Hillsdale Park (South Buffalo Creek) Stream Restoration
Greensboro, North Carolina
Annual Monitoring Report
Monitoring Year 2006

Monitoring Year: 2006
Measurement Year 3
As-Built Date: 2004
NCEEP Project Number 177

January 2007

HILLSDALE PARK (SOUTH BUFFALO CREEK) STREAM RESTORATION
2006 MONITIORING REPORT

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I. EXECUTIVE SUMMARY/PROJECT ABSTRACT

The Hillsdale Park Stream Restoration Site includes 5,302 linear feet of South Buffalo Creek and 529 linear feet of a tributary within the City of Greensboro, Guilford County, North Carolina. The site was constructed between February and March 2004. The following report provides the Year 3, 2006 Monitoring information.

Overall, the project is doing well with a few minor areas of erosion and several sections where coir fiber matting has pulled away from the bank. The problem areas should be watched and remedial options developed if they get worse.

The vegetation monitoring for Hillsdale Park was based on the new Carolina Vegetation Survey (CVS) protocol for recording vegetation. There is no prior data available to determine a comparison of this protocol to earlier monitoring years. This report will summarize the vegetation results as well as describe the new protocol for vegetation monitoring.

II. PROJECT BACKGROUND

A. Location and Setting

The Hillsdale Park Stream Restoration Site includes 5,302 linear feet of South Buffalo Creek and 529 linear feet of a tributary referred to as Tributary HR3. These streams are tributaries to the Haw River (USGS 8-digit hydrologic unit 03030002, 14-digit hydrologic unit 03030002020050). The site is located in the City of Greensboro near the intersection of Interstate 40 and High Point Road (US Highway 29A) in Guilford County, North Carolina (See Figure 1).

B. Mitigation Structure and Objectives

South Buffalo Creek and its unnamed tributary (HR3) are located in Hillsdale Park, a community park in the City of Greensboro. The existing stream channels had low sinuosity and varying levels of incision due to historic channelization. The alternative of creating a stable meandering stream with bankfull stage corresponding to the existing floodplain elevation was evaluated. However, topographic and development restrictions did not allow for a new channel pattern to be established. The existing incised channels were enhanced by excavating new floodplain benches at the design bankfull stage and installing structures to improve bed features and control channel grade.

The mitigation plan consisted of a Priority 3 restoration of South Buffalo Creek along with establishment of a 25-foot vegetated buffer on both banks of Reach 1 (STA 10+00 to 40+45) and on the left bank in Reach 2 (STA 40+45 to 62+12). Stream bank stabilization was performed on Reach 2. Three rock cross vanes were constructed to stabilize Tributary HR3 upstream of its confluence with Reach 2.

Additional details regarding the structure and objectives of the project are provided in Table 1.

