was crape myrtle (*Lagerstroemia indica*, 32 percent of all volunteers), which was planted prior to the restoration and only appear along the first reach. The second most abundant species is winged elm (*Ulmus alata*, 25 percent of all volunteers). This hardwood species is native to North Carolina and may contribute to the project's stability and overall success.

Tables 1 through 5 in Appendix A contain specifics about vigor and damage by species and plot. Photos of the vegetation monitoring plots can also be found in Appendix A.

3.1.1. Vegetation Problem Areas

See Table 6, Figure B.1.-Current Conditions Plan View, and Vegetation Problem Area Photos in Appendix A.

Two vegetation problem areas were identified in Reach 2 (Figure B.1., Table 1). The area close to the first foot-bridge (Stations 235-300) was probably insufficiently planted at the time of construction. The second vegetation problem area in Reach 2 (Stations 320-530) has experienced poor survival of planted woody stems and continues to be dominated by fescue. At this point, no remedial action is recommended, but the areas should be observed and replanting may be necessary in the future.

In Reach 3 (Figure B.1.) the right top of bank area near cross-sections 4 and 5 (Stations 1000-1060) has a low survival of planted woody vegetation. Although, sedges and other non-woody vegetation are well-established in this area, it should be monitored in case remedial action is needed in the future. No remediation is recommended at this time.

3.1.2. Current Conditions Plan View

See Figure B.1. in Appendix B for the Current Conditions Plan View.

3.2. Stream Assessment

RJG&A staff evaluated the condition and success of the Stillhouse Creek Stream Restoration project during August and September 2008. Overall, the site is maintaining its as-built dimension, pattern, and profile.

3.2.1. Procedural Items

3.2.1.1. Morphometric Criteria

No as-built cross sections were established. Instead, RJG&A staff selected and installed five cross section sites for annual monitoring in November 2007. The second annual monitoring data were collected during August 2008. For the longitudinal profile, the entire stream restoration (1,210 linear feet) was surveyed. Survey points included thalweg, bankfull, beginning and end of each stream feature, and water surface. Photographs were taken at all cross sections and at the 10 permanent photo locations (established by RJG&A in June 2007).

The 2008 quantitative data and qualitative evaluations indicate that the structure and function of the entire restoration project continues to closely match the as-built conditions (i.e. little change has occurred).

3.2.1.2. Hydrologic Criteria

A crest gauge was installed on the Stillhouse Creek site on 14 June 2007. The gauge was checked on 1 May 2008 and at least one bankfull event occurred since the gauge was last checked on 27 November 2007. The crest gauge was “reset” (that is, the piece of wood was washed off and new cork added) at this time. When checked in August 2008, the

presence of cork above the bankfull line indicated that at least one additional bankfull event had occurred since 1 May. This was supported by on-site qualitative evidence (rack and drift lines and downed vegetation/stems above the bankfull elevation) (Table V). NC CRONOS does not have a weather station in Hillsborough, but precipitation data from a National Weather Service (NWS) COOP station 312515 in Durham County indicates that bankfull events may have occurred after rainfall events on March 4 (2.00”), July 5 (2.39”), August 28 (4.82”), September 6 (3.98”), and September 26 (2.18”) (NC CRONOS 2009).

Exhibit Table V. Verification of Bankfull Events – Stillhouse Creek Stream Restoration - EEP Project #363			
Date of Data Collection	Date of Occurrence (mm/dd/yy)	Method	Photo # (if available)
1 May 2008	27 Nov. 2007 – 30 April 2008 CRONOS data suggest 4 March 2008 or 27-28 April 2008	Crest Gauge	NA
26 August 2008	1 May 2008 – 25 August 2008 CRONOS data suggest 5 July 2008	Crest Gauge	NA

3.2.1.3. Bank Stability Assessments

Table VI BEHI and Sediment Export Estimates only apply to Monitoring year 5 and were not performed during 2008 (monitoring year 2).

3.2.2. Current Conditions Plan View

The Current Conditions Plan View for streams can be found in Appendix B.

3.2.3. Problem Areas Table

Minor problem areas were observed in August 2008 including the formation of small bars along riffles and piping. Exhibit Table B.1 in Appendix B identifies these problem areas by station, along with suspected causes and representative photos. In all cases, the problems are considered a low-priority. A number of problems identified during the spring 2008 evaluation have resolved themselves, probably due to the increased rainfall over the summer.

3.2.4. Numbered issue photo section

Representative problem area photos listed in Table B.1 can be found in Appendix B immediately following Table B.1.

3.2.5. Fixed station photos

Permanent photopoint images can be found in Appendix B.

3.2.6. Stability Assessment Table

Exhibit Table VII. Categorical Stream Feature Visual Stability Assessment- Stillhouse Creek Stream Restoration - EEP Project #363				
Reach 1 (245 feet)				
Feature	Initial*	MY-01	MY-02	MY-03
A. Riffles	100%	100%	100%	
B. Pools	100%	100%	100%	
C. Thalweg	100%	NA	NA	
D. Meanders	100%	NA	NA	
E. Bed General	100%	NA	NA	
F. Vanes/J Hooks, etc.	100%	100%	100%	
G. Wads and Boulders	100%	NA	NA	
Reach 2 (400 feet)				
A. Riffles	100%	99%	100%	
B. Pools	100%	98%	98%	
C. Thalweg	100%	93%	100%	
D. Meanders	100%	75%	100%	
E. Bed General	100%	NA	NA	
F. Vanes/J Hooks, etc.	100%	100%	100%	
G. Wads and Boulders	100%	NA	NA	
Reach 3 (565 feet)				
A. Riffles	100%	100%	73%	
B. Pools	100%	82%	97%	
C. Thalweg	100%	94%	75%	
D. Meanders	100%	75%	75%	
E. Bed General	100%	NA	NA	
F. Vanes/J Hooks, etc.	100%	90%	94%	
G. Wads and Boulders	100%	NA	NA	

*These percentages are assumed. The As-built Report did not contain any visual stability assessment data.

Exhibit Table VIII. Baseline Morphology and Hydraulic Summary
Stillhouse Creek Stream Restoration – EEP Project #363
Segment/Reach: 1 – 3 (855 feet)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Reference Reach Stream			Design			As-built		
	Min	Max	Med	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Dimension																		
BF Width (ft)	-	-	-	-	-	-	6.0	7.6	7.0	7.3	12.4	9.7	7.5	9.5	-	-	-	-
Floodprone Width (ft)	-	-	-	-	-	-	17.1	47.0	35.1	27.0	74.0	49.6	23	176	-	-	-	-
Bankfull Cross Sectional Area (ft ²)	-	-	-	-	-	-	5.6	8.1	7.3	7.3	13.2	10.35	-	-	9.0	-	-	-
Bankfull Mean Depth (ft)	-	-	-	-	-	-	0.8	1.4	1.0	0.9	1.3	1.1	0.95	1.2	-	-	-	-
Bankfull Max Depth (ft)	-	-	-	-	-	-	1.2	2.0	1.7	1.6	2.0	1.8	1.3	2.4	-	-	-	-
Width/Depth Ratio	-	-	-	-	-	-	4.4	9.3	7.1	7.3	14.0	9.3	6.0	10.0	-	-	-	-
Entrenchment Ratio	-	-	-	-	-	-	2.3	6.3	5.1	2.7	10.1	5.6	2.7	20.7	-	-	-	-
Bank Height Ratio	-	-	-	-	-	-	1.0	1.4	1.13	1.0	1.25	1.06	-	-	1.0	-	-	-
Wetted Perimeter (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydraulic Radius (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pattern																		
Channel Beltwidth (ft)	-	-	-	-	-	-	6	19	11.6	12.4	16.7	13.7	8.5	19.6	-	8.7	24.7	16.3
Radius of Curvature (ft)	-	-	-	-	-	-	8.7	16.5	12.2	6.5	20.5	14.6	12.8	23.8	-	4.6	32.7	10.0
Meander Wavelength (ft)	-	-	-	-	-	-	29	116	63	21.2	57.0	34.7	12.8	39.1	-	23.8	75.4	37.8
Meander Width Ratio	-	-	-	-	-	-	0.9	2.7	1.7	1.0	2.3	1.4	1.0	2.3	-	-	-	-
Profile																		
Riffle Length (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.4	15.3	6.6
Riffle Slope (ft/ft)	-	-	-	-	-	-	-	-	-	0.00	0.054	0.0204	0.006	0.017	-	-0.003	0.140	0.029
Pool Length (ft)	-	-	-	-	-	-	11.0	46.5	22.5	7.5	17.0	11.8	8.5	19.6	-	9.4	76.0	22.8
Pool Spacing (ft)	-	-	-	-	-	-	-	-	37.2	-	-	21.5	-	-	15.3	0	18.2	5.0
Substrate																		
d50 (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d84 (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Additional Reach Parameters																		
Valley Length (ft)	-	-	-	-	-	-	672	-	-	168	-	-	672	-	-	672	-	-
Channel Length (ft)	-	-	-	-	-	-	748	-	-	267.5	-	-	946	-	-	855	-	-
Sinuosity (ft)	-	-	-	-	-	-	1.1	-	-	1.6	-	-	1.4	-	-	1.3	-	-
Water Surface Slope (ft/ft)	-	-	-	-	-	-	0.0126	-	-	0.0094	-	-	0.0086	-	-	0.011	-	-
BF slope (ft/ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rosgen Classification	-	-	-	-	-	-	E4	-	-	E4/5	-	-	E4	-	-	-	-	-
*Habitat Index	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Macrobenthos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Exhibit Table VIII. Baseline Morphology and Hydraulic Summary
Stillhouse Creek Stream Restoration – EEP Project #363
Segment/Reach: 4 (355 feet)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Reference Reach Stream			Design			As-built		
	Min	Max	Med	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Dimension																		
BF Width (ft)	-	-	-	-	-	-	9.8	14.8	11.8	23.1	28.0	25.6	14.9	19.5		-	-	-
Floodprone Width (ft)	-	-	-	-	-	-	15.5	26.8	19.3	33.0	35.0	33.7	17.9	35.1		-	-	-
Bankfull Cross Sectional Area (ft ²)	-	-	-	-	-	-	19.2	24.7	21.7	68.5	48.9	43.5	18	22		-	-	-
Bankfull Mean Depth (ft)	-	-	-	-	-	-	1.7	2.0	1.9	1.5	1.9	1.7	1.1	1.2		-	-	-
Bankfull Max Depth (ft)	-	-	-	-	-	-	2.6	2.8	2.7	2.4	2.9	2.7	1.7	1.9		-	-	-
Width/Depth Ratio	-	-	-	-	-	-	4.9	8.6	6.2	12.4	17.2	15.2	12.4	17.2		-	-	-
Entrenchment Ratio	-	-	-	-	-	-	1.4	1.8	1.6	1.2	1.4	1.3	1.2	1.8		-	-	-
Bank Height Ratio	-	-	-	-	-	-	2.5	2.9	2.6	1.0	1.0	1.0	1.0			-	-	-
Wetted Perimeter (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydraulic Radius (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pattern																		
Channel Beltwidth (ft)	-	-	-	-	-	-	-	-	-	40	51	43.7	23.8	39		12.0	27.9	19.6
Radius of Curvature (ft)	-	-	-	-	-	-	-	-	-	19.5	54.0	41.25	29.8	39.0		25.4	55.4	40.3
Meander Wavelength (ft)	-	-	-	-	-	-	-	-	-	130	245	168	39	94		96.2	187.8	132.6
Meander Width Ratio	-	-	-	-	-	-	-	-	-	1.6	2.0	1.7	1.6	2.0		-	-	-
Profile																		
Riffle Length (ft)	-	-	-	-	-	-	-	-	-	9.5	29.0	18.4	6.0	19.5		2.5	40.1	17.3
Riffle Slope (ft/ft)	-	-	-	-	-	-	-	-	-	0.008	0.016	0.012	0.017	0.034		0.043	0.164	0.129
Pool Length (ft)	-	-	-	-	-	-	-	-	-	8.2	68.0	31.2	5	53		15.0	42.6	70.1
Pool Spacing (ft)	-	-	-	-	-	-	-	-	-	27.2	129.0	62.4	39	94		0	40.1	11.1
Substrate																		
d50 (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d84 (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Additional Reach Parameters																		
Valley Length (ft)	-	-	-	-	-	-	-	-	282	-	-	325	-	-	282	-	-	282
Channel Length (ft)	-	-	-	-	-	-	-	-	314	-	-	348	-	-	314	-	-	355
Sinuosity (ft)	-	-	-	-	-	-	-	-	1.1	-	-	1.07	-	-	1.1	-	-	1.3
Water Surface Slope (ft/ft)	-	-	-	-	-	-	-	-	0.017	-	-	0.008	-	-	0.017	-	-	0.020
BF slope (ft/ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rosgen Classification	-	-	-	-	-	-	-	-	G4c/1	-	-	B4c/1	-	-	B4/1	-	-	-
*Habitat Index	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Macrobenthos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Exhibit Table IX. Morphology and Hydraulic Monitoring Summary – Stillhouse Creek Stream Restoration – EEP Project #363

