THIRD FORK/FOREST HILLS CREEK STREAM RESTORATION – NCEEP
Project #139

2008 MONITORING REPORT – YEAR 4 - FINAL
January 2009

Submitted to:

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

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CONDUCTED FOR THE NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

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1.0 Executive Summary

The Third Fork Creek stream restoration project is located in southwest-central Durham, North Carolina, in the headwaters of the Third Fork Creek watershed (US Geological Survey 14-digit Hydrologic Unit Code 03030002060120) within the New Hope Creek Sub-basin of the Upper Cape Fear River (NC Division of Water Quality Sub-basin 03-06-05). The project has restored approximately 3,025 linear feet of perennial stream in the Cape Fear River Basin. Evaluation and design were initiated during the summer of 2002. Construction was completed in January 2005.

The 2008 Initial Assessment was conducted by RJG&A in May. Subsequent qualitative evaluations were conducted during September and October 2008. The fourth annual vegetation monitoring data were collected during July 2008, using EEP's most-recent monitoring protocol. The fourth annual geomorphologic monitoring data were collected during September 2008.

Overall, the restoration project appears to have met its design goals. The average live planted woody stem density (875 live stems per acre) has exceeded the vegetation success criteria (320 live stems per acre) by 173 percent. According to records provided by EEP, herbicide treatment was performed on the site in July, August, and October to reduce the presence of invasive exotic species. Based on our last visit to the site in late October these treatments appear to have been effective.

2.0 Project Background

2.1. Project Goals and Objectives

According to the 2003 Restoration Plan (KCI 2003), the stream restoration project's goals and objectives are to:

- Restore stable channel morphology that is capable of moving the flows and sediment provided by its watershed;
- Reduce sediment-related water quality impacts resulting from lateral bank erosion and bed degradation;
- Improve aquatic habitat diversity through the reestablishment of riffle-pool bed variability and the use of in-stream structures;
- Restore vegetative riparian buffers utilizing native plant species; and,
- Improve natural aesthetics in an urban park setting.

2.2. Project Structure, Mitigation Type, and Approach

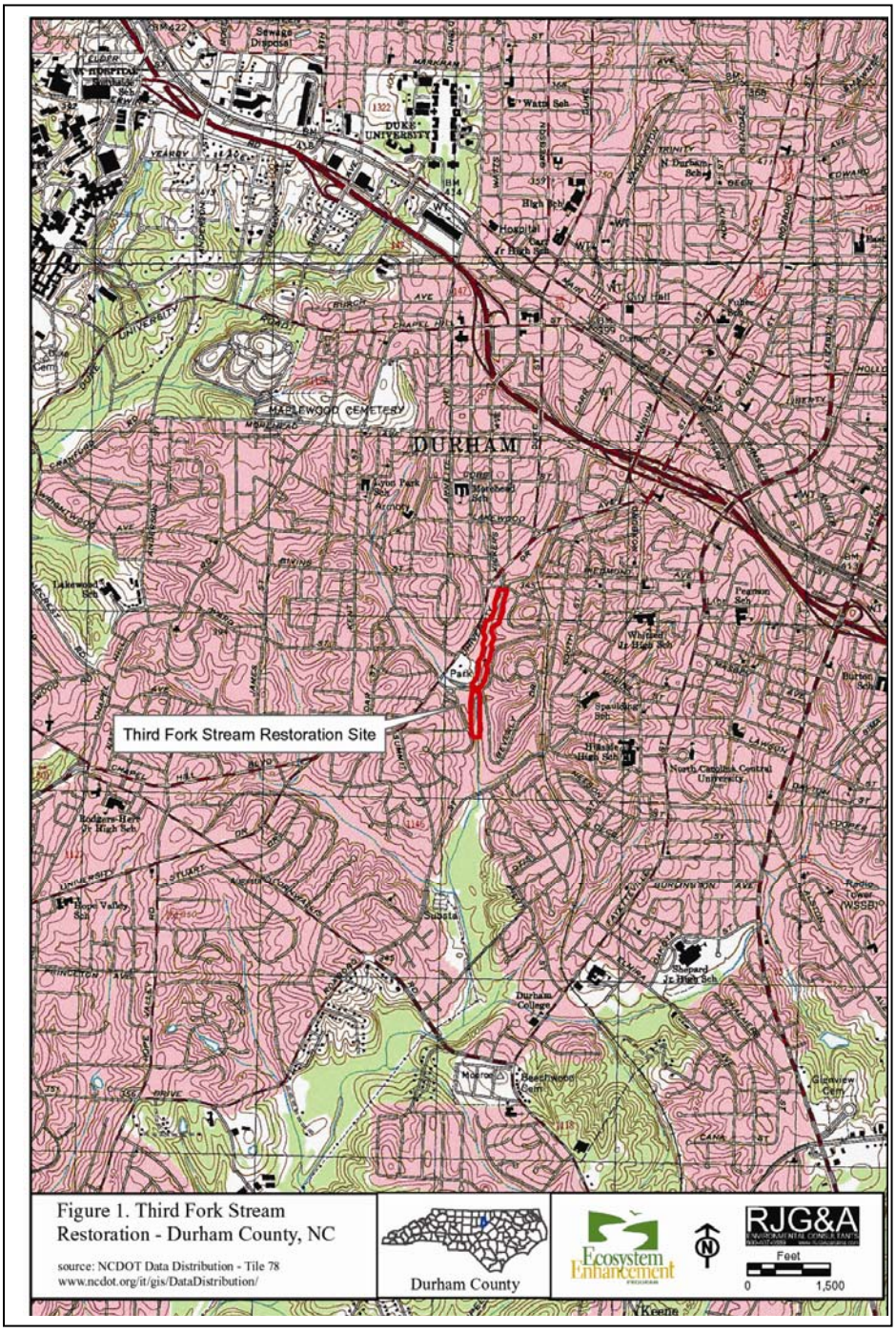
A priority 2 stream restoration approach was used to design and reestablish approximately 3,025 linear feet of meandering, bankfull channel and a new floodplain along Third Fork Creek. The project restored riffle-pool sequencing and used cross-vane and j-hook in-stream structures to provide grade control. The unnamed tributary that enters from the upper reach's left bank (station 20+33) was incorporated and stabilized with a grade control structure to match the grade of the restored channel. Coir fiber matting and live staking were installed/planted to help stabilize the graded stream banks. Native species were planted in a 50-foot wide buffer on both sides the restored stream.

2.3 Location and Setting

The entire restoration site is contained within Forest Hills Park, which is owned by the City of Durham. To get to the Third Fork Creek restoration site from NC 147, take exit 12C. At the end of the off-ramp, drive north on Duke Street. At the first light, take a left on Jackson and then a left on to Vickers. Take Vickers to the intersection with University Drive (US 15/501 Business). Forest Hills Park will be directly in front of you. Take a right on to University and park in the parking lot across from West Forest Hills Boulevard (Figure 1).

The upstream boundary of the restoration project is downstream from where Third Fork Creek emerges from the box culvert under the northern stretch East Forest Hills Boulevard. The stream restoration extends downstream along the main channel from this point to the southern edge of the Forest Hills Park. The double box culvert under the southern stretch of the East Forest Hills Boulevard loop divides the restoration into upper and lower reaches. An unnamed tributary to Third Fork Creek joins the lower reach on the downstream end of the culvert. The lower reach therefore has a significantly larger watershed.

Forest Hills Park is dominated by lawn/open space with relatively little mature canopy cover (less than 25 percent). A playground and other facilities with impervious cover (e.g swimming pool, tennis courts, and picnic shelter) are located near the southern portion of the restoration's upper reach. The surrounding area is highly urbanized. The majority of the land use is dedicated to residential and commercial development and secondary roads. Prior to the restoration, both project reaches were incised and had active bed degradation and channel widening characterized by severe bank erosion.



2.4. History and Background

KCI Associates of North Carolina designed the Third Fork (Forest Hills Park) stream restoration. The restoration plan was completed in February 2003 and construction was completed approximately two years later. As-built data collection occurred in March 2005 and the as-built and year one monitoring reports were submitted in December 2005. Robert J. Goldstein and Associates collected year two monitoring data and submitted the Year 2 report in December 2006 and the Year 3 report in October 2007. Year four monitoring data were collected in July and September 2008.

Exhibit Table I. Project Restoration Components
Third Fork Creek Stream Restoration – EEP Project #139 – Durham, NC

Reach ID	Existing Feet/Acres	Mitigation Type	Approach	Footage	Stationing	Comment
Upstream	2,900	R	P2	1,600	10+00-26+00	Realigned channel with restored floodplain to convey stormflow/ sediment and restore aquatidc habitat
Downstream		R	P2	1,525	26+00 – 40+25	

Exhibit Table II. Activity and Reporting History - Third Fork Creek Stream Restoration – EEP Project #139– Durham, NC

Activity or Report	Data Collection	Completion
Restoration Plan	2002	February 2003
Construction	NA	January 2005
Temporary S&E mix applied	NA	NA
Permanent seed mix applied	NA	NA
Bare Root Planting	NA	NA
Mitigation Plan	NA	December 2005 (report date)
As-built	March 2005	December 2005 (report date)
Year 1 Monitoring		December 2005 (report date)
Vegetation	September 2005	
Geomorphological	September 2005	
Year 2 Monitoring		December 2006 (report date)
Vegetation	September 2006	
Geomorphological	October 2006	
Year 3 Monitoring		October 2007 (report date)

Vegetation	July 2007	
Geomorphological	July 2007	
Year 4 Monitoring		November 2008 (report date)
Vegetation	July 2008	
Geomorphological	September 2008	

Exhibit Table III. Project Contacts - Third Fork Creek Stream Restoration – EEP Project #139 – Durham, NC	
Design:	KCI Associates of North Carolina, P.A. Landmark Center II, Suite 220 4601 Six Forks Road Raleigh, North Carolina 27609 Mr. Joe Pfeiffer (919) 783-9214
Construction Contractor:	Not Provided
Planting Contractor:	Not Provided
Seeding Contractor:	Not Provided
Seed Mix Sources:	Not Provided
Nursery Stock Suppliers:	Not Provided
Monitoring Performers (2005):	KCI Associates of North Carolina, P.A. Landmark Center II, Suite 220 4601 Six Forks Road Raleigh, North Carolina 27609 Mr. Joe Pfeiffer (919) 783-9214
Monitoring Performers (2006 - 2008):	RJG&A 1221 Corporation Parkway, Suite 100 Raleigh, NC 27616 Mr. Sean Doig (919) 872-1174

