Horse Creek Stream Restoration
Mitigation Plan (Baseline Monitoring)
Wake County, North Carolina

North Carolina Department of Environment and Natural Resources
Ecosystem Enhancement Program

August 14, 2006

Design and 2005 (Year 0) Monitoring completed by:
Dewberry & Davis, Inc.
2301 Rexwoods Drive
Suite 200
Raleigh, NC 27606

NCEEP Project # 182
Dewberry Project # 02050

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Project Summary

The North Carolina Ecosystem Enhancement Program (EEP), formerly the North Carolina Wetland Restoration Program (WRP), identified Horse Creek, located on the Wake Forest Country Club (WFCC) property, as a stream restoration site. The majority of the stream bank length lacked naturally occurring vegetation which had resulted in increased bank erosion and reduced buffer filtration rates. The restoration of Horse Creek reattached the stream to the floodplain in a new alignment and increased the stream length and sinuosity. The Unnamed Tributary to Horse Creek (UT) was entrenched and lacked sinuosity. The design for the UT raised the channel elevation and reattached the stream to the floodplain along a new alignment.

Report Summary

This report serves as the mitigation report requirement of the project and consists of five sections:

- Executive Summary;
- Project Background Information;
- Project Condition and Monitoring Results (Vegetation and Stream Assessments),
- Methodology; and
- Report and Data Submission Format.

Figures, tables, and representative photographs have been included as appropriate in the text. Supplemental and Supporting information is included in the Appendix.

Summary of Results

Overall, Horse Creek and its Unnamed Tributary appear to be functioning well. Both the channel and the riparian area have been improved. Neither stream shows signs of bank erosion, aquatic and terrestrial habitats have been improved on each stream, and the maintenance staff has commented on the lower water levels during storm events. The dimension and pattern of the constructed stream seem to be comparable to the design in the majority of each stream.

The stream restoration has improved the following conditions:

- Reduction of downstream sedimentation by stabilizing eroding stream banks within the WFCC property;
- Replacement of a degraded stream reach with a stabilized stream which supports natural stream processes;
- Reduction in property loss within the WFCC property;
- Improved aquatic habitat, including pools for fish; and
- Improved aesthetics of the restored stream reach.

Additionally, the restoration of the riparian buffer expects to have the following benefits as the buffer matures:

- Improved aquatic habitat due to the reduction in water temperature from shading of riparian trees;

- Nitrogen reduction to Falls Lake and the Neuse River by establishing new riparian buffer to filter nutrients along the denuded reach within the WFCC;
- Additional source water protection for Falls Lake, the City of Raleigh's water supply; and
- Establishment of riparian corridor for wildlife between existing wooded areas.

Vegetative Results - Eighteen vegetative plots were monitored along Horse Creek and its Unnamed Tributary. Of the eighteen, only three had a full compliment of plants. Seven of the eighteen had 75 percent survival rate at this point in time. Eleven of the eighteen had less than the 75 percent survival rate that is required. Two (2) of the eighteen had zero (0) percent survival.

The vegetative assessment yielded 11 vegetative problem features along Horse Creek and its Unnamed Tributary. These features were identified as bare bank and bare floodplain. With the exception of two locations, vegetation had rooted on the stream bank. However, on the floodplain, vegetation was dead in several areas due to possible land owner maintenance and in other areas due to an undetermined cause. In addition to the problem areas discovered, stem counts were performed in eighteen 10m x 10m plots located to provide a representative sample of the entire project area. Stem Counts and Visual Assessments were made of the stream banks and surrounding floodplain. This analysis was used to determine if the planted vegetation has survived. A complete stream assessment methodology is discussed in Chapter Three.

Stream Results - The stream assessment yielded 11 possible problem areas along Horse Creek and its Unnamed Tributary. All of the areas in this section are labeled problem areas on the plan view; however, after further analysis the areas were divided into three categories within this report:

- Problem Areas;
- Areas of Concern; and
- Areas Differing from Design (labeled Areas of Difference).

Areas defined as Problem Areas are those that have already shown instability, likely to need continual monitoring, and possibly need maintenance in the future. Areas of Concern are reaches that show signs of change that may lead to instability in the future, but currently are stable. These areas should continue to be monitored, as they may or may not become unstable in the future. The third areas are Areas of Difference. Areas of Difference are areas that differ from the design in some way, but have stabilized. These areas are assumed to remain stable, but because deserve documentation due to their deviation from the design. There were three areas deemed Problem Areas, six areas deemed Areas of Concern, and two are Areas of Difference.

1 PROJECT BACKGROUND

The Horse Creek watershed is north of the City of Raleigh in Wake County, North Carolina. The watershed is located entirely within the Piedmont Physiographic Region and has a drainage area of approximately 22 square miles at its former confluence with the Neuse River. The Horse Creek watershed is roughly bounded by Falls Lake to the south, US 1 (Capital Boulevard) to the east, NC Highway 96 to the north, and State Roads (SR) 1922, 1923, and 1139 along the western watershed boundary. The northern watershed limit along NC Highway 96 forms the boundary between the Tar-Pamlico River basin to the north and the Neuse River basin to the south. The project site is located entirely on the Wake Forest Golf and Country Club. The drainage area at the upstream limit of the site is approximately 7.9 square miles and is 9.8 square miles at the downstream end of the project site.

1.1 LOCATION AND SETTING

From Raleigh, follow Capital Boulevard/US-1 North to Wake Forest. Wake Forest Country Club is on the left at 13239 Capital Boulevard. Access is no longer available through the Wake Forest Country Club drive and parking lot, as part of the unpaved access road has been sold. Access is available along a Town of Wake Forest sanitary sewer and power easement from a point on Jenkins Road approximately 2500 feet west of the intersection of Jenkins Road and Capital Boulevard/US-1 North. The project is entirely within the Wake Forest Country Club golf course property in Wake Forest, North Carolina.

1.2 STRUCTURE AND OBJECTIVES

Prior to restoration Horse Creek was a Rosgen Type C5/E5 stream and was identified as a stream restoration site by the North Carolina Ecosystem Enhancement Program (EEP), formerly the North Carolina Wetland Restoration Program (WRP). Although C and E stream types are usually stable, Horse Creek was actively eroding and the degradation of the stream and a lack of naturally occurring vegetation on the streambank resulted in bank erosion, reduced buffer filtration rates, sediment deposition, undercutting of streambank trees and a loss of in-stream features and habitat. Additionally, recent upstream development had begun to put increased stress on this site.

The overall mitigation strategy for Horse Creek called for an increase riffle pool features, shaping of the bankfull, and restoration and repair of the riparian buffer along the project reach. The stream restoration was designed to improve bank stability, reduce erosion rates, improve aquatic habitat, and replace or augment the vegetated riparian buffer.

In General, the restoration supported, wholly or in part, the following EEP goals:

- Protection and improvement of water quality by restoring wetland, stream and riparian area functions and values lost through historic, current, and future impacts.

Specifically, the stream restoration aimed to have the following benefits:

- Reduction of downstream sedimentation by stabilizing eroding stream banks within the WFCC property;
- Replacement of a degraded stream reach with a stabilized stream which supports natural stream processes;

- Reduction in property loss within the WFCC property;
- Improved aquatic habitat, including pools for fish, woody debris for habitat, and reduction in water temperature from shading of riparian trees; and
- Improved aesthetics of the restored stream reach.

Specifically, the restoration of the riparian buffer aimed to have the following benefits:

- Nitrogen reduction to Falls Lake and the Neuse River by establishing new riparian buffer to filter nutrients along the denuded reach within the WFCC;
- Additional source water protection for Falls Lake, the City of Raleigh's water supply; and
- Establishment of riparian corridor for wildlife between existing wooded areas.

1.3 PROJECT HISTORY AND BACKGROUND

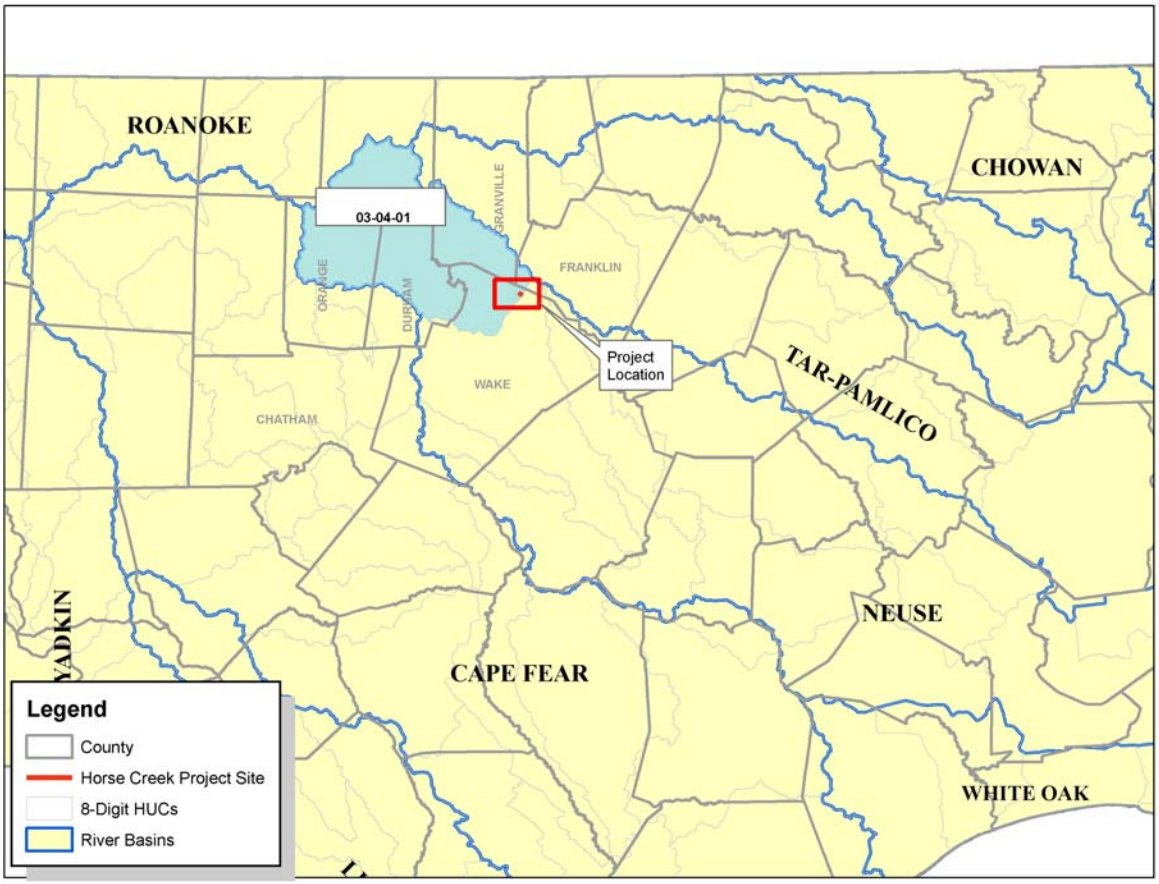
The North Carolina Ecosystem Enhancement Program (EEP), formerly the North Carolina Wetland Restoration Program (WRP), identified Horse Creek, located on the Wake Forest Country Club (WFCC) property, as a stream restoration site as part of the NCWRP Targeted Local Watershed 65020. Horse Creek is a tributary of the Neuse River and discharges into Falls Lake.

Before restoration of the creek took place, removal of vegetation along the creek had resulted in increased opportunity for bank erosion and reduced filtration rates. The channel was in the process of transitioning from its natural state to one in which active stream bank erosion was occurring. Scour pools had developed immediately downstream of flow constrictions caused by the golf cart bridges and the large metal culvert and the large wooded area along the eastern side of the downstream portion of Horse Creek contained a large number of invasive, exotic plant species.

Prior to construction Horse Creek was a C5/E5 stream that was moving towards instability due to various on-site and off-site factors. The design cross-sections for Horse Creek were developed to create a Rosgen C5 stream. The bank angles were lowered based on guidelines for sandy loam soils. Natural meander was added to the stream, however this did not increase the stream length or sinuosity. Efforts to increase sinuosity were limited by several onsite physical constraints, including three existing bridges and one culvert whose locations were to remain unchanged and specific areas within fairways that are identified as landing zones for golfers.

The pre-existing channel for the Unnamed Tributary to Horse Creek was entrenched and lacked sinuosity. The restoration raised the channel elevation and reattached the stream to the floodplain along a new alignment. The Unnamed Tributary to Horse Creek was transformed from a G5c to an E5 and was made more sinuous than its previous state. Although the riparian area around the Unnamed Tributary to Horse Creek had several mature overstory trees, the understory was virtually nonexistent and was planted, similarly to Horse Creek, upon the completion of construction.

Figure 1: Horse Creek Vicinity Map



The Horse Creek Stream Restoration Project encompassed two reaches of stream to be restored along with the restoration of the riparian buffer along as much of the stream reaches as possible. The details of restoration are laid out in the tables below. Table 1 identifies each reach; Table 2 lists the objectives; Table 3 conveys the dates associated with each restoration activity; Table 4 identifies the parties responsible for each portion of the restoration efforts; and Table 5 provides background information about the project site.

Table 1: Project Mitigati0n Structure and Objectives Table
Horse Creek Stream Restoration / Project Number 71082

Project Segment or Reach ID	Mitigation Type	Approach	Linear Footage or Acreage	Stationing	Comment
Horse Creek	R	P1	2,825	00+00 to 28+25	Relocation of entire channel
Unnamed Tributary to Horse Creek	R	P1	550	00+00 to 5+50	Relocation of entire channel

R = Restoration
EI = Enhancement I
EII = Enhancement II
S = Stabilization
P1 = Priority I
P2 = Priority II
P3 = Priority III
SS = Stream Bank Stabilization

Table 2: Project Activity and Reporting History

Project Activity and Reporting History Horse Creek Stream Restoration / Project Number 71082			
Activity or Report	Calendar year of Planned Completion	Data Collection Phase	Actual Completion Date
Restoration Plan	Unknown	July 2002	November 27, 2002
Mitigation Plan	Unknown	June 2005	August 14, 2006
Construction	Unknown	NA	April 1, 2005
Temporary S&E Mix Applied to entire project area	Unknown	NA	April 1, 2005
As-Built Report	Unknown	NA	April 1, 2005
Permanent Seed mix applied to reach	Unknown	NA	April 1, 2005
Containerized plantings for reach	Unknown	NA	April 1, 2005
Initial-Year 1 Monitoring	June 2006	August 2006	Unknown
Year 2 Monitoring	June 2007	June 2007	Unknown
Year 3 Monitoring	June 2008	June 2008	Unknown
Year 4 Monitoring	June 2009	June 2009	Unknown
Year 5 Monitoring	June 2010	June 2010	Unknown

Table 3: Project Contact Table

Project Contact Table Project Number 71082 (Horse Creek)			
Designer	Dewberry and Davis, Inc.	Firm Information/Address	2301 Rexwoods Drive, Suite 200 Raleigh, NC 27607-3366
Primary project designing POC	Kenneth Ashe, PE	POC phone number	(919) 881-9939
Construction Contractor	Contaminant Control, Inc.	Firm Information/Address	438-C Robeson Street Fayetteville, NC 28301
Construction contractor POC	Allen Eudy, Project Manager	POC phone number	(910) 484-7000
Planting Contractor	HARP	Firm Information/Address	PO Box 655 Newell, NC 28126
Planting contractor POC		POC phone number	(704) 687-4061
Seeding Contractor	Seneca Landscapes	Company Information/Address	705 Comphrey Court Wake Forest NC 27587
Planting Contractor POC	Andrew VanVlack	POC phone number	(919) 570-6163
Seed Mix Sources	Mellow Marsh Farm	Company and Contact Phone	(919) 742-1200
Nursery Stock Suppliers	Mellow Marsh Farm	Company and Contact Phone	(919) 742-1200
Monitoring Performers	Dewberry and Davis, Inc.	Firm Information/Address	2301 Rexwoods Drive, Suite 200 Raleigh, NC 27607-3366
Stream Monitoring POC	Kenneth Ashe, PE	POC phone number	(919) 881-9939
Vegetation Monitoring POC	Kenneth Ashe, PE	POC phone number	(919) 881-9939
Wetland Monitoring POC	NA	POC phone number	NA

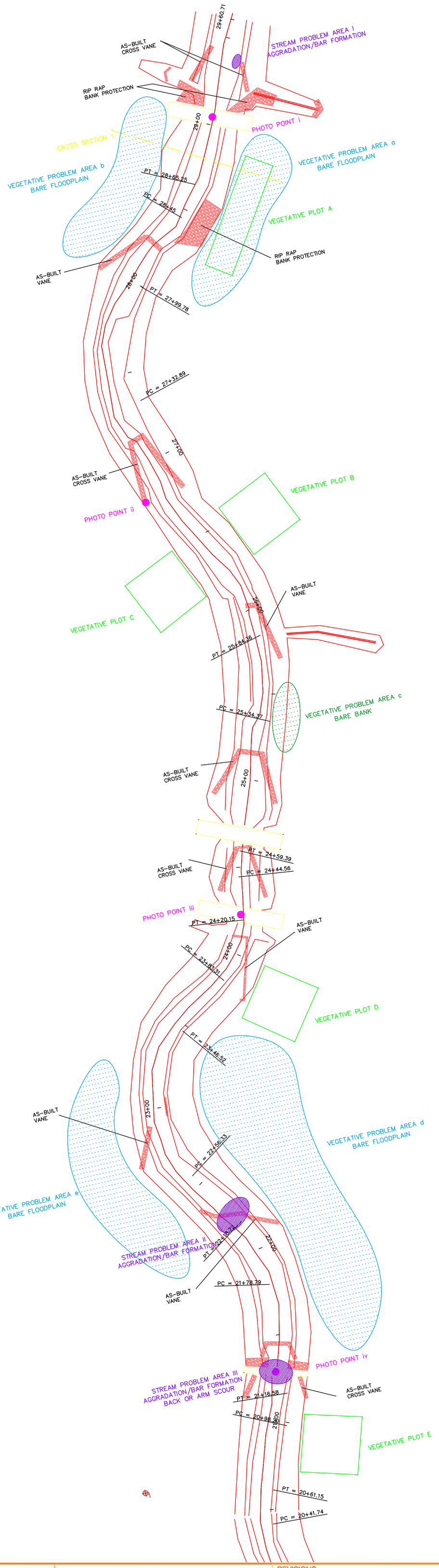
Table 4: Project Background Table

Project Background Table Project Number 71082 (Horse Creek)		
Project Background Table	**Horse Creek**	**Unnamed Tributary to Horse Creek**
Project County	Wake County	Wake County
Drainage Area	7.9 square miles	80 acres
Drainage impervious cover estimate (%)	7.80%	< 5%
Stream Order	Third Order	First Order
Physiographic Region	Piedmont	Piedmont
Ecoregion	45f	45f
Rosgen Classification of As-built	C5	E5
Cowardin Classification	NA	NA
Dominant soil types	Cecil, Pacolet, Appling, Chewacla	Cecil, Pacolet, Appling, Chewacla
Reference site ID	Little Beaverdam Creek	Unnamed Tributary to Lower Barton Creek
USGS HUC for Project and Reference	03020201065020	03020201065020
NCDWQ Sub-basin for Project and Reference	Neuse River Subbasin 03-04-01	Neuse River Subbasin 03-04-01
NCDWQ classification for Project and Reference	WS-IV NSW	WS-IV NSW
Any portion of any project segment 303d listed?	No	No
Any portion of any project segment upstream of a 303d listed segment?	No	No
Reasons for 303d listing or stressor	NA	NA
% of project easement fenced	0%	0%

1.4 MONITORING PLAN VIEW

Figure 2: Monitoring Plan View Sheets

Monitoring Plan View Sheets 1 - 4 are located between pages 7 and 8.



MONITORING AREAS

HORSE CREEK STREAM RESTORATION NC ECOSYSTEM ENHANCEMENT PROGRAM

REVISIONS			
#	By	Date	Remarks

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 027462 KENNETH W. ASHE

File Number 02050
Sheet 1 of 4
Drawing File Name
DDI Project Code 02050
Date AUGUST 14, 2006
Scale
CAD by KA
Designer KA

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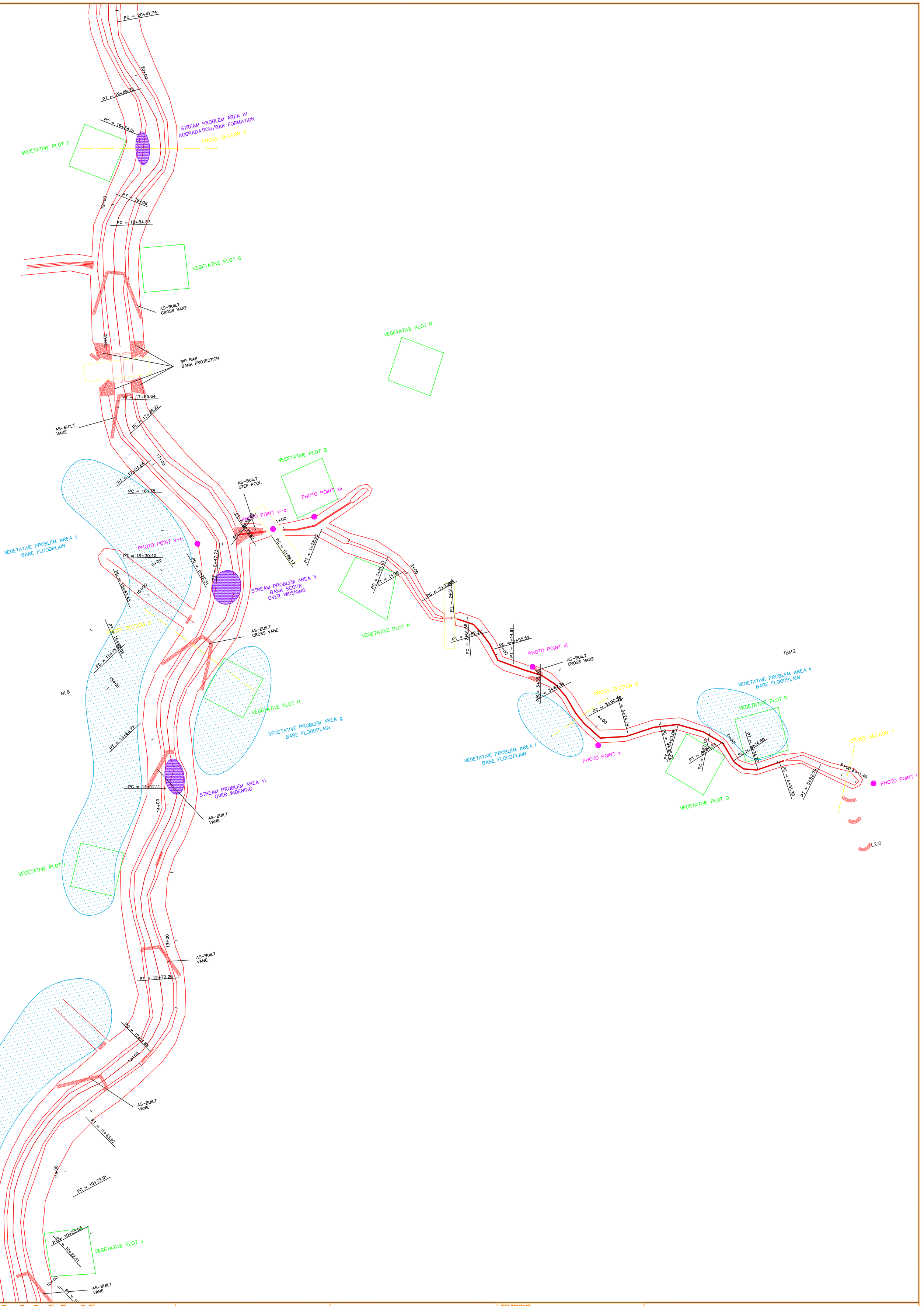

File Number 02050

Sheet 2 of 4

Drawing File Name

DDI Project Code 02050

Date AUGUST 14, 2006

Scale

CAD by KA

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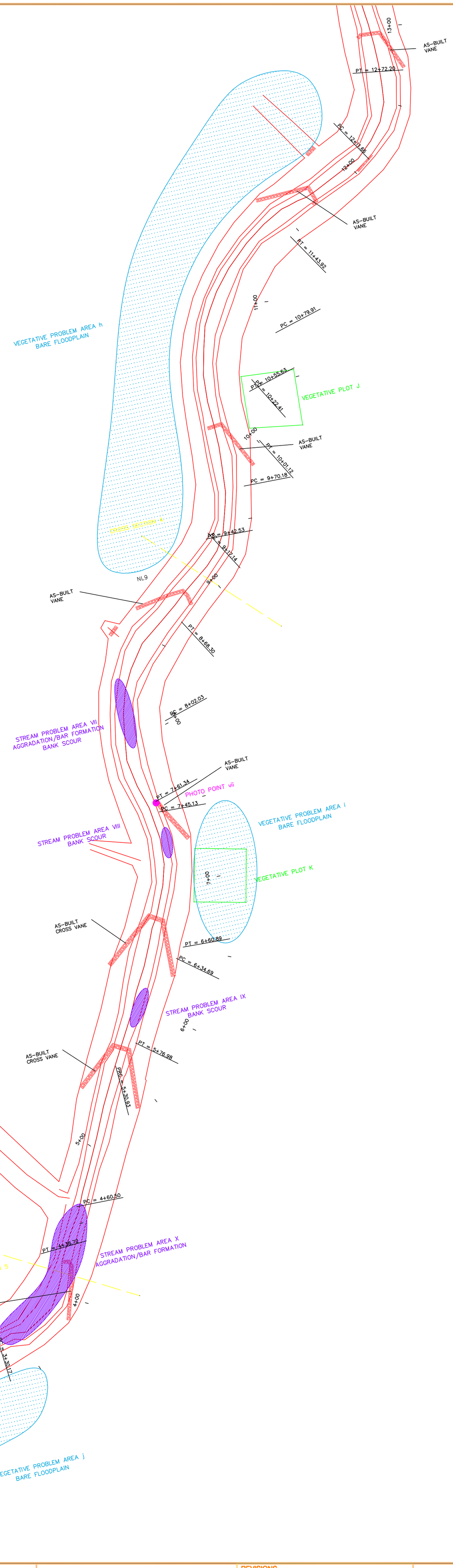

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Sheet	3 of 4
Drawing File Name	
DDI Project Code	02050
Date	AUGUST 14, 2006
Scale	
CAD by	KA
Designer	KA

