Paschal Golf Course (Richland Creek)
Stream Restoration Monitoring Report
DMS Project # 276
DMS Contract # 004927
Monitoring Year 05

Submitted to:

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

Construction Completed: May 2010
Data Collection: August 2016
Submitted: November 2016

Monitoring Firm

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1.0 EXECUTIVE SUMMARY / PROJECT ABSTRACT

The Paschal Golf Course (Richland Creek) Stream Restoration Site, completed in May 2010, restored a total of 2,919 linear feet of stream and 167,092 square feet of buffer restoration in the Neuse River Basin. The project is located in the USGS Hydrologic Unit 03020201070060. This HU is within the DMS' Neuse River Basin Local Watershed Plan and is also listed as a Targeted Local Watershed (TLW) in DMS' *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 efficient sediment transport.
- Plant native trees and shrubs throughout the site.
- Grade a floodplain adjacent to the stream.

The vegetation monitoring success criterion for the planted stream riparian zone is a density of 320 stems/acre after the third year of monitoring and an allowance for 10% mortality in the fourth and fifth years with a final density of 260 stems/acre. Before the start of the MY-04 growing season the site was replanted in areas of low stem density. The fifth-year vegetation monitoring followed the Level 2 CVS-EEP vegetation monitoring protocol. The site's average density for this monitoring period was 324 planted stems/acre, including live stakes, and 306 planted stems/acre, excluding live stakes. Including volunteers, the site averaged 3,070 total stems/acre. One of the vegetation monitoring plots in the streamside planting area (Plot 1) had a planted stem density below the fifth-year success criterion of 260 stems/acre. Of the plots in the buffer restoration area (Plots 2, 3, 4, 5, and 7), Plots 4 and 7 had planted stem densities below the fifth-year success criterion of 320 stems/acre. There were many loblolly pine and sweetgum volunteers throughout the easement; in certain areas these volunteers were extremely dense. In late summer of 2013, after the vegetation monitoring, the loblolly pine density was reduced to improve the condition of the site for the planted vegetation. Autumn olive *(Elaeagnus umbellate)* is scattered throughout the lower half of the site. This species appears to be a remnant left over from the pre-restoration conditions of the site as well as new volunteer stems from the nearby wooded area. See Figure 3, Current Condition Plan View, for further information on the occurrence of invasive species within the site.

Fifth-year monitoring found Richland Creek to be mostly stable, with only minor changes from the baseline conditions. The stream has two areas of localized bank erosion near stationing 14+50 and 26+15. All other areas of erosion or mass wasting reported in previous years' reports were repaired in March 2016. Several beaver dams were noted during the 2016 monitoring. As of the end of year site visit on 11/28/16, two beaver dams are present at stationing 13+40 and 16+90. The longitudinal and cross-sectional data also reflect the overall stability in the project streams. As a part of the stream success criterion, the stream must experience at least two bankfull events, each in separate monitoring years. The site has experienced multiple bankfull events since construction.

Summary information/data related to the occurrence of items such as beaver or encroachment and statistics related to performance of various project and monitoring elements can be found in the tables and

figures in the report appendices. Narrative background and supporting information formerly found in these reports can be found in the Baseline Monitoring Report and in the Mitigation Plan (formerly the Restoration Plan) documents available on the DMS' website. All raw data supporting the tables and figures in the appendices are available from DMS upon request.

2.0 METHODOLOGY

The survey data were collected with a total station instrument.

The stationing for the longitudinal profile is based on the thalweg stationing and has been adjusted to match grade control structures from previous longitudinal profiles.

The CVS-EEP protocol, Level 2 (http://cvs.bio.unc.edu/methods.htm) was used to collect vegetation data from the site.

3.0 REFERENCES

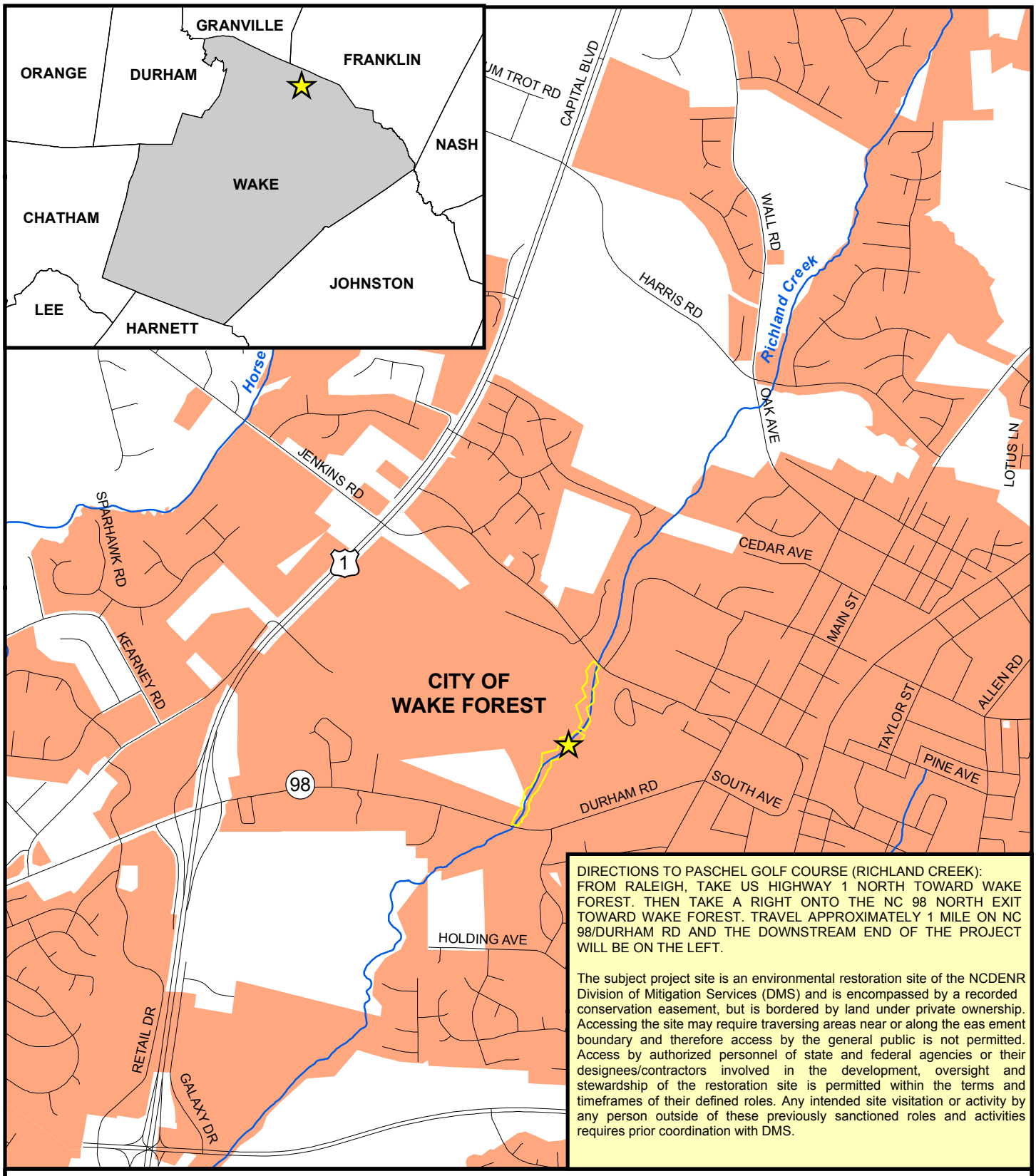
Lee, M.T., R.K. Peet, S.D. Roberts, and T.R. Wentworth. 2006. CVS-EEP Protocol for Recording Vegetation, Version 4.0 (http://cvs.bio.unc.edu/methods.htm)

NCEEP. 2010. Neuse River Basin Restoration Priorities. (http://portal.ncdenr.org/c/document_library/get_file?uuid=665be84c-cf93-477b-918c-1993778ef11f&groupId=60329)

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

Appendix A

Project Vicinity Map and Background 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 Division of Mitigation Services (DMS) 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 eas ement 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 DMS.

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

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

KCI ASSOCIATES OF NC

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 12/19/2011 by KCI.
Image Source: NC Statewide Orthoimagery, 2010.
Note: Image taken during project construction.

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	167,092.2		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		
Elapsed Time Since Grading Complete: 6 yr 7 months **Elapsed Time Since Planting Complete: 6 yr 7 months** **Number of Reporting Years: 5**		
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	Aug 2011	Dec 2011
Year 2 Monitoring	Aug 2012	Nov 2012
Year 3 Monitoring	Jun 2013	Dec 2013
Supplemental Planting		Feb 2014
Year 4 Monitoring	Jun 2014	Nov 2014
Stream repairs		Mar 2014
Year 5 Monitoring	Aug 2016	Nov 2016

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 **Repair Designer**	KCI Associates of North Carolina 4505 Falls of Neuse Road, Suite 400 Raleigh, NC 27609
POC	Adam Spiller (919) 278-2514
Repair Contractor	Fluvial Solutions, Inc. PO Box 28748 Raleigh, NC 27611
Repair Contractor POC	Peter Jelenevsky (919)605-6134

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	-

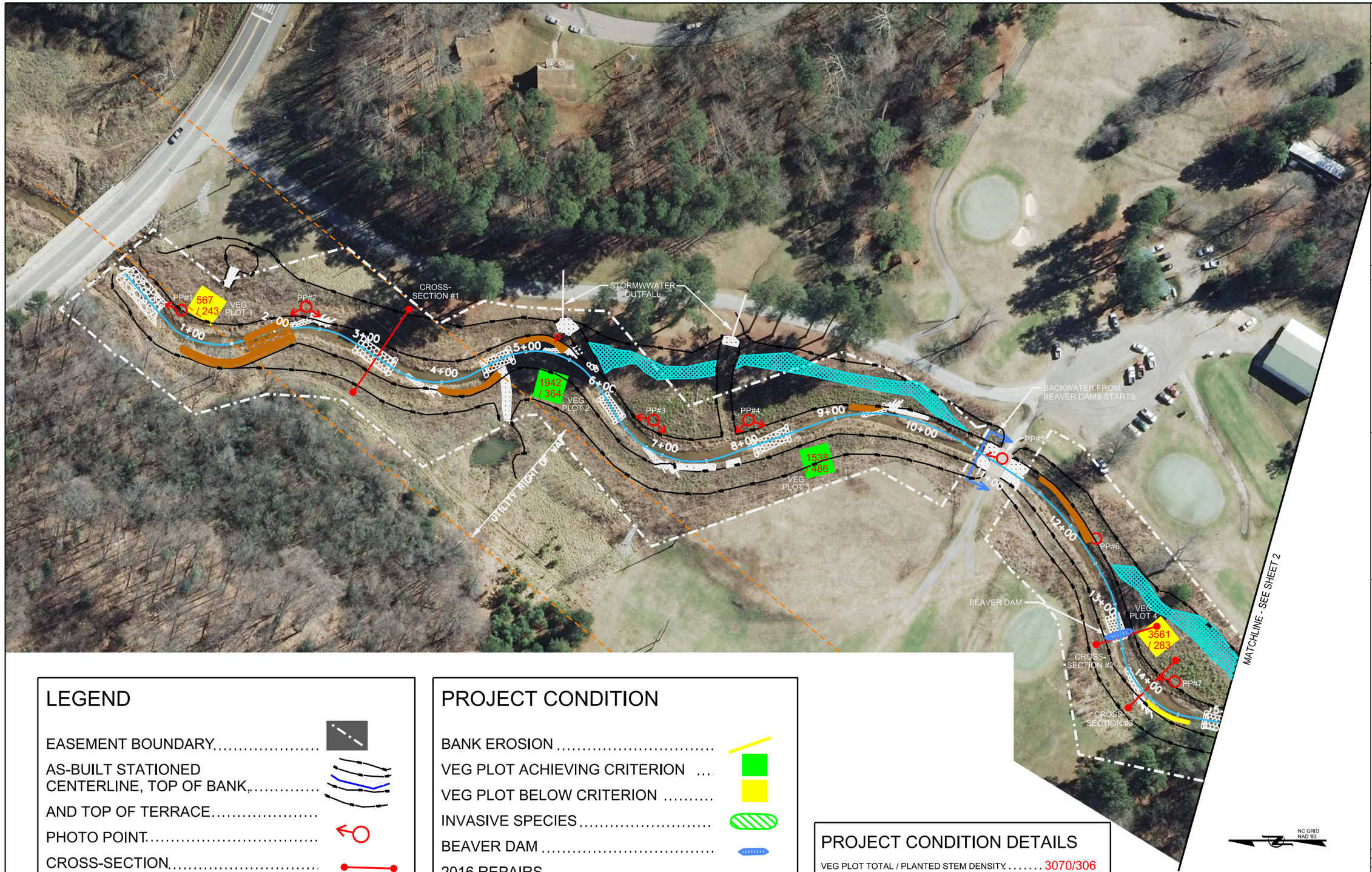
"N/A" is for items that do not apply.