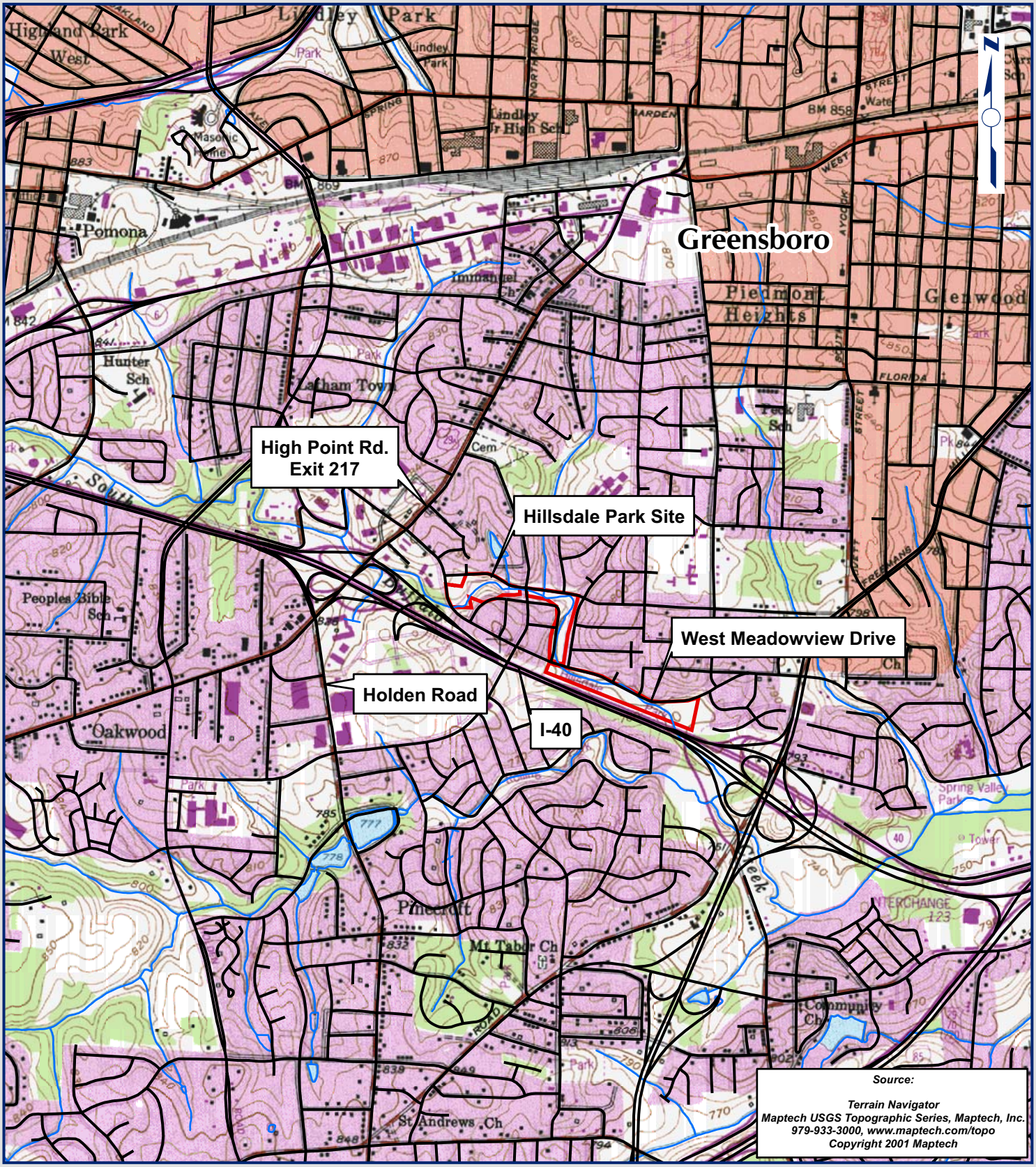

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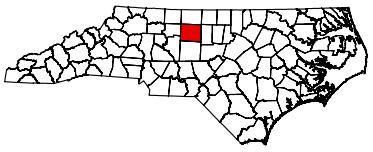
Figure 1.
Hillsdale Park Stream Restoration Site
Vicinity Map
Guilford County, NC



0 1,000 2,000 4,000 Feet

Table I. Project Mitigation Structure and Objectives Table Hillsdale Park Stream Mitigation/Project No. 177							
Project Segment or Reach ID	**Mitigation Type**	**Approach**	**Linear Footage**	**Mitigation Ratio**	**Mitigation Units**	**Stationing**	**Comment**
Reach HR1	Enhancement	Priority 3	3,037	1:1.50	2,025	10+00 to 40+45	Bankfull benches and rock cross vanes
Reach HR2	Stabilization	Bank Stabilization	2,265	1:1.00	2,265	40+45 to 62+12	Root wads and stabilization
Tributary HR3	Stabilization	Bank Stabilization	138	1:1.00	138	10+00 to 11+66	Stabilization using rock cross vanes
Mitigation Unit Summations							
Stream (lf)	**Riparian Wetland (ac)**	**Nonriparian Wetland (ac)**		**Total Wetland (ac)**		**Buffer (ac)**	**Comment**
4,428	0.00	0.00		0.00		0.00	

C. Project History and Background

The construction of South Buffalo Creek was completed in early 2004 with the As-Built survey occurring in February 2005. Year 1 monitoring took place in April 2005 with Year 2 monitoring occurring in October 2005. Additional details regarding the timeline of the project are provided in Table 2 below.

Table II. Project Activity and Reporting History Hillsdale Park Stream Restoration/Project No. 177			
Activity or Report	**Scheduled Completion**	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan	NA	NA	February 2005
Final Design-90%	NA	NA	NA
Construction	NA	NA	March 15, 2004
Temporary S&E mix applied to entire project area	NA	NA	NA
Permanent seed mix applied to reach/segments 1&2	NA	NA	NA
Containerized and B&B plantings for reach/segments 1&2	NA	NA	March 15, 2004
Mitigation Plan /As-Built (Year 0 Monitoring-baseline)	NA	NA	February 2005
Year 1 Monitoring	NA	April 2005	April 2005
Year 2 Monitoring	NA	October 2005	November 2005
Year 3 Monitoring	Fall 2006	October 2006	December 2006
Year 4 Monitoring	Fall 2007		
Year 5 Monitoring	Fall 2008		

NA-Historical project documents necessary to provide these data were unavailable at the time of this report submission

The project was designed by Buck Engineering. Construction was performed by LJ, Incorporated. Monitoring activities for Year 3 were performed by WK Dickson and Co., Inc. Additional information regarding contractors is shown in Table III.

Table III. Project Contact Table **Hillsdale Park Stream Restoration/Project No. 177**	
Designer POC	Buck Engineering Mr. Mike Rooney 8000 Regency Parkway, Suite 200 Cary, NC 27511 (919) 463-5490
Construction Contractor POC	LJ, Incorporated Mr. Arden Reiser PO Box 3188 Mooresville, North Carolina 28117 (704) 799-2670
Planting Contractor POC	NA
Seeding Contractor POC	NA
Seed Mix Sources	NA
Nursery Stock Suppliers	NA
Monitoring POC	WK Dickson and Co., Inc. Mr. Daniel Ingram 3101 John Humphries Wynd Raleigh, NC 27612 (919) 782-0495

NA-Historical project documents necessary to provide these data were unavailable at the time of this report submission

The project is located within Guilford County, within the ecoregion of the Southern Outer Piedmont in the Piedmont physiographic province of North Carolina. The site is located within a highly urbanized area. Additional information regarding this stream is included in Table IV.