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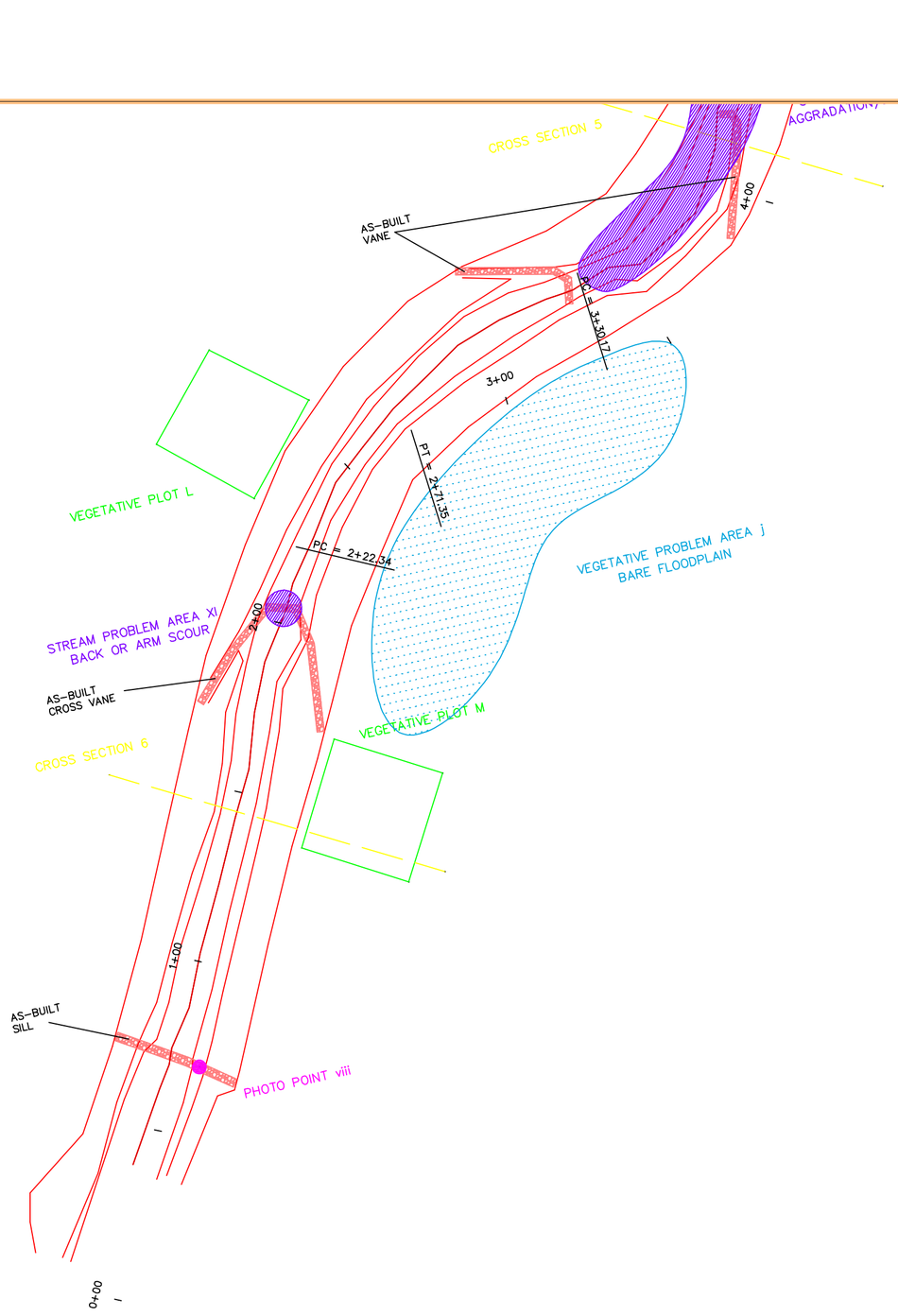

MONITORING AREAS

HORSE CREEK
STREAM RESTORATION
NC ECOSYSTEM
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Date AUGUST 14, 2006
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The requirements and specific methodology used for the stream morphology, vegetative plot, and problem area monitoring are discussed in Chapter Three along with information about the establishment of photo points.

Stem Counts and Visual Assessments were made of the stream banks and surrounding floodplain. This analysis was used to determine if the planted vegetation has survived. A complete stream assessment methodology is discussed in Chapter Three.

Stem Counts

The Stem Count assessment revealed that most of the plots did not meet the 80% survival criteria. Only 5 of the 18 plots had survival rates greater than 80%. Among the plots that did not meet the survival criteria several had very low survival rates and two plots had a survival rate of 0% with no planted vegetation present within the plot.

Problem Areas

The vegetative problem areas were classified into four categories: bare bank, bare bench, bare floodplain and invasive/exotic populations. With the exception of one bare bank area, all of the vegetative problem areas were bare floodplain. Areas were included as bare floodplain if the planted vegetation was present but had been significantly disturbed such as having been mowed around, or if the area contained vegetation, but none of the vegetation that had been planted.

2.1 VEGETATIVE ASSESSMENT

Within the planted buffer, species survival was determined within 50 feet of the top of the stream banks in 10m by 10m vegetative plots. Species density and survival were documented as well as any introduction of species not installed during the buffer planting. Areas with less than 75 percent survival rate will be replanted and any invasive species will be removed. The construction contractor, Contaminant Control, Inc. is required by contract to complete these activities.

The temporary marking method for the vegetative plot marking was minimal. Because the area is a golf course, no flagging was used; rather, caps were placed on the ends of the metal conduits. Ideally, the markers will be unnoticeable to the public but easily recognized by staff with the use of a monitoring plan view sheet.

Eighteen vegetative plots were laid out and monitored along Horse Creek and its Unnamed Tributary. Of the eighteen, only three had a full compliment of plants. Seven of the eighteen had 75 percent survival rate at this point in time. Eleven of the eighteen had less than the 75 percent survival rate that is required. Two of the eighteen had zero percent survival. More specific data is located in the tables that follow throughout this chapter.

2.1.1 SOIL DATA

Horse Creek runs through Chewacla soils. The soils of this mapping unit are on the flood plains of streams. Infiltration is good and surface runoff is slow. Table 6 lists specific soils data for Chewacla soils.

Table 5: Preliminary Soil Data

Preliminary Soil Data Project Number 71082 (Horse Creek)					
Series	**Max Depth (in.)**	**% Clay on Surface**	**K**	**T**	**OM %**
Chewacla, Cm	65	10-27	0.28	5	1-4

The Unnamed Tributary to Horse Creek flows through Mantachie, Wehadkee, and Chewacla soils. The information needed to complete the Preliminary Soil Data Table was unavailable for these soils so short descriptions of each soil type are included below.

Mantachie soils have good infiltration and slow to medium surface runoff. Flooding is frequent but of short duration. These soils are in depressions and draws in the uplands and have 0 to 4 percent slopes. Wehadkee silt loam is a poorly drained soil with 0 to 2 percent slopes on the flood plains of streams. Infiltration is good and surface runoff is slow to ponded. This soil is wet and subject to overflow and ponding.

Additional information on the soils located in the watershed upstream of Horse Creek is provided in Appendix A, Table 17.

2.1.2 VEGETATIVE PROBLEM AREAS

Problem areas were defined as either lacking vegetation or containing exotic non-native species. Each problem area was categorized as one of the following: Bare Bank, Bare Bench, Bare Floodplain, or Invasive Population. All problem areas were identified within the project boundary and listed in Table 7 along with appropriate location information and a brief statement regarding the probable cause. At least one representative photo is provided for each category and arranged sequentially in Appendix A.

Table 6: Vegetative Problem Areas

Vegetative Problem Areas Project Number 71082 (Horse Creek)						
Feature/Issue	**Area**	**Station #/Range**	**Bank**	**Probable Cause**	**Comments**	**Photo #**
Bare Bank	c	4+00 - 4+50	Left	Cause undetermined		788
Bare Bench	NA	None Observed	NA	NA		NA
Bare Floodplain	a	0+80 - 1+40	Left	Land owner maintenance or grazing by wildlife	No sign of wildlife grazing.	780
	b	0+80 - 1+40	Right	Land owner maintenance or grazing by wildlife	No sign of wildlife grazing.	783
	d	5+80 - 8+00	Left	Land owner maintenance or grazing by wildlife	No sign of wildlife grazing.	791
	e	5+00 - 6+00	Right	Land owner maintenance	Approx 15 ft unmowed	875
	f	14+00 - 17+00	Right	Land owner maintenance	Vegetation on 2 ft spacing and mowed around	813
	g	14+00 - 15+00	Left	Land owner maintenance		811
	h	17+00 - 20+50	Right	Land owner maintenance	Planted vegetation mowed around	832
	i	22+50 - 23+80	Left	Does not appear to be maintained or suffer from predation. Lack of sun and water not deemed to be issues. Possible soil deficiencies.		819
	j	25+50 - 26+50	Left	Does not appear to be maintained or suffer from predation. Lack of sun and water not deemed to be issues. Possible soil deficiencies.		822
	k	0+80 - 2+00 (UT)	Right	Plot lacked planted species; however, it had an abundance of good volunteer species.		848
	l	1+50 - 2+50 (UT)	Left	Possible lack of sunlight. Possible land owner maintenance.		849
Invasive/Exotic Population	NA	NA	NA	Chineese privet (*ligustrum sinense*) and Japanese honeysuckle (*Lonicera japonica*) were spotted within the project reach, but none was found within vegetative plots. Currently, invasive/exotic populations were not large enough to constitute problem areas of their own.		NA

2.1.3 VEGETATIVE PROBLEM AREAS PLAN VIEW

Figure 3: Vegetative Problem Areas Plan View Sheets

Vegetative Problem Areas Plan View Sheets 1 - 4 are located between pages 11 and 12.

VEGETATIVE PROBLEM AREAS

HORSE CREEK STREAM RESTORATION

N.C. ECOSYSTEM ENHANCEMENT PROGRAM

WAKE FOREST, NC

REVISIONS

#	By	Date	Remarks

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 027462 KENNETH W. ASHE

Date: SEPTEMBER 30, 2005
DDI Project Code: WRP
Drawing File Name: PROBLEM AREAS
Sheet: 1 of 4
File Number: 02050
Scale: 1" = 30'
CAD by: JAU
Designer: KWA

Z:\Graphics\LOGO\Dewberry (CMYK)-New.jpg

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VEGETATIVE PROBLEM AREAS

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WAKE FOREST, NC

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CAD by JAU | Designer KWA

Scale 1 = 30'

Date SEPTEMBER 30, 2005

DDI Project Code WRP

Drawing File Name PROBLEM AREAS

Sheet 2 of 4

File Number 02050

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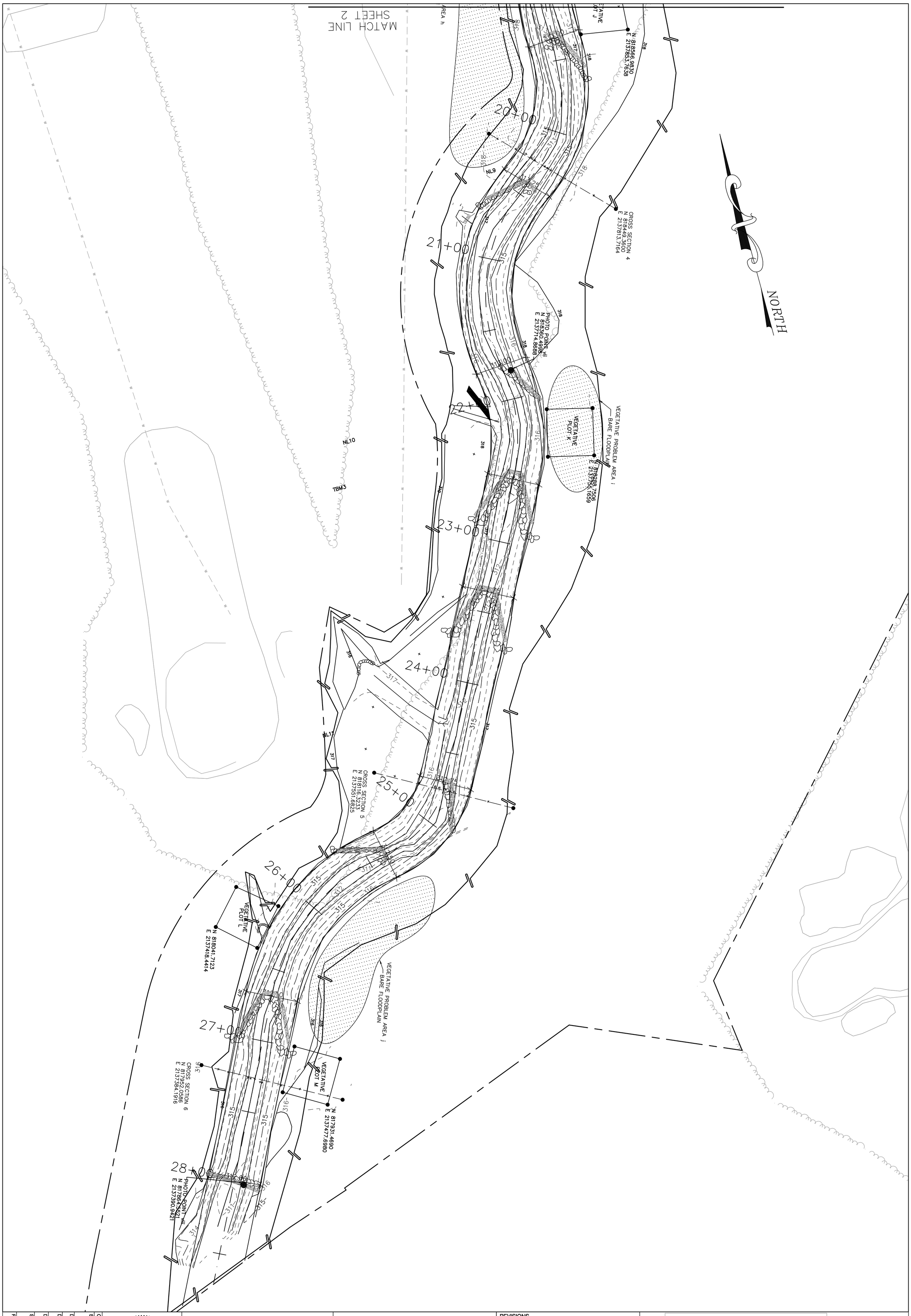

VEGETATIVE PROBLEM AREAS

HORSE CREEK STREAM RESTORATION

N.C. ECOSYSTEM ENHANCEMENT PROGRAM

WAKE FOREST, NC

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KENNETH W. ASHE
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027462
NORTH CAROLINA
PROFESSIONAL

File Number 02050
Sheet 3 of 4
Drawing File Name PROBLEM AREAS
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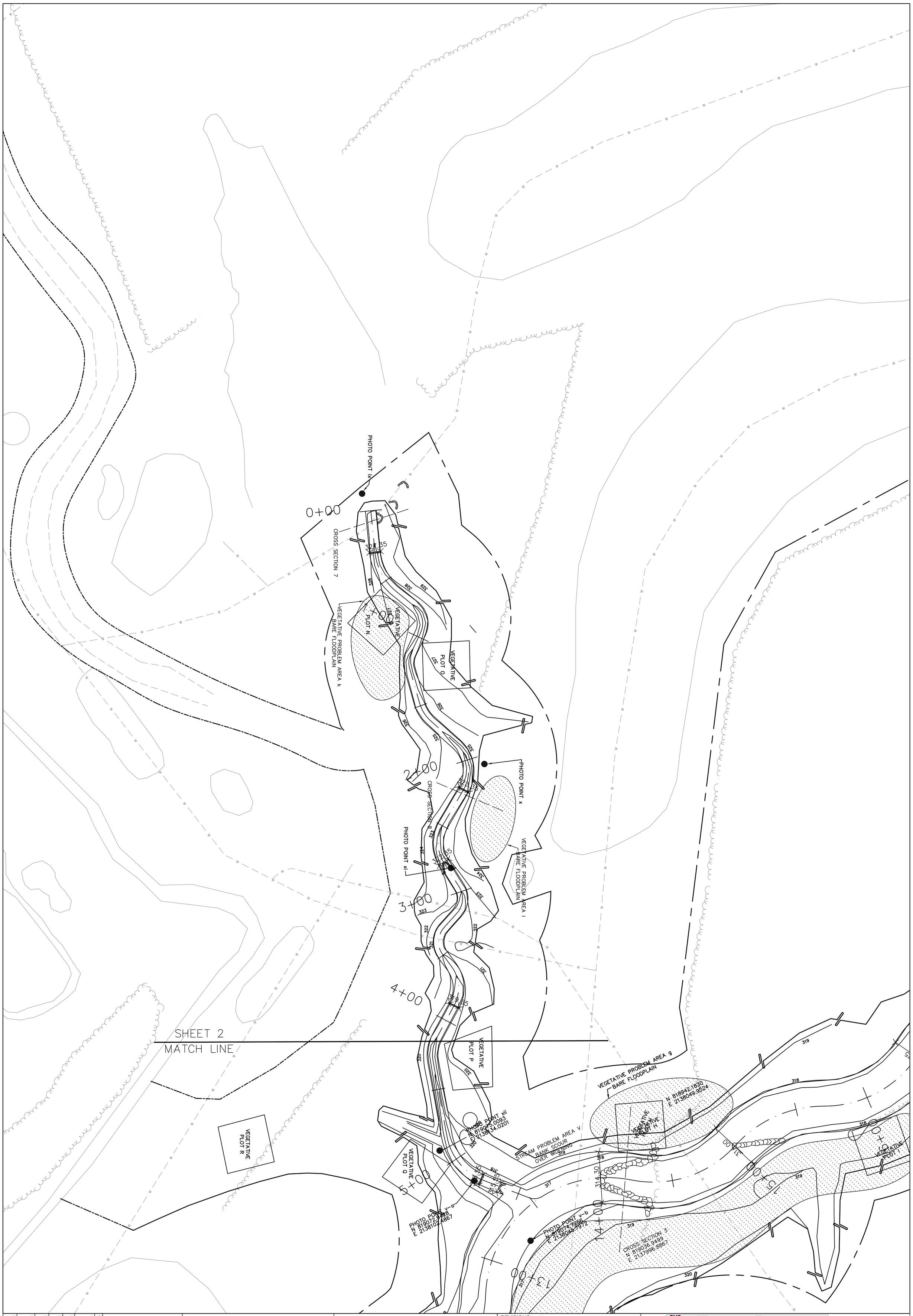

VEGETATIVE PROBLEM AREAS

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2.1.4 STEM COUNTS

Stem counts were conducted within randomly placed 10m x 10m plots. Because the original design required a narrower riparian buffer along the fairways, one of the plots that is located in the fairway for Hole #1 has dimensions 5m x 20m in order to adequately represent the riparian buffer in that location. This variation was discussed and approved by EEP prior to monitoring. The chosen plot locations were scattered throughout the project in order to obtain a representative sample of the entire area of disturbance. The corners of each plot were marked with 18" x 1/2" sections of rebar driven into the ground. Because of the location of this project, the metal conduit was driven flush into the ground in order to avoid damage to golf course maintenance equipment. Each rebar stake was then marked with a plastic cap and each plot was identified by letter in the sequence in which they were sampled.

The stem count procedure only applied to planted woody vegetation. For shrubby species with multiple stems, the base was considered one stem. Trees with two or more main stems branching from the base, or near the ground, were considered one stem.

Planted stems were only declared dead when foliage was completely absent, or if breaking a stem fails to reveal living tissue. If all of the foliage has been removed by grazing animals, the plant's status was based on whether it has the potential to recover and produce new growth.

Table 7: Stem Counts for each species arranged by plot

Stem Counts for each species arranged by plot Project Number 71082																					
Species		**Plots**																	**Initial**	**Year 1**	**Survival**
Scientific Name	**Common Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Totals**	**Totals**	**%**
Tree																					
Betula nigra	River Birch												1						1	NA	NA
Cornus florida	Flowering Dogwood					2													2	NA	NA
Diospyros virginiana	Persimmon										1	1							2	NA	NA
Fraxinus pennsylvanica	Green Ash						1	7											8	NA	NA
Juniperus virginiana	Eastern Red Cedar																		0	NA	NA
Magnolia virginiana	Sweetbay Magnolia						1	2						1					4	NA	NA
Nyssa sylvatica	Black Gum		1							1		1	2	1			1		3	10	NA	NA
Platanus occidentalis	Sycamore					1	1			1		1							1	5	NA	NA
Quercus alba	White Oak										1									1	NA	NA
Salix nigra	Black Willow						1						1							2	NA	NA
Shrubs																					
Aronia arbutifolia	Red Chokeberry		1			1														2	NA	NA
Cephalanthus occidentalis	Buttonbush											2		1				1		4	NA	NA
Euonymus americanus	Strawberry Bush			2																2	NA	NA
Ilex decidua	Deciduous Holly																			0	NA	NA
Ilex glabra	Inkberry		1																	1	NA	NA
Itea virginica	Virginia Willow						1				1		1	2					1	6	NA	NA
Lindera benzoin	Spicebush					5			5	3		1	1	6	1	1		4		27	NA	NA
Salix sericea	Silky Willow									1			1	3						5	NA	NA
Sambucus Canadensis	Common Elderberry															1				1	NA	NA
Dead/Unidentifiable																					
Dead						1	2			6	2	2	4	3		1	1	3	1	26	NA	NA
Unidentifiable (too small)				1			2													3	NA	NA
Total																					
Total number living		0	3	3	0	9	7	9	5	6	3	6	7	14	1	2	1	5	5	86	NA	NA

2.1.5 VEGETATIVE PLOT PHOTOS

Two representative digital photos of each sample plot was taken on the same day vegetative sampling was conducted. These photos are provided in Appendix A and identified by plot number and the date when it was taken.

2.2 STREAM ASSESSMENT

Dimension, pattern, profile, BEHI, and pebble-count measurements of the restored channel were completed and the stream geomorphology was classified using the results of the survey data and the Rosgen (1996) system. This analysis was used to check channel stability, particle-size distribution of channel materials, sediment transport; and streambank erosion rate and to determine if stabilization and grade-control structures are functioning properly. A complete stream assessment methodology is discussed in Chapter Three.

Dimension

The typical sections for the Horse Creek Stream Restoration called for a channel 36 feet wide, max riffle depth of 4.5 feet, a width to depth ratio of just greater than twelve, a bank height ratio (BHR) of one, and an area of 106.5 square feet. The post construction stream assessment provided mean values of 37.4 feet wide, 5.4 feet deep, a width to depth ratio of 11.84, a bank height ratio (BHR) of one, and an area of 118.9 square feet. The surveyed cross-sections were only slightly wider and deeper than the design; consequently the sections were slightly larger than the design sections in area and had a slightly smaller width to depth ratio. More dimension measurements and calculations can be found in the tables that follow within this chapter.

The Unnamed Tributary to Horse Creek was designed to have a channel 7 feet wide, 1.3 feet deep, a width to depth ratio of just greater than nine, a bank height ratio (BHR) of one, and an area of 5.4 square feet. The stream assessment provided mean values for the Unnamed Tributary of 6.5 feet wide, 1.3 feet deep, a width to depth ratio of 8.0, a bank height ratio (BHR) of 1.5, and an area of 5.3 square feet. The surveyed cross-section was very close to the shape of the design; however, the constructed section was several inches too deep for the bankfull channel to be consistently connected to the floodplain. The upstream end of the reach is very close to a BHR of 1.0; however, the BHR gradually increases to 1.5 near the middle of the reach and even higher until its confluence with Horse Creek. The small size of the creek serves to amplify the BHR. At the point at which the BHR is 1.5, the stream has been constructed only 6 inches deeper than design grade. Despite this deviation from design the Unnamed Tributary to Horse Creek is currently stable and showing no signs of erosion.

Pattern

Overall the pattern of the newly constructed reach of Horse Creek was in fairly close agreement with the design. Meander wavelengths and beltwidths were very close to the design; while radii of curvature, while still close, showed more variation. Pattern measurements and calculations are found in the tables that follow within this chapter.

Profile

The profile of the newly built reach of Horse Creek has significant variation from the design. The profile of the Unnamed Tributary to Horse Creek was much closer to the design profile. Profile measurements and calculations for both reaches can be found in the tables that follow within this

chapter. Due to the extent of the deviations from design in the profile; they are more likely (than dimension and pattern deviations) to be the cause of future problems.

Problem Areas

All of the areas in this section are labeled problem areas on the plan view; however, after further analysis the areas were divided into three categories:

- Problem Areas;
- Areas of Concern; and
- Areas of Differing from Design (labeled Areas of Difference).

Areas defined as Problem Areas are those that have already shown instability, likely to need continual monitoring, and possibly need maintenance in the future. Areas of Concern are reaches that show signs of change that may lead to instability in the future, but currently are stable. These areas should continue to be monitored, as they may or may not become unstable in the future. The third areas are Areas of Difference. Areas of Difference are areas that differ from the design in some way, but are stable. These areas are assumed to remain stable, but are documented due to their deviation from the design. There were three areas deemed Problem Areas, six deemed Areas of Concern, and two are Areas of Difference. More detail on each of these areas is presented in the tables that follow and in Appendix B.

2.2.1 PROBLEM AREAS PLAN VIEW

A plan view of the problem areas is located in Figure 3 on the following page.

2.2.2 PROBLEM AREAS TABLE SUMMARY

Table 9 provides categorical features issues by station, the suspected cause, and denotes the number of a representative photo of the condition in Appendix B.

Figure 4: Stream Problem Areas Plan View Sheets

Stream Problem Areas Plan View Sheets 1 - 4 are located between pages 15 and 16.

STREAM PROBLEM AREAS

HORSE CREEK STREAM RESTORATION

N.C. ECOSYSTEM ENHANCEMENT PROGRAM

WAKE FOREST, NC

REVISIONS			
#	By	Date	Remarks

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 027462 KENNETH W. ASHE

CAD by JAU | Designer KWA

Scale 1" = 30'

Date SEPTEMBER 30, 2005

DDI Project Code WRP

Drawing File Name PROBLEM AREAS

Sheet 1 of 4

File Number 02050

Z:\Graphics\LOGO\Dewberry (CMYK)-New.jpg

Dewberry & Davis, Inc.