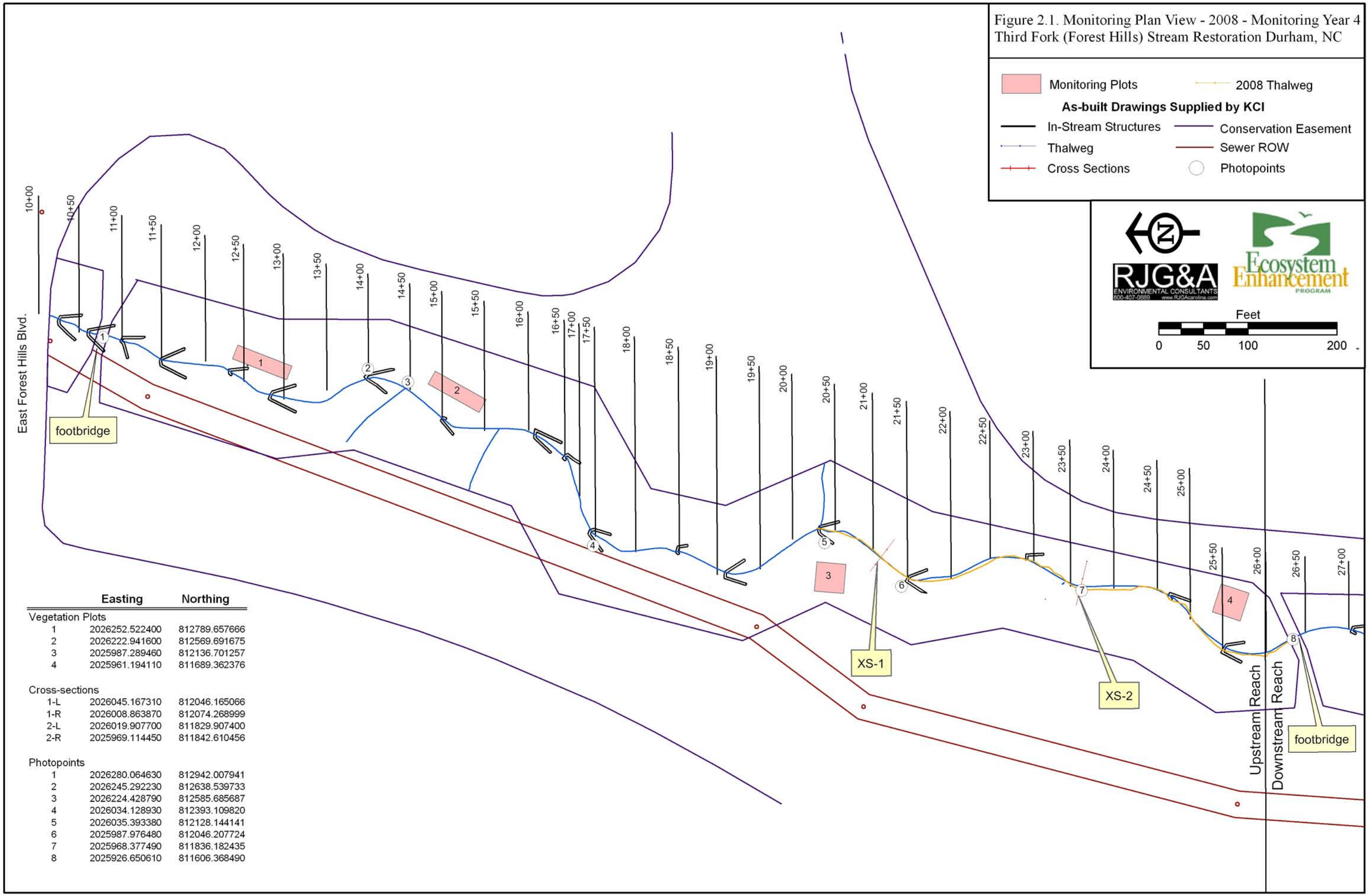
Exhibit Table IV. Project Background - Third Fork Creek Stream – EEP Project #139	
County	Durham
Drainage Area	1,126.4 acres (1.76 square miles)
Drainage Impervious Cover Estimate (%)	44%
Stream Order	Second Order
Physiographic Region	Piedmont
Ecoregion	Triassic Basins
Rosgen Classification of As-built	
Upper Reach	F5, G5, E5
Lower Reach	C5
Dominant Soil Types	
Upstream Reach	Congaree
Downstream Reach	Congaree
Reference Site ID	North Prong Creek
USGS HUC for Project and Reference	03030002060120, 0303002060140

Exhibit Table IV. Project Background - Third Fork Creek Stream – EEP Project #139	
NCDWQ Sub-basin for Project and Reference	03-06-05, 03-06-05
NCDWQ Classification for Project and Reference	C
Any portion of the project segment 303d listed?	Yes
Any portion of the project segment upstream of a 303d listed segment?	Yes
Reasons for 303d Listing or Stressor	Turbidity, low dissolved oxygen, fecal coliform bacteria
% of Project Easement Fenced	0%

2.5. Monitoring Plan View

See Figure 2.1 and 2.2 for the Monitoring Plan View.

Figure 2.1. Monitoring Plan View - 2008 - Monitoring Year 4
Third Fork (Forest Hills) Stream Restoration Durham, NC



	Easting	Northing
Vegetation Plots		
1	2026252.522400	812789.657666
2	2026222.941600	812569.691675
3	2025987.289460	812136.701257
4	2025961.194110	811689.362376
Cross-sections		
1-L	2026045.167310	812046.165066
1-R	2026008.863870	812074.268999
2-L	2026019.907700	811829.907400
2-R	2025969.114450	811842.610456
Photopoints		
1	2026280.064630	812942.007941
2	2026245.292230	812638.539733
3	2026224.428790	812585.685687
4	2026034.128930	812393.109820
5	2026035.393380	812128.144141
6	2025987.976480	812046.207724
7	2025968.377490	811836.182435
8	2025926.650610	811606.368490

	Easting	Northing
Vegetation Plots		
5	2025825.804140	811325.105992
6	2025751.559070	810836.827402
7	2025773.300850	810651.892462
8	2025829.725470	810411.548741
Cross-sections		
3-L	2025870.880914	810673.554871
3-R	2025770.851314	810650.406271
4-L	2025798.603914	810554.818971
4-R	2025759.096714	810575.310971
Photopoints		
9	2025883.659280	811374.025644
10	2025782.503210	811250.741684
11	2025792.618820	811001.328751
12	2025781.870990	810914.081641
13	2025766.697570	810688.630051
14	2025800.837750	810416.773115

Figure 2.2. Monitoring Plan View - 2008 - Monitoring Year 4
Third Fork (Forest Hills) Stream Restoration Durham, NC

Monitoring Plots
2008 Thalweg

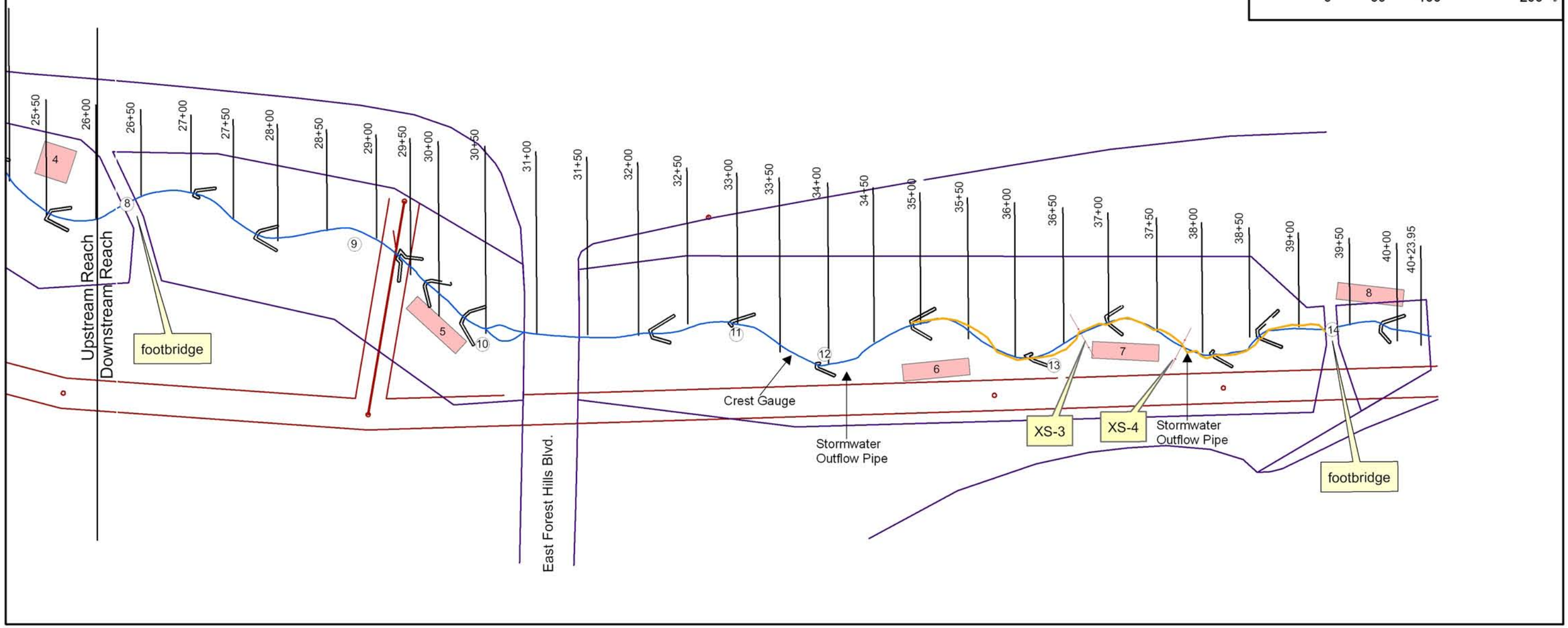
As-built Drawings Supplied by KCI

In-Stream Structures
Conservation Easement
Thalweg
Sewer ROW
Cross Sections
Photopoints

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

Ecosystem Enhancement PROGRAM

Feet
0 50 100 200



3.0 Project Conditions and Monitoring Results

RJG&A's 2008 initial assessment was completed on 6 May. Quantitative vegetation and geomorphologic data were collected between 12 and 20 July. Another qualitative evaluation was conducted on 29 October 2008.

As was true in 2006 and 2007, structural failure and compromise were recorded in a number of specific locations. Overall, though, the restoration project appears to be adequately transporting urban sediment loads and restoring aquatic habitat (i.e. meeting its design functions/goals).

In our evaluation in May 2008 we noted that several exotic invasive species continued to have a presence in the restoration area, particularly bankfull benches and floodplain terraces. However due to herbicidal treatment during the summer and fall the density of these species was notably reduced. Planted woody stem density remains high.

3.1 . Vegetation Assessment

Planted woody vegetation appeared to be successful when qualitatively evaluated during October 2008. The average live, planted woody stem density for all plots was 22 individuals per plot, including live stakes. According to the Excel file exported from the CVS/EEP data entry tool, the planted stem density per acre is 875 (excluding live stakes). This number is down from 905 stems per acre in 2007. This 2008 density exceeds the required 320 live stems per acre by 173 percent. Stem density is highest for *Callicarpa americana*, *Fraxinus pennsylvanica*, and *Platanus occidentalis* (Table 5, Appendix A). Mortality in the vegetation plots remains low (less than 2%).

Monitoring plot photos are also located in Appendix A.

3.1.1. Vegetation Problem Areas

Colonization of bankfull benches and floodplain terraces by invasive woody species and vines was observed during the spring 2008 assessment, however herbicidal treatment performed on the site during July, August, and October 2008 appear to have substantially reduced this problem by the fall of 2008. No thriving colonies of Japanese hops (*Humulus japonicus*) or porcelainberry (*Ampelopsis brevipedunculata*) were observed during the late October 2008 visit and the only one cluster of princess trees (*Paulownia tomentosa*) were observed near vegetation monitoring plot 6, although individual trees are still scattered throughout the site.

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

3.1.2. Current Conditions Plan View

The Current Conditions Plan View may be found in Appendix B.1.

3.2. Stream Assessment

3.2.1. Procedural Items

3.2.1.1. Morphometric Criteria
RJG&A personnel qualitatively evaluated the site during May and October 2008. In September 2008, cross section, pattern, and longitudinal profile data were collected. Survey data were collected at four cross-sections and along approximately 350 linear feet of both the upstream and downstream reaches. Photographs were taken at the four cross sections and at the 14 permanent photo locations that were established by KCI.