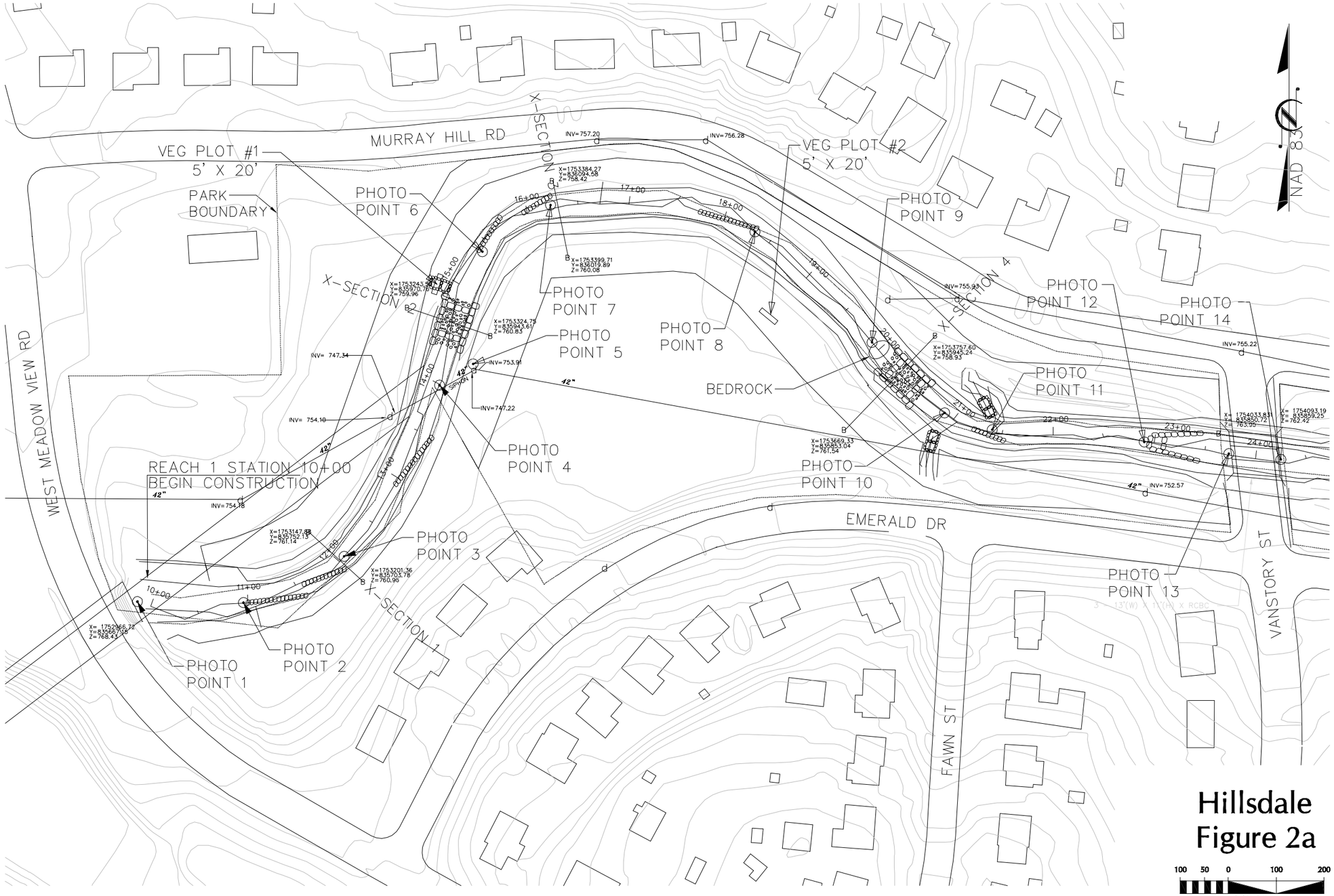
Table IV. Project Background Table **Hillsdale Park Stream Restoration/Project No. 177**	
Project County	Guilford
Drainage Area	
South Buffalo Creek	10.0 sq. mi.
Tributary	0.29 sq. mi.
Drainage impervious cover estimate (%)	>20%
Stream Order	
South Buffalo Creek	3rd order
Tributary	1st order
Physiographic Region	Piedmont
Ecoregion	Southern Outer Piedmont
Rosgen Classification of As-Built	B4c
Cowardian Classification	N/A
Dominant Soil Types	Congaree loam, Enon-Urban land complex, Mecklenburg-Urban land complex
Reference Site ID	E5, Ut Lake Jeanette (Guilford), McClintock 1 & 2 (Mecklenburg); B4c, DuHart (Gaston), Silas (Forsyth), Morgan (Orange)
USGS HUC for Project	03030002 (Cape Fear)
USGS HUC for Reference	Ut Lake Jeanette 03030002, McClintock 03050103, DuHart 03050102, Silas 03040101, Morgan 03030002
NCDWQ Sub-basin for Project	030602
NCDWQ Sub-basin for Reference	Ut Lake Jeanette 030602, McClintock 030834, DuHart 030836, Silas 030704, Morgan 030606
NCDWQ Classification for Project	C, NSW
NCDWQ Classification for Reference	Ut Lake Jeanette-WSIII, NSW; McClintock-C, DuHart-WS-V, Silas-C, Morgan-WS-II, HQW, NSW, CA
Any Portion of any project segment 303d listed?	Yes-all of South Buffalo Creek and its tributaries
Any portion of any project segment upstream of a 303d listed segment?	Yes, South Buffalo Creek to confluence with Buffalo Creek
Reasons for 303d listing or stressor	Impaired biological stressor, stressor not identified, Urban runoff-storm sewers
% of project easement fenced	None

D. Monitoring Plan View

A series of monitoring devices have been installed on site. A total of twelve (12) individual cross-sections were located. Cross-sections were plotted from left to right facing downstream. Each cross-section is also a designated photographic point that is photographed annually. There are forty-five (45) permanent photo points located at various points along the length of the channel. Seven (7) vegetation-monitoring plots were randomly located within the riparian buffer of the Hillsdale Park Stream Restoration project. The locations of all monitoring devices are shown on Figures 2a through 2d (Monitoring Plan View).