2301 Rexwoods Drive, Suite 200
Raleigh, NC 27607-3366
Telephone : (919) 881-9939 Fax : (919) 881-9923
www.dewberry.com

Engineers
Planners
Surveyors

STREAM PROBLEM AREAS

HORSE CREEK STREAM RESTORATION

N.C. ECOSYSTEM ENHANCEMENT PROGRAM

WAKE FOREST, NC

REVISIONS

#	By	Date	Remarks

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 027462 KENNETH W. ASHE

CAD by JAU | Designer KWA

Scale: 1" = 30'

Date: SEPTEMBER 30, 2005

DDI Project Code: WRP

Drawing File Name: PROBLEM AREAS

Sheet: 2 of 4

File Number: 02050

Z:\Graphics\LOGO\Dewberry (CMYK)-New.jpg

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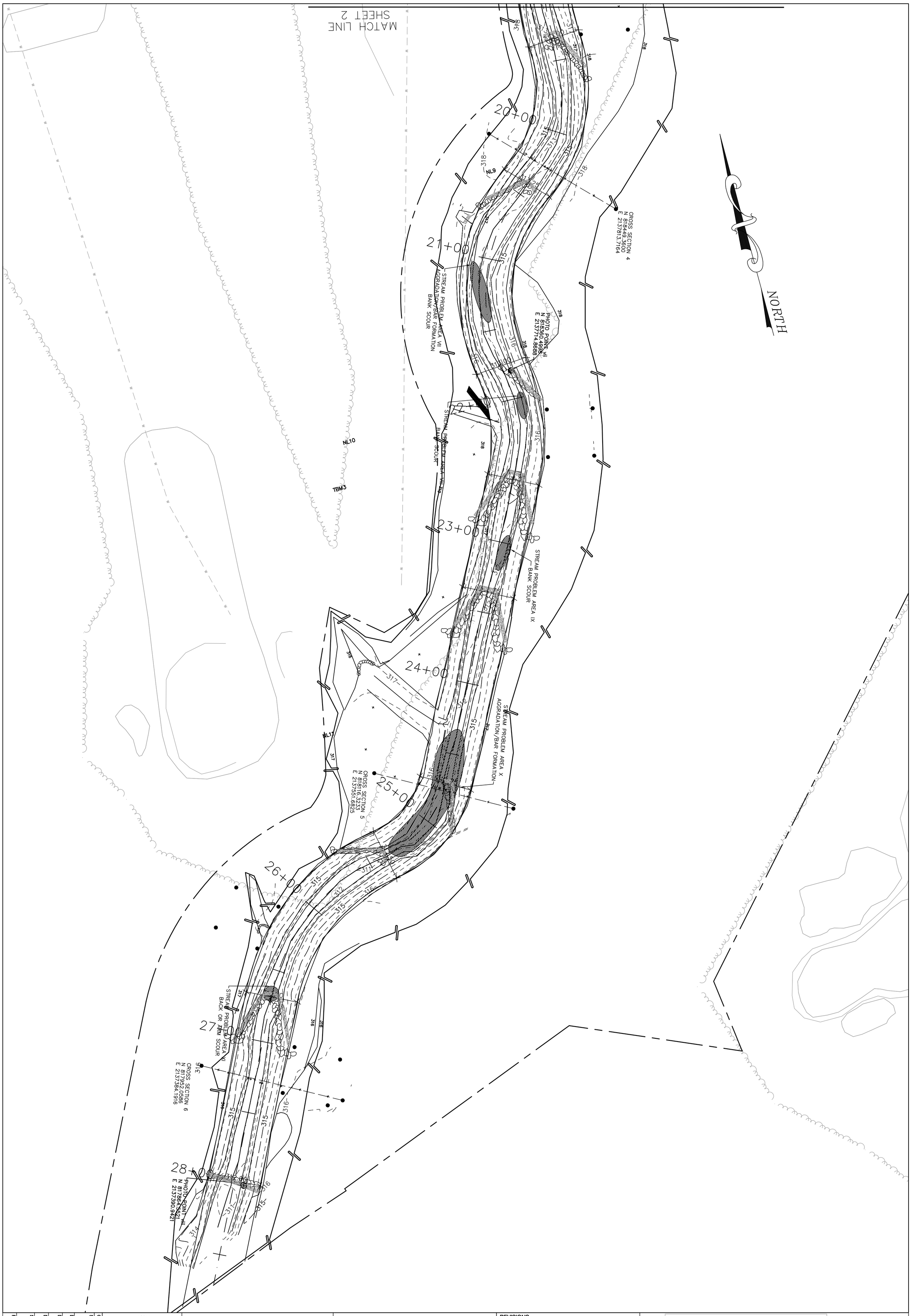

STREAM PROBLEM AREAS

HORSE CREEK STREAM RESTORATION

N.C. ECOSYSTEM ENHANCEMENT PROGRAM

WAKE FOREST, NC

REVISIONS			
#	By	Date	Remarks

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 027462 KENNETH W. ASHE

CAD by JAU | Designer KWA
Scale 1" = 30'
Date SEPTEMBER 30, 2005
DDI Project Code WRP
Drawing File Name PROBLEM AREAS
Sheet 3 of 4
File Number 02050

Z:\Graphics\LOGO\Dewberry (CMYK)-New.jpg

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PHOTO POINT ix
N 818792.4361
E 2138492.4409

CROSS SECTION 7
N 818822.2922
E 2138484.9145

PHOTO POINT x
N 818865.2276
E 2138300.3492

CROSS SECTION 6
N 818897.0447
E 2138315.0287

PHOTO POINT xi
N 818931.7451
E 2138266.4974

PHOTO POINT xii
N 819073.0093
E 2138154.0201

PHOTO POINT v-a
N 819072.4198
E 2138102.4867

PHOTO POINT v-b
N 819074.7256
E 2138045.7972

CROSS SECTION 3
N 819036.9499
E 2137996.8867

STREAM PROBLEM AREA V
BANK SCOUR
OVER WIDENING

STREAM PROBLEM AREA VI
OVER WIDENING

SHEET 2
MATCH LINE

STREAM PROBLEM AREAS

HORSE CREEK STREAM RESTORATION

N.C. ECOSYSTEM ENHANCEMENT PROGRAM

WAKE FOREST, NC

REVISIONS

#	By	Date	Remarks

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CAD by JAU | Designer KWA
Scale 1" = 30'
Date SEPTEMBER 30, 2005
DDI Project Code WRP
Drawing File Name PROBLEM AREAS
Sheet 4 of 4
File Number 02050

Table 8: Stream Problem Areas

Stream Problem Areas Project Number 71082 (Horse Creek)				
Feature Issue	**Station numbers**	**Suspected Cause**	**Area**	**Photo number**
Aggradation/Bar Formation				
Problem Area I	0+20	Increased upstream construction as land use changes from agricultural to residential	Problem	911
Problem Area II	7+50	Flow directed too close to outside of bend	Problem	
Problem Area III	8+50	Woody debris	Concern	
Problem Area IV	10+00	Flow directed too close to outside of bend	Concern	
Problem Area VII	21 + 25	Bank sloughing thought to cause bar which is disrupting flow vectors	Concern	
Problem Area X	25+00	Bank erosion has caused bar formation. Bar formation has squeezed flow to right side of channel. Flow now directed around vane and into bank below vane. Subsequently, flow bounces off the outside of bend sharply back towards inside of bend. Finally, flow is squeezed by clay outcropping further into bank and flow eventually improves direction over rock vane.	Problem	
Bank scour				
Problem Area V	13+80	See Channel Over widening	Difference	904
Problem Area VII	21+20	See Aggradation/Bar Formation	Concern	
Problem Area VIII	22+00	Undetermined	Concern	
Problem Area IX	23+10	Vegetation never established	Concern	
Engineered structures-back or arm scour				
Problem Area III	8+50	See Aggradation/Bar Formation	Concern	920
Problem Area XI	26+70	Construction deviated considerably from Design	Concern	
Channel Over widening				
Problem Area V	13+80	Suspected bank failure before vegetation established	Difference	898
Problem Area VI	15+40	Suspected bank failure before vegetation established	Difference	

2.2.3 NUMBERED ISSUES PHOTO SECTION

An example issue photo is provided for each of the feature issues listed in Table 9. The intention of these photos is not to every occurrence within an issue category, but to provide a photo that is representative of the feature issue category.

Photo 1: Aggradation/Bar Formation, 25+00 (0911) 06/22/05

Photo 2: Bank Scour, 23+10 (0904) 06/22/05

Photo 3: Engineered Structure – back or arm scour, 26+70 (0920) 06/22/05

Photo 4: Channel Over widening, 15+40 (0898) 06/22/05

2.2.4 FIXED PHOTO STATION PHOTOS

Stream photos from the established photo stations were collected at the same time as the vegetation photos. These photos are located in Appendix B.

2.2.5 STABILITY ASSESSMENT TABLE

This table is a semi-quantitative summary of results from the visual inspection conducted over each reach. It is designed to assess each structural feature category by deriving a simple performance percentage.

Table 9: Categorical Stream Feature Visual Stability Assessment – Horse Creek

Categorical Stream Feature Visual Stability Assessment Project Number 71082 (Horse Creek) Segment/Reach: Horse Creek						
Feature	**Initial***	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	65%					
B. Pools	50%					
C. Thalweg	80%					
D. Meanders	80%					
E. Bed General	95%					
F. Channel General	90%					
G. Banks	85%					
H. Vanes / J Hooks etc.	60%					
I. Wads and Boulders	NA					
*Evaluation based on As-built features and not design features						

Table 10: Categorical Stream Feature Visual Stability Assessment – Unnamed Tributary

Categorical Stream Feature Visual Stability Assessment Project Number 71082 (Horse Creek) Segment/Reach: Unnamed Tributary						
Feature	**Initial***	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	90%					
B. Pools	80%					
C. Thalweg	100%					
D. Meanders	100%					
E. Bed General	100%					
F. Channel General	100%					
G. Banks	100%					
H. Vanes / J Hooks etc.	NA					
I. Wads and Boulders	NA					
*Evaluation based on As-built features and not design features						

2.2.6 QUANTITATIVE MEASURES SUMMARY TABLES

These tables house all of the quantitative summary data from the cross-sectional surveys, longitudinal surveys and pebble counts. The associated raw data and plots are located in Appendix B.

Table 11: Baseline Morphology and Hydraulic Summary Horse Creek

Baseline Morphology and Hydraulic Summary Project Number 71082 Segment/Reach: Horse Creek (2899 feet)																		
Parameter	USGS Gage Data			Regional Curve			Pre-Existing			Project Reference			Design			As-built		
Dimension	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
BF Width (ft)	NA	NA	NA		31.2		20.1	38.8	32.6	16.8	28.2	27.6	36	36	36	36.7	38.6	37.4
Floodprone Width (ft)	NA	NA	NA	NA	NA	NA	407	700	599.3	200	200	200		>600			>600	
BF Cross Sectional Area (ft^2)	NA	NA	NA		98.3		61.9	98.5	82.5	56.2	59	57.4	106.5	106.5	106.5	110.1	126.5	118.9
BF Mean Depth (ft)	NA	NA	NA		3.1		1.9	3.7	2.5	2.0	2.1	2.1	3.0	3.0	3.0	2.9	3.4	3.2
BF Max Depth (ft)	NA	NA	NA	NA	NA	NA	3.9	6.1	4.1	2.8	3.2	3.0	4.5	4.5	4.5	15+	15+	15+
Width/Depth Ratio	NA	NA	NA	NA	NA	NA	6.4	20.5	11.3	12.8	14.2	13.3	12.2	12.2	12.2	10.8	13.5	11.8
Entrenchment Ratio	NA	NA	NA	NA	NA	NA	13	21.9	18.4	9.2	9.6	9.4	11.3	11.3	11.3	2.6	2.7	2.7
Wetted Perimeter (ft)	NA	NA	NA	NA	NA	NA	32.7	60.5	40.6	36.2	89.5	56.0	37.6	38.6	38.1	34.3	41.0	37.7
Hydraulic radius (ft)	NA	NA	NA	NA	NA	NA	1.21	2.44	2.03	0.52	1.35	0.93	2.83	2.93	2.88	2.60	3.50	3.00
Pattern	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Channel Beltwidth (ft)	NA	NA	NA	NA	NA	NA	19	102	44	35	36	36	68	126	97	47	97	69
Radius of Curvature (ft)	NA	NA	NA	NA	NA	NA	4	137	30	13	53	25	70	144	107	32	132	76
Meander Wavelength (ft)	NA	NA	NA	NA	NA	NA	24	261	94	100	112	106	108	216	162	131	369	212
Meander Width ratio	NA	NA	NA	NA	NA	NA	0.8	8.0	2.9	3.6	4.1	3.8	3.0	6.0	4.5	3.5	9.9	5.7
Profile	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Riffle length (ft)	NA	NA	NA	NA	NA	NA	7	57	25	11	42	27	5	50	29	5	59	22
Riffle slope (ft/ft)	NA	NA	NA	NA	NA	NA	0	0	---	0.011	0.014	0.013	0.002	0.032	0.008	0.0019	0.0048	0.0021
Pool length (ft)	NA	NA	NA	NA	NA	NA	9.0	54.0	26.6	26.0	48.0	33.0	20.0	74.4	51.7	25.6	131.2	69.6
Pool spacing (ft)	NA	NA	NA	NA	NA	NA	18.0	97.5	50.2	37.0	102.0	69.5	44.0	144.0	94.0	37.5	324.6	129.3
Substrate	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
d50 (mm)	NA	NA	NA	NA	NA	NA		0.2			4.9			0.2			0.13	
d84 (mm)	NA	NA	NA	NA	NA	NA		2.3			16.5			2.3			0.5	
Additional Reach Parameter	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Valley Length (ft)	NA	NA	NA	NA	NA	NA		2645			203			2645			2645	
Channel Length (ft)	NA	NA	NA	NA	NA	NA		2890			220			2885			2899	
Sinuosity	NA	NA	NA	NA	NA	NA		1.09			1.09			1.09			1.10	
Water Surface Slope (ft/ft)	NA	NA	NA	NA	NA	NA		0.0016			0.0027		---	---	---	---	---	---
BF slope (ft/ft)	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---
Rosgen Classification	NA	NA	NA	NA	NA	NA		C5/E5			C4			C5/E5			C5/E5	
Number of Bankfull Events	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---
Extent of BF floodplain (acres)	NA	NA	NA	NA	NA	NA		37.12			1.86			37.12			37.12	
BEHI	NA	NA	NA	NA	NA	NA	21	43	36	---	---	---	NA	NA	NA	9	21	14
Habitat Index	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	NA	NA	NA	---	---	---
Macrobenthos	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 12: Baseline Morphology and Hydraulic Summary - Unnamed Tributary

Baseline Morphology and Hydraulic Summary Project Number 71082 Segment/Reach: Unnamed Tributary to Horse Creek (550 feet)																		
Parameter	USGS Gage Data			Regional Curve			Pre-Existing			Project Reference			Design			As-built		
Dimension	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
BF Width (ft)	NA	NA	NA	5.1			3.8	5.8	4.6	3.6	5.7	4.7			7.5			6.5
Floodprone Width (ft)	NA	NA	NA	NA	NA	NA	6.4	6.4	5.5	10.5	10.5	10.5	>200			>200		
BF Cross Sectional Area (ft^2)	NA	NA	NA	5.6			2.4	3.7	2.5	3.3	3.6	3.3			5.4			5.3
BF Mean Depth (ft)	NA	NA	NA	0.8			0.6	0.6	0.5	0.7	0.8	0.7			0.77			0.81
BF Max Depth (ft)	NA	NA	NA	NA	NA	NA	0.4	2.2	0.5	0.4	2.2	0.6			1.3			1.3
Width/Depth Ratio	NA	NA	NA	NA	NA	NA	---	---	8.4	4.4	6.6	5.5			9.7			8.0
Entrenchment Ratio	NA	NA	NA	NA	NA	NA	---	---	1.2	2.2	2.2	2.2			>20			>20
Wetted Perimeter (ft)	NA	NA	NA	NA	NA	NA	---	---	---	14.2	28.3	21.2			8.6			10.4
Hydraulic radius (ft)	NA	NA	NA	NA	NA	NA	---	---	---	0.12	0.25	0.19			0.87			0.51
Pattern	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Channel Beltwidth (ft)	NA	NA	NA	NA	NA	NA	9.4	18.4	14.1	62.0	62.0	62.0	21.0	35.0	28.0	7.6	28.2	15.9
Radius of Curvature (ft)	NA	NA	NA	NA	NA	NA	8.8	38.9	18.7	3.5	23.6	13.5	14.0	35.0	22.5	15.8	61.0	31.2
Meander Wavelength (ft)	NA	NA	NA	NA	NA	NA	38.2	88.4	57.2	18.0	32.0	25.0	28.0	53.0	40.5	54.1	107.2	81.4
Meander Width ratio	NA	NA	NA	NA	NA	NA	8.3	19.2	12.4	3.8	6.8	5.3	3.7	4.7	5.4	5.8	11.5	8.6
Profile	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Riffle length (ft)	NA	NA	NA	NA	NA	NA	---	---	---	8	20	15	4.0	20.0	10.2	92.0	215.2	151.4
Riffle slope (ft/ft)	NA	NA	NA	NA	NA	NA	---	---	---	0.033	0.060	0.045	0.100	0.325	0.119	0.024	0.043	0.031
Pool length (ft)	NA	NA	NA	NA	NA	NA	---	---	---	5	9	8	11.8	39.1	24.3	21.3	39.3	30.9
Pool spacing (ft)	NA	NA	NA	NA	NA	NA	---	---	---	17.4	35.1	23.1	5.3	9.8	7.5	150.9	273.4	212.2
Substrate	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
d50 (mm)	NA	NA	NA	NA	NA	NA	3.7			4.9			3.7			0.125		
d84 (mm)	NA	NA	NA	NA	NA	NA	20.4			74			20.4			0.5		
Additional Reach Parameter	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Valley Length (ft)	NA	NA	NA	NA	NA	NA	591			68			479*			479*		
Channel Length (ft)	NA	NA	NA	NA	NA	NA	612			101			550			548		
Sinuosity	NA	NA	NA	NA	NA	NA	1.04			1.49			1.15			1.15		
Water Surface Slope (ft/ft)	NA	NA	NA	NA	NA	NA	0.017			0.0263			---	---	---	---	---	---
BF slope (ft/ft)	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---
Rosgen Classification	NA	NA	NA	NA	NA	NA	G4c			E4			E4			E4		
Number of Bankfull Events	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---
Extent of BF floodplain (acres)	NA	NA	NA	NA	NA	NA	2.71			2.71			2.71			2.71		
BEHI	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	7.5	13.5	10.5
Habitat Index	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---
Macrobenthos	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

*Valley Length shortened in As-built due to change in location of confluence with Horse Creek

Table 13: Morphology and Hydraulic Monitoring Summary Horse Creek

Morphology and Hydraulic Monitoring Summary
Project Number 71082
Segment/Reach: Horse Creek (2825 feet)

Parameter	Cross Section 1 Riffle						Cross Section 2 Pool						Cross Section 3 Pool						Cross Section 4 Riffle						Cross Section 5 Pool						Cross Section 6 Riffle					
	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5
Dimension																																				
BF Width (ft)	37						39						31						39						34						37					
Floodprone Width (ft)	>600						>600						>600						>600						>600						>600					
BF Cross Sectional Area (ft^2)	120						126						99						110						95						126					
BF Mean Depth (ft)	3.3						3.2						3.2						2.9						2.8						3.4					
BF Max Depth (ft)	5.7						5.7						7						5.1						5.3						5.5					
Width/Depth Ratio	11						12						9.9						14						12						11					
Entrenchment Ratio	>2.7						---						---						>2.6						---						>2.7					
Wetted Perimeter (ft)	34						41						36						40						36						39					
Hydraulic radius (ft)	3.5						3.1						2.8						2.7						2.6						3.2					
Substrate																																				
d50 (mm)	0.13						0.15						0.16						0.10						0.12						0.12					
d84 (mm)	0.75						0.50						0.35						0.50						0.37						4.00					

Parameter	MY-00 (2005)			MY-01 (2006)			MY-02 (2007)			MY-03 (2008)			MY-04 (2009)			MY-05 (2010)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Pattern																		
Channel Beltwidth (ft)	47	97	69															
Radius of Curvature (ft)	32	132	76															
Meander Wavelength (ft)	131	369	212															
Meander Width ratio	3.5	9.9	5.7															
Profile																		
Riffle length (ft)	5	59	22															
Riffle slope (ft)	0.003	0.087	0.027															
Pool length (ft)	26	131	70															
Pool spacing (ft)	38	325	129															
Additional Reach Parameters																		
Valley Length (ft)	2645																	
Channel Length (ft)	2899																	
Sinuosity	1.09																	
Water Surface Slope (ft/ft)	---	---	---															
BF slope (ft/ft)	---	---	---															
Rosgen Classification	C5/E5																	
Number of Bankfulll Events	---	---	---															
Extent of BF floodplain (area)	37.12																	
BEHI	9	21	14															
Habitat Index	---	---	---															
Macrobenthos	---	---	---															

Table 14: Morphology and Hydraulic Monitoring Summary Unnamed Tributary

Morphology and Hydraulic Monitoring Summary Project Number 71082 Segment/Reach: Unnamed Tributary to Horse Creek (550 feet)												
Parameter	Cross Section 7 Pool						Cross Section 8 Riffle					
	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	15						6.5					
Floodprone Width (ft)	>200						>200					
BF Cross Sectional Area (ft^2)	21						5.3					
BF Mean Depth (ft)	1.4						0.8					
BF Max Depth (ft)	2.6						1.3					
Width/Depth Ratio	11						8.0					
Entrenchment Ratio	---						> 20					
Wetted Perimeter (ft)	28						10.4					
Hydraulic radius (ft)	0.7						1.3					
Substrate												
d50 (mm)	0.19						0.12					
d84 (mm)	1.00						0.18					

Parameter	MY-00 (2005)			MY-01 (2006)			MY-02 (2007)			MY-03 (2008)			MY-04 (2009)			MY-05 (2010)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Pattern																		
Channel Beltwidth (ft)	7.6	28.2	15.9															
Radius of Curvature (ft)	15.8	61	31.2															
Meander Wavelength (ft)	54.1	107.2	81.4															
Meander Width ratio	5.8	12	8.6															
Profile																		
Riffle length (ft)	92.0	216.2	151.4															
Riffle slope (ft)	0.024	0.043	0.031															
Pool length (ft)	21.31	39.28	30.86															
Pool spacing (ft)	150.9	273.41	212.16															
Additional Reach Parameters																		
Valley Length (ft)		499																
Channel Length (ft)		540																
Sinuosity		1.08																
Water Surface Slope (ft/ft)	---	---	---															
BF slope (ft/ft)	---	---	---															
Rosgen Classification		E4																
Number of Bankfulll Events	---	---	---															
Extent of BF floodplain (area)		2.71																
BEHI	7.5	13.5	10.5															
Habitat Index	---	---	---															
Macrobenthos	---	---	---															

2.3 WETLAND ASSESSMENT

Wetlands are not a part of this project.

3 METHODOLOGY

3.1 STREAM AND BUFFER ASSESSMENT

In general, monitoring data should provide the USACOE and NCDWQ with evidence that the goals of the project were met. Specifically, the purpose of the Horse Creek Stream Restoration Monitoring Plan is to:

- Check channel stability by measuring dimension, pattern, and profile; particle-size distribution of channel materials; sediment transport; and streambank erosion rates.
- Determine if stabilization and grade-control structures are functioning properly.
- Determine if the specific objectives of the restoration have been met.

In order to accomplish these objectives, the monitoring efforts are organized into three types of assessments stream morphology, vegetative plots, and photo points. With the exception of a vegetative plot modification (stem counts in fairway plots discussed in Chapter VI, Section 2.1), the monitoring methods employed were established using standard regulatory guidance and procedures documents listed below.

- USACOE (2003) Stream Mitigation Guidelines. USACOE, USEPA, NCWRC, NCDENR-DWQ
- Rosgen, D. L. (1996) Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, CO
- Harrelson, et al. (1994) *Stream Channel Reference Sites*. USDA Forest Service Manual

Current agency stream-mitigation monitoring requirements include morphology, photo-documentation, and vegetation. These parameters are required to be monitored at least once a year for five years after construction. The required monitoring shall be performed each year for the 5-year monitoring period and no less than two bankfull flow events must be documented through the monitoring period. If less than two bankfull events occur during the first 5 years, monitoring will continue until the second bankfull event is documented. The bankfull events must occur during separate monitoring years. In the event that the required bankfull events do not occur during the five-year monitoring period, the Corps and DWQ, in consultation with the resource agencies, may determine that further monitoring is not required. It is suggested that all bankfull occurrences be monitored and reported through the required monitoring period. A monitoring report will be prepared annually. Deviations from this protocol may be acceptable when they can be justified.

3.2 STREAM MORPHOLOGY ASSESSMENT

Requirements

If the restored stream section is less than 3,000 lf, the longitudinal profile should include the entire 3,000 lf, if the stream section is greater than 3,000 lf, the profile should be conducted for either 30 % of the restored stream or 3,000 lf (whichever is greater).

Permanent cross-sections should be established at an approximate frequency of one per 20 (bankfull-width) lengths. In general, the locations should be selected to represent approximately 50% pools and

50% riffle areas. Flexibility in the location and frequency will be allowed for cross-sections and should be based on best professional judgment. The selection of locations should always include areas that may be predisposed for potential problems. In the case of very narrow streams, two cross-sections per 1,000 lf will generally be sufficient. The as-built survey should also include photo documentation at all cross-sections and structures, a plan view diagram, a longitudinal profile, vegetation information and a pebble count for at least six cross-sections (or all cross sections if less than six required for project).

Pebble Counts are generally required at each cross-section and along the entire profile of each reach of stream. No less than 100 pebbles are to be measured at each cross-section count. Similarly a minimum of 100 pebbles is required of the longitudinal pebble count. The longitudinal collection should be performed in features representative of the reach.

Methods Applied

Two types of stream surveys, cross-sectional and longitudinal, were completed for both project construction and project monitoring, follow the methodology contained in the USDA Forest Service Manual, *Stream Channel Reference Sites* (Harrelson, et al. 1994). Dimension, pattern, and profile measurements of the restored channel were measured.

The stream geomorphology was classified using the results of the survey data and the Rosgen (1996) system. Because both Horse Creek and its Unnamed Tributary were less than 3,000 lf in length their entire profile was surveyed. The survey was stationed from upstream to downstream starting at 0+00.

Six (three riffles and three pools) permanent cross-section were taken on Horse Creek and two (one riffle and one pool) were surveyed on the Unnamed Tributary. Eighteen inch pieces of rebar were driven level with the ground and capped to denote the location of the permanent cross-sections. All cross-sections were surveyed left to right facing downstream.

