EEP Project Closeout Summary

Project ID & Status

Project Name/Number:	Clear Creek
EEP ID	092
County:	Henderson
Project Type:	Stream Restoration
Current Status:	5 Years of Monitoring complete

Project Setting & Classifications

Basin:	French Broad
Physiographic Region:	Mountain
Ecoregion:	Blue Ridge Belt
USGS Hydro Unit:	06010105
NCDWQ Subbasin:	04-03-02
Trout Water:	No
Designer:	EcoLogic Associates
Monitoring	Kimley-Horn, SEC

Project Timeline

Milestone	Date
Construction Completed	October 2002
As-built survey	October 2002
Monitoring Year-1	December 2004
Monitoring Year-2	December 2005
Monitoring Year-3	January 2007
Monitoring Year-4	February 2008
Monitoring Year-5	December 2008

Table 1. Project Restoration Components and Mitigation Assets

Stream			Asset Data										Watershed Data and Characteristics						
	Drainage/Hydrology Component	Restoration Component	Asset				Ratio							Wetland	DA	Stream	%	Land	
			Map #	Approach	Level	Ratio	Multip	Feet	SMU	Acres	WMU		P/I/E	Type	(SM)	Order	Imper	Use	303d
	Clear Creek	Reach 1	1	P1	R	1.00	1.00	1196	1196	-	-		P	-	44	4th	20%	Ag-Past	No

P1 = Priority I Restoration
P2 = Priority II Restoration
P3 = Priority III Restoration

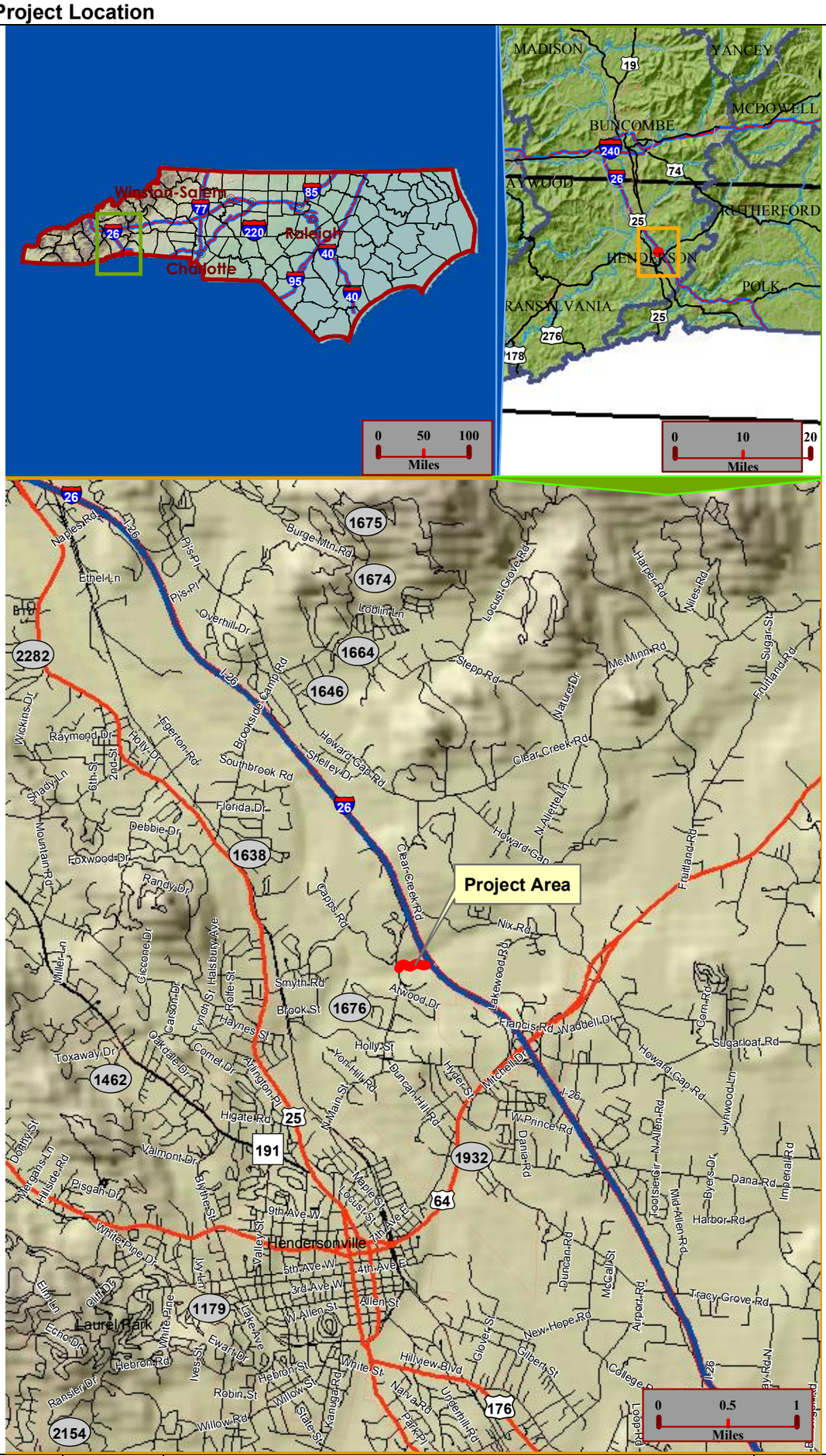
R = Restoration
E = Wetland Enhancement
EI = Stream Enhancement I
EII = Stream Enhancement II
C = Wetland Creation
P = Preservation

