STILLHOUSE CREEK STREAM RESTORATION – Project # 363
2009 FINAL MONITORING REPORT – YEAR 3
January 2010

Submitted to:

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

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

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2009 FINAL MONITORING REPORT – YEAR 3

CONDUCTED FOR THE NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

APPENDICES

I. Executive Summary/Project Abstract

As outlined in the 2005 Restoration 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

In August 2009 RJG&A staff used the CVS-EEP monitoring protocol, level 2, to evaluate the planted woody stem survival in eight permanent vegetation plots. The average live planted woody stem density (323 live stems per acre) has met the vegetation success criteria (320 live stems per acre in Year 3). Generally, planted woody stem survival and vigor are high, although planted stem density lags behind in Reach 2. There are scattered woody invasives, including *Ligustrum sinense* (Chinese privet) and *Ailanthus altissima* (tree of heaven), throughout the conservation easement, especially in Reach 4.

RJG&A staff collected cross-section, longitudinal, and pebble data in August 2009. Overall, the site is maintaining its as-built dimension, pattern, and profile. Low flows due to a drought allowed terrestrial grasses to establish themselves in some riffles in Reach 2. However, based on experience in prior years, we expect this problem to resolve itself over the winter, when the average stream flow tends to be higher. Evaluation of the crest gauge on 6 March 2009 and 12 August 2009 indicate that several bankfull events had occurred in 2009. This was supported by on-site qualitative evidence. Several areas of piping were noted in Reach 4. However, this represents a minor problem; vanes received an overall score of 92% during the qualitative assessment done in August 2009.

Summary information/data related to the occurrence of items such as beaver or encroachment and statistics related to performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Narrative background and supporting information formerly found in these reports can be found in the mitigation and restoration plan documents available on EEP's website. All raw data supporting the tables and figures in the appendices are available from EEP upon request.

II. 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.

2.1. 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.

2.2. Vegetation Methodology

Four representative vegetation survey plots were selected and installed in reaches 1, 2, 3 and 4 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 3, Level 1 (planted woody stems) and Level 2 (volunteer woody stems) data collection was performed in August 2009. 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.

III. References

CDM (2005). *Stillhouse Creek Stream Restoration Project Sediment and Erosion Control Plan*. Provided by NCEEP, November 2007.

Harrelson, Cheryl, C. L. Rawlins, and John Potpondy. (1994). *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* USDA, Forest Service. General Technical Report RM-245.

Lee, Michael T., Peet, Robert K., Roberts, Steven D., Wentworth, Thomas R. (2006). *CVS-EEP Protocol for Recording Vegetation Version 4.0*. Retrieved October 30, 2006, from: http://www.nceep.net/business/monitoring/veg/datasheets.htm.

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.

Rosgen, D L (1996) *Applied River Morphology*. Wildland Hydrology Books, Pagosa Springs, CO.

Rosgen, DL. (1997). "A Geomorphological Approach to Restoration of Incised Rivers. In *Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision*, ed. S.S.Y. Wang, E.J. Langendoen and F.B. Shields, Jr. University of Mississippi Press, Oxford, MS.

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. General Figures and Plan Views

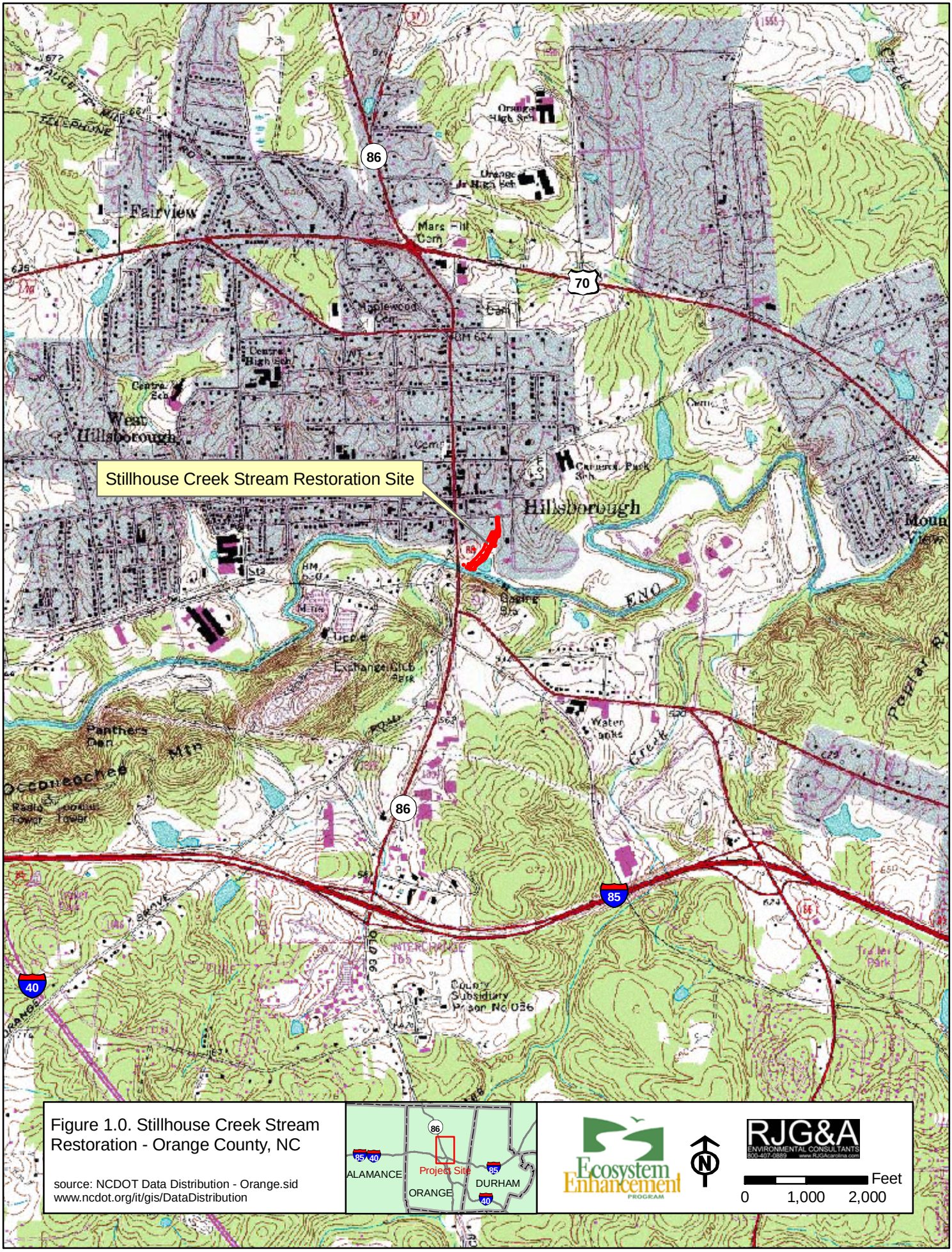


Figure 1.0. Stillhouse Creek Stream Restoration - Orange County, NC

source: NCDOT Data Distribution - Orange.sid
www.ncdot.org/it/gis/DataDistribution

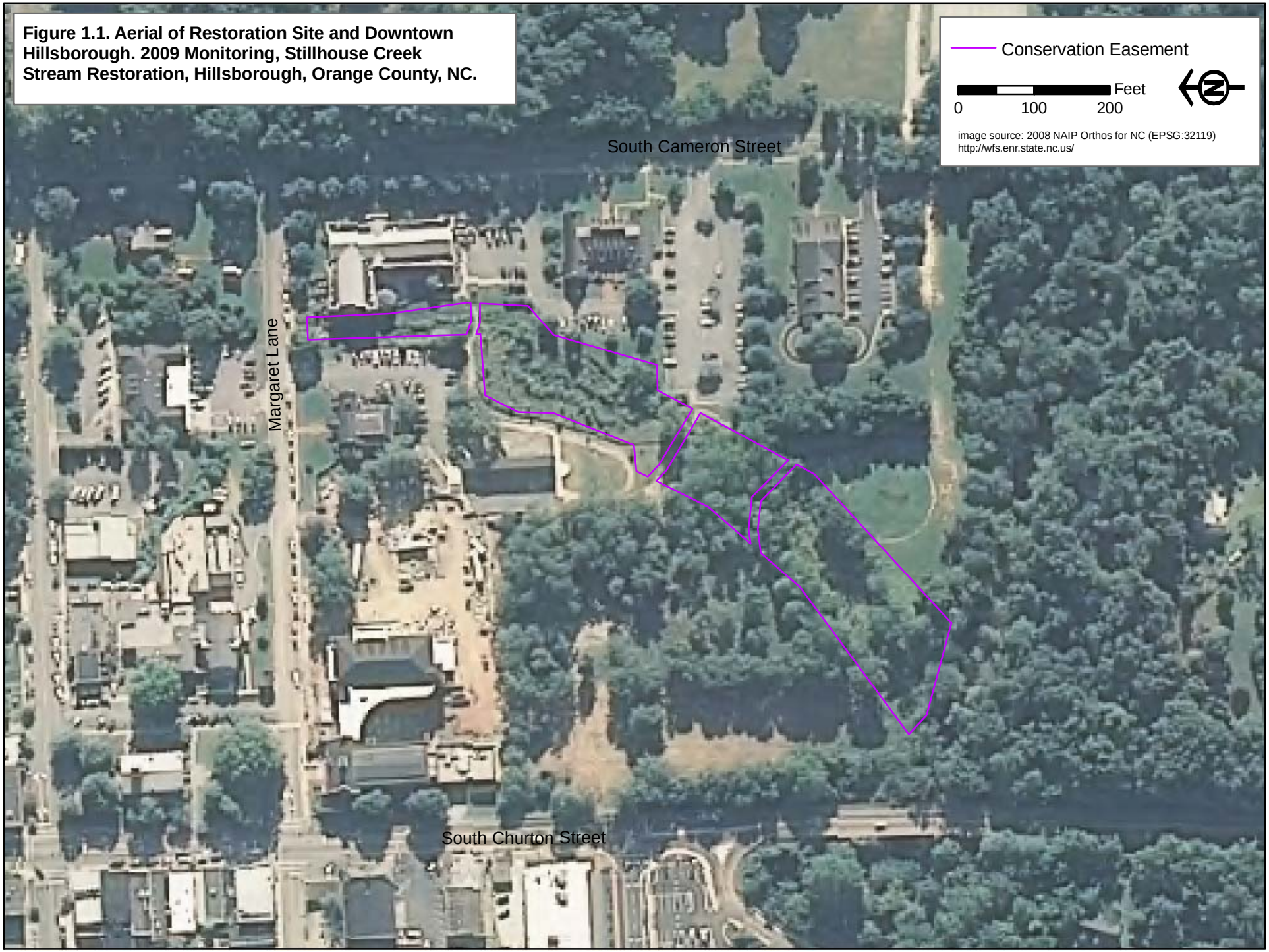


Figure 1.1. Aerial of Restoration Site and Downtown Hillsborough. 2009 Monitoring, Stillhouse Creek Stream Restoration, Hillsborough, Orange County, NC.