"-" is for items that are unavailable.

"U" is for items that are unknown.

Appendix B

Visual Assessment Data



LEGEND

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

PROJECT CONDITION

- BANK EROSION
- VEG PLOT ACHIEVING CRITERION
- VEG PLOT BELOW CRITERION
- INVASIVE SPECIES
- BEAVER DAM
- 2016 REPAIRS

PROJECT CONDITION DETAILS

VEG PLOT TOTAL / PLANTED STEM DENSITY	3070/306
STRUCTURE PIPING	P
STRUCTURE NOT PROTECTING BANK	B

IMAGE SOURCE: NC 2013 STATEWIDE ORTHOIMAGERY

NC GRID
NAD '83

-50 -25 0 50 100
GRAPHIC SCALE

REVISIONS

SYM.	DESCRIPTION	DATE	APPROVED

NCDEQ DIVISION OF MITIGATION SERVICES

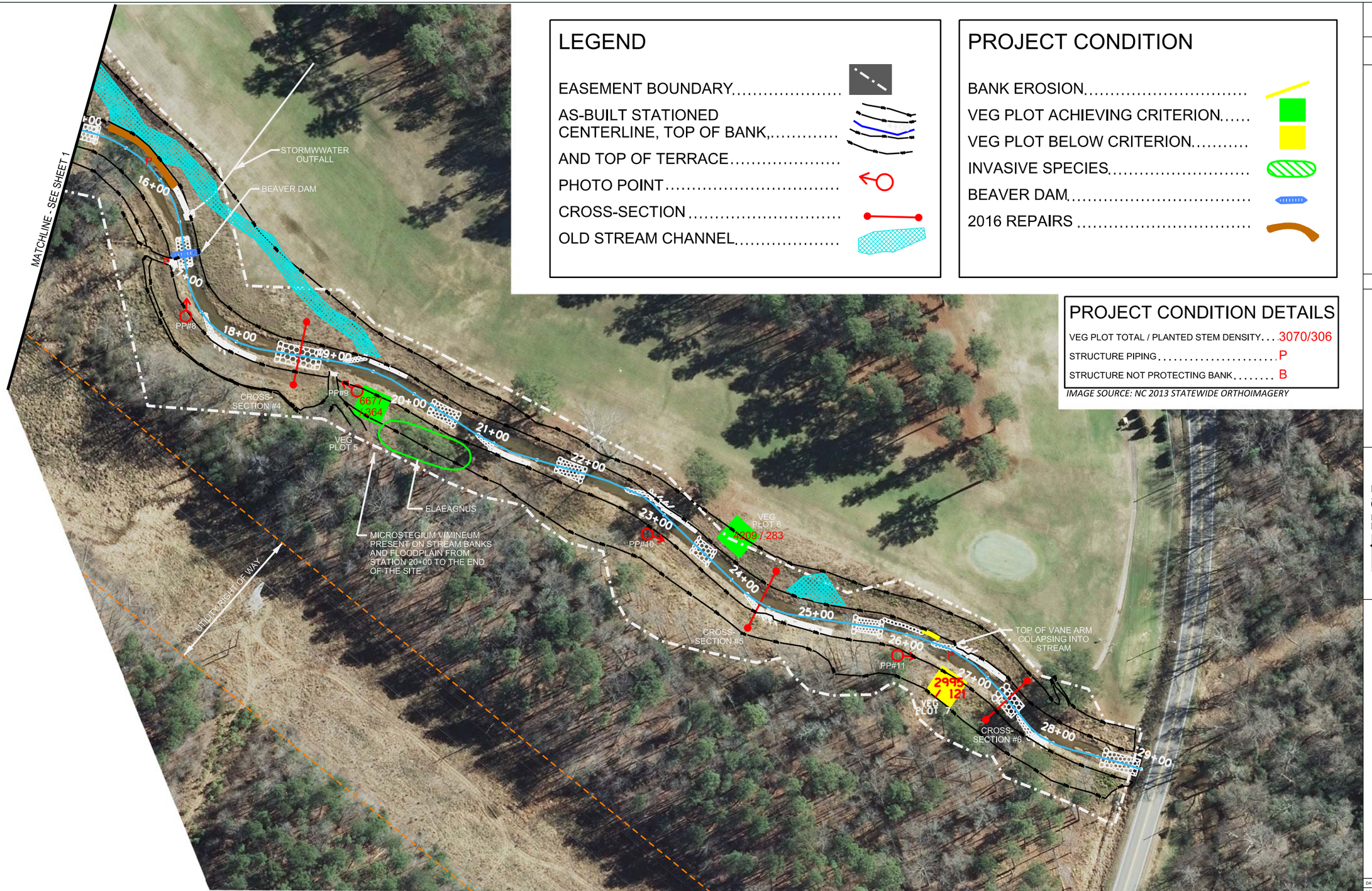
KCI
ASSOCIATES OF NC
ENGINEERS PLANNERS SCIENTISTS
4505 FALLS OF NEUSE ROAD
RALEIGH, NORTH CAROLINA 27609

PASCHAL GOLF COURSE (RICHLAND CREEK)
PROJECT #276 - MONITORING YEAR 5

WAKE FOREST, WAKE COUNTY, NORTH CAROLINA

DATE: NOV 2016
SCALE: 1" = 100'
FIGURE 3

CURRENT CONDITION PLAN VIEW



LEGEND

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- AS-BUILT STATIONED CENTERLINE, TOP OF BANK,
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PROJECT CONDITION

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- 2016 REPAIRS

PROJECT CONDITION DETAILS

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STRUCTURE PIPING	P
STRUCTURE NOT PROTECTING BANK	B

IMAGE SOURCE: NC 2013 STATEWIDE ORTHOIMAGERY

REVISIONS

DIM.	DESCRIPTION	DATE	APPROVED

NCDEQ DIVISION OF MITIGATION SERVICES

KCI ASSOCIATES OF NC
ENGINEERS PLANNERS SCIENTISTS
4505 FALLS OF NEUSE ROAD
RALEIGH, NORTH CAROLINA 27609

PASCHAL GOLF COURSE (RICHLAND CREEK) PROJECT #276 - MONITORING YEAR 5

WAKE FOREST, WAKE COUNTY, NORTH CAROLINA

DATE: NOV 2016
SCALE: 1" = 100'

FIGURE 3

CURRENT CONDITION PLAN VIEW

Table 5. Visual Stream Morphology Stability Assessment							
Project Number and Name: 276 - Paschal Golf Course (Richland Creek) **Assessed Length 2,919** **Reach - Richland Creek**							
Major Channel Category	**Channel Sub-Category**	**Metric**	**Number Stable, Performing as Intended**	**Total Number in As-built**	**Number of Unstable Segments**	**Amount of Unstable Footage**	**% Stable, Performing as Intended**
1. Bed	1. **Vertical Stability** (Riffle and Run units)	1. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			1	30	99%
		2. Degradation - Evidence of downcutting			0	0	100%
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	17	17			100%
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	13	13			100%
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	13	13			100%
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	17	17			100%
		2. Thalweg centering at downstream of meander (Glide)	17	17			100%
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			3	60	99%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			5	185	97%
				Totals	8	245	96%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	16	16			100%
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	15	15			100%
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	1	2			50%
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	14	16			88%
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	16	16			100%

Table 6. Vegetation Condition Assessment
Project Number and Name: 276 - Paschal Golf Course (Richland Creek)

Planted Acreage 7.2 **Easement Acreage 8.5**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.1 acre	Pattern and Color	0	0.00	0.0%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acre	Pattern and Color	0	0.00	0.0%
			Total	0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25 acre	Pattern and Color	0	0.00	0.0%
			Cumulative Total	0	0.00	0.0%
4. Invasive Areas of Concern	Areas or points (if too small to render as polygons at map scale).	1,000 SF	Pattern and Color	2	1.35	15.9%
5. Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	Pattern and Color	0	0.00	0.0%

Stream Station Photos

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

Photo Point #1 – Looking upstream at fish ramp 11/29/2016 MY-05

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

Photo Point #2 – Looking downstream 11/29/2016 MY-05

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

Photo Point #2 – Looking upstream 11/29/2016 MY-05

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

Photo Point #3 – Looking downstream 11/29/2016 MY-05

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

Photo Point #3 – Looking upstream 11/29/2016 MY-05

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

Photo Point #4 – Looking downstream 11/29/2016 MY-05

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

Photo Point #4 – Looking upstream 11/29/2016 MY-05

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

Photo Point #5 – Looking upstream from bridge 11/29/2016 MY-05

Photo Point #6 – 8/6/2010 – Baseline

Photo Point #6 – 11/29/2016 MY-05

Photo Point #7 – 8/6/2010 – Baseline

Photo Point #7 – 11/29/2016 MY-05

Photo Point #8 – 8/6/2010– Baseline

Photo Point #8 – 11/29/2016 MY-05

Photo Point #9 –8/6/2010– Baseline

Photo Point #9 –11/29/2016 MY-05

Photo Point #10 – 8/6/2010 – Baseline

Photo Point #10 – 11/29/2016 MY-05

Photo Point #11 – 8/6/2010– Baseline

Photo Point #11 – 11/29/2016 MY-05

Problem Area Photos

Bank Erosion Station 14+50– 5/17/16

Bank Erosion Station 26+15 – 5/17/16

Beaver Dam Station 13+40 – 11/29/16

Beaver Dam Station 16+90 – 11/29/16

Vegetation Plot Photos

Veg Plot #1 – 9/8/2016

Veg Plot #2 – 9/8/2016

Veg Plot #3 – 9/8/2016

Veg Plot #4 – 9/8/2016

Veg Plot #5 – 9/8/2016

Veg Plot #6 – 9/8/2016

Veg Plot #7 – 9/8/2016

Appendix C

Vegetation Plot Data

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

Stream Vegetation Totals (per acre)

Plot ID	[1]Stream Stems	[2]Volunteers	[3]Total	Success Criteria Met?
1	243	323	566	No
6	283	3,926	4,209	Yes
Project Avg	263	2,125	2,388	

Buffer Vegetation Totals (per acre)

Plot ID	[4]Buffer Stems	Success Criteria Met?
2	364	Yes
3	486	Yes
4	283	No
5	364	Yes
7	121	No
Project Avg	324	

[1]Stream Stems Native planted woody stems. Includes shrubs, does NOT include live stakes.