SMU =Stream Mitigation Units
WMU = Wetland Mitigation Units
P/I/E = Perennial, Intermittent, Ephemeral

Table 2.Asset Summary

Level	Feet	SMU	Acres	WMU
R	1196	1196		
E				
EI				
EII				
C				
P				
	1196	**1196**		

Figure 1: Project Location



Prepared For	Project	Clear Creek Stream Closeout Report (2009) Henderson County, North Carolina	Prepared By
Ecosystem Enhancement Program	Date	Project Number	Kimley-Horn and Associates, Inc.
	06/25/2009	092	

Background and Project History

The Clear Creek restoration site is located in a relatively low slope mountain valley in Henderson County, NC. It is a fourth order tributary to Mud Creek in the French Broad River Basin. The restoration reach runs through a former overgrazed pasture between I-26 and Clear Creek Road. The watershed of this section of Clear Creek has a drainage area of approximately 44 square miles.

Clear Creek is listed as Class C waters, protected for secondary recreation, fishing, wildlife, and aquatic life propagation and survival, and agriculture. There are no restrictions on watershed development activities.

Prior to January 1951, the date of the oldest aerial photograph available at the Henderson County NRCS Office, Clear Creek was straightened. Presumably, it was straightened for agricultural purposes and for construction of a sanitary sewer line, as the county was predominantly rural at that time. Successive aerial photographs show the construction of I-26 in 1965. A 1969 aerial photograph (NCDOT) shows Clear Creek flowing straight, wide and shallow, typical of an F stream type. The 1994 photograph shows that Clear Creek is trying to re-establish meanders. See aerials from 2001 (pre-construction and from 2007 post-construction) in Figure 2.

Shortly after construction, successive Hurricane events in 2004 generated several isolated instances of bank scour, which have advanced little over the monitoring period. The percentage of bank exhibiting scour has maintained levels between 8 and 10% since that time, with little advancement. In between the large storms related to the remnant hurricanes of 2004, the bank was hardened in an emergency measure near the old channel plug at the top of the project. The flow vectors coming into the project under the I-26 bridge led to concerns after the first event that the forecasted, second event might re-enter or avulse into the abandoned channel on stream left. The North Carolina Ecosystem Enhancement Program (EEP) always intended to regrade and replant this area once additional observation provided confidence that the vectors and conditions would not lead to an avulsion. This was carried out in winter of 2008/2009 and while equipment was already on site, another area between station 9+00 and 10+00 on stream right was repaired as well. This area did not seem to completely arrest its advancement as with the other areas of bank scour and the adjacent floodplain exhibited poorer soil conditions and lesser vegetation success. This included bank resloping and root wrap installation to an area greater than the bounds of observed instability as well as installation of additional plantings.