Figure 2.0. Current Conditions Plan View
2009 Monitoring, Stillhouse Creek Stream Restoration, Hillsborough, Orange County, NC

Photopoints
Cross-Sections
2009 Thalweg
As-Built Thalweg
Rock Structures
Vegetation Monitoring Plots
Easement Boundary

Stream Problem Areas
Piping

Vegetation Problem Areas
Debris in Buffer
Low Planted Stem Success
High Invasive Vegetation Density

0 100 200 Feet

Margaret Lane

0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1210

pp1 pp2 pp3 pp4 pp5 pp6 pp7 pp8 pp9 pp10

xs1 xs2 xs3 xs4 xs5

1 2 3 4

footbridge footbridge footbridge

pocket wetland pocket wetland pocket wetland

Reach 1 Reach 2 Reach 2 Reach 3 Reach 3 Reach 4

Ecosystem Enhancement Program

RJG&A ENVIRONMENTAL CONSULTANTS 800-407-0889 www.RJGAcarolina.com

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. General Project Tables

Table 1. Project Restoration Components Stillhouse Creek Stream Restoration – EEP Project #363					
Reach ID	Type	Approach	Linear Feet/Acres	Stationing	Comment
Reach 1	R	P2	223 lf	00+00-02+23	Shallow pools, small meanders, and steep riffles
Reach 2	R	P1	400 lf	02+35-6+35	Realigned, reconnected to floodplain
Reach 3	EI	P4	196 lf	6+35-6+85, 6+97-8+43	Banks stabilized
Reach 4	R	P3	355 lf	8+55-12+10	Connected to floodprone area
Riparian Buffer	R	--	1.12 acres	00+00 - 12+10	--

R=Restoration; E1=Enhancement I; P1=Priority 1; P2=Priority 2; P3=Priority 3; P4=Priority 4

Table 2. 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	
Year 2 Monitoring		November 2008
Qualitative Evaluation	May and October 2008	
Vegetation	August 2008	
Geomorphologic	August 2008	
Year 3 Monitoring		August 2009
Qualitative Evaluation	March and August 2009	
Vegetation	August 2009	
Geomorphologic	August 2009	

Table 3. Project Contacts Stillhouse Creek Stream Restoration - EEP Project #363	
Designer Primary project design POC	NRCS Angela Greene
Construction Contractor Construction Contractor POC	Fluvial Solutions Peter Jelenevsky
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 Sean Doig (919) 872-1174

Table 4. Project Attribute Table
Stillhouse Creek Stream Restoration – EEP Project #363

Project County	Orange
Physiographic Region	152 Acres (0.24 square miles)
Ecoregion	Carolina Slate Belt
Project River Basin	Neuse
USGS HUC for Project (14 digit)	03020201030020
NCDWQ Sub-basin for Project	03-04-01
Within extent of EEP Watershed Plan?	-
WRC Class (Warm, Cool, Cold)	-
% of project easement fenced or demarcated	0%
Beaver activity observed during design phase?	-

Restoration Component Attribute Table

	Reach 1	Reach 2	Reach 3	Reach 4
Drainage area	0.14			0.22
Stream order	First			
Restored length (feet)	235	400	220	355
Perennial or Intermittent	Perennial			
Watershed type (Rural, Urban, Developing etc.)	Urban	Urban	Urban	Urban
Watershed LULC Distribution (e.g.)	-	-	-	-
Residential	-	-	-	-
Ag-Row Crop	-	-	-	-
Ag-Livestock	-	-	-	-
Forested	-	-	-	-
Etc.	-	-	-	-
Watershed impervious cover (%)	-	-	-	-
NCDWQ AU/Index number	27-2-(7)	27-2-(7)	27-2-(7)	27-2-(7)
NCDWQ classification	C-NSW	C-NSW	C-NSW	C-NSW
303d listed?	No	No	No	No
Upstream of a 303d listed segment?	No	No	No	No
Reasons for 303d listing or stressor	NA	NA	NA	NA
Total acreage of easement	2.09 acres			
Total vegetated acreage within the easement	-	-	-	-
Total planted acreage as part of the restoration	-	-	-	-
Rosgen classification of pre-existing	E4	E4	E4	G4c/1
Rosgen classification of As-built[1]	E4	E4	E4	B4/1
Valley type	-	-	-	-
Valley slope	0.012	0.012	0.012	0.0185
Valley side slope range (e.g. 2-3.%)	-	-	-	-
Valley toe slope range (e.g. 2-3.%)	-	-	-	-
Cowardin classification	NA	NA	NA	NA
Trout waters designation	No	No	No	No
Species of concern, endangered etc.? (Y/N)	No	No	No	No
Dominant soil series and characteristics				
Series	Georgeville	Georgeville	Georgeville	Congaree
Depth	65	65	65	63
Clay%	5-27	5-27	5-27	5-25
K	0.43	0.43	0.43	0.28
T	3	3	3	5

Appendix C. Vegetation Assessment Data

Table 5. Vegetation Plot Mitigation Success Summary Table

Vegetation Monitoring Plot Photos

Table 6. Vegetation Metadata

Table 7. Stem Count Total and Planted by Plot and Species

Vegetation Problem Area Photos (electronic submission only)

Vegetation Problem Areas Inventory Table (electronic submission only)

Table 5. Vegetation Plot Mitigation Success Summary Table Stillhouse Creek Stream Restoration - EEP Project #363		
Vegetation Plot ID	Vegetation Survival Threshold Met	Tract Mean
01	Y	75%
02	N	
03	Y	
04	Y	

Appendix C. Vegetation Monitoring Plot Photographs - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

Plot 1 (10/31/07)

Plot 1 (8/16/09)

Plot 2 (10/31/07)

Plot 2 (8/16/09)

Appendix C. Vegetation Monitoring Plot Photographs - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

Plot 3 (10/31/07)

Plot 3 (8/16/09)

Plot 4 (11/05/07)

Plot 4 (8/16/09)

Table 6. Vegetation Metadata

Report Prepared By	sean doig
Date Prepared	8/7/2009 15:28
database name	cvs-eep-entrytool-v2.2.7.mdb
database location	C:\Users\UNC Support\Desktop
computer name	UNC-L3AM972
file size	33906688

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.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
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)	4
Sampled Plots	4

Appendix C. Table 7. Planted and Total Stem Counts.
EEP Project Code 363. Project Name: Stillhouse Creek (G)

			Current Plot Data (MY2 2009)												Annual Means								
			E363-jo&sd-0001			E363-jo&sd-0002			E363-jo&sd-0003			E363-jo&sd-0004			MY2 (2009)			MY1 (2007)			MY0 (2007)		
Scientific Name	Common Name	Species Type	P-LS	P-all	T	P-LS	P-all	T	P-LS	P-all	T	P-LS	P-all	T	P-LS	P-all	T	P-LS	P-all	T	P-LS	P-all	T
Acer negundo	boxelder	Tree												3			3						9
Acer rubrum	red maple	Tree																					3
Ailanthus altissima	tree of heaven	Tree																					2
Betula nigra	river birch	Tree																					1
Carpinus caroliniana	American hornbeam	Shrub Tree																					2
Carya	hickory	Tree																					2
Carya cordiformis	bitternut hickory	Tree						1									1						
Carya illinoinensis	pecan	Tree																					5
Carya ovata	shagbark hickory	Tree																					1
Celtis laevigata	sugarberry	Shrub Tree						9			2			3			14						63
Cornus amomum	silky dogwood	Shrub	3	3	3				2	2	2				5	5	5	5	5	5	5	5	5
Fraxinus pennsylvanica	green ash	Tree					2	2		1	1		2	5		5	8		5	5		6	8
Ilex verticillata	common winterberry	Shrub Tree		3	3					1	1		1	1		5	5		6	6		6	6
Juglans nigra	black walnut	Tree						2			1						3						
Lagerstroemia indica	crapemyrtle	Shrub Tree			9												9						40
Ligustrum sinense	Chinese privet	Shrub Tree									1			3			4						4
Lindera benzoin	northern spicebush	Shrub Tree								1	1		1	1		2	2		2	2		2	2
Liquidambar styraciflua	sweetgum	Tree																					2
Liriodendron tulipifera	tuliptree	Tree											1	1		1	1		1	1		1	1
Morella cerifera	wax myrtle	Shrub Tree		3	3		1	1		6	7		1	1		11	12		12	12		12	12
Nyssa sylvatica	blackgum	Tree											1	1		1	1		1	1		1	1
Platanus occidentalis	American sycamore	Tree					2	2								2	2		2	2		2	2
Quercus nigra	water oak	Tree			6												6						18
Quercus phellos	willow oak	Tree								1	1		1	1		2	2		2	2		2	2
Quercus rubra	northern red oak	Tree								3	3					3	3		5	5		5	5
Rhus copallinum	flameleaf sumac	Shrub Tree																					1
Salix nigra	black willow	Tree																					1
Sambucus canadensis	Common Elderberry	Shrub Tree	4	4	4										4	4	4	4	4	4	5	5	5
Ulmus alata	winged elm	Tree																					1
		Stem count	7	13	28	0	5	17	2	15	20	0	8	20	9	41	85	9	45	45	10	47	204
		size (ares)	1			1			1			1			4			4			4		
		size (ACRES)	0.02			0.02			0.02			0.02			0.10			0.10			0.10		
		Species count	2	4	6	0	3	6	1	7	10	0	7	10	2	11	18	2	11	11	2	11	27
		Stems per ACRE	283.3	526.1	1133	0	202.3	688	80.94	607	809.4	0	323.7	809.4	91.05	414.8	860	91.05	455.3	455.3	101.2	475.5	2064

Appendix C. Vegetation Problem Area Photos - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

VP1. Landscape debris thrown in buffer (8/16/2009)

VP2. Low planted stem density (8/16/2009)

VP3. *Ailanthus altissima* near station 860 (8/16/2009)

VP4. *Ligustrum sinense* near station 800 (3/6/2009)

Appendix C.

Vegetation Problem Area Inventory Table – Stillhouse Creek Stream Restoration EEP Project #363			
Feature/Issue	**Station/Range**	**Probable Cause**	**Photo #**
Vegetation knocked down or buried under landscaping debris	130-160	Trimmed branches from bushes adjacent to the easement were thrown into the riparian buffer.	VP1
Low planted stem density	450-580	Soil compaction or insufficient planting density.	VP2
Exotic invasive vegetation	775-1115	Off-site introduction of seeds, either from upstream or outside the conservation easement	VP3 & VP4

Appendix D. Stream Assessment Data

Stream Station Photos
Table 8. Visual Morphological Stability Assessment
Table 9. Verification of Bankfull Events
Cross sections with Annual Overlays
Longitudinal Profiles with Annual Overlays
Pebble Count Plots with Annual Overlays
Baseline Stream Data Summary Table (electronic submission only)
Morphology and Hydraulic Summary (electronic submission only)
Stream Problem Area Photos (electronic submission only)
Stream Problem Areas Inventory Table (electronic submission only)

Appendix D. Permanent Photopoint Photographs - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

PP #1 – Looking Downstream (06/14/07)

PP #1 – Looking Downstream (03/06/09)

PP #2 – Looking Downstream (06/14/07)

PP #2 – Looking Downstream (03/06/09)

Appendix D. Permanent Photopoint Photographs - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

PP #3 – Looking Downstream (06/14/07)

PP #3 – Looking Downstream (03/06/09)

PP #4 – Looking Downstream (06/14/07)

PP #4 – Looking Downstream (03/06/09)

Appendix D. Permanent Photopoint Photographs - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

PP #5 – Looking Upstream (06/14/07)

PP #5 – Looking Upstream (03/06/09)

PP #6 – Looking Upstream (06/14/07)

PP #6 – Looking Upstream (03/06/09)

Appendix D. Permanent Photopoint Photographs - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