3.2.1.2. Hydrologic Criteria
A crest gauge with granulated cork was installed along the right bank at station 33+75 on 13 June 2007. The evaluation of Third Fork Creek in 2008 indicates that at least two storm events resulted in flows over the designed/built bankfull elevation. The crest gauge was evaluated on 6 May 2008 and the only cork remaining inside the gauge was stuck around the cap, indicating that a bankfull storm event had occurred. This conclusion was supported by evidence of rack and drift lines on the bankfull benches throughout the restoration. After this evaluation, the gauge was re-filled with approximately five cubic inches of ground cork. The gauge was again evaluated on 28 October 2008. Again, the only granulated cork remaining inside the gauge was inside the cap at the top, indicating that at least one bankfull event had occurred since 6 May. 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”), April 27-28 (1.84”), 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
Third Fork Stream Restoration – EEP Project #139

Date of Data Collection	Date of Occurrence	Method	Photo # (if available)
6 May 2008	12 October 2007 – 5 May 2008 CRONOS data suggest 4 March 2008 or 27-28 April 2008	Crest Gauge Evaluation	NA
28 October 2008	6 May – 28 October 2008 CRONOS data suggest 5 July, 28 August, 6 September, and 26 September 2008	Crest Gauge Evaluation	NA

3.2.2. Current Conditions Plan View
The Current Conditions Plan View can be found in Appendix B.1.

3.2.3. Problem Areas Table
Overall, the site is maintaining its as-built dimension, pattern, and profile. Several areas of bank slump/undercut have stabilized and are no longer considered problem areas. Two areas of bank undercut/scour should be closely monitored. One begins at station 34+10 and the willows on the collapsing bank are impeding water flow; the other is located at near the bottom of the downstream reach beginning at 38+00 and is new as of this summer. The former is depicted in photo SP4 and the latter is depicted in photo SP3 in

Appendix B.3. The remaining bank slumps and undercuts are relatively minor and should continue to be monitored to ensure that they continue to equilibrate over time. Appendix B.2. outlines problem areas by station, along with suspected causes and representative photos.

3.2.4. Numbered Issue Photo Section

Representative problem area photos listed in Table B.1. are located in Appendix B.3.

3.2.5. Fixed Station Photos

Permanent photopoint images are located in Appendix B.4.

3.2.6. Stability Assessment Table

The visual stability assessment was conducted on October 28, 2008 and the findings are summarized below. More detailed information can be found in Appendix B5. Low scores for certain features are due to the accumulation of fine sediment at the site, which is creating filled-in pools, mid-stream bars, off-center thalwegs, overly-active eroding meanders, and slumping banks. This fine sediment is both transported from upstream and off-site into the project area and also enters the stream due to scour and bank slump in the project area. Secondarily, debris build-up in certain stream segments has aggravated this problem. Specific examples of these problems are discussed in Section 3.2.3. and Appendices B2 and B3.

Exhibit Table VII. Categorical Stream Feature Visual Stability Assessment
Third Fork Creek Stream Restoration – EEP Project #139

Feature	Initial*	MY-01	MY-02	MY-03	MY-04	MY-05
Upstream Reach (1600 Feet)						
A. Riffles	100%	NA	92%	86%	78%	
B. Pools	100%	NA	87%	87%	80%	
C. Thalweg	100%	NA	69%	97%	100%	
D. Meanders	100%	NA	90%	98%	98%	
E. Bed General	100%	NA	100%	100%	95%	
F. Bank	100%	NA	NA	98%	98%	
G. Vanes/J Hooks, etc.	100%	NA	93%	96%	96%	
H. Wads and Boulders	NA	NA	NA	NA	NA	
Downstream Reach (1425 Feet)						
A. Riffles	100%	NA	56%	56%	82%	
B. Pools	100%	NA	56%	56%	64%	
C. Thalweg	100%	NA	57%	57%	57%	
D. Meanders	100%	NA	67%	67%	82%	
E. Bed General	100%	NA	100%	100%	100%	
F. Bank	100%	NA	NA	NA	81%	
F. Vanes/J Hooks, etc.	100%	NA	89%	94%	92%	
G. Wads and Boulders	100%	NA	NA	NA	NA	

*These percentages are assumed. Neither the As-built Monitoring Report nor the First Year Monitoring Report contained any visual stability assessment data.

Exhibit Table VIII. Baseline Morphology and Hydraulic Summary - Third Fork Creek Stream Restoration– EEP Project #139 – Upstream Reach																		
Parameters	**USGS Data**			**Regional Curve Int.**			**Pre-Existing Condition**			**Reference Reach**			**Design**			**As-Built**		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bankfull Width (ft)	NA	NA	NA	NA	NA	NA	21.8	26.8	NA	NA	NA	17.8	NA	NA	27	NA	NA	NA
Floodprone Width (ft)	NA	NA	NA	NA	NA	NA	29.2	400.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bankfull Area (sq ft)	NA	NA	NA	NA	NA	NA	45.1	57.2	NA	NA	NA	26.2	NA	NA	60	NA	NA	NA
Mean Depth (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.5	NA	NA	2.2	NA	NA	NA
Maximum Depth (ft)	NA	NA	NA	NA	NA	NA	NA	NA	4.7	NA	NA	3.0	NA	NA	4.0	NA	NA	NA
Width/Depth Ratio	NA	NA	NA	NA	NA	NA	8.3	15.9	NA	NA	NA	12.1	NA	NA	12.1	NA	NA	NA
Entrenchment Ratio	NA	NA	NA	NA	NA	NA	1.1	18.3	NA	NA	NA	33.7	2.3	14.8	NA	NA	NA	NA
Bank Height Ratio	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wetted Perimeter (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydraulic Radius (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pattern																		
Channel Beltwidth (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	158	NA	NA	120.0	NA	NA	NA
Radius of Curvature (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	37.0	40.0	NA	60.0	75.0	NA	NA	NA	NA
Meander Wavelength	NA	NA	NA	NA	NA	NA	NA	NA	NA	94.0	143.0	NA	160	190	NA	NA	NA	NA
Meander Width ratio	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.9	NA	NA	4.4	NA	NA	NA
Profile																		
Riffle length (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Riffle slope (ft/ft)	NA	NA	NA	NA	NA	NA	0.2	0.6	NA	0.2	2.1	NA	0.3	0.3	NA	NA	NA	NA
Pool length (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.0	30.0	NA	27.0	40.0	NA	NA	NA	NA
Pool spacing (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	40.0	85.5	NA	60.0	125.0	NA	NA	NA	NA
Substrate																		
d50 (mm)	NA	NA	NA	NA	NA	NA	0.3	0.4	NA	NA	NA	0.2	0.3	0.4	NA	NA	NA	NA
d84 (mm)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Additional Reach Parameters																		
Valley Length (ft)	NA			NA			NA			NA			NA			NA		
Channel Length (ft)	NA			NA			1890			407			2083			NA		
Sinuosity	NA			NA			1.03			1.28			1.13			NA		
Water Surface Slope (ft/ft)	NA			NA			0.25			0.24			0.25			NA		
BF slope (ft/ft)	NA			NA			NA			NA			NA			NA		
Rosgen Classification	NA			NA			F5, G5, E5			C5			C5			NA		
Habitat Index	NA			NA			NA			NA			NA			NA		
Macrobenthos	NA			NA			NA			NA			NA			NA		

Exhibit Table VIII. Baseline Morphology and Hydraulic Summary - Third Fork Creek Stream Restoration– EEP Project #139 – Downstream Reach																		
Parameters	**USGS Data**			**Regional Curve Int.**			**Pre-Existing Condition**			**Reference Reach**			**Design**			**As-Built**		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bankfull Width (ft)	NA	NA	NA	NA	NA	NA	NA	NA	29.5	NA	NA	17.8	NA	NA	30.0	NA	NA	NA
Floodprone Width (ft)	NA	NA	NA	NA	NA	NA	62.0	400.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bankfull Area (sq ft)	NA	NA	NA	NA	NA	NA	NA	NA	71.4	NA	NA	26.2	NA	NA	75.0	NA	NA	NA
Mean Depth (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.5	NA	NA	NA	NA	2.5	NA	NA	NA
Maximum Depth (ft)	NA	NA	NA	NA	NA	NA	NA	NA	5.8	3.0	NA	NA	NA	NA	4.3	NA	NA	NA
Width/Depth Ratio	NA	NA	NA	NA	NA	NA	NA	NA	12.2	NA	NA	12.1	NA	NA	12.0	NA	NA	NA
Entrenchment Ratio	NA	NA	NA	NA	NA	NA	NA	NA	6.8	NA	NA	33.7	NA	NA	6.7	NA	NA	NA
Bank Height Ratio	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wetted Perimeter (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydraulic Radius (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pattern																		
Channel Beltwidth (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	158	NA	NA	90.0	NA	NA	NA	NA	NA
Radius of Curvature (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	37.0	40.0	NA	60.0	80.0	NA	NA	NA	NA
Meander Wavelength	NA	NA	NA	NA	NA	NA	NA	NA	NA	94.0	143.0	NA	180	200.0	NA	NA	NA	NA
Meander Width ratio	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.9	NA	NA	3.0	NA	NA	NA
Profile																		
Riffle length (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Riffle slope (ft/ft)	NA	NA	NA	NA	NA	NA	0.3	0.3	NA	0.2	2.1	NA	NA	NA	0.3	NA	NA	NA
Pool length (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.0	30.0	NA	30.0	45.0	NA	NA	NA	NA
Pool spacing (ft)	NA	NA	NA	NA	NA	NA	NA	NA	NA	40.0	85.5	NA	70.0	140.0	NA	NA	NA	NA
Substrate																		
d50 (mm)	NA	NA	NA	NA	NA	NA	0.4	0.4	NA	NA	NA	0.2	NA	NA	0.4	NA	NA	NA
d84 (mm)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Additional Reach Parameters																		
Valley Length (ft)	NA			NA			NA			NA			NA			NA		
Channel Length (ft)	NA			NA			900			407			925			NA		
Sinuosity	NA			NA			1.01			1.28			1.10			NA		
Water Surface Slope (ft/ft)	NA			NA			0.20			0.24			0.20			NA		
BF slope (ft/ft)	NA			NA			NA			NA			NA			NA		
Rosgen Classification	NA			NA			C5			C5			C5			NA		
Habitat Index	NA			NA			NA			NA			NA			NA		
Macrobenthos	NA			NA			NA			NA			NA			NA		

Table IX. Morphology and Hydraulic Monitoring Summary - Third Fork Creek Stream Restoration - EEP Project #139 Upstream Reach												
	XS 1-Riffle						XS 2-Pool					
Dimension	As-built	MY1	MY2	MY3	MY4	MY5	As-built	MY1	MY2	MY3	MY4	MY5
Floodprone Width (ft)	240.00	240.00	240.00	240.00	240.00		240.00	240.00	240.00	240.00	240.00	
Bankfull Width (ft)	27.66	27.11	28.63	27.46	27.35		26.43	26.39	27.62	27.39	34.54	
Bankfull Area (sq ft)	61.64	61.37	62.47	61.28	63.29		70.07	72.88	76.71	77.42	83.22	
Mean Depth (ft)	2.23	2.26	2.18	2.23	2.31		2.65	2.76	2.78	2.83	2.41	
Maximum Depth (ft)	3.96	3.95	4.19	4.23	4.36		4.81	5.11	5.45	5.59	6.00	
Width/Depth Ratio	12.41	12.00	13.12	11.8	11.82		9.97	NA	9.94	9.69	14.34	
Entrenchment Ratio	8.68	8.85	8.38	8.74	8.78		9.08	NA	8.69	8.67	6.95	
Bank Height Ratio	1.00	1.00	1.03	1.02	1.04		1.00	1.03	1.03	1.03	1.00	
Wetted Perimeter (ft)	NA	NA	30.91	30.12	30.25		NA	NA	31.70	31.14	38.72	
Hydraulic Radius (ft)	NA	NA	2.02	NA	2.09		NA	NA	2.42	2.49	2.15	
Substrate												
d50 (mm)	NA	0.06	0.04	0.36	0.04		NA	0.06	0.09	0.14	0.05	
d84 (mm)	NA	0.06	0.06	1.88	0.09		NA	0.10	0.78	1.63	0.93	
Pattern		**As-built**		**MY1**		**MY2**		**MY3**		**MY4**		**MY5**
Channel Beltwidth (ft)		NA		NA		33.88		29.28		31.82		
Radius of Curvature (ft)		NA		NA		69.42		60.58		46.09		
Meander Wavelength		NA		NA		177.65		182.45		181.68		
Meander Width ratio		NA		NA		1.20		2.12		1.17		
Profile												
Riffle length (ft)		NA		NA		51.43		55.57		43.37		
Riffle slope (ft/ft)		NA		NA		0.002		0.002		0.002		
Pool length (ft)		NA		NA		28.60		47.39		54.8		
Pool spacing (ft)		NA		NA		35.95		21.96		43.76		
Additional Reach Parameters												
Valley Length (ft)		NA		NA		310		310		310		
Channel Length (ft)		NA		NA		350		350		343		
Sinuosity		NA		NA		1.13		1.13		1.11		
Water Surface Slope (ft/ft)		NA		NA		0.0018		0.0018		0.0016		
BF slope (ft/ft)		NA		NA		0.0007		0.0007		0.0035		
Rosgen Classification		NA		NA		C5		C5		C5		
Habitat Index		NA		NA		NA		NA		NA		
Macrobenthos		NA		NA		NA		NA		NA		