Figure 2: Pre-Post Construction Aerial Photographs

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Figure 3: Project Site Map

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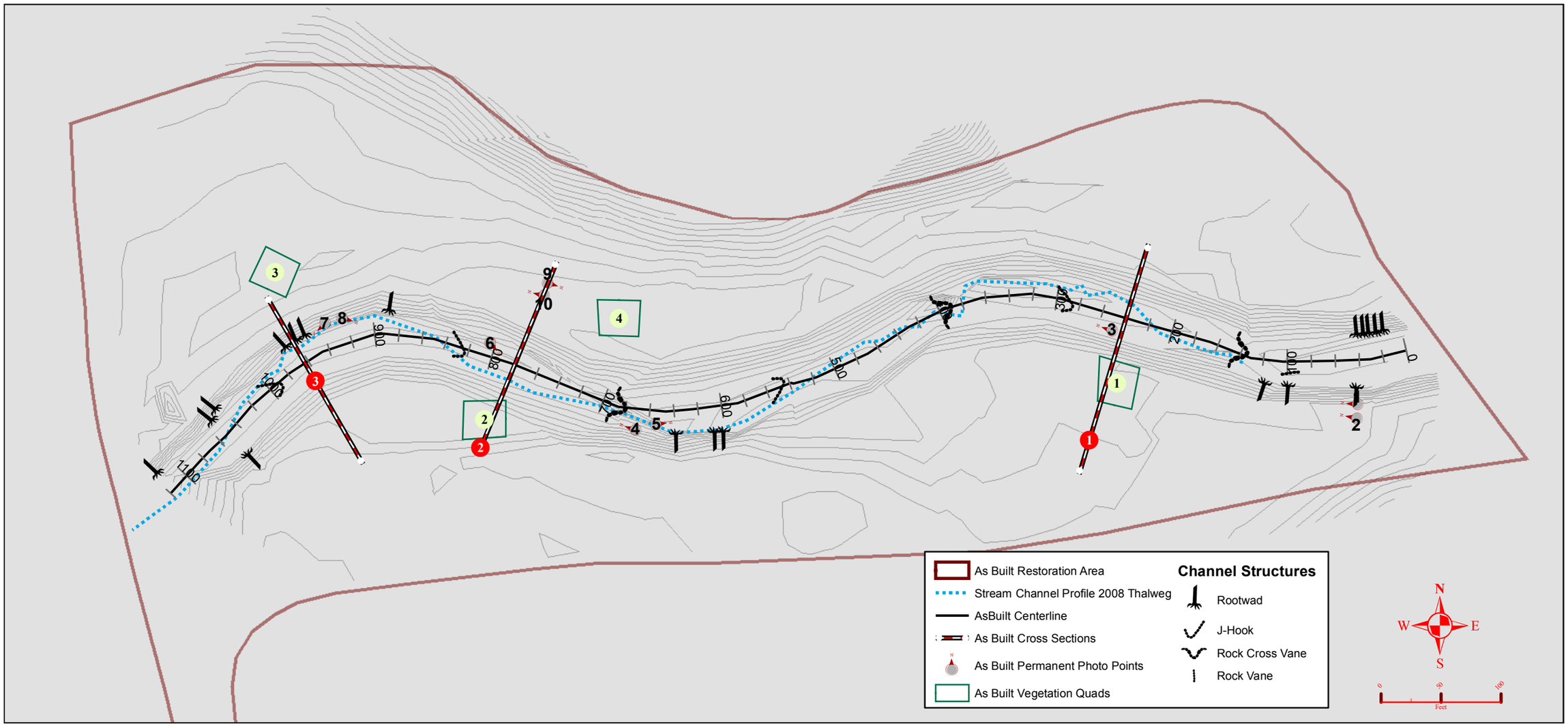

Figure 4. Monitoring Plan View

		
Clear Creek – Before Construction (2001)	Clear Creek – Before Construction (2001)	Clear Creek – Before Construction (2001)
Figure 5: Pre-Existing Condition Photos		