PP #7 – Looking Downstream (06/14/07)

PP #7 – Looking Downstream (03/06/09)

PP #8 – Looking Downstream (06/14/07)

PP #8 – Looking Downstream (03/06/09)

Appendix D. Permanent Photopoint Photographs - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

PP #9 – Looking Downstream (06/14/07)

PP #9 – Looking Downstream (03/06/09)

PP #10 – Looking Upstream (06/14/07)

PP #10 – Looking Upstream (03/06/09)

Table 8. Visual Morphological Stability 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	5	7	0/0	71	
	2. Armor stable	5	7	0/0	71	
	3. Facet grade appears stable	5	7	0/0	71	
	4. Minimal evidence of embedding/fining	5	7	0/0	71	
	5. Length appropriate	5	7	0/0	71	**71**
B. Pools	1. Present	7	8	0/0	88	
	2. Sufficiently deep	7	8	0/0	88	
	3. Length appropriate	7	8	0/0	88	**88**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	4	4	0/0	NA	
	2. Downstream of meander (glide/inflection) centering	4	4	0/0	NA	**100**
D. Meanders	1. Outer bend in state of limited/controlled erosion	4	4	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation	0	4	0/0	0	
	3. Apparent Rc within spec	4	4	0/0	100	
	4. Sufficient floodplain access and relief	4	4	0/0	100	**100**
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	NA	NA	0/0	100	
	2. Channel bed degradation – areas of increasing downcutting or head cutting	NA	NA	0/0	100	**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	NA	100	
	2. Height appropriate	7	7	NA	100	
	3. Angle and geometry appear appropriate	7	7	NA	100	
	4. Free of piping or other structural failures	7	7	NA	100	**100**
H. Wads/ Boulders	1. Free of scour	NA	NA	NA	NA	
	2. Footing stable	NA	NA	NA	NA	**NA**

Table 8. Visual Morphological Stability Assessment

Stillhouse Creek Stream Restoration Project - Reach 2 - Project #363

(400 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	
	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	**100**
B. Pools	1. Present	15	15	0/0	100	
	2. Sufficiently deep	15	15	0/0	100	
	3. Length appropriate	14	15	1/15	96	**99**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	15	15	0/0	100	
	2. Downstream of meander (glide/inflection) centering	15	15	0/0	100	**100**
D. Meanders	1. Outer bend in state of limited/controlled erosion	15	15	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation	0	15	0/0	0	
	3. Apparent Rc within spec	15	15	0/0	100	
	4. Sufficient floodplain access and relief	15	15	0/0	100	**100**
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	NA	NA	0/0	100	
	2. Channel bed degradation – areas of increasing downcutting or head cutting	NA	NA	0/0	100	**NA**
F. Bank	1. Actively eroding, wasting, or slumping bank	NA	NA	0/0	100	**100**
G. Vanes	1. Free of back or arm scour	0	1	1/3	0	
	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	**75**
H. Wads/ Boulders	1. Free of scour	NA	NA	0/0	NA	
	2. Footing stable	NA	NA	0/0	NA	**NA**

Table 8. Visual Morphological Stability Assessment

Stillhouse Creek Stream Restoration Project - Reach 3

(220 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	2	4	2/20	50	
	2. Armor stable	2	4	0/0	50	
	3. Facet grade appears stable	2	4	0/0	50	
	4. Minimal evidence of embedding/fining	2	4	0/0	50	
	5. Length appropriate	2	4	2/20	50	**50**
B. Pools	1. Present	6	7	1/15	86	
	2. Sufficiently deep	6	7	0/0	86	
	3. Length appropriate	6	7	2/40	86	**86**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	4	4	0/0	100	
	2. Downstream of meander (glide/inflection) centering	4	4	0/0	100	**100**
D. Meanders	1. Outer bend in state of limited/controlled erosion	4	4	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation	0	4	0/0	0	
	3. Apparent Rc within spec	4	4	0/0	100	
	4. Sufficient floodplain access and relief	4	4	0/0	100	**100**
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	NA	NA	0/0	100	
	2. Channel bed degradation – areas of increasing downcutting or head cutting	NA	NA	0/0	100	**NA**
F. Bank	1. Actively eroding, wasting, or slumping bank	NA	NA	0/0	100	**100**
G. Vanes	1. Free of back or arm scour	4	4	0/0	100	
	2. Height appropriate	4	4	0/0	100	
	3. Angle and geometry appear appropriate	4	4	0/0	100	
	4. Free of piping or other structural failures	4	4	0/0	100	**100**
H. Wads/ Boulders	1. Free of scour	NA	NA	NA	NA	
	2. Footing stable	NA	NA	NA	NA	**NA**

Table 8. Visual Morphological Stability Assessment

Table B1. Visual Morphological Assessment Stillhouse Creek Stream Restoration Project - Reach 4

(355 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	5	5	0/0	100	
	2. Armor stable	5	5	0/0	100	
	3. Facet grade appears stable	5	5	0/0	100	
	4. Minimal evidence of embedding/fining	5	5	0/0	100	
	5. Length appropriate	5	5	0/0	100	**100**
B. Pools	1. Present	8	8	0/0	100	
	2. Sufficiently deep	8	8	0/0	100	
	3. Length appropriate	8	8	0/0	100	**100**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	4	4	0/0	100	
	2. Downstream of meander (glide/inflection) centering	4	4	0/0	100	**100**
D. Meanders	1. Outer bend in state of limited/controlled erosion	4	4	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation	0	4	0/0	0	
	3. Apparent Rc within spec	4	4	0/0	100	
	4. Sufficient floodplain access and relief	4	4	0/0	100	**100**
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	NA	NA	0/0	100	
	2. Channel bed degradation – areas of increasing downcutting or head cutting	NA	NA	0/0	100	**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	8	8	0/0	100	
	2. Height appropriate	8	8	0/0	100	
	3. Angle and geometry appear appropriate	8	8	0/0	100	
	4. Free of piping or other structural failures	5	8	3/6	100	**100**
H. Wads/ Boulders	1. Free of scour	NA	NA	NA	NA	
	2. Footing stable	NA	NA	NA	NA	**NA**

Table 9. 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)**
14 June 2007	Unknown	On-site high water indicators	NA
7 October 2007	None	Crest Gauge	NA
27 November 2007	7 October 2007 – 26 November 2007 CRONOS data suggests 24-27 October 2007 (4.47”)	Crest Gauge	NA
1 May 2008	27 Nov. 2007 – 30 April 2008 CRONOS data suggest 4 March 2008 (2.00”)	Crest Gauge	NA
26 August 2008	1 May 2008 – 25 August 2008 CRONOS data suggest 5 July 2008 (2.39”)	Crest Gauge	NA
6 March 2009	August 28 (4.82”), September 6 (3.98”), and September 26 (2.18”) December 12, 2008 (2.43”) or March 1-2, 2009 (1.33”)	Crest Gauge	NA
12 August 2009	6 June 2009 (2.39”), 10 June 2009 (1.31”), or 1 August 2009 (1.38”)	Crest Gauge	NA

River Basin:	Neuse
Watershed:	Stillhouse Creek
XS ID	XS 1 (riffle)
Reach:	1
Date:	8/6/2009
Field Crew:	S.D. and J.O.

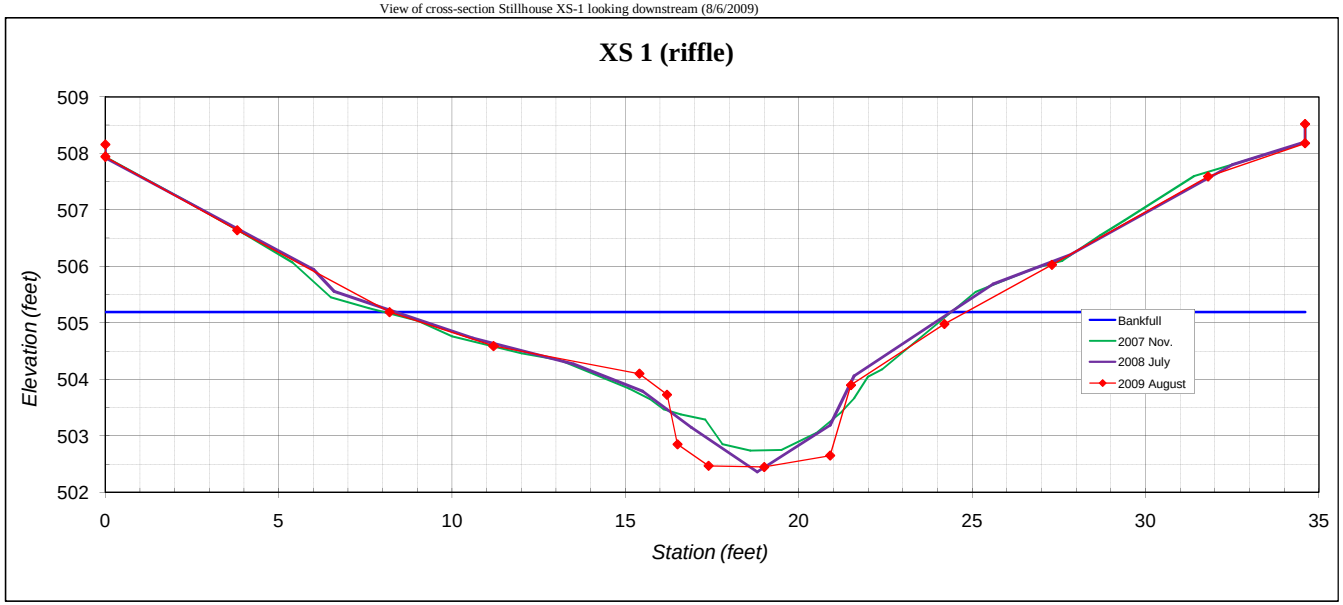
Station	Rod Ht.	Elevation
0	4.63	508.16
0	4.85	507.94
3.8	6.15	506.64
8.2	7.6	505.19
11.2	8.2	504.59
15.4	8.69	504.10
16.2	9.06	503.73
16.5	9.94	502.85
17.4	10.32	502.47
19	10.34	502.45
20.9	10.14	502.65
21.5	8.89	503.90
24.2	7.81	504.98
27.3	6.76	506.03
31.8	5.2	507.59
34.6	4.61	508.18
34.6	4.27	508.52

SUMMARY DATA

Floodprone Elevation (ft)	507.93
Bankfull Elevation (ft)	505.19
Floodprone Width (ft)	34.44
Bankfull Width (ft)	16.62
Entrenchment Ratio	2.07
Mean Depth (ft)	1.26
Maximum Depth (ft)	2.74
Width/Depth Ratio	13.19
Bankfull Area (sq ft)	20.94
Wetted Perimeter (ft)	18.54
Hydraulic Radius (ft)	1.13

Stream Type: B

View of cross-section Stillhouse XS-1 looking downstream (8/6/2009)



River Basin:	Neuse
Watershed:	Stillhouse Creek
XS ID	XS 2 (pool)
Reach:	2
Date:	8/6/2009
Field Crew:	S.D. and J.O.

