Baseline Monitoring Document and As-Built Report
Final
Paschal Golf Course (Richland Creek) Stream Restoration
EEP Project #276
2010

Submitted to:

Ecosystem Enhancement PROGRAM

NCEEP, 1652 Mail Service Center, Raleigh, NC 27699-1652

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EXECUTIVE SUMMARY

The Paschal Golf Course (Richland Creek) Stream Restoration Site, completed in May 2010, restored a total of 2,919 linear feet of stream in the Neuse River Basin. The project is located in the USGS Hydrologic Unit 03020201070060. This HU is within the EEP's Neuse River Basin Local Watershed Plan and is also listed as a Targeted Local Watershed (TLW) in EEP's *Draft - Neuse River Basin Restoration Priorities 2010*. The project goals and objectives are listed below.

Project Goals

- Restore a stable channel morphology and floodplain to the project stream that is capable of moving the flows and sediment provided by its watershed.
- Improve water quality by reducing bank erosion and bed degradation.
- Provide a riparian management zone that is compatible with the surrounding uses (golf course and electrical transmission corridor) and yet retains the ecological function of the riparian zone.
- Enhance aquatic and terrestrial habitat in the stream corridor.

Project Objectives

- Restore 2,919 linear feet of stable stream channel with the appropriate pattern, profile, and dimension that can support the sediment transport system
- Plant native trees and shrubs throughout the site.
- Grade a floodplain adjacent to the stream.

The project site, which is protected by an 8.5-acre permanent conservation easement held by the State of North Carolina, is situated in Wake County in the Northern Outer Piedmont ecoregion of the Piedmont physiographic province. The site is located along Richland Creek, bounded by Stadium Drive at the upstream limits of the site and NC-98 at the downstream limits of the site on the Paschal Golf Course in the Town of Wake Forest. The site's 7.8-square mile watershed is mostly urban east of the site and rural/residential to the west. The stream has been directly adjacent to the golf course since the course's construction in 1917. As a result of the highly managed landuse surrounding the site, the stream has been impacted by straightening, buffer clearing and other hydrologic changes. The upper 300 feet of the project are within an electrical transmission corridor, which has historically been managed by the utility company, maintaining vegetation below 12' tall. The pre-restoration assessment classified the upper portion of the stream as an unstable C4 stream type and the lower part as an F4 stream. The assessment also found the stream had significant eroding banks for most of its length. The restoration plan called for building a stable C4 stream channel with appropriate meander geometry, consistent bankfull width, increased pool depths, steeper riffles, flatter pools, and native riparian vegetation on the banks. The design was developed using two reference reaches, an upstream reach of Richland Creek and UT to Lake Wheeler, which is in Raleigh, North Carolina. There were only limited modifications made to the design and planting plan during construction, which included lengthening three constructed riffles and improving various storm water conveyances to the project stream.

The monitoring components were installed in early July 2010. The monitoring plan includes longitudinal profile along the entire stream length and six cross-sections, four in riffles and two in pools. Eleven permanent photo points have been established with a total of fourteen photos to be taken annually. To determine the success of the planted buffer, seven permanent vegetation monitoring plots were established according to the CVS-EEP protocol. These monitoring components shall be evaluated on a yearly basis or until the success criteria are met. The first year of monitoring will take place in 2011.

1.0 Project Goals, Background and Attributes

1.1 Location and Setting

The project site, which is protected by an 8.5-acre permanent conservation easement held by the State of North Carolina, is situated in Wake County in the Northern Outer Piedmont ecoregion of the Piedmont physiographic province. The site is located along Richland Creek, bounded by Stadium Drive at the upstream limits of the site and NC-98 at the downstream limits of the site on the Paschal Golf Course in the Town of Wake Forest. The site's 7.8-square mile watershed is mostly urban east of the site and rural/residential to the west. See Figure 1 in Appendix A.

The project is located in the USGS Hydrologic Unit 03020201 of the Neuse River Basin and drains approximately 7.8 square miles.

1.2 Project Goals and Objectives

Project Goals

- Restore a stable channel morphology and floodplain to the project stream that is capable of moving the flows and sediment provided by its watershed.
- Improve water quality by reducing bank erosion and bed degradation.
- Provide a riparian management zone that is compatible with the surrounding uses (golf course and electrical transmission corridor) and yet retains the ecological function of the riparian zone.
- Enhance aquatic and terrestrial habitat in the stream corridor.

Project Objectives

- Restore 2,919 linear feet of stable stream channel with the appropriate pattern, profile, and dimension that can support the sediment transport system
- Plant native trees and shrubs throughout the site.
- Grade a floodplain adjacent to the stream.

1.3 Project Structure, Restoration Type and Approach

This project restored 2,919 linear feet of Richland (Station 00+00 – 29+19). See Figure 2 in Appendix A for an overview of the site layout. The entire project was designed with the one set of design criteria and is one continuous reach. There is a 47' easement exception at Station 11+00 where a golf cart bridge crosses the stream. This 47' is not eligible for credit. From approximately Stations 01+50 to 04+50 the stream is under an electrical transmission right of way and has vegetation restrictions requiring trimming of all vegetation to 12' or under. There is also a golf play-over area on both sides of the golf cart bridge over Richland Creek. This part of the easement also has a vegetation maintenance plan. The project begins after it flows under the Stadium Drive bridge at the northern part of the site. A concrete utility crossing immediately after the bridge created a blockage to fish passage. To allow fish passage, a rock ramp fishway was built, linking Richland Creek up and downstream of the bridge.

The site has been directly adjacent to the golf course since the course's construction in 1917. As a result of the highly managed landuse surrounding the site, the stream has been highly impacted by straightening, buffer clearing and other hydrologic changes. The pre-restoration assessment classified the upper portion of the stream as an unstable C4 stream

type and the lower part as an F4 stream. The assessment found the stream had significant eroding banks for most of its length. The restoration plan called for building a stable C4 stream channel with appropriate meander geometry, consistent bankfull width, increased pool depths, steeper riffles, flatter pools, and native riparian vegetation on the banks. The design was developed using two reference reaches, an upstream reach of Richland Creek and UT to Lake Wheeler, which is in Raleigh, North Carolina. There were no significant changes in the design and planting plan during the construction process.

1.4 Project History, Contacts and Attribute Data

The project was first identified as a candidate for restoration by Wake County NRCS District Conservationist Tom Hill. This project has been in the planning phases since 2004 with the final restoration plan completed in June 2007. Construction began in December 2009. The site was completed and planted in May 2010.

2.0 Success Criteria

2.1 Dimension

The dimensional data from the yearly cross-section survey should show minimal change over the course of the monitoring period. However, some change is natural and expected, indicating that the site is settling post-construction. Changes that may indicate destabilizing conditions include significant widening or deepening of the riffle section or a consistent trend of change over the course of the monitoring. For a pool cross-section, deepening is frequently a positive change while consistent filling of the pool may indicate destabilization.

2.2 Pattern and Profile

For the profile, the reach under assessment should not demonstrate any trends in thalweg aggradation or degradation over any significant continuous portion of its length. The profile should also demonstrate contrasting bedform diversity against the pre-existing condition. Bedform distributions, riffle/pool lengths and slopes will vary, but should do so around design distributions. The majority of pools should be maintained at greater depths with lower water surface slopes while riffles should be shallow with greater water surface slopes. Pattern features should show little adjustment over the monitoring period.

2.3 Substrate

Substrate measurements, from annual pebble count data, should indicate the progression towards, or the maintenance of, the anticipated distributions from the design phase. While stream projects are designed to transport bedload in equilibrium and carry overall sediment loads at bankfull, fines can be transported even at low discharges and upstream instability beyond design projections can also lead to deposition as storm events recede in areas of energy dissipation such as restoration reaches. This can have the effect of obscuring bedform and fining of riffles especially in the first few years after the implementation of a stream project. In many cases subsequent narrowing and reduction of W/D ratios as a project develops/stabilizes can then increase transport efficiency and return bedform to intended distributions, but some fining can persist due to upstream disturbance.

2.4 Sediment Transport

Maintenance of sediment transport will be evident by stable features in the monitored cross-sections and profile. From these two indicators, there should be no evidence of any significant trend in aggradation or degradation throughout the channel.

2.5 Vegetation

Vegetation success is based on the criteria established in the USACE Stream Mitgation Guidelines (2003). This document states that vegetation monitoring results indicate the following planted stem density minimums in the corresponding monitoring years: 320 stems/acre through year three, 288 stems/acre in year four, and 260 stems/acre in year five. If monitoring indicates that the specified survival rate is not being met, appropriate corrective actions will be developed to include invasive species control, the removal of dead/dying plants, and replanting.

2.6 Hydrology

A minimum of two bankfull events, occurring in separate years, must be documented within the monitoring period.

3.0 Monitoring Plan

3.1 Dimension

Six permanent monitoring cross-sections have been established on the site. Four riffle cross-sections and two pool cross-sections have been installed on Richland Creek. Permanent monuments of rebar in concrete have been established at each end of these cross-sections. These cross-sections will be surveyed each year, with measurements occurring at bankfull, top of bank, edge of water, and other significant breaks in slope.

3.2 Profile

The entire profile of the restored streams will be surveyed each monitoring year. The profile will be surveyed in detail, documenting the elevations of the thalweg, water surface, and bankfull. Pool and riffle features will be called out to calculate feature slopes and lengths.

3.3 Pattern

Pattern measurements have been taken for the as-built condition and are documented in this report. Future pattern measurements will not be taken unless there is evidence that significant geomorphological adjustments have occurred.

3.4 Substrate

Pebble counts will be conducted annually at all of the permanent cross-sections. These pebble counts will be used to calculate the sediment distribution at the cross-sections and the D50 and D84 at each location.

3.5 Visual Assessment

A visual assessment of the stream to include an assessment of the bank (lateral stability), bed (vertical stability), the easement boundary, and site vegetation will be completed each year to document the necessary parameters required for the EEP monitoring report.

3.6 Vegetation

Seven vegetation plots were set up and assessed for the baseline vegetation monitoring. Vegetation data collection must follow the CVS-EEP Protocol for Recording Vegetation (Lee et al. 2006, http://cvs.bio.unc.edu/methods.htm). The baseline vegetation monitoring was conducted as Level 1: Inventory of Planted Stems, as will the first year monitoring. Beginning in year two and continuing throughout the rest of the monitoring period, the site will be monitored using the Level 2 protocol.

3.7 Digital Photos

Eleven permanent photo stations have been established as part of the baseline monitoring. Three of these photo stations have two photos assigned to them, so there is a total of 14 photos taken from these photo stations. Starting in the first monitoring year, these photos will be taken in late October / early November, so that vegetative conditions are similar at the site between monitoring years.

3.8 Watershed Conditions

Yearly monitoring will document any evident changes in the watershed. Any large hydrologic events in the watershed, such as tropical storms or hurricanes, will also be documented in the yearly monitoring reports.

4.0 Baseline Conditions

The site was built as designed without any significant changes from the design plans.

A detailed baseline survey was conducted post-construction by KCI in early July 2010. The baseline survey of the longitudinal profile and cross-sections shows that the as-built Richland Creek channel closely reflects the design conditions.

A few species from the planting plan were unavailable at the designed quantities at the time of planting. This resulted in fewer planted stems of hackberry (*Celtis laevigata*), willow oak (*Quercus phellos*), and sweet pepperbush (*Clethra alnifolia*) and additional stems of sycamore (*Platanus occidentalis*), chokeberry (*Aronia arbutifolia*), blackgum (*Nyssa sylvatica*), and elderberry (*Sambucus Canadensis*) were planted, along with stems of spicebush (*Lindera benzoin*) and swamp chestnut oak (*Quercus michauxii*), which were not in the original planting plan. The seven vegetation monitoring plots established during the baseline conditions survey calculated a total site average of 1,159 planted stems/acre and 659 planted stems/acre when excluding live stakes. All plots had an average density of at least 486 total planted stems/acre.

5.0 Maintenance and Contingency Plans

Problem areas at the Paschal Golf Course (Richland Creek) Restoration Site will be dealt with accordingly based on the severity of the problem and at the discretion of the EEP. Site maintenance may include reinstallation of coir matting, removal of debris from the channel,

stabilization of bank erosion with protective structures, or adjustments to in-stream structures. All maintenance activities will be documented in the yearly monitoring reports.

The baseline monitoring was conducted with a total station instrument. The longitudinal stationing is based on the horizontal layout of the surveyed thalweg. The Level 1 CVS-EEP protocol (http://cvs.bio.unc.edu/methods.htm) was used to collect vegetation data.