Table IX. Morphology and Hydraulic Monitoring Summary - Third Fork Creek Stream Restoration - EEP Project #139 Downstream Reach

	XS 3-Riffle						XS 4-Pool					
Dimension	As-built	MY1	MY2	MY3	MY4	MY5	As-built	MY1	MY2	MY3	MY4	MY5
Floodprone Width (ft)	240.00	240.00	240.00	240.00	240		240.00	240.00	240.00	240.00	240.00	
Bankfull Width (ft)	30.33	29.00	28.65	32.07	30.28		24.03	23.29	23.94	24.28	24.69	
Bankfull Area (sq ft)	54.61	53.46	51.94	64.17	69.49		59.65	60.40	60.73	68.79	63.78	
Mean Depth (ft)	1.80	1.84	1.81	2.17	2.29		2.48	2.59	2.79	2.83	2.58	
Maximum Depth (ft)	3.28	3.48	3.64	4.59	4.73		5.00	4.97	4.72	4.77	4.73	
Width/Depth Ratio	16.85	15.70	15.80	13.64	13.19		9.68	NA	7.81	8.57	9.56	
Entrenchment Ratio	7.91	8.28	8.38	8.11	7.93		9.99	NA	11.01	9.89	9.72	
Bank Height Ratio	1.08	1.04	1.13	1.15	1.07		1.11	1.12	1.05	1.09	1.13	
Wetted Perimeter (ft)	NA	NA	31.23	32.35	32.93		NA	NA	25.36	27.91	28.20	
Hydraulic Radius (ft)	NA	NA	1.66	1.98	2.11		NA	NA	2.39	2.46	2.26	
Substrate												
d50 (mm)		0.49	6.27	0.76	0.76			1.00	0.85	0.78	1.14	
d84 (mm)		1.50	16.60	9.65	9.65			2.00	11.30	3.17	4.42	
Pattern		**As-built**		**MY1**		**MY2**		**MY3**		**MY4**		**MY5**
Channel Beltwidth (ft)		NA		NA		35.77		47.47		38.09		
Radius of Curvature (ft)		NA		NA		57.96		56.59		40.69		
Meander Wavelength		NA		NA		162.56		183.76		176.63		
Meander Width ratio		NA		NA		1.54		1.61		1.48		
Profile												
Riffle length (ft)		NA		NA		14.24		8.45		35.67		
Riffle slope (ft/ft)		NA		NA		0.02		0.03		0.02		
Pool length (ft)		NA		NA		101.45		51.15		53.00		
Pool spacing (ft)		NA		NA		23.28		30.45		57.00		
Additional Reach Parameters												
Valley Length (ft)		NA		NA		308		310		310		
Channel Length (ft)		NA		NA		350		350		353		
Sinuosity		NA		NA		1.14		1.13		1.14		
Water Surface Slope (ft/ft)		NA		NA		0.0009		0.001		0.0008		
BF slope (ft/ft)		NA		NA		0.0003		0.0046		0.0021		
Rosgen Classification		NA		NA		C5b		E5		E5		
Habitat Index		NA		NA		NA		N/A		N/A		
Macrobenthos		NA		NA		NA		N/A		N/A		

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 spring 2008 versions of the CCPV.

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

Eight representative vegetation survey plots were selected and installed in the upstream and downstream reaches during September 2006. Where appropriate, the new monitoring plots were co-located with the first year monitoring plots. All plots measure 100 square meters in area and are either 10 meters by 10 meters, or five meters by 20 meters. Pursuant to the guidelines, the four corners of each plot (e.g. 0,0; 0,10; 10,0; and 10,10; or 0,0; 0,20; 5,0; and 5,20.) marked with 18 inch long one half inch diameter galvanized steel conduit were relocated in 2008. Within each plot, each planted woody stem location (x and y) recorded in 2006 was relocated. No mortality was observed.

Level 1 (planted woody stems) and Level 2 (volunteer woody stems) data collection was performed in all plots, pursuant to the most recent CVS/EEP protocol (Lee *et al* 2006). 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. Because the dimensions of the plots installed in 2006 are different than the first annual vegetation monitoring plots, direct comparison with the first year data is inappropriate.

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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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	10/21/2008 10:41
database name	139ThirdForkCreek-2008Resamping-EntryTool-v2.2.5.mdb
database location	C:\Documents and Settings\Owner\Desktop\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	139
project Name	Third Fork Creek
Description	Stream Restoration
River Basin	Cape Fear
length(ft)	3,025
stream-to-edge width (ft)	50
area (sq m)	35,948
Required Plots (calculated)	8
Sampled Plots	8

Appendix A.1.

Table 2. Vigor by Species

	Species	4	3	2	1	0	Missing	Unknown
	Alnus serrulata	15	1			2		
	Amelanchier arborea	1						
	Betula nigra	12						
	Callicarpa americana	21		2	1			
	Cephalanthus occidentalis	1		1				
	Clethra alnifolia	1						
	Cornus amomum	15					1	
	Fraxinus pennsylvanica	18						
	Itea virginica	11	1	2				
	Salix nigra	2						
	Sambucus canadensis	4						
	Symphoricarpos orbiculatus	16		1				
	Viburnum nudum	2						
	Morella cerifera	8		1				
	Viburnum dentatum	7						
	Ilex decidua	3				1		
	Ilex opaca	2	2					
	Cercis canadensis	1					1	
	Hamamelis virginiana	8						
	Platanus occidentalis	16	2					
TOT:	**20**	**164**	**6**	**7**	**1**	**3**	**2**	

Appendix A.1.

Table 3. Damage by Plot

	plot	All Damage Categories	(no damage)	Rodents	Vine Strangulation
	139-jo,sd-0005-year:2	10	10		
	139-jo,sd-0007-year:2	17	17		
	139-sd-0008-year:2	10	10		
	139-wjs-0001-year:2	35	34		1
	139-WJS-0002-year:2	29	29		
	139-wjs-0003-year:2	37	37		
	139-wjs-0004-year:2	13	13		
	139-WM-0006-year:2	33	32	1	
TOT:	**8**	**184**	**182**	**1**	**1**

Appendix A.1.

Table 4. Damage by Species

	Species	All Damage Categories	(no damage)	Rodents	Vine Strangulation
	Alnus serrulata	18	18		
	Amelanchier arborea	1	1		
	Betula nigra	12	12		
	Callicarpa americana	24	24		
	Cephalanthus occidentalis	2	2		
	Cercis canadensis	2	2		
	Clethra alnifolia	1	1		
	Cornus amomum	16	16		
	Fraxinus pennsylvanica	19	19		
	Hamamelis virginiana	8	8		
	Ilex decidua	4	4		
	Ilex opaca	4	4		
	Itea virginica	14	14		
	Morella cerifera	9	8	1	
	Platanus occidentalis	18	17		1
	Salix nigra	2	2		
	Sambucus canadensis	4	4		
	Symphoricarpos orbiculatus	17	17		
	Viburnum dentatum	7	7		
	Viburnum nudum	2	2		
TOT:	**20**	**184**	**182**	**1**	**1**

Appendix A.1.

Table 5. Planted Stems by Plot and Species

	Species	Total Planted Stems	# plots	avg# stems	plot 139-jo,sd-0005-year:2	plot 139-jo,sd-0007-year:2	plot 139-sd-0008-year:2	plot 139-wjs-0001-year:2	plot 139-WJS-0002-year:2	plot 139-wjs-0003-year:2	plot 139-wjs-0004-year:2	plot 139-WM-0006-year:2
	Alnus serrulata	16	7	2.29	1	2		4	1	4	1	3
	Amelanchier arborea	1	1	1			1					
	Betula nigra	12	7	1.71	1	2	1		2	1	2	3
	Callicarpa americana	24	6	4		2	1	5	8	5		3
	Cephalanthus occidentalis	2	1	2						2		
	Cercis canadensis	1	1	1				1				
	Clethra alnifolia	1	1	1				1				
	Cornus amomum	15	8	1.88	2	1	1	3	3	2	1	2
	Fraxinus pennsylvanica	18	6	3	2		2		3	3	2	6
	Hamamelis virginiana	8	6	1.33		1	2	1	1	1		2
	Ilex decidua	3	3	1	1			1	1			
	Ilex opaca	4	3	1.33				1			2	1
	Itea virginica	14	5	2.8		2		6	1	4		1
	Morella cerifera	9	4	2.25		3		2		1		3
	Platanus occidentalis	18	7	2.57		2	1	7	2	1	2	3
	Salix nigra	2	1	2	2							
	Sambucus canadensis	4	3	1.33		1		1				2
	Symphoricarpos orbiculatus	17	8	2.12	1	1	1	2	3	5	2	2
	Viburnum dentatum	7	2	3.5					3	4		
	Viburnum nudum	2	2	1					1			1
TOT:	**20**	**178**	**20**		**10**	**17**	**10**	**35**	**29**	**33**	**12**	**32**

Appendix A.1.