Reach 1 (235 feet)*

Parameter	Cross Section 1-Riffle				
	MY1	MY2	MY3	MY4	MY5
Dimension					
BF Width (ft)	18.4	18.68			
Floodprone Width (ft)	34.44	34.44			
BF Cross-Sectional Area (sq ft)	24.28	26.01			
BF Mean Depth (ft)	1.32	1.39			
BF Max Depth (ft)	2.71	3.20			
Width/Depth Ratio	13.95	13.42			
Entrenchment Ratio	1.87	1.84			
Bank Height Ratio	1.19	1.12			
Wetted Perimeter (ft)	19.5	20.02			
Hydraulic Radius (ft)	1.24	1.30			
Substrate					
d50 (mm)	0.04	0.98			
d84 (mm)	5.7	45			

*Reaches outlined in this table are from the Sediment and Erosion Control Plan and were not provided to RJG&A until after the draft monitoring report for monitoring year one was completed and submitted to NCEEP in November 2007. Without this information, RJG&A made its own determination about reach breaks. Analysis of the data collected in year one and subsequent monitoring years is based on the reach breaks assigned to the project in the fall of 2007.

+ Since mean, not median, values were provided for the baseline data, we have continued this approach for Table IX.

	MY-01 (2007)			MY-02 (2008)			MY-03 (2009)			MY-04 (2010)			MY-05 (2011)		
Pattern	min	max	mean+	min	max	mean+	min	max	mean+	min	max	mean+	min	max	mean+
Channel Beltwidth (ft)	7.6	12.1	10.6	8.6	11.7	10.5									
Radius of Curvature (ft)	NA	NA	NA	NA	NA	NA									
Meander Wavelength (ft)	NA	NA	NA	NA	NA	NA									
Meander Width ratio			0.6			0.6									
Profile															
Riffle length (ft)	2	14	8.3	4	32	16.2									
Riffle slope (ft/ft)	-0.04	0.06	0.01	-0.02	0.02	0.01									
Pool length (ft)	10	30	19	7	25	14									
Pool spacing (ft)	0	14	7.3	32	0	12.1									
Additional Reach Parameters	MY-01			MY-02			MY-03			MY-04			MY-05		
Valley Length (ft)	230			230											
Channel Length (ft)	245			245											
Sinuosity	1.07			1.07											
Water Surface Slope (ft/ft)	0.009			0.009											
BF slope (ft/ft)	0.01			0.008											
Rosgen Classification	B6			B5											
Habitat Index	NA			NA											
Macrobenthos	NA			NA											

**Exhibit Table IX. Morphology and Hydraulic Monitoring Summary – Stillhouse Creek Steam Restoration – EEP Project #363
Reach 2 (400 feet)***

Parameter	Cross Section 2-Pool					Cross Section 3-Riffle									
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5					
Dimension															
BF Width (ft)	15.82	19.12				12.41	13.18								
Floodprone Width (ft)	94.5	94.50				107	107.00								
BF Cross-Sectional Area (sq ft)	22.62	23.90				8.61	8.43								
BF Mean Depth (ft)	1.46	1.25				0.69	0.64								
BF Max Depth (ft)	2.62	2.85				1.14	1.31								
Width/Depth Ratio	11.07	15.30				17.87	20.60								
Entrenchment Ratio	6	4.94				8.7	8.12								
Bank Height Ratio	1.17	1.08				1.13	1.25								
Wetted Perimeter (ft)	17.21	20.64				13.12	13.49								
Hydraulic Radius (ft)	1.31	1.16				0.66	0.63								
Substrate															
d50 (mm)	6.85	0.42				6.85	11.3								
d84 (mm)	14.59	17.2				36.88	42.05								
	MY-01 (2007)			MY-02 (2008)			MY-03 (2009)			MY-04 (2010)			MY-05 (2011)		
Pattern	min	max	mean+	min	max	mean+	min	max	mean+	min	max	mean+	min	max	mean+
Channel Beltwidth (ft)	9.1	23.6	18.5	14.4	27.0	19.3									
Radius of Curvature (ft)	2.6	11.6	4.9	2.7	10.8	5.1									
Meander Wavelength (ft)	27.2	40	33	26.5	40.0	32.7									
Meander Width ratio			1.3			1.0									
Profile															
Riffle length (ft)	7	20	10.9	6	11	8.1									
Riffle slope (ft/ft)	-0.07	0.06	0.003	-0.020	0.060	0.024									
Pool length (ft)	9	28	17	6	26	14.3									
Pool spacing (ft)	0	26	10.9	0	65	12.3									
Additional Reach Parameters	MY-01			MY-02			MY-03			MY-04			MY-05		
Valley Length (ft)	286			286											
Channel Length (ft)	400			392											
Sinuosity	1.40			1.37											
Water Surface Slope (ft/ft)	0.008			0.009											
BF slope (ft/ft)	0.007			0.007											
Rosgen Classification	C4			C4											
Habitat Index	NA			NA											
Macrobenthos	NA			NA											

Exhibit Table IX. Morphology and Hydraulic Monitoring Summary – Stillhouse Creek Stream Restoration – EEP Project #363
Reach 3 (565 feet)*

Parameter	Cross Section 4 - Riffle					Cross Section 5 - Pool									
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5					
Dimension															
BF Width (ft)	12.44	14.66				8.36	11.53								
Floodprone Width (ft)	29.3	29.30				26.48	26.48								
BF Cross-Sectional Area (sq ft)	13.16	14.47				11.4	15.87								
BF Mean Depth (ft)	1.06	0.99				1.36	1.38								
BF Max Depth (ft)	2.06	2.20				1.93	2.33								
Width/Depth Ratio	11.75	14.86				6.13	8.38								
Entrenchment Ratio	2.36	2.00				3.17	2.30								
Bank Height Ratio	1.10	1.11				1.24	1.22								
Wetted Perimeter (ft)	13.23	15.45				9.96	12.77								
Hydraulic Radius (ft)	0.99	0.94				1.14	1.24								
Substrate															
d50 (mm)	2.67	3				16	22.6								
d84 (mm)	58.57	83.5				50.7	2048								
	MY-01 (2007)			MY-02 (2008)			MY-03 (2009)			MY-04 (2010)			MY-05 (2011)		
Pattern	min	max	mean+	min	max	mean+	min	max	mean+	min	max	mean+	min	max	mean+
Channel Beltwidth (ft)	12	27.6	20.9	9.5	26.8	20.0									
Radius of Curvature (ft)	10.4	53.7	27.1	9.5	47.2	25.9									
Meander Wavelength (ft)	70.7	187	111.7	61.5	166.0	107.1									
Meander Width ratio			2			1.37									
Profile															
Riffle length (ft)	4	41	16.4	6	44	22.4									
Riffle slope (ft/ft)	-0.004	0.12	0.04	0.02	0.09	0.04									
Pool length (ft)	18	48	27.9	6	53	25.3									
Pool spacing (ft)	0	44	15.4	3	53	22.8									
Additional Reach Parameters	MY-01			MY-02			MY-03			MY-04			MY-05		
Valley Length (ft)		507			507										
Channel Length (ft)		565			563										
Sinuosity		1.11			1.11										
Water Surface Slope (ft/ft)		0.018			0.019										
BF slope (ft/ft)		0.016			0.016										
Rosgen Classification		C4			B4										
Habitat Index		NA			NA										
Macrobenthos		NA			NA										

IV. Methodology

Monitoring methodologies follow the current EEP-provided templates and guidelines (Lee *et al* 2006). Photographs were taken digitally. A Trimble Geo XT handheld mapping-grade unit was used to collect cross section, vegetation corner, photopoint, and problem area locations. Additional notations were written on the as-built plan sheets.

4.1. Stream Methodology

Methods employed were a combination those specified in the Mitigation Plan, the First Annual Monitoring Report, and standard regulatory guidance and procedures documents. Stream monitoring data was collected using the techniques described in US ACE Stream Mitigation Guidelines, US Forest Service's Stream Channel Reference Sites, and Applied River morphology (USACE, 2003; Harrelson et al., 1994; Rosgen, 1996). A South Total Station and Nikon automatic level were used for collecting all geomorphic data. Photographs facing downstream were taken at each cross section.

4.2. Vegetation Methodology

Four representative vegetation survey plots were selected and installed in reaches 1, 2, and 3 during October 2007, pursuant to the EEP/CVS vegetation monitoring protocol (Lee *et al* 2006). All plots measure 100 square meters and are either 10 meters by 10 meters, or five meters by 20 meters. The four corners of each plot (either 10x100 or 5x20 feet) were marked with 18-inch long, one-half-inch diameter galvanized steel conduit.

For monitoring year 2, Level 1 (planted woody stems) and Level 2 (volunteer woody stems) data collection was performed in August 2008. Within each plot, each planted woody stem location (x and y) was recorded, and height and live stem diameter were recorded for each stem location. All planted stems were identified with pink flagging. Vegetation was identified using Weakley (Weakley 2007). Photos were taken of each vegetation plot from the 0,0 corner.

Tables 1 through 5 in Appendix A contain the data from the vegetation monitoring. Monitoring plot photos can also be found in Appendix A.

References

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- Radford, A.E., H.E. Ahles, and C.R. Bell (1968). *Manual of the Vascular Flora of the Carolinas*. University of North Carolina Press. Chapel Hill, NC.
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- USACOE (2003) *Stream Mitigation Guidelines*. USACOE, USEPA, NCWRC, NCDENR-DWQ
- Weakley, Alan (2007). *Flora of the Carolinas, Virginia, Georgia, and Surrounding Areas*. Retrieved March 27, 2007 from: <http://www.herbarium.unc.edu/flora.htm>.