[2]Volunteers Native woody stems. NOT planted.

[3]Total Planted + volunteer native woody stems. Includes live stakes.

[4]Buffer Stems Native planted hardwood trees. Does NOT include live stakes and shrubs.

Table 8. CVS Vegetation Plot Metadata Paschal Golf Course (Richland Creek) / Project No. 276	
Report Prepared By	Randall Jones
Date Prepared	8/18/2016 13:20
database name	KCI-2014-R.mdb
database location	M:\2012\16122606_Richland Creek Monitoring\Veg
computer name	12-3ZV4FP1
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	304
project Name	Richland Creek
Description	
River Basin	Neuse
length(ft)	
stream-to-edge width (ft)	
area (sq m)	
Required Plots (calculated)	
Sampled Plots	7

			Current Plot Data (MY5 2016)																				
			304-01-0001			304-01-0002			304-01-0003			304-01-0004			304-01-0005			304-01-0006			304-01-0007		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negundo	boxelder	Tree																		1			
Acer rubrum	red maple	Tree																		1			
Alnus serrulata	hazel alder	Shrub				1	1	1	1	1	1												
Aronia arbutifolia	Red Chokeberry	Shrub													1	1	1	3	3	3			
Baccharis	baccharis	Shrub												5			2			3			
Baccharis halimifolia	eastern baccharis	Shrub																					
Betula nigra	river birch	Tree												24			5			1			
Carya illinoinensis	pecan	Tree												1									
Celtis	hackberry	Tree																					
Celtis laevigata	sugarberry	Tree																					
Celtis occidentalis	common hackberry	Tree																					
Cephalanthus occidentalis	common buttonbush	Shrub	1	1	1				2	2	2				1	1	1						
Cercis canadensis	eastern redbud	Tree						1															
Clethra alnifolia	coastal sweetpepperbu	Shrub				1	1	1															
Cornus	dogwood	Shrub or T	1	1	1																		
Cornus amomum	silky dogwood	Shrub	3	3	3		1	1															
Diospyros virginiana	common persimmon	Tree				1	1	2									1			1			1
Elaeagnus umbellata	autumn olive	Exotic																					
Fraxinus pennsylvanica	green ash	Tree							4	4	4	2	2	2	2	2	2	1	1	3			
Juniperus virginiana	eastern redcedar	Tree												5									
Ligustrum sinense	Chinese privet	Exotic																					
Liquidambar styraciflua	sweetgum	Tree			6			4			6			7			61			36			39
Liriodendron tulipifera	tuliptree	Tree				1	1	1	1	1	1						8			3			
Morella cerifera	wax myrtle	shrub																					2
Myrica gale	sweetgale	Shrub															1			1			
Nyssa sylvatica	blackgum	Tree																					
Pinus taeda	loblolly pine	Tree			2			30			20			39			73			47			22
Platanus occidentalis	American sycamore	Tree	1	1	1	4	4	4	4	4	4	5	5	5			4	2	2	3	3	3	9
Quercus laurifolia	laurel oak	Tree													1	1	1						
Quercus michauxii	swamp chestnut oak	Tree																1	1	1			
Quercus nigra	water oak	Tree																					
Quercus palustris	pin oak	Tree													1	1	1						
Quercus phellos	willow oak	Tree													3	3	4						
Salix nigra	black willow	Tree																					
Salix sericea	silky willow	Shrub				1	3	3															
Sambucus canadensis	Common Elderberry	Shrub																					
Ulmus alata	winged elm	Tree																					
Ulmus americana	American elm	Tree																					1
Unknown		Shrub or Tree																					
Viburnum dentatum	southern arrowwood	Shrub																					
	Stem count		6	6	14	9	12	48	12	12	38	7	7	88	9	9	165	7	7	104	3	3	74
	size (ares)		1			1			1			1			1			1			1		
	size (ACRES)		0.02			0.02			0.02			0.02			0.02			0.02			0.02		
	Species count		4	4	6	6	7	10	5	5	7	2	2	8	6	6	14	4	4	13	1	1	6
	Stems per ACRE		243	243	567	364	486	1942	486	486	1538	283	283	3561	364	364	6677	283	283	4209	121	121	2995

Table 9. CVS Stem Count Total and Planted by Plot and Species
Paschal Golf Course (Richland Creek) / Project No. 276

Scientific Name	Common Name	Species Type	Annual Means																	
			MY5 (2016)			MY4 (2014)			MY3 (2013)			MY2 (2012)			MY1 (2011)			MY0 (2010)		
			PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negu	boxelder	Tree			1			3												
Acer rubru	red maple	Tree			1															
Alnus serr	hazel alde	Shrub	2	2	2	5	5	6	6	6	6	6	6	6	6	6	6	8	8	8
Aronia arb	Red Choke	Shrub	4	4	4	7	7	7	9	9	9	13	13	13	7	7	7			
Baccharis	baccharis	Shrub			10									1						
Baccharis	eastern ba	Shrub						13												
Betula nig	river birch	Tree			30			116			63			33			1			
Carya illin	pecan	Tree			1															
Celtis	hackberry	Tree							2	2	2	2	2	2	3	3	3	3	3	3
Celtis laev	sugarberr	Tree				2	2	2												
Celtis occi	common h	Tree																1	1	1
Cephalant	common b	Shrub	4	4	4	3	3	5	3	3	3	3	3	3	3	3	3	5	5	5
Cercis can	eastern re	Tree			1															
Clethra al	coastal sw	Shrub	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Cornus	dogwood	Shrub or T	1	1	1															
Cornus am	silky dogw	Shrub	3	4	4	5	7	8	5	9	9	5	11	11	9	19	19	18	54	54
Diospyros	common p	Tree	1	1	5	2	2	7	2	2	2	1	1	1	2	2	2	4	4	4
Elaeagnus	autumn ol	Exotic									1									
Fraxinus p	green ash	Tree	9	9	11	9	9	13	6	6	8	7	7	8	8	8	8	8	8	8
Juniperus	eastern re	Tree			5			7												
Ligustrum	Chinese p	Exotic									5									
Liquidamb	sweetgum	Tree			159			366			135			84			2			
Liriodendr	tuliptree	Tree	2	2	13	4	4	10			1			2			2			
Morella ce	wax myrtl	shrub			2			6												
Myrica gal	sweetgale	Shrub			2															
Nyssa sylv	blackgum	Tree										2	2	7	4	4	7	5	5	5
Pinus taed	loblolly pi	Tree			233			414			952			657			10			
Platanus o	American	Tree	19	19	30	19	19	33	19	19	32	19	19	32	19	19	31	20	20	20
Quercus la	laurel oak	Tree	1	1	1	1	1	1	1	1	1	1	1	1						
Quercus n	swamp ch	Tree	1	1	1	1	1	1	1	1	1				1	1	1	1	1	1
Quercus n	water oak	Tree																1	1	1
Quercus p	pin oak	Tree	1	1	1	1	1	1												
Quercus p	willow oa	Tree	3	3	4	4	4	12	3	3	3	3	3	4	4	4	4	6	6	6
Salix nigra	black willo	Tree						4			3									
Salix seric	silky willo	Shrub	1	3	3	1	3	3	1	4	4	1	4	8	1	20	20	1	21	21
Sambucus	Common	Shrub														1	1	1	12	12
Ulmus ala	winged el	Tree									2									
Ulmus am	American	Tree			1			18												
Unknown		Shrub or Tree													8	10	10	28	40	40
Viburnum	southern a	Shrub							1	1	1	1	1	1	1	1	1	1	1	1
Stem count			53	56	531	67	71	1059	62	69	1246	67	76	877	79	111	141	114	193	193
size (ares)			7			7			7			7			7			7		
size (ACRES)			0.17			0.17			0.17			0.17			0.17			0.17		
Species count			15	15	27	15	15	24	14	14	22	14	14	19	15	16	20	17	17	17
Stems per ACRE			306	324	3070	387	410	6122	358	399	7203	387	439	5070	457	642	815	659	1116	1116

Appendix D

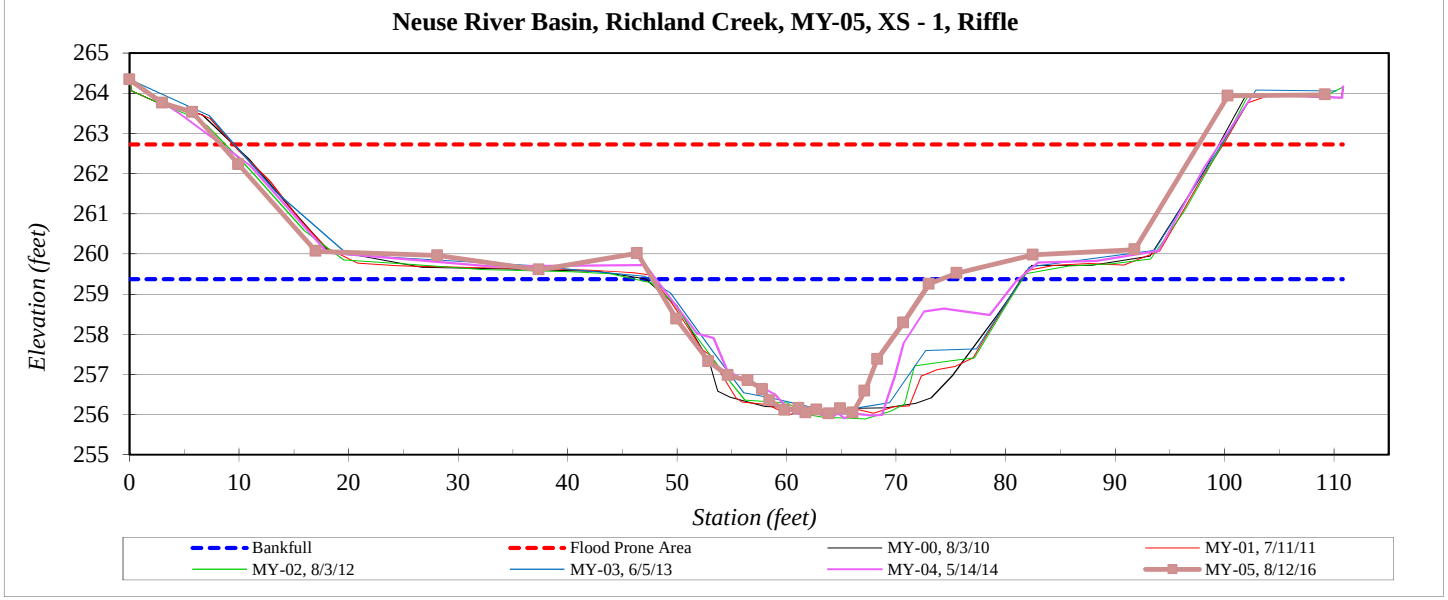
Stream Survey Data

Cross-Section Plots

River Basin:	Neuse
Watershed:	Richland Creek, MY-05
XS ID	XS - 1, Riffle
Drainage Area (sq mi):	7.8
Date:	8/12/2016
Field Crew:	T. Seelinger, R Jones

Station	Elevation
0.0	264.34
3.0	263.75
5.7	263.53
10.0	262.23
17.0	260.07
28.1	259.96
37.4	259.60
46.4	260.01
49.9	258.38
52.9	257.32
54.6	256.98
56.5	256.85
57.8	256.63
58.5	256.35
59.8	256.11
61.1	256.16
61.8	256.05
62.8	256.12
63.9	256.02
64.9	256.15
66.0	256.04
67.1	256.58
68.3	257.38
70.7	258.28
73.0	259.25
75.6	259.52
82.5	259.98
91.8	260.11
100.3	263.93
109.2	263.96
109.3	264.15