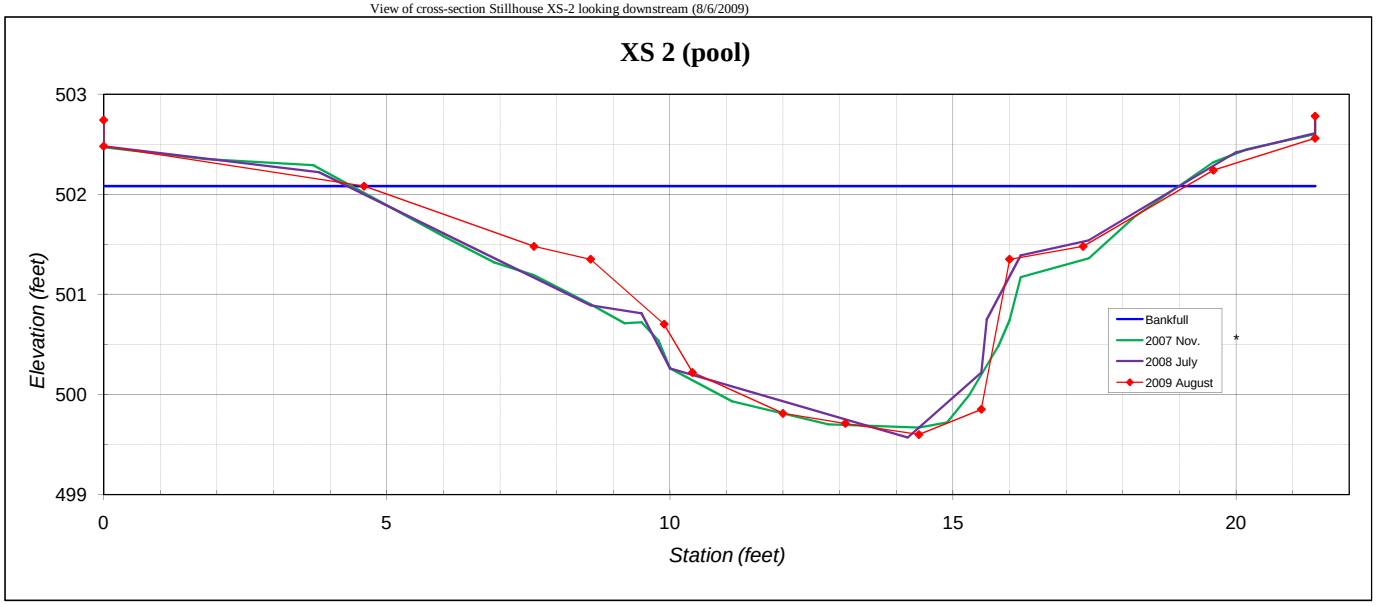
Station	Rod Ht.	Elevation
0	4.71	502.74
0	4.97	502.48
4.6	5.37	502.08
7.6	5.97	501.48
8.6	6.1	501.35
9.9	6.75	500.70
10.4	7.23	500.22
12	7.64	499.81
13.1	7.74	499.71
14.4	7.85	499.60
15.5	7.6	499.85
16	6.1	501.35
17.3	5.97	501.48
19.6	5.21	502.24
21.4	4.89	502.56
21.4	4.67	502.78

SUMMARY DATA

Floodprone Elevation (ft)	504.56
Bankfull Elevation (ft)	502.08
Floodprone Width (ft)	94.50
Bankfull Width (ft)	14.52
Entrenchment Ratio	6.51
Mean Depth (ft)	1.21
Maximum Depth (ft)	2.48
Width/Depth Ratio	12.04
Bankfull Area (sq ft)	17.49
Wetted Perimeter (ft)	16.20
Hydraulic Radius (ft)	1.08

Stream Type: C

View of cross-section Stillhouse XS-2 looking downstream (8/6/2009)



River Basin:	Neuse
Watershed:	Stillhouse Creek
XS ID	XS 3 (riffle)
Reach:	2
Date:	8/6/2009
Field Crew:	S.D. and J.O.

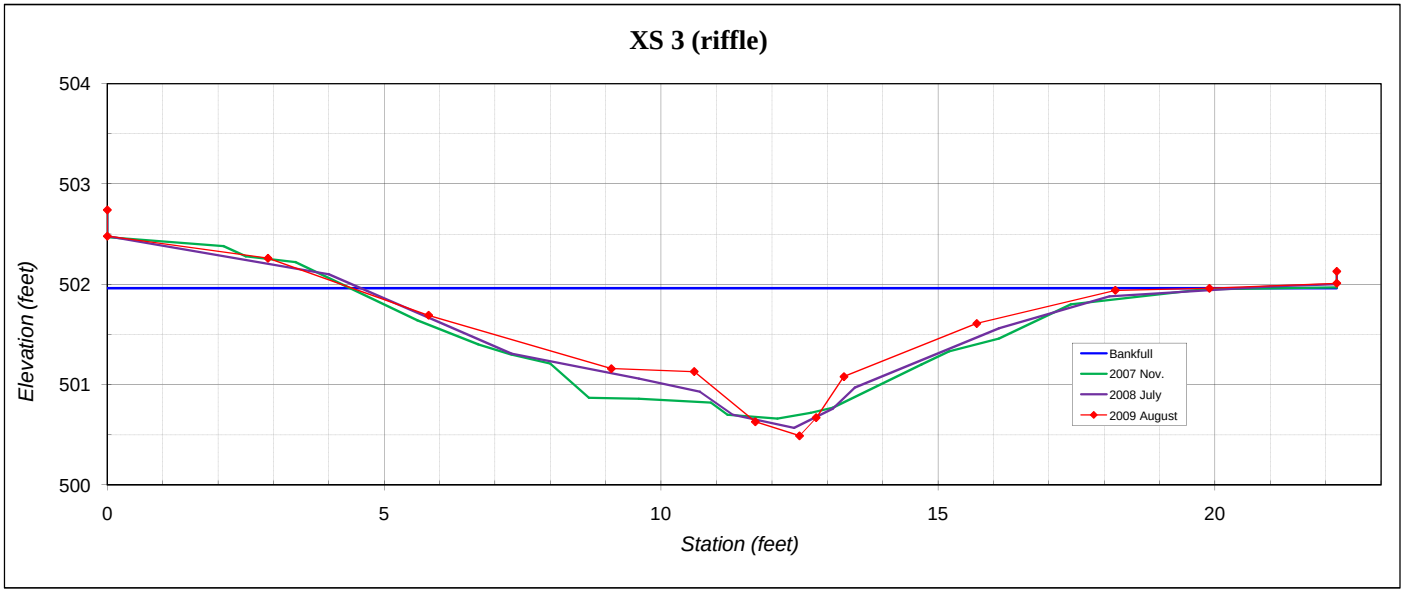
Station	Rod Ht.	Elevation
0	4.71	502.74
0	4.97	502.48
2.9	5.19	502.26
5.8	5.76	501.69
9.1	6.29	501.16
10.6	6.32	501.13
11.7	6.82	500.63
12.5	6.96	500.49
12.8	6.78	500.67
13.3	6.37	501.08
15.7	5.84	501.61
18.2	5.51	501.94
19.9	5.49	501.96
22.2	5.44	502.01
22.2	5.32	502.13

SUMMARY DATA

Floodprone Elevation (ft)	503.43
Bankfull Elevation (ft)	501.96
Floodprone Width (ft)	107.00
Bankfull Width (ft)	15.47
Entrenchment Ratio	6.91
Mean Depth (ft)	0.54
Maximum Depth (ft)	1.47
Width/Depth Ratio	28.53
Bankfull Area (sq ft)	8.39
Wetted Perimeter (ft)	15.94
Hydraulic Radius (ft)	0.53

Stream Type: C

View of cross-section Stillhouse XS-3 looking downstream (8/6/2009)



River Basin:	Neuse
Watershed:	Stillhouse Creek
XS ID	XS 4 (riffle)
Reach:	4
Date:	8/6/2009
Field Crew:	S.D. and J.O.

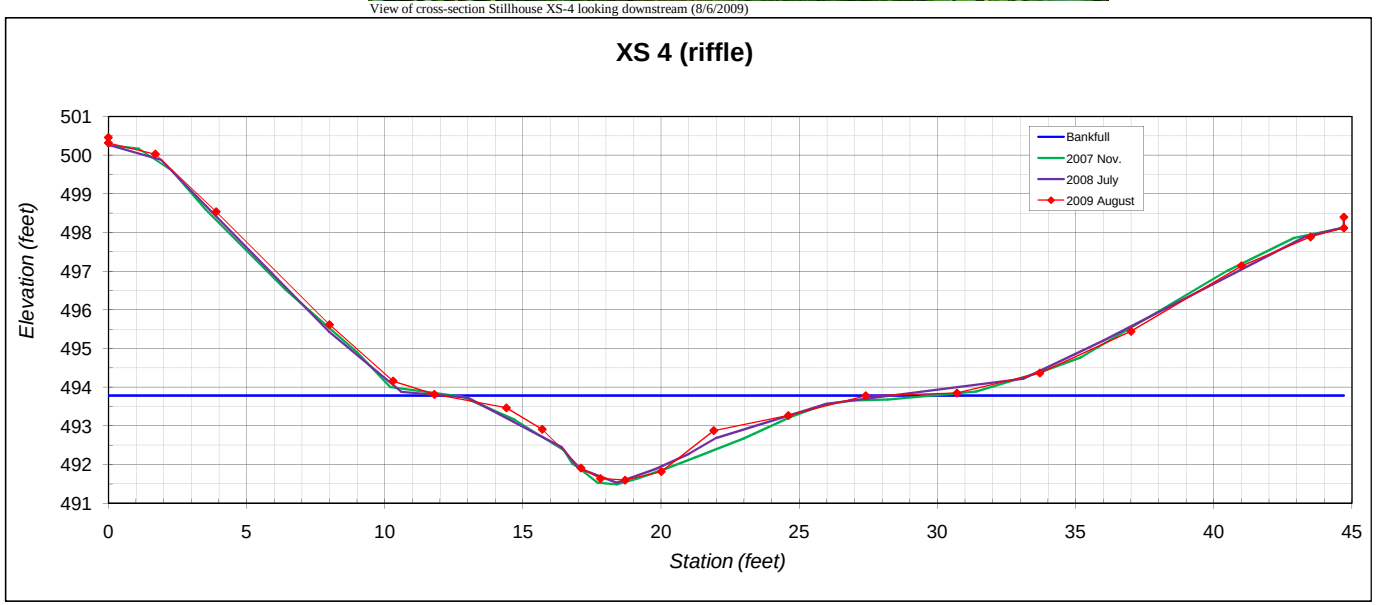
Station	Rod Ht.	Elevation
0	2.3	500.46
0	2.44	500.32
1.7	2.73	500.03
3.9	4.22	498.54
8	7.14	495.62
10.3	8.6	494.16
11.8	8.94	493.82
14.4	9.29	493.47
15.7	9.85	492.91
17.1	10.85	491.91
17.8	11.12	491.64
18.7	11.16	491.60
20	10.94	491.82
21.9	9.88	492.88
24.6	9.49	493.27
27.4	8.98	493.78
30.7	8.91	493.85
33.7	8.39	494.37
37	7.31	495.45
41	5.62	497.14
43.5	4.87	497.89
44.7	4.64	498.12
44.7	4.36	498.40

SUMMARY DATA

Floodprone Elevation (ft)	495.96
Bankfull Elevation (ft)	493.78
Floodprone Width (ft)	29.30
Bankfull Width (ft)	15.30
Entrenchment Ratio	1.91
Mean Depth (ft)	0.94
Maximum Depth (ft)	2.18
Width/Depth Ratio	16.25
Bankfull Area (sq ft)	15.30
Wetted Perimeter (ft)	16.18
Hydraulic Radius (ft)	0.89

Stream Type: B

View of cross-section Stillhouse XS-4 looking downstream (8/6/2009)



River Basin:	Neuse
Watershed:	Stillhouse Creek
XS ID	XS 5 (pool)
Reach:	4
Date:	8/6/2009
Field Crew:	S.D. and J.O.