Table 6. Vegetation Problem Areas – Third Fork Creek Stream Restoration EEP Project #139			
Feature/Issue	**Station/Range**	**Probable Cause**	**Photo #**
Compacted/ Disturbed	3014-3085	Disturbed area not replanted	VP1
Exotic invasives colonizing site	3430-3470	Introduction of waterborne seeds from offsite	VP2

A.2. Representative Vegetation Problem Photos - Year 4 - 2008 - Third Fork Creek Stream Restoration (EEP Project #139)

VP1 (7/18/2008)

VP2 (7/18/2008)

Appendix A3. Vegetation Monitoring Plot Photographs - 2008 - Third Fork Creek Stream Restoration

Plot 1 (July 20, 2007)

Plot 1 (July 18, 2008)

Plot 2 (July 20, 2007)

Plot 2 (July 18, 2008)

Appendix A3. Vegetation Monitoring Plot Photographs - 2008 - Third Fork Creek Stream Restoration

Plot 3 (July 13, 2007)

Plot 3 (July 18, 2008)

Plot 4 (July 20, 2007)

Plot 4 (July 18, 2008)

Appendix A3. Vegetation Monitoring Plot Photographs - 2008 - Third Fork Creek Stream Restoration

Plot 5 (July 20, 2007)

Plot 5 (July 18, 2008)

Plot 6 (July 20, 2007)

Plot 6 (July 18, 2008)

Appendix A3. Vegetation Monitoring Plot Photographs - 2008 - Third Fork Creek Stream Restoration

Plot 7 (July 20, 2007)

Plot 7 (July 18, 2008)

Plot 8 (July 20, 2007)

Plot 8 (July 18, 2008)

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.1.1. Current Condition Plan View. 2008 Monitoring
Third Fork (Forest Hills) Stream Restoration Durham, NC

2008 Thalweg

Stream Problem Areas

- Aggradation (Pool)
- Aggradation (Riffle)
- Vane Backcut/Scour
- UT/Stormwater Headcut
- Structure Not Holding Grade
- Boulder Failure
- Bank Undercut/Slump

Vegetation Problem Areas

- Compacted/Disturbed
- Invasive Woody Stems

As-built Drawings Supplied by KCI

- In-Stream Structures
- Thalweg
- Cross Sections
- Conservation Easement
- Sewer ROW
- Monitoring Plots

East Forest Hills Blvd.

footbridge

10+00 10+50 11+00 11+50 12+00 12+50 13+00 13+50 14+00 14+50 15+00 15+50 16+00 16+50 17+00 17+50 18+00 18+50 19+00 19+50 20+00 20+50 21+00 21+50 22+00 22+50 23+00 23+50 24+00 24+50 25+00 25+50 26+00 26+50 27+00

1 2 3 4 5 6 7 8

1 2 3 4

XS-1

XS-2

Upstream Reach

Downstream Reach

footbridge

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N

Feet

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Ecosystem Enhancement PROGRAM

N

Feet
0 50 100 200

Figure B.1.2. Current Condition Plan View. 2008 Monitoring
Third Fork (Forest Hills) Stream Restoration Durham, NC

2008 Thalweg

Stream Problem Areas

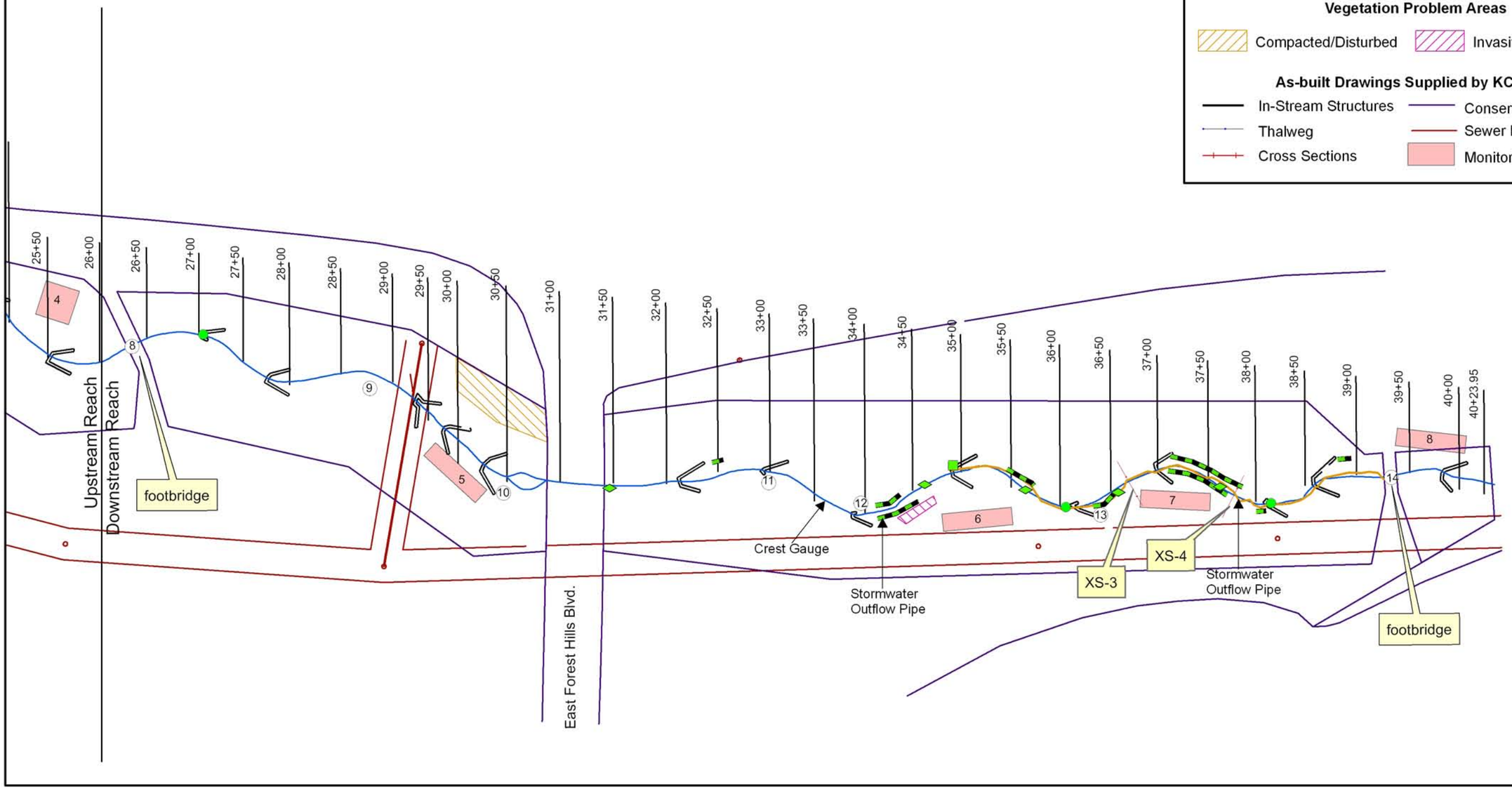
- Aggradation (Pool)
- Aggradation (Riffle)
- Vane Backcut/Scour
- UT/Stormwater Headcut
- Structure Not Holding Grade
- Boulder Failure
- Bank Undercut/Slump

Vegetation Problem Areas

- Compacted/Disturbed
- Invasive Woody Stems

As-built Drawings Supplied by KCI

- In-Stream Structures
- Thalweg
- Cross Sections
- Conservation Easement
- Sewer ROW
- Monitoring Plots



Appendix B2. Stream Problem Areas Table - Year 4 - 2008 - Third Fork Creek Stream Restoration (EEP Project #139)

Feature/Issue	Station	Suspected Cause	Photo #
Aggradation (pool)	1025	Sediment from offsite/upstream	SP1
Aggradation (pool)	1068	Sediment from offsite/upstream	SP1
Aggradation (pool)	1110	Sediment from offsite/upstream	SP1
Aggradation (pool)	1158	Sediment from offsite/upstream	SP1
Aggradation (pool)	1290	Sediment from offsite/upstream	SP1
Headcut at UT/stormwater	1443	Insufficient armor	SP2
Bank undercut/slump	1900-1910	No armor/rootwad	SP3 & SP4
Bank undercut/slump	1930-1955	No armor/rootwad	SP3 & SP4
Boulder failure	2050	Unknown	SP5
Vane backcut/scour	2146	Insufficient/no coarse backfill	SP6
Structure not holding grade	2704	Undersized materials/poor installation	SP7
Aggradation (riffle)	3152	Sediment from offsite/upstream	SP8
Bank undercut/slump	3244-3255	No armor/rootwad	SP3 & SP4
Bank undercut/slump (left bank)	3410-3436	Willows on slumping bank have fallen into channel and are holding debris. Problem aggravated by high storm flows.	SP3 & SP4
Bank undercut/slump (right bank)	3410-3450	No armor/rootwad	SP3 & SP4
Aggradation (riffle)	3460	Sediment from offsite/upstream	SP8
Vane backcut/scour	3490	Insufficient/no coarse backfill	SP6
Bank undercut/slump	3546-3576	No armor/rootwad	SP3
Aggradation (riffle)	3580	Sediment from offsite/upstream	SP8
Structure not holding grade	3620	Undersized materials/poor installation	SP7
Bank undercut/slump	3630-3657	No armor/rootwad	SP3
Aggradation (riffle)	3640	Sediment from offsite/upstream	SP8
Bank undercut/slump (right bank)	3710-3771	No armor/rootwad	SP3
Bank undercut/slump (left bank)	3715-3790	No armor/rootwad	SP3
Aggradation (riffle)	3770	Sediment from offsite/upstream	SP8
Bank undercut/slump	3800-3810	No armor/rootwad	SP3 & SP4
Structure not holding grade	3820	Undersized materials/poor installation	SP7
Bank undercut/slump	3850-3863	No armor/rootwad	SP3 & SP4

B3. Representative Stream Problem Photos - Year 4 - 2008 - Third Fork Creek Stream Restoration (EEP Project #139)

SP1-Aggradation (pool) (10/28/2008)

SP2-Headcut in UT/Stormwater (10/28/2008)

SP3-Bank undercut/scour (10/28/2008)

SP4-Bank slump resulting in choked channel (10/28/2008)

B3. Representative Stream Problem Photos - Year 4 - 2008 - Third Fork Creek Stream Restoration (EEP Project #139)

SP5-Boulder failure (10/28/2008)

SP6-Vane backcut (10/28/2008)

SP7-Structure not holding grade (10/28/2008)

SP8-Aggradation (riffle) (10/28/2008)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration - Project #139

PP #1 – Looking Upstream (07/16/07)

PP #1 – Looking Upstream (05/06/08)

PP #2 – Looking Upstream (07/16/07)

PP #2 – Looking Upstream (05/06/08)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration - Project #139

PP #3 – Ditch Entering Stream (07/16/07)

PP #3 – Ditch Entering Stream (05/06/08)

PP #4 – Looking Downstream (07/16/07)

PP #4 – Looking Downstream (05/06/08)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration - Project #139

PP #5 – UT Entering Stream (07/16/07)

PP #5 – UT Entering Stream (05/06/08)

PP #6 – Looking Downstream (07/16/07)

PP #6 – Looking Downstream (05/06/08)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration - Project #139

PP #7 – Looking Downstream (07/16/07)

PP #7 – Looking Downstream (05/06/08)

PP #8 – Looking Upstream (07/16/07)

PP #8 – Looking Upstream (05/06/08)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration - Project #139

PP #9 – Looking Upstream (07/16/07)

PP #9 – Looking Upstream (10/31/08)

PP #10 – Looking Downstream (11/20/06)

PP #10 – Looking Downstream (05/06/08)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration - Project #139

PP #11 – Looking Upstream (07/16/07)

PP #11 – Looking Upstream (10/31/08)

PP #12 – Looking Upstream (07/16/07)

PP #12 – Looking Upstream (10/31/08)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration - Project #139

PP #13 – Looking Upstream (07/16/07)

PP #13 – Looking Upstream (10/31/08)

PP #14 – Looking Upstream (07/16/07)

PP #14 – Looking Upstream (10/31/08)

Appendix B.5. Visual Morphology Stability Assessment - Third Fork Stream Restoration Project - Project #139
Upstream Reach (1600 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	10	10	NA	100	
	2. Armor stable	10	10	NA	100	
	3. Facet grade appears stable	10	10	NA	100	
	4. Minimal evidence of embedding/fining	0	10	NA	0	
	5. Length appropriate	9	10	NA	90	**78**
B. Pools	1. Present	12	15	NA	80	
	2. Sufficiently deep	12	15	NA	80	
	3. Length appropriate	12	15	NA	80	**80**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	16	16	NA	100	
	2. Downstream of meander (glide/inflection) centering	16	16	NA	100	**100**
D. Meanders	1. Outer bend in state of limited/controlled erosion	15	16	NA	94	
	2. Of those eroding, # w/concomitant point bar formation	0	1	NA	100	
	3. Apparent Rc within spec	16	16	NA	100	
	4. Sufficient floodplain access and relief	16	16	NA	100	**98**
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	NA	NA	5/150	91	
	2. Channel bed degradation – areas of increasing downcutting or head cutting	NA	NA	1/30	98	**95**
F. Bank	1. Actively eroding, wasting, or slumping bank	NA	NA	2/35	98	**98**
G. Vanes	1. Free of back or arm scour	22	23	NA	96	
	2. Height appropriate	22	23	NA	96	
	3. Angle and geometry appear appropriate	22	23	NA	96	
	4. Free of piping or other structural failures	22	23	NA	96	**96**
H. Wads/ Boulders	1. Free of scour	NA	NA	NA	NA	
	2. Footing stable	NA	NA	NA	NA	**NA**