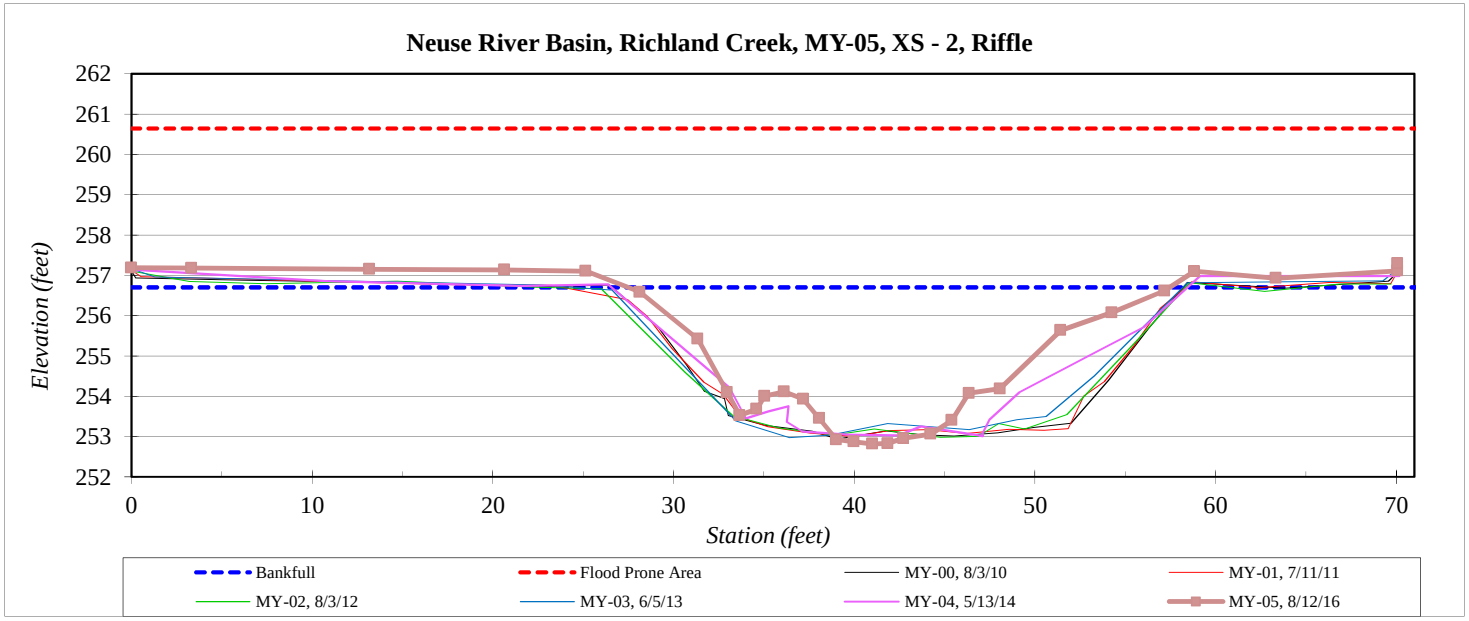
SUMMARY DATA	
Bankfull Elevation:	259.4
Bankfull Cross-Sectional Area:	55.5
Bankfull Width:	26.4
Flood Prone Area Elevation:	262.7
Flood Prone Width:	89.3
Max Depth at Bankfull:	3.4
Mean Depth at Bankfull:	2.1
W / D Ratio:	12.5
Entrenchment Ratio:	3.4
Bank Height Ratio:	1.0



River Basin:	Neuse
Watershed:	Richland Creek, MY-05
XS ID	XS - 2, Riffle
Drainage Area (sq mi):	7.8
Date:	8/12/2016
Field Crew:	T. Seelinger, R Jones

Station	Elevation
0.0	257.19
3.3	257.18
13.2	257.15
20.6	257.14
25.1	257.10
28.1	256.59
31.3	255.42
33.0	254.10
33.7	253.53
34.6	253.68
35.0	254.00
36.1	254.11
37.2	253.93
38.1	253.45
39.0	252.92
40.0	252.87
41.0	252.82
41.8	252.83
42.7	252.95
44.2	253.06
45.4	253.40
46.3	254.08
48.1	254.19
51.4	255.63
54.3	256.07
57.2	256.62
58.8	257.10
63.3	256.93
70.1	257.11
70.1	257.29

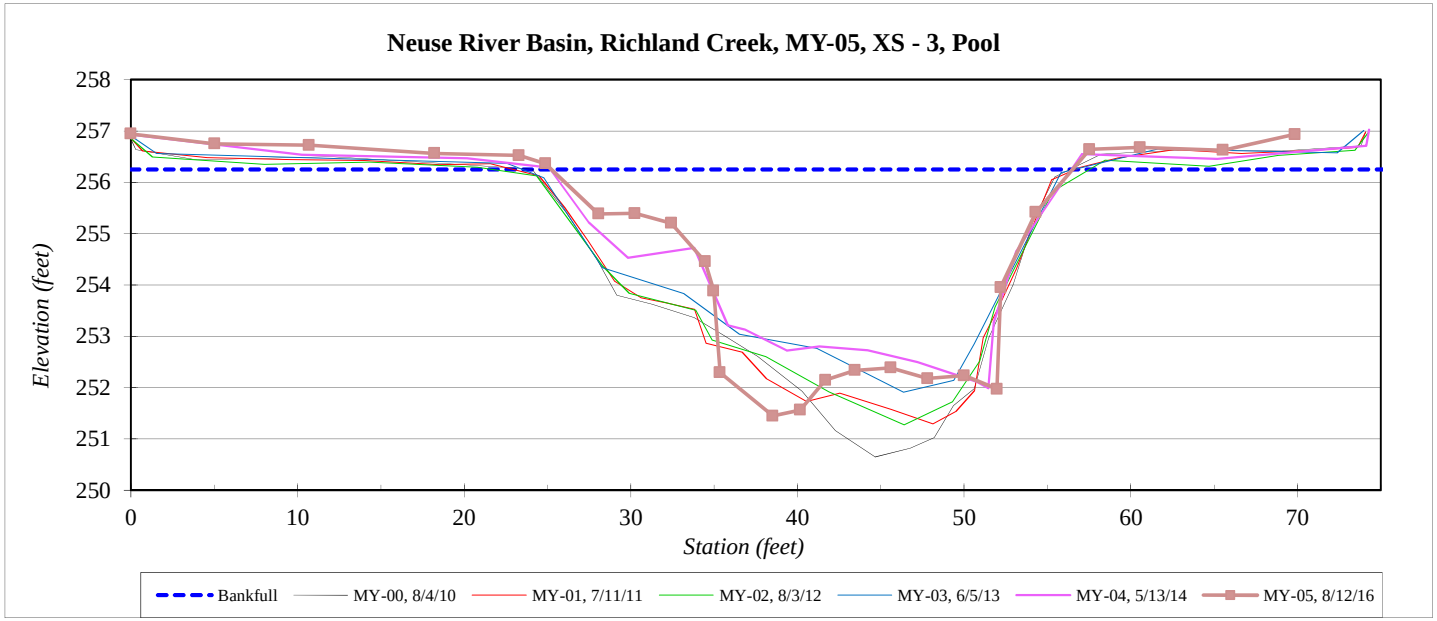
SUMMARY DATA	
Bankfull Elevation:	256.7
Bankfull Cross-Sectional Area:	65.6
Bankfull Width:	30.4
Flood Prone Area Elevation:	260.6
Flood Prone Width:	> 70
Max Depth at Bankfull:	3.9
Mean Depth at Bankfull:	2.2
W / D Ratio:	14.1
Entrenchment Ratio:	2.3
Bank Height Ratio:	1.0



River Basin:	Neuse
Watershed:	Richland Creek, MY-05
XS ID	XS - 3, Pool
Drainage Area (sq mi):	7.8
Date:	8/12/2016
Field Crew:	T. Seelinger, R Jones

Station	Elevation
0.0	256.94
5.0	256.75
10.7	256.72
18.2	256.56
23.3	256.52
24.9	256.36
28.1	255.38
30.2	255.39
32.4	255.20
34.5	254.46
35.0	253.88
35.4	252.29
38.5	251.45
40.2	251.56
41.7	252.14
43.4	252.33
45.6	252.38
47.8	252.18
50.0	252.23
52.0	251.97
52.2	253.95
54.3	255.41
57.5	256.64
60.6	256.68
65.5	256.62
69.9	256.93

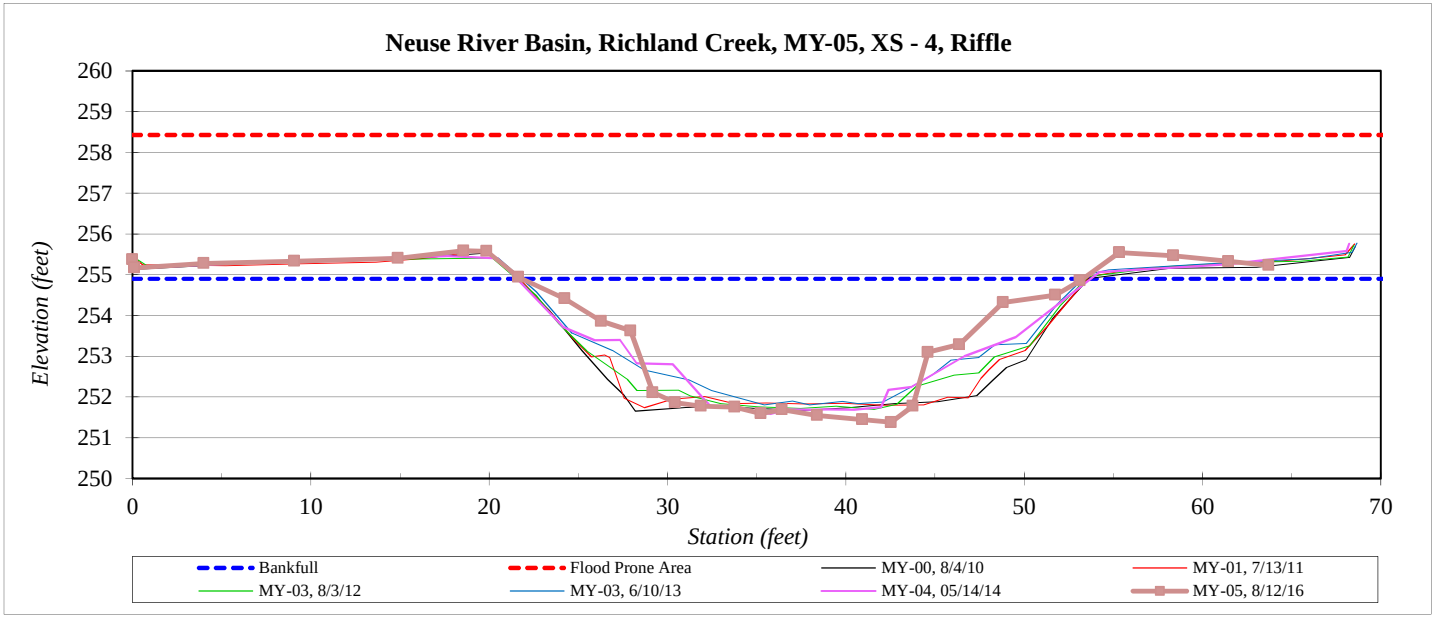
SUMMARY DATA	
Bankfull Elevation:	256.3
Bankfull Cross-Sectional Area:	85.2
Bankfull Width:	31.3
Flood Prone Area Elevation:	-
Flood Prone Width:	-
Max Depth at Bankfull:	4.8
Mean Depth at Bankfull:	2.7
W / D Ratio:	11.5
Entrenchment Ratio:	-
Bank Height Ratio:	-