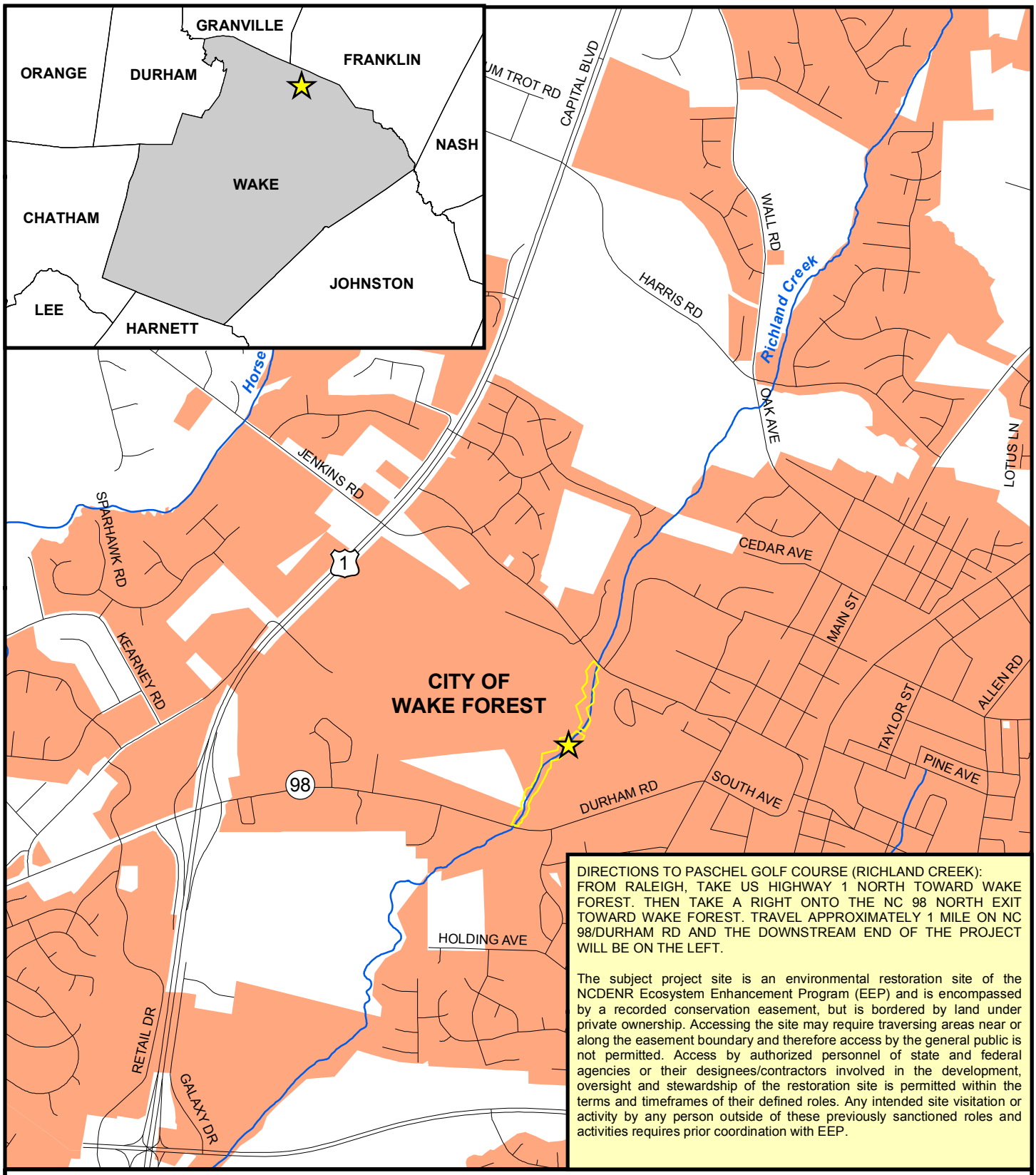
6.0 References

Lee, Michael T., R.K. Peet, S.D. Roberts, and T.R. Wentworth. 2006. CVS-EEP Protocol for Recording Vegetation, Version 4.0 (http://cvs.bio.unc.edu/methods.htm)

USACE. 2003. Stream Mitigation Guidelines. USACE, NCDENR-DWQ, USEPA, NCWRC.

APPENDIX A

General Figures and Tables



DIRECTIONS TO PASCHEL GOLF COURSE (RICHLAND CREEK):
FROM RALEIGH, TAKE US HIGHWAY 1 NORTH TOWARD WAKE FOREST. THEN TAKE A RIGHT ONTO THE NC 98 NORTH EXIT TOWARD WAKE FOREST. TRAVEL APPROXIMATELY 1 MILE ON NC 98/DURHAM RD AND THE DOWNSTREAM END OF THE PROJECT WILL BE ON THE LEFT.

The subject project site is an environmental restoration site of the NCDENR Ecosystem Enhancement Program (EEP) and is encompassed by a recorded conservation easement, but is bordered by land under private ownership. Accessing the site may require traversing areas near or along the easement boundary and therefore access by the general public is not permitted. Access by authorized personnel of state and federal agencies or their designees/contractors involved in the development, oversight and stewardship of the restoration site is permitted within the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activities requires prior coordination with EEP.

Figure 1. Vicinity Map - Paschal Golf Course (Richland Creek), Project No. 276

KCI

Project Location
Roads
Major Streams and Rivers
Municipalities
Project Easement

N
W E
S

1:24,000

0.2 0.1 0 0.2
Miles

Ecosystem Enhancement PROGRAM

Figure 2. Site Map
Paschal Golf Course (Richland Creek)
Project No. 276

KCI ASSOCIATES OF NC

Ecosystem Enhancement PROGRAM

N

0 150 300
Feet

Project Easement
Thalweg
Buffer Restoration
Utility Right of Way
Play Over Area
Managed Golf Course Area
Existing Jurisdictional Wetland

1:1,800
1 inch = 150 feet

Map created 12/15/2010 by KCI.

Table 1a. Project Components Paschal Golf Course (Richland Creek) / Project No. 276									
Project Component or Reach ID	**Existing Feet/Acres**	**Restoration Level**	**Approach**	**Linear Footage or Square Feet***	**Stationing**	**Mitigation Ratio**	**Mitigation Credits+**	**BMP Elements**	**Comment**
Richland Creek	N/A	R	P2	2,919	10+00 - 39+80	1:1	2,766		In-stream structures, including offset rock cross vanes, riffle grade controls, and rock sills, were used to stabilize restored channel. Planted a riparian buffer.
Buffer		R		167,092.2		1:1	167,092		Buffer was planted with native vegetation.

*Linear footage does not include the stream length that runs under a golf cart bridge through an easement exception. Square feet of buffer are limited to the areas of the buffer that meet the regulatory criteria for buffer restoration credit. See Figure 2 for the locations of the creditable buffer.

+The credits have been reduced to account for areas where the stream flows through vegetation management zones within the easement. These management areas are depicted on Figure 2. They include a utility right of way and a play over area for the golf course. Under the utility right of way the buffer will be allowed to grow to a height of 12'. Due to this restriction the 309 mitigation credits that would be generated by the stream in the right of way is reduced by 25% to 231 stream credits. The vegetation in the play over area will be trimmed to a few feet high. Due to this restriction, the 151 mitigation credits that would be generated by the stream in the play over area are reduced by 50% to 76 stream credits. There is 2,459 lf of stream that does not have any reductions and will generate 2,459 credits.

Table 1b. Component Summations Paschal Golf Course (Richland Creek) / Project No. 276							
Restoration Level	**Stream (lf)**	**Riparian Wetland (Ac)**		**Non-Ripar (Ac)**	**Upland (Ac)**	**Buffer (Ac)**	**BMP**
		Riverine	**Non-Riverine**				
Restoration	2,919					3.84	
Enhancement							
Enhancement I							
Enhancement II							
Creation							
Preservation							
HQ Preservation							
		0	0				
Totals (Feet/Acres)	**2,919**	**0**		**0**	**0**	**3.84**	**0**
MU Totals	**2,766**	**0**		**0**	**0**	**3.84**	**0**

Table 2. Project Activity & Reporting History Paschal Golf Course (Richland Creek) / Project No. 276		
Activity or Report	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan	2004	June 2007
Final Design - Construction Plans		Sept 2007
Construction		May 2010
Planting		May 2010
Baseline Monitoring/Report	Aug 2010	Dec 2010
Year 1 Monitoring		
Year 2 Monitoring		
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		

Table 3. Project Contacts Paschal Golf Course (Richland Creek) / Project No. 276	
Designer	EcoLogic Associates, P.C. 3808 Clifton Road Greensboro, NC 27407
Primary Project Design POC	Mark Taylor, PE (336) 632-4441
Construction Contractor	River Works 8000 Regency Parkway, Suite 200 Cary, NC 27518
Construction Contractor POC	William Pedersen (919) 459-9034
Planting Contractor	H + J Forest Service
Planting Contractor POC	Matt Hitch (910) 264-1612
Monitoring Performers	KCI Associates of North Carolina 4601 Six Forks Road, Suite 220 Raleigh, NC 27609
Monitoring POC	Adam Spiller (919) 278-2514

Table 4. Project Attributes Paschal Golf Course (Richland Creek) / Project No. 276	
Project County	Wake County
Physiographic Region	Piedmont
Ecoregion	Northern Outer Piedmont
River Basin	Neuse
USGS HUC	03020201
NCDWQ Sub-Basin	03-04-02
Within Extent of EEP Watershed Plan	Yes - Draft - Neuse River Basin Restoration Priorities 2010
WRC Class	Warm
% of Project Easement Demarcated	70%, with wooden bollards
Beaver Activity Observed During Design Phase	Yes
Restoration Component Attributes	
Drainage Area (sq.mi.)	7.8
Stream Order	Second
Restored Length (feet)	2,919
Perennial or Intermittent	Perennial
Watershed Type	Suburban
Watershed LULC Distribution	
Forest/Wetland	35%
Agricultural/Managed Herbaceous	35%
Developed	30%
Watershed Impervious Cover	10%
NCDWQ AU/Index Number	27-21
NCDWQ Classification	C; NSW
303d Listed	U
Upstream of 303d Listed Segment	U
Reasons for 303d Listing or Stressor	U
Total Acreage of Easement	8.5
Total Vegetated Acreage within Easement	1.3
Total Planted Acreage as Part of Restoration	7.2
Rosgen Classification of Pre-Existing	C4/F4
Rosgen Classification of As-Built	C4
Valley Type	-
Valley Slope	0.002
Valley Side Slope Range	-
Valley Toe Slope Range	-
Cowardin Classification	-
Trout Waters Designation	No
Species of Concern, Endangered, Etc.	None
Dominant Soil Series and Characteristics	
Series	Chewacla
Depth	Deep
Clay%	-
K	-
T	-

"N/A" is for items that do not apply.

"-" is for items that are unavailable.

"U" is for items that are unknown.