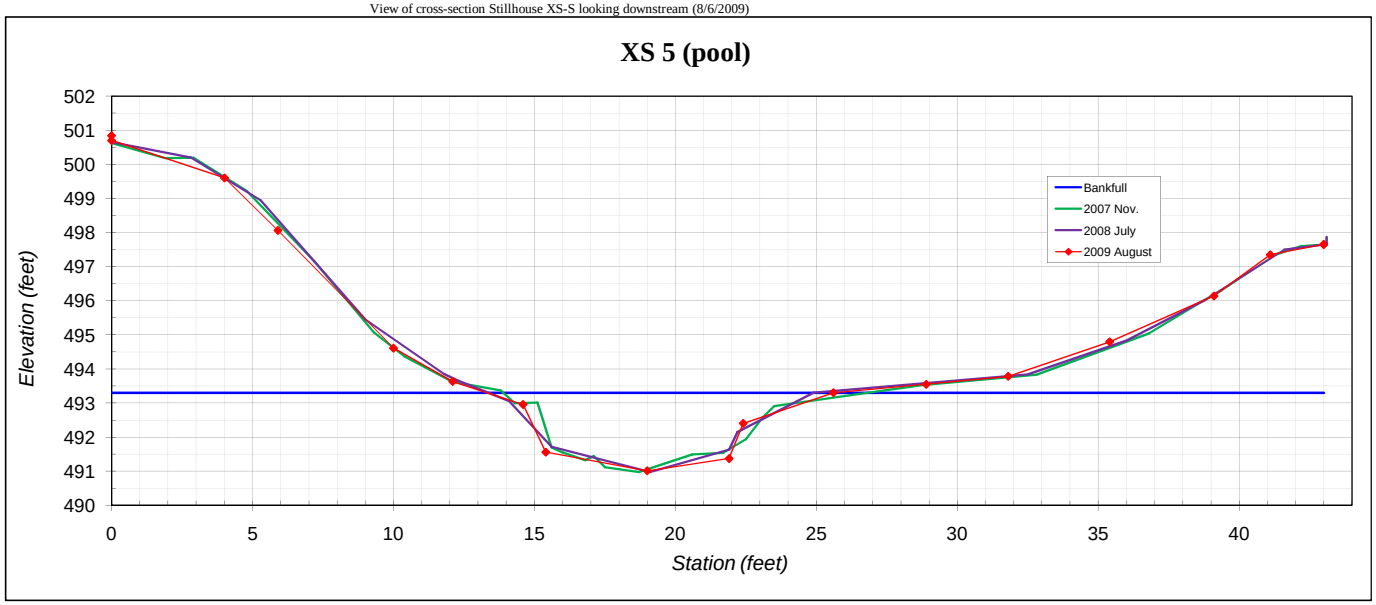
Station	Rod Ht.	Elevation
0	2.09	500.84
0	2.23	500.70
4	3.33	499.60
5.9	4.87	498.06
10	8.32	494.61
12.1	9.3	493.63
14.6	9.98	492.95
15.4	11.37	491.56
19	11.92	491.01
21.9	11.56	491.37
22.4	10.53	492.40
25.6	9.63	493.30
28.9	9.38	493.55
31.8	9.15	493.78
35.4	8.14	494.79
39.1	6.79	496.14
41.1	5.58	497.35
43	5.28	497.65
43	5.28	497.65

SUMMARY DATA

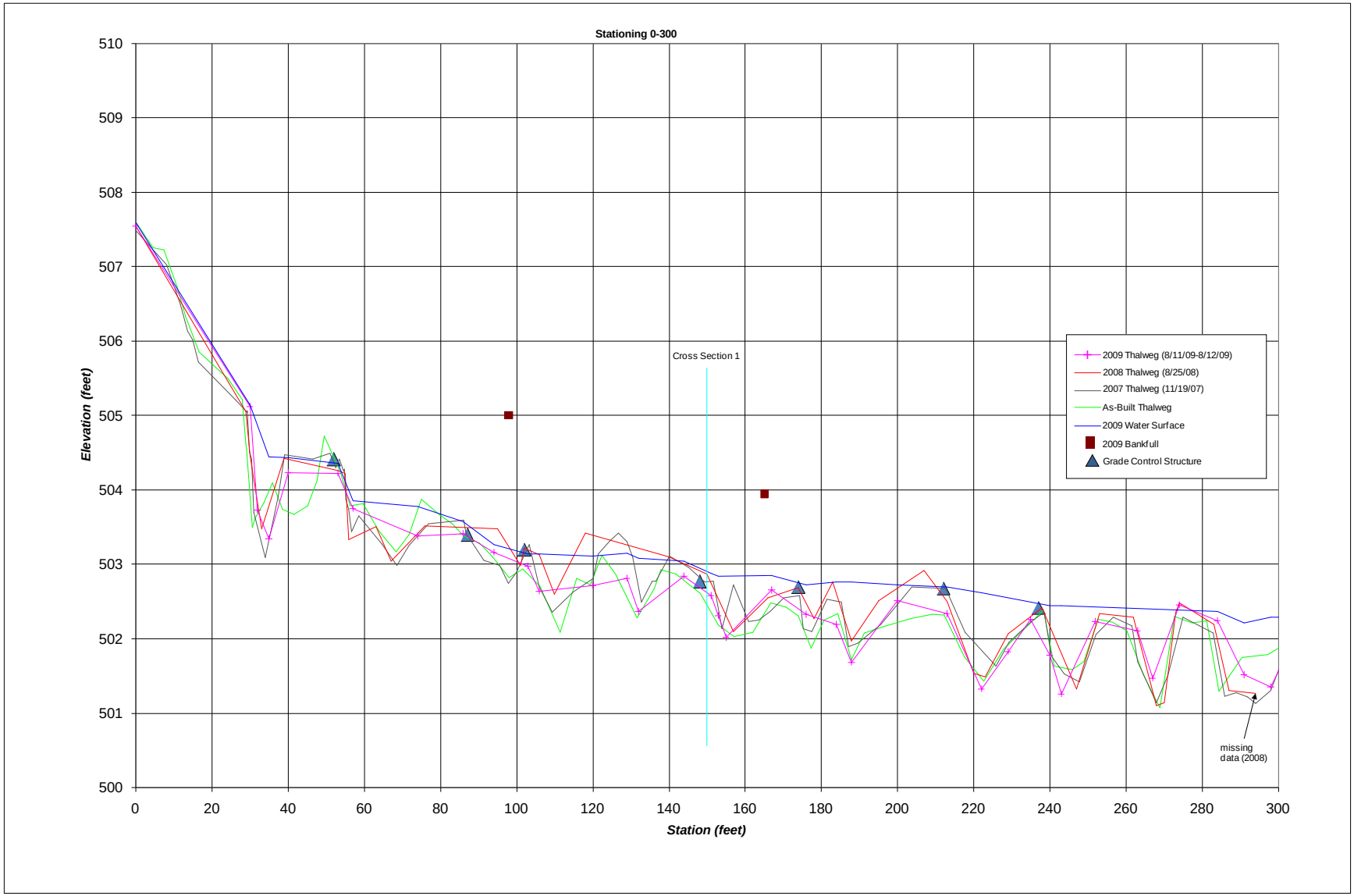
Floodprone Elevation (ft)	495.59
Bankfull Elevation (ft)	493.30
Floodprone Width (ft)	26.48
Bankfull Width (ft)	12.29
Entrenchment Ratio	2.16
Mean Depth (ft)	1.35
Maximum Depth (ft)	2.29
Width/Depth Ratio	9.10
Bankfull Area (sq ft)	16.58
Wetted Perimeter (ft)	13.97
Hydraulic Radius (ft)	1.19

Stream Type: B

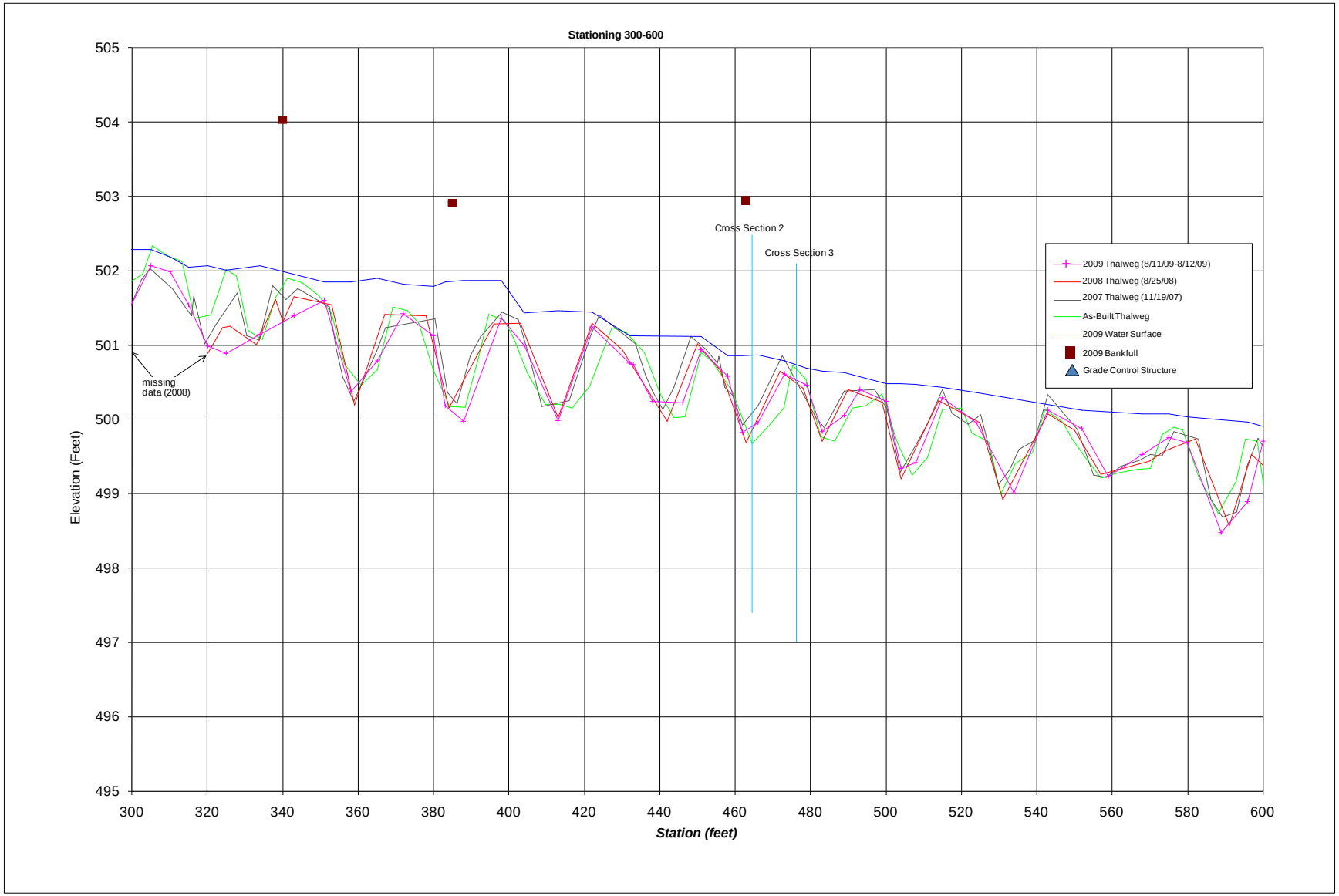
View of cross-section Stillhouse XS-S looking downstream (8/6/2009)