Appendix A Vegetation Data

A1. Vegetation Data Tables

Table 1. Vegetation Metadata

Table 2. Vegetation Vigor by Species

Table 3. Damage by Species

Table 4. Damage by Plot

Table 5. Stem Count by Plot and Species

Table 6. Vegetation Problem Areas

A2. Vegetation Problem Area Photos

A3. Vegetation Monitoring Plot Photos

Appendix A.1.

Table 1. Vegetation Metadata

Report Prepared By	Sean Doig	
Date Prepared		10/14/2008 14:15
database name	363StillhouseCreek-2008Resampling-EntryTool-v2.2.5.mdb	
database location	C:\Documents and Settings\Owner\Desktop\EEP 2008\CVS EEP	
computer name	GATELAP	

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	363
project Name	Stillhouse
Description	stream restoration
River Basin	Cape Fear River Basin
length(ft)	1,210
stream-to-edge width (ft)	20-80
area (sq m)	8,457.93
Required Plots (calculated)	5
Sampled Plots	5

Appendix A.1.

Table 2. Vegetation Vigor by Species

	Species	4	3	2	1	0	Missing	Unknown
	Cornus amomum	3		2				
	Fraxinus pennsylvanica	5				1		
	Ilex verticillata	6						
	Nyssa sylvatica		1					
	Quercus phellos	2				1		
	Sambucus canadensis	4				1		
	Morella cerifera	11	1					
	Quercus rubra	3		2				
	Lindera benzoin	1	1					
	Liriodendron tulipifera	1						
	Platanus occidentalis	2						
TOT:	11	38	3	4		3		

Appendix A.1.

Table 3. Vegetation Damage by Species

Species	All Damage Categories (no damage)		Game	Unknown	Vine Strangulation
Cornus amomum	5	3			2
Fraxinus pennsylvanica	6	6			
Ilex verticillata	6	5			1
Lindera benzoin	2	1			1
Liriodendron tulipifera	1	1			
Morella cerifera	12	11			1
Nyssa sylvatica	1	1			
Platanus occidentalis	2	2			
Quercus phellos	3	1		1	1
Quercus rubra	5	3	1		1
Sambucus canadensis	5	5			
TOT: 11	48	39	1	1	7

Appendix A.1.

Table 4. Vegetation Damage by Plot

	<i>plot</i>	<i>All Damage Categories</i>		<i>(no damage)</i>	<i>Game</i>	<i>Unknown</i>	<i>Vine Strangulation</i>
	363-jo&sd-0001-year:1	15	15				
	363-jo&sd-0002-year:1	5	5				
	363-jo&sd-0003-year:1	18	11			7	
	363-jo&sd-0004-year:1	10	8	1	1		
TOT:	4	48	39	1	1	7	7

Appendix A.1.

Table 5. Stem Count by Plot and Species

	Species	Total Planted Stems			plot 363-jo&sd-0001-year:1			
		# plots	avg# stems					
	Cornus amomum	5	2	2.5	3		2	
	Fraxinus pennsylvanica	5	3	1.67		2	1	2
	Ilex verticillata	6	3	2	3		2	1
	Lindera benzoin	2	2	1			1	1
	Liriodendron tulipifera	1	1	1				1
	Morella cerifera	12	4	3	4	1	6	1
	Nyssa sylvatica	1	1	1				1
	Platanus occidentalis	2	1	2		2		
	Quercus phellos	2	2	1			1	1
	Quercus rubra	5	2	2.5			4	1
	Sambucus canadensis	4	1	4	4			
TOT:	11	45	11		14	5	17	9

Appendix A.1.

Table 6. Vegetation Problem Areas – Stillhouse Creek Stream Restoration			
EEP Project #363			
Feature/Issue	Station/Range	Probable Cause	Photo #
Limited woody stem planting/survival	235-300	Planting oversight	VP1
Low planted woody stem vigor	320-530	Soil compaction and/or competition from fescue	VP2
Low planted woody stem vigor	1000-1060	Soil compaction	VP3

A.2. Representative Vegetation Problem Photos - Year 2 - 2008 - Stillhouse Creek Stream Restoration (EEP Project #363)



VP1 (10/28/2008)



VP2 (10/28/2008)



VP3 (10/28/2008)

Appendix A.3. Vegetation Monitoring Plot Photos

Vegetation Monitoring Plot Photographs - Year 2 - 2008 - Stillhouse Creek Stream Restoration (EEP Project #363)



Plot 1 (10/31/07)



Plot 1 (7/17/08)



Plot 2 (10/31/07)



Plot 2 (7/17/08)

Appendix A.3. Vegetation Monitoring Plot Photos

Vegetation Monitoring Plot Photographs - Year 2 - 2008 - Stillhouse Creek Stream Restoration (EEP Project #363)



Plot 3 (10/31/07)



Plot 3 (7/17/08)



Plot 4 (11/05/07)



Plot 4 (7/17/08)

Appendix B Geomorphologic Raw Data

Figure B1. Current Conditions Plan View

B2. Stream Problem Areas Table

B3. Representative Stream Problem Area Photos

B4. Stream Photo-station Photos

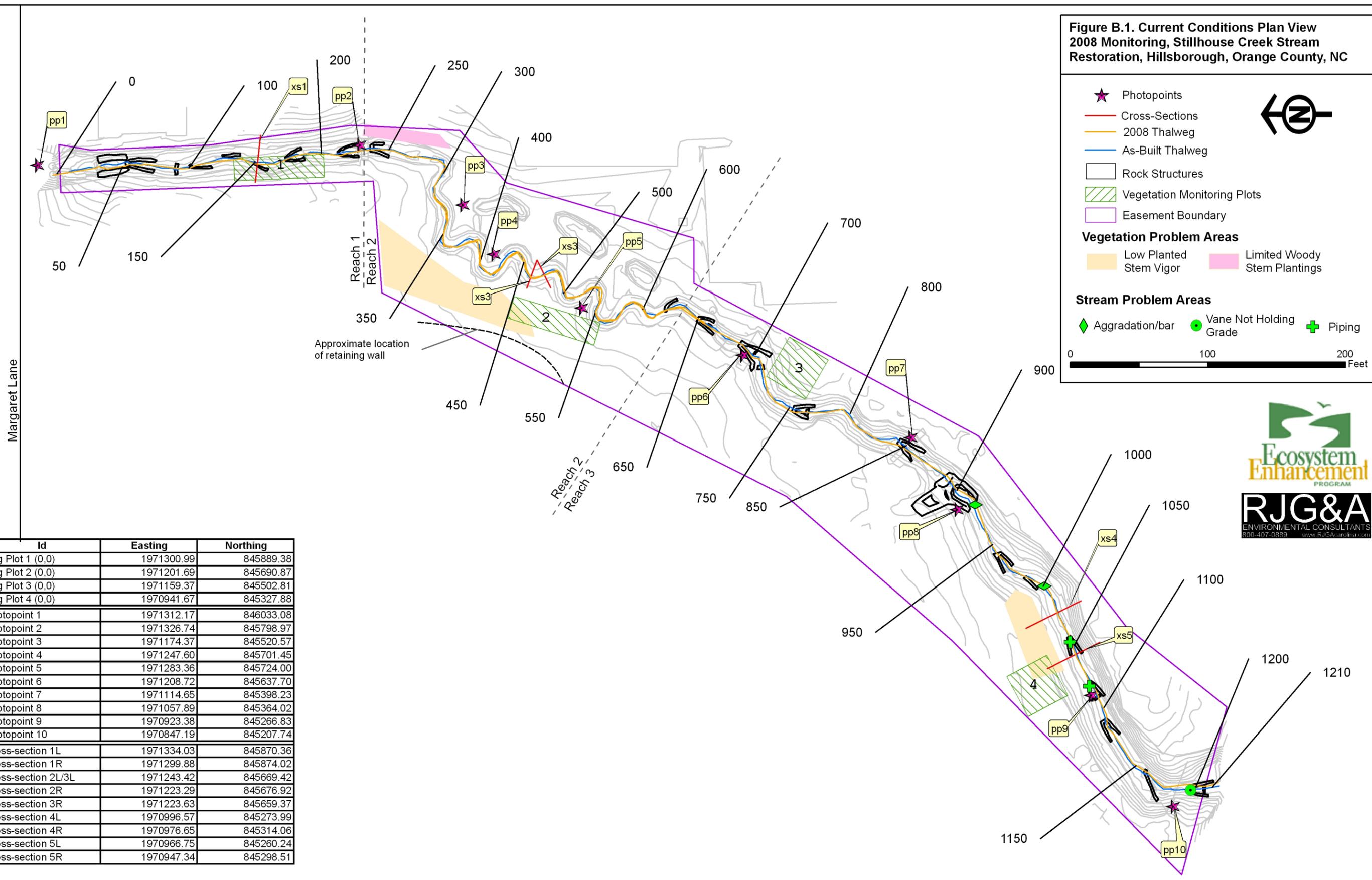
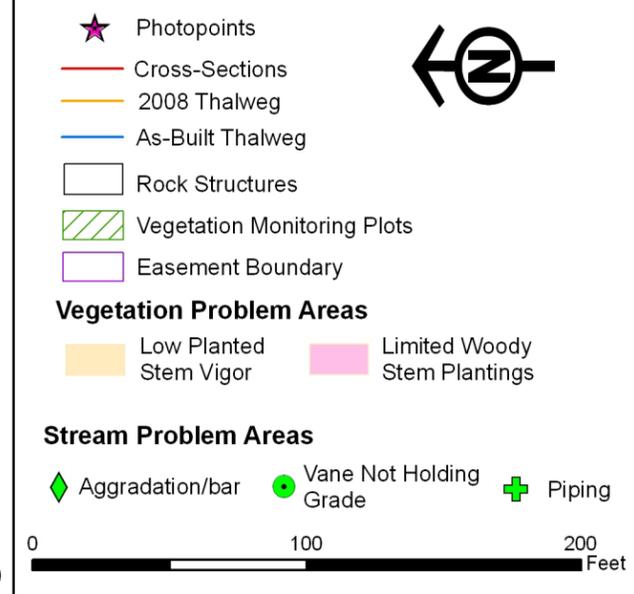
B5. Qualitative Visual Stability Assessment Table

B6. Cross section Plots and Raw Data Tables

B7. Longitudinal Plots and Raw Data Tables

B8. Pebble Counts

**Figure B.1. Current Conditions Plan View
2008 Monitoring, Stillhouse Creek Stream
Restoration, Hillsborough, Orange County, NC**