APPENDIX B

Morphological Summary Data and Plots

Table 5. Baseline Stream Data Summary

Paschal Golf Course (Richland Creek) / Project No. 276

Parameter	Regional Curve			Pre-Existing Condition						Reference Reach Data (Upper Richland Creek)						Design			As-built					
Dimension and Substrate - Riffle	LL	UL	Eq.	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Med	Max	Min	Mean	Med	Max	SD	n
Bankfull Width (ft)				22			35.0			28.0			32.0				33.0		31.9	32.7	32.2	34.4	1.2	4
Floodprone Width (ft)				28			60				>100						100		>60	>72	>69	>90	12.8	4
Bankfull Mean Depth (ft)				1.4			2.8			2.3			2.4				2.6		2.4	2.6	2.6	2.8	0.2	4
Bankfull Max Depth (ft)				3.4			3.8				3.75						3.4		3.3	3.5	3.5	3.8	0.2	4
Bankfull Cross-Sectional Area (ft^2)				48			72			67			75				85.0		80.2	84.2	83.7	89.3	4.1	4
Width/Depth Ratio				12.0			13.8			12.2			13.3				12.1		11.4	12.7	12.5	14.5	1.3	4
Entrenchment Ratio				1.7			1.9			3.1			3.6				3.0		>1.9	>2.0	>2.0	>2.0	0.0	4
Bank Height Ratio					1.2						1.1						1.0		1.0	1.0	1.0	1.0	0.0	4
d50 (mm)					12.0												12.0		4.1	12.7	14.0	20.0	8.0	4
Profile																								
Riffle Length (ft)																			14	48	30	177	42	20
Riffle Slope (ft/ft)				0.0200			0.0370			0.0050			0.0090				0.0056		0.0011	0.0089	0.0075	0.0212	0.0067	20
Pool Length (ft)				23			96			5			25				41		8	74	82	150	42	19
Pool Max Depth					4.0						4.6						5.5		4.3	5.0		5.6	0.92	2
Pool Spacing (ft)				38			258			25			90			150		230	63	153	155	216	49	19
Pool Volume (ft^3)																								
Pattern																								
Channel Beltwidth (ft)				22			71			100			300			60		300	37	78	83	116	25	9
Radius of Curvature (ft)				32			98			37			70			80		100	80	90	90	100	10	14
Rc:Bankfull width (ft/ft)					1.34					1.1			2.1				2.4		2.5	2.8	2.8	3.1		
Meander Wavelength (ft)				110			300			110			200			220		330	259	321	312	395	45	11
Meander Width Ratio					1.59					9.3			10.7				9.0		1.1	2.4	2.5	3.5		
Substrate, bed and transport parameters																								
Ri%/Ru%/P%/G%/S%																								
SC% / Sa% / G% / C% / B% / Be%																			0% / 16% / 55% / 27% / 2% / 0%					
d16 / d35 / d50 / d84 / d95 / di^p / di^{sp} (mm)				1.5 / 7.3 / 12 / 35 / 49 / - / -															1.9 / 20 / 34 / 54 / 87 / 120 / - / -					
Reach Shear Stress (competency) lb/ft^2				0.35												0.40			0.40					
Max part size (mm) mobilized at bankfull				20-80												20-90			31					
Stream Power (transport capacity) W/m^2																								
Additional Reach Parameters																								
Drainage Area (SM)				7.8						4.8						7.8			7.8					
Impervious cover estimate				10%												10%			10%					
Rosgen Classification				F4/1						C4						C4/1			C4/1					
Bankfull Velocity (fps)				3.1 - 7.0						3.6 - 5.0						5.0								
Bankfull Discharge (cfs)				305 - 400						260 - 280						425								
Valley length (ft)				2,710															2,710					
Channel thalweg length (ft)																			2,919					
Sinuosity				1.22						1.1						1.20			1.10					
Water Surface Slope (Channel) (ft/ft)				0.0028						0.0040						0.0028			0.0028					
BF slope (ft/ft)																0.0028			0.0027					
Bankfull Floodplain Area (acres)																								
Proportion over wide (%)																								
Entrenchment Class (ER Range)																								
Incision Class (BHR Range)																								
BEHI VL% / L% / M% / H% / VH% / E%																								
Channel Stability or Habitat Metric																								
Biological or Other																								

Table 6. Morphology and Hydraulic Monitoring Summary (Dimensional Parameters)
Paschal Golf Course (Richland Creek) / Project No. 276

Dimension and Substrate	Cross-Section 1 (Riffle)							Cross-Section 2 (Riffle)							Cross-Section 3 (Pool)							Cross-Section 4 (Riffle)							Cross-Section 5 (Pool)						
Based on fixed baseline elevation	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	34.4							31.9							31.4							32.1							31.5						
Floodprone Width (ft)	>90							>70							-							>68							-						
Bankfull Mean Depth (ft)	2.4							2.8							3.3							2.5							2.9						
Bankfull Max Depth (ft)	3.4							3.8							5.6							3.3							4.3						
Bankfull Cross-Sectional Area (ft^2)	81.7							89.3							104.0							80.2							90.8						
Bankfull Width/Depth Ratio	14.5							11.4							-							12.8							-						
Bankfull Entrenchment Ratio	>2.0							>2.0							-							>2.0							-						
Bankfull Bank Height Ratio	1.0							1.0							-							1.0							-						
Cross-Sectional Area Between End Pins (ft^2)	477.5							111.4							135.7							100.1							106.4						
d50 (mm)	2.0							34.0							0.4							46.0							1.7						

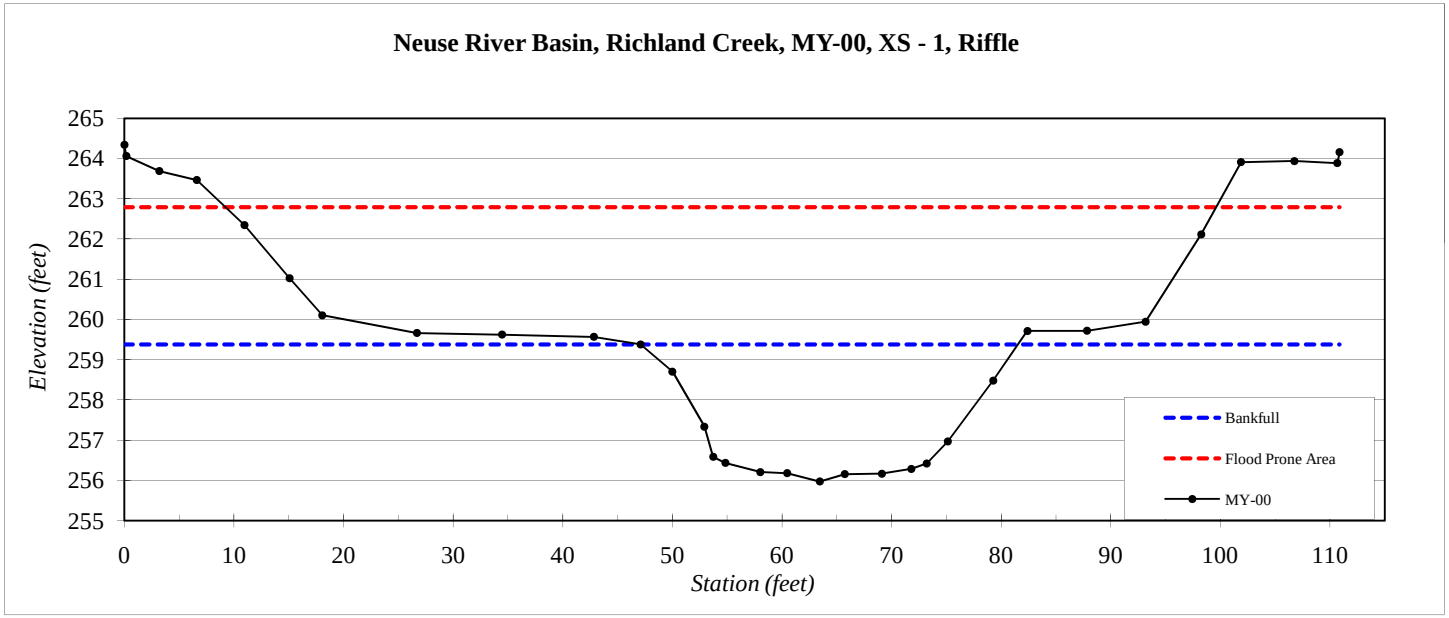
	Cross-Section 6 (Riffle)						
Based on fixed baseline elevation	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	32.2						
Floodprone Width (ft)	>60						
Bankfull Mean Depth (ft)	2.7						
Bankfull Max Depth (ft)	3.5						
Bankfull Cross-Sectional Area (ft^2)	85.6						
Bankfull Width/Depth Ratio	12.1						
Bankfull Entrenchment Ratio	>1.9						
Bankfull Bank Height Ratio	1.0						
Cross-Sectional Area Between End Pins (ft^2)	94.3						
d50 (mm)	44.0						

Cross-Section Plots

River Basin:	Neuse
Watershed:	Richland Creek, MY-00
XS ID	XS - 1, Riffle
Drainage Area (sq mi):	7.8
Date:	8/3/2010
Field Crew:	A. French, L. Lord

Station	Elevation
0.0	264.34
0.2	264.06
3.2	263.69
6.6	263.46
11.0	262.35
15.1	261.02
18.1	260.10
26.7	259.66
34.5	259.62
42.8	259.57
47.1	259.38
50.0	258.70
52.9	257.33
53.7	256.58
54.8	256.43
58.0	256.20
60.5	256.17
63.4	255.97
65.7	256.15
69.1	256.17
71.8	256.28
73.2	256.42
75.1	256.96
79.3	258.48
82.4	259.71
87.8	259.72
93.2	259.94
98.2	262.11
101.9	263.91
106.7	263.94
110.7	263.88
110.9	264.16

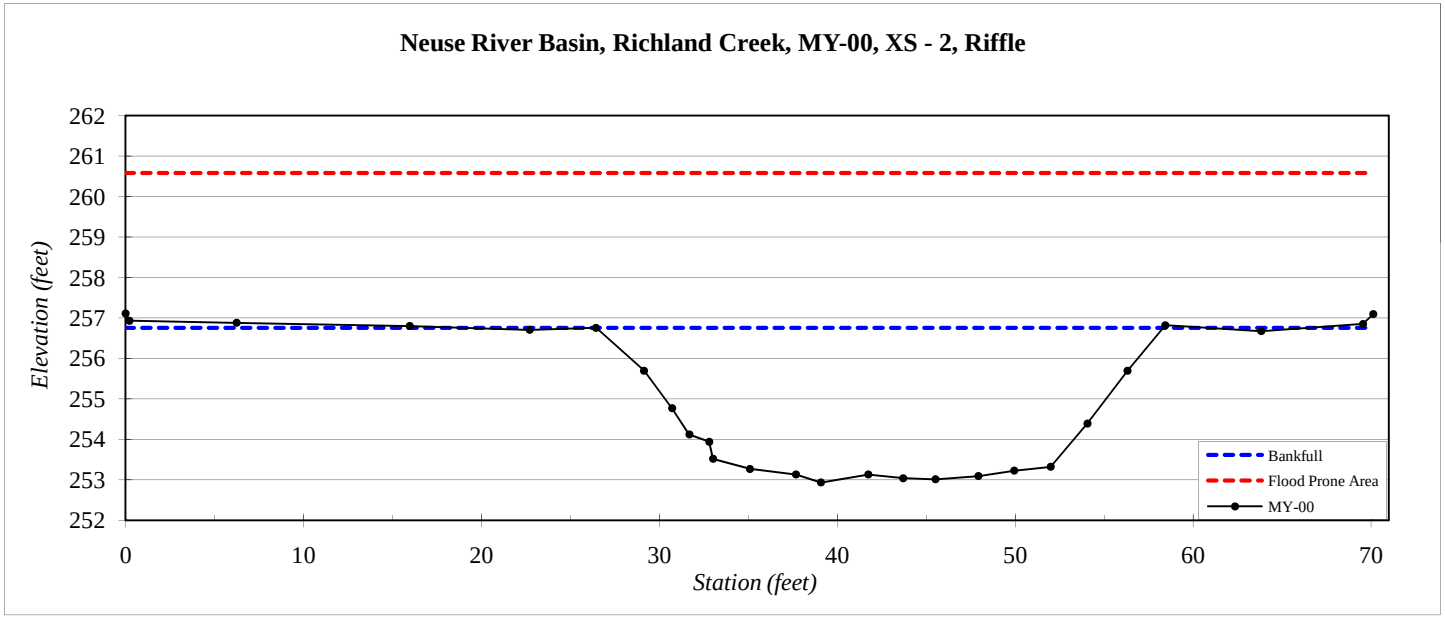
SUMMARY DATA	
Bankfull Elevation:	259.4
Bankfull Cross-Sectional Area:	81.7
Bankfull Width:	34.4
Flood Prone Area Elevation:	262.8
Flood Prone Width:	>90
Max Depth at Bankfull:	3.4
Mean Depth at Bankfull:	2.4
W / D Ratio:	14.5
Entrenchment Ratio:	2.6
Bank Height Ratio:	1.0



River Basin:	Neuse
Watershed:	Richland Creek, MY-00
XS ID	XS - 2, Riffle
Drainage Area (sq mi):	7.8
Date:	8/3/2010
Field Crew:	A. French, L. Lord

Station	Elevation
0.0	257.11
0.2	256.93
6.2	256.88
16.0	256.80
22.7	256.71
26.4	256.76
29.1	255.70
30.7	254.77
31.7	254.12
32.8	253.94
33.0	253.52
35.1	253.27
37.7	253.13
39.1	252.94
41.8	253.14
43.7	253.04
45.5	253.02
47.9	253.09
50.0	253.23
52.0	253.33
54.1	254.40
56.3	255.70
58.4	256.82
63.8	256.68
69.6	256.85
70.1	257.10