Pebble counts were competed at each cross-section and longitudinally. No fewer than 100 pebbles were measured at each cross-section. More than 100 pebbles were measured for the longitudinal count and pebbles were collected in the same proportion as the ratio of riffle length to pool length throughout the reach.

In addition to the required assessments, Bank Hazard Erodibility Index (BEHI) assessments were taken at each of the eight cross-sections. BEHI assessments were made prior to construction as well.

Success Criteria

Minimal changes in the cross sections, profile, and substrate composition are to be expected. It is important to evaluate the changes that occur during the monitoring period to determine if they represent a movement toward a more unstable condition. When analyzing monitoring results, physical parameters of particular concern include:

- width-to-depth ratio,
- entrenchment ratio,
- bank height ratio,
- radius-of-curvature ratio,
- feature slopes, and
- substrate composition.

Deviations from the design values on these parameters may lead to significant channel instability. Because each restoration project will have its own critical values, the values that determine the geomorphic threshold for a particular stream must be determined on a case-by-case basis. Adjustments that do not exceed the critical values may be attributed to changes within or along the channel that signal increased stability, such as added vegetation on the banks.

Indicators that the stream is not functioning successfully include, but are not limited to the presence of:

- Channel aggradation or degradation,
- Bank erosion
- Lack of riparian vegetation establishment
- Developing instream bars (should be absent)
- Significant change from the as-built dimension and the as-built longitudinal profile.

Additionally the riffle/pool spacing should remain fairly constant and pools should not be filling in (aggradation) or riffles starting to change to pools (degradation). Accordingly pebble counts should show a change in the size of bed material toward a desired composition

Results

Results are discussed in Chapter Two of this report.

3.3 VEGETATIVE PLOT ASSESSMENT

Requirements

Survival of vegetation should be evaluated using survival plots or direct counts along the entire corridor of the restored stream. Survival of vegetation inside the riparian buffer may be documented for the monitoring period through stem-counts and photographic documentation of the entire length of the buffered corridor. Stem-counts and photographs to be recorded at pre-established 10x10 m stations/plot areas that comprise five percent of the total riparian buffer area. If the initial (year-one) survey does not show 80 percent survival, plant supplemental vegetation the next winter. Vegetation should be sampled during the growing season. Ideally, this would be mid-summer in June or July.

Methods Applied

Two photographs were taken at each plot; the photo location is discussed in the Photo Point Establishment section. The plots were marked with rebar in the same manor as the permanent cross-sections. The counts included only woody vegetation and shrubs. Results and probable causes for mortalities are located in Chapter Two.

Success Criteria

The criteria for vegetative success are eighty percent species survival.

Results

Results are discussed in Chapter Two of this report.

3.4 PHOTO POINT ESTABLISHMENT

Requirements

Photo documentation is required twice a year; in the summer and the winter. Photo documentation is required of all cross-sections, vegetative plots, and problem areas.

Methods Applied

Photographs were taken upstream, downstream, and from each bank at each cross-section. At each vegetative plot, one photo was taken from the center of the side of the plot closest to the stream bank. An additional photo was taken from the center of the side of the plot furthest from the stream bank. The photo points taken at problem areas were not as structured, the number at each area varied according to the complexity of the area. In addition to the photo points required for the cross-sections, vegetative plots, and problem areas; photo points were taken at intermittent locations in order to provide a more extensive visual survey of the stream.

Success Criteria

The photo points are used to supplement the stream and riparian data and aid in the analysis of the success of each. More so than achieving a criterion for success, a lack of photos at a particular point of importance along the stream would constitute failure. The photos should also aid in showing succession in the plant community over time.

Results

Results are discussed in Chapter Two of this report.

4 REPORT AND DATA SUBMISSION FORMAT

The data included in this report is in the following form:

- 2 Hardcopies of the report
- A master folder with the name 71082_Horse_Creek to house all e-files
- A subfolder named “Report” including the following:
    - A consolidated PDF document through the end of Section 1- Background
    - A consolidated PDF document of the entire report including plan views
- A second subfolder named “Support Files” with three subfolders a named:
    - Vegetation
    - Stream
    - Monitoring Plan View
- Both the Vegetation and Stream subfolders contain three subfolders named:
    - Photo Folder
    - Plan Folder
    - Data Spreadsheet
- The vegetation spreadsheet workbook includes a spreadsheet for each of the following:
    - Summary tables for all plots
    - E-versions of all raw data sheets
- The stream data spreadsheet workbook includes a spreadsheet for each of the following:
    - Summary table XIV
    - Raw Data Tables
    - Precipitation/Hydrology Plots

APPENDIX A VEGETATION RAW DATA

A.1 VEGETATION SURVEY DATA TABLES

Table 15: Vegetation Survey Data Table

Stem Counts for each species arranged by plot Project Number 71082																							
Species		Plots																		Initial	Year 1	Survival
Scientific Name	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Totals	Totals	%
Tree																						
Betula nigra	River Birch												1							1	NA	NA
Cornus florida	Flowering Dogwood					2														2	NA	NA
Diospyros virginiana	Persimmon										1	1								2	NA	NA
Fraxinus pennsylvanica	Green Ash						1	7												8	NA	NA
Juniperus virginiana	Eastern Red Cedar																			0	NA	NA
Magnolia virginiana	Sweetbay Magnolia						1	2						1						4	NA	NA
Nyssa sylvatica	Black Gum		1							1		1	2	1			1		3	10	NA	NA
Platanus occidentalis	Sycamore					1	1			1		1							1	5	NA	NA
Quercus alba	White Oak										1									1	NA	NA
Salix nigra	Black Willow						1						1							2	NA	NA
Shrubs																						
Aronia arbutifolia	Red Chokeberry		1			1														2	NA	NA
Cephalanthus occidentalis	Buttonbush											2		1				1		4	NA	NA
Euonymus americanus	Strawberry Bush			2																2	NA	NA
Ilex decidua	Deciduous Holly																			0	NA	NA
Ilex glabra	Inkberry		1																	1	NA	NA
Itea virginica	Virginia Willow						1				1		1	2					1	6	NA	NA
Lindera benzoin	Spicebush					5			5	3		1	1	6	1	1		4		27	NA	NA
Salix sericea	Silky Willow									1			1	3						5	NA	NA
Sambucus Canadensis	Common Elderberry															1				1	NA	NA
Dead/Unidentifiable																						
Dead						1	2			6	2	2	4	3		1	1	3	1	26	NA	NA
Unidentifiable (too small)				1			2													3	NA	NA
Total																						
Total number living		0	3	3	0	9	7	9	5	6	3	6	7	14	1	2	1	5	5	86	NA	NA

Table 16: Preliminary Soil Data for Horse Creek Watershed

Preliminary Soil Data					
Project Number 71082					
Series	Max Depth (in.)	% Clay on Surface	K	T	OM %
Altavista	0-20	10-27	0.24	5	0.5-3
	20-57	18-35	0.24		
	57-72	---	---		
Appling Ap	0-11	5-20	0.24	4	0.5-2
	11-35	35-60	0.28		
	35-65	20-50	0.28		
Appling Ap	0-9	5-20	0.24	4	0.5-2
	9-44	35-50	0.28		
	44-72	---	---		
Appling Au	0-12	5-20	0.24	4	0.5-2
	12-48	35-60	0.28		
	48-55	20-50	0.28		
	55-65	---			
Cecil CaB	0-8	5-20	0.28	4	0.5-1
	8-55	35-70	0.28		
	55-65	---	---		
Cecil CeB2	0-8	27-40	0.28	3	0.5-1
	8-58	35-70	0.28		
	58-65	---	---		
Cecil CeC2	0-2	27-40	0.28	3	0.5-1
	2-7	27-40	0.28		
	7-55	35-70	0.28		
	55-65	---	---		
Chewacla	0-6	10-27	0.28	5	1-4
	6-19	18-35	0.28		
	19-65	---	---		
Colfax	Information Unavailable				
Durham	0-11	2-10	0.17	4	0.5-2
	11-49	18-35	0.20		
	49-62	8-30	0.20		
Enon EnB	0-5	7-27	0.32	3	0.5-2
	5-48	35-60	0.28		
	48-65	---	---		
Enon EnC	0-5	7-27	0.32	3	0.5-2
	5-25	35-60	0.28		
	25-65	---	---		
Helena He	0-12	5-20	0.24	4	0.5-2
	12-19	20-35	0.28		
	19-50	35-60	0.28		
	50-72	---	---		
Helena He	0-11	5-20	0.24	4	0.5-2
	11-26	20-35	0.28		
	26-44	35-60	0.28		
	44-65	---	---		
Lloyd	Information Unavailable				
Madison	Information Unavailable				
Mantachie	Information Unavailable				
Pacolet Pa	0-8	8-20	0.2	3	0.5-2
	8-25	35-65	0.28		
	25-40	15-30	0.28		
	40-65	10-25	0.28		
Pacolet Pa	0-10	8-20	0.2	3	0.5-2
	10-26	35-65	0.28		
	26-34	15-30	0.28		
	34-65	10-25	0.28		
Udorthents	No Distinct Values				
Wake Con	No Distinct Values				
Wedowee	0-10	5-20	0.24	3	0.5-3
	10-35	35-45	0.28		
	35-62	15-30	0.28		
Wedowee	0-12	5-20	0.24	3	0.5-3
	12-35	35-45	0.28		
	35-65	15-30	0.28		
Wedowee	0-7	5-20	0.24	3	0.5-3
	7-23	35-45	0.28		
	23-65	15-30	0.28		
Wedowee	0-12	5-20	0.24	3	0.5-3
	12-20	35-45	0.28		
	20-65	15-30	0.28		
Wehadkee	0-7	5-20	0.24	5	2-5
	7-63	---	---		
Wehadkee	0-7	5-20	0.24	5	2-5
	7-63	---	---		
Worsham	0-8	---	0.43	2	1-3
	8-45	---	0.43		
	45-50	---	0.43		

A.2 VEGETATION PROBLEM AREA PHOTOS

Photo 5: Vegetative Problem Area c, 4+00 – 4+50 (0788 – Left Bank) 06/22/05

Problem: Bare Bank
Probable Cause: Cause undetermined

Photo 6: Vegetative Problem Area a, 0+80 – 1+40 (0780 – Left Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Possible land owner maintenance.

Photo 7: Vegetative Problem Area b, 0+80 – 1+40 (0783 – Right Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Possible land owner maintenance.

Photo 8: Vegetative Problem Area d, 5+80 – 8+00 (0791 – Left Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Possible land owner maintenance.

Photo 9: Vegetative Problem Area e: 5+00 – 6+00 (0875 – Right Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Possible land owner maintenance.
Comment: Approximately 15 ft is unmowed.

Photo 10: Vegetative Problem Area f, 14+00 – 17+00 (0813 – Right Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Possible land owner maintenance.
Comment: Vegetation Planted on 2 ft spacing and mowed around.

Photo 11: Vegetative Problem Area g, 14+00 – 15+00 (0811 – Left Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Possible land owner maintenance.

Photo 12: Vegetative Problem Area h, 17+00 – 20+50 (0832 – Right Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Possible land owner maintenance.

Photo 13: Vegetative Problem Area i, 22+50 – 23+80 (0819 – Left Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Does not appear to be maintained or suffer from predation. Lack of sun and water not deemed to be issues. Possible soil deficiencies.

Photo 14: Vegetative Problem Area j, 25+50 – 26+50 (0822 – Left Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Does not appear to be maintained or suffer from predation. Lack of sun and water not deemed to be issues. Possible soil deficiencies.

Photo 15: Vegetative Problem Area k, 0+80 – 2+00 UT (0848–Right Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Lack of planted species, abundance of volunteer species.

Photo 16: Vegetative Problem Area l, 1+50 – 2+50 UT (Left Bank) 06/22/05

Problem: Bare Floodplain
Probable Cause: Possible lack of sunlight. Possible land owner maintenance.

A.3 VEGETATION MONITORING PLOT PHOTOS

Photo 17: Vegetative Plot A, 0+90–1+60 (0779–looking from stream) 06/22/05

Photo 18: Vegetative Plot A, 0+90–1+60 (0780–looking toward stream) 06/22/05

Photo 19: Vegetative Plot B, 3+30–3+60 (0785–looking from stream) 06/22/05

Photo 20: Vegetative Plot B, 3+30–3+60 (0786–looking toward stream) 06/22/05

Photo 21: Vegetative Plot C, 3+30–3+60 (0789–Looking from stream) 06/22/05

Photo 22: Vegetative Plot C, 3+30–3+60 (0790–Looking toward stream) 06/22/05

Photo 23: Vegetative Plot D, 5+90–6+20 (0791–looking from stream) 06/22/05

Photo 24: Vegetative Plot D, 5+90–6+20 (0792–looking toward stream) 06/22/05

Photo 25: Vegetative Plot E, 8+70-9+00 (0793–looking from stream) 06/22/05

Photo 26: Vegetative Plot E, 8+70-9+00 (0794–looking toward stream) 06/22/05

Photo 27: Vegetative Plot F, 10+40-10+70 (0798–looking from stream) 06/22/05

Photo 28: Vegetative Plot F, 10+40-10+70 (0799–looking toward stream) 06/22/05

Photo 29: Vegetative Plot G, 11+10-11+40 (0800–looking from stream) 06/22/05

Photo 30: Vegetative Plot G, 11+10-11+40 (0801–looking toward stream) 06/22/05

Photo 31: Vegetative Plot H, 14+40-14+70 (0811–looking from stream) 06/22/05

Photo 32: Vegetative Plot H, 14+40-14+70 (0812–looking toward stream) 06/22/05

Photo 33: Vegetative Plot I, 16+00-16+30 (0813–looking from stream) 06/22/05

Photo 34: Vegetative Plot I, 16+00-16+30 (0814–looking toward stream) 06/22/05

Photo 35: Vegetative Plot J, 19+20-19+50 (0817–looking from stream) 06/22/05

Photo 36: Vegetative Plot J, 19+20-19+50 (0818–looking toward stream) 06/22/05

Photo 37: Vegetative Plot K, 22+30-22+60 (0819–looking from stream) 06/22/05

Photo 38: Vegetative Plot K, 22+30-22+60 (0820–looking toward stream) 06/22/05

Photo 39: Vegetative Plot L, 26+30-26+60 (0834–looking from stream) 06/22/05

Photo 40: Vegetative Plot L, 26+30-26+60 (0835–looking toward stream) 06/22/05

Photo 41: Vegetative Plot M, 27+20-27+50 (0821–looking from stream) 06/22/05

Photo 42: Vegetative Plot M, 27+20-27+50 (0822–looking toward stream) 06/22/05

Photo 43: Vegetative Plot N, 0+60-0+90 UT (0847–looking from stream) 06/22/05

Photo 44: Vegetative Plot N, 0+60-0+90 UT (0848–looking toward stream) 06/22/05

Photo 45: Vegetative Plot O, 1+40-1+70 UT (0849–looking from stream) 06/22/05

Photo 46: Vegetative Plot O, 1+40-1+70 UT (0850–looking toward stream) 06/22/05

Photo 47: Vegetative Plot P, 4+20-4+50 UT (0857–looking from stream) 06/22/05

Photo 48: Vegetative Plot P, 4+20-4+50 UT (0858–looking toward stream) 06/22/05

Photo 49: Vegetative Plot Q, 4+80-4+50 UT (0862–looking from stream) 06/22/05

Photo 50: Vegetative Plot Q, 4+80-4+50 UT (0863–looking toward stream) 06/22/05

Photo 51: Vegetative Plot R, On UT to UT (0864–looking from stream) 06/22/05

Photo 52: Vegetative Plot R, On UT to UT (0865–looking toward stream) 06/22/05

B.1 PROBLEM AREAS PLAN VIEW

The following page contains the plan view sheet that shows all of the "problem areas". All of the areas in this section are labeled problem areas on the plan view; however, after further analysis the areas were divided into three categories in the report:

- Problem Areas;
- Areas of Concern; and
- Areas of Differing from Design (labeled Areas of Difference).

Problem Areas are those that have already shown instability, likely to need continual monitoring, and possibly need maintenance in the future. Areas of Concern are reaches that show signs of change that may lead to instability in the future, but currently are stable. These areas should continue to be monitored, as they may or may not become unstable in the future. The third areas are Areas of Difference. Areas of Difference are areas that differ from the design in some way, but have stabilized. These areas are assumed to remain stable, but because deserve documentation due to their deviation from the design.

All three types of areas are located on the following map and they remain in order for ease of use. The pictures that follow also remain in chronological order to reduce confusion.

Figure 5: Problem Areas Plan View Sheets

Problem Areas Plan View Sheets 1 - 4 are located between pages 60 and 61. Stream and Vegetative Problem Areas are shown on these sheets.

B.2 REPRESENTATIVE STREAM PROBLEM AREA PHOTOS

Photo 53: Problem Area I, 0+20 (0868 - Looking upstream) 06/22/05

Category: Problem Area.
Problem: Sedimentation.
Probable Cause: Upstream sub-development construction has increased the sediment supply of the stream temporarily.

Photo 54: Problem Area II, 7+50 (0873 - Looking downstream) 06/22/05

Category: Problem Area.
Problem: Flow directed too close to the right bank (in the foreground) and as a result, bouncing off the bank, and being directed too close to the left bank (in the background of the photo). The shift in the thalweg is creating the formation of a mid-channel bar that is quickly gathering vegetation.
Probable Cause: The upstream rock-vane is not turning the flow enough to keep it off of the outside of the meander bend. The additional rock, placed as toe protection is helping to bounce the flow to the opposite bank, duplicating the problem of flow direction immediately downstream as well.

Photo 55: Problem Area III, 8+50 (0882 - Looking downstream) 06/22/05

Category: Area of Concern.
Problem: Beginning formation of vegetated mid-channel bars.
Probable Cause: The structure above the walking bridge is poorly formed and adversely affects flow vectors. Additionally, the woody debris downstream of the bridge and structure is also negatively influencing flow and aiding in the formation of the mid-channel bars. The vegetation appears to be maintaining an appropriate width at this point. Future monitoring visits should determine if the bars are able to gain enough mass to cause diversion of the flow.

Photo 56: Problem Area IV, 10+00 (0885 - Looking upstream) 06/22/05

Category: Area of Concern.
Problem: Elongation of point-bar and mild undercutting of outside of bend signaling possible lateral migration of meander bend.
Probable Cause: The flow is not being turned enough (there is nothing artificial in place to force the turn) therefore it is creating undue stress on the outside of the bend. If the bend migrates significantly, causing bank erosion on the outside of the bend this will become a problem area. Conversely, if the migration is minimal and the vegetation protects the outside of the bend than this area will no longer be of a concern.

Photo 57: Problem Area V, 13+80 (0893 - Looking downstream) 06/22/05

Category: Area of Difference.
Problem: Channel has developed a pool that is much wider than the design pool.
Probable Cause: Bank failure, possibly due to slow establishment of vegetation, on the outside of the meander bend. Point-bar has not migrated and vegetation appears to have stabilized banks, so at this point in time there does not seem to be any lateral migration. Currently, the vegetation appears to have stabilized the pool; therefore, this pool is being treated as a feature experiencing natural variation and has not generated any cause for concern. This feature is denoted only because it differs from the design and will not be photographed in the future unless it shows signs of moving towards instability.

Photo 58: Problem Area VI, 15+40 (0898 - Looking upstream) 06/22/05

Category: Area of Difference.
Problem: Channel has developed a pool that is much wider than the design pool.
Probable Cause: Bank failure, possibly due to slow establishment of vegetation, on the right bank. Vegetation appears to have stabilized banks, so at this point in time there does not seem to be any lateral migration occurring. Currently, the vegetation appears to have stabilized the pool; therefore, this pool is being treated as a feature experiencing natural variation and has not generated any cause for concern. This feature is denoted only because it differs from the design and will not be photographed in the future unless it shows signs of moving towards instability.

Photo 59: Problem Area VII, 21+20 (0908 - Looking downstream) 06/22/05

Category: Area of Concern.
Problem: Formation of vegetated mid-channel bars and consequently flow vector modification.
Probable Cause: The right bank appears to have sloughed into the channel causing the formation of a bar. This bar is adversely affecting the direction of flow for approximately twenty-five feet immediately downstream. It is possible that the sloughed material will be transported by the channel and the flow vectors will recuperate in time. If the channel is not rehabilitated the bar will grow and increase the disruption of the flow vectors. In future visits it will be important to establish if the channel is moving towards or away from a state of equilibrium.

Photo 60: Problem Area VIII, 22+00 (0909 – From Right Bank) 06/22/05

Category: Area of Concern.
Problem: Undercutting of left bank immediately downstream of Rock-Vane.
Probable Cause: The area immediately upstream of the rock-vane has over widened and the flow has begun to run parallel to the vane instead of across it. This change in flow vector has rendered the vane ineffective. Consequently the bank protection below the structure is not occurring.

Photo 61: Problem Area IX, 23+10 (0905 – Looking upstream) 06/22/05

Photo 62: Problem Area IX, 23+10 (0904 – Looking upstream) 06/22/05

Category: Area of Concern.
Problem: Undercutting of left bank downstream of Cross-Vane.
Probable Cause: The construction of the Cross-vane directs the stream at the right bank at low flow conditions. The flow then bounces to the opposite bank. The flow direction coupled with the lack of vegetation on the left bank has resulted in undercutting. This reach is too narrow and a small amount of widening, in this case through bank erosion, probably would not be the worst thing that could happen; as long as the vegetation is able to stabilize the section before it over widens. If the reach straightens itself out, it would also alleviate some of the damaging effects that are transferring downstream. While not the only cause of the downstream problems, Area IX is are putting additional stress on Area X.

Photo 63: Problem Area X, 25+00 (0911 – Looking downstream) 06/22/05

Photo 64: Problem Area X, 25+00 (0910 – Looking upstream) 06/22/05

Photo 65: Problem Area X, 25+00 (0912 – Looking downstream) 06/22/05

Photo 66: Problem Area X, 25+00 (0914 – Looking upstream) 06/22/05

Photo 67: Problem Area X, 25+00 (0918 – From Right Bank) 06/22/05

Photo 68: Problem Area X, 25+00 (0919 – Looking upstream) 06/22/05

Category: Problem Area.
Problem: Aggradation, Flow redirection, and erosion.
Probable Cause: A middle channel bar has formed in the channel, presumably using the bank failure immediately upstream as its sediment supply, and has redirected flow towards the right bank (Photo 0911). This has scoured the bank and bounces the flow back across the channel parallel to the rock-vane, rendering the vane ineffective (Photo 0910). At this point the right bank is scouring while the left bank aggrades upstream of the vane (Photo 0912). Without the influence of the vane, the flow has been angled too sharply towards the outside of the bend and is causing erosion of the left (outer) bank and the migration of the point bar (Photo 0914). After leaving the eroding bank the flow is squeezed through what appears to be a clay "projection" that directs the flow back into the right bank at an unfortunate angle again and then again toward the left bank (Photo 0918). With this added stress both the right and left banks are eroding at this point. Finally the flow vector is improved by passing through a J-hook vane (Photo 0919).

Photo 69: Problem Area XI, 26+70 (0920 – Looking upstream) 06/22/05

Photo 70: Problem Area XI, 26+70 (0921 – From Right Bank) 06/22/05

Category: Area of Concern.
Problem: Channel has widened at pool.
Probable Cause: Cross-vane lacks appropriate structure, (Photo 0920) most notably header rocks are missing (Photo 0921). Vegetation appears to have stabilized banks, so at this point in time there does not seem to be any lateral migration occurring. Currently, this is more an area of concern to be watched than a problem area, but should the pool continue to widen or should the concentration of flow be shifted inappropriately the stability of the channel could be compromised.