Id	Easting	Northing
Veg Plot 1 (0,0)	1971300.99	845889.38
Veg Plot 2 (0,0)	1971201.69	845690.87
Veg Plot 3 (0,0)	1971159.37	845502.81
Veg Plot 4 (0,0)	1970941.67	845327.88
Photopoint 1	1971312.17	846033.08
Photopoint 2	1971326.74	845798.97
Photopoint 3	1971174.37	845520.57
Photopoint 4	1971247.60	845701.45
Photopoint 5	1971283.36	845724.00
Photopoint 6	1971208.72	845637.70
Photopoint 7	1971114.65	845398.23
Photopoint 8	1971057.89	845364.02
Photopoint 9	1970923.38	845266.83
Photopoint 10	1970847.19	845207.74
Cross-section 1L	1971334.03	845870.36
Cross-section 1R	1971299.88	845874.02
Cross-section 2L/3L	1971243.42	845669.42
Cross-section 2R	1971223.29	845676.92
Cross-section 3R	1971223.63	845659.37
Cross-section 4L	1970996.57	845273.99
Cross-section 4R	1970976.65	845314.06
Cross-section 5L	1970966.75	845260.24
Cross-section 5R	1970947.34	845298.51



Appendix B.2. Stream Problem Areas Table - Reach 3

Feature/Issue	Station	Suspected Cause	Photo #
Aggradation/bar	918	Insufficient flow	SP1
Aggradation/bar	1006	Insufficient flow	SP2
Piping	1047	Insufficient coarse backfill	SP3
Piping	1082	Insufficient coarse backfill	SP3
Vane not holding grade	1197	Height not appropriate	SP4

B.3. Representative Stream Problem Photos - Year 2 - 2008 - Stillhouse Creek Stream Restoration (EEP Project #363)



SP1 (10/28/2008)



SP2 (10/28/2008)



SP3 (10/28/2008)



SP4 (10/28/2008)

Appendix B4. Permanent Photopoint Photographs - Stillhouse Creek Stream Restoration



PP #1 – Looking Downstream (06/14/07)



PP #1 – Looking Downstream (05/01/08)



PP #2 – Looking Downstream (06/14/07)



PP #2 – Looking Downstream (05/01/08)

Appendix B4. Permanent Photopoint Photographs - Stillhouse Creek Stream Restoration



PP #3 – Looking Downstream (06/14/07)



PP #3 – Looking Downstream (05/01/08)



PP #4 – Looking Downstream (06/14/07)



PP #4 – Looking Downstream (05/01/08)

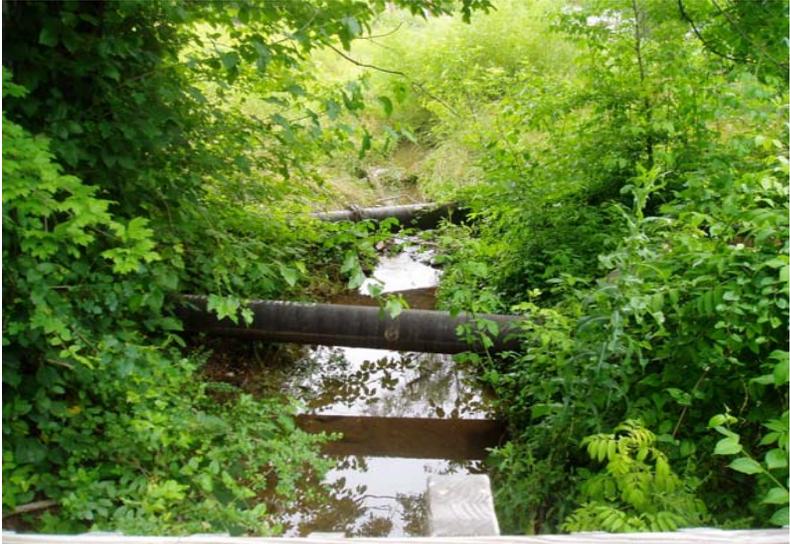
Appendix B4. Permanent Photopoint Photographs - Stillhouse Creek Stream Restoration



PP #5 – Looking Upstream (06/14/07)



PP #5 – Looking Upstream (05/01/08)



PP #6 – Looking Upstream (06/14/07)



PP #6 – Looking Upstream (05/01/08)

Appendix B4. Permanent Photopoint Photographs - Stillhouse Creek Stream Restoration



PP #7 – Looking Downstream (06/14/07)



PP #7 – Looking Downstream (05/01/08)



PP #8 – Looking Downstream (06/14/07)



PP #8 – Looking Downstream (05/01/08)

Appendix B4. Permanent Photopoint Photographs - Stillhouse Creek Stream Restoration



PP #9 – Looking Downstream (06/14/07)



PP #9 – Looking Downstream (05/01/08)



PP #10 – Looking Upstream (06/14/07)



PP #10 – Looking Upstream (05/01/08)

**Appendix B.5. Visual Morphological Assessment Stillhouse Creek Stream Restoration Project - Reach 1 - Project #363
(245 Linear Feet)**

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	Percent Performing in Stable Condition	Feature Performing Mean (%)
A. Riffles	1. Present	7	7	0/0	100	100
	2. Armor stable	7	7	0/0	100	
	3. Facet grade appears stable	7	7	0/0	100	
	4. Minimal evidence of embedding/fining	7	7	0/0	100	
	5. Length appropriate	7	7	0/0	100	
B. Pools	1. Present	8	8	0/0	100	100
	2. Sufficiently deep	8	8	0/0	100	
	3. Length appropriate	8	8	0/0	100	
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	4	4	0/0	100	100
	2. Downstream of meander (glide/inflection) centering	4	4	0/0	100	
D. Meanders	1. Outer bend in state of limited/controlled erosion	4	4	0/0	100	100
	2. Of those eroding, # w/concomitant point bar formation	4	4	0/0	100	
	3. Apparent Rc within spec	4	4	0/0	100	
	4. Sufficient floodplain access and relief	4	4	0/0	100	
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	0	0	0/0	100	100
	2. Channel bed degradation – areas of increasing downcutting or head cutting	0	0	0/0	100	
F. Bank	1. Actively eroding, wasting, or slumping bank	NA	NA	0/0	100	100
G. Vanes	1. Free of back or arm scour	7	7	0/0	100	100
	2. Height appropriate	7	7	0/0	100	
	3. Angle and geometry appear appropriate	7	7	0/0	100	
	4. Free of piping or other structural failures	7	7	0/0	100	
H. Wads/Boulder	1. Free of scour	0	0	0/0	NA	NA
	2. Footing stable	0	0	0/0	NA	

**Appendix B.5. Visual Morphological Assessment Stillhouse Creek Stream Restoration Project - Reach 2 - Project #363
(392 Linear Feet)**

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	Percent Performing in Stable Condition	Feature Performing Mean (%)
A. Riffles	1. Present	14	14	0/0	100	100
	2. Armor stable	14	14	0/0	100	
	3. Facet grade appears stable	14	14	0/0	100	
	4. Minimal evidence of embedding/fining	14	14	0/0	100	
	5. Length appropriate	14	14	0/0	100	
B. Pools	1. Present	15	15	0/0	100	98
	2. Sufficiently deep	15	15	0/0	100	
	3. Length appropriate	14	15	1/26	93	
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	15	15	0/0	100	100
	2. Downstream of meander (glide/inflection) centering	15	15	0/0	100	
D. Meanders	1. Outer bend in state of limited/controlled erosion	15	15	0/0	100	100
	2. Of those eroding, # w/concomitant point bar formation	15	15	0/0	100	
	3. Apparent Rc within spec	15	15	0/0	100	
	4. Sufficient floodplain access and relief	15	15	0/0	100	
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	0	0	0/0	100	100
	2. Channel bed degradation – areas of increasing downcutting or head cutting	0	0	0/0	100	
F. Bank	1. Actively eroding, wasting, or slumping bank	NA	NA	0/0	100	100
G. Vanes	1. Free of back or arm scour	1	1	0/0	100	100
	2. Height appropriate	1	1	0/0	100	
	3. Angle and geometry appear appropriate	1	1	0/0	100	
	4. Free of piping or other structural failures	1	1	0/0	100	
H. Wads/Bould	1. Free of scour	0	0	0/0	NA	NA
	2. Footing stable	0	0	0/0	NA	

**Appendix B.5. Visual Morphological Assessment Stillhouse Creek Stream Restoration Project - Reach 3 - Project #363
(563 Linear Feet)**

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	Percent Performing in Stable Condition	Feature Performing Mean (%)
A. Riffles	1. Present	9	12	0/0	75	73
	2. Armor stable	9	12	0/0	75	
	3. Facet grade appears stable	9	12	0/0	75	
	4. Minimal evidence of embedding/fining	9	12	0/0	75	
	5. Length appropriate	8	12	1/44	67	
B. Pools	1. Present	13	13	0/0	100	97
	2. Sufficiently deep	13	13	0/0	100	
	3. Length appropriate	12	13	1/53	92	
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	6	8	2/5	75	75
	2. Downstream of meander (glide/inflection) centering	6	8	2/16	75	
D. Meanders	1. Outer bend in state of limited/controlled erosion	4	4	NA	100	75
	2. Of those eroding, # w/concomitant point bar formation	0	4	NA	0	
	3. Apparent Rc within spec	4	4	NA	100	
	4. Sufficient floodplain access and relief	4	4	NA	100	
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	0	0	2/10	98	99
	2. Channel bed degradation – areas of increasing downcutting or head cutting	0	0	0/0	100	
F. Bank	1. Actively eroding, wasting, or slumping bank	NA	NA	0/0	100	100
G. Vanes	1. Free of back or arm scour	12	12	0/0	100	94
	2. Height appropriate	11	12	1/2	92	
	3. Angle and geometry appear appropriate	12	12	0/0	100	
	4. Free of piping or other structural failures	10	12	2/4	83	
H. Wads/Bould	1. Free of scour	0	0	0/0	NA	NA
	2. Footing stable	0	0	0/0	NA	

Appendix B.6. Cross Section Plots and Photo - Year 2 - 2008 - Stillhouse Creek Stream Restoration -NCEEP #402

River Basin: Neuse
 Watershed: Stillhouse Creek
 XS ID: XS 1 (riffle)
 Reach: 1
 Date: 7/17/2008
 Field Crew: S.D. and J.O.