River Basin:	Neuse
Watershed:	Richland Creek, MY-05
XS ID	XS - 4, Riffle
Drainage Area (sq mi):	7.8
Date:	8/12/2016
Field Crew:	T. Seelinger, R Jones

Station	Elevation
0.0	255.37
0.1	255.17
4.0	255.28
9.1	255.33
14.9	255.40
18.6	255.59
19.9	255.58
21.6	254.94
24.2	254.41
26.3	253.86
27.9	253.62
29.2	252.11
30.4	251.86
31.9	251.78
33.8	251.75
35.2	251.60
36.4	251.69
38.4	251.55
40.9	251.45
42.5	251.38
43.8	251.78
44.6	253.10
46.4	253.29
48.8	254.32
51.8	254.50
53.1	254.86
55.3	255.54
58.4	255.47
61.45	255.33
63.72	255.23

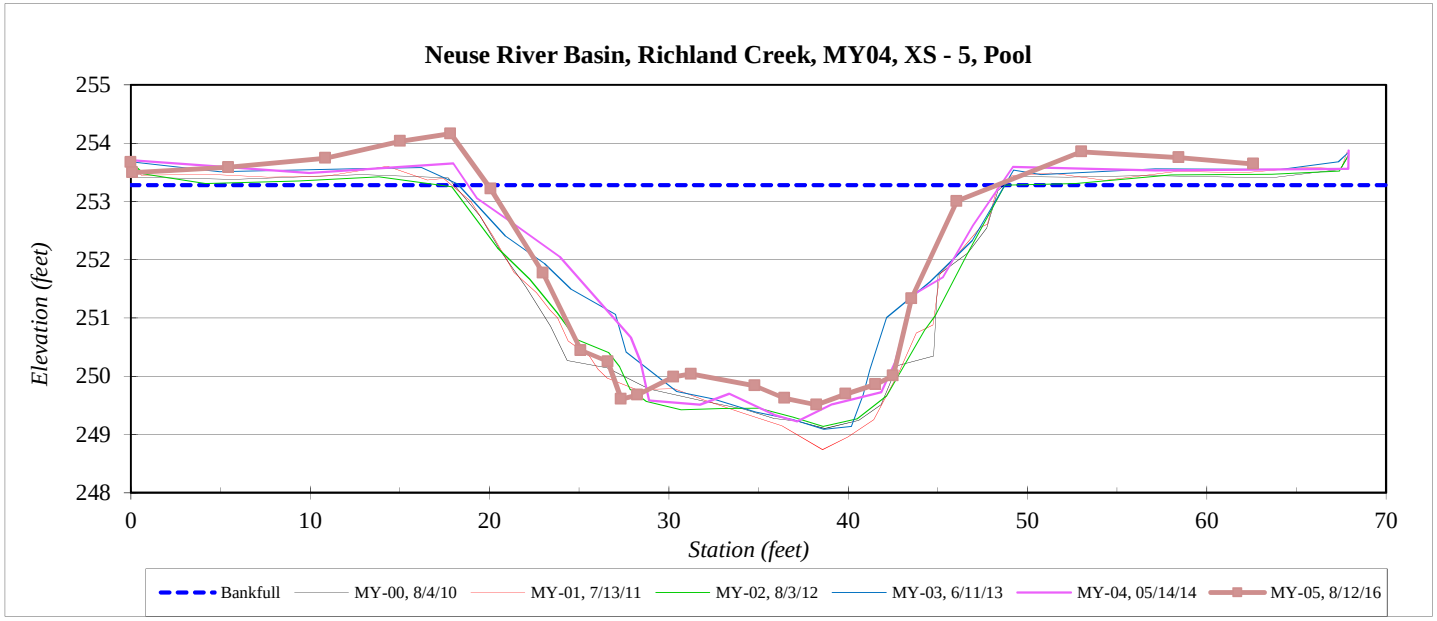
SUMMARY DATA	
Bankfull Elevation:	254.9
Bankfull Cross-Sectional Area:	63.8
Bankfull Width:	31.4
Flood Prone Area Elevation:	258.4
Flood Prone Width:	> 68
Max Depth at Bankfull:	3.5
Mean Depth at Bankfull:	2.0
W / D Ratio:	15.5
Entrenchment Ratio:	2.0
Bank Height Ratio:	1.0



River Basin:	Neuse
Watershed:	Richland Creek, MY-05
XS ID	XS - 5, Pool
Drainage Area (sq mi):	7.8
Date:	8/12/2016
Field Crew:	T. Seelinger, R Jones

Station	Elevation
0.0	253.67
0.1	253.49
5.4	253.58
10.8	253.74
15.0	254.03
17.8	254.16
20.1	253.21
23.0	251.77
25.1	250.44
26.6	250.25
27.3	249.61
28.2	249.68
30.3	249.99
31.2	250.04
34.8	249.84
36.5	249.62
38.2	249.51
39.9	249.69
41.5	249.86
42.5	250.01
43.5	251.33
46.1	253.00
53.0	253.85
58.4	253.75
62.6	253.64

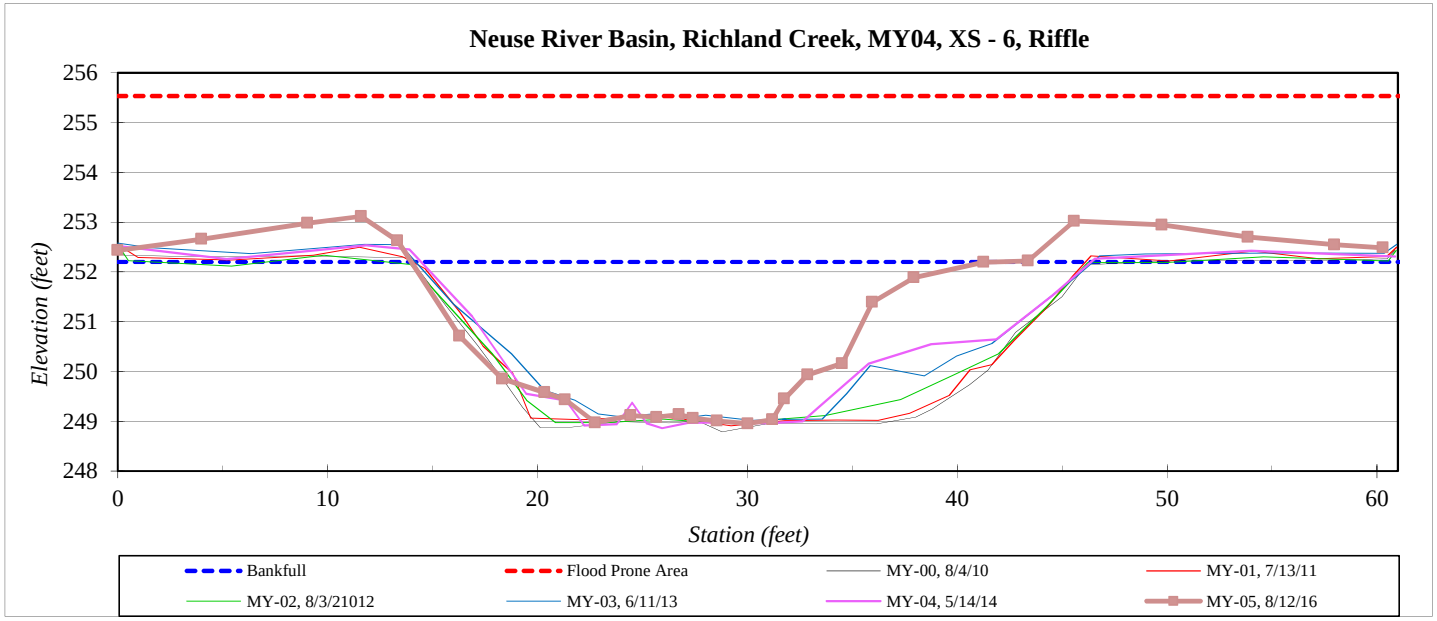
SUMMARY DATA	
Bankfull Elevation:	253.3
Bankfull Cross-Sectional Area:	76.3
Bankfull Width:	29.7
Flood Prone Area Elevation:	-
Flood Prone Width:	-
Max Depth at Bankfull:	3.9
Mean Depth at Bankfull:	2.6
W / D Ratio:	11.5
Entrenchment Ratio:	-
Bank Height Ratio:	1.0



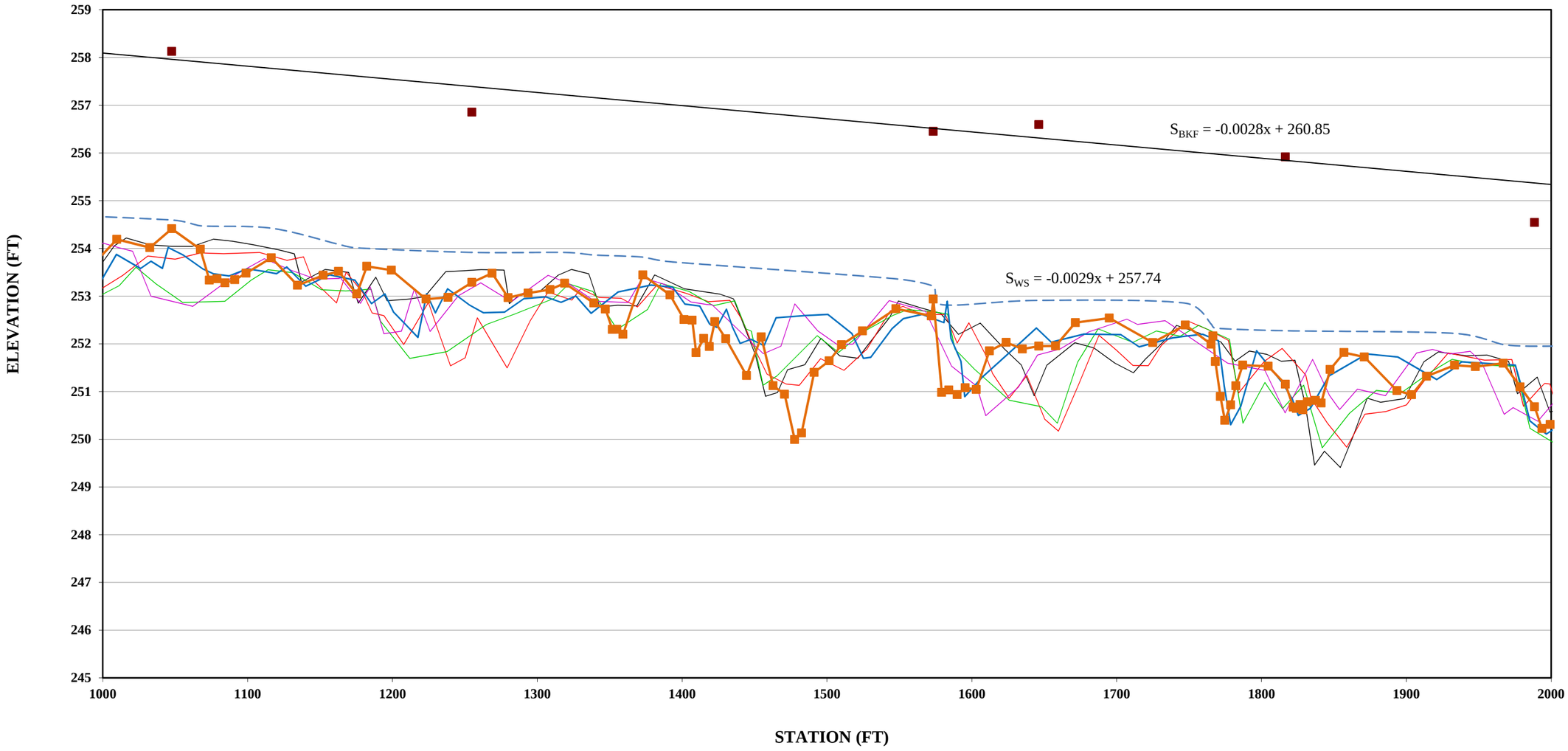
River Basin:	Neuse
Watershed:	Richland Creek, MY-05
XS ID	XS - 6, Riffle
Drainage Area (sq mi):	7.8
Date:	8/12/2016
Field Crew:	T. Seelinger, R Jones