B.3 STREAM PHOTO-STATION PHOTOS

Photo 71: Photo Point i, 0+50 (0777 – looking upstream) 06/22/05

Photo 72: Photo Point i, 0+50 (0778 – looking downstream) 06/22/05

Photo 73: Photo Point ii, 2+50 (0875 – looking upstream) 06/22/05

Photo 74: Photo Point ii, 2+50 (0876 – looking downstream) 06/22/05

Photo 75: Photo Point iii, 5+40 (0787 – looking upstream) 06/22/05

Photo 76: Photo Point iii, 5+40 (0788 – looking downstream) 06/22/05

Photo 77: Photo Point iv, 8+00 (0877 – looking upstream) 06/22/05

Photo 78: Photo Point iv, 8+00 (0878 – looking downstream) 06/22/05

Photo 79: Photo Point v-a, 13+50 (0805 – looking upstream) 06/22/05

Photo 80: Photo Point v-b, 13+50 (0806 – looking downstream) 06/22/05

Photo 81: Photo Point vi, 17+50 (0815 – looking upstream) 06/22/05

Photo 82: Photo Point vi, 17+50 (0816 – looking downstream) 06/22/05

Photo 83: Photo Point vii, 21+50 (0902 – looking upstream) 06/22/05

Photo 84: Photo Point vii, 21+50 (0903 – looking downstream) 06/22/05

Photo 85: Photo Point viii, 28+00 (0922 – looking upstream) 06/22/05

Photo 86: Photo Point viii, 28+00 (0923 – looking downstream) 06/22/05

Photo 87: Photo Point ix, 0+00 UT (0838 – looking downstream) 06/22/05

Photo 88: Photo Point ix, 0+00 UT (0839 – looking downstream) 06/22/05

Photo 89: Photo Point ix, 0+00 UT (0840 – looking upstream) 06/22/05

Photo 90: Photo Point x, 2+08 UT (0845 – looking upstream) 06/22/05

Photo 91: Photo Point x, 2+08 UT (0846 – looking downstream) 06/22/05

Photo 92: Photo Point xi, 3+48 UT (0851 – looking upstream) 06/22/05

Photo 93: Photo Point xi, 3+48 UT (0852 – looking downstream) 06/22/05

Photo 94: Photo Point xii, 5+18 UT (0859–looking upstream into UT) 06/22/05

Photo 95: Photo Point xii, 5+18 UT (0860 – upstream into UT to UT) 06/22/05

Photo 96: Photo Point xii, 5+18 UT (0861 – looking downstream) 06/22/05

B.4 QUALITATIVE VISUAL STABILITY ASSESSMENT

Table 17: Qualitative Visual Stability Assessment – Horse Creek

Qualitative Visual Stability Assessment						
Project Number 71082 (Horse Creek)						
Segment/ Reach: Horse Creek (2825 feet)						
Feature Category	Metric (per As-built and reference baselines)	(# Stable) Number Performing as Intended	Total number per As-built	Total Number/ feet in unstable state	% Perform in Stable Condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	6	6	NA	100	
	2. Armor stable (e.g. no displacement)?	6	6	NA	100	
	3. Facet grade appears stable?	6	6	NA	100	
	4. Stable interval grade?	0	6	NA	0	
	5. Feature spacing appropriate?	0	6	NA	0	
	6. Minimal evidence of embedding/fining?	5	6	NA	83	
	7. Depth appears appropriate for current discharge?	6	6	NA	100	
	8. Length appropriate?	1	6	NA	17	**63%**
B. Pools	1. Present? (e.g. not subject to severe aggradation?)	15	15	NA	100	
	2. Sufficiently deep (Max Pool D: Mean Bkf > 1.6?)	6	15	NA	40	
	3. Thalweg located outer bend?	11	15	NA	73	
	4. Spacing appropriate?	4	14	NA	29	
	5. Non-aggrading (not filling)?	9	15	NA	60	
	6. Length appropriate?	6	15	NA	40	**57%**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	17	21	NA	81	
	2. Downstream of meander (glide/inflection) centering?	17	21	NA	81	**81%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	17	21	NA	81	
	2. Of those eroding, # w/ concomitant point bar formation?	3	4	NA	75	
	3. Apparent Rc within spec?	13	21	NA	62	
	4. Sufficient floodplain access and relief?	21	21	NA	100	**79%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	NA	NA	6/140	2	
	2. Channel bed degradation - areas of increased down-cutting or head cutting?	NA	NA	0	0	**98%**
F. Channel Capac./Dimen.	1. Channel width: depth appears out of design/type spec?	NA	NA	1/80	8	**92%**
G. Banks	1. Apparent scour points from channel processes	NA	NA	6/140	2	
	2. Apparent cut points from overland flow	NA	NA	0	0	
	3. Apparent cut or scour from flood water re-entry to channel (e.g. inadequate floodplain	NA	NA	0	0	
	4. Tension cracks?	NA	NA	0	0	
	5. Unstable cantilever blocks	NA	NA	0	0	
	6. Bank gradient in excess of 40%?	NA	NA	0	0	
	7. Collapse/slumping	NA	NA	1/40	4	
	8. Ratio of bank height: bankfull height elevated	NA	NA	0	0	**94%**
H. Vanes	1. Free of back or arm scour?	20	24	NA	83	
	2. Height appropriate?	12	24	NA	50	
	3. Angle and geometry appear appropriate?	6	24	NA	25	
	4. Free of piping or other structural failures?	20	24	NA	83	**60%**
I. Wads/Boulders	1. Free of scour?	NA	NA	NA	NA	NA
	2. Footing stable?	NA	NA	NA	NA	NA

Table 18: Qualitative Visual Stability Assessment – Unnamed Tributary

Qualitative Visual Stability Assessment Project Number 71082 (Horse Creek) Segment/ Reach: Unnamed Tributary to Horse Creek (550 feet)						
Feature Category	**Metric (per As-built and reference baselines)**	**(# Stable) Number Performing as Intended**	**Total number per As-built**	**Total Number/ feet in unstable state**	**% Perform in Stable Condition**	**Feature Perform. Mean or Total**
A. Riffles	1. Present?	3	3	NA	100	
	2. Armor stable (e.g. no displacement)?	3	3	NA	100	
	3. Facet grade appears stable?	3	3	NA	100	
	4. Stable interval grade?	3	3	NA	100	
	5. Feature spacing appropriate?	3	3	NA	100	
	6. Minimal evidence of embedding/fining?	3	3	NA	100	
	7. Depth appears appropriate for current discharge?	3	3	NA	100	
	8. Length appropriate?	0	3	NA	0	**87.5**
B. Pools	1. Present? (e.g. not subject to severe aggradation?)	3	3	NA	100	
	2. Sufficiently deep (Max Pool D: Mean Bkf > 1.6?)	3	3	NA	100	
	3. Thalweg located outer bend?	3	3	NA	100	
	4. Spacing appropriate?	0	3	NA	0	
	5. Non-aggrading (not filling)?	3	3	NA	100	
	6. Length appropriate?	2	3	NA	67	**78**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	10	10	NA	100	
	2. Downstream of meander (glide/inflection) centering?	10	10	NA	100	**100**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	10	10	NA	100	
	2. Of those eroding, # w/ concomitant point bar formation?	0	0	NA	0	
	3. Apparent Rc within spec?	10	10	NA	100	
	4. Sufficient floodplain access and relief?	10	10	NA	100	**75**
E. Bed General	1. General channel bed aggradation areas (bar formation)	NA	NA	0	0	
	2. Channel bed degradation - areas of increased down-cutting or head cutting?	NA	NA	0	0	**100**
F. Channel Capac./Dimen.	1. Channel width: depth appears out of design/type spec?	NA	NA	0	0	**100**
G. Banks	1. Apparent scour points from channel processes	NA	NA	0	0	
	2. Apparent cut points from overland flow	NA	NA	0	0	
	3. Apparent cut or scour from flood water re-entry to channel (e.g. inadequate floodplain access?)	NA	NA	0	0	
	4. Tension cracks?	NA	NA	0	0	
	5. Unstable cantilever blocks.	NA	NA	0	0	
	6. Bank gradient in excess of 40%?	NA	NA	0	0	
	7. Collapse/slumping	NA	NA	0	0	
	8. Ratio of bank height: bankfull height elevated	NA	NA	0	0	**100**
H. Vanes	1. Free of back or arm scour?	NA	NA	0	0	
	2. Height appropriate?	NA	NA	0	0	
	3. Angle and geometry appear appropriate?	NA	NA	0	0	
	4. Free of piping or other structural failures?	NA	NA	0	0	**100**
I. Wads/Boulders	1. Free of scour?	NA	NA	NA	NA	
	2. Footing stable?	NA	NA	NA	NA	NA

B.5 CROSS SECTION PLOTS AND RAW DATA TABLES

Table 19: Cross Section 1, Station 1+00

As-Built Conditions								
Xsec: 1		Station: 1+00		Feature: Riffle		Bankfull Hydraulic Geometry		
Survey Data & Notes								
FPR	TOB	BKF	STA	H_20	EL	Depth	Width	Area
LFPR			0.0		321.91	0.00	0.0	0.00
			13.1		322.30	0.00	0.0	0.00
	LTOB	LBKF	27.8		321.10	0.00	14.7	0.00
			37.5		317.50	3.60	9.7	17.50
			39.1		316.30	4.80	1.6	6.59
			41.2		315.40	5.70	2.1	11.08
			52.1		316.50	4.60	10.9	55.88
			55.2		317.60	3.50	3.2	12.80
		RBKF	64.5		321.10	0.00	9.3	16.24
	RTOB		68.7		322.70	0.00	0.0	0.00
			85.2		323.70	0.00	0.0	0.00
RFPR			99.8		324.12	0.00	0.0	0.00
Feature	**W_{FPA}**	**EL_{BKF}**	**W_{BKF}**	**D_{BKF}**	**W/D**	**A_{BKF}**	**Dmax**	**ER**
Riffle	**99.8**	**321.1**	**36.7**	**3.27**	**11.2**	**120.1**	**5.7**	**2.7**

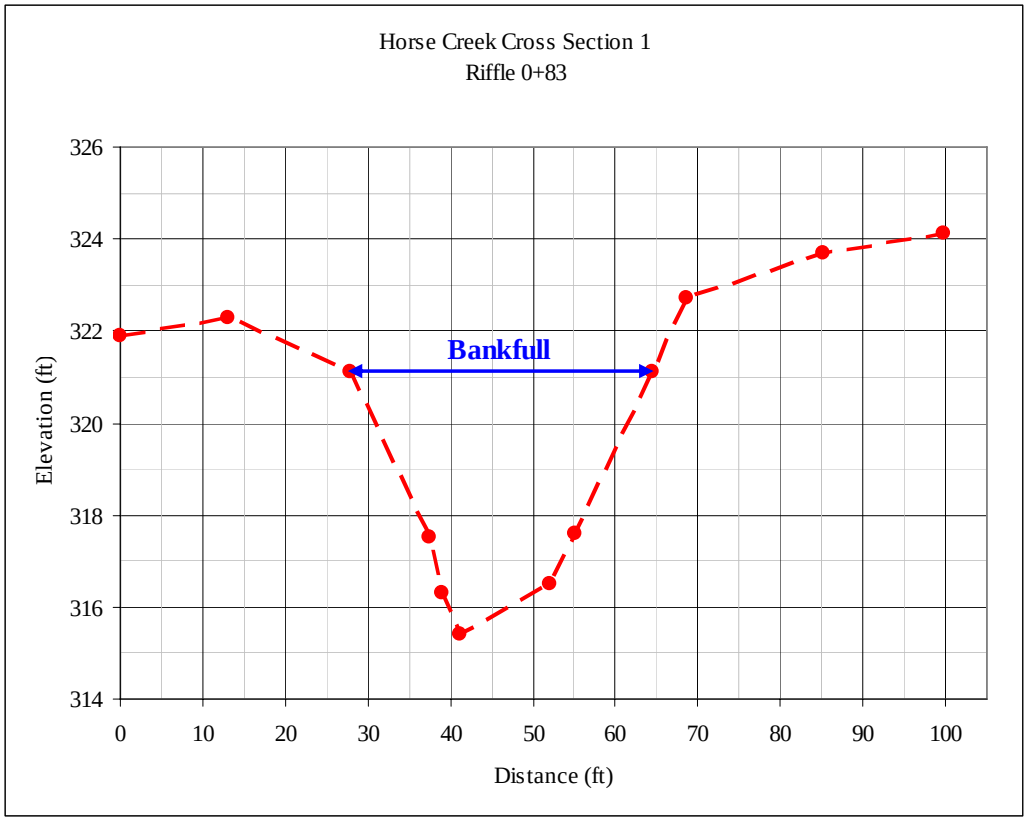


Table 20: Cross Section 2, Station 10+30

As-Built Conditions								
Xsec: 2		Station: 10+30		Feature: Pool		Bankfull Hydraulic Geometry		
Survey Data & Notes								
FPR	TOB	BKF	STA	H_20	EL	Depth	Width	Area
LFPR			0.0		320.41	0.00	0.0	0.00
			21.2		320.10	0.00	0.0	0.00
	LTOB	LBKF	28.8		319.60	0.00	7.6	0.00
			34.7		316.50	3.10	5.9	9.11
			37.0		314.60	5.00	2.3	9.32
			39.7		313.90	5.70	2.7	14.55
			48.8		315.30	4.30	9.1	45.25
			54.0		315.70	3.90	5.2	21.36
			58.2		317.00	2.60	4.3	13.85
	RTOB	RBKF	67.6		319.60	0.00	9.4	12.22
			85.7		320.40	0.00	0.0	0.00
RFPR			99.6		320.73	0.00	0.0	0.00

Feature	W_{FPA}	EL_{BKF}	W_{BKF}	D_{BKF}	W/D	A_{BKF}	Dmax	ER
Pool	**99.6**	**319.6**	**38.8**	**3.24**	**12.0**	**125.7**	**5.7**	**Pool**

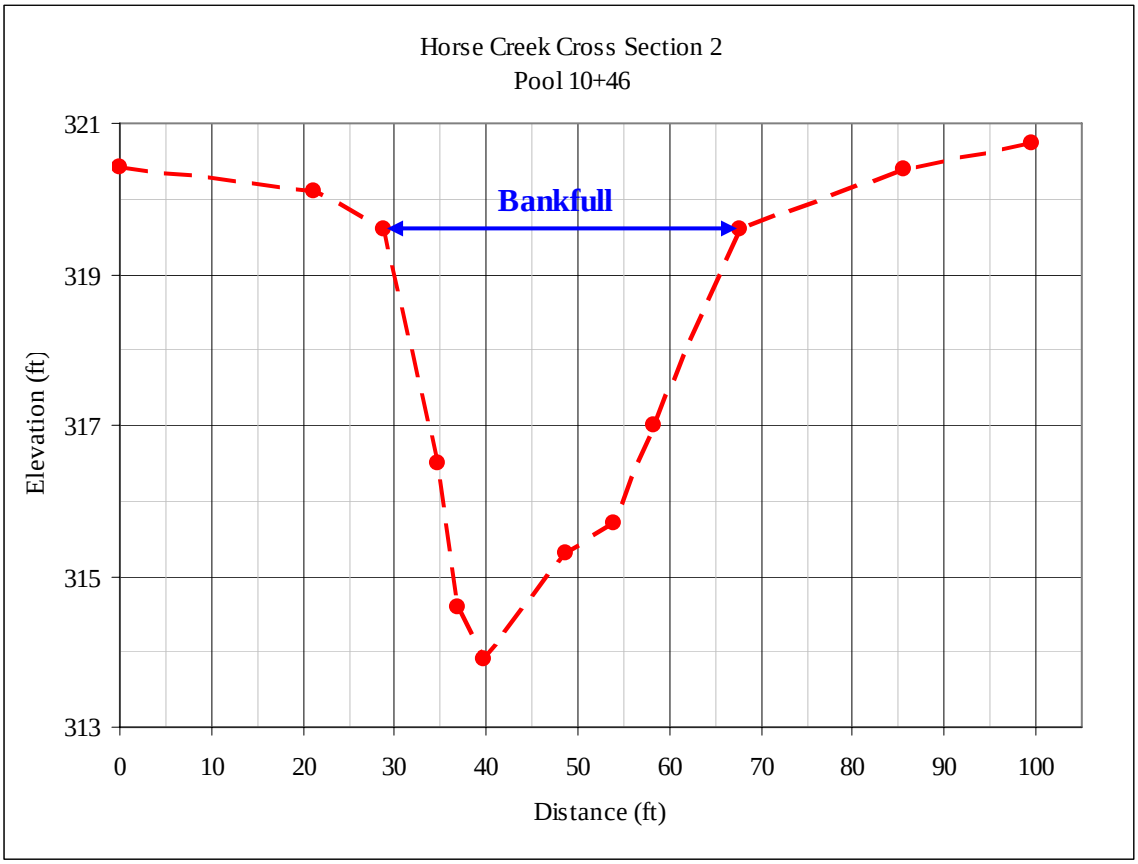


Table 21: Cross Section 3, Station 14+40

As-Built Conditions								
Xsec: 3		Station: 14+40		Feature: Pool		Bankfull Hydraulic Geometry		
Survey Data & Notes								
FPR	TOB	BKF	STA	H_20	EL	Depth	Width	Area
LFPR			0.0		319.55	0.00	0.0	0.00
			19.2		319.20	0.00	0.0	0.00
	LTOB	LBKF	34.0		318.20	0.00	14.8	0.00
			43.5		315.30	2.90	9.5	13.82
			45.4		313.30	4.90	1.9	7.33
			48.1		311.20	7.00	2.7	16.30
			54.6		312.00	6.20	6.5	42.57
			56.3		314.20	4.00	1.7	8.62
			58.0		316.70	1.50	1.7	4.70
		RBKF	65.3		318.20	0.00	7.3	5.47
	RTOB		67.7		318.70	0.00	0.0	0.00
			87.9		319.40	0.00	0.0	0.00
RFPR			100.7		319.89	0.00	0.0	0.00

Feature	W_{FPA}	EL_{BKF}	W_{BKF}	D_{BKF}	W/D	A_{BKF}	Dmax	ER
Pool	**100.7**	**318.2**	**31.3**	**3.16**	**9.9**	**98.8**	**7.0**	**Pool**

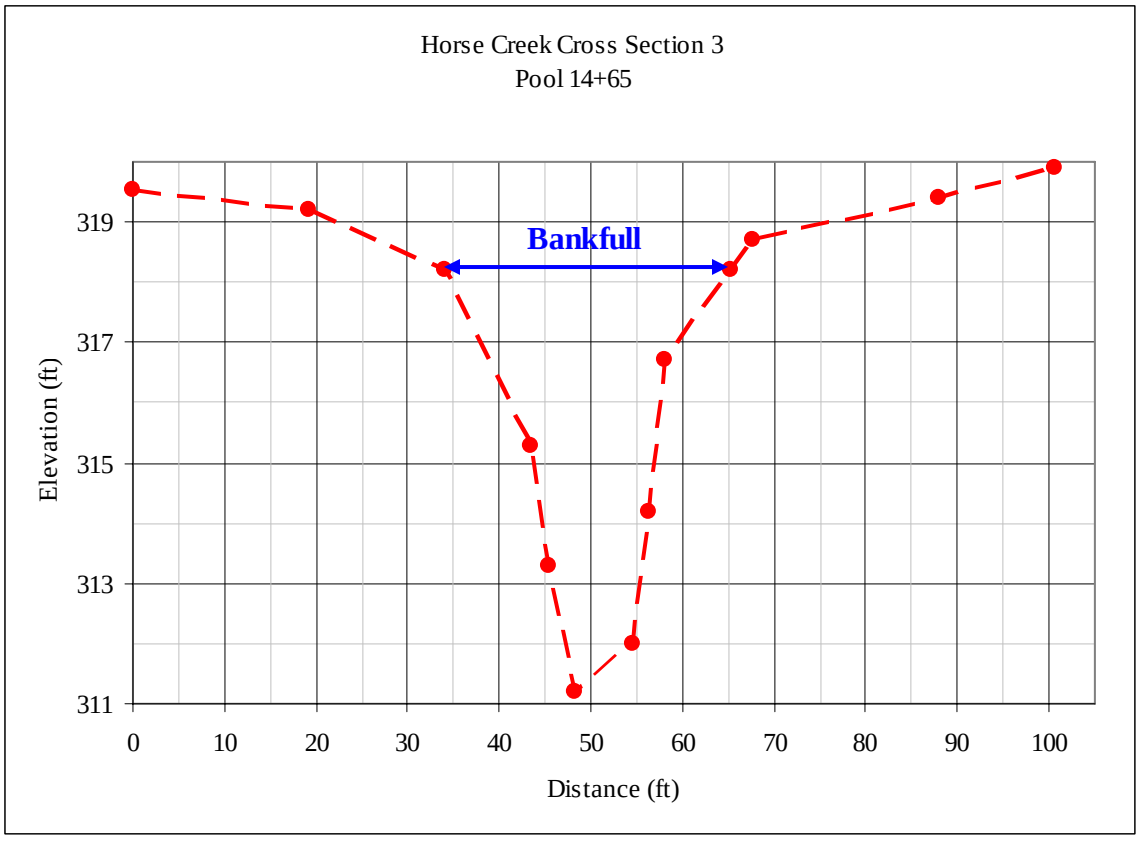


Table 22: Cross Section 4, Station 20+60

As-Built Conditions								
Xsec: 4		Station: 20+60		Feature: Riffle		Bankfull Hydraulic Geometry		
Survey Data & Notes								
FPR	TOB	BKF	STA	H_20	EL	Depth	Width	Area
LFPR			0.0		318.39	0.00	0.0	0.00
			17.9		318.50	0.00	0.0	0.00
	LTOB	LBKF	40.8		317.70	0.00	22.8	0.00
			52.2		314.20	3.50	11.4	20.00
			55.0		313.00	4.70	2.8	11.40
			57.2		312.60	5.10	2.3	11.02
			65.3		313.30	4.40	8.1	38.33
			68.1		314.60	3.10	2.8	10.35
			72.7		315.60	2.10	4.6	12.01
		RBKF	79.3		317.70	0.00	6.7	7.00
	RTOB		80.6		318.10	0.00	0.0	0.00
			95.1		318.40	0.00	0.0	0.00
RFPR			102.0		318.24	0.00	0.0	0.00

Feature	W_{FPA}	EL_{BKF}	W_{BKF}	D_{BKF}	W/D	A_{BKF}	Dmax	ER
Riffle	**102.0**	**317.7**	**38.6**	**2.85**	**13.5**	**110.1**	**5.1**	**2.6**

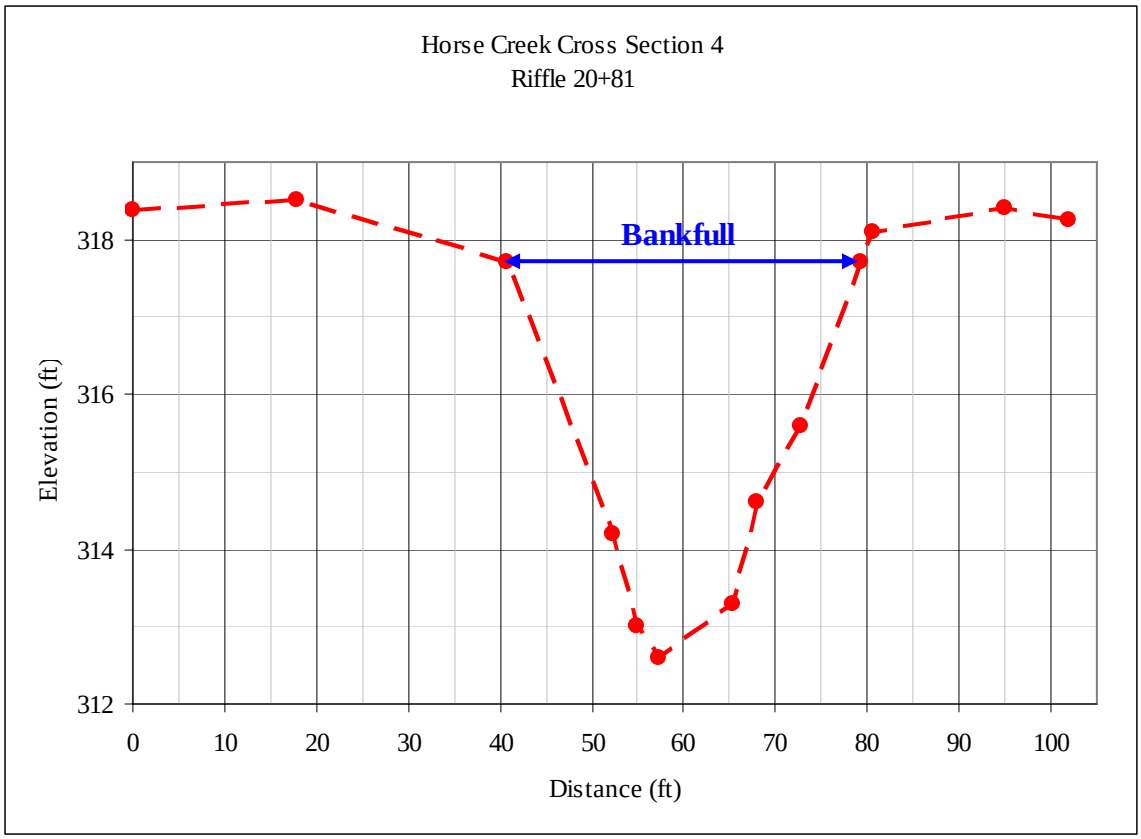


Table 23: Cross Section 5, Station 25+00

As-Built Conditions								
Xsec: 5		Station: 25+00		Feature: Pool		Bankfull Hydraulic Geometry		
Survey Data & Notes								
FPR	TOB	BKF	STA	H_20	EL	Depth	Width	Area
LFPR			0.0		317.02	0.00	0.0	0.00
			17.9		317.10	0.00	0.0	0.00
	LTOB	LBKF	32.7		317.00	0.00	14.8	0.00
			42.5		313.70	3.30	9.8	16.24
			45.2		311.70	5.30	2.7	11.61
			48.6		311.80	5.20	3.4	17.75
			53.1		312.20	4.80	4.5	22.65
			56.1		314.10	2.90	3.0	11.47
		RBKF	66.7		317.00	0.00	10.6	15.36
	RTOB		67.4		317.20	0.00	0.0	0.00
			84.8		317.60	0.00	0.0	0.00
RFPR			99.1		317.67	0.00	0.0	0.00

Feature	W_{FPA}	EL_{BKF}	W_{BKF}	D_{BKF}	W/D	A_{BKF}	Dmax	ER
Pool	**99.1**	**317.0**	**34.0**	**2.79**	**12.2**	**95.1**	**5.3**	**Pool**

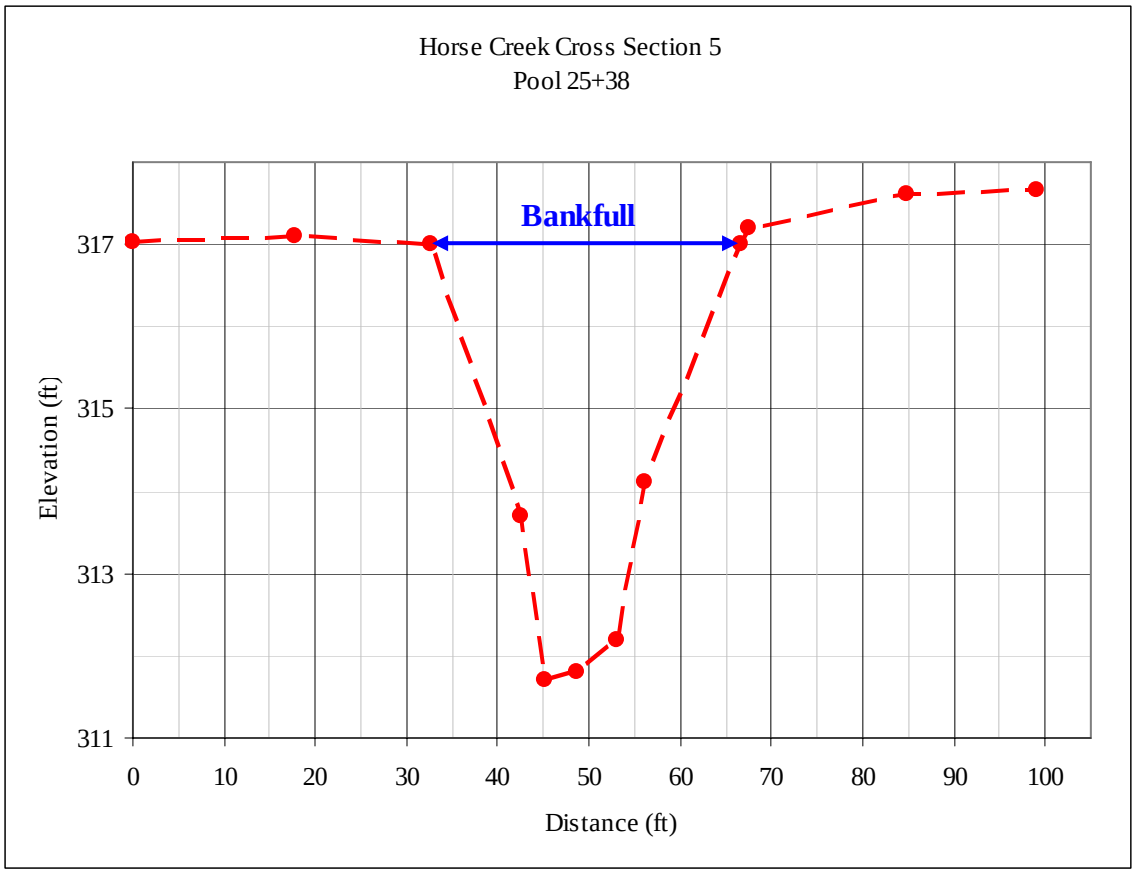


Table 24: Cross Section 6, Station 27+00

As-Built Conditions								
Xsec: 6		Station: 27+00		Feature: Riffle		Bankfull Hydraulic Geometry		
Survey Data & Notes								
FPR	TOB	BKF	STA	H_20	EL	Depth	Width	Area
LFPR			0.0		315.95	0.65	0.0	0.00
			10.5		315.80	0.80	10.5	7.60
	LTOB	LBKF	43.6		316.60	0.00	33.1	13.26
			56.7		312.60	4.00	13.1	26.24
			58.3		311.60	5.00	1.5	6.89
			62.3		311.10	5.50	4.0	21.21
			65.3		311.40	5.20	3.0	15.84
			67.0		312.90	3.70	1.8	7.79
		RBKF	80.6		316.60	0.00	13.6	25.07
	RTOB		81.3		316.80	0.00	0.0	0.00
			88.3		316.50	0.10	7.0	0.35
RFPR			100.4		316.33	0.27	12.0	2.23