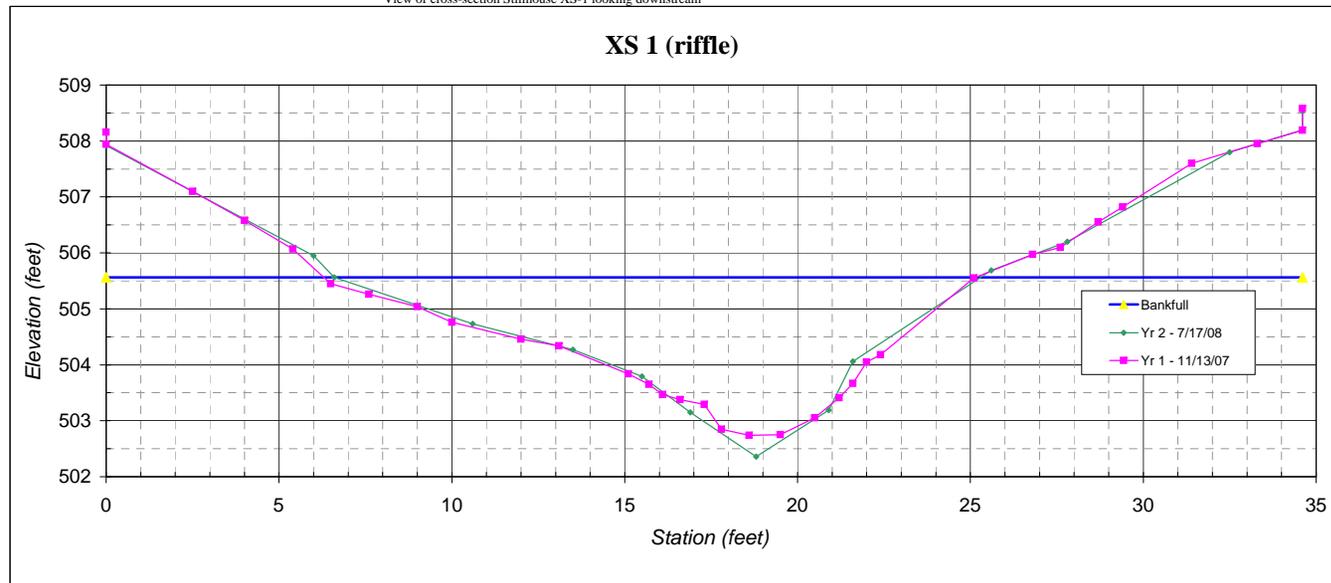
Station	Rod Ht.	Elevation
0	4.09	508.16
0	4.33	507.92
6	6.3	505.95
6.6	6.69	505.56
10.6	7.52	504.73
13.5	7.98	504.27
15.5	8.46	503.79
16.9	9.1	503.15
18.8	9.89	502.36
20.9	9.06	503.19
21.6	8.19	504.06
25.6	6.56	505.69
27.8	6.05	506.20
32.5	4.45	507.80
34.6	4.05	508.20
34.6	3.71	508.54

SUMMARY DATA
 Floodprone Elevation (ft) 508.76
 Bankfull Elevation (ft) 505.56
 Floodprone Width (ft) 34.44
 Bankfull Width (ft) 18.68
 Entrenchment Ratio 1.84
 Mean Depth (ft) 1.39
 Maximum Depth (ft) 3.20
 Width/Depth Ratio 13.42
 Bankfull Area (sq ft) 26.01
 Wetted Perimeter (ft) 20.02
 Hydraulic Radius (ft) 1.30

Stream Type: B5



View of cross-section Stillhouse XS-1 looking downstream



Appendix B.6. Cross Section Plots and Photo - Year 2 - 2008 - Stillhouse Creek Stream Restoration -NCEEP #402

River Basin: Neuse
 Watershed: Stillhouse Creek
 XS ID: XS 2 (pool)
 Reach: 2
 Date: 7/17/2008
 Field Crew: S.D. and J.O.

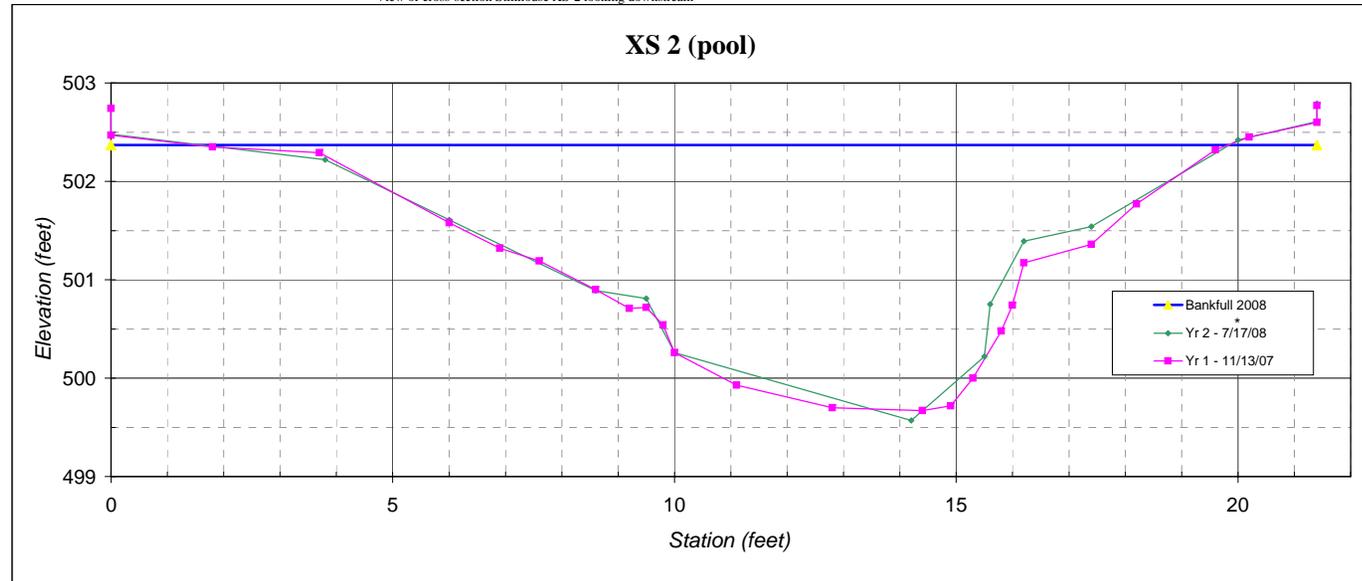
Station	Rod Ht.	Elevation
0	4.71	502.74
0	4.97	502.48
3.8	5.23	502.22
6	5.84	501.61
8.6	6.56	500.89
9.5	6.64	500.81
10	7.19	500.26
14.2	7.88	499.57
15.5	7.23	500.22
15.6	6.7	500.75
16.2	6.06	501.39
17.4	5.91	501.54
20	5.03	502.42
21.4	4.84	502.61
21.4	4.66	502.79

SUMMARY DATA		
Floodprone Elevation (ft)		505.27
Bankfull Elevation (ft)		502.42
Floodprone Width (ft)		94.50
Bankfull Width (ft)		19.12
Entrenchment Ratio		4.94
Mean Depth (ft)		1.25
Maximum Depth (ft)		2.85
Width/Depth Ratio		15.30
Bankfull Area (sq ft)		23.90
Wetted Perimeter (ft)		20.64
Hydraulic Radius (ft)		1.16

Stream Type: CS



View of cross-section Stillhouse XS-2 looking downstream



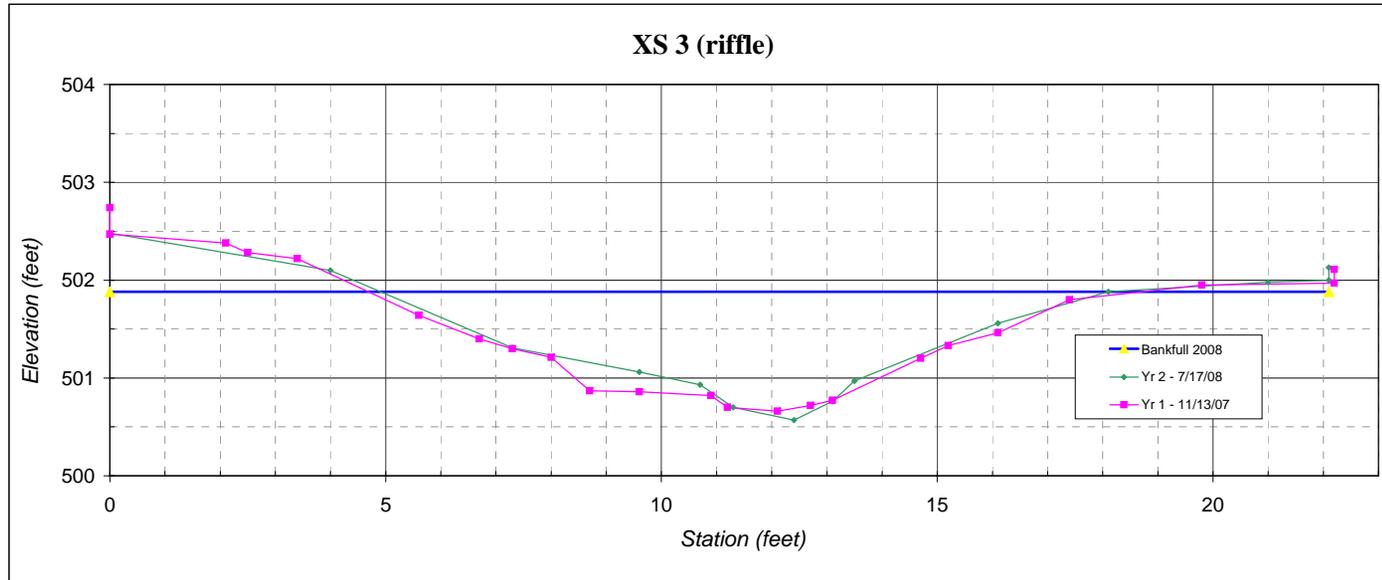
River Basin: Neuse
 Watershed: Stillhouse Creek
 XS ID: XS 3 (riffle)
 Reach: 2
 Date: 7/17/2008
 Field Crew: S.D. and J.O.

Station	Rod Ht.	Elevation
0	4.71	502.74
0	4.97	502.48
4	5.35	502.10
7.3	6.14	501.31
9.6	6.39	501.06
10.7	6.52	500.93
11.3	6.75	500.70
12.4	6.88	500.57
13.1	6.69	500.76
13.5	6.48	500.97
16.1	5.89	501.56
18.1	5.57	501.88
21	5.47	501.98
22.1	5.45	502.00
22.1	5.32	502.13

SUMMARY DATA
 Floodprone Elevation (ft) 503.19
 Bankfull Elevation (ft) 501.88
 Floodprone Width (ft) 107.00
 Bankfull Width (ft) 13.18
 Entrenchment Ratio 8.12
 Mean Depth (ft) 0.64
 Maximum Depth (ft) 1.31
 Width/Depth Ratio 20.60
 Bankfull Area (sq ft) 8.43
 Wetted Perimeter (ft) 13.49
 Hydraulic Radius (ft) 0.63
 Stream Type: C4



View of cross-section Stillhouse XS-3 looking downstream



Appendix B.6. Cross Section Plots and Photo - Year 2 - 2008 - Stillhouse Creek Stream Restoration -NCEEP #402

River Basin: Neuse
 Watershed: Stillhouse Creek
 XS ID: XS 4 (riffle)
 Reach: 3
 Date: 7/17/2008
 Field Crew: S.D. and J.O.