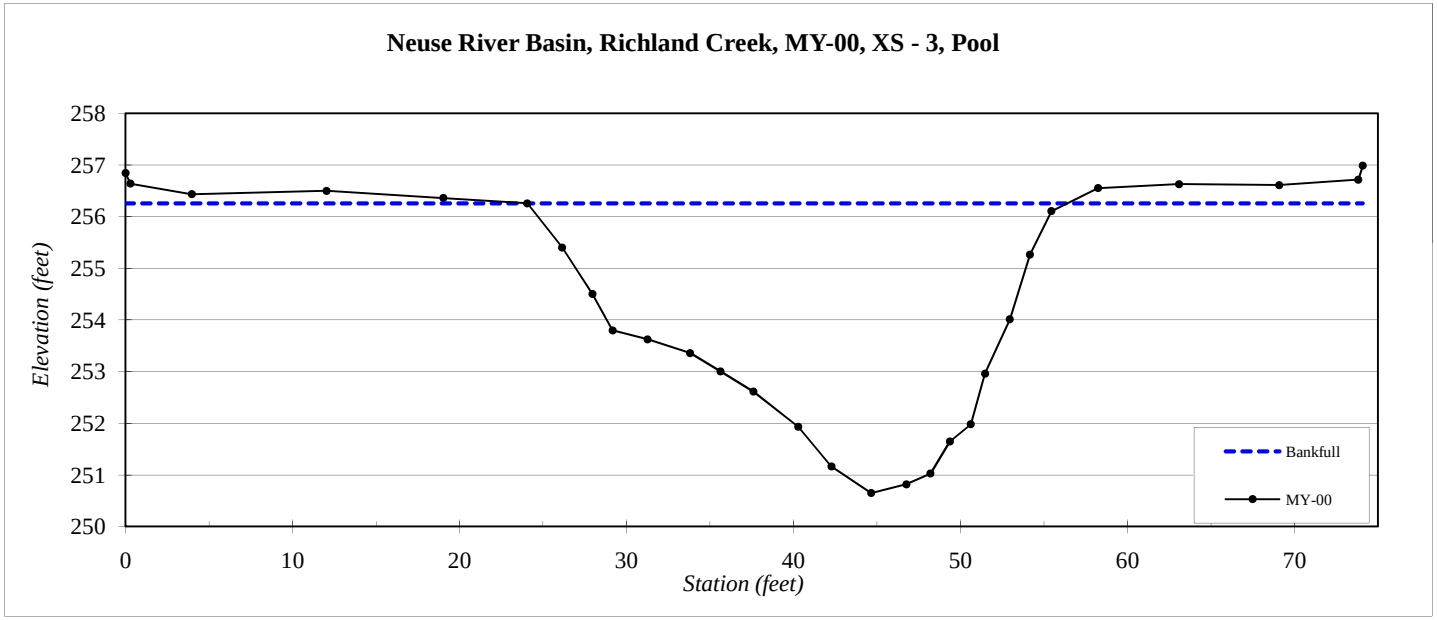
SUMMARY DATA	
Bankfull Elevation:	256.8
Bankfull Cross-Sectional Area:	85.6
Bankfull Width:	30.6
Flood Prone Area Elevation:	260.6
Flood Prone Width:	>70
Max Depth at Bankfull:	3.8
Mean Depth at Bankfull:	2.8
W / D Ratio:	10.9
Entrenchment Ratio:	2.3
Bank Height Ratio:	1.0



River Basin:	Neuse
Watershed:	Richland Creek, MY-00
XS ID	XS - 3, Pool
Drainage Area (sq mi):	7.8
Date:	8/4/2010
Field Crew:	A. French, L. Lord

Station	Elevation
0.0	256.84
0.3	256.64
4.0	256.43
12.0	256.50
19.0	256.36
24.1	256.26
26.1	255.40
28.0	254.50
29.2	253.80
31.3	253.62
33.8	253.36
35.6	253.01
37.6	252.61
40.3	251.93
42.3	251.16
44.6	250.65
46.8	250.82
48.2	251.03
49.4	251.65
50.6	251.98
51.5	252.96
53.0	254.01
54.2	255.26
55.4	256.11
58.2	256.55
63.1	256.63
69.1	256.61
73.8	256.71
74.1	256.99

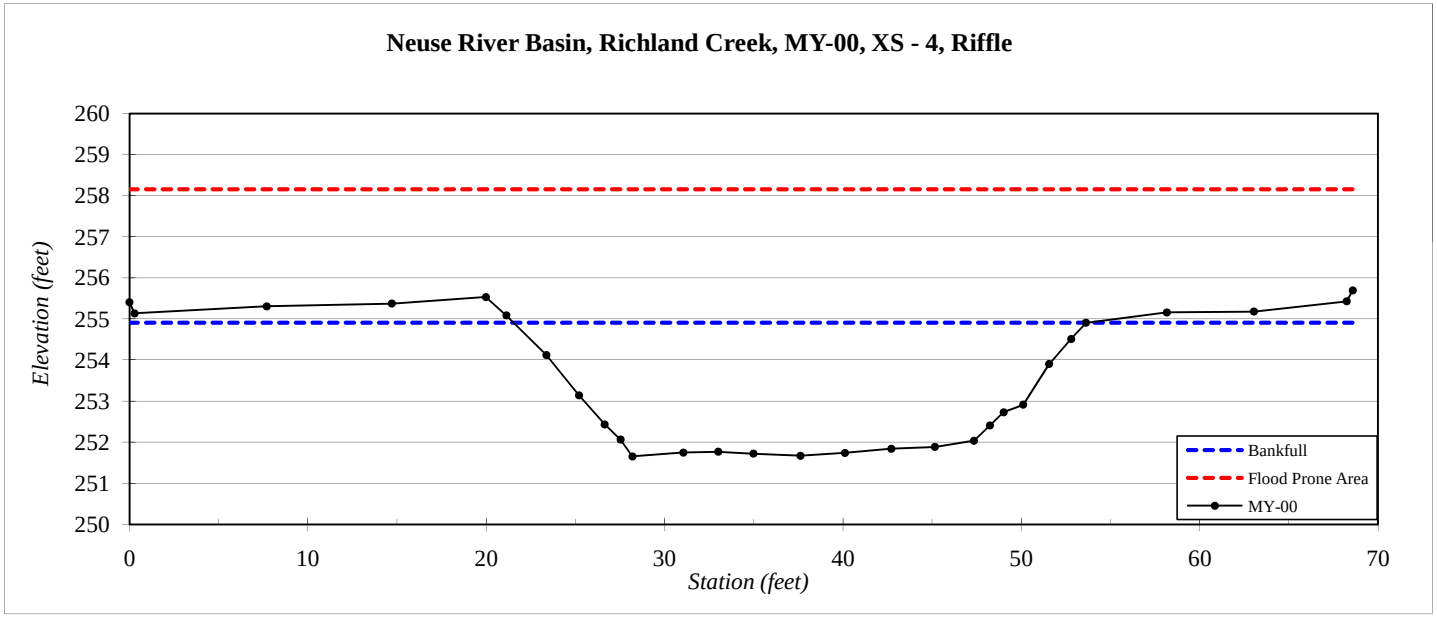
SUMMARY DATA	
Bankfull Elevation:	256.3
Bankfull Cross-Sectional Area:	104.0
Bankfull Width:	31.4
Flood Prone Area Elevation:	-
Flood Prone Width:	-
Max Depth at Bankfull:	5.6
Mean Depth at Bankfull:	3.3
W / D Ratio:	-
Entrenchment Ratio:	-
Bank Height Ratio:	1.0



River Basin:	Neuse
Watershed:	Richland Creek, MY-00
XS ID	XS - 4, Riffle
Drainage Area (sq mi):	7.8
Date:	8/4/2010
Field Crew:	A. French, L. Lord

Station	Elevation
0.0	255.40
0.3	255.13
7.7	255.31
14.7	255.37
20.0	255.53
21.1	255.08
23.4	254.12
25.2	253.14
26.6	252.43
27.5	252.06
28.2	251.65
31.0	251.75
33.0	251.77
35.0	251.72
37.6	251.67
40.1	251.74
42.7	251.84
45.2	251.89
47.4	252.04
48.2	252.41
49.0	252.73
50.1	252.91
51.6	253.90
52.8	254.51
53.6	254.91
58.2	255.16
63.0	255.18
68.2	255.43
68.6	255.69

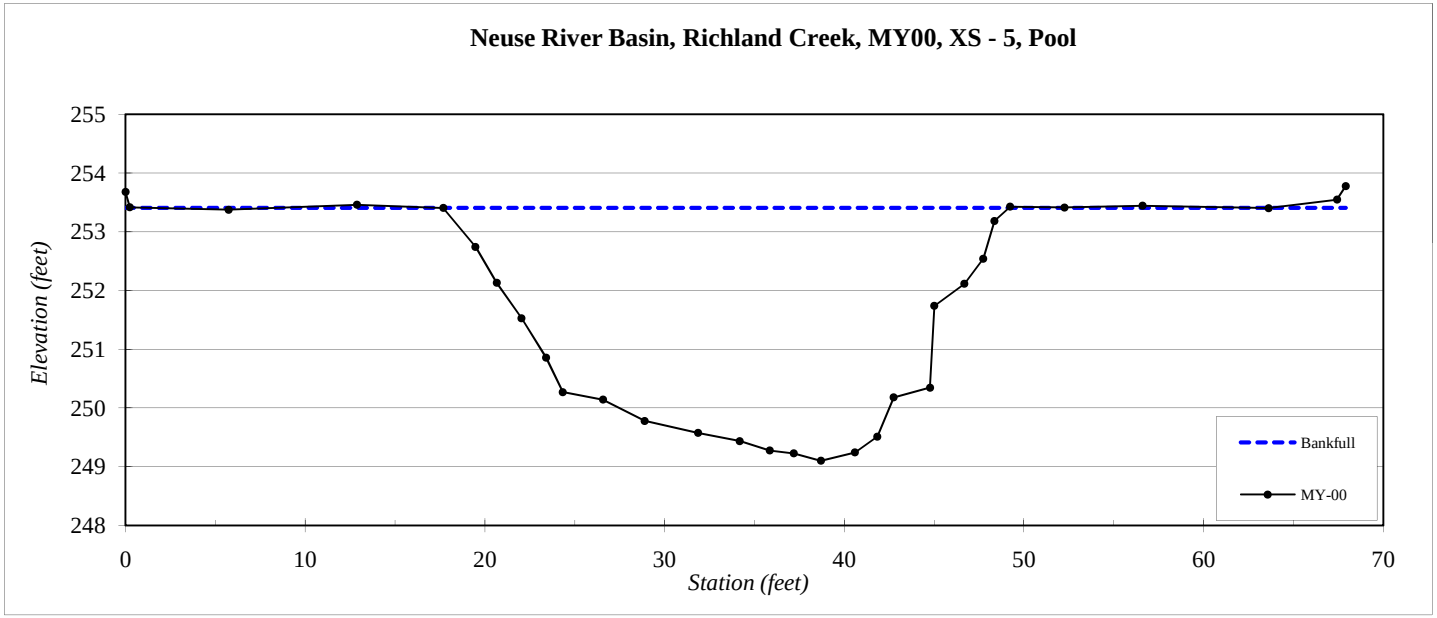
SUMMARY DATA	
Bankfull Elevation:	254.9
Bankfull Cross-Sectional Area:	80.2
Bankfull Width:	32.1
Flood Prone Area Elevation:	258.2
Flood Prone Width:	>68
Max Depth at Bankfull:	3.3
Mean Depth at Bankfull:	2.5
W / D Ratio:	12.8
Entrenchment Ratio:	2.1
Bank Height Ratio:	1.0



River Basin:	Neuse
Watershed:	Richland Creek, MY-00
XS ID	XS - 5, Pool
Drainage Area (sq mi):	7.8
Date:	8/4/2010
Field Crew:	A. French, L. Lord

Station	Elevation
0.0	253.68
0.2	253.42
5.7	253.38
12.9	253.46
17.7	253.41
19.5	252.74
20.7	252.13
22.0	251.53
23.4	250.85
24.3	250.27
26.6	250.14
28.9	249.78
31.9	249.58
34.2	249.43
35.9	249.28
37.2	249.23
38.7	249.10
40.6	249.24
41.8	249.51
42.8	250.18
44.8	250.35
45.0	251.74
46.7	252.11
47.7	252.54
48.4	253.18
49.2	253.43
52.3	253.41
56.6	253.44
63.6	253.40
67.4	253.55
67.9	253.78