Clear Creek – As-Built Station 1+00 Facing Downstream	Clear Creek – Year 5 (2008) Station 1+00 Facing Downstream	Clear Creek – As-Built Station 7+80 Right Floodplain Facing Upstream	Clear Creek – Year 5 (2008) Station 7+80 Right Floodplain Facing Upstream
			

Figure 6: As-Built Photo Comparison

Clear Creek – Hurricane Ivan (09/2004) Station 0+00 Facing Downstream	Clear Creek – Hurricane Frances (09/2004) Station 7+80 Facing Upstream	Clear Creek – Year 5 (2008) Station 7+80 Facing Upstream Compare to Hurricane Frances Photo	Clear Creek – Year 5 (2008) Station 5+50 Facing Upstream Note established vegetation along banks.
			

Figure 7: Stream Photos

Channel Stability

Dimension

Through the five year monitoring period, the riffle cross section areas have averaged 6% to 18% larger than the as-built conditions. A portion of this increase could be attributed to XS1 and XS2 being re-set during the monitoring year 2 morphological survey. Heavy flooding events in 2004 (see figure 6 photos of Hurricanes Ivan and Frances) generated several isolated instances of bank scour and some impact to three in-stream structures. These conditions have not noticeably advanced after their initial occurrence. The channel prior to restoration was classified as an F5 stream type, wide and shallow. The channel was constructed as a C4 stream type. The entrenchment ratio for the stream was maintained throughout the monitoring period, which indicates healthy floodplain capacity. There appeared to be some lateral migration in cross section three, but this may have been a lateral shift in the survey by the monitoring consultant. The bankfull area increased for XS1 and XS3 during monitoring year 2, however the subsequent years showed a trend towards as-built conditions. The pool cross section exhibited greater depth than that of the riffles, indicating the maintenance of distinct bedform features during the monitoring period. The project's dimensions currently represent an E/C channel and exhibit steep inner meanders, which can present pressure on the outer meander. Some meanders have exhibited modest, slow lateral migration, but this appears to be at a sustainable rate such that the inner meander builds at a complementary modest rate. Collectively, these conditions indicate stability or stable trends of the restored reach. The plots below show some of the conditions of the channel dimensions for the project.