Station	Rod Ht.	Elevation
0	2.12	500.46
0	2.31	500.27
1.9	2.7	499.88
3.5	3.87	498.71
8	7.15	495.43
10.6	8.7	493.88
13	8.85	493.73
16.4	10.13	492.45
17	10.67	491.91
18.4	11.05	491.53
19.8	10.69	491.89
21	10.3	492.28
22	9.89	492.69
26	9	493.58
33.1	8.36	494.22
36	7.37	495.21
43.3	4.68	497.90
44.7	4.44	498.14
44.7	4.18	498.40

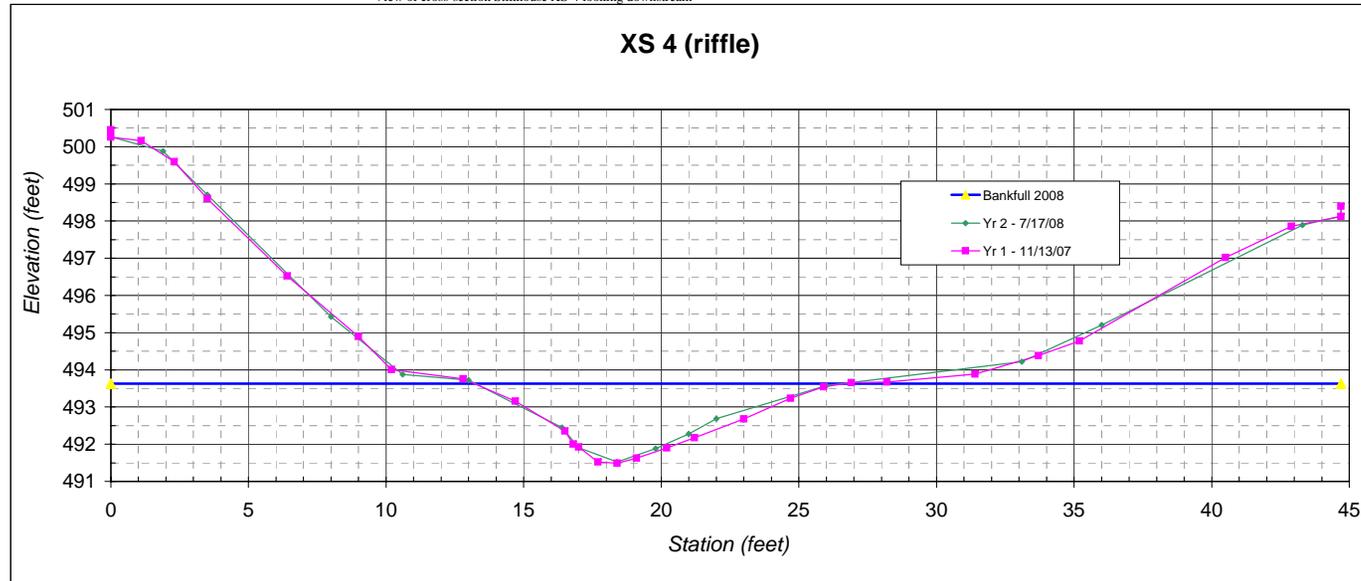
SUMMARY DATA

Floodprone Elevation (ft)	495.83
Bankfull Elevation (ft)	493.63
Floodprone Width (ft)	29.30
Bankfull Width (ft)	14.66
Entrenchment Ratio	2.00
Mean Depth (ft)	0.99
Maximum Depth (ft)	2.20
Width/Depth Ratio	14.86
Bankfull Area (sq ft)	14.47
Wetted Perimeter (ft)	15.45
Hydraulic Radius (ft)	0.94

Stream Type: B4



View of cross-section Stillhouse XS-4 looking downstream



Appendix B.6. Cross Section Plots and Photo - Year 2 - 2008 - Stillhouse Creek Stream Restoration -NCEEP #402

River Basin: Neuse
 Watershed: Stillhouse Creek
 XS ID: XS 5 (pool)
 Reach: 3
 Date: 7/17/2008
 Field Crew: S.D. and J.O.

Station	Rod Ht.	Elevation
0	1.74	500.84
0	1.93	500.65
2.8	2.38	500.20
5.3	3.65	498.93
9	7.13	495.45
11.8	8.73	493.85
12.3	8.93	493.65
14.1	9.52	493.06
15.6	10.86	491.72
19.1	11.61	490.97
21.9	10.95	491.63
22.2	10.43	492.15
24.9	9.28	493.30
32.5	8.74	493.84
36	7.75	494.83
38.8	6.56	496.02
41.6	5.08	497.50
43.1	4.92	497.66
43.1	4.71	497.87

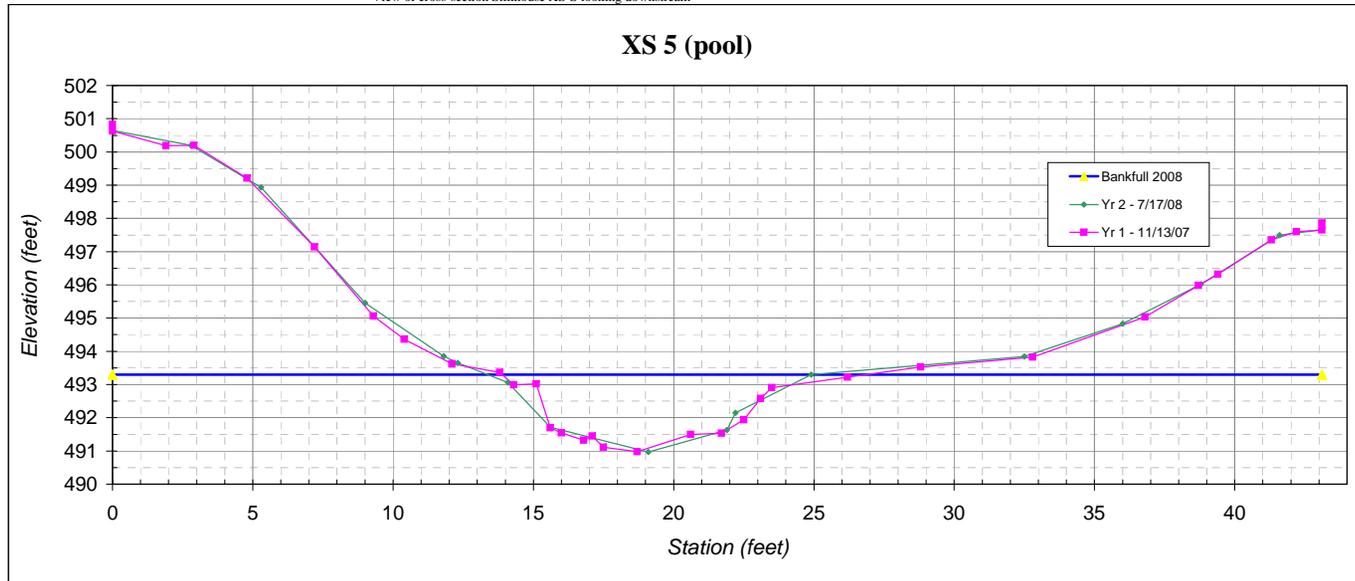
SUMMARY DATA

Floodprone Elevation (ft)	495.63
Bankfull Elevation (ft)	493.30
Floodprone Width (ft)	26.48
Bankfull Width (ft)	11.53
Entrenchment Ratio	2.30
Mean Depth (ft)	1.38
Maximum Depth (ft)	2.33
Width/Depth Ratio	8.38
Bankfull Area (sq ft)	15.87
Wetted Perimeter (ft)	12.77
Hydraulic Radius (ft)	1.24