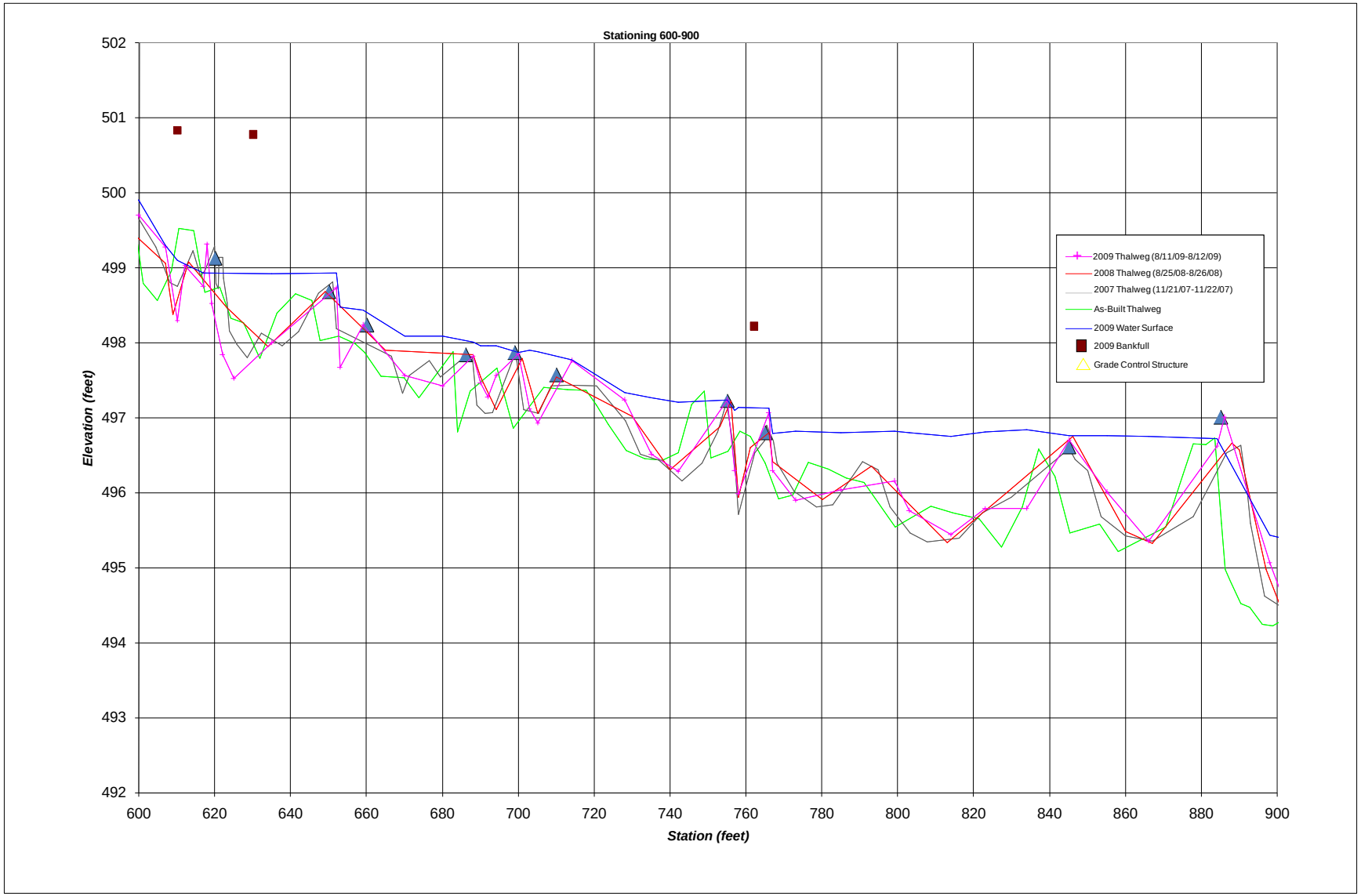
Appendix D. Longitudinal Profiles with Annual Overlays



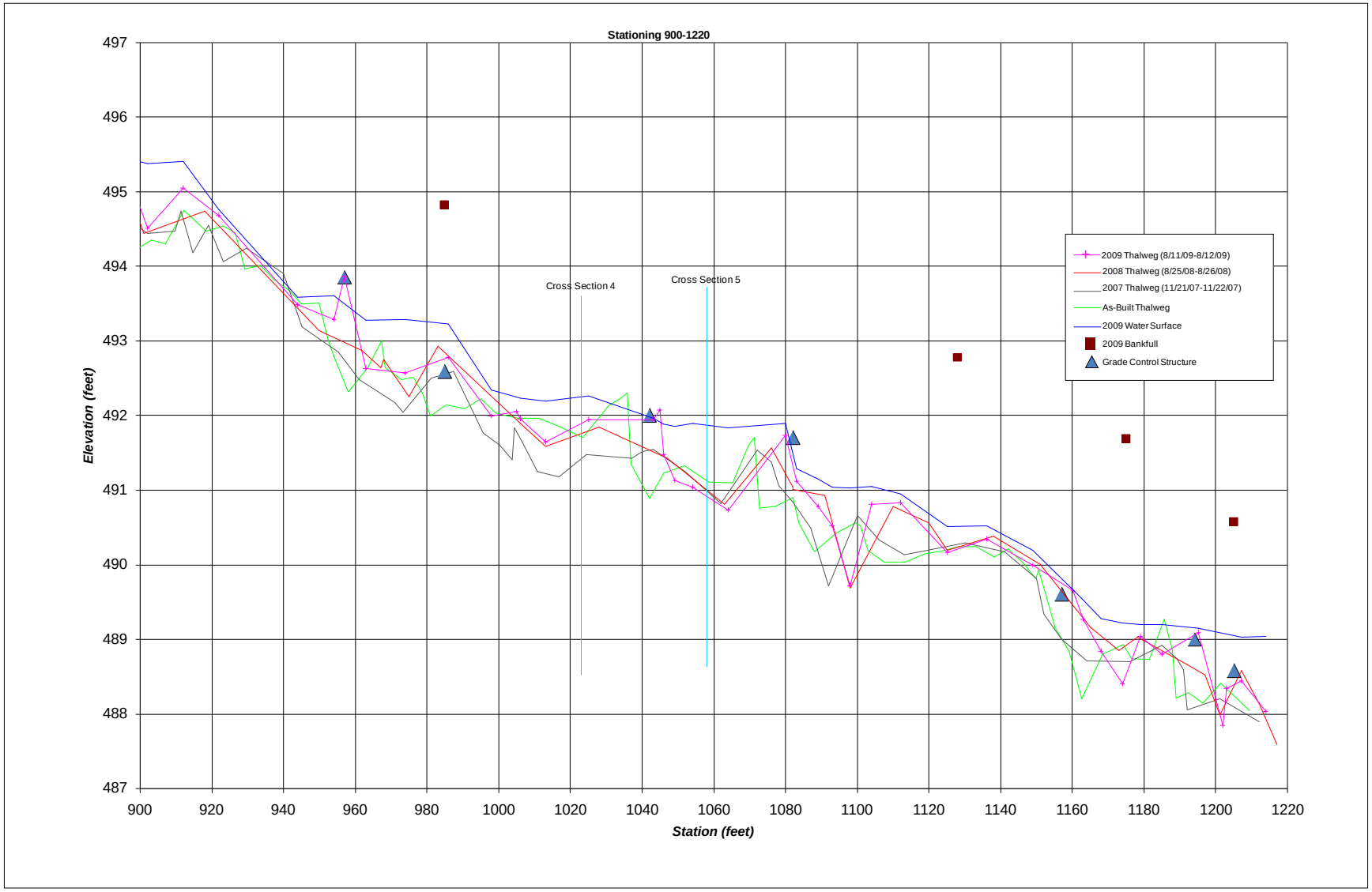
Appendix D. Longitudinal Profiles with Annual Overlays



Appendix D. Longitudinal Profiles with Annual Overlays



Appendix D. Longitudinal Profiles with Annual Overlays



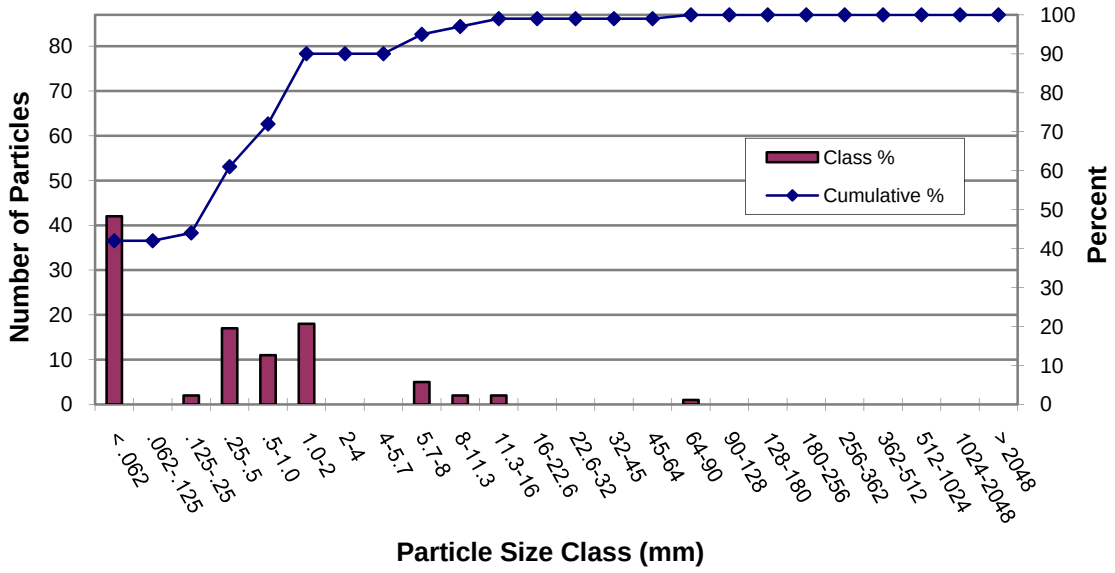
Appendix D. Pebble Counts - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