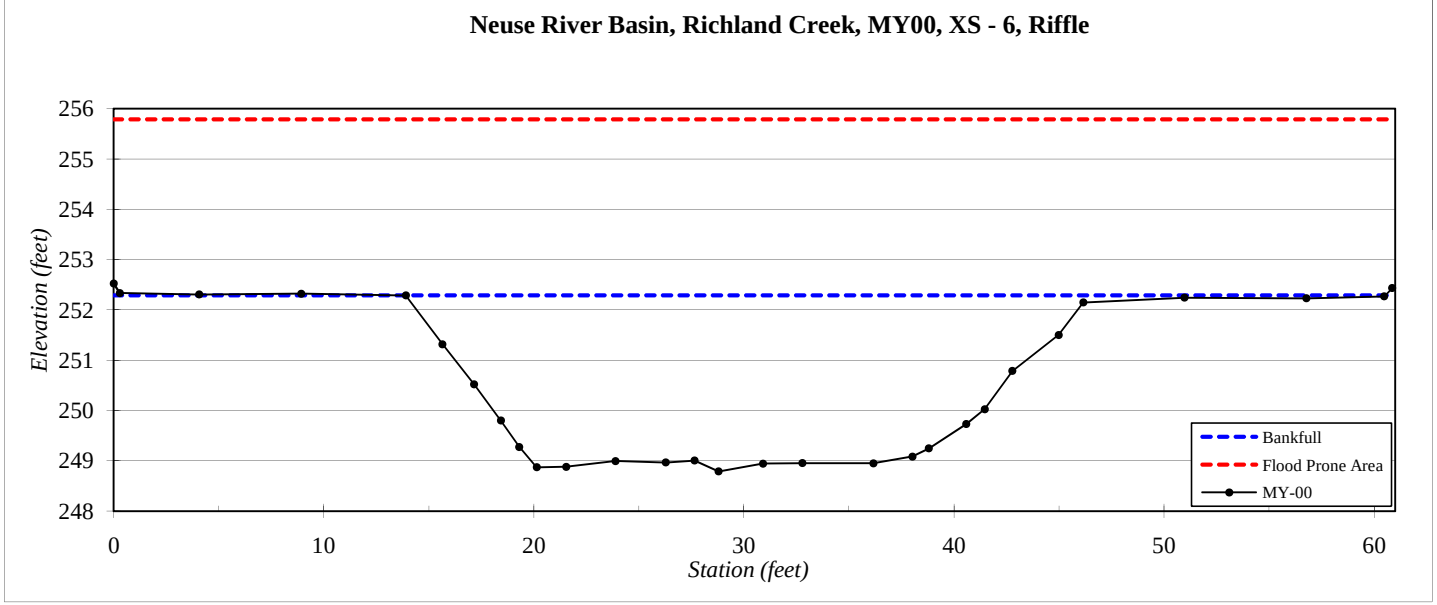
SUMMARY DATA	
Bankfull Elevation:	253.4
Bankfull Cross-Sectional Area:	90.8
Bankfull Width:	31.5
Flood Prone Area Elevation:	-
Flood Prone Width:	-
Max Depth at Bankfull:	4.3
Mean Depth at Bankfull:	2.9
W / D Ratio:	-
Entrenchment Ratio:	-
Bank Height Ratio:	1.0



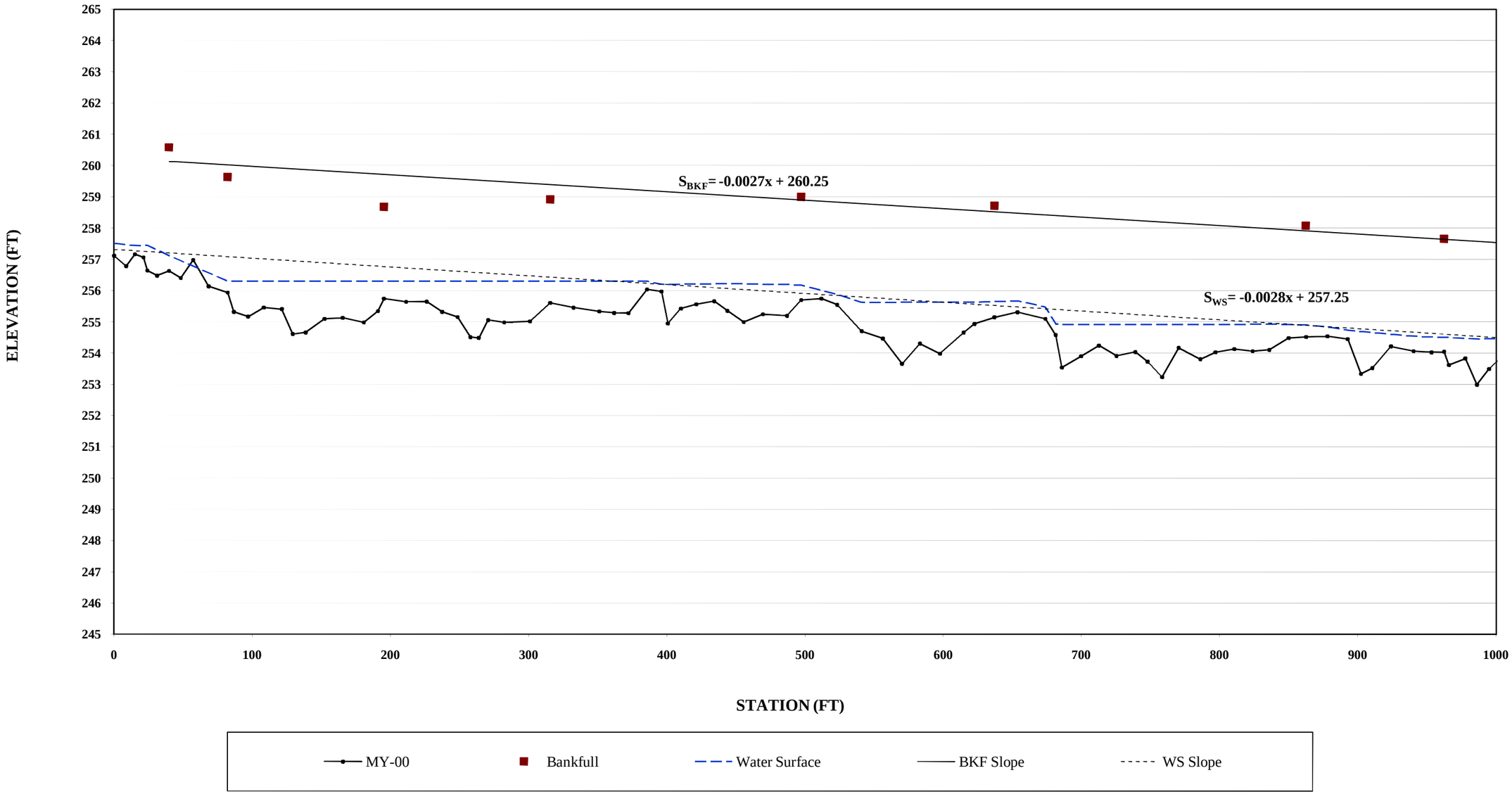
River Basin:	Neuse
Watershed:	Richland Creek, MY-00
XS ID	XS - 6, Riffle
Drainage Area (sq mi):	7.8
Date:	8/4/2010
Field Crew:	A. French, L. Lord

Station	Elevation
0.0	252.52
0.3	252.34
4.1	252.31
8.9	252.32
13.9	252.29
15.6	251.32
17.2	250.52
18.4	249.80
19.3	249.27
20.1	248.87
21.5	248.88
23.9	248.99
26.3	248.97
27.7	249.00
28.8	248.79
30.9	248.95
32.8	248.95
36.2	248.95
38.0	249.09
38.8	249.25
40.6	249.73
41.5	250.03
42.8	250.79
45.0	251.50
46.2	252.15
51.0	252.24
56.8	252.23
60.5	252.27
60.9	252.43

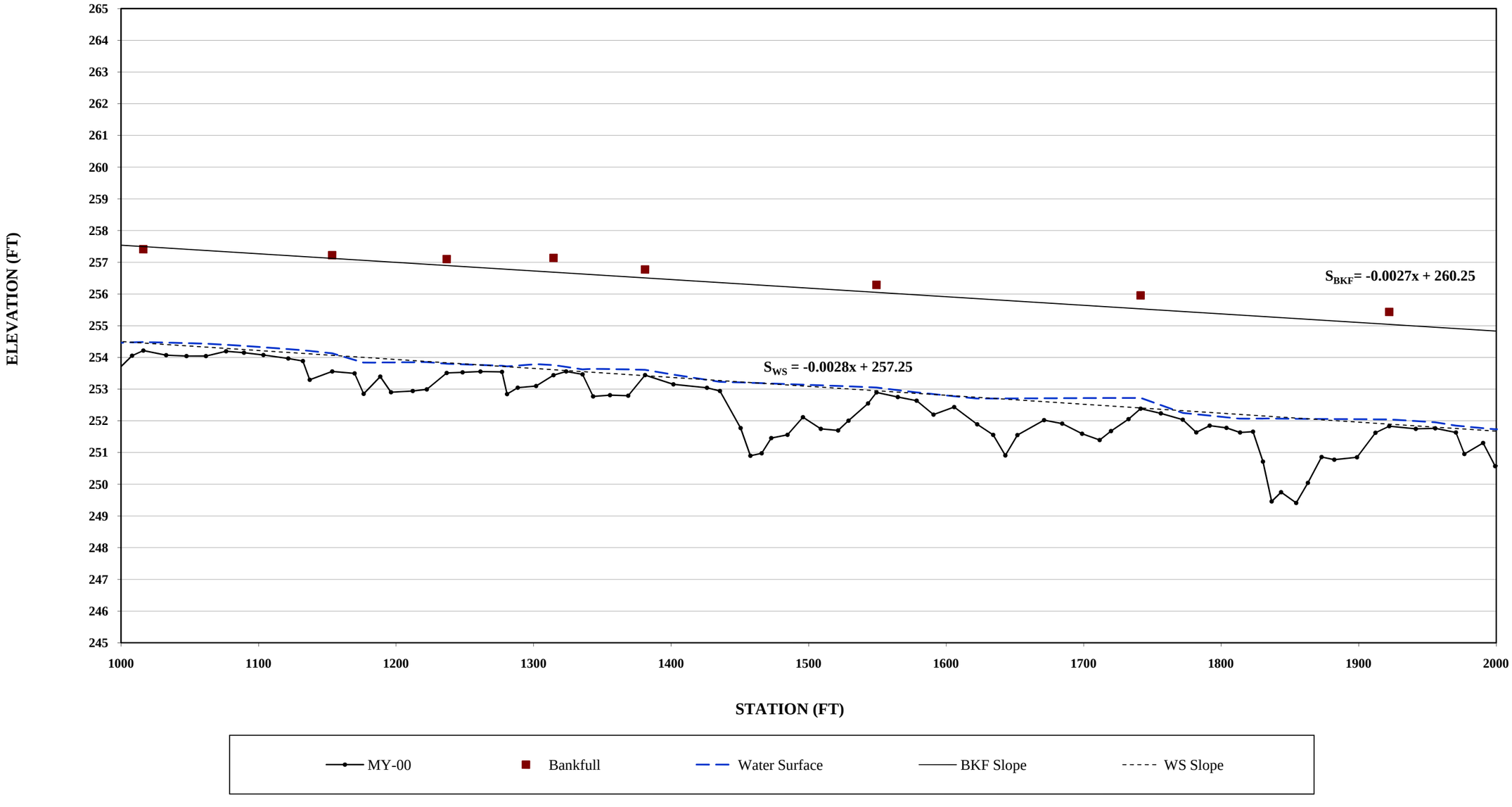
SUMMARY DATA	
Bankfull Elevation:	252.3
Bankfull Cross-Sectional Area:	85.6
Bankfull Width:	32.2
Flood Prone Area Elevation:	255.8
Flood Prone Width:	>60
Max Depth at Bankfull:	3.5
Mean Depth at Bankfull:	2.7
W / D Ratio:	12.1
Entrenchment Ratio:	1.9
Bank Height Ratio:	1.0