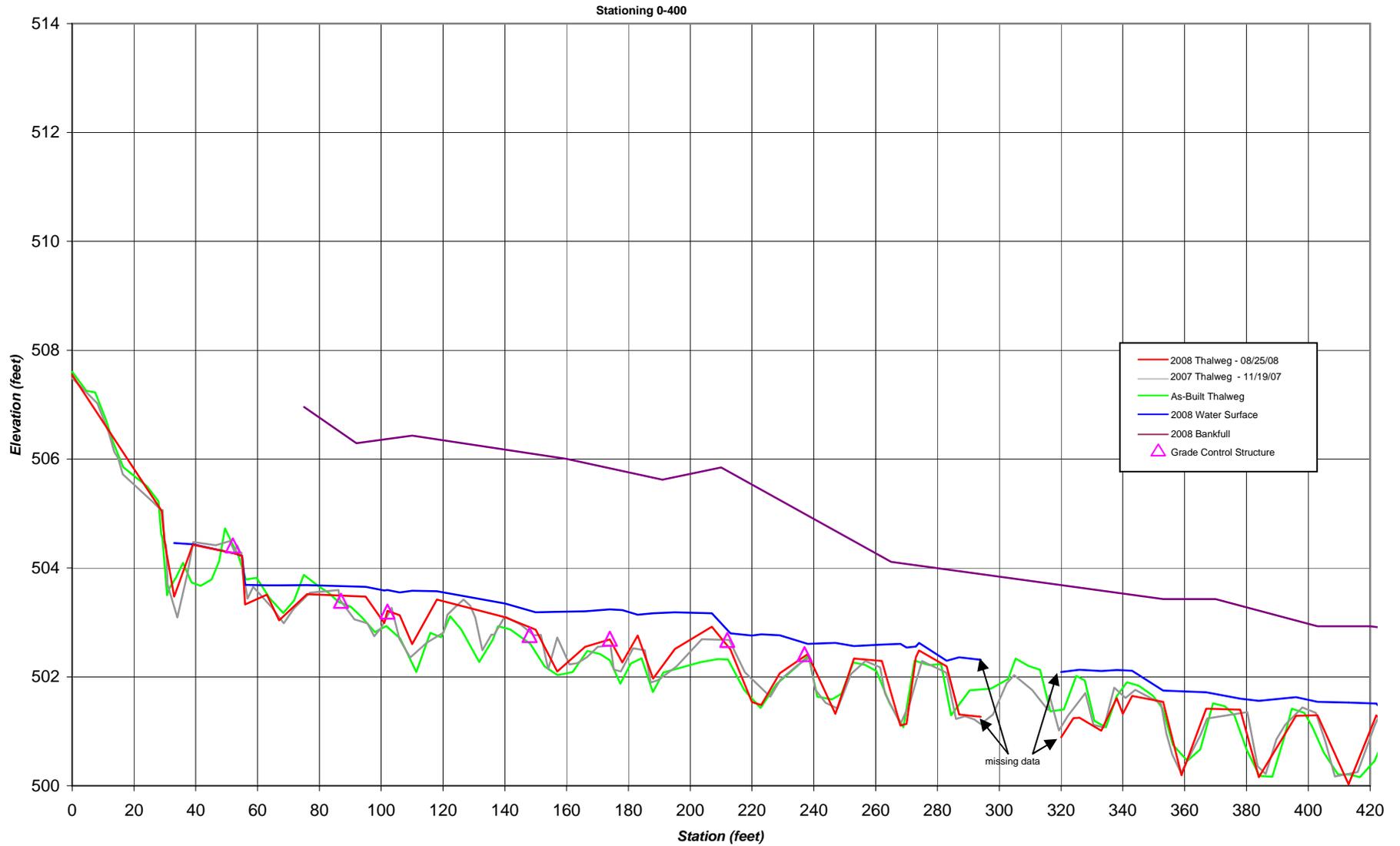
Stream Type: E4



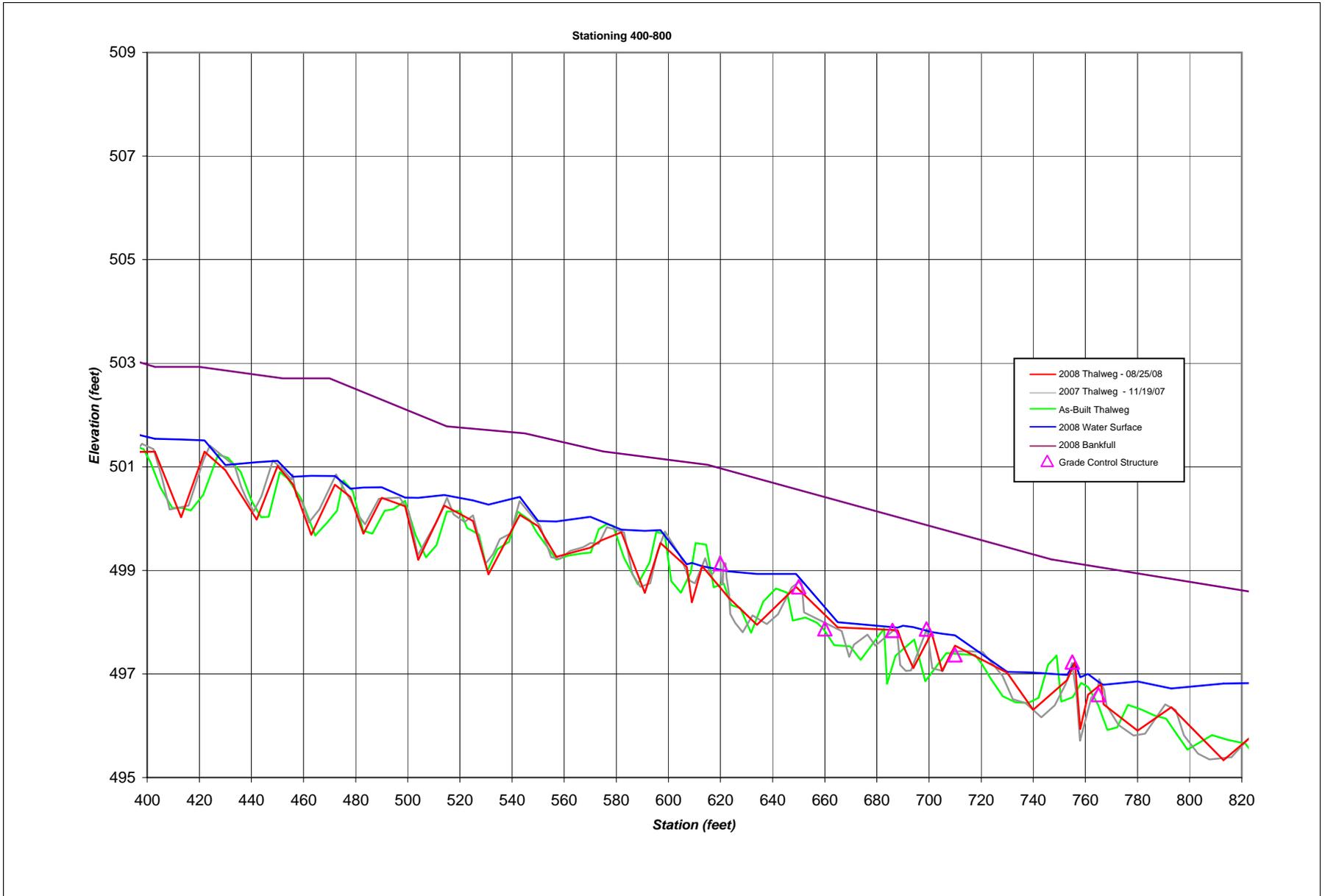
View of cross-section Stillhouse XS-S looking downstream



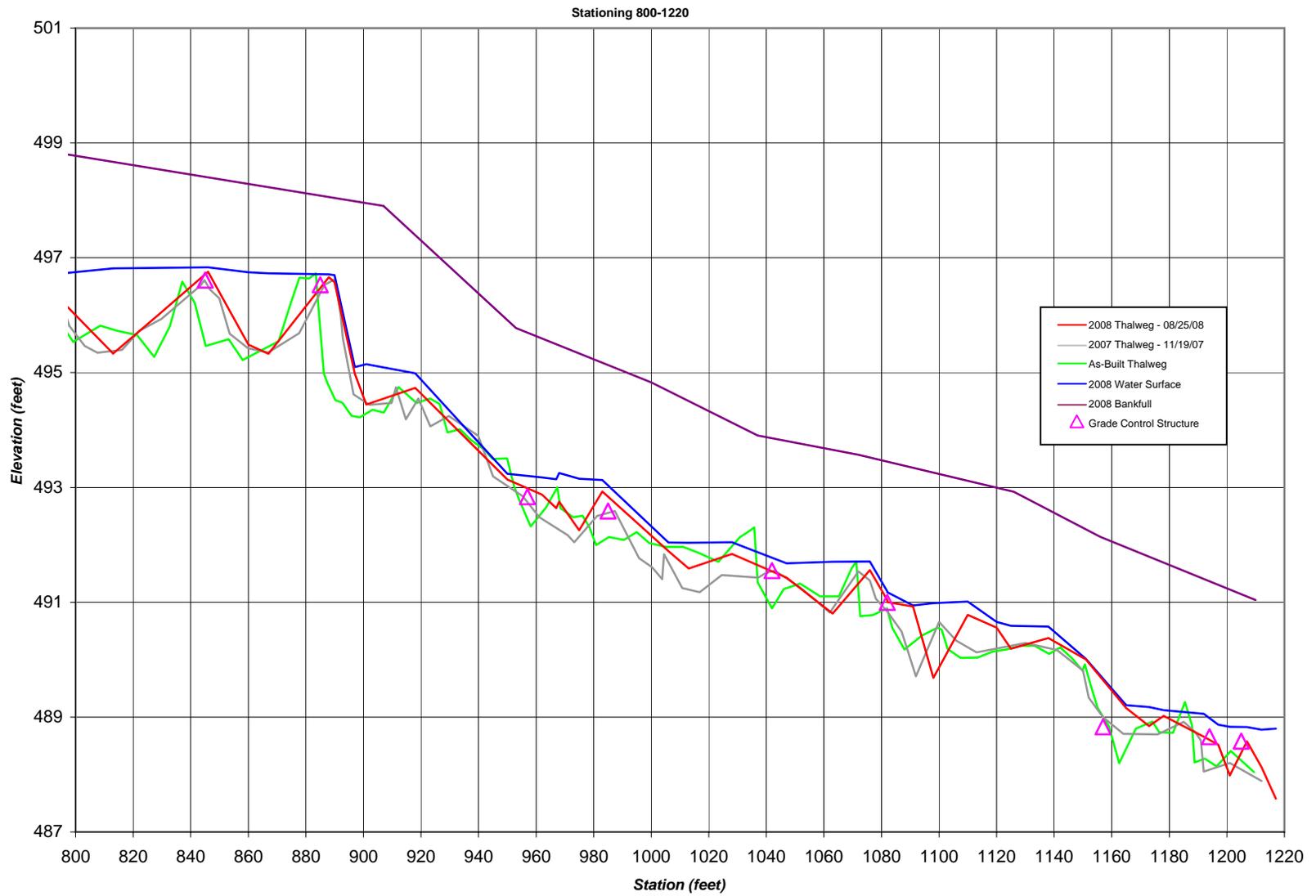
Appendix B.7. Longitudinal Plots - Stillhouse Creek Stream Restoration - EEP Project #363



B7. Longitudinal Plots and Raw Data Tables - Stillhouse Creek Stream Restoration - EEP Project #363



B7. Longitudinal Plots and Raw Data Tables - Stillhouse Creek Stream Restoration - EEP Project #363



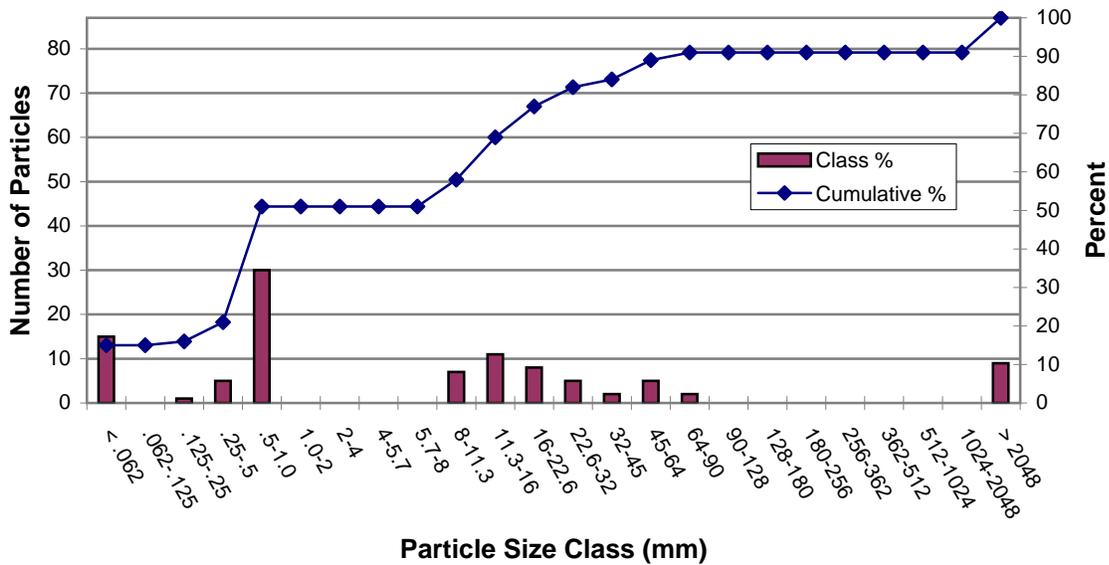
Appendix B.8. Pebble Count - Stillhouse Creek Stream Restoration Second Year Monitoring 7/17/08

Cross Section One

S/C	Particle	Size Range (mm)	Total #	Class %	Cumulative %
	Silt/Clay	< .062	15	15	15
Sand	Very Fine Sand	.062-.125		0	15
	Fine Sand	.125-.25	1	1	16
	Medium Sand	.25-.5	5	5	21
	Coarse Sand	.5-1.0	30	30	51
	Very Course Sand	1.0-2		0	51
Gravel	Very Fine Gravel	2-4		0	51
	Fine Gravel	4-5.7		0	51
	Fine Gravel	5.7-8		0	51
	Medium Gravel	8-11.3	7	7	58
	Medium Gravel	11.3-16	11	11	69
	Coarse Gravel	16-22.6	8	8	77
	Coarse Gravel	22.6-32	5	5	82
	Very Course Gravel	32-45	2	2	84
	Very Course Gravel	45-64	5	5	89
Cobble	Small Cobble	64-90	2	2	91
	Small Cobble	90-128		0	91
	Medium Cobble	128-180		0	91
	Large Cobble	180-256		0	91
Boulder	Small Boulders	256-362		0	91
	Small Boulders	362-512		0	91
	Medium Boulders	512-1024		0	91
	Large Boulders	1024-2048		0	91
	Bedrock	> 2048	9	9	100
Total			100		

d₅₀ = 0.98 mm

d₈₄ = 45 mm



Appendix B.8. Pebble Count - Stillhouse Creek Stream Restoration Second Year Monitoring 7/17/08