Station	Elevation
0.0	252.43
4.0	252.66
9.0	252.98
11.6	253.12
13.3	252.63
16.3	250.71
18.3	249.86
20.3	249.58
21.3	249.43
22.8	248.97
24.4	249.12
25.7	249.08
26.7	249.14
27.4	249.06
28.6	249.01
30.0	248.95
31.2	249.03
31.8	249.45
32.9	249.93
34.5	250.16
36.0	251.39
37.9	251.89
41.3	252.20
43.4	252.22
45.6	253.02
49.7	252.95
53.9	252.70
58.0	252.55
60.3	252.49

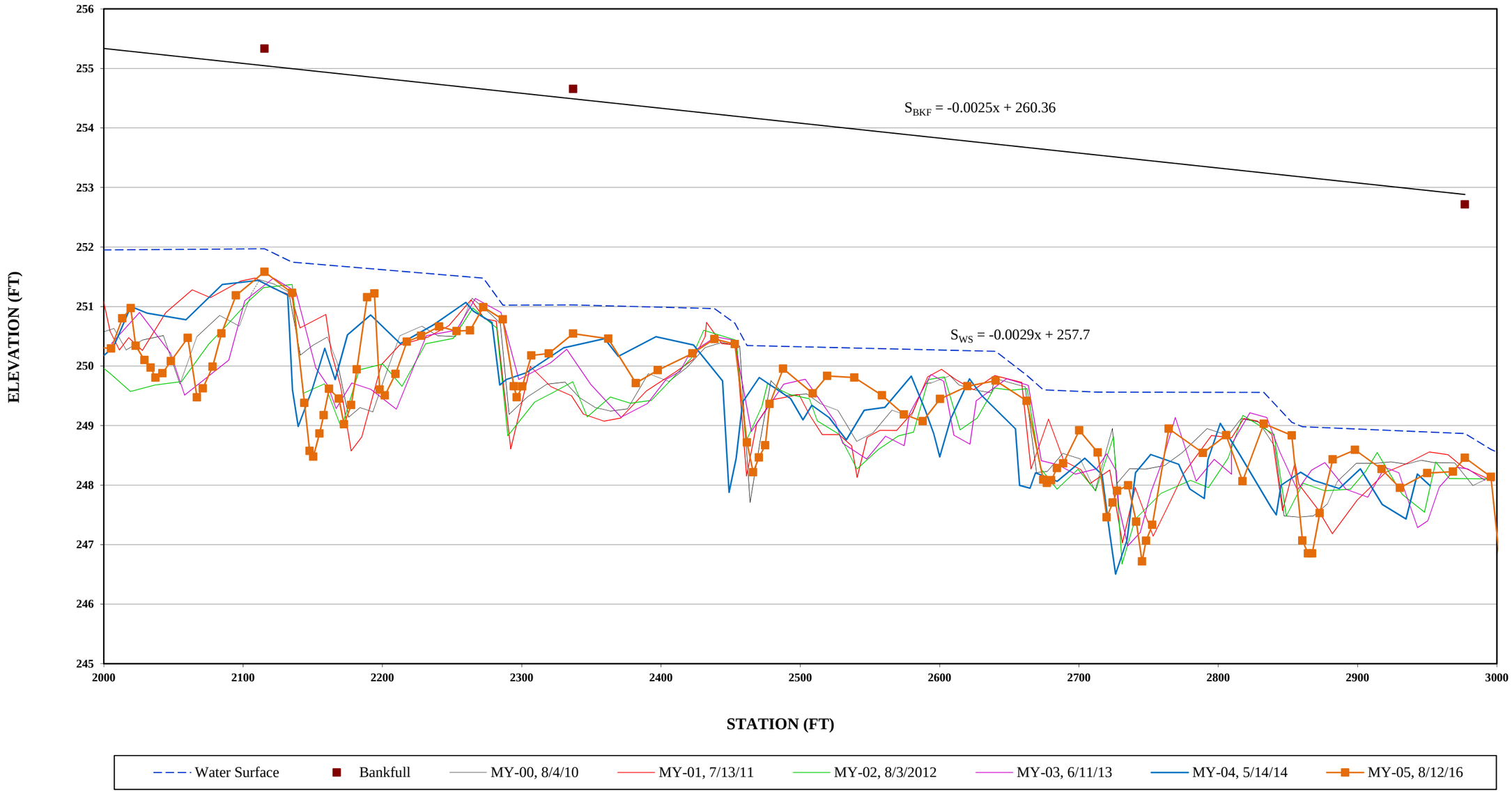
SUMMARY DATA	
Bankfull Elevation:	252.2
Bankfull Cross-Sectional Area:	58.5
Bankfull Width:	29.7
Flood Prone Area Elevation:	255.5
Flood Prone Width:	56.3
Max Depth at Bankfull:	3.3
Mean Depth at Bankfull:	2.0
W / D Ratio:	15.0
Entrenchment Ratio:	1.9
Bank Height Ratio:	1.0



Longitudinal Profile
Richland Creek
DMSProject Number 304, MY-05
Stations 10+00 - 20+00



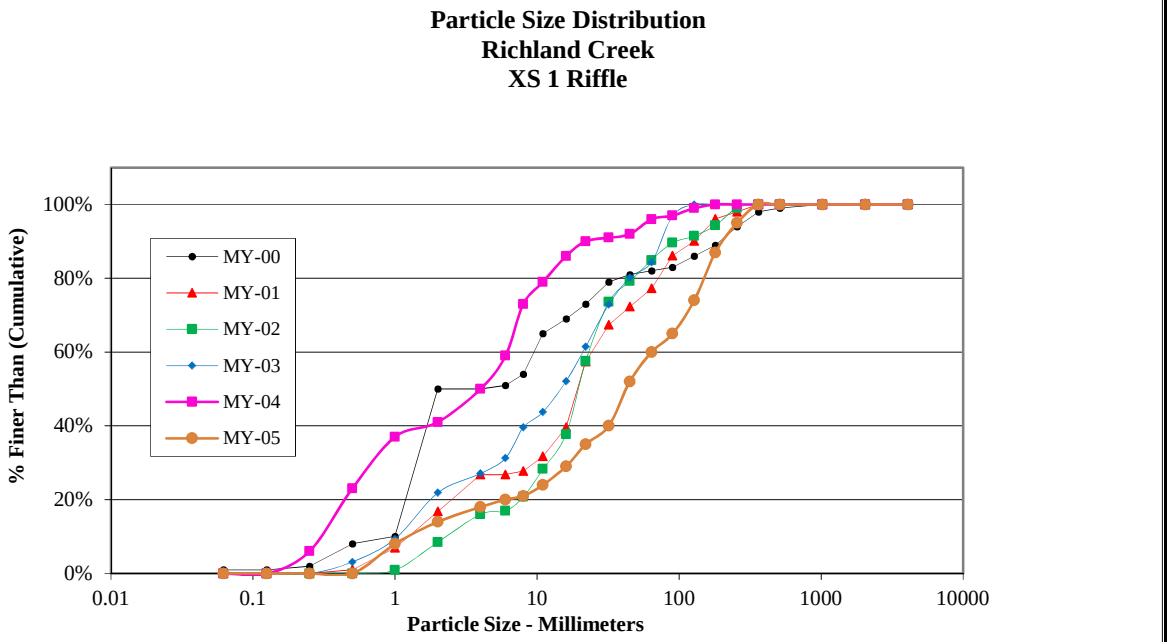
Longitudinal Profile
Richland Creek
DMS Project Number 304, MY-05
Stations 20+00 - 30+00



Pebble Count Plots

Cross-Section 1 Riffle - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	
Coarse	.50 - 1	D	8
Very Coarse	1 - 2	S	6
Very Fine	2 - 4		4
Fine	4 - 5.7	G	2
Fine	5.7 - 8	R	1
Medium	8 - 11.3	A	3
Medium	11.3 - 16	V	5
Coarse	16 - 22.6	E	6
Coarse	22.6 - 32	L	5
Very Coarse	32 - 45	S	12
Very Coarse	45 - 64		8
Small	64 - 90	C	5
Small	90 - 128	O	9
Large	128 - 180	B	13
Large	180 - 256	L	8
Small	256 - 362	B	5
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:

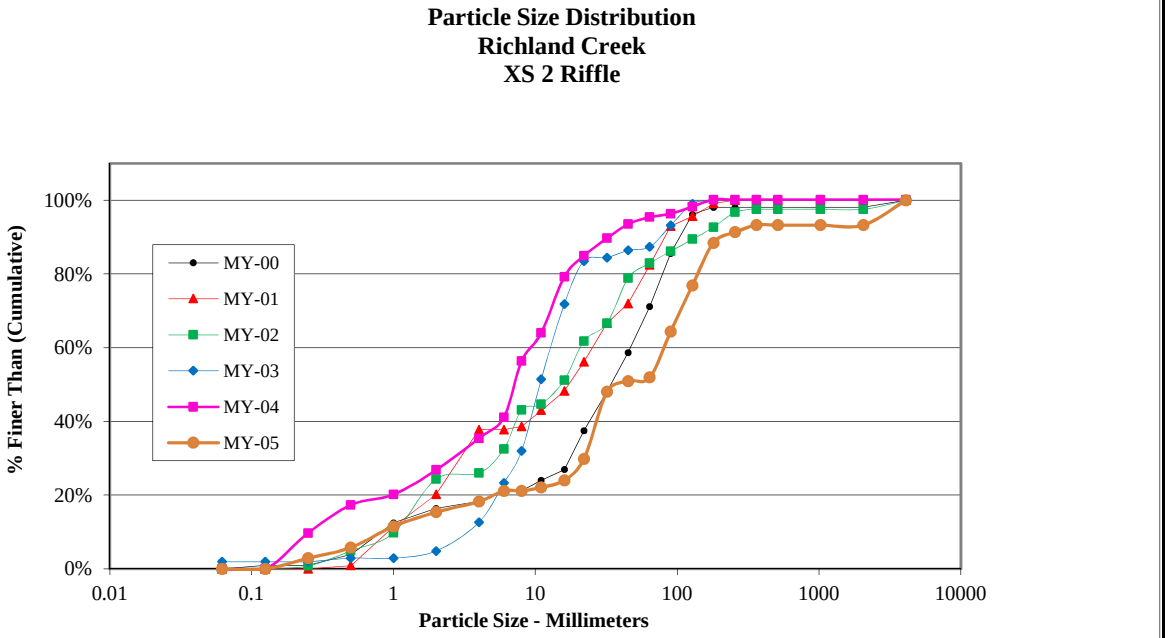


Size (mm)	
D16	1
D35	16
D50	30
D65	64
D84	118
D95	180

Size Distribution	
mean	12.9
dispersion	12.6
skewness	-0.27

Type	
silt/clay	0%
sand	14%
gravel	46%
cobble	35%
boulder	5%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 2 Riffle - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	3
Medium	.25 - .50	N	3
Coarse	.50 - 1	D	6
Very Coarse	1 - 2	S	4
Very Fine	2 - 4		3
Fine	4 - 5.7	G	3
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	1
Medium	11.3 - 16	V	2
Coarse	16 - 22.6	E	6
Coarse	22.6 - 32	L	19
Very Coarse	32 - 45	S	3
Very Coarse	45 - 64		1
Small	64 - 90	C	13
Small	90 - 128	O	13
Large	128 - 180	B	12
Large	180 - 256	L	3
Small	256 - 362	B	2
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	7
		Total	104
Note:			