Appendix B.5. Visual Morphology Stability Assessment - Third Fork Stream Restoration Project - Project #139
Downstream Reach (1525 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	10	10	NA	100	
	2. Armor stable	10	10	NA	100	
	3. Facet grade appears stable	10	10	NA	100	
	4. Minimal evidence of embedding/fining	4	10	NA	40	
	5. Length appropriate	7	10	NA	70	**82**
B. Pools	1. Present	9	12	NA	75	
	2. Sufficiently deep	6	12	NA	50	
	3. Length appropriate	8	12	NA	67	**64**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	4	7	NA	57	
	2. Downstream of meander (glide/inflection) centering	4	7	NA	57	**57**
D. Meanders	1. Outer bend in state of limited/controlled erosion	4	7	NA	57	
	2. Of those eroding, # w/concomitant point bar formation	0	3	NA	100	
	3. Apparent Rc within spec	5	7	NA	71	
	4. Sufficient floodplain access and relief	7	7	NA	100	**82**
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	NA	NA	5/55	96	
	2. Channel bed degradation – areas of increasing downcutting or head cutting	NA	NA	3/25	98	**100**
F. Bank	1. Actively eroding, wasting, or slumping bank	NA	NA	9/295	81	**81**
G. Vanes	1. Free of back or arm scour	8	9	NA	89	
	2. Height appropriate	9	9	NA	100	
	3. Angle and geometry appear appropriate	9	9	NA	100	
	4. Free of piping or other structural failures	7	9	NA	78	**92**
H. Wads/ Boulders	1. Free of scour	NA	NA	NA	NA	
	2. Footing stable	NA	NA	NA	NA	**NA**

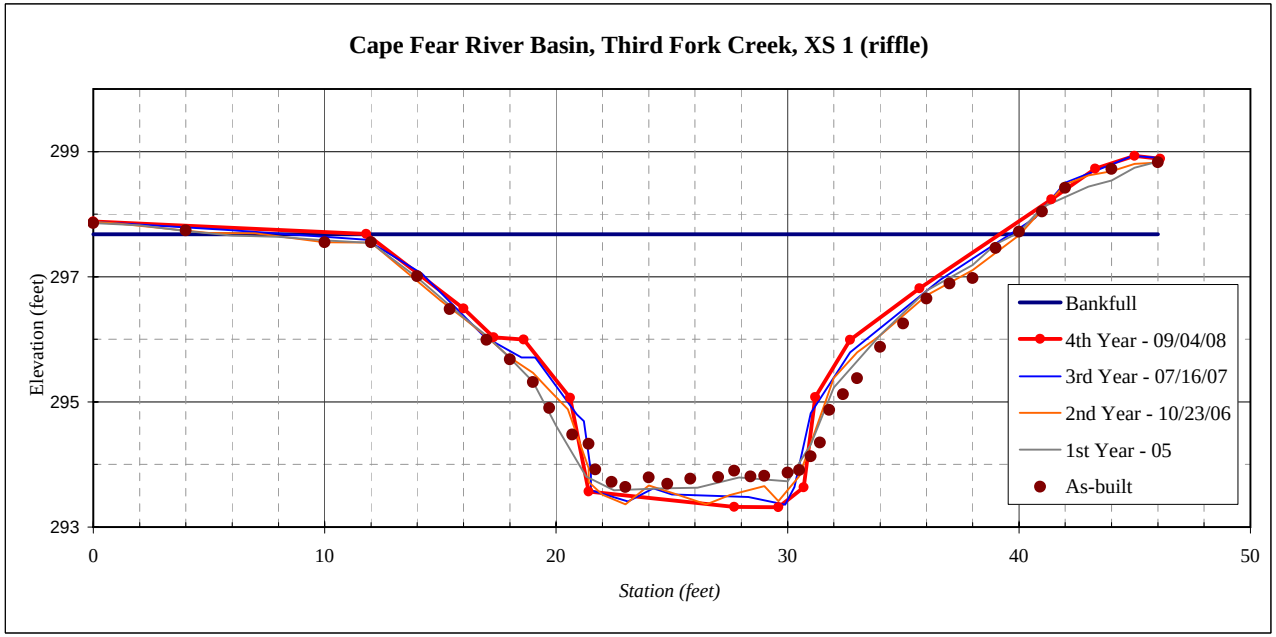
River Basin:	Cape Fear
Watershed:	Third Fork Creek
XS ID	XS 1 (riffle)
Reach:	Upstream
Date:	9/4/2008
Field Crew:	J. O'Neal, S. Doig

Station	Elevation
0	297.70
11.8	297.50
16	296.31
17.3	295.85
18.6	295.82
20.6	294.88
21.4	293.39
27.7	293.14
29.6	293.14
30.7	293.45
31.2	294.89
32.7	295.81
35.7	296.64
41.4	298.06
43.3	298.55
45	298.75
46.1	298.71

SUMMARY DATA	
Floodprone Elevation (ft)	302.04
Bankfull Elevation (ft)	297.68
Floodprone Width (ft)	240.00
Bankfull Width (ft)	27.35
Entrenchment Ratio	8.78
Mean Depth (ft)	2.31
Maximum Depth (ft)	4.36
Width/Depth Ratio	11.82
Bankfull Area (sq ft)	63.29
Wetted Perimeter (ft)	30.25
Hydraulic Radius (ft)	2.09

View of cross-section #1 looking downstream

Stream Type:	E5



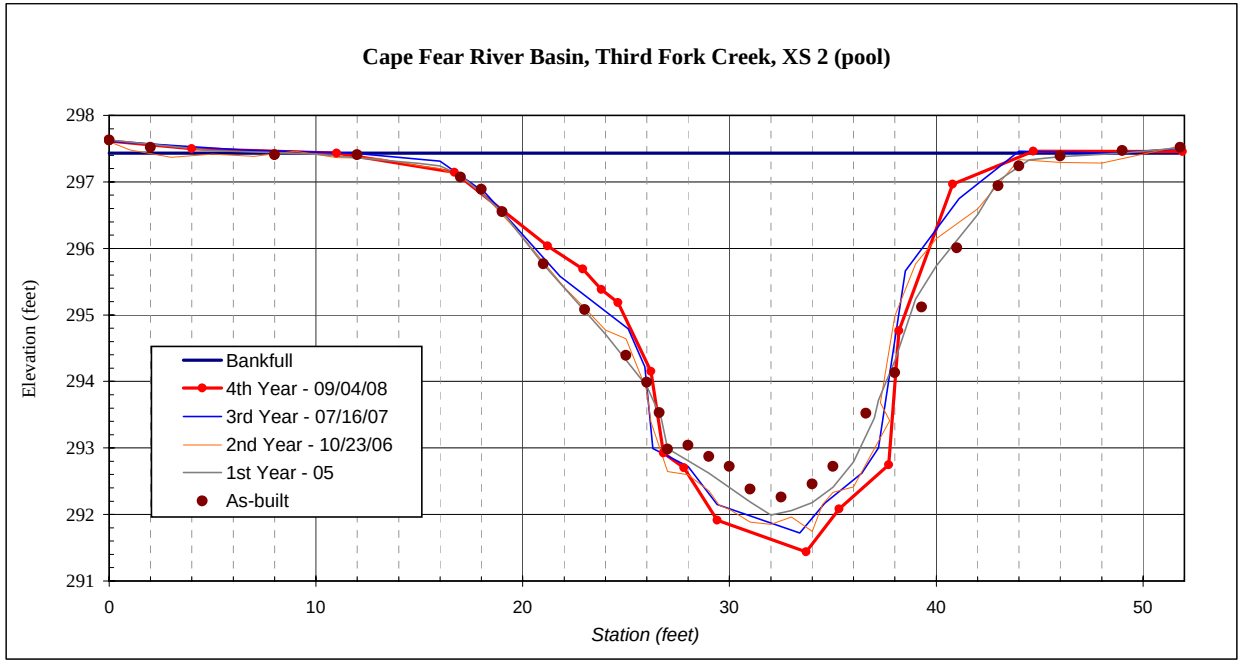
River Basin:	Cape Fear
Watershed:	Third Fork Creek
XS ID	XS 2 (pool)
Reach:	Upstream
Date:	9/4/2008
Field Crew:	J. O'Neal, S. Doig

Station	Elevation
0.00	297.61
4.00	297.50
11.00	297.43
16.70	297.14
21.20	296.04
22.90	295.69
23.80	295.38
24.60	295.18
26.20	294.15
26.80	292.92
27.80	292.70
29.40	291.92
33.70	291.44
35.30	292.08
37.70	292.75
38.20	294.76
40.80	296.96
44.70	297.46
51.90	297.46

SUMMARY DATA	
Floodprone Elevation (ft)	303.44
Bankfull Elevation (ft)	297.44
Floodprone Width (ft)	240
Bankfull Width (ft)	34.54
Entrenchment Ratio	6.95
Mean Depth (ft)	2.41
Maximum Depth (ft)	6
Width/Depth Ratio	14.34
Bankfull Area (sq ft)	83.22
Wetted Perimeter (ft)	38.72
Hydraulic Radius (ft)	2.15

View of cross-section #2 looking downstream

Stream Type:	C5c



B6. Cross Section Plots, Photos, and Raw Data Tables - Third Fork Stream Restoration Monitoring Year 4 (2008) - Project #139

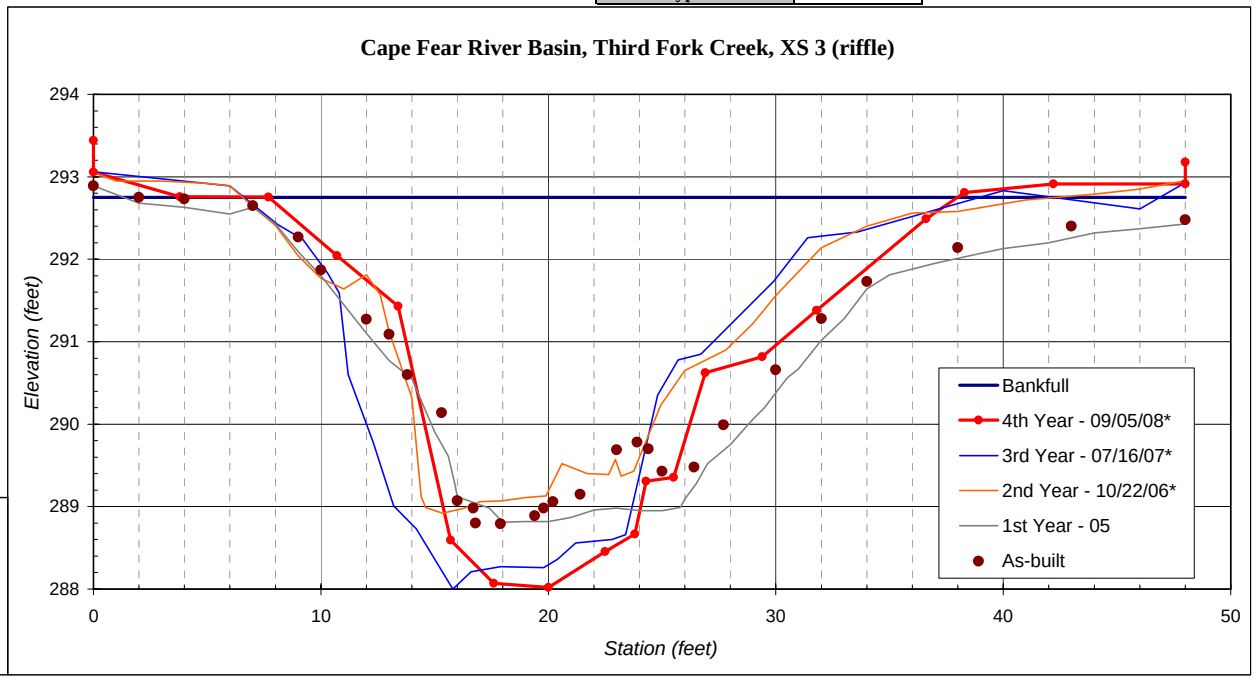
River Basin:	Cape Fear
Watershed:	Third Fork Creek
XS ID	XS 3 (riffle)
Reach:	Downstream
Date:	9/5/2008
Field Crew:	J. O'Neal, S. Doig

Station	Elevation
0	293.44
0	293.06
3.8	292.76
7.7	292.75
10.7	292.04
13.4	291.43
15.7	288.60
17.6	288.07
20	288.02
22.5	288.45
23.8	288.67
24.3	289.31
25.5	289.35
26.9	290.62
29.4	290.82
31.8	291.38
36.6	292.49
38.3	292.81
42.2	292.91
48	292.91
48	293.18

SUMMARY DATA	
Floodprone Elevation (ft)	297.48
Bankfull Elevation (ft)	292.75
Floodprone Width (ft)	240.00
Bankfull Width (ft)	30.28
Entrenchment Ratio	7.93
Mean Depth (ft)	2.29
Maximum Depth (ft)	4.73
Width/Depth Ratio	13.19
Bankfull Area (sq ft)	69.49
Wetted Perimeter (ft)	32.93
Hydraulic Radius (ft)	2.11

View of cross-section #3 looking downstream

Stream Type:	C5



*the original (as-built and 1st year) cross section was not relocated in 2006. Subsequent years' data represent relocation based best professional judgment, which appropriately approximates the original location.