LEGEND

- STREAM TOP OF BANK
- STREAM CENTERLINE
- VEG PLOT
- SINGLE-ARM DEFLECTOR
- OUTLET BASIN
- DROP CROSS-VANE
- CONSTRUCTED RIFFLE
- DOUBLE-WING DEFLECTOR
- PHOTO POINT
- J-HOOK
- BOULDER CLUSTER
- BEDROCK



Hillsdale
Figure 2a

100 50 0 100 200
SCALE (FT)

PROJECT MANAGER	DPI
DRAWN BY	TRS
APPROVED BY	
DRAWING SCALE	1"=100'
SURVEY DATE	
MAP DATE	
PROJECT NUMBER	5045700RA

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TITLE:

YEAR 3 MONITORING PLAN VIEW
HILLSDALE PARK
GREENSBORO
NORTH CAROLINA

LEGEND

- STREAM TOP OF BANK
- STREAM CENTERLINE
- VEG PLOT
- SINGLE–ARM DEFLECTOR
- OUTLET BASIN
- DROP CROSS–VANE
- CONSTRUCTED RIFFLE
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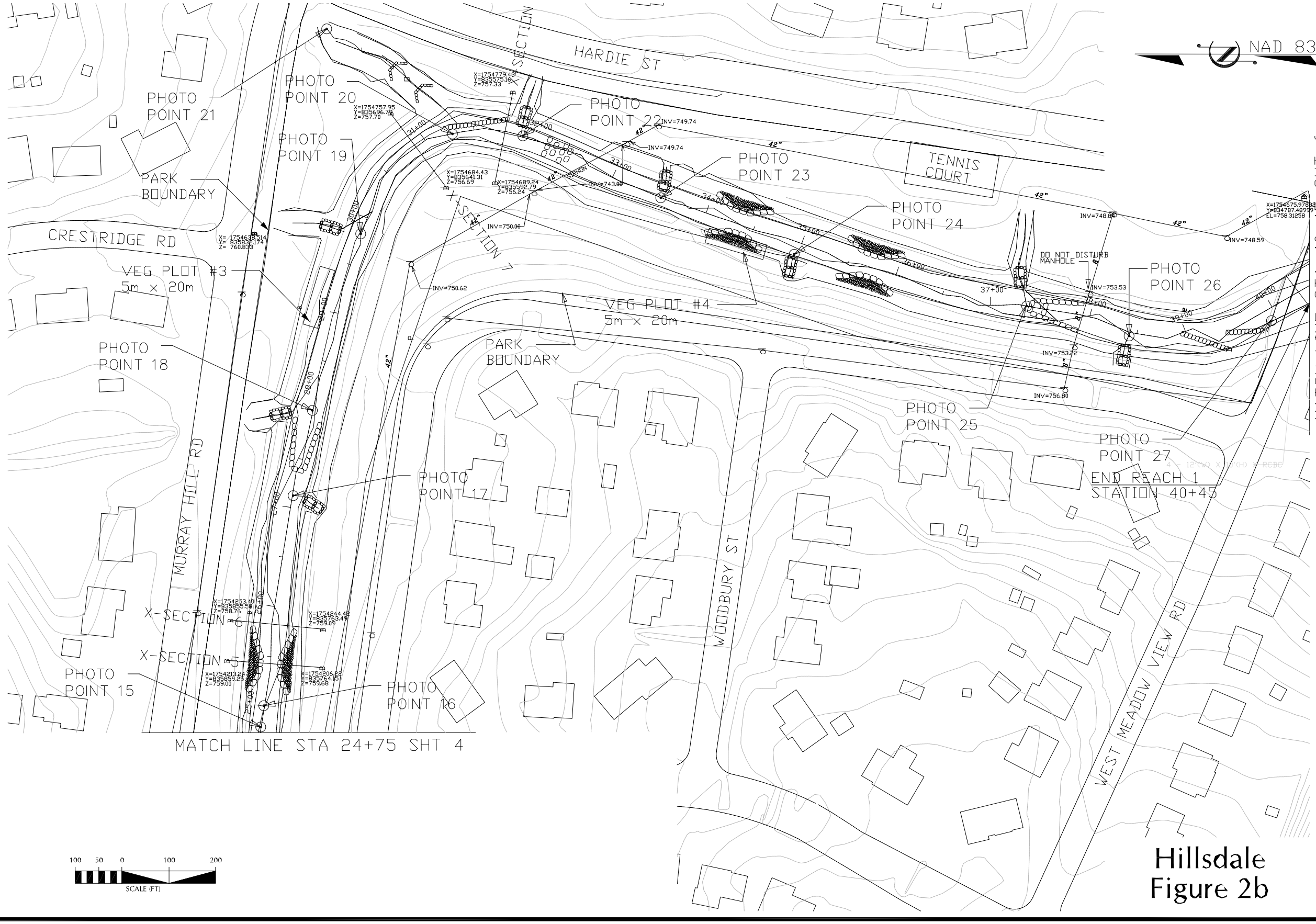