Feature	W_{FPA}	EL_{BKF}	W_{BKF}	D_{BKF}	W/D	A_{BKF}	Dmax	ER
Riffle	**100.4**	**316.6**	**37.0**	**3.42**	**10.8**	**126.5**	**5.5**	**2.7**

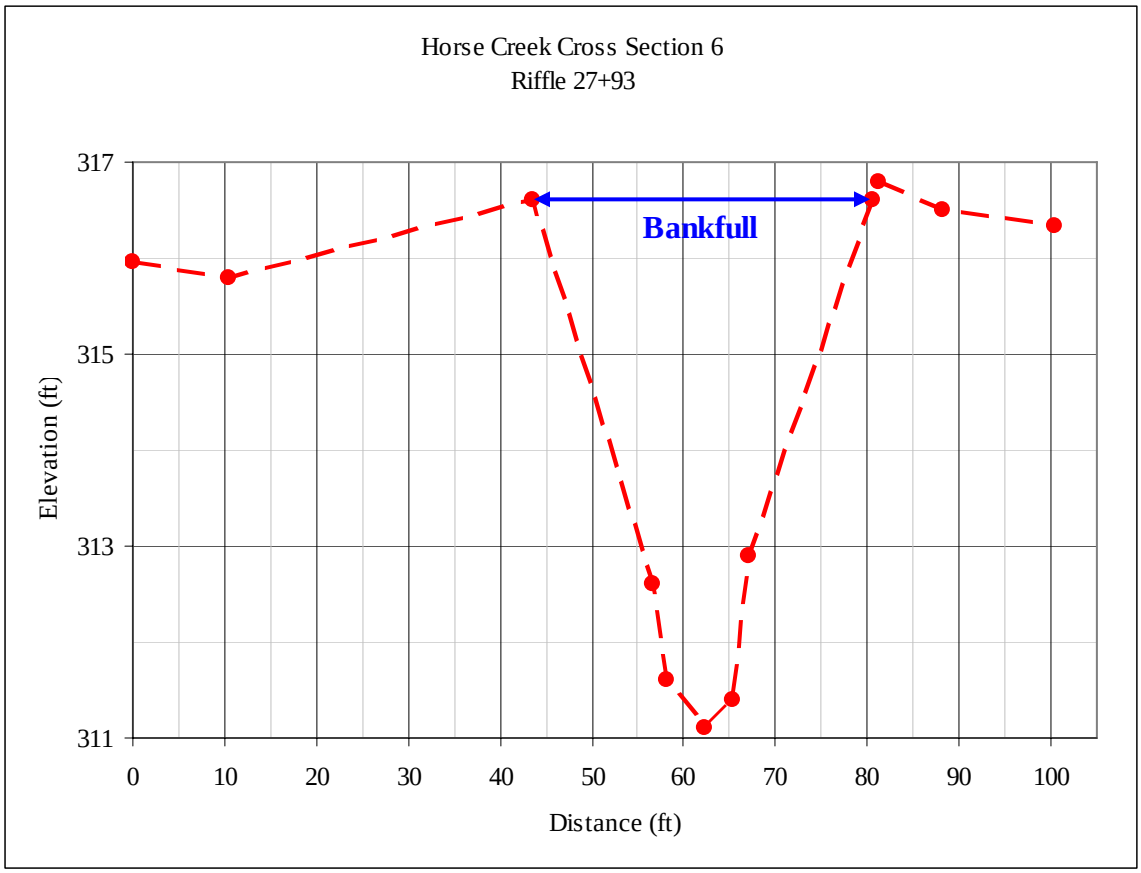


Table 25: Cross Section 7, Station 0+08 (UT)

As-Built Conditions								
Xsec: 7		Station: 0+08 (UT)		Feature: Pool		Bankfull Hydraulic Geometry		
Survey Data & Notes								
FPR	TOB	BKF	STA	H_20	EL	Depth	Width	Area
LFPR			0.0		330.65	0.00	0.0	0.00
			8.3		329.40	0.00	0.0	0.00
	LTOB		19.3		328.70	0.00	0.0	0.00
		LBKF	20.7		328.00	0.00	1.4	0.00
			22.5		327.10	0.90	1.8	0.81
			27.1		326.10	1.90	4.6	6.43
			31.4		326.90	1.10	4.3	6.38
		RBKF	33.2		328.00	0.00	1.8	0.99
			34.3		328.70	0.00	0.0	0.00
	RTOB		34.3		328.80	0.00	0.0	0.00
			41.7		329.90	0.00	0.0	0.00
RFPR			50.6		330.74	0.00	0.0	0.00

Feature	W_{FPA}	EL_{BKF}	W_{BKF}	D_{BKF}	W/D	A_{BKF}	Dmax	ER
Pool	50.6	328.0	12.4	1.17	10.6	14.6	1.9	Pool

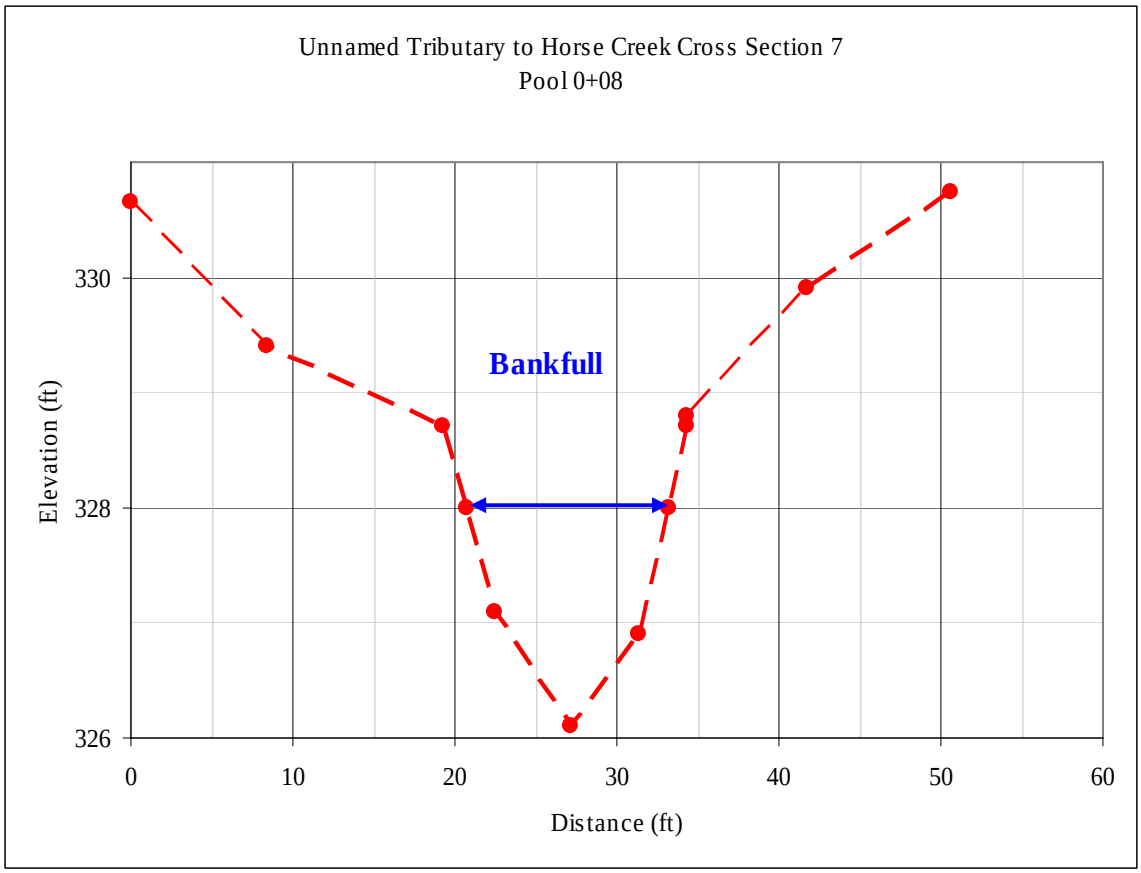
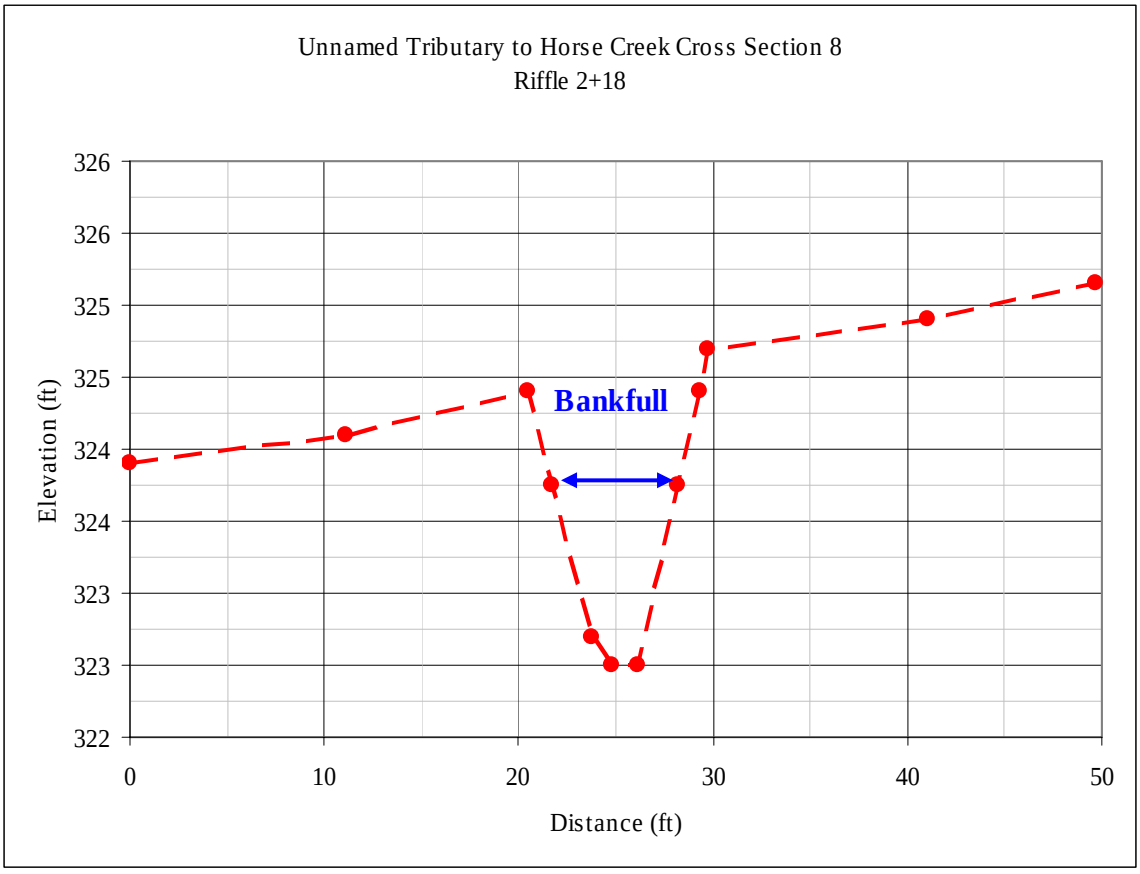


Table 26: Cross Section 8, Station 2+18 (UT)

As-Built Conditions								
Xsec: 8		Station: 2+18 (UT)		Feature: Riffle		Bankfull Hydraulic Geometry		
Survey Data & Notes								
FPR	TOB	BKF	STA	H_20	EL	Depth	Width	Area
LFPR			0.0		323.90	0.00	0.0	0.00
			11.1		324.10	0.00	0.0	0.00
	LTOB		20.5		324.40	0.00	0.0	0.00
		LBKF	21.7		323.75	0.00	1.3	0.00
			23.8		322.70	1.05	2.0	1.06
			24.8		322.50	1.25	1.0	1.17
			26.2		322.50	1.25	1.4	1.75
		RBKF	28.2		323.75	0.00	2.1	1.29
			29.3		324.40	0.00	0.0	0.00
	RTOB		29.8		324.70	0.00	0.0	0.00
			41.1		324.90	0.00	0.0	0.00
RFPR			49.7		325.15	0.00	0.0	0.00

Feature	W_{FPA}	EL_{BKF}	W_{BKF}	D_{BKF}	W/D	A_{BKF}	Dmax	ER
Riffle	**49.7**	**323.8**	**8.8**	**0.81**	**8.0**	**5.3**	**1.3**	**7.6**



B.6 LONGITUDINAL PLOTS AND RAW DATA TABLES

Table 27: Longitudinal Plots and Raw Data Tables

The Longitudinal Plots and Raw Data Tables are located on the following pages.

B.7 Pebble Count Plots and Raw Data Tables

Table 28: Pebble Count, Cross Section 1 – Riffle

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	1 - Riffle	
Date:	27/06/2005			Station No:	1+00	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	17	16%	16%
Very Fine	0.061	0.125	Sand	37	35%	51%
Fine	0.125	0.25		25	24%	75%
Medium	0.25	0.5		5	5%	80%
Coarse	0.5	1		7	7%	87%
Very Coarse	1	2		3	3%	90%
Very Fine	2	4	Gravel	5	5%	94%
Fine	4	5.7		2	2%	96%
Fine	5.7	8		2	2%	98%
Medium	8	11.3		0	0%	98%
Medium	11.3	16		0	0%	98%
Coarse	16	22.6		0	0%	98%
Coarse	22.6	32		0	0%	98%
Very Coarse	32	45		0	0%	98%
Very Coarse	45	64		0	0%	98%
Small	64	90	Cobble	0	0%	98%
Small	90	128		0	0%	98%
Large	128	180		0	0%	98%
Large	180	256		2	2%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	105	100%	---
			D_{50}	0.13		
			D_{84}	0.75		

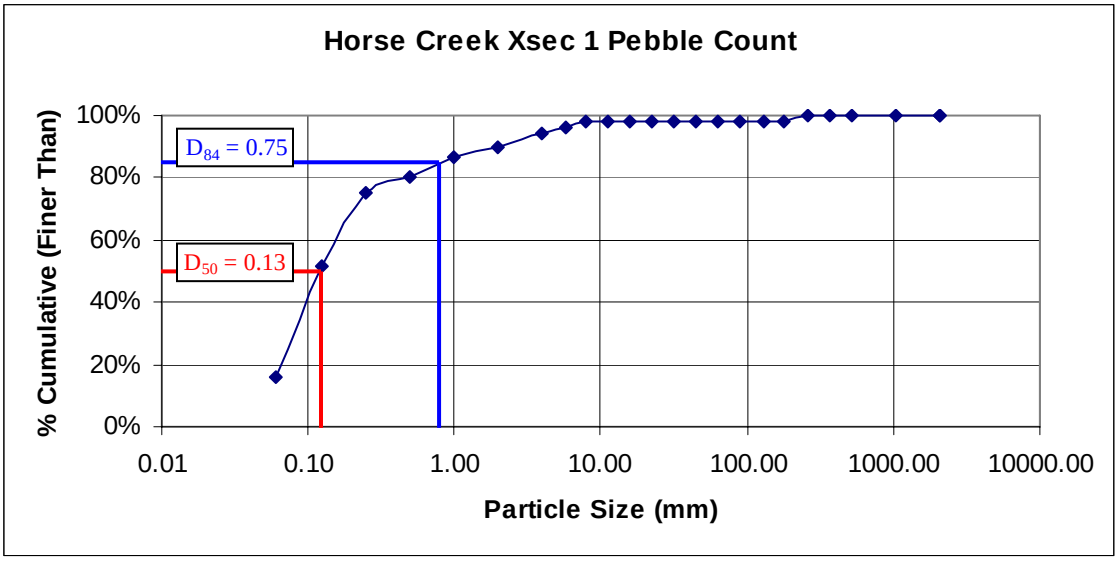


Table 29: Pebble Count, Cross Section 2 – Pool

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	2 - Pool	
Date:	27/06/2005			Station No:	10+30	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	10	8%	8%
Very Fine	0.061	0.125	Sand	48	38%	46%
Fine	0.125	0.25		25	20%	66%
Medium	0.25	0.5		20	16%	82%
Coarse	0.5	1		14	11%	93%
Very Coarse	1	2		4	3%	96%
Very Fine	2	4	Gravel	1	1%	97%
Fine	4	5.7		0	0%	97%
Fine	5.7	8		0	0%	97%
Medium	8	11.3		1	1%	98%
Medium	11.3	16		1	1%	98%
Coarse	16	22.6		0	0%	98%
Coarse	22.6	32		2	2%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	126	100%	---
			D_{50}	0.15		
			D_{84}	0.50		

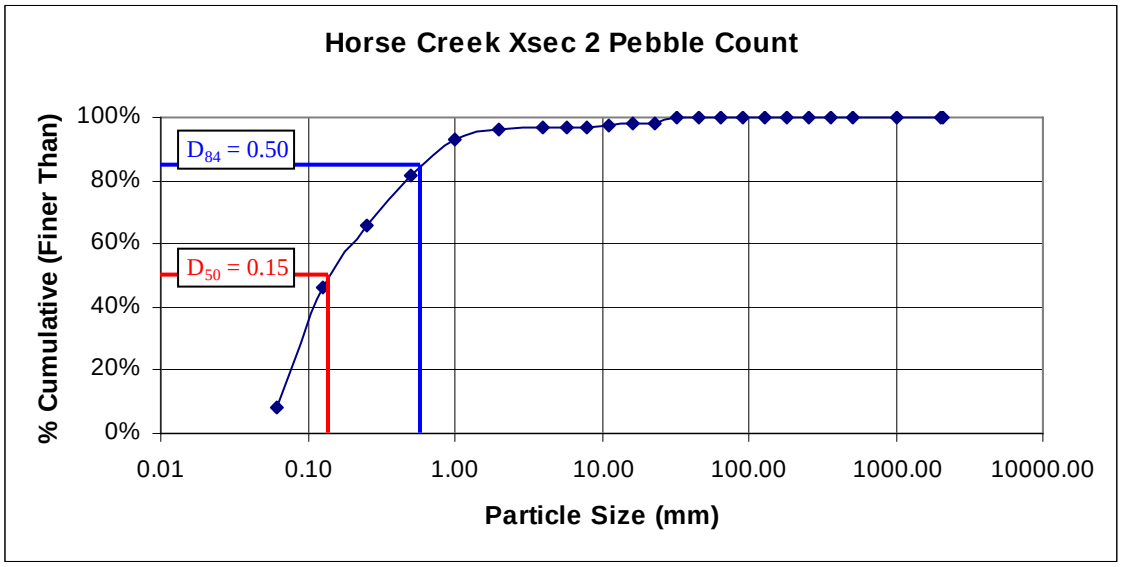


Table 30: Pebble Count, Cross Section 3 – Pool

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	3 - Pool	
Date:	27/06/2005			Station No:	14+40	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	2	2%	2%
Very Fine	0.061	0.125	Sand	40	39%	41%
Fine	0.125	0.25		37	36%	77%
Medium	0.25	0.5		20	19%	96%
Coarse	0.5	1		3	3%	99%
Very Coarse	1	2		1	1%	100%
Very Fine	2	4	Gravel	0	0%	100%
Fine	4	5.7		0	0%	100%
Fine	5.7	8		0	0%	100%
Medium	8	11.3		0	0%	100%
Medium	11.3	16		0	0%	100%
Coarse	16	22.6		0	0%	100%
Coarse	22.6	32		0	0%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	103	100%	---
			D_{50}	0.16		
			D_{84}	0.35		

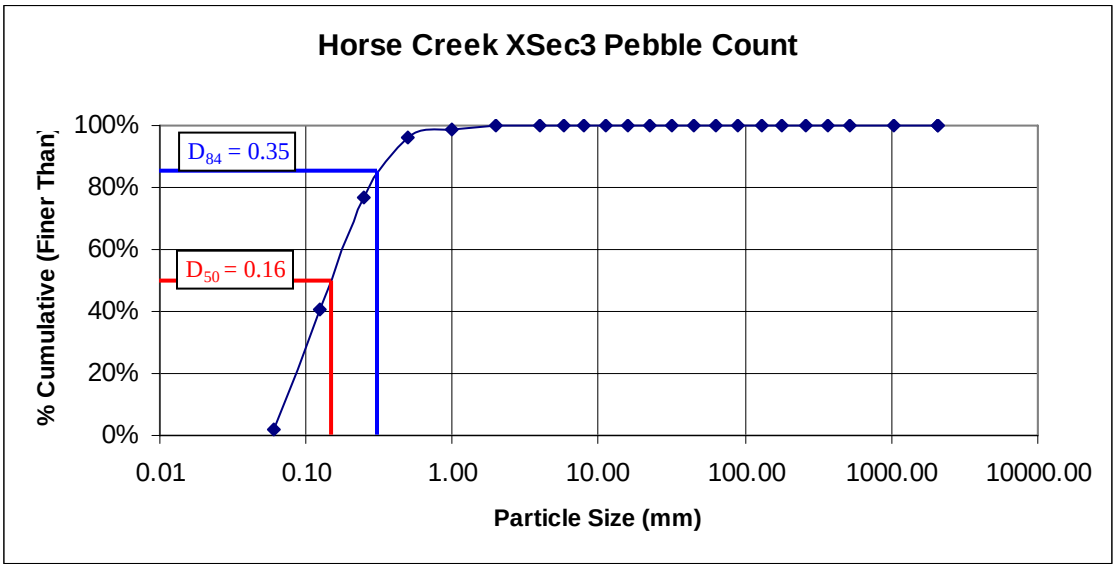


Table 31: Pebble Count, Cross Section 4 – Riffle

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	4 - Riffle	
Date:	27/06/2005			Station No:	20+60	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	33	33%	33%
Very Fine	0.061	0.125	Sand	27	27%	59%
Fine	0.125	0.25		13	13%	72%
Medium	0.25	0.5		12	12%	84%
Coarse	0.5	1		4	4%	88%
Very Coarse	1	2		6	6%	94%
Very Fine	2	4	Gravel	2	2%	96%
Fine	4	5.7		1	1%	97%
Fine	5.7	8		1	1%	98%
Medium	8	11.3		1	1%	99%
Medium	11.3	16		0	0%	99%
Coarse	16	22.6		0	0%	99%
Coarse	22.6	32		1	1%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	101	100%	---
			D_{50}	0.10		
			D_{84}	0.50		

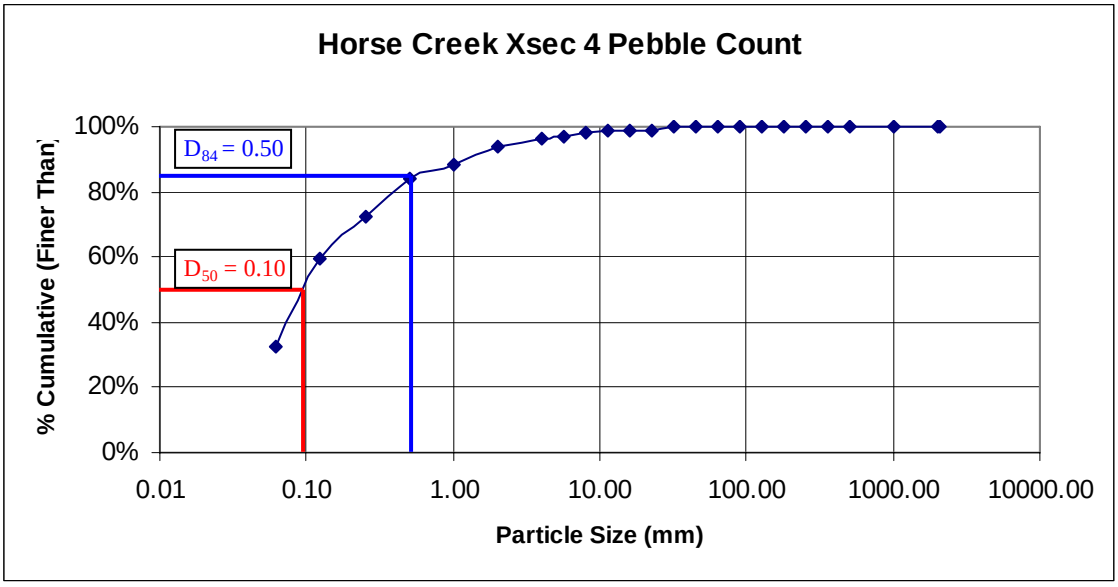


Table 32: Pebble Count, Cross Section 5 – Pool

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	5 - Pool	
Date:	27/06/2005			Station No:	25+00	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	27	27%	27%
Very Fine	0.061	0.125	Sand	27	27%	54%
Fine	0.125	0.25		16	16%	70%
Medium	0.25	0.5		20	20%	90%
Coarse	0.5	1		6	6%	96%
Very Coarse	1	2		3	3%	99%
Very Fine	2	4	Gravel	1	1%	100%
Fine	4	5.7		0	0%	100%
Fine	5.7	8		0	0%	100%
Medium	8	11.3		0	0%	100%
Medium	11.3	16		0	0%	100%
Coarse	16	22.6		0	0%	100%
Coarse	22.6	32		0	0%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	100	100%	---
			D_{50}	0.12		
			D_{84}	0.37		