B6. Cross Section Plots, Photos, and Raw Data Tables - Third Fork Stream Restoration Monitoring Year 4 (2008) - Project #139

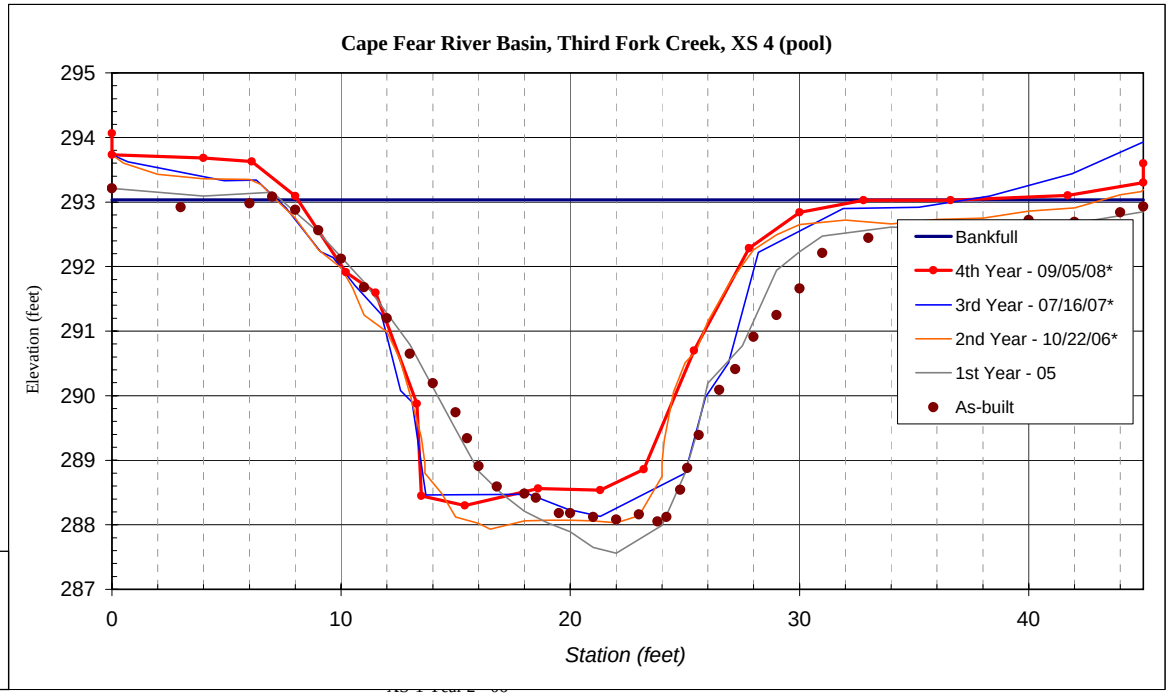
River Basin:	Cape Fear
Watershed:	Third Fork Creek
XS ID	XS 4 (pool)
Reach:	Downstream
Date:	9/5/2008
Field Crew:	J. O'Neal, S. Doig

Station	Elevation
0	294.06
0	293.73
4	293.68
6.1	293.63
8	293.09
10.2	291.91
11.5	291.60
13.3	289.88
13.5	288.45
15.4	288.30
18.6	288.56
21.3	288.53
23.2	288.86
25.4	290.70
27.8	292.28
30	292.84
32.8	293.03
36.6	293.03
41.7	293.10
45	293.30
45	293.60

SUMMARY DATA	
Floodprone Elevation (ft)	297.38
Bankfull Elevation (ft)	293.03
Floodprone Width (ft)	240.00
Bankfull Width (ft)	24.69
Entrenchment Ratio	9.72
Mean Depth (ft)	2.58
Maximum Depth (ft)	4.73
Width/Depth Ratio	9.56
Bankfull Area (sq ft)	63.78
Wetted Perimeter (ft)	28.20
Hydraulic Radius (ft)	2.26

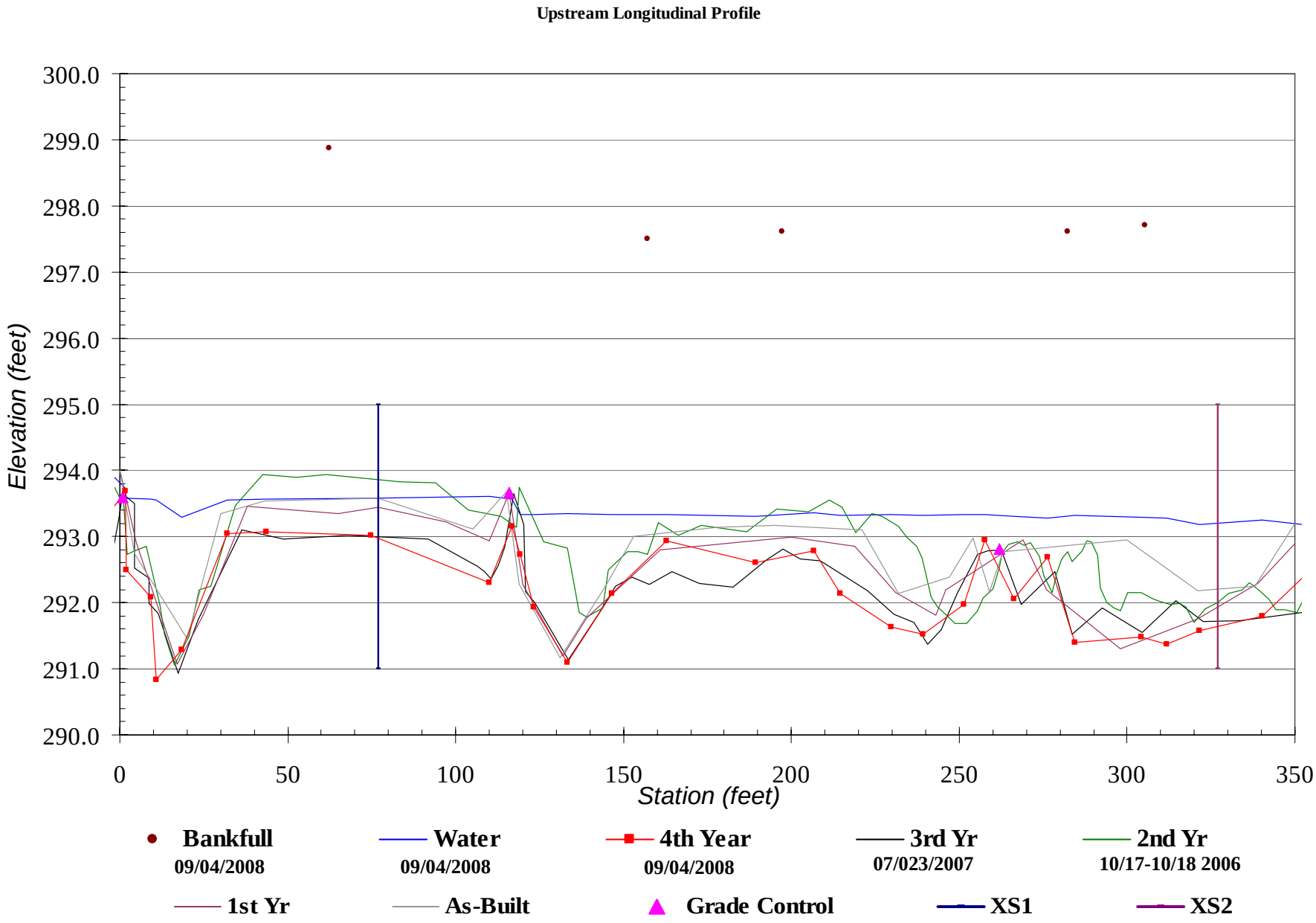
View of cross-section #3 looking downstream

Stream Type:	E5

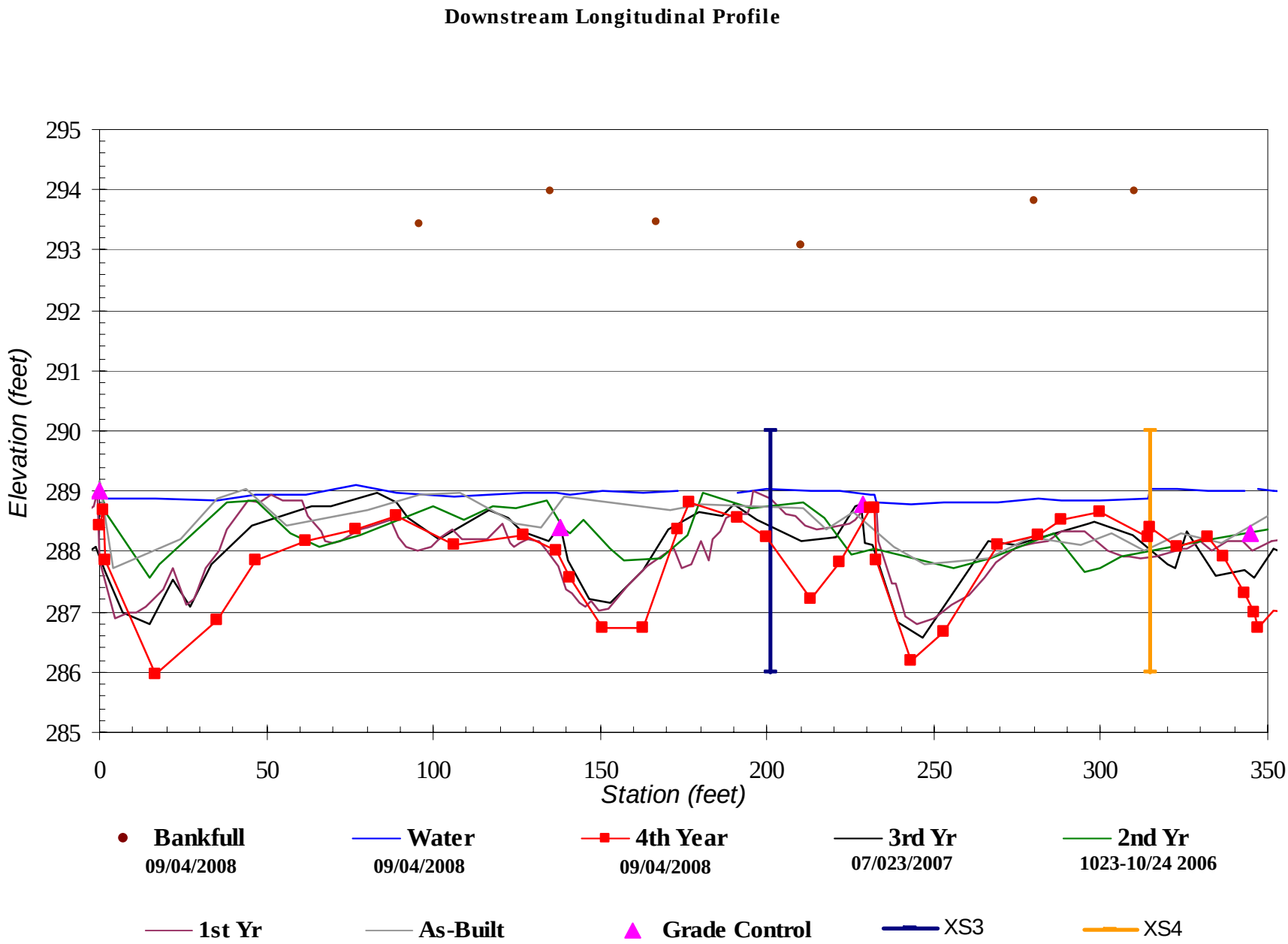


*the original (as-built and 1st year) cross section was not relocated in 2006. Subsequent years' data represent relocation based best professional judgment, which appropriately approximates the original location.