Hillsdale Figure 2b

PROJECT MANAGER	DPI
DRAWN BY	TRS
APPROVED BY	
DRAWING SCALE	1"=100'
SURVEY DATE	
MAP DATE	
PROJECT NUMBER	5045700RA

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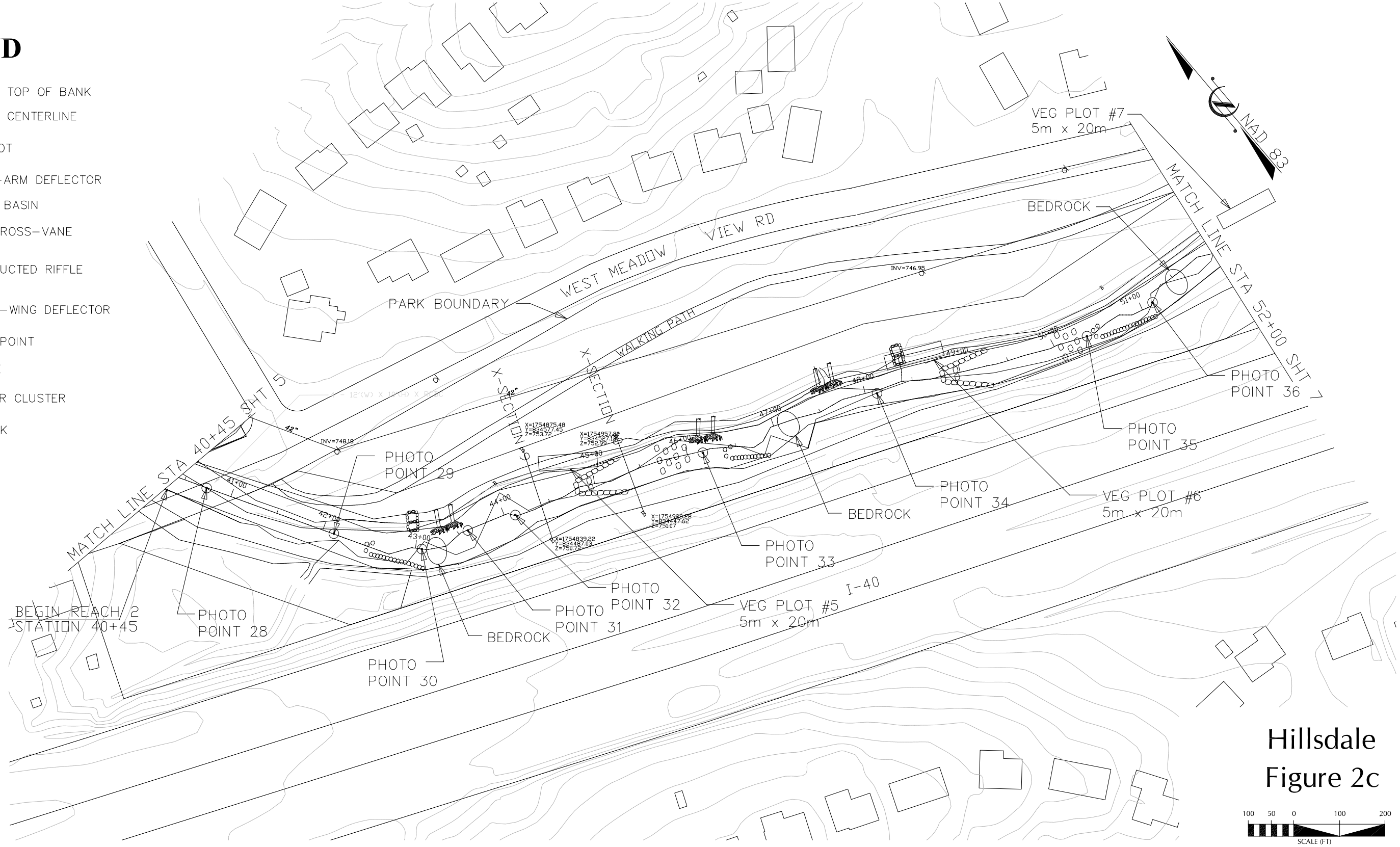

Hillsdale
Figure 2c

100 50 0 100 200
SCALE (FT)