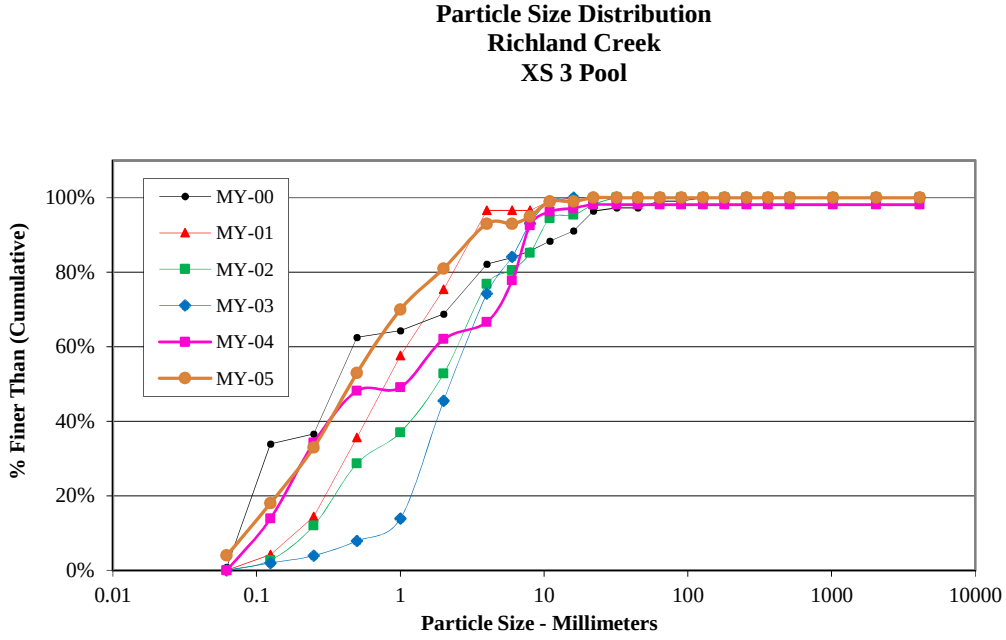
Size (mm)	
D16	1
D35	18
D50	28
D65	65
D84	112
D95	1224

Size Distribution	
mean	11.4
dispersion	14.2
skewness	-0.28

Type	
silt/clay	0%
sand	15%
gravel	37%
cobble	39%
boulder	2%
bedrock	7%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 3 Pool - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	4
Very Fine	.062 - .125	S	14
Fine	.125 - .25	A	15
Medium	.25 - .50	N	20
Coarse	.50 - 1	D	17
Very Coarse	1 - 2	S	11
Very Fine	2 - 4		12
Fine	4 - 5.7	G	
Fine	5.7 - 8	R	2
Medium	8 - 11.3	A	4
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	1
Coarse	22.6 - 32	L	
Very Coarse	32 - 45	S	
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:



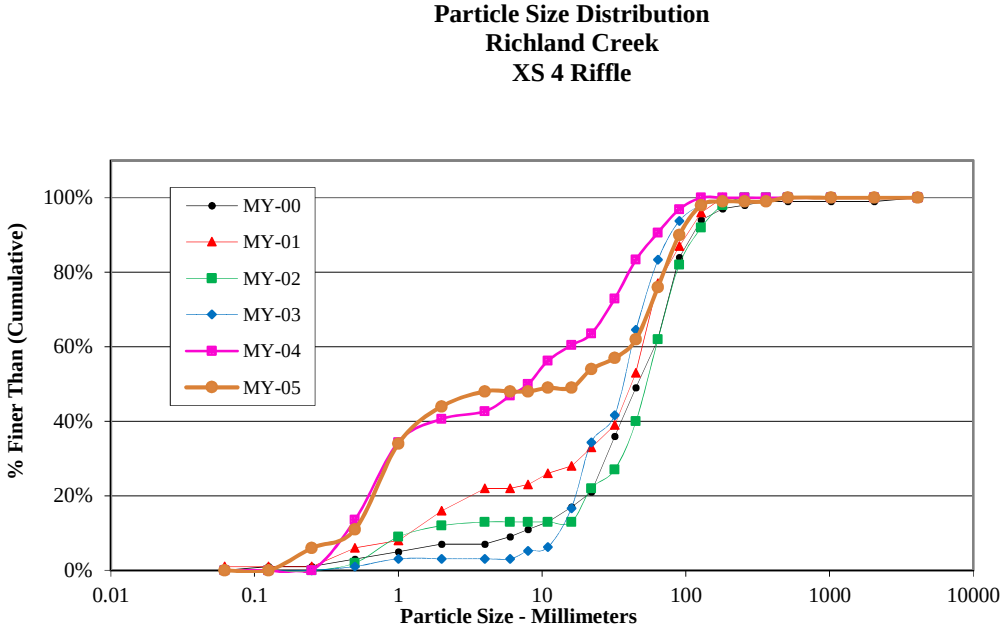
Size (mm)	
D16	0.0
D35	0.1
D50	0.2
D65	0.4
D84	1.2
D95	5.7

Size Distribution	
mean	0.2
dispersion	5.0
skewness	0.02

Type	
silt/clay	4%
sand	77%
gravel	19%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 4 Riffle - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	6
Medium	.25 - .50	N	5
Coarse	.50 - 1	D	23
Very Coarse	1 - 2	S	10
Very Fine	2 - 4		4
Fine	4 - 5.7	G	
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	1
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	5
Coarse	22.6 - 32	L	3
Very Coarse	32 - 45	S	5
Very Coarse	45 - 64		14
Small	64 - 90	C	14
Small	90 - 128	O	8
Large	128 - 180	B	1
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	1
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:



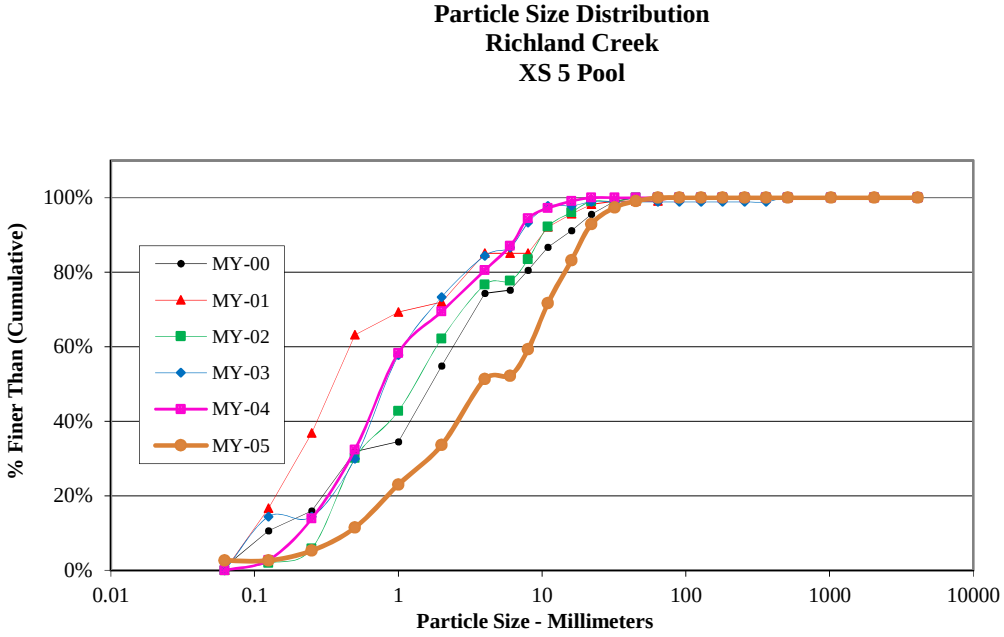
Size (mm)	
D16	0
D35	1
D50	12
D65	34
D84	55
D95	79

Size Distribution	
mean	4.0
dispersion	23.1
skewness	-0.32

Type	
silt/clay	0%
sand	44%
gravel	32%
cobble	23%
boulder	1%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 5 Pool - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	3
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	3
Medium	.25 - .50	N	7
Coarse	.50 - 1	D	13
Very Coarse	1 - 2	S	12
Very Fine	2 - 4		20
Fine	4 - 5.7	G	1
Fine	5.7 - 8	R	8
Medium	8 - 11.3	A	14
Medium	11.3 - 16	V	13
Coarse	16 - 22.6	E	11
Coarse	22.6 - 32	L	5
Very Coarse	32 - 45	S	2
Very Coarse	45 - 64		1
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	113

Note:



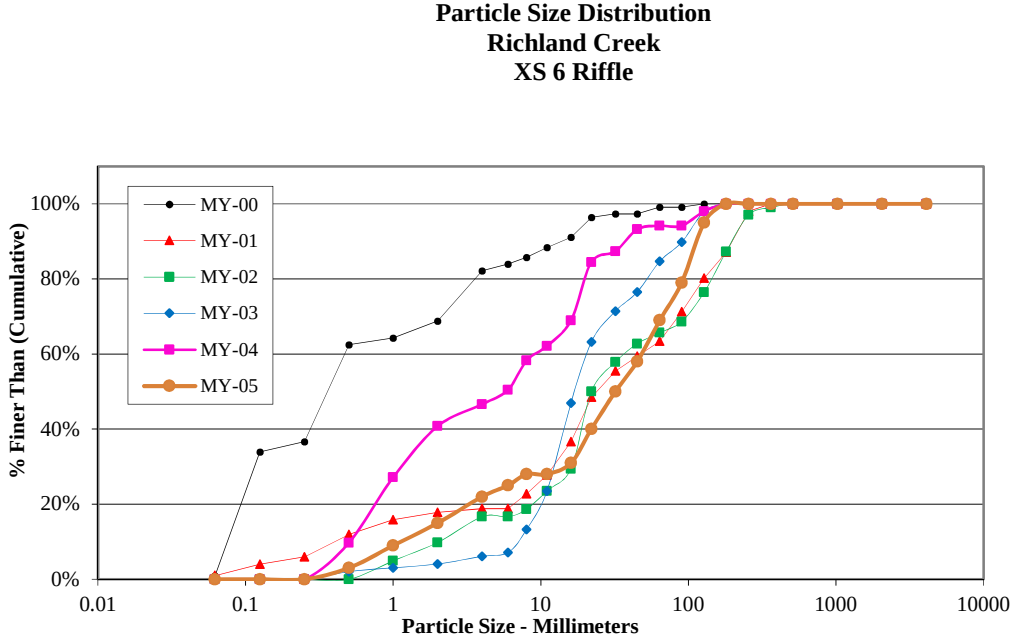
Size (mm)	
D16	0
D35	1
D50	2
D65	7
D84	12
D95	19