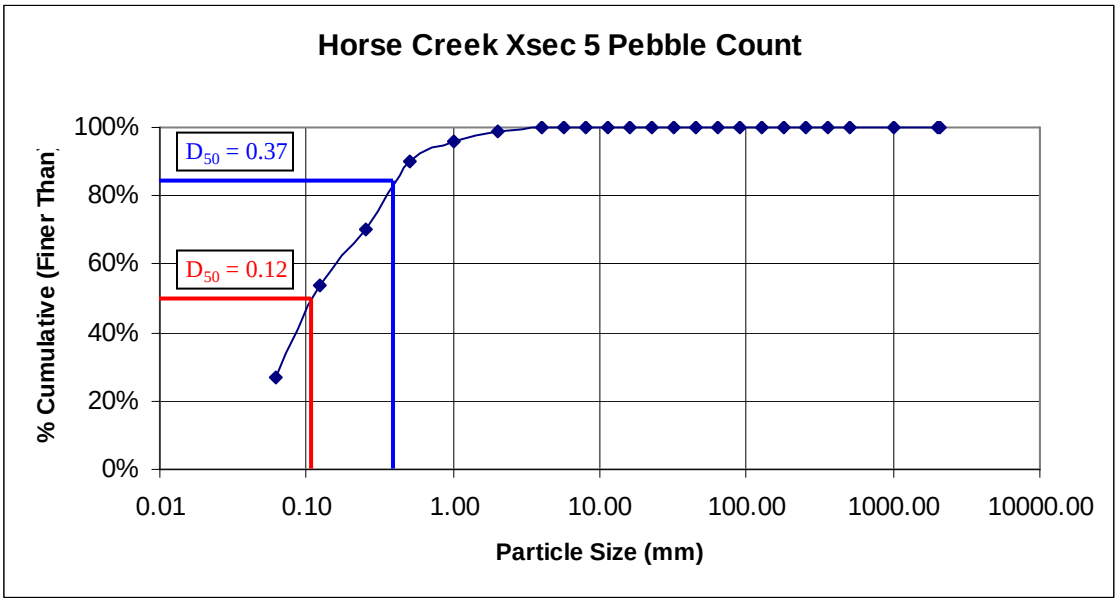


Table 33: Pebble Count, Cross Section 6 – Riffle

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	6 - Riffle	
Date:	27/06/2005			Station No:	27+00	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	35	35%	35%
Very Fine	0.061	0.125	Sand	21	21%	55%
Fine	0.125	0.25		5	5%	60%
Medium	0.25	0.5		14	14%	74%
Coarse	0.5	1		3	3%	77%
Very Coarse	1	2		5	5%	82%
Very Fine	2	4	Gravel	2	2%	84%
Fine	4	5.7		4	4%	88%
Fine	5.7	8		2	2%	90%
Medium	8	11.3		2	2%	92%
Medium	11.3	16		3	3%	95%
Coarse	16	22.6		5	5%	100%
Coarse	22.6	32		0	0%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	101	100%	---
			D_{50}	0.12		
			D_{84}	4.00		

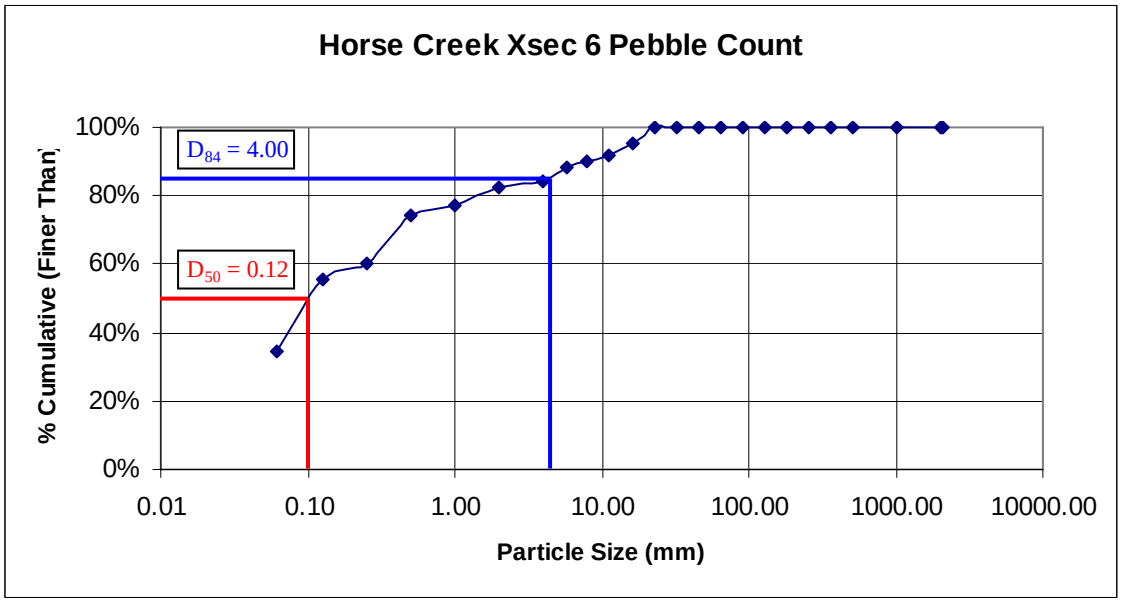


Table 34: Pebble Count, Cross Section 7 – Pool

Site Name:	Unnamed Tributary to Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	7 - Pool	
Date:	27/06/2005			Station No:	0+08 (UT)	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	30	26%	26%
Very Fine	0.061	0.125	Sand	21	18%	44%
Fine	0.125	0.25		13	11%	55%
Medium	0.25	0.5		20	17%	72%
Coarse	0.5	1		14	12%	84%
Very Coarse	1	2		9	8%	91%
Very Fine	2	4	Gravel	4	3%	95%
Fine	4	5.7		2	2%	97%
Fine	5.7	8		0	0%	97%
Medium	8	11.3		1	1%	97%
Medium	11.3	16		0	0%	97%
Coarse	16	22.6		0	0%	97%
Coarse	22.6	32		1	1%	98%
Very Coarse	32	45		1	1%	99%
Very Coarse	45	64		0	0%	99%
Small	64	90	Cobble	1	1%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	117	100%	---
			D_{50}	0.19		
			D_{84}	1.00		

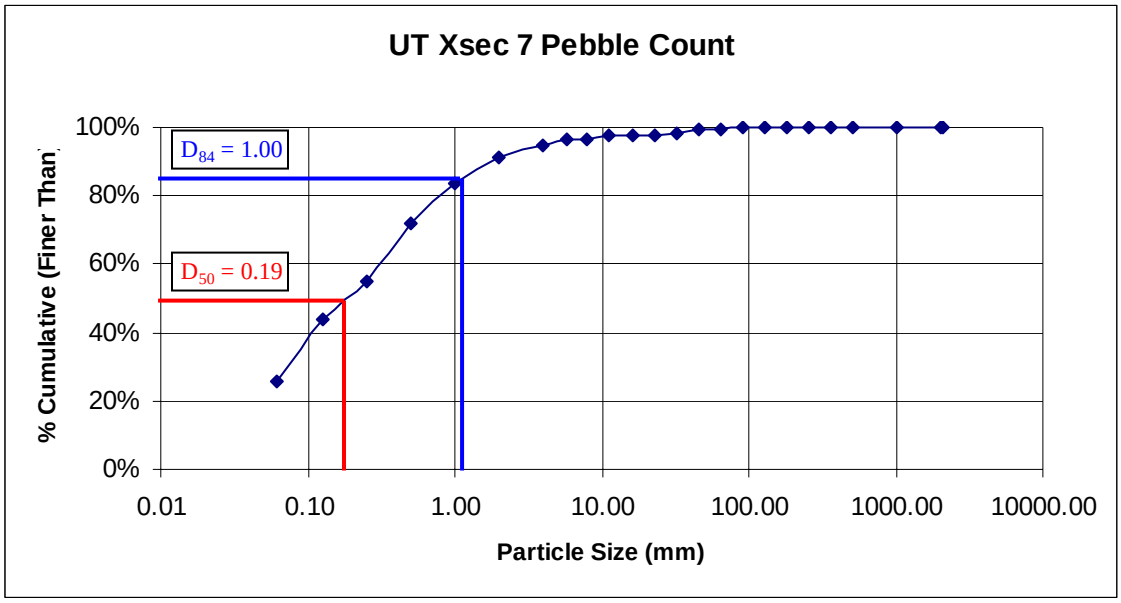


Table 35: Pebble Count, Cross Section 8 – Riffle

Site Name:	Unnamed Tributary to Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	8 - Riffle	
Date:	27/06/2005			Station No:	2+18 (UT)	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	17	17%	17%
Very Fine	0.061	0.125	Sand	38	38%	54%
Fine	0.125	0.25		38	38%	92%
Medium	0.25	0.5		5	5%	97%
Coarse	0.5	1		0	0%	97%
Very Coarse	1	2		0	0%	97%
Very Fine	2	4	Gravel	0	0%	97%
Fine	4	5.7		2	2%	99%
Fine	5.7	8		0	0%	99%
Medium	8	11.3		0	0%	99%
Medium	11.3	16		0	0%	99%
Coarse	16	22.6		0	0%	99%
Coarse	22.6	32		0	0%	99%
Very Coarse	32	45		0	0%	99%
Very Coarse	45	64		0	0%	99%
Small	64	90	Cobble	1	1%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	101	100%	---
			D_{50}	0.12		
			D_{84}	0.18		

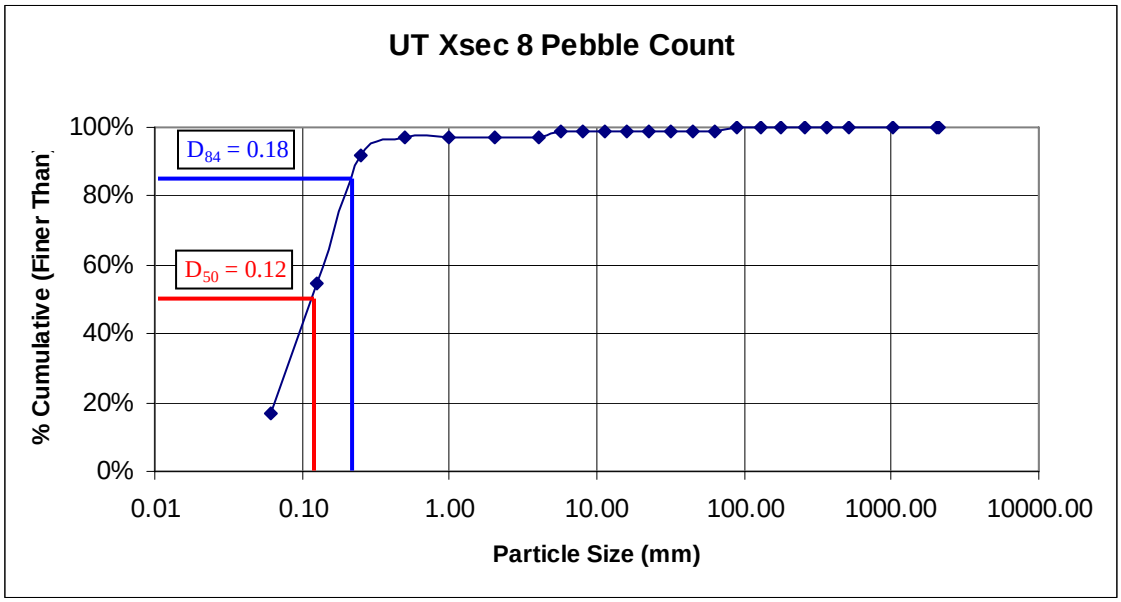


Table 36: Horse Creek Longitudinal Pebble Count

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec: Longitudinal		
Date:	27/06/2005			Station No:		
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	124	19%	19%
Very Fine	0.061	0.125	Sand	200	31%	51%
Fine	0.125	0.25		121	19%	70%
Medium	0.25	0.5		91	14%	84%
Coarse	0.5	1		37	6%	90%
Very Coarse	1	2		22	3%	94%
Very Fine	2	4	Gravel	11	2%	95%
Fine	4	5.7		7	1%	96%
Fine	5.7	8		5	1%	97%
Medium	8	11.3		4	1%	98%
Medium	11.3	16		4	1%	98%
Coarse	16	22.6		5	1%	99%
Coarse	22.6	32		3	0%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		2	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	636	100%	---
			D_{50}	0.13		
			D_{84}	0.50		

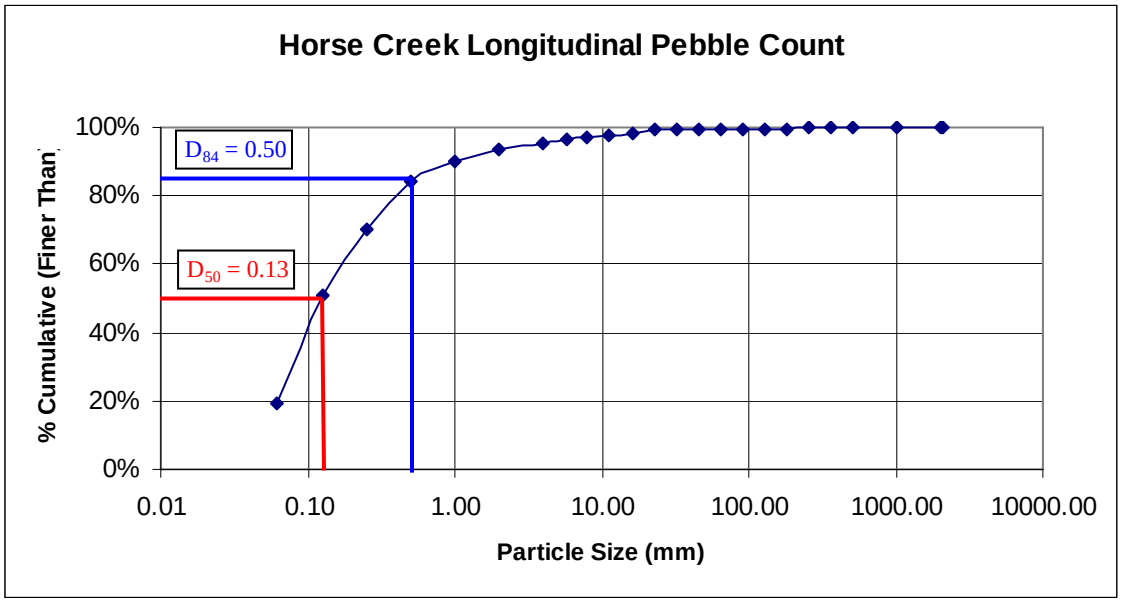
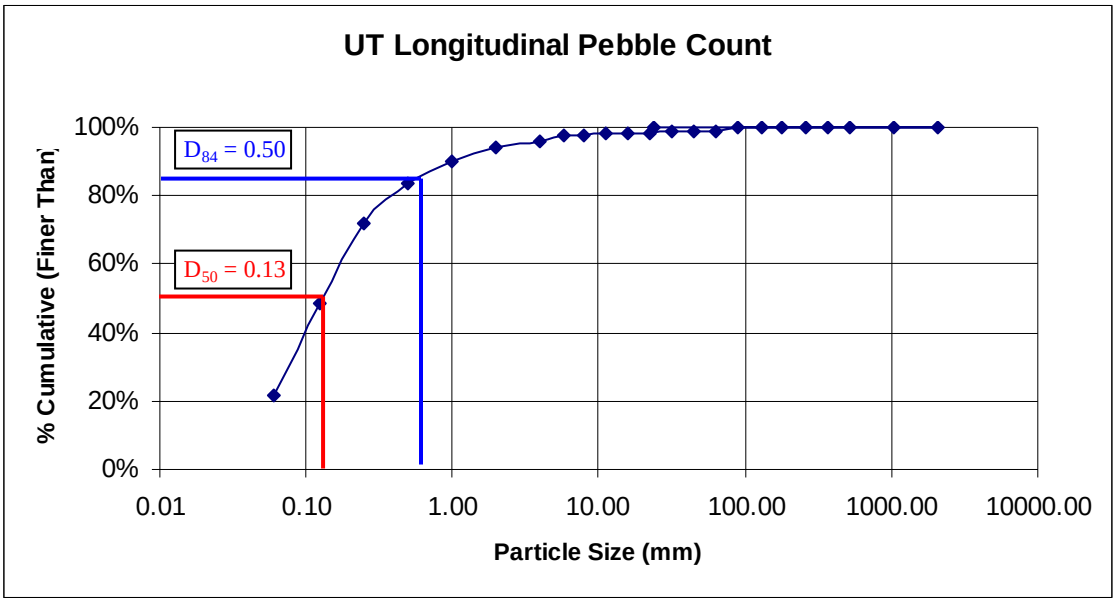


Table 37: Unnamed Tributary Longitudinal Pebble Count

Site Name:	Unnamed Tributary to Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec: Longitudinal		
Date:	27/06/2005			Station No:		
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	47	22%	22%
Very Fine	0.061	0.125	Sand	59	27%	49%
Fine	0.125	0.25		51	23%	72%
Medium	0.25	0.5		25	11%	83%
Coarse	0.5	1		14	6%	90%
Very Coarse	1	2		9	4%	94%
Very Fine	2	4	Gravel	4	2%	96%
Fine	4	5.7		4	2%	98%
Fine	5.7	8		0	0%	98%
Medium	8	11.3		1	0%	98%
Medium	11.3	16		0	0%	98%
Coarse	16	22.6		0	0%	98%
Coarse	22.6	32		1	0%	99%
Very Coarse	32	45		1	0%	99%
Very Coarse	45	64		0	0%	99%
Small	64	90	Cobble	2	1%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	218	100%	---
			D_{50}	0.13		
			D_{84}	0.50		



B.8 BANK EROSION HAZARD INDEX RAW DATA TABLES

Table 38: BEHI – Cross Section 1

Bank Erosion Hazard Index

Stream: Horse Creek
Station: 1+00
Xsec: 1

Feature: Riffle- Left Bank
Crew: M. O'Rourke, S. Slagle
Date: 23-Jun-05

Criteria	Very Low		Low		Moderate		High		VeryHigh		Extreme		Observed
	value	index	value	index	value	index	value	index	value	index	value	index	Index
Bank ht. / bankfull ht.	1.0 - 1.9	1.0 - 1.9	1.10-1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1
Root Depth / bank ht.	1.0 - 0.9	1.0 - 1.9	.89 - .50	2.0 - 3.9	.49 - .30	4.0 - 5.9	.29 - .15	6.0 - 7.9	.14 - .05	8.0 - 9.0	< .05	10	1.9
Root Density (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	2
Bank Angle (degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	2.5
Surface Protection (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	2

Subtotal: 9.4

Adjustments: 0

Total: 9.4

Adjustments

Bank Materials	
Bedrock	Very Low
Cobble	Low
Gravel	Decrease by one category unless mixture of gravel/sand is greater than 50%
Sand	Increase value by up to 10 points
Silt / Clay	none
Stratification	Adjust 5 - 10 points upward depending on position of unstable layers in relation to bankfull

Table 39: BEHI – Cross Section 2

Bank Erosion Hazard Index

Stream: Horse Creek
Station: 10+30
Xsec: 2

Feature: Pool-Left Bank
Crew: M. O'Rourke, S. Slagle
Date: 23-Jun-05

Criteria	Very Low		Low		Moderate		High		VeryHigh		Extreme		Observed
	value	index	value	index	value	index	value	index	value	index	value	index	Index
Bank ht. / bankfull ht.	1.0 - 1.9	1.0 - 1.9	1.10-1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1
Root Depth / bank ht.	1.0 - 0.9	1.0 - 1.9	.89 - .50	2.0 - 3.9	.49 - .30	4.0 - 5.9	.29 - .15	6.0 - 7.9	.14 - .05	8.0 - 9.0	< .05	10	3
Root Density (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	4.3
Bank Angle (degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	3.8
Surface Protection (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	4.3

Subtotal: 16.4

Adjustments: 0

Total: 16.4

Adjustments

Bank Materials

Bedrock	Very Low
Cobble	Low
Gravel	Decrease by one category unless mixture of gravel/sand is greater than 50%
Sand	Increase value by up to 10 points
Silt / Clay	none

Stratification — Adjust 5 - 10 points upward depending on position of unstable layers in relation to bankfull

Table 40: BEHI – Cross Section 3

Bank Erosion Hazard Index

Stream: Horse Creek
Station: 14+40
Xsec: 3

Feature: Pool-Left Bank
Crew: M. O'Rourke, S. Slagle
Date: 23-Jun-05

Criteria	Very Low		Low		Moderate		High		VeryHigh		Extreme		Observed
	value	index	value	index	value	index	value	index	value	index	value	index	Index
Bank ht. / bankfull ht.	1.0 - 1.9	1.0 - 1.9	1.10-1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1
Root Depth / bank ht.	1.0 - 0.9	1.0 - 1.9	.89 - .50	2.0 - 3.9	.49 - .30	4.0 - 5.9	.29 - .15	6.0 - 7.9	.14 - .05	8.0 - 9.0	< .05	10	1.9
Root Density (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	1.5
Bank Angle (degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	5.9
Surface Protection (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	1.1

Subtotal: 11.4

Adjustments: 0

Total: 11.4

Adjustments

Bank Materials

Bedrock	Very Low
Cobble	Low
Gravel	Decrease by one category unless mixture of gravel/sand is greater than 50%
Sand	Increase value by up to 10 points
Silt / Clay	none

Stratification — Adjust 5 - 10 points upward depending on position of unstable layers in relation to bankfull

Table 41: BEHI – Cross Section 4

Bank Erosion Hazard Index

Stream: Horse Creek
Station: 20+60
Xsec: 4

Feature: Riffle-Left Bank
Crew: M. O'Rourke, S. Slagle
Date: 23-Jun-05

Criteria	Very Low		Low		Moderate		High		VeryHigh		Extreme		Observed
	value	index	value	index	value	index	value	index	value	index	value	index	Index
Bank ht. / bankfull ht.	1.0 - 1.9	1.0 - 1.9	1.10-1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1
Root Depth / bank ht.	1.0 - 0.9	1.0 - 1.9	.89 - .50	2.0 - 3.9	.49 - .30	4.0 - 5.9	.29 - .15	6.0 - 7.9	.14 - .05	8.0 - 9.0	< .05	10	2.5
Root Density (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	2.5
Bank Angle (degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	3
Surface Protection (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	2.5

Subtotal: 11.5

Adjustments: 0

Total: 11.5

Adjustments

Bank Materials	
Bedrock	Very Low
Cobble	Low
Gravel	Decrease by one category unless mixture of gravel/sand is greater than 50%
Sand	Increase value by up to 10 points
Silt / Clay	none
Stratification	Adjust 5 - 10 points upward depending on position of unstable layers in relation to bankfull

Table 42: BEHI – Cross Section 5 – Right Bank

Bank Erosion Hazard Index

Stream: Horse Creek
Station: 25+00
Xsec: 5

Feature: Pool-Right Bank
Crew: M. O'Rourke, S. Slagle
Date: 23-Jun-05

Criteria	Very Low		Low		Moderate		High		VeryHigh		Extreme		Observed
	value	index	value	index	value	index	value	index	value	index	value	index	Index
Bank ht. / bankfull ht.	1.0 - 1.9	1.0 - 1.9	1.10-1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1
Root Depth / bank ht.	1.0 - 0.9	1.0 - 1.9	.89 - .50	2.0 - 3.9	.49 - .30	4.0 - 5.9	.29 - .15	6.0 - 7.9	.14 - .05	8.0 - 9.0	< .05	10	5
Root Density (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	4.5
Bank Angle (degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	6
Surface Protection (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	4.5

Subtotal: 21

Adjustments: 0

Total: 21

Adjustments

Bank Materials

Bedrock	Very Low
Cobble	Low
Gravel	Decrease by one category unless mixture of gravel/sand is greater than 50%
Sand	Increase value by up to 10 points
Silt / Clay	none

Stratification — Adjust 5 - 10 points upward depending on position of unstable layers in relation to bankfull

Table 43: BEHI – Cross Section 5 – Left Bank

Bank Erosion Hazard Index

Stream: Horse Creek
Station: 25+00
Xsec: 5

Feature: Pool-Left Bank
Crew: M. O'Rourke, S. Slagle
Date: 23-Jun-05

Criteria	Very Low		Low		Moderate		High		VeryHigh		Extreme		Observed
	value	index	value	index	value	index	value	index	value	index	value	index	Index
Bank ht. / bankfull ht.	1.0 - 1.9	1.0 - 1.9	1.10-1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1
Root Depth / bank ht.	1.0 - 0.9	1.0 - 1.9	.89 - .50	2.0 - 3.9	.49 - .30	4.0 - 5.9	.29 - .15	6.0 - 7.9	.14 - .05	8.0 - 9.0	< .05	10	3
Root Density (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	1.7
Bank Angle (degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	4
Surface Protection (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	1.7

Subtotal: 11.4

Adjustments: 0

Total: 11.4

Adjustments

Bank Materials

Bedrock	Very Low
Cobble	Low
Gravel	Decrease by one category unless mixture of gravel/sand is greater than 50%
Sand	Increase value by up to 10 points
Silt / Clay	none

Stratification — Adjust 5 - 10 points upward depending on position of unstable layers in relation to bankfull

Table 44: BEHI – Cross Section 6

Bank Erosion Hazard Index

Stream: Horse Creek
Station: 27+00
Xsec: 6

Feature: Riffle-Right Bank
Crew: M. O'Rourke, S. Slagle
Date: 23-Jun-05

Criteria	Very Low		Low		Moderate		High		VeryHigh		Extreme		Observed
	value	index	value	index	value	index	value	index	value	index	value	index	Index
Bank ht. / bankfull ht.	1.0 - 1.9	1.0 - 1.9	1.10-1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1
Root Depth / bank ht.	1.0 - 0.9	1.0 - 1.9	.89 - .50	2.0 - 3.9	.49 - .30	4.0 - 5.9	.29 - .15	6.0 - 7.9	.14 - .05	8.0 - 9.0	< .05	10	3.5
Root Density (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	2.5
Bank Angle (degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	3
Surface Protection (%)	100 - 80	1.0 - 1.9	3.5	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	3.5

Subtotal: 13.5

Adjustments: 0

Total: 13.5

Adjustments

Bank Materials

Bedrock	Very Low
Cobble	Low
Gravel	Decrease by one category unless mixture of gravel/sand is greater than 50%
Sand	Increase value by up to 10 points
Silt / Clay	none

Stratification — Adjust 5 - 10 points upward depending on position of unstable layers in relation to bankfull