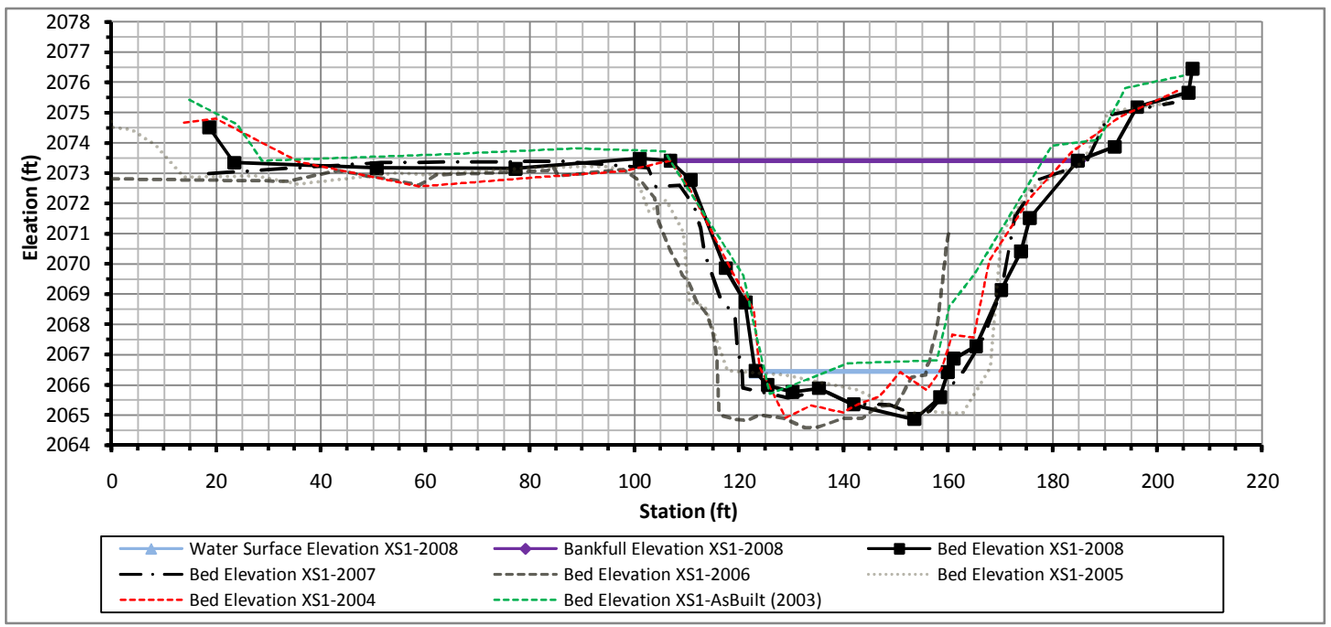

Figure 8. Cross Section 1 (Riffle)

Table 3. Cross-Sectional Areas Based on As-Built BKF

XS ID	MY0	MY1	MY2	MY3	MY4	MY5	Mean
XS 1	335	338	446	387	371	418	383
XS 2	352	337	361	356	358	372	356
XS 3	337	322	444	343	397	388	372

Cross Section 1 (Riffle) Photo (2008)

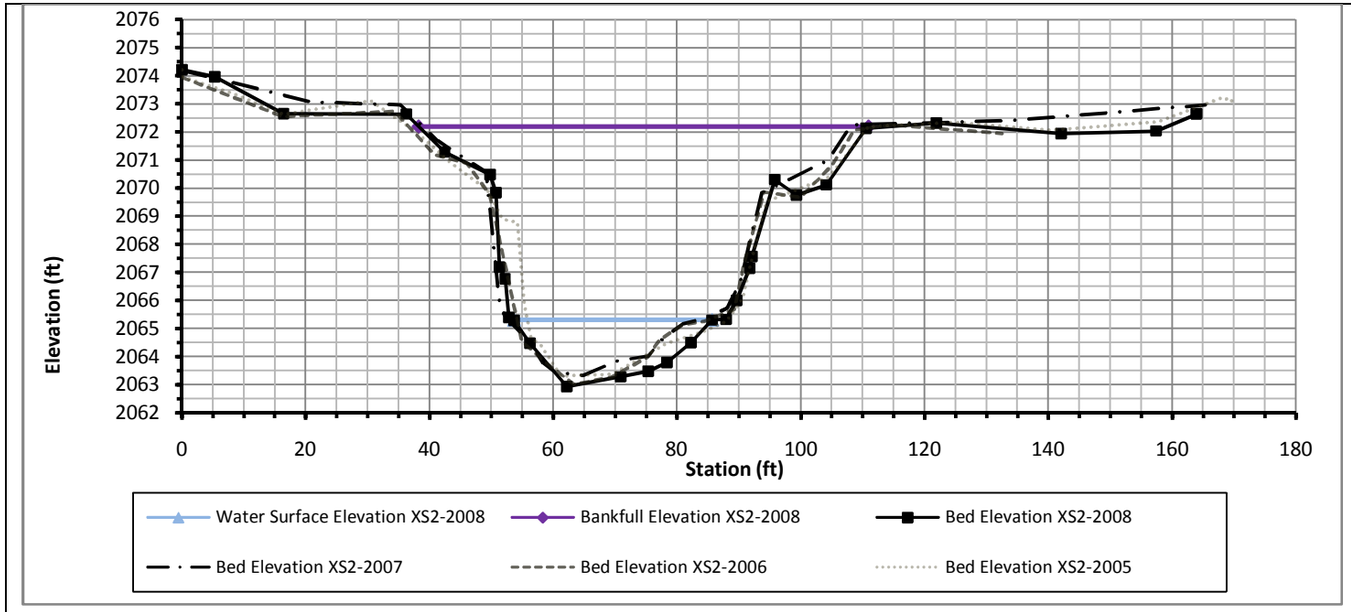

Figure 8. Cross Section 2 (Riffle)

Cross Section 2 (Riffle) Photo (2008)