Cross Section One-Reach 1

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	42	42	42
Sand	Very Fine Sand	.062-.125		0	42
	Fine Sand	.125-.25	2	2	44
	Medium Sand	.25-.5	17	17	61
	Coarse Sand	.5-1.0	11	11	72
	Very Course Sand	1.0-2	18	18	90
Gravel	Very Fine Gravel	2-4		0	90
	Fine Gravel	4-5.7		0	90
	Fine Gravel	5.7-8	5	5	95
	Medium Gravel	8-11.3	2	2	97
	Medium Gravel	11.3-16	2	2	99
	Coarse Gravel	16-22.6		0	99
	Coarse Gravel	22.6-32		0	99
	Very Course Gravel	32-45		0	99
	Very Course Gravel	45-64		0	99
Cobble	Small Cobble	64-90	1	1	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
	Total		100		

d_{50} = 0.34 mm

d_{84} = 1.7 mm



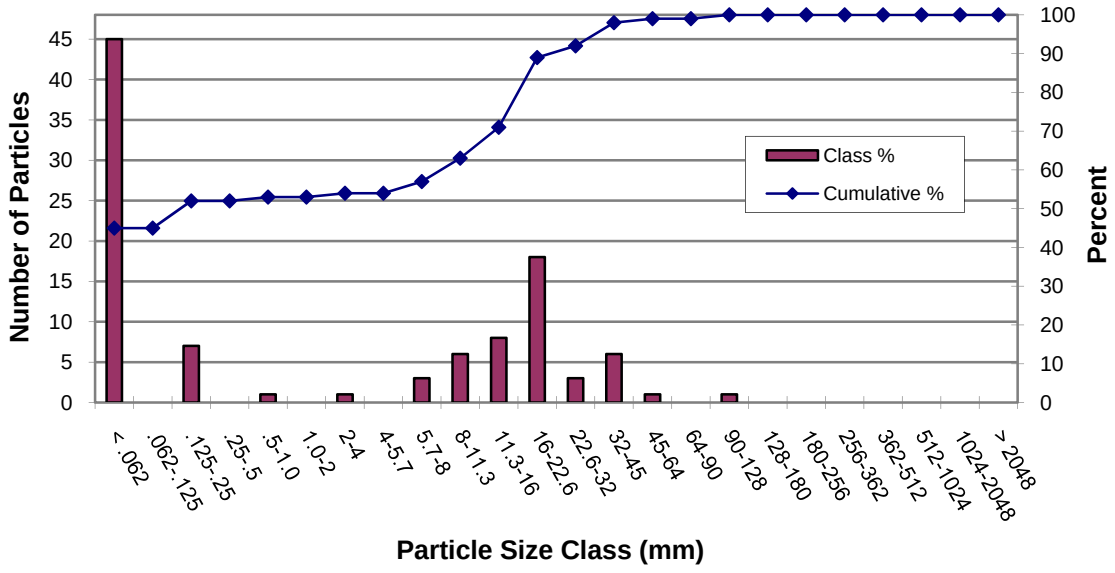
Appendix D. Pebble Counts - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

Cross Section Two-Reach 2

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	45	45	45
Sand	Very Fine Sand	.062-.125		0	45
	Fine Sand	.125-.25	7	7	52
	Medium Sand	.25-.5		0	52
	Coarse Sand	.5-1.0	1	1	53
	Very Course Sand	1.0-2		0	53
Gravel	Very Fine Gravel	2-4	1	1	54
	Fine Gravel	4-5.7		0	54
	Fine Gravel	5.7-8	3	3	57
	Medium Gravel	8-11.3	6	6	63
	Medium Gravel	11.3-16	8	8	71
	Coarse Gravel	16-22.6	18	18	89
	Coarse Gravel	22.6-32	3	3	92
	Very Course Gravel	32-45	6	6	98
	Very Course Gravel	45-64	1	1	99
Cobble	Small Cobble	64-90		0	99
	Small Cobble	90-128	1	1	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
	Total		100		

d_{50} = 0.21 mm

d_{84} = 20.8 mm



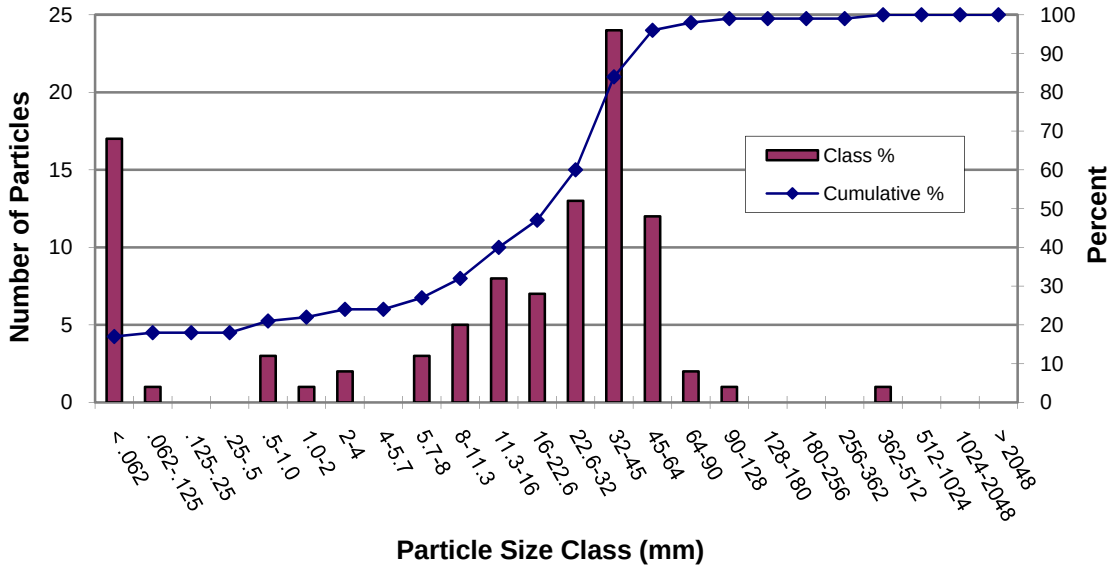
Appendix D. Pebble Counts - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

Cross Section Three-Reach 2

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	17	17	17
Sand	Very Fine Sand	.062-.125	1	1	18
	Fine Sand	.125-.25		0	18
	Medium Sand	.25-.5		0	18
	Coarse Sand	.5-1.0	3	3	21
	Very Course Sand	1.0-2	1	1	22
Gravel	Very Fine Gravel	2-4	2	2	24
	Fine Gravel	4-5.7		0	24
	Fine Gravel	5.7-8	3	3	27
	Medium Gravel	8-11.3	5	5	32
	Medium Gravel	11.3-16	8	8	40
	Coarse Gravel	16-22.6	7	7	47
	Coarse Gravel	22.6-32	13	13	60
	Very Course Gravel	32-45	24	24	84
	Very Course Gravel	45-64	12	12	96
Cobble	Small Cobble	64-90	2	2	98
	Small Cobble	90-128	1	1	99
	Medium Cobble	128-180		0	99
	Large Cobble	180-256		0	99
Boulder	Small Boulders	256-362		0	99
	Small Boulders	362-512	1	1	100
	Medium Boulders	512-1024		0	100
	Large Boulders	1024-2048		0	100
	Bedrock	> 2048		0	100
	Total		100		

d_{50} = 24.8 mm

d_{84} = 45.0 mm



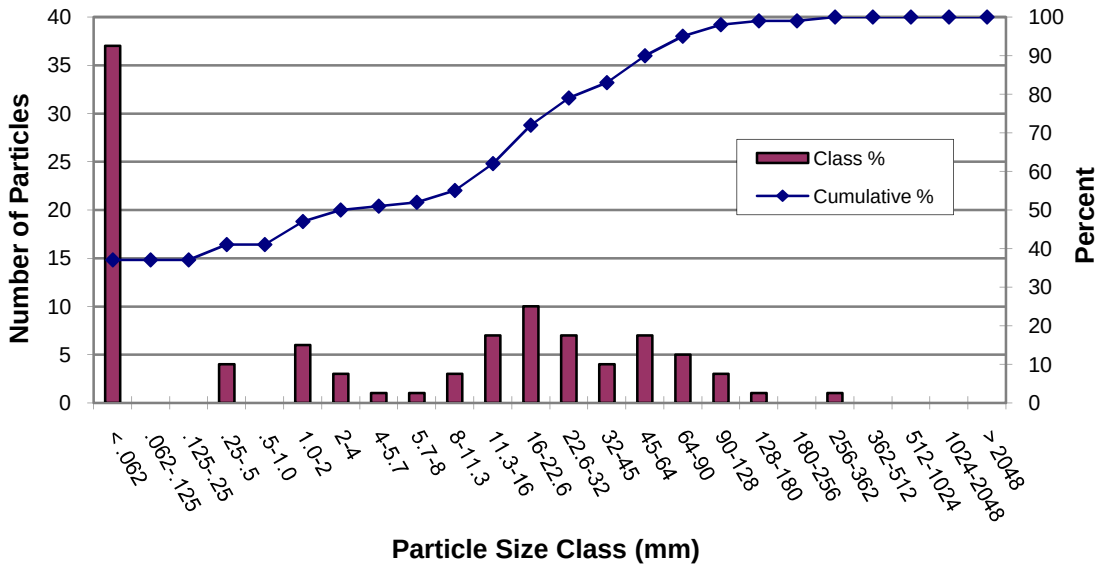
Appendix D. Pebble Counts - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

Cross Section Four-Reach 4

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	37	37	37
Sand	Very Fine Sand	.062-.125		0	37
	Fine Sand	.125-.25		0	37
	Medium Sand	.25-.5	4	4	41
	Coarse Sand	.5-1.0		0	41
	Very Course Sand	1.0-2	6	6	47
Gravel	Very Fine Gravel	2-4	3	3	50
	Fine Gravel	4-5.7	1	1	51
	Fine Gravel	5.7-8	1	1	52
	Medium Gravel	8-11.3	3	3	55
	Medium Gravel	11.3-16	7	7	62
	Coarse Gravel	16-22.6	10	10	72
	Coarse Gravel	22.6-32	7	7	79
	Very Course Gravel	32-45	4	4	83
	Very Course Gravel	45-64	7	7	90
Cobble	Small Cobble	64-90	5	5	95
	Small Cobble	90-128	3	3	98
	Medium Cobble	128-180	1	1	99
	Large Cobble	180-256		0	99
Boulder	Small Boulders	256-362	1	1	100
	Small Boulders	362-512		0	100
	Medium Boulders	512-1024		0	100
	Large Boulders	1024-2048		0	100
	Bedrock	> 2048		0	100
	Total		100		

d_{50} = 4.0 mm

d_{84} = 47.7 mm



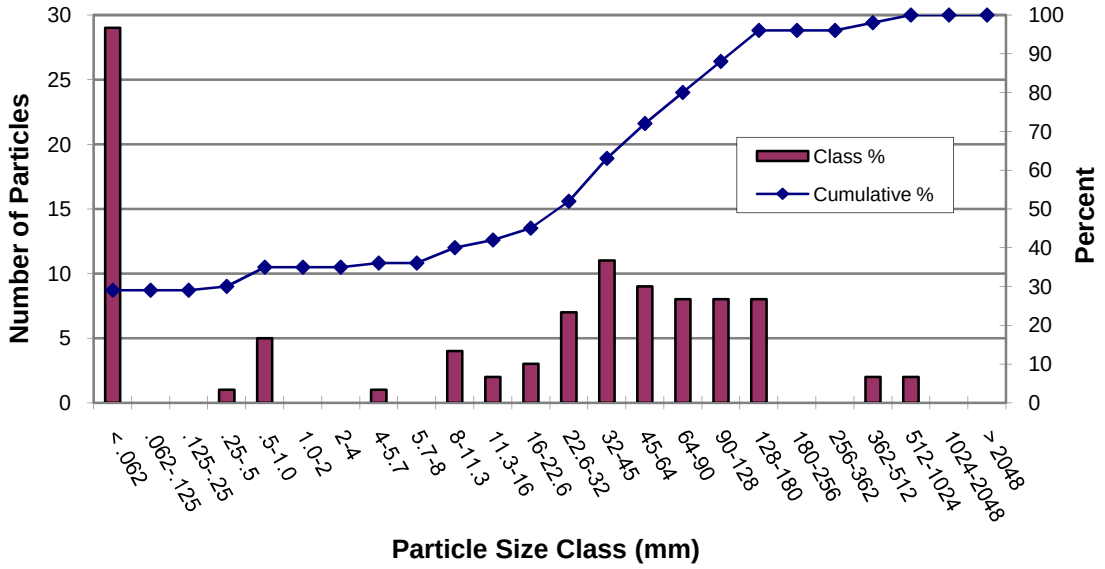
Appendix D. Pebble Counts - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