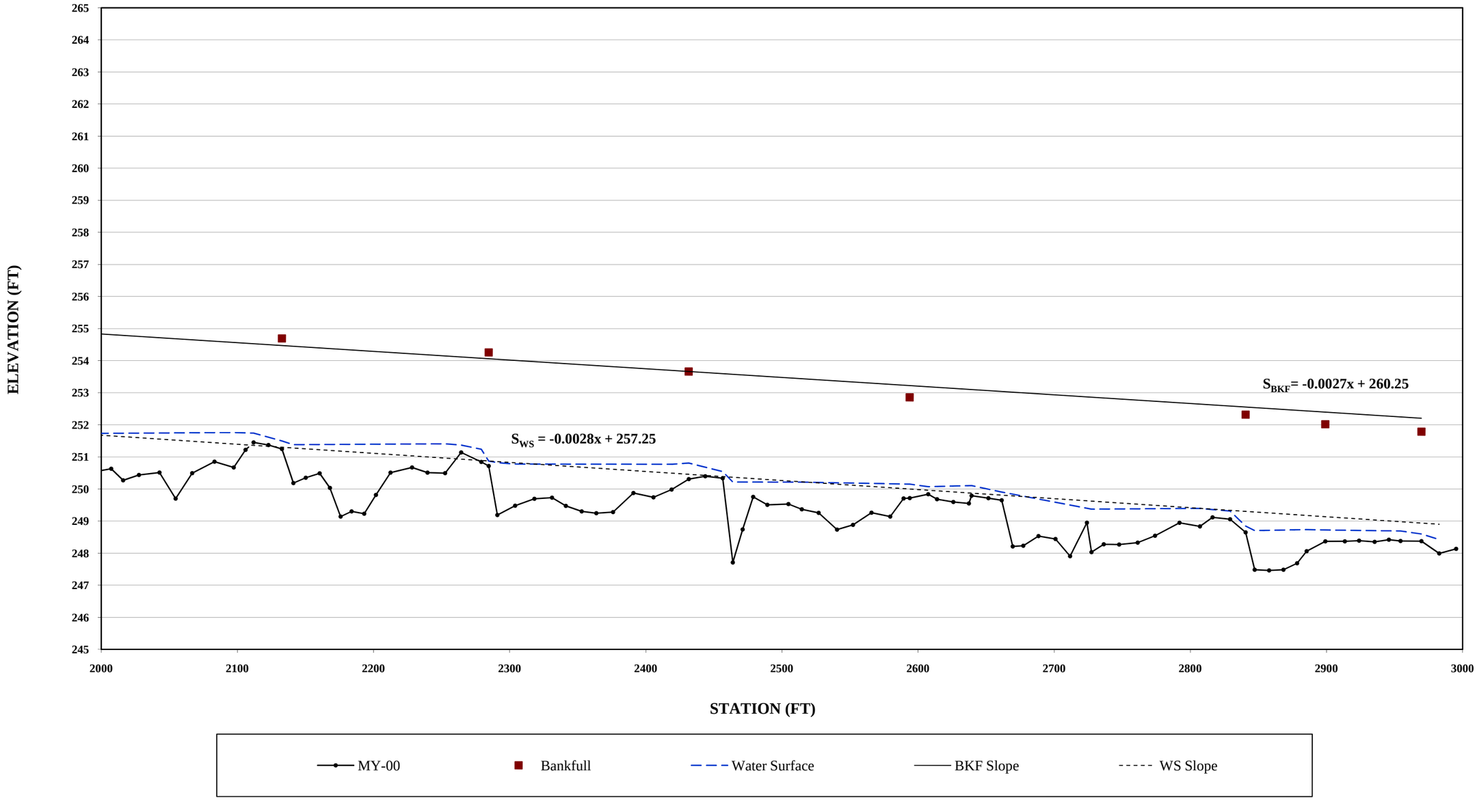
Longitudinal Profile
Richland Creek
EEP Project Number 304- MY-00
Stations 0+00 - 10+00



Longitudinal Profile
Richland Creek
EEP Project Number 304- MY-00
Stations 10+00 - 20+00



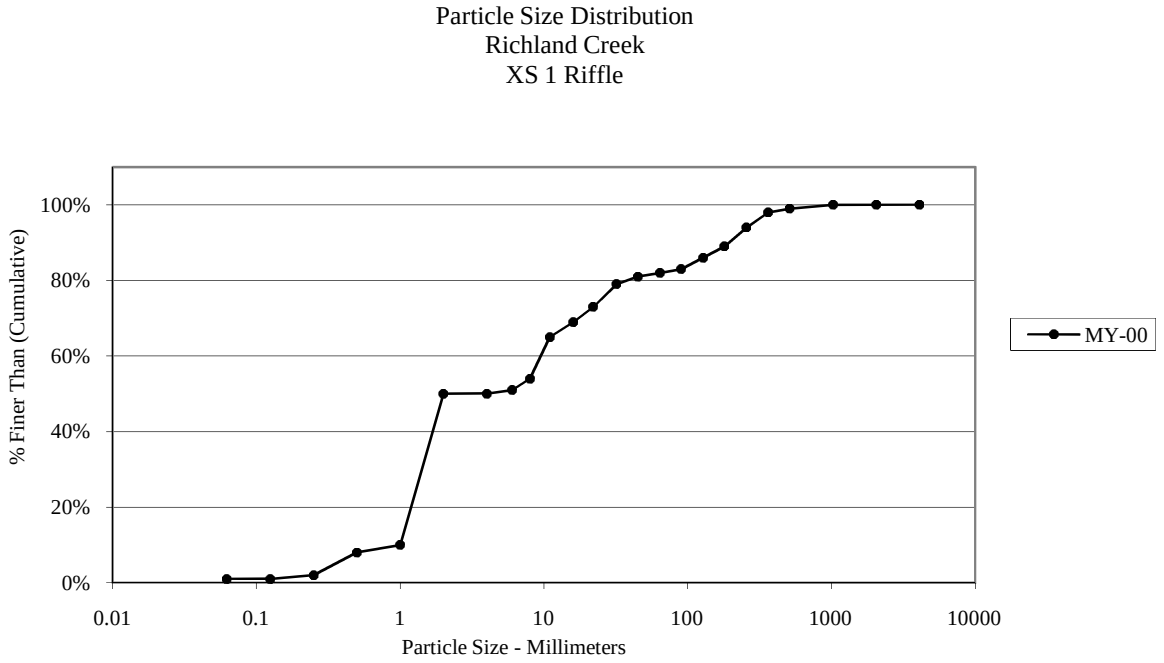
Longitudinal Profile
Richland Creek
EEP Project Number 304- MY-00
Stations 20+00 - 30+00



Pebble Count Plots

Cross-Section 1 Riffle - MY-00			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	1
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	1
Medium	.25 - .50	N	6
Coarse	.50 - 1	D	2
Very Coarse	1 - 2	S	40
Very Fine	2 - 4		
Fine	4 - 5.7	G	1
Fine	5.7 - 8	R	3
Medium	8 - 11.3	A	11
Medium	11.3 - 16	V	4
Coarse	16 - 22.6	E	4
Coarse	22.6 - 32	L	6
Very Coarse	32 - 45	S	2
Very Coarse	45 - 64		1
Small	64 - 90	C	1
Small	90 - 128	O	3
Large	128 - 180	B	3
Large	180 - 256	L	5
Small	256 - 362	B	4
Small	362 - 512	L	1
Medium	512 - 1024	D	1
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:



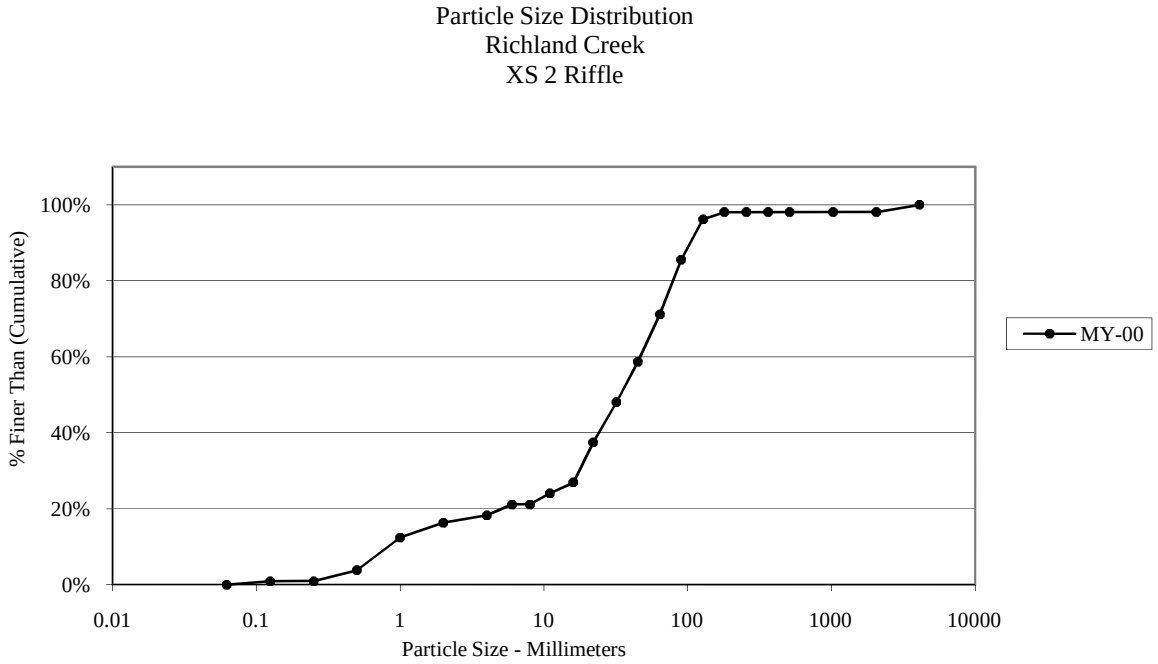
Size (mm)	
D16	1.1
D35	1.5
D50	2
D65	11
D84	100
D95	280

Size Distribution	
mean	10.5
dispersion	25.9
skewness	0.51

Type	
silt/clay	1%
sand	49%
gravel	32%
cobble	12%
boulder	6%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 2 Riffle - MY-00			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	1
Fine	.125 - .25	A	
Medium	.25 - .50	N	3
Coarse	.50 - 1	D	9
Very Coarse	1 - 2	S	4
Very Fine	2 - 4		2
Fine	4 - 5.7	G	3
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	3
Medium	11.3 - 16	V	3
Coarse	16 - 22.6	E	11
Coarse	22.6 - 32	L	11
Very Coarse	32 - 45	S	11
Very Coarse	45 - 64		13
Small	64 - 90	C	15
Small	90 - 128	O	11
Large	128 - 180	B	2
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	2
		Total	104

Note:



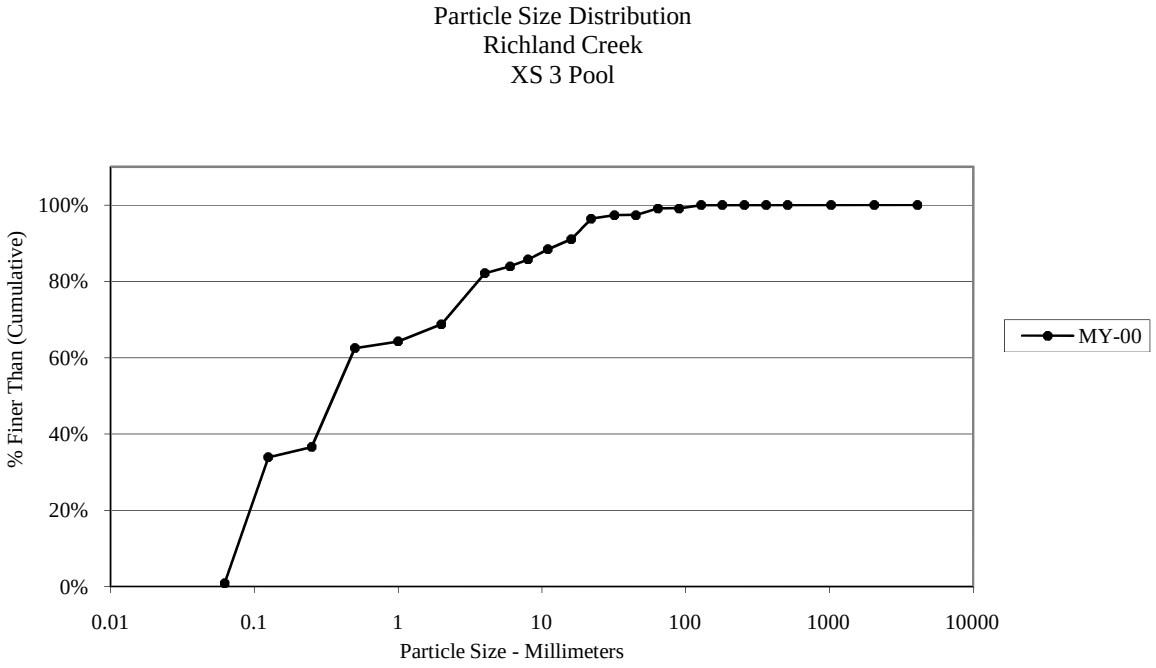
Size (mm)	
D16	1.9
D35	20
D50	34
D65	54
D84	87
D95	120