PROJECT MANAGER	DRAWING SCALE
DPI	1"=100'
DRAWN BY	SURVEY DATE
TRS	
APPROVED BY	MAP DATE
PROJECT NUMBER	
5045700RA	

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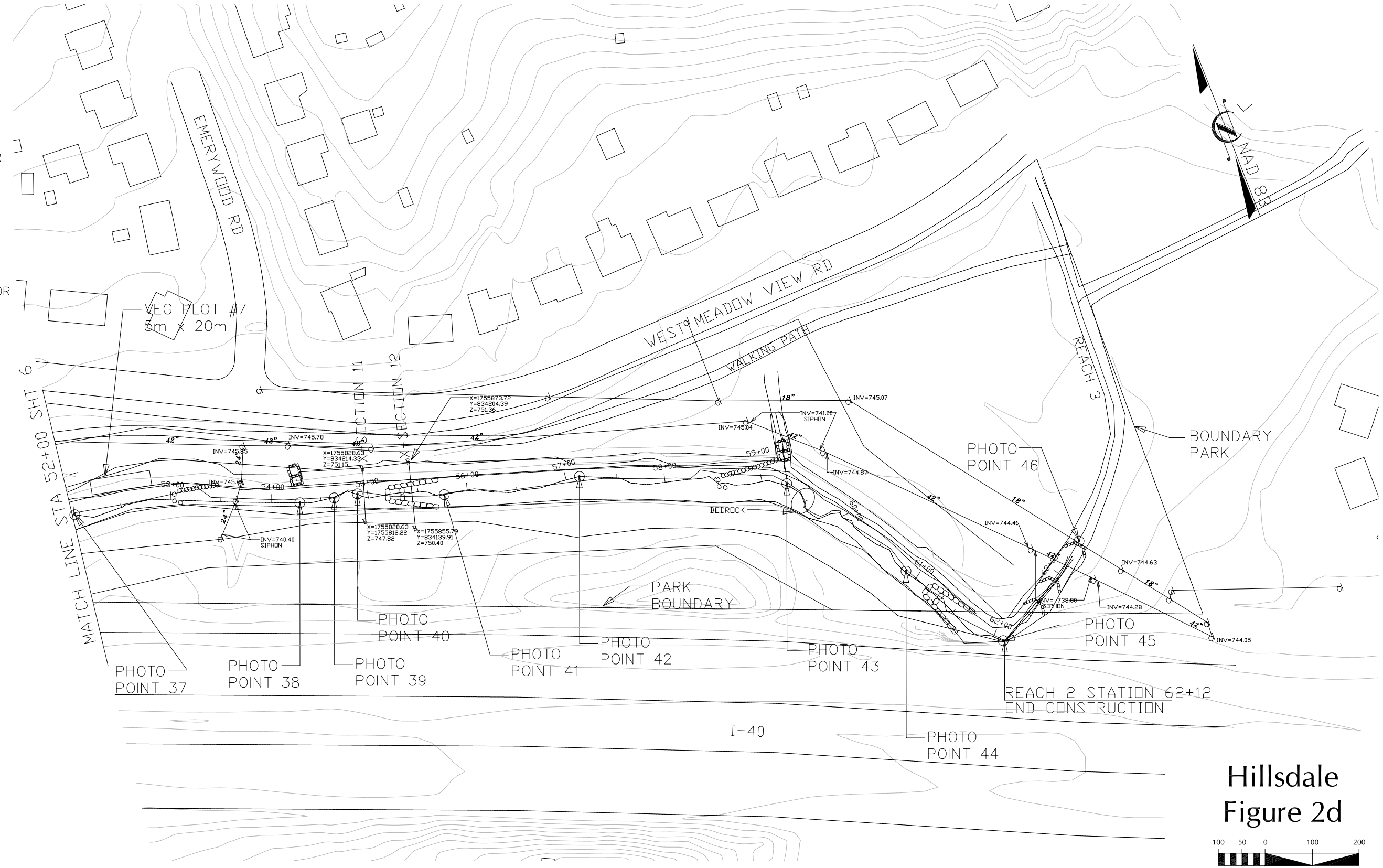

PROJECT MANAGER	DRAWING SCALE
DPI	1"=100'
DRAWN BY	SURVEY DATE
TRS	
APPROVED BY	MAP DATE
PROJECT NUMBER	
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YEAR 3 MONITORING PLAN VIEW
HILLSDALE PARK
GREENSBORO
NORTH CAROLINA

III. PROJECT CONDITION AND MONITORING RESULTS

Monitoring results are discussed below. An initial visual survey was conducted on March 10, 2006 with a more detailed monitoring survey (evaluation of vegetation plots) conducted in October 2006.

A. Vegetation Assessment

Planted zones related to the stream restoration consist of the riparian buffer zone and the stream banks. The riparian buffer zone initiates at the top of the bank and continues out perpendicular to the immediate channel following the general pattern of the meandering channel. The planted stream bank initiates at the normal base flow elevation and extends to the top of bank or interface with the floodplain.

A new protocol known as "CVS-EEP Protocol for Recording Vegetation" was followed in order to do Year 3 vegetation monitoring. The new protocol defines a plot as a randomly selected 10 m x 10 m standard shape consisting of one or more modules based on representative characteristics of the site. The protocol states that the plots should be designed to achieve both unbiased and repeatable measurements. Five distinct types of plot records, called levels, are used to recognize the increasing level of detail and complexity across the sequence. The lower levels require less detail and fewer types of information about both vegetation and environment. Level 1 and Level 2 plots were used for the vegetation monitoring for Hillsdale.

1. Soil Data

Soils present in the riparian areas adjacent to South Buffalo Creek are characteristic of those found in alluvial landforms in the Southern Outer Piedmont. However, extensive grading and dredging has likely modified much of the naturally occurring soils on site.

Congaree soils (*Oxyaquic Udifluvents*) are the prevalent map unit along the channel. Formed in recent alluvial sediments, they are deep, well to moderately well drained soils with moderate permeability.

Other soil series found along the stream corridor are Enon-Urban land complex and Mecklenburg-Urban land complex soils. Enon soils (*Ultic Hapludalfs*) are very deep, well drained, slowly permeable soils found on ridgetops and side slopes in the Piedmont. Mecklenburg soils (*Ultic Hapludalfs*) are very deep, well drained soils with slow permeability.

2. Vegetative Problem Areas

Several areas with minimal vegetation were observed in August 2006 and seven exotic and/or invasive species were observed within the plots during the vegetation sampling. These include thorny olive (*Elaeagnus punguns*), Chinese lespedeza (*Lespedeza cuneata*), common wormwood (*Artemisia vulgaris*), Japanese honeysuckle (*Lonicera japonica*), mimosa (*Albizia julibrissin*), multiflora rose (*Rosa multiflora*), and porcelain berry (*Ampelopsis brevipedunculata)*).

The site, especially Plot 1 (Station 16+00), is heavily covered in porcelain berry. This woody perennial vine is very aggressive and has a tendency to grow over vegetation, including small shrubs and trees. It has currently covered a number of the small seedling and live stake plantings. It is recommended that action be taken to control and eradicate the porcelain berry at this site.