Cross Section Five-Reach 4

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	29	29	29
Sand	Very Fine Sand	.062-.125		0	29
	Fine Sand	.125-.25		0	29
	Medium Sand	.25-.5	1	1	30
	Coarse Sand	.5-1.0	5	5	35
	Very Course Sand	1.0-2		0	35
Gravel	Very Fine Gravel	2-4		0	35
	Fine Gravel	4-5.7	1	1	36
	Fine Gravel	5.7-8		0	36
	Medium Gravel	8-11.3	4	4	40
	Medium Gravel	11.3-16	2	2	42
	Coarse Gravel	16-22.6	3	3	45
	Coarse Gravel	22.6-32	7	7	52
	Very Course Gravel	32-45	11	11	63
	Very Course Gravel	45-64	9	9	72
Cobble	Small Cobble	64-90	8	8	80
	Small Cobble	90-128	8	8	88
	Medium Cobble	128-180	8	8	96
	Large Cobble	180-256		0	96
Boulder	Small Boulders	256-362		0	96
	Small Boulders	362-512	2	2	98
	Medium Boulders	512-1024	2	2	100
	Large Boulders	1024-2048		0	100
	Bedrock	> 2048		0	100
	Total		100		

d_{50} = 29.3 mm

d_{84} = 109 mm



Baseline Morphology and Hydraulic Summary Table
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		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
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		-			-			-			-			-			-	

Baseline Morphology and Hydraulic Summary Table
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		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
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		-			-			-			-			-			-	

Morphology and Hydraulic Monitoring Summary Table – Stillhouse Creek Steam Restoration – EEP Project #363

Reach 1 (235 feet)

Parameter	Cross Section 1-Riffle				
Dimension	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	18.4	18.68	16.62		
Floodprone Width (ft)	34.44	34.44	34.44		
BF Cross-Sectional Area (sq ft)	24.28	26.01	20.94		
BF Mean Depth (ft)	1.32	1.39	1.26		
BF Max Depth (ft)	2.71	3.20	2.74		
Width/Depth Ratio	13.95	13.42	13.19		
Entrenchment Ratio	1.87	1.84	2.07		
Bank Height Ratio	1.19	1.12	1.11		
Wetted Perimeter (ft)	19.5	20.02	18.54		
Hydraulic Radius (ft)	1.24	1.30	1.13		
Substrate					
d50 (mm)	0.04	0.98	0.34		
d84 (mm)	5.7	45	1.67		

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

	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	7.5	11.1	9.7						
Radius of Curvature (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA						
Meander Wavelength (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA						
Meander Width ratio			0.6			0.6			0.65						
Profile															
Riffle length (ft)	2	14	8.3	4	32	16.2	7	29	15.8						
Riffle slope (ft/ft)	-0.04	0.06	0.01	-0.02	0.02	0.01	0.00	0.04	0.02						
Pool length (ft)	10	30	19	7	25	14	10	26	18.0						
Pool spacing (ft)	0	14	7.3	0	32	12.1	0	29	13.2						
Additional Reach Parameters	MY-01			MY-02			MY-03			MY-04			MY-05		
Valley Length (ft)	230			230			230								
Channel Length (ft)	245			245			242								
Sinuosity	1.07			1.07			1.05								
Water Surface Slope (ft/ft)	0.009			0.009			0.011								
BF slope (ft/ft)	0.01			0.008			0.02								
Rosgen Classification	B6			B5			B5								
Habitat Index	NA			NA			NA								
Macrobenthos	NA			NA			NA								

Morphology and Hydraulic Monitoring Summary Table – Stillhouse Creek Steam Restoration – EEP Project #363

Reach 2 (400 feet)

Parameter	Cross Section 2-Pool					Cross Section 3-Riffle				
Dimension	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	15.82	19.12	14.52			12.41	13.18	15.47		
Floodprone Width (ft)	94.5	94.5	94.5			107	107	107		
BF Cross-Sectional Area (sq ft)	22.62	23.90	17.49			8.61	8.43	8.39		
BF Mean Depth (ft)	1.46	1.25	1.21			0.69	0.64	0.54		
BF Max Depth (ft)	2.62	2.85	2.48			1.14	1.31	1.47		
Width/Depth Ratio	11.07	15.30	12.04			17.87	20.60	28.53		
Entrenchment Ratio	6	4.94	6.51			8.7	8.12	6.91		
Bank Height Ratio	1.17	1.08	1.19			1.13	1.25	1.20		
Wetted Perimeter (ft)	17.21	20.64	16.2			13.12	13.49	15.94		
Hydraulic Radius (ft)	1.31	1.16	1.08			0.66	0.63	0.53		
Substrate										
d50 (mm)	6.85	0.42	0.21			6.85	11.3	24.8		
d84 (mm)	14.59	17.2	20.8			36.88	42.05	45.0		

	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	9.3	25.8	18.4						
Radius of Curvature (ft)	2.6	11.6	4.9	2.7	10.8	5.1	3.6	11.3	5.6						
Meander Wavelength (ft)	27.2	40	33	26.5	40.0	32.7	26.1	40.8	32.5						
Meander Width ratio			1.3			1.0			1.2						
Profile															
Riffle length (ft)	7	20	10.9	6	11	8.1	5	11	7.5						
Riffle slope (ft/ft)	-0.07	0.06	0.003	-0.02	0.06	0.02	-0.14	0.01	0.02						
Pool length (ft)	9	28	17	6	26	14.3	4	41	18.8						
Pool spacing (ft)	0	26	10.9	0	65	12.3	0	11	5.7						

Additional Reach Parameters	MY-01	MY-02	MY-03	MY-04	MY-05
Valley Length (ft)	286	286	286		
Channel Length (ft)	400	392	393		
Sinuosity	1.40	1.37	1.37		
Water Surface Slope (ft/ft)	0.008	0.009	0.008		
BF slope (ft/ft)	0.007	0.007	0.011		
Rosgen Classification	C4	C4	C4		
Habitat Index	NA	NA	NA		
Macrobenthos	NA	NA	NA		

Morphology and Hydraulic Monitoring Summary Table – Stillhouse Creek Steam Restoration – EEP Project #363

Reach 3 (220 feet)

	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)	12.55	27.37	20.13	9.53	26.84	17.33	9.53	27.71	18.31						
Radius of Curvature (ft)	12.35	23.88	17.74	9.54	24.26	16.03	9.07	24.59	15.57						
Meander Wavelength (ft)	70.79	96.17	79.34	61.50	97.09	76.15	60.44	85.35	74.45						
Meander Width ratio			NA*			NA*			NA*						
Profile															
Riffle length (ft)	4	41	21.3	20	39	29.5	14	29	21.5						
Riffle slope (ft/ft)	0.02	0.03	0.02	0.02	0.03	0.025	0.01	0.04	0.03						
Pool length (ft)	21	48	33	22	53	35.4	7	46	30.0						
Pool spacing (ft)	0	41	12.8	0	39	28.8	0	29	10.75						
Additional Reach Parameters	MY-01			MY-02			MY-03			MY-04			MY-05		
Valley Length (ft)	198			198			198								
Channel Length (ft)	227			219			224								
Sinuosity	1.15			1.11			1.13								
Water Surface Slope (ft/ft)	0.010			0.010			0.008								
BF slope (ft/ft)	0.012			0.016			0.017								
Rosgen Classification	NA*			NA*			NA*								
Habitat Index	NA			NA			NA								
Macrobenthos	NA			NA			NA								

*Meander width ratio is calculated by dividing average channel beltwidth by average bankfull width for the cross-sections in the reach. The cross-sections at Stillhouse Creek were established in monitoring year 1 based on the understanding that the restoration included three reaches. Data provided at a later date indicated that there are 4 reaches at the restoration. Unfortunately, there no cross sections were established in Reach 3 and therefore meander width ratio cannot be calculated. Additionally, a Rosgen classification cannot be determined without cross-section data.

Morphology and Hydraulic Monitoring Summary Table – Stillhouse Creek Steam Restoration – EEP Project #363

Reach 4 (355 feet)*

Parameter	Cross Section 4 - Riffle					Cross Section 5 - Pool				
Dimension	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	12.4	14.7	15.3			8.4	11.5	12.3		
Floodprone Width (ft)	29.3	29.3	29.3			26.5	26.5	26.5		
BF Cross-Sectional Area (sq ft)	13.2	14.5	15.3			11.4	15.9	16.6		
BF Mean Depth (ft)	1.06	0.99	0.94			1.36	1.38	1.35		
BF Max Depth (ft)	2.06	2.20	2.18			1.93	2.33	2.29		
Width/Depth Ratio	11.75	14.86	16.25			6.13	8.38	9.10		
Entrenchment Ratio	2.36	2.00	1.91			3.17	2.30	2.16		
Bank Height Ratio	1.10	1.11	1.17			1.24	1.22	1.11		
Wetted Perimeter (ft)	13.23	15.45	6.18			9.96	12.77	13.97		
Hydraulic Radius (ft)	0.99	0.94	0.89			1.14	1.24	1.19		
Substrate										
d50 (mm)	2.67	3	4			16	22.6	29.3		
d84 (mm)	58.57	83.5	47.7			50.7	2048	109		

	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)	20.35	38.40	27.36	19.74	38.97	26.80	18.25	38.25	25.76						
Radius of Curvature (ft)	27.51	51.55	39.40	26.64	51.72	39.80	24.68	54.22	40.10						
Meander Wavelength (ft)	105.56	187.83	153.28	104.51	181.47	148.86	117.72	177.28	149.67						
Meander Width ratio			2.63			2.05			1.87						
Profile															
Riffle length (ft)	4	25	14.78	6	44	20.43	8	45	22						
Riffle slope (ft/ft)	-0.003	0.12	0.04	0.02	0.09	0.04	-0.006	0.04	0.01						
Pool length (ft)	18	47	25.67	6	29	19.67	14	35	23						
Pool spacing (ft)	0	41	17	0	44	19.75	0	45	18.86						

Additional Reach Parameters	MY-01	MY-02	MY-03	MY-04	MY-05
Valley Length (ft)	327	327	327		
Channel Length (ft)	366	361	359		
Sinuosity	1.12	1.10	1.10		
Water Surface Slope (ft/ft)	0.023	0.023	0.017		
BF slope (ft/ft)	0.023	0.023	0.019		
Rosgen Classification	B4	B4	B4		
Habitat Index	NA	NA	NA		
Macrobenthos	NA	NA	NA		

Appendix D. Representative Stream Problem Photos - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

SP1 (8/12/2009)

SP2 (8/12/2009)

Appendix D. Stream Problem Areas Table - Year 3 - 2009 - Stillhouse Creek Stream Restoration (EEP Project #363)

Feature/Issue	Station	Suspected Cause	Photo #
Reach 3			
Piping	960	Insufficient coarse backfill	SP1
Piping	1047	Insufficient coarse backfill	SP2
Piping	1082	Insufficient coarse backfill	NA