Size Distribution	
mean	12.9
dispersion	10.2
skewness	-0.33

Type	
silt/clay	0%
sand	16%
gravel	55%
cobble	27%
boulder	2%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 3 Pool - MY-00			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	1
Very Fine	.062 - .125	S	37
Fine	.125 - .25	A	3
Medium	.25 - .50	N	29
Coarse	.50 - 1	D	2
Very Coarse	1 - 2	S	5
Very Fine	2 - 4		15
Fine	4 - 5.7	G	2
Fine	5.7 - 8	R	2
Medium	8 - 11.3	A	3
Medium	11.3 - 16	V	3
Coarse	16 - 22.6	E	6
Coarse	22.6 - 32	L	1
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		2
Small	64 - 90	C	
Small	90 - 128	O	1
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	112

Note:



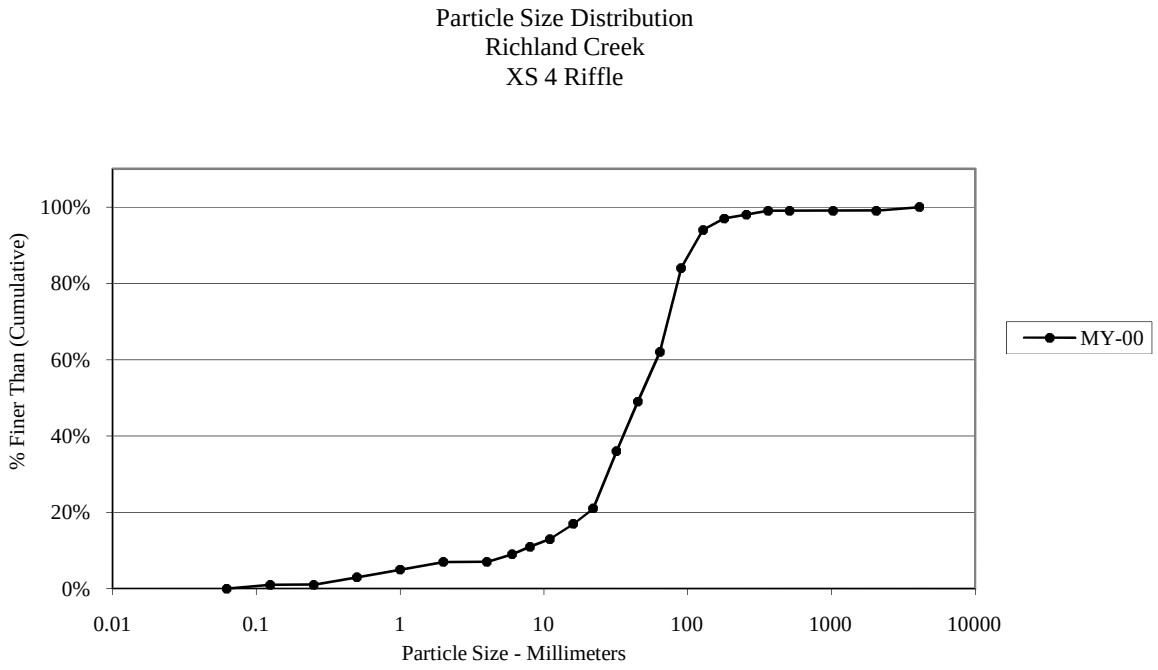
Size (mm)	
D16	0.085
D35	0.16
D50	0.36
D65	1.1
D84	6.1
D95	20

Size Distribution	
mean	0.7
dispersion	10.6
skewness	0.22

Type	
silt/clay	1%
sand	68%
gravel	30%
cobble	1%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 4 Riffle - MY-00			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	1
Fine	.125 - .25	A	
Medium	.25 - .50	N	2
Coarse	.50 - 1	D	2
Very Coarse	1 - 2	S	2
Very Fine	2 - 4		
Fine	4 - 5.7	G	2
Fine	5.7 - 8	R	2
Medium	8 - 11.3	A	2
Medium	11.3 - 16	V	4
Coarse	16 - 22.6	E	4
Coarse	22.6 - 32	L	15
Very Coarse	32 - 45	S	13
Very Coarse	45 - 64		13
Small	64 - 90	C	22
Small	90 - 128	O	10
Large	128 - 180	B	3
Large	180 - 256	L	1
Small	256 - 362	B	1
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	1
		Total	100

Note:



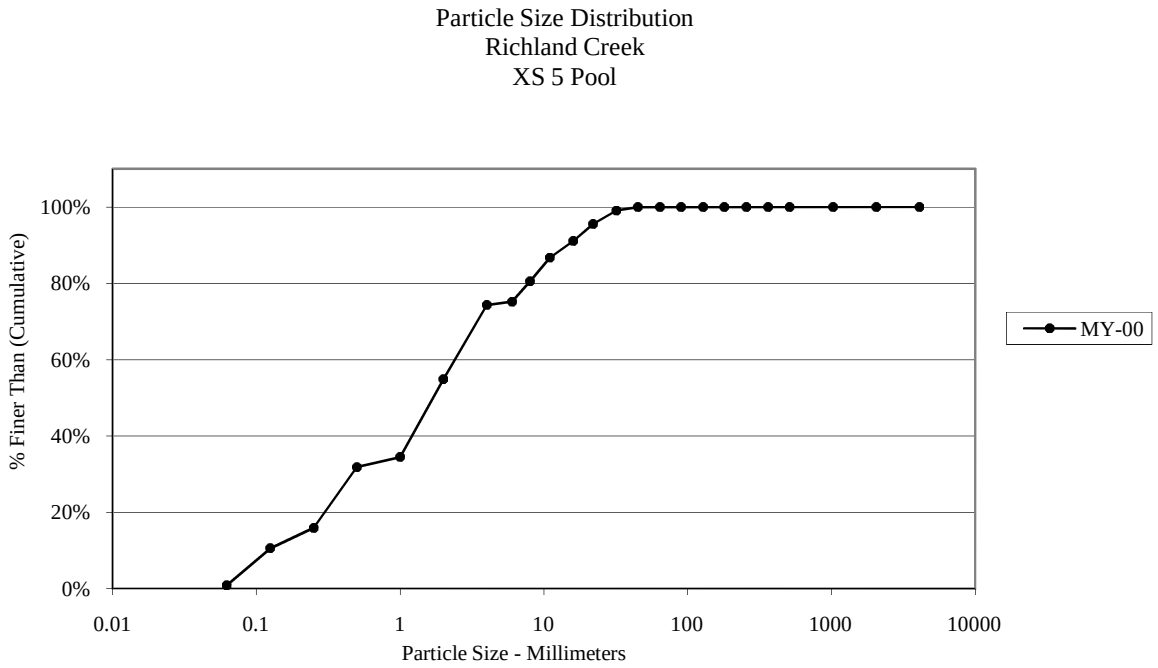
Size (mm)	
D16	15
D35	31
D50	46
D65	67
D84	90
D95	140

Size Distribution	
mean	36.7
dispersion	2.5
skewness	-0.11

Type	
silt/clay	0%
sand	7%
gravel	55%
cobble	36%
boulder	2%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 5 Pool - MY-00			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	1
Very Fine	.062 - .125	S	10
Fine	.125 - .25	A	6
Medium	.25 - .50	N	15
Coarse	.50 - 1	D	3
Very Coarse	1 - 2	S	19
Very Fine	2 - 4		17
Fine	4 - 5.7	G	1
Fine	5.7 - 8	R	6
Medium	8 - 11.3	A	7
Medium	11.3 - 16	V	5
Coarse	16 - 22.6	E	5
Coarse	22.6 - 32	L	4
Very Coarse	32 - 45	S	1
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:



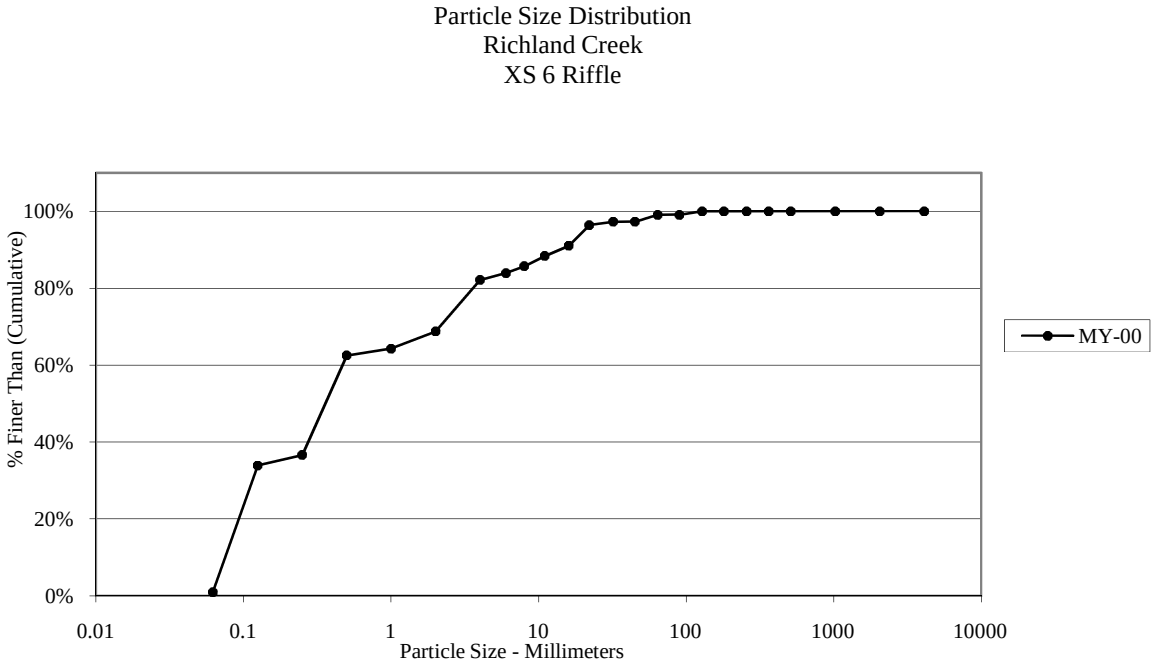
Size (mm)	
D16	0.22
D35	1
D50	1.7
D65	3.1
D84	11.0
D95	22

Size Distribution	
mean	1.6
dispersion	7.1
skewness	-0.03

Type	
silt/clay	1%
sand	53%
gravel	46%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 6 Riffle - MY-00			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	1
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	2
Coarse	.50 - 1	D	2
Very Coarse	1 - 2	S	18
Very Fine	2 - 4		
Fine	4 - 5.7	G	1
Fine	5.7 - 8	R	2
Medium	8 - 11.3	A	7
Medium	11.3 - 16	V	7
Coarse	16 - 22.6	E	3
Coarse	22.6 - 32	L	7
Very Coarse	32 - 45	S	6
Very Coarse	45 - 64		7
Small	64 - 90	C	9
Small	90 - 128	O	8
Large	128 - 180	B	11
Large	180 - 256	L	9
Small	256 - 362	B	4
Small	362 - 512	L	2
Medium	512 - 1024	D	1
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	4
		Total	111

Note:



Size (mm)	
D16	1.6
D35	15
D50	44
D65	91
D84	200
D95	470

Size Distribution	
mean	17.9
dispersion	16.0
skewness	-0.27

Type	
silt/clay	1%
sand	20%
gravel	36%
cobble	33%
boulder	10%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

APPENDIX C

Vegetation Data

Table 7. Vegetation Plot Data
Paschal Golf Course (Richland Creek) / Project No. 276