All vegetative problem areas are described in Table 6 in Appendix A. The vegetative plan view is provided in Appendix A.

3. Stem Counts

3.1 Methodology

Vegetation monitoring at Hillsdale Park consisted of seven 10 m x10 m plots. The method used to count woody stems followed the protocol described in the "CVS-EEP Protocol for Recording Vegetation". The tables provided in Appendix A were derived from the software used for entering the data collected during vegetation monitoring. Table 2 in Appendix A gives a description of the vigor of each species found in each plot. The vigor of a plant is determined by the extent of any damage incurred by the plant on its bark, leafy material, or tissue. Woody stems are also counted in each plot. The intent of recording natural woody stems is to assess the overall recovery and compositional trajectory of the plot. A tally is made for the number of stems for each size class for each species found. Table 5 in Appendix A lists species found in each plot and is tallied by the number found in each plot.

4. Vegetation Plot Photos

Photos of the vegetation plots are located in Section A-2 of Appendix A. For levels 1 and 2, one photograph is required for each plot, generally taken from the plot origin toward the diagonally opposite corner.

B. Stream Assessment

WK Dickson and Co., Inc personnel performed an initial site visit at Hillsdale Park on August 7th & 8th, 2006. During the field visit qualitative observations were recorded regarding the condition of the stream restoration project. Cross section and longitudinal surveys were also performed at the time of this visit. Twelve cross sections and approximately 3,000 linear feet of stream profile were surveyed. Photographs were taken at all permanent photo points. A bed material analysis was not performed since this is a sand/small gravel stream. No significant coarsening is expected over time. A pebble count was performed for Year 3, but no data are available for comparison from earlier monitoring periods. The photographs show that vegetation is generally growing well and is a good combination of woody and herbaceous growth. Banks are stable with no unusual bank erosion. At this time, no repairs are recommended. The problem areas should be watched and if the problems worsen over time, then solutions should be discussed to assess the reason for the problem and potential options to fix the areas. Stream problem areas are described in Appendix B, Table B.1.

No crest gauges are installed at this site to document bankfull flow events. The following USGS stream gauge data had been used in past reports to verify bankfull events. Although this technique has been used to establish the occurrence of bankfull events for the history of this project, it is not scientifically valid. It is, at the current time, the only means available to infer the occurrence of bankfull discharge(s) at the site as no high water marks were observed in the field. A crest gauge should be installed at the site immediately. A potential occurrence was extrapolated based on USGS stream gauge discharge data for South Buffalo Creek at US 220 (approximately 2 miles southeast of project site) with a drainage area of 15.4 square miles. Bankfull events were determined by comparing the stream discharge (cfs) against the drainage area on the urban piedmont regional curve. According to the urban piedmont curve, a bankfull event occurs on a stream with a 15.4 square mile drainage area when the discharge is between

1,538 and 1,704 cfs. Based on USGS data at least one bankfull event occurred in 2006 at South Buffalo Creek at US 220. This bankfull event occurred on July 23, 2006 with a discharge of 1,890 cfs. Several high flows were recorded for 2006. On June 23, 24 and July 22 peak discharges were recorded at 1,670; 1,260; and 1,310 cubic feet per second respectively.

Figure 3. USGS Stream Gauge Discharge Data for South Buffalo Creek at US 220.

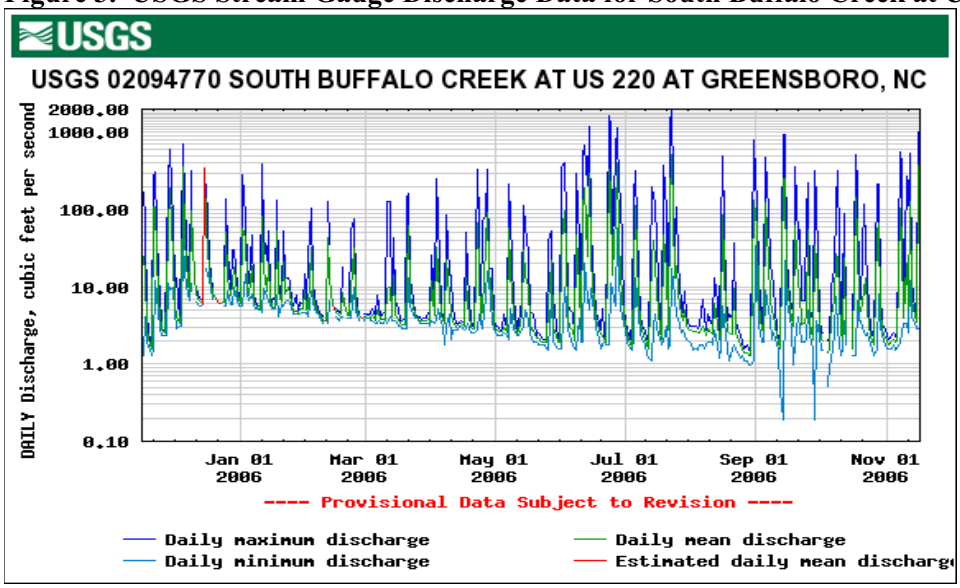

Table V lists bankfull events and high flows as they occurred in 2006.