Size Distribution	
mean	2.0
dispersion	6.0
skewness	0.01

Type	
silt/clay	3%
sand	31%
gravel	66%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 6 Riffle - MY-05			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	3
Coarse	.50 - 1	D	6
Very Coarse	1 - 2	S	6
Very Fine	2 - 4		7
Fine	4 - 5.7	G	3
Fine	5.7 - 8	R	3
Medium	8 - 11.3	A	
Medium	11.3 - 16	V	3
Coarse	16 - 22.6	E	9
Coarse	22.6 - 32	L	10
Very Coarse	32 - 45	S	8
Very Coarse	45 - 64		11
Small	64 - 90	C	10
Small	90 - 128	O	16
Large	128 - 180	B	5
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	1
D35	13
D50	23
D65	40
D84	71
D95	90

Size Distribution	
mean	8.9
dispersion	11.8
skewness	-0.30

Type	
silt/clay	0%
sand	15%
gravel	54%
cobble	31%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Table 10. Baseline Stream Data Summary: Richland Creek - 2,919 lf
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 11a. Monitoring - Cross-Section Morphology Data
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	33.6	35.4	34.0	33.1	26.4		31.9	35.2	35.6	33.6	31.9	30.4		31.4	33.9	36.1	33.2	31.3	31.3		32.1	31.9	31.9	31.5	32.2	31.4		31.5	32.5	31.9	30.5	29.7	29.7	
Floodprone Width (ft)	>90	>90	>90	>90	>90	>90		>70	>70	>70	>70	>70	>70		-	-	-	-	-	-		>68	>68	>68	>68	>68	>68		-	-	-	-	-	-	
Bankfull Mean Depth (ft)	2.4	2.4	2.2	2.1	1.9	2.1		2.8	2.5	2.5	2.5	2.4	2.2		3.3	2.9	2.7	2.6	2.5	2.7		2.5	2.4	2.3	2.1	2.1	2.0		2.9	2.8	2.7	2.4	2.5	2.6	
Bankfull Max Depth (ft)	3.4	3.4	3.5	3.3	3.5	3.4		3.8	3.8	3.7	3.7	3.7	3.9		5.6	5.0	5.0	4.3	4.3	4.8		3.3	3.2	3.2	3.1	3.3	3.5		4.3	4.7	4.1	4.2	4.1	3.9	
Bankfull Cross-Sectional Area (ft^2)	81.7	79.9	78.5	72.1	63.8	55.5		89.3	88.5	87.6	84.0	76.3	65.6		104.0	99.2	97.8	86.3	78.9	85.2		80.2	76.5	73.1	66.6	67.2	63.8		90.8	90.6	85.0	74.4	73.3	76.3	
Bankfull Width/Depth Ratio	14.5	14.1	16.0	16.0	17.2	12.5		11.4	14.0	14.5	13.5	13.3	14.1		-	-	-	-	-	-		12.8	13.3	13.9	14.9	15.4	15.5		-	-	-	-	-	-	
Bankfull Entrenchment Ratio	>2.0	>2.0	>2.2	>2.2	>2.8	3.4		>2.0	>1.8	>2.0	>2.0	>2.0	>2.3		-	-	-	-	-	-		>2.0	>2.1	>2.2	>2.2	>2.2	>2.0		-	-	-	-	-	-	
Bankfull Bank Height Ratio	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0		-	-	-	-	-	-		1.0	1.0	1.0	1.0	1.0	1.0		-	-	-	-	-	-	
Cross-Sectional Area Between End Pins (ft^2)	477.5	478.0	477.4	460.5	479.8	457.3		111.4	108.6	114.4	110.9	85.4	89.2		135.7	134.2	135.6	123.3	123.0	116.9		100.1	100.6	96.2	105.9	100.1	80.2		106.4	110.6	107.4	99.8	102.8	85.2	
d50 (mm)	2.0	19.0	20.0	20.0	6.0	30.0		34.0	17.0	15.0	7.9	7.1	28		0.4	0.8	1.7	2.2	2.0	0.2		46.0	42.0	53.0	51.0	11.0	12.0		1.7	0.4	1.3	1.1	1.6	2.0	

	Cross-Section 6 (Riffle)						
Based on fixed baseline elevation	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	32.2	32.6	33.3	32.3	31.9	29.7	
Floodprone Width (ft)	>60	>60	>60	>60	>61	>61	
Bankfull Mean Depth (ft)	2.7	2.5	2.3	2.2	2.2	2.0	
Bankfull Max Depth (ft)	3.5	3.4	3.2	3.2	3.3	3.3	
Bankfull Cross-Sectional Area (ft^2)	85.6	82.2	77.9	70.2	69.7	58.5	
Bankfull Width/Depth Ratio	12.1	12.9	14.2	14.8	14.6	15.0	
Bankfull Entrenchment Ratio	>1.9	>1.8	>1.9	>1.9	>1.9	>1.9	
Bankfull Bank Height Ratio	1.0	1.0	1.0	1.0	1.0	1.0	
Cross-Sectional Area Between End Pins (ft^2)	94.3	94.1	92.1	87.1	81.2	64.6	
d50 (mm)	44.0	24.0	22.0	23.0	7.7	23.0	

Table 11b. Monitoring - Stream Reach Morphology Data Table
Paschal Golf Course (Richland Creek) / Project No. 276
Richland Creek (2,919 ft.)

Parameter	MY01 (2011)						MY02 (2012)						MY03 (2013)						MY04 (2014)						MY05 (2015)					
Dimension	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
Bankfull Width (ft)	31.9	34.2	33.1	35.2	3.0	4	31.9	34.1	34.4	35.6	1.8	4	30.5	32.5	32.8	34.0	1.3	4	31.5	32.9	33.0	34.0	1.2	4	26.3	28.7	28.5	31.4	2.4	4
Floodprone Width (ft)	68	72	69	90	13	4	60	72	69	89	12	4	60	73	69	92	12	4	60	70	70	90	13	4	60	70	70	90	13	4
Bankfull Mean Depth (ft)	2.3	2.4	2.4	2.5	0.1	4	2.2	2.3	2.3	2.5	0.1	4	2.1	2.3	2.3	2.6	0.2	4	2.1	2.2	2.2	2.5	0.2	4	2.0	2.1	2.1	2.1	0.05	4
Bankfull Max Depth (ft)	3.2	3.5	3.4	3.8	0.3	4	3.2	3.4	3.4	3.7	0.2	4	3.1	3.6	3.5	4.3	0.5	4	3.1	3.4	3.4	3.7	0.3	4	3.2	3.5	3.4	3.9	0.3	4
Bankfull Cross-Sectional Area (ft^2)	76.5	81.8	81.1	88.6	5.1	4	73.1	79.3	78.2	87.6	6.1	4	66.6	75.6	73.3	86.3	7.9	4	66.6	73.2	71.2	84.0	7.5	4	55.3	59.6	59.7	63.8	4.7	4
Width/Depth Ratio	12.9	14.3	13.7	16.8	1.8	4	13.9	14.7	14.4	16.0	0.9	4	13.5	14.8	14.9	16.0	1.0	4	13.5	14.8	14.9	16.0	1.0	4	12.5	13.8	13.6	15.5	1.3	4
Entrenchment Ratio	1.8	1.9	1.9	2.1	0.2	4	1.8	2.1	2.1	2.6	0.3	4	1.9	2.2	2.2	2.7	0.3	4	1.9	2.2	2.2	2.7	0.3	4	2.0	2.5	2.2	3.4	0.6	4
Bank Height Ratio	1.0	1.0	1.0	1.0	0.0	4	1.0	1.0	1.0	1.0	0.0	4	1.0	1.0	1.0	1.0	0.0	4	1.0	1.0	1.0	1.0	0.0	4	1.0	1.0	1.0	1.0	0.0	4
Pattern																														
Channel Beltwidth (ft)	37	78	83	116	25	9																								
Radius of Curvature (ft)	80	91.1	90	100	9	9																								
Rad. of Curv. : Bankfull Width (ft/ft)	2.5	2.7	2.7	2.6																										
Meander Wavelength (ft)	259	321	312	395	45	11																								
Meander Width Ratio	1.2	2.3	2.5	3.0																										
Profile																														
Riffle Length (ft)	18.1	40.6	30.3	103.0	22.6	17	16.7	33.0	25.5	65.8	15.5	18	13.7	29.1	25.0	78.2	16.0	18	8.8	24.7	22.9	56.3	13.0	21	14.1	27.1	21.0	56.1	12.0	19
Riffle Slope (ft/ft)	0.001	0.010	0.008	0.020	0.006	17	0.002	0.010	0.010	0.030	0.010	18	0.001	0.023	0.008	0.010	0.006	18	0.001	0.615	0.017	12.591	2.744	21	0.003	0.013	0.013	0.032	0.008	19
Pool Length (ft)	31.0	71.8	73.6	121.5	24.5	17	11.5	67.8	77.8	119.9	30.7	17	8.9	77.6	73.7	128.5	32.4	16	7.2	25.4	24.8	45.5	10.0	17	9.8	27.1	23.5	63.3	15.8	24
Pool Max Depth (ft)	4.7	4.9	-	5.0	-	2	4.1	4.6	-	5.0	-	2	4.2	4.3	-	4.3	-	2	4.1	4.2	-	4.3	-	2	3.9	4.4	-	4.8	-	2
Pool Spacing (ft)	85.6	172.4	168.8	261.9	44.9	16	51.3	160.6	159.0	256.0	53.5	16	129.9	185.2	165.3	278.2	47.2	15	47.2	127.2	150.2	245.3	65.0	16	24.5	121.8	123.7	273.4	68.3	23
Additional Reach Parameters																														
Valley Length (ft)	2,710						2,710						2,710						2,710						2,710					
Channel Thalweg Length (ft)	2,919						2,919						2,919						2,919						2,919					
Sinuosity	1.1						1.1						1.1						1.1						1.1					
Water Surface Slope (ft/ft)	0.0032						0.0034						0.0034						0.0034						0.0033					
Bankfull Slope (ft/ft)	0.0029						0.0025						0.0025						0.0025						0.0026					
Rosgen Classification	C4						C4						C5						C5						C5					
SC% / Sa% / G% / C% / B% / Be%	0.33%/36%/47%/16%/0.67%						0%/29%/54%/16%/1%						0%/25%/67%/12%/0%/0%						0%/39%/55%/6%/0%						1%/33%/43%/21%/1%/1%					
d16 / d35 / d50 / d65/ d84 / d95	1.1/10/17/65/110						4.6/13/19/31/66/135						6.7/12/18/25/50/86						0.7/2.1/5.9/13.3/25.8/71.3						0.7/8.1/16/35/61/266					
% of Reach with Eroding Banks	1%						2%						5%						3%						1%					

Appendix E

Hydrology Data

Table 12. Verification of Bankfull Events Paschal Golf Course (Richland Creek) / Project No. 276			
Date of Data Collection	**Date of Occurrence**	**Method**	**Photo #**
5/17/2010	5/17/2010	Photographed on site	1, See Below
9/28/2011	9/16/2011	Crest gauge	None
11/5/2012	unknown	Crest gauge and indicators of storm event	None
6/10/2013	6/7/2013	Photographed on site	2, see below
11/15/2013	unknown	Photographed on site	3, see below
5/28/2014	unknown	Photographed on site	4, see below
11/10/2014	unknown	Photographed on site	5, see below
11/29/2016	10/8/2016	Nearby automatic rain gauge recorded 6.44" of rain, photos taken on site	6, see below

Photo #1 - Bankfull Event, 5/17/2010

Photo #2 – Bankfull Evidence (wrack lines), 6/10/2013

Photo #3 – Bankfull Evidence (wrack lines), 11/15/2013

Photo #4 – Bankfull Evidence (wrack lines), 5/28/2014

Photo #5 – Bankfull Evidence (wrack lines), 11/10/2014

Photo #6 – Bankfull Evidence (wrack lines), 11/29/2016