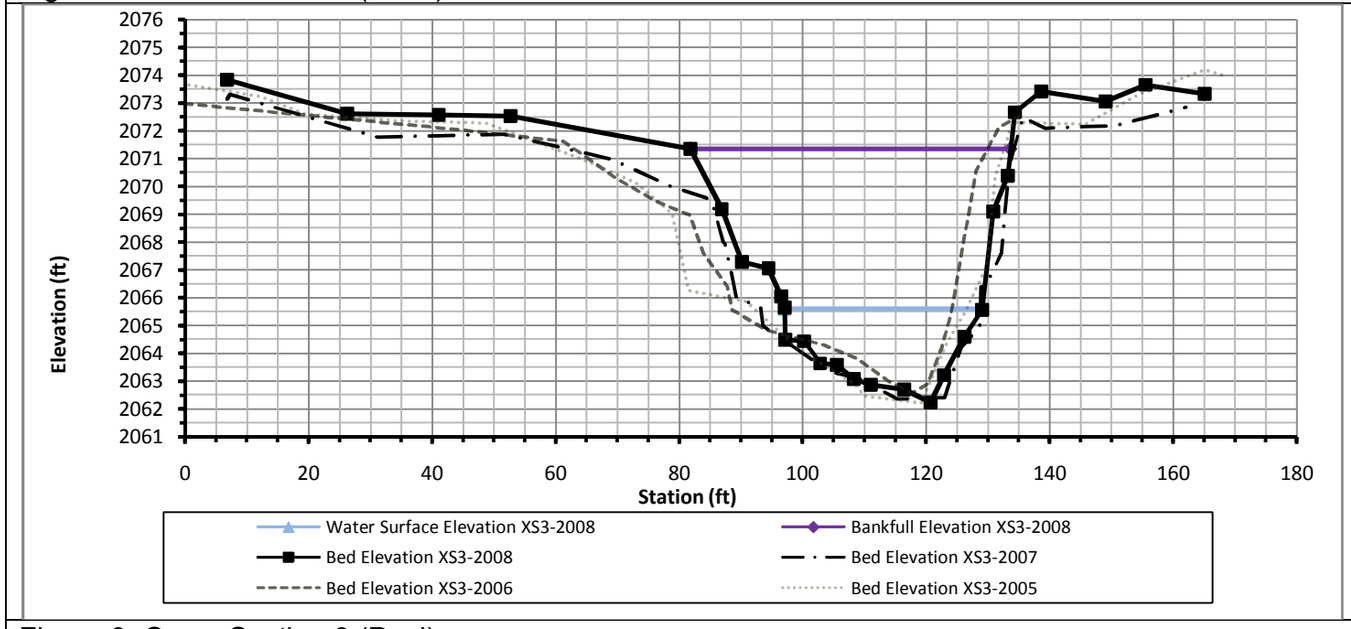

Figure 9. Cross Section 3 (Pool)

Cross Section 3 (Pool) Photo (2008)

Profile

The riffles, pools, and thalweg have maintained or improved function over the course of the five year monitoring period. Overall the bed has maintained feature faceting, but has been subject to imports of sand and as a result the thalweg has been shifting. It has generally been controlled by the project structures and woody debris that has been introduced and passed through the reach at various points in the project's history. Pools and bed faceting have been maintained in overall quantity, but these bed features (other than those tied to the engineered structures) have oscillated in their longitudinal position in response to the above factors. Some of the variability exhibited with baseline and year-1 monitoring may vary due to a different method of survey with subsequent measurements.