Table V. Verification of High Flows/Bankfull Events
Hillsdale Park Stream Restoration/Project No. 177

Date of Data Collection	Date of Occurrence	Method	Photo # (if available)
2006	June 23, 2006	Proximal USGS gauge resource (high flow)	NA
2006	June 24, 2006	Proximal USGS gauge resource (high flow)	NA
2006	July 22, 2006	Proximal USGS gauge resource (high flow)	NA
2006	July 23, 2006	Proximal USGS gauge resource (bankfull event)	NA

Bank Erodibility Hazard Index (BEHI)

The entire reach that was monitored was separated into separate reaches that were categorized based on BEHI parameters such as bank height/bankfull height, root depth/bank height, root density percentage, bank angle, and surface protection percentage.

Methodology

The Bank Erodibility Hazard Index (BEHI) is a method of assessing stream bank erosion potential (Rosgen, 1996). The method used for finding BEHI for Hillsdale was that a representative group of segments for each stream were chosen based upon the vegetation and the characteristics of the banks. Segments were chosen such that a range of disturbance was represented. For each designated segment, approximately the same footage of channel was characterized on both sides. At the beginning of the segment, a stretch of stream with relatively consistent characteristics (i.e eroded banks adjacent to a well maintained area) was assessed for bankfull height, bank height, root depth and density, surface protection, and bank angle. Bank

materials and soil types were also observed. Bankfull height and bank height were measure with a survey rod while root density, root depth and surface protection were assesses based on judgement and general knowledge of the vegetation on the banks. Each stretch of stream was delineated and measured according to its characteristics. Occasionally, the left and right side of the stream did not coincide where each segment began and ended. In such cases, the length of the segment along one side may correspond with two or more segments totaling the same distance on the other side of the stream.

Results
The BEHI rating for most of the stream was Moderate to High. The vegetation appears to be the driving characteristic that created such high ratings. The banks are covered in porcelain berry vines and other invasive species that offer little surface protection and have very little root density. These vines choke out larger species along the banks. The roots on the vines do not grow very far into the ground and do not have the capacity to hold the bank together as would very large trees or woody vegetation. In most cases the bank height and bankfull height were the same, but the bank angle was steeper along some segments as compared with others. These conditions resulted in values that created a rating of Moderate to High.

1. Problem Areas Plan View

An assessment of the stability of the channel was preformed on August 8, 2006, by WK Dickson and Co., Inc. Several areas of concern were observed and documented including localized bank scour, aggradation, and failure of the engineered structures. These problem areas are located in Appendix B, Section B-1.

2. Problem Areas Table Summary

The Problem Areas Table Summary is located in Appendix B as Table B.1.

3. Representative Stream Problem Areas Photos Section

Representative photos of each category of stream problem area were taken and are shown in Appendix B, Section B-3.

4. Fixed Photo Station Photos

Photos from established photo stations were collected on August 8 and 9, 2006 during the stream survey. These photos are included in Appendix B, Section B-4.

5. Stability Assessment

A visual qualitative assessment was performed to inspect channel facets, meanders, bed, banks, and installed structures. This visual assessment was confirmed and enhanced with a quantitative assessment of the physical stream survey. The goal of this assessment is to provide a percentage of the features listed in Table VI that are in a state of stability.

Table VI. Categorical Stream Feature Visual Stability Assessment Hillsdale Park Stream Restoration/Project No. 177 Reach HR1/ (3,037 feet)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	100%	100%	91%		
B. Pools	100%	95%	100%	87%		
C. Thalweg	100%	100%	50%	87.5%		
D. Meanders	100%	100%	96.7%	77.5%		
E. Bed General	100%	100%	96.7%	100%		
F. Bank Condition	NA	NA	NA	98%		
G. Vanes/J-Hooks etc.	100%	100%	100%	100%		
H. Wads and Boulders	100%	100%	100%	100%		
Reach HR2 (2,265 feet)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	100%	100%	98%		
B. Pools	100%	95%	95%	83%		
C. Thalweg	100%	100%	NA	NA		
D. Meanders	100%	100%	NA	NA		
E. Bed General	100%	100%	100%	100%		
F. Bank Condition	NA	NA	NA	98%		
G. Vanes/J-Hooks etc.	100%	100%	100%	100%		
H. Wads and Boulders	100%	100%	93.8%	100%		

Note: Year 1 estimates are based upon review of text within the Buck Engineering Year 1 Monitoring Report.

6. Quantitative Morphology

The following tables (Table VII and Table VIII) summarize the quantitative data collected from the cross-sectional and longitudinal stream survey. These data were analyzed and summarized, and then compared with baseline data (i.e. as-built and previous year's data) available for this project. The SRI urban Piedmont curve was used to determine an average bankfull cross-sectional area, and bankfull was placed at the elevation that would yield this area (for 2006 cross-sections). When the elevations chosen for bankfull were plotted on the longitudinal profile, the points formed a reasonably uniform slope that was consistent with the low flow water surface slope. The baseline that has been chosen for 2006 is consistent with the regional curve and will provide accurate illustrations of departure if bankfull is located in the same manner for future years of monitoring. The results of analysis of the data show that there are some disparities between the 2006 data and previous year's data. This can be explained by the fact that bankfull elevation for previous years was chosen at a different elevation than the 2006 bankfull elevation. The bankfull elevation for 2006 was assumed to be top of bank which is typical for a newly restored stream. This was not the case for baseline or the previous year's analysis. Plots for

previous years assumed a lower bankfull elevation than top of bank which would be nearly impossible to locate because of the lack of natural indicators on a newly restored stream. The Quantitative Morphology Tables illustrate the degree of departure, if any, of