			Current Plot Data (MY0 2010)																					Annual Means		
			304-01-0001			304-01-0002			304-01-0003			304-01-0004			304-01-0005			304-01-0006			304-01-0007			MY0 (2010)		
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	P-LS	P-all	T
Alnus serrulata	hazel alder	Shrub Tree					5	5		3	3														8	8
Celtis	hackberry												2	2		1	1								3	3
Celtis occidentalis	common hackberry	Shrub Tree														1	1								1	1
Cephalanthus occidentalis	common buttonbush	Shrub Tree					1	1		1	1											3	3		5	5
Clethra alnifolia	coastal sweetpepperbush	Shrub		1	1		2	2																	3	3
Cornus amomum	silky dogwood	Shrub		15	15	14	15	15		1	1		1	1	12	12	12				10	10	10	36	54	54
Diospyros virginiana	common persimmon	Tree											1	1		3	3								4	4
Fraxinus pennsylvanica	green ash	Tree								2	2		2	2		2	2					2	2		8	8
Nyssa sylvatica	blackgum	Tree					1	1		2	2					1	1		1	1					5	5
Platanus occidentalis	American sycamore	Tree					4	4		5	5		5	5		1	1		2	2		3	3		20	20
Quercus michauxii	swamp chestnut oak	Tree																	1	1					1	1
Quercus nigra	water oak	Tree																	1	1					1	1
Quercus phellos	willow oak	Tree											2	2		4	4								6	6
Salix sericea	silky willow	Shrub Tree				5	6	6							9	9	9				6	6	6	20	21	21
Sambucus canadensis	Common Elderberry	Shrub Tree				1	1	1		1	1				5	5	5				5	5	5	11	12	12
Unknown		unknown		1	1	1	5	5		2	2		5	5	5	10	10		7	7	6	10	10	12	40	40
Viburnum dentatum	southern arrowwood	Shrub Tree											1	1											1	1
Stem count			0	17	17	21	40	40	0	17	17	0	19	19	31	49	49	0	12	12	27	39	39	79	193	193
size (ares)				1			1			1			1			1			1			1			7	
size (ACRES)				0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.17	
Species count			0	3	3	4	9	9	0	8	8	0	8	8	4	11	11	0	5	5	4	7	7	4	17	17
Stems per ACRE			0	688	688	849.8	1619	1619	0	688	688	0	768.9	768.9	1255	1983	1983	0	485.6	485.6	1093	1578	1578	456.7	1116	1116

P-LS = Planted Live Stakes
P-all = Planted Stems, including live stakes
T = Total stems, including planted and volunteer stems

Vegetation Plot Photos

Veg Plot #1 – 8/6/2010

Veg Plot #2 – 8/6/2010

Veg Plot #3 – 8/6/2010

Veg Plot #4 – 8/6/2010

Veg Plot #5 – 8/6/2010

Veg Plot #6 – 8/6/2010

Veg Plot #7 – 8/6/2010

APPENDIX D

Stream Photos

Photo Point #1 – Looking upstream at fish ramp 8/6/2010

Photo Point #3 – Looking downstream 8/6/2010

Photo Point #2 – Looking downstream 8/6/2010

Photo Point #3 – Looking upstream 8/6/2010

Photo Point #2 – Looking upstream 8/6/2010

Photo Point #4 – Looking downstream 8/6/2010

Photo Point #4 – Looking upstream 8/6/2010

Photo Point #7 – 8/6/2010

Photo Point #5 – Looking upstream from bridge 8/6/2010

Photo Point #8 – 8/6/2010

Photo Point #6 – 8/6/2010

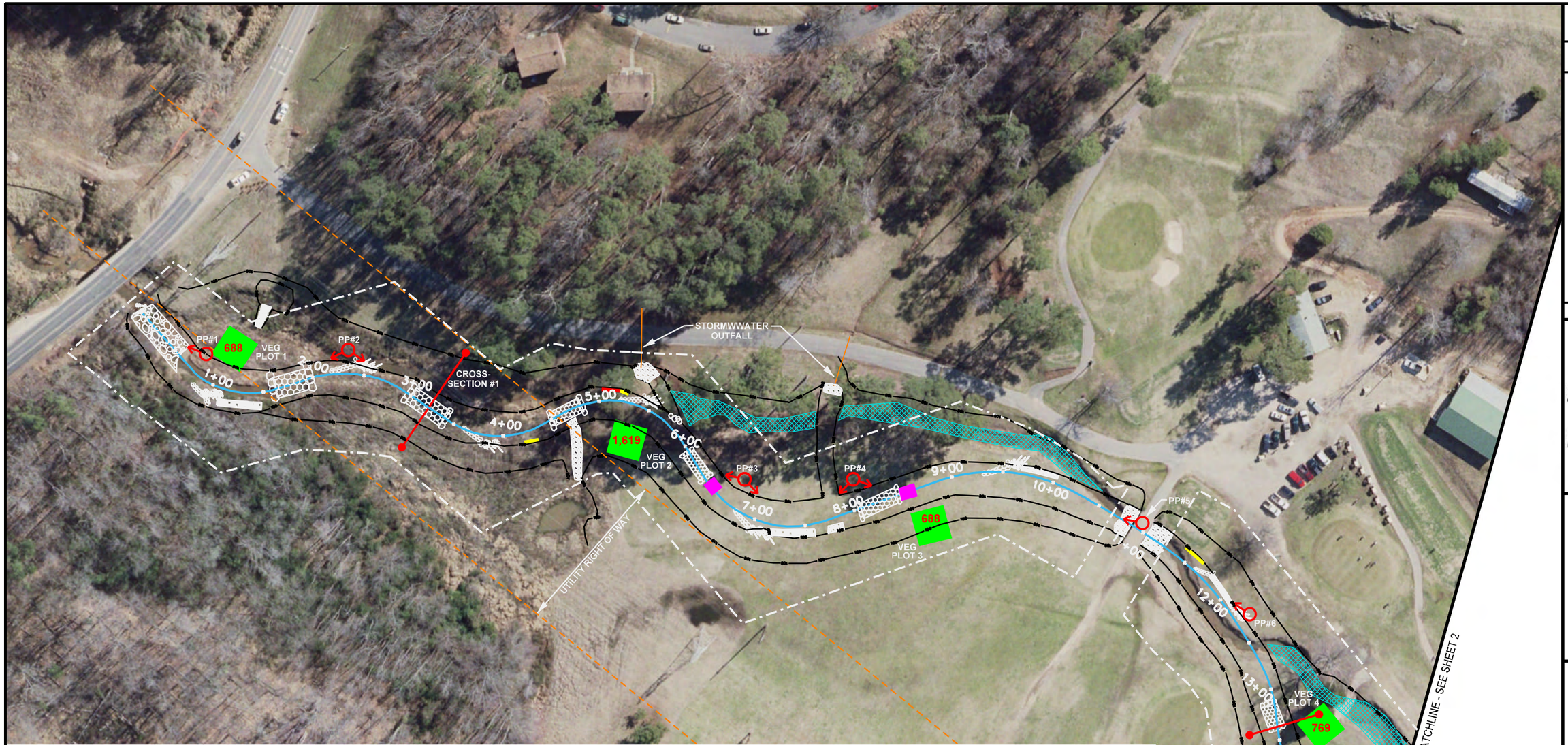
Photo Point #9 –8/6/2010

Photo Point #10 – 8/6/2010

Photo Point #11 – 8/6/2010

APPENDIX E

Current Condition Plan View



LEGEND

- EASEMENT BOUNDARY
- AS-BUILT STATIONED CENTERLINE, TOP OF BANK, AND TOP OF TERRACE
- PHOTO POINT
- CROSS-SECTION
- OLD STREAM CHANNEL

PROJECT CONDITION

- STREAM BED DEGRADATION
- BANK EROSION
- UNDERCUT BANK
- MASS WASTING OF BANK
- VEG PLOT ACHIEVING DENSITY CRITERION
- VEG PLOT BELOW DENSITY CRITERION

PROJECT CONDITION DETAILS

VEG PLOT PLANTED STEM DENSITY	890
STRUCTURE PIPING	P

NC GRID NAD '83

–50 –25 0 50 100
GRAPHIC SCALE

REVISIONS

NO.	DESCRIPTION	DATE	APPROVED

Ecosystem Enhancement PROGRAM

KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

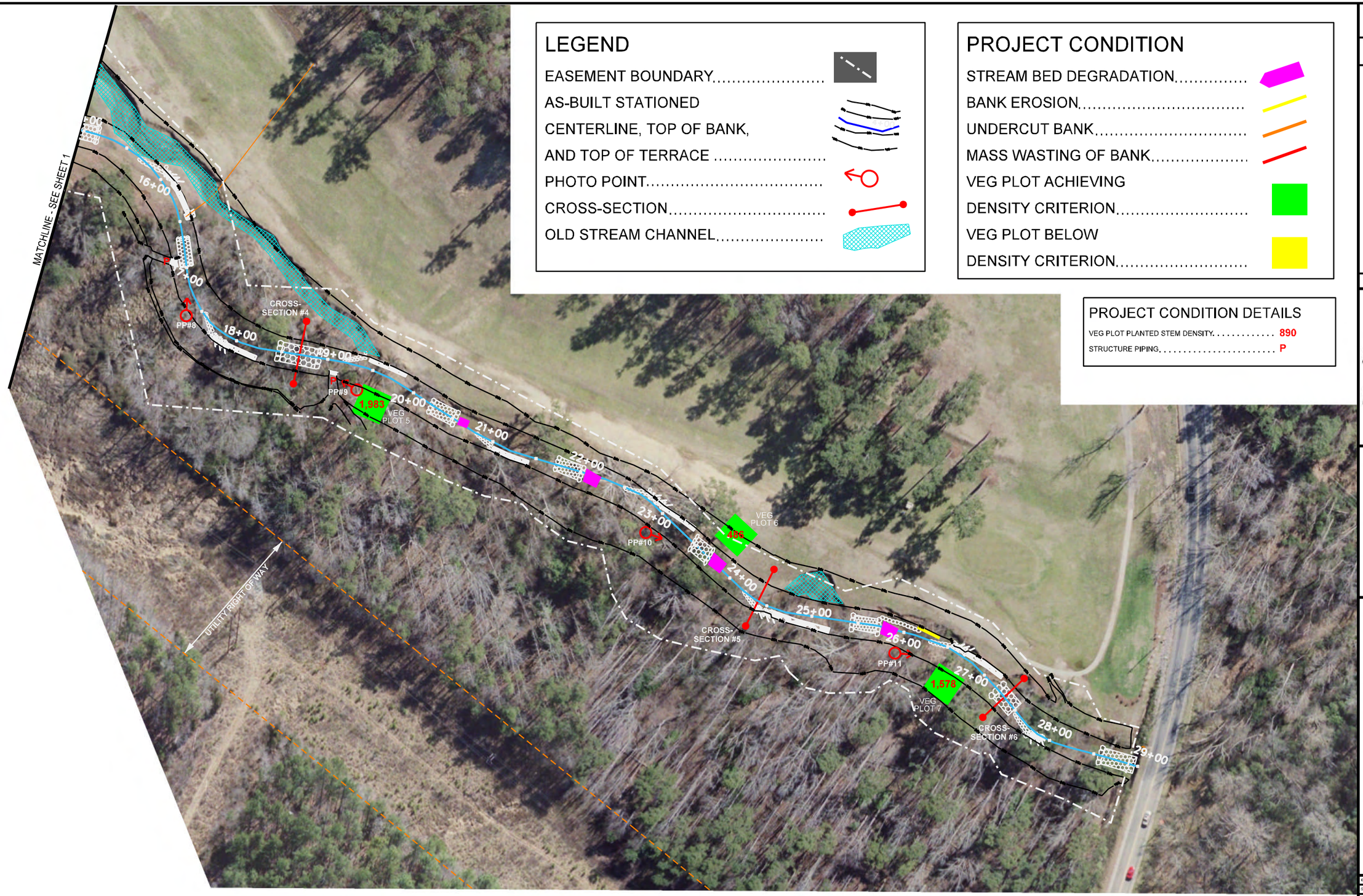
PASCHAL GOLF COURSE (RICHLAND CREEK)
PROJECT #276 - BASELINE MONITORING

WAKE FOREST, WAKE COUNTY, NORTH CAROLINA

DATE: DEC 2010
SCALE: 1" = 100'

CURRENT CONDITION PLAN VIEW

SHEET 1 OF 2



LEGEND

- EASEMENT BOUNDARY
- AS-BUILT STATIONED CENTERLINE, TOP OF BANK, AND TOP OF TERRACE
- PHOTO POINT
- CROSS-SECTION
- OLD STREAM CHANNEL

PROJECT CONDITION

- STREAM BED DEGRADATION
- BANK EROSION
- UNDERCUT BANK
- MASS WASTING OF BANK
- VEG PLOT ACHIEVING DENSITY CRITERION
- VEG PLOT BELOW DENSITY CRITERION

PROJECT CONDITION DETAILS

VEG PLOT PLANTED STEM DENSITY	890
STRUCTURE PIPING	P

–50 –25 0 50 100
GRAPHIC SCALE

NC GRID NAD '83

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

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WAKE FOREST, WAKE COUNTY, NORTH CAROLINA

DATE: DEC 2010
SCALE: 1" = 100'

CURRENT CONDITION PLAN VIEW