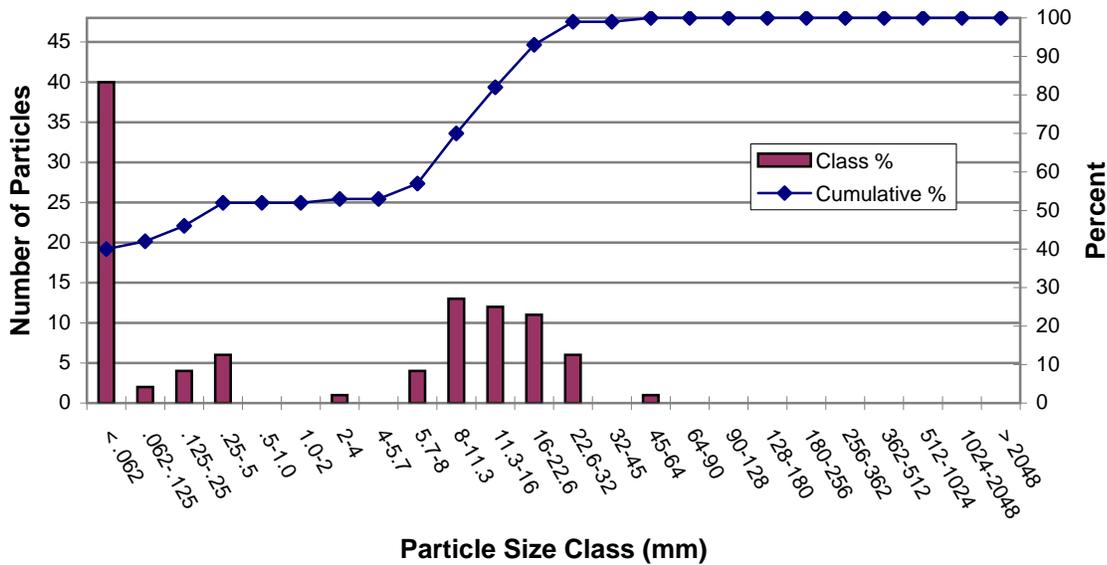
Cross Section Two

S/C	Particle	Size Range (mm)	Total #	Class %	Cumulative %
	Silt/Clay	< .062	40	40	40
Sand	Very Fine Sand	.062-.125	2	2	42
	Fine Sand	.125-.25	4	4	46
	Medium Sand	.25-.5	6	6	52
	Coarse Sand	.5-1.0		0	52
	Very Course Sand	1.0-2		0	52
Gravel	Very Fine Gravel	2-4	1	1	53
	Fine Gravel	4-5.7		0	53
	Fine Gravel	5.7-8	4	4	57
	Medium Gravel	8-11.3	13	13	70
	Medium Gravel	11.3-16	12	12	82
	Coarse Gravel	16-22.6	11	11	93
	Coarse Gravel	22.6-32	6	6	99
	Very Course Gravel	32-45		0	99
	Very Course Gravel	45-64	1	1	100
Cobble	Small Cobble	64-90		0	100
	Small Cobble	90-128		0	100
	Medium Cobble	128-180		0	100
	Large Cobble	180-256		0	100
Boulder	Small Boulders	256-362		0	100
	Small Boulders	362-512		0	100
	Medium Boulders	512-1024		0	100
	Large Boulders	1024-2048		0	100
	Bedrock	> 2048		0	100

d₅₀ = 0.42 mm

d₈₄ = 17.2 mm

Total 100



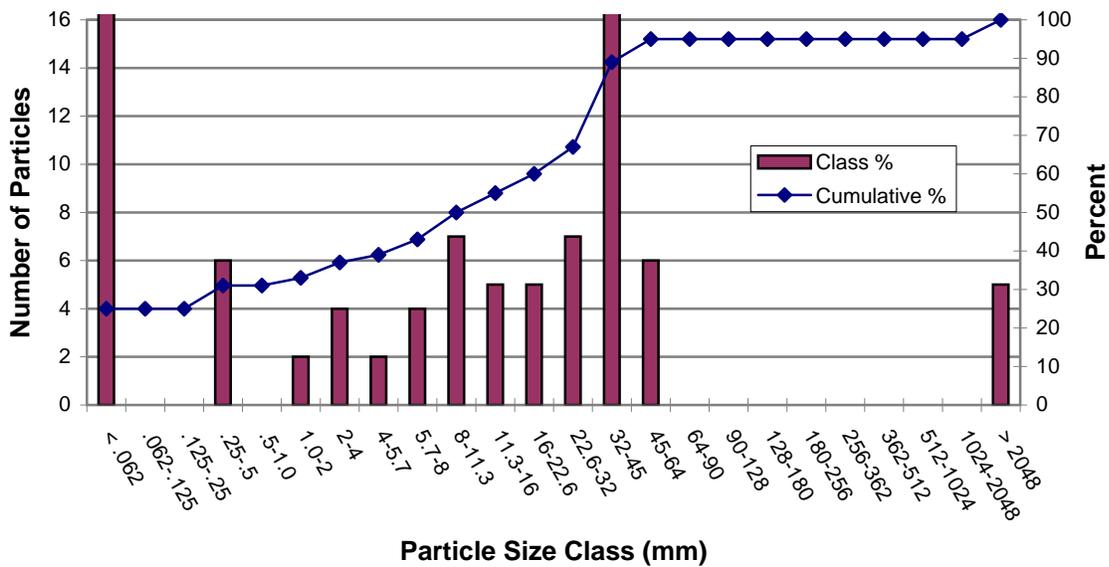
Appendix B.8. Pebble Count - Stillhouse Creek Stream Restoration Second Year Monitoring 7/17/08

Cross Section Three

S/C	Particle	Size Range (mm)	Total #	Class %	Cumulative %
	Silt/Clay	< .062	25	25	25
Sand	Very Fine Sand	.062-.125		0	25
	Fine Sand	.125-.25		0	25
	Medium Sand	.25-.5	6	6	31
	Coarse Sand	.5-1.0		0	31
	Very Course Sand	1.0-2	2	2	33
Gravel	Very Fine Gravel	2-4	4	4	37
	Fine Gravel	4-5.7	2	2	39
	Fine Gravel	5.7-8	4	4	43
	Medium Gravel	8-11.3	7	7	50
	Medium Gravel	11.3-16	5	5	55
	Coarse Gravel	16-22.6	5	5	60
	Coarse Gravel	22.6-32	7	7	67
	Very Course Gravel	32-45	22	22	89
	Very Course Gravel	45-64	6	6	95
Cobble	Small Cobble	64-90		0	95
	Small Cobble	90-128		0	95
	Medium Cobble	128-180		0	95
	Large Cobble	180-256		0	95
Boulder	Small Boulders	256-362		0	95
	Small Boulders	362-512		0	95
	Medium Boulders	512-1024		0	95
	Large Boulders	1024-2048		0	95
	Bedrock	> 2048	5	5	100

d₅₀ = 11.3 mm
d₈₄ = 42.05 mm

Total 100

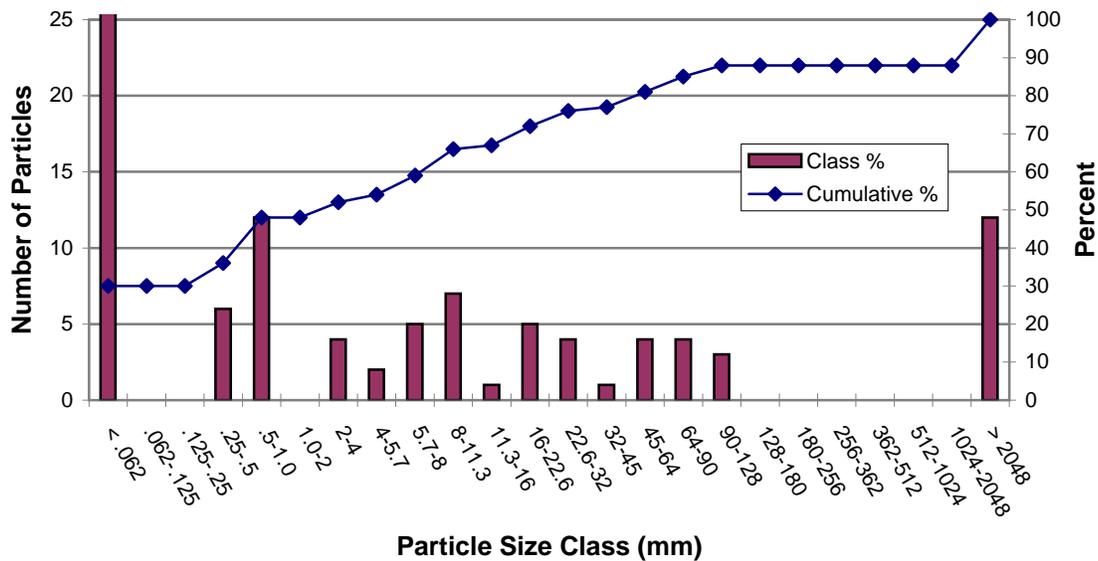


Appendix B.8. Pebble Count - Stillhouse Creek Stream Restoration Second Year Monitoring 7/17/08

Cross Section Four

S/C	Particle	Size Range (mm)	Total #	Class %	Cumulative %
	Silt/Clay	< .062	30	30	30
Sand	Very Fine Sand	.062-.125		0	30
	Fine Sand	.125-.25		0	30
	Medium Sand	.25-.5	6	6	36
	Coarse Sand	.5-1.0	12	12	48
	Very Course Sand	1.0-2		0	48
Gravel	Very Fine Gravel	2-4	4	4	52
	Fine Gravel	4-5.7	2	2	54
	Fine Gravel	5.7-8	5	5	59
	Medium Gravel	8-11.3	7	7	66
	Medium Gravel	11.3-16	1	1	67
	Coarse Gravel	16-22.6	5	5	72
	Coarse Gravel	22.6-32	4	4	76
	Very Course Gravel	32-45	1	1	77
	Very Course Gravel	45-64	4	4	81
Cobble	Small Cobble	64-90	4	4	85
	Small Cobble	90-128	3	3	88
	Medium Cobble	128-180		0	88
	Large Cobble	180-256		0	88
Boulder	Small Boulders	256-362		0	88
	Small Boulders	362-512		0	88
	Medium Boulders	512-1024		0	88
	Large Boulders	1024-2048		0	88
	Bedrock	> 2048	12	12	100
Total			100		

d₅₀ = 3.00 mm
d₈₄ = 83.50 mm



Appendix B.8. Pebble Count - Stillhouse Creek Stream Restoration Second Year Monitoring 7/17/08

Cross Section Five

S/C	Particle	Size Range (mm)	Total #	Class %	Cumulative %
	Silt/Clay	< .062	25	25	25
Sand	Very Fine Sand	.062-.125		0	25
	Fine Sand	.125-.25		0	25
	Medium Sand	.25-.5		0	25
	Coarse Sand	.5-1.0	1	1	26
	Very Course Sand	1.0-2		0	26
Gravel	Very Fine Gravel	2-4	2	2	28
	Fine Gravel	4-5.7		0	28
	Fine Gravel	5.7-8	1	1	29
	Medium Gravel	8-11.3	8	8	37
	Medium Gravel	11.3-16	9	9	46
	Coarse Gravel	16-22.6	4	4	50
	Coarse Gravel	22.6-32	5	5	55
	Very Course Gravel	32-45	6	6	61
	Very Course Gravel	45-64	5	5	66
Cobble	Small Cobble	64-90	3	3	69
	Small Cobble	90-128		0	69
	Medium Cobble	128-180	3	3	72
	Large Cobble	180-256		0	72
Boulder	Small Boulders	256-362		0	72
	Small Boulders	362-512		0	72
	Medium Boulders	512-1024		0	72
	Large Boulders	1024-2048		0	72
	Bedrock	> 2048	28	28	100
Total			100		

d₅₀ = 22.6 mm
d₈₄ = 2048 mm