B7. Longitudinal Profile -Third Fork Stream Restoration Monitoring Year 4 (2008) - Project #139



B7. Longitudinal Profile -Third Fork Stream Restoration Monitoring Year 4 (2008) - Project #139



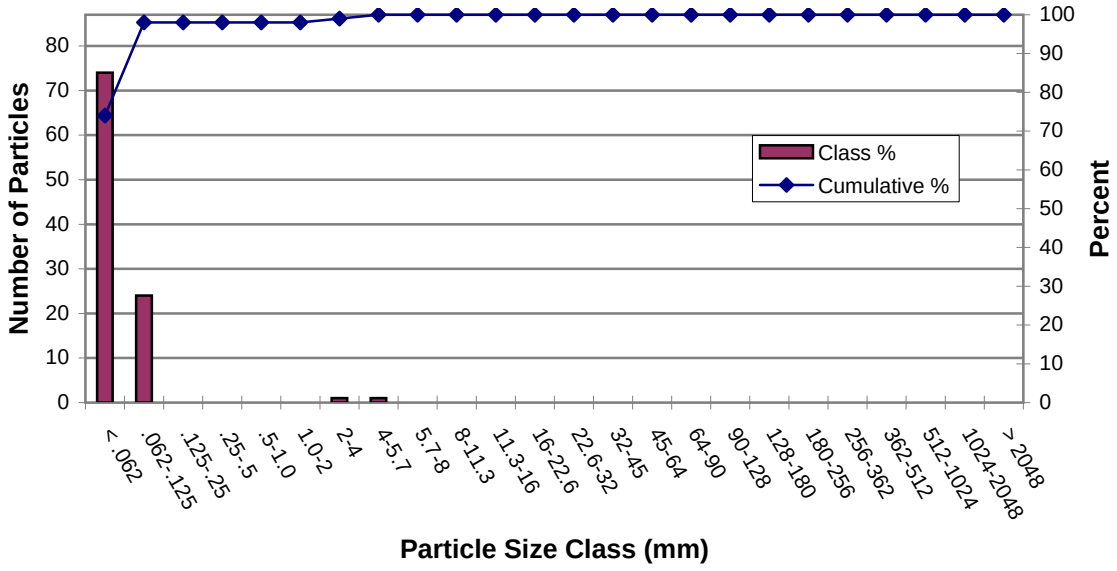
B8. Pebble Count - Third Fork Creek Stream Restoration Fourth Year Monitoring 10/29/2008

Cross Section One

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	74	74	74
Sand	Very Fine Sand	.062-.125	24	24	98
	Fine Sand	.125-.25		0	98
	Medium Sand	.25-.5		0	98
	Coarse Sand	.5-1.0		0	98
	Very Course Sand	1.0-2		0	98
Gravel	Very Fine Gravel	2-4	1	1	99
	Fine Gravel	4-5.7	1	1	100
	Fine Gravel	5.7-8		0	100
	Medium Gravel	8-11.3		0	100
	Medium Gravel	11.3-16		0	100
	Coarse Gravel	16-22.6		0	100
	Coarse Gravel	22.6-32		0	100
	Very Course Gravel	32-45		0	100
	Very Course Gravel	45-64		0	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
	Total		100		

d_{50} = 0.04 mm

d_{84} = 0.09 mm



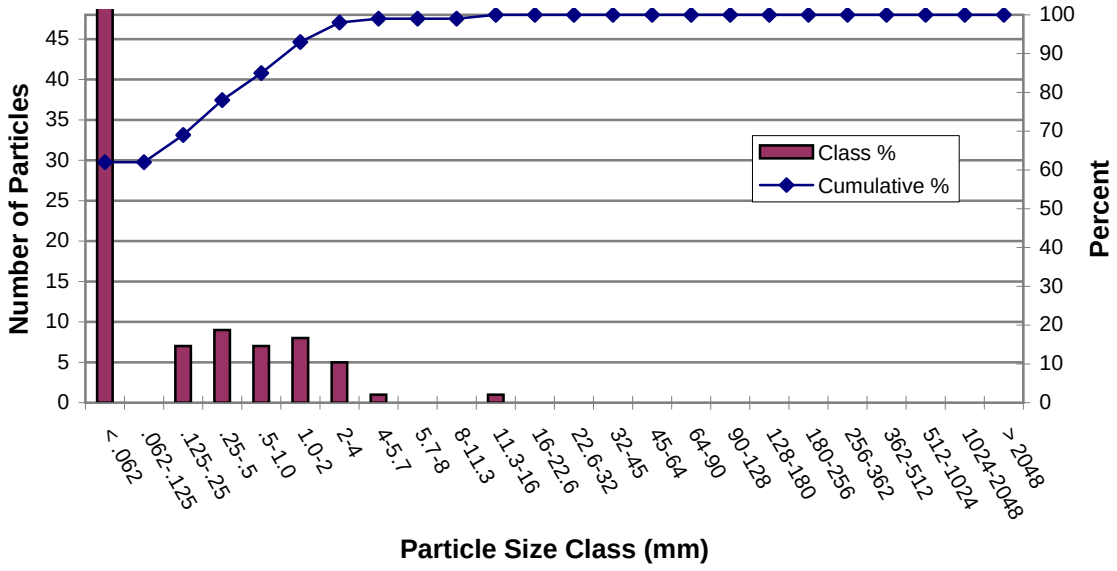
B8. Pebble Count - Third Fork Creek Stream Restoration Fourth Year Monitoring 10/29/2008

Cross Section Two

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	62	62	62
Sand	Very Fine Sand	.062-.125		0	62
	Fine Sand	.125-.25	7	7	69
	Medium Sand	.25-.5	9	9	78
	Coarse Sand	.5-1.0	7	7	85
	Very Course Sand	1.0-2	8	8	93
Gravel	Very Fine Gravel	2-4	5	5	98
	Fine Gravel	4-5.7	1	1	99
	Fine Gravel	5.7-8		0	99
	Medium Gravel	8-11.3		0	99
	Medium Gravel	11.3-16	1	1	100
	Coarse Gravel	16-22.6		0	100
	Coarse Gravel	22.6-32		0	100
	Very Course Gravel	32-45		0	100
	Very Course Gravel	45-64		0	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
	Total		100		

d_{50} = 0.05 mm

d_{84} = 0.93 mm



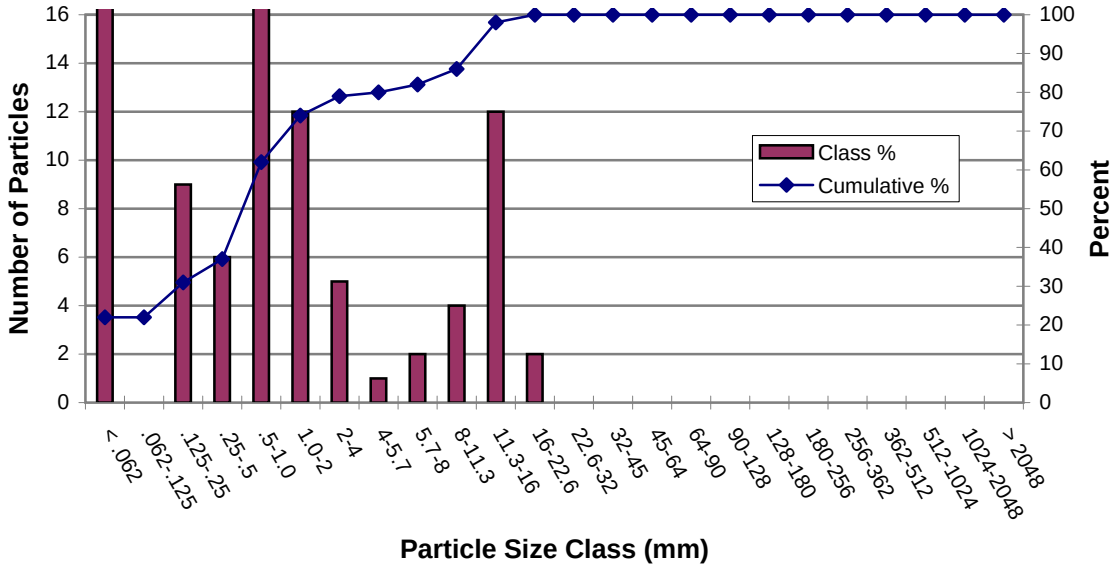
B8. Pebble Count - Third Fork Creek Stream Restoration Fourth Year Monitoring 10/29/2008

Cross Section Three

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	22	22	22
Sand	Very Fine Sand	.062-.125	0	0	22
	Fine Sand	.125-.25	9	9	31
	Medium Sand	.25-.5	6	6	37
	Coarse Sand	.5-1.0	25	25	62
	Very Course Sand	1.0-2	12	12	74
Gravel	Very Fine Gravel	2-4	5	5	79
	Fine Gravel	4-5.7	1	1	80
	Fine Gravel	5.7-8	2	2	82
	Medium Gravel	8-11.3	4	4	86
	Medium Gravel	11.3-16	12	12	98
	Coarse Gravel	16-22.6	2	2	100
	Coarse Gravel	22.6-32		0	100
	Very Course Gravel	32-45		0	100
	Very Course Gravel	45-64		0	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
	Total		100		

d_{50} = 0.76 mm

d_{84} = 9.65 mm



B8. Pebble Count - Third Fork Creek Stream Restoration Fourth Year Monitoring 10/29/2008

Cross Section Four

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	12	12	12
Sand	Very Fine Sand	.062-.125	6	6	18
	Fine Sand	.125-.25	6	6	24
	Medium Sand	.25-.5	16	16	40
	Coarse Sand	.5-1.0	8	8	48
	Very Course Sand	1.0-2	14	14	62
Gravel	Very Fine Gravel	2-4	20	20	82
	Fine Gravel	4-5.7	8	8	90
	Fine Gravel	5.7-8	6	6	96
	Medium Gravel	8-11.3	2	2	98
	Medium Gravel	11.3-16	2	2	100
	Coarse Gravel	16-22.6		0	100
	Coarse Gravel	22.6-32		0	100
	Very Course Gravel	32-45		0	100
	Very Course Gravel	45-64		0	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
	Total		100		

d_{50} = 1.14 mm

d_{84} = 4.42 mm