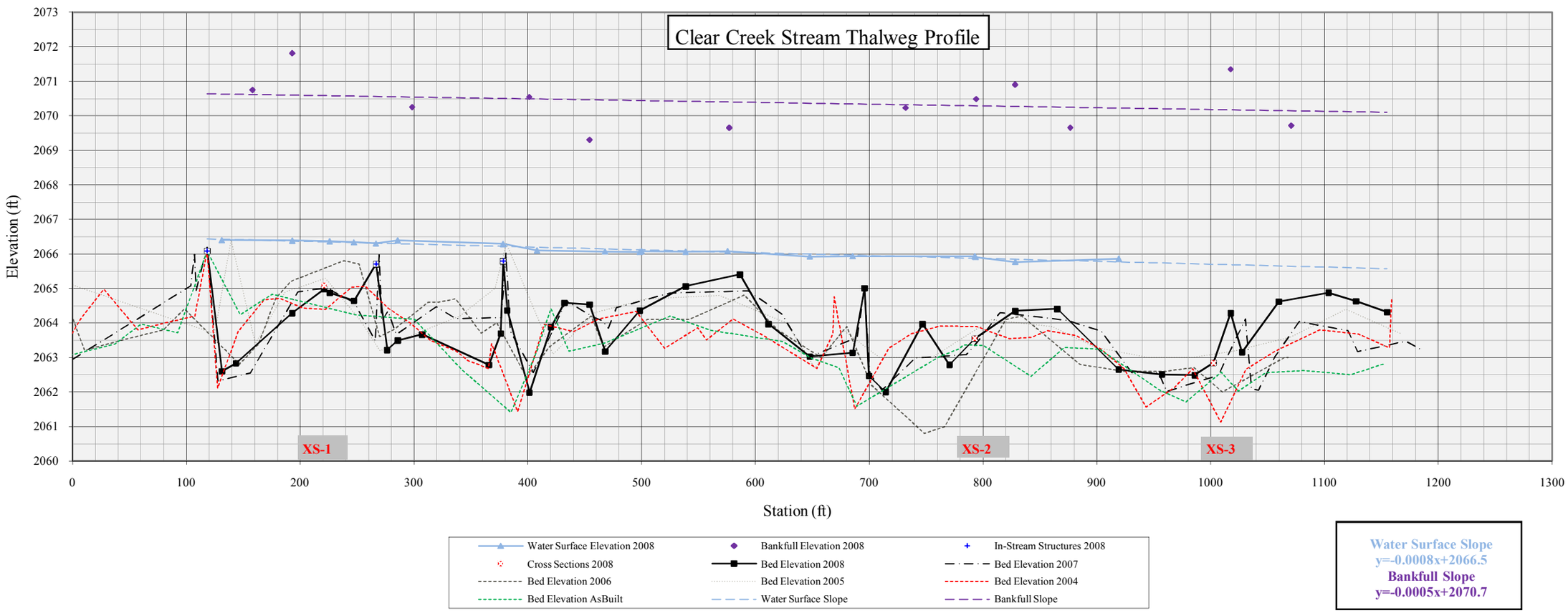

Figure 10. Clear Creek Longitudinal Profile

Substrate

As described previously the site has been subject to the import and presence of sand, which has contributed to a shifting thalweg and although the bed has maintained pools and a diversity of bed facets, the overlaying material is definitively finer than intended, limiting coarser riffle bedforms.

XS1 – Riffle: 5 year mean – Very coarse sand (d50) to Medium gravel (d84).
XS2 – Riffle: 5 year mean - Very fine gravel (d50) to Medium gravel (d84).
XS3 – Pool: 5 Year Mean – Coarse sand (d50) to Fine gravel (d84).

Table 4. Project Bedform Substrate Data

Cross Section 1 (Riffle)	D50 (mm)	D84 (mm)	Cross Section 2 (Riffle)	D50 (mm)	D84 (mm)	Cross Section 3 (Pool)	D50 (mm)	D84 (mm)
MY0			**MY0**			**MY0**		
MY1	11.5	27	**MY1**	11.5	27	**MY1**	1.7	7
MY2			**MY2**			**MY2**		
MY3	0.1	9.5	**MY3**	0.3	5.6	**MY3**	0.2	14.5
MY4	0.7	4.6	**MY4**	1.1	4	**MY4**	0.2	0.8
MY5	0.2	9.5	**MY5**	0.2	10.4	**MY5**	0.2	4.7
Average	0.3	7.9	**Average**	0.5	6.7	**Average**	0.2	6.7

Status of Engineered Structures

Three structures designed to provide bank protection exhibited some loss of structural integrity or did not provide complete bank protection as intended. These conditions are believed to be the result of flooding events from 2004 and 2005 (See figure 6 photos of Hurricanes Ivan and Frances) and have not noticeably advanced since their initial onset. Also, associated with the flooding events of 2004 and 2005 are several isolated instances of bank scour, which have advanced little over the monitoring period. Other in-stream structures are holding grade and directing the flow into the center of the channel properly.