Table 45: BEHI – Cross Section 7

Bank Erosion Hazard Index

Stream: Unnamed Tributary to Horse Creek
Station: 0+08
Xsec: 7

Feature: Pool-Left Bank
Crew: M. O'Rourke, S. Slagle
Date: 23-Jun-05

Criteria	Very Low		Low		Moderate		High		VeryHigh		Extreme		Observed
	value	index	value	index	value	index	value	index	value	index	value	index	Index
Bank ht. / bankfull ht.	1.0 - 1.9	1.0 - 1.9	1.10-1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1
Root Depth / bank ht.	1.0 - 0.9	1.0 - 1.9	.89 - .50	2.0 - 3.9	.49 - .30	4.0 - 5.9	.29 - .15	6.0 - 7.9	.14 - .05	8.0 - 9.0	< .05	10	3
Root Density (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	3.5
Bank Angle (degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	3
Surface Protection (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	3

Subtotal: 13.5

Adjustments: 0

Total: 13.5

Adjustments

Bank Materials

Bedrock	Very Low
Cobble	Low
Gravel	Decrease by one category unless mixture of gravel/sand is greater than 50%
Sand	Increase value by up to 10 points
Silt / Clay	none

Stratification — Adjust 5 - 10 points upward depending on position of unstable layers in relation to bankfull

Table 46: BEHI – Cross Section 8

Bank Erosion Hazard Index

Stream: Unnamed Tributary to Horse Creek
Station: 2+18
Xsec: 8

Feature: Riffle-Left Bank
Crew: M. O'Rourke, S. Slagle
Date: 23-Jun-05

Criteria	Very Low		Low		Moderate		High		VeryHigh		Extreme		Observed
	value	index	value	index	value	index	value	index	value	index	value	index	Index
Bank ht. / bankfull ht.	1.0 - 1.9	1.0 - 1.9	1.10-1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1
Root Depth / bank ht.	1.0 - 0.9	1.0 - 1.9	.89 - .50	2.0 - 3.9	.49 - .30	4.0 - 5.9	.29 - .15	6.0 - 7.9	.14 - .05	8.0 - 9.0	< .05	10	1
Root Density (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	1.5
Bank Angle (degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	2.5
Surface Protection (%)	100 - 80	1.0 - 1.9	79 - 55	2.0 - 3.9	54 - 30	4.0 - 5.9	29 - 15	6.0 - 7.9	14 - 5	8.0 - 9.0	< 5	10	1.5

Subtotal: 7.5

Adjustments: 0

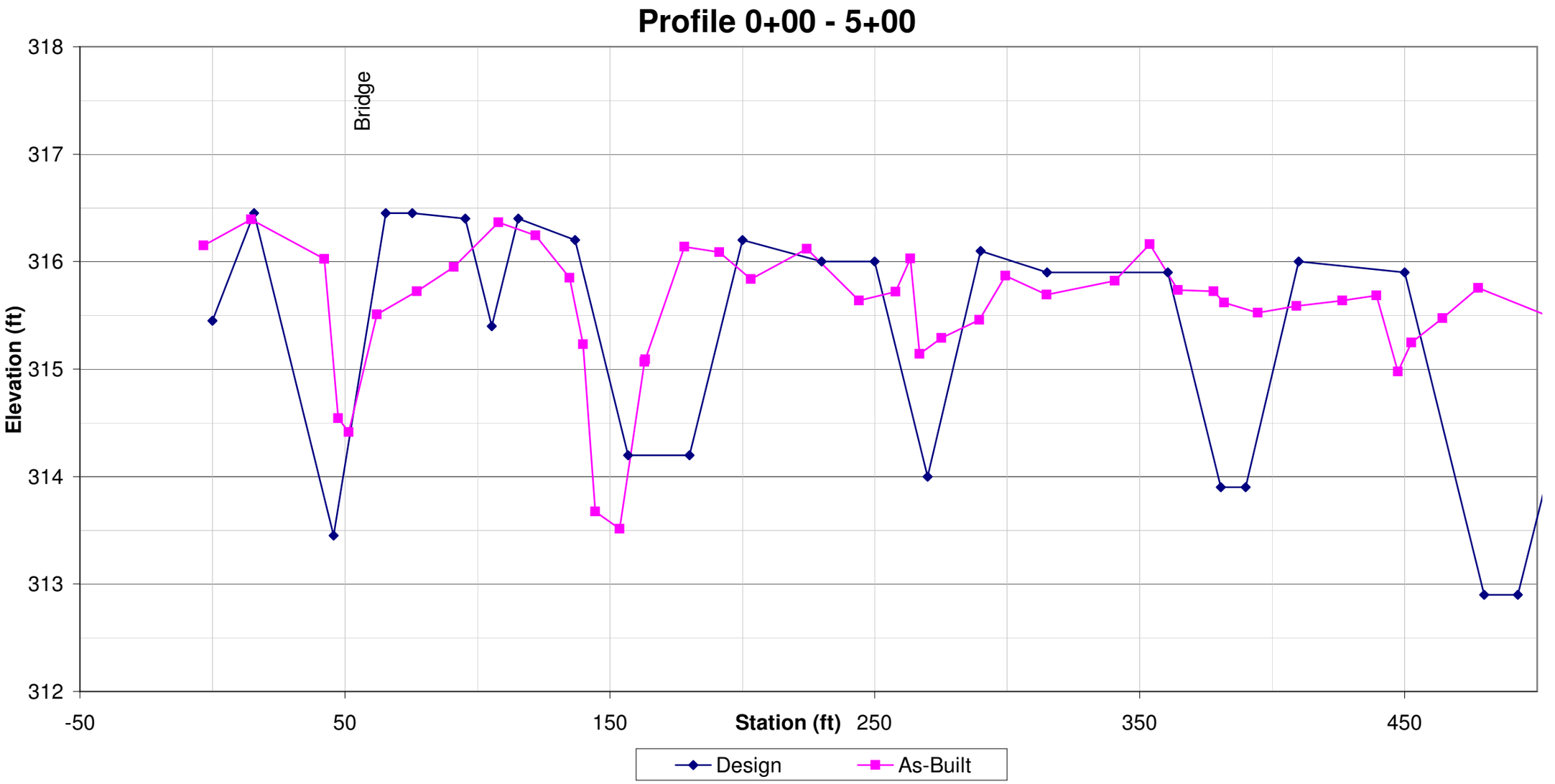
Total: 7.5

Adjustments

Bank Materials

Bedrock	Very Low
Cobble	Low
Gravel	Decrease by one category unless mixture of gravel/sand is greater than 50%
Sand	Increase value by up to 10 points
Silt / Clay	none

Stratification — Adjust 5 - 10 points upward depending on position of unstable layers in relation to bankfull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Bridge
318
317
316
315
314
313
312
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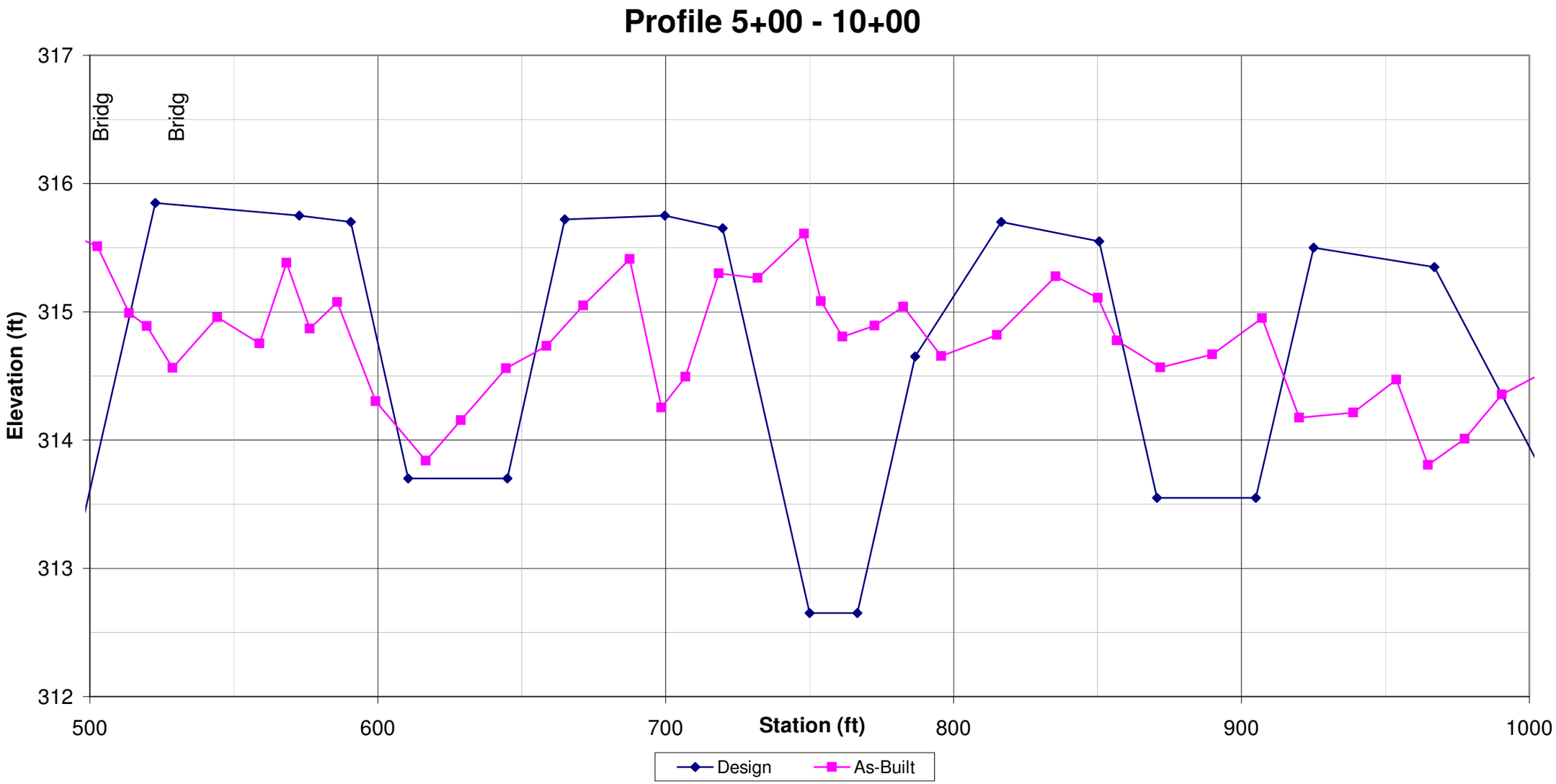
50
150
Station (ft)
250
350
450
Design
As-Built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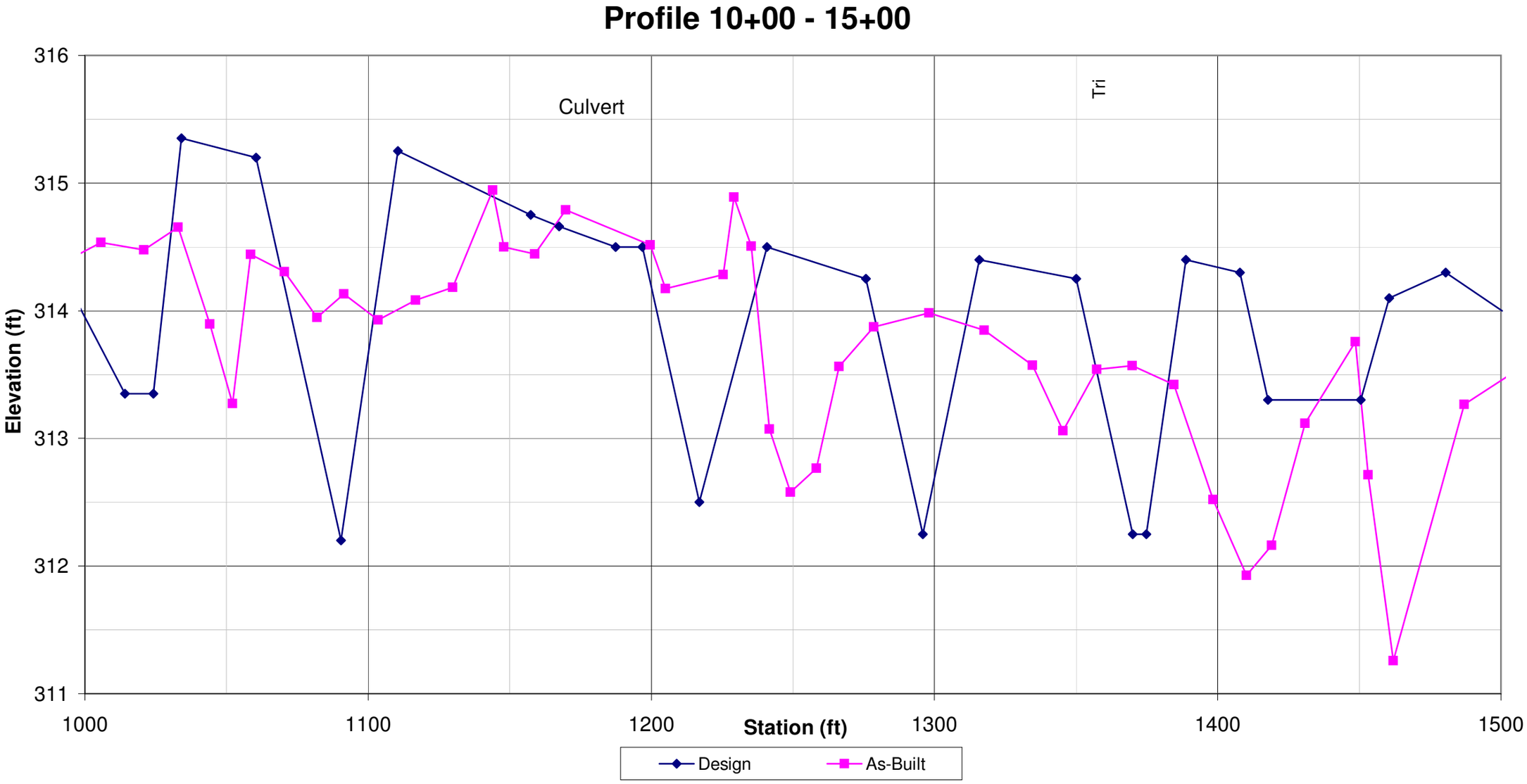
317
316
315
314
313
312
Elevation (ft)
Bridg
Bridg
500
600
700
800
900
1000
Station (ft)
Design
As-Built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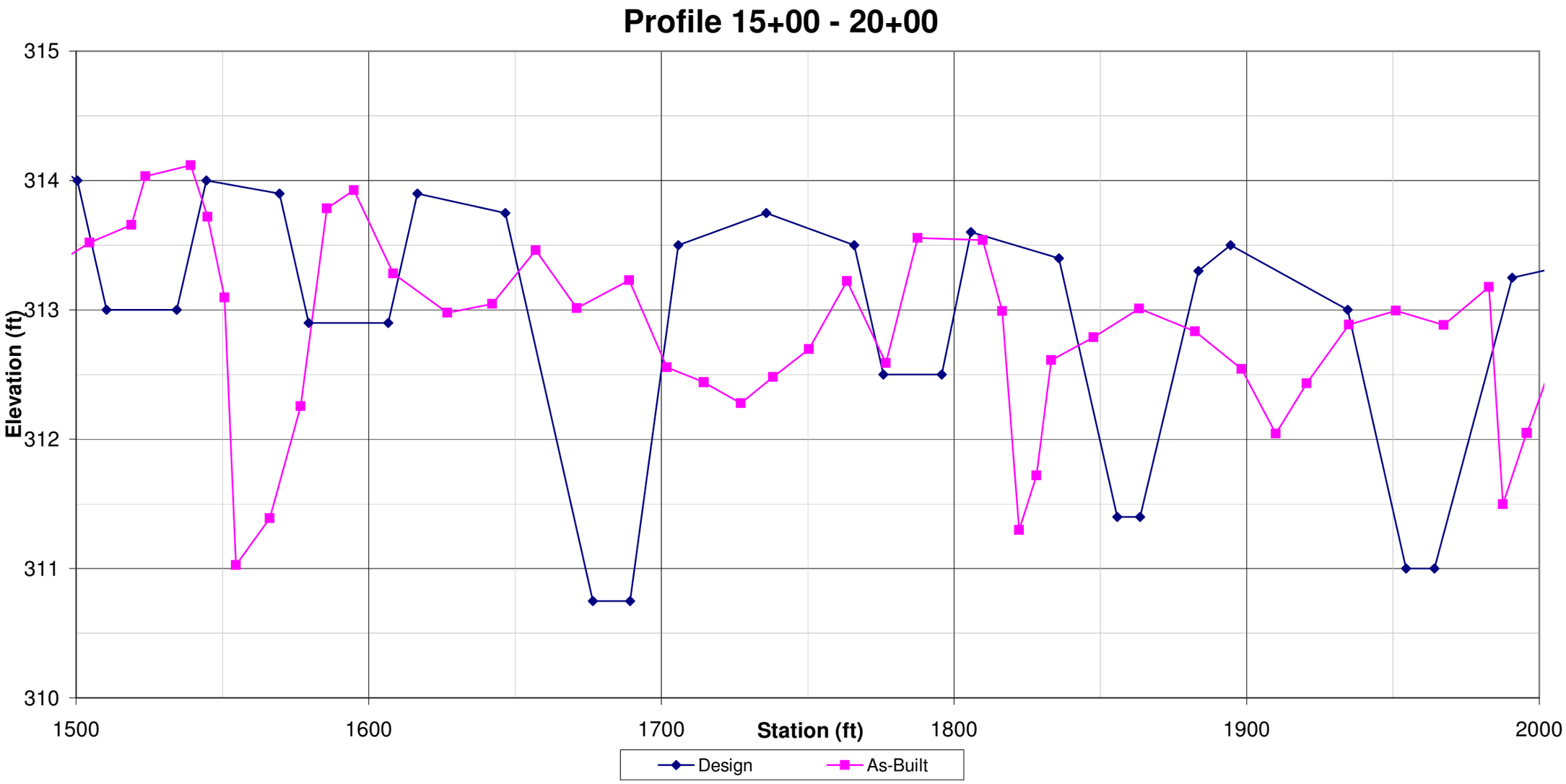
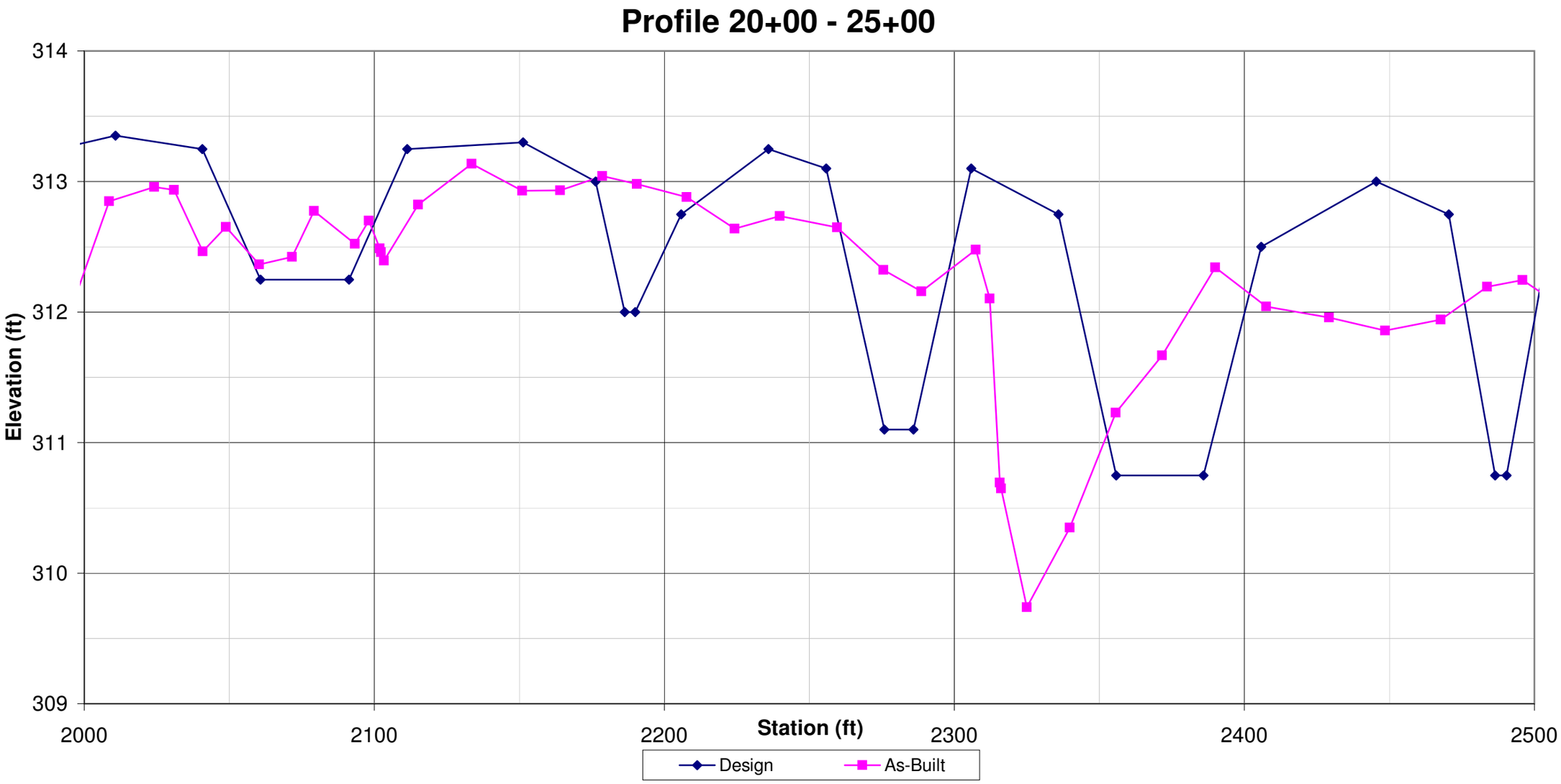
Culvert
Tri
316
315
314
313
312
311
Elevation (ft)
1000
1100
1200
1300
1400
1500
Station (ft)
Design
As-Built


Profile 15+00 - 20+00
315
314
313
312
311
310
Elevation (ft)
1500
1600
1700
1800
1900
2000
Station (ft)
Design
As-Built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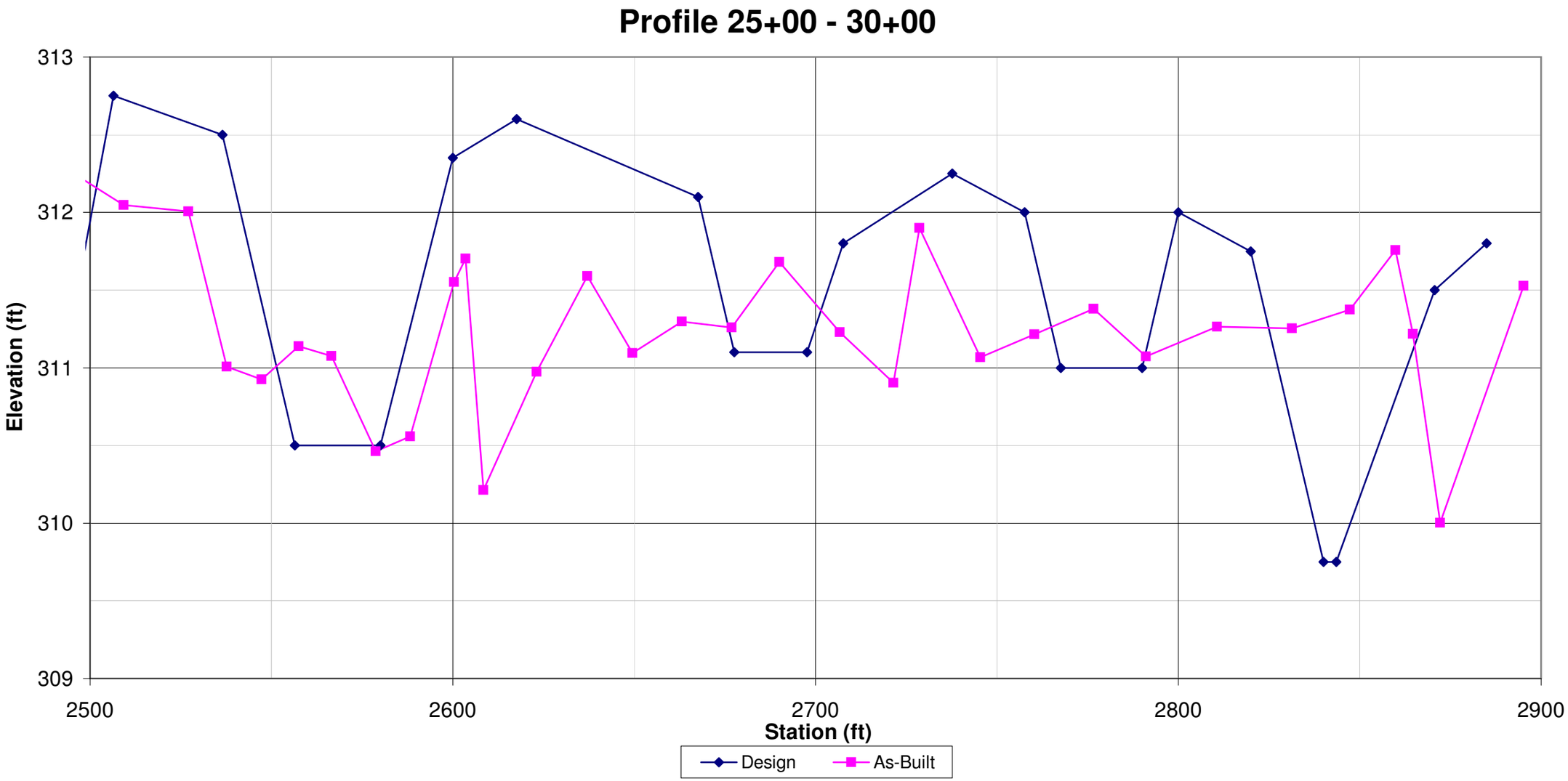
314
313
312
311
310
309
Elevation (ft)
2000
2100
2200
2300
2400
2500
Station (ft)
Design
As-Built


Profile 25+00 - 30+00
313
312
311
310
309
Elevation (ft)
2500
2600
2700
2800
2900
Station (ft)
Design
As-Built

APPENDIX C COMPREHENSIVE PHOTO COLLECTION (CD ONLY)

See attached CD.