Bankfull Events

There were three recorded bankfull events during the five year monitoring period, of which occurred on 07/02/03, 09/08/04, and 10/13/08. Alluvial deposition on the floodplain can be seen in figure 11 below.

Figure 11. Evidence of Bankfull Event (10/13/2008)

Table 6. Project Stem Counts

Stem Counts per Acre by Plot											
				Plots							
				1		2		3		4	
MY	Year	Avg. (P)	Avg. (V)	P*	V*	P*	V*	P*	V*	P*	V*
1	2004	1578.3	N/A	242.8	N/A	2711.4	N/A	809.4	N/A	2549.5	N/A
2	2005	566.6	N/A	728.4	N/A	688.0	N/A	202.3	N/A	647.5	N/A
3	2006	465.4	1112.9	566.6	2509.1	607.0	1618.7	202.3	283.3	485.6	40.5
4	2007	455.3	2033.5	566.6	5746.5	526.1	1983.0	202.3	161.9	526.1	242.8
5	2008	414.8	1527.7	526.1	4249.2	728.4	1416.4	121.4	283.3	283.3	161.9

**P = Planted Stems; V = Volunteer Stems*

Success criteria for the project require 260 live stems per acre within the restoration area during year 5 of a 5-year monitoring period.
The data in table 5 shows that the vegetation for the Clear Creek site has met the success criteria for the monitoring period. Plot 3 contains less planted stems, but total stems including volunteers exceed success criteria. The volunteer stems greatly outnumber the planted stems in plots one and two, because of the River Birch that is colonizing on that bank. Monitoring year 1 data is also significantly higher than other years, which may have been a result of using a different form of measurement. Overall the site is showing good vegetation growth and is meeting the success criteria.

VQ1: Vegetation Quad 1
Taken: 10/13/2008

VQ2: Vegetation Quad 2
Taken: 10/13/2008

VQ3: Vegetation Quad 3
Taken: 10/13/2008

VQ4: Vegetation Quad 4
Taken: 10/13/2008

Figure 12. Vegetation Quad Photos (Year 5)

Project Goals, Outcomes and Conclusions

The goals for the Clear Creek Stream Restoration project were to (1) improve water quality by reducing sediment load generated by eroding banks, (2) re-establish stable channel dimension, pattern and profile to Clear Creek through the process of stream restoration, (3) restore a functioning floodplain, (4) establish a riparian buffer of woody plant species, preferably native, (5) enhance aquatic and terrestrial habitats in the stream corridor, and (6) stabilize banks to safeguard a sanitary sewer line that runs parallel to Clear Creek on the south side of the channel.

Analysis of the data throughout the monitoring period indicates the project's goals have been largely met. The stream bank conditions have been improved, thus improving water quality downstream. The channel dimension, pattern and profile are all within reasonable morphological parameters of the design specifications for the site, which were based off of reference data. The floodplain was successfully reconnected to the channel, shown by the data from the crest gage and the alluvial material that has been deposited on the floodplain over time. The vegetation on site was successful, with three of the four vegetation quads meeting the success criteria when considering only planted stem counts. The fourth vegetation quad with lower planted stem counts exceeded success criteria when considering additional volunteer stem counts. The average planted stem count for the entire site exceeded success criteria.

The five year monitoring process that included annual visual assessments and geomorphic surveys indicated that the project reach was performing within established success criteria ranges. There were isolated sections of limited bank scour and some loss of structural integrity due to flooding from Hurricane Ivan and Frances in 2004. These instances have advanced little over the monitoring period. Overall the project reach continues to be stable. The geomorphic measurements are within the ranges of the design parameters. In conclusion, the characteristics of the project's assets and their measured performance yielded the ratios listed in table 1. EEP considers the project to be on a stable trajectory and seeks regulatory closure on the assets in tables 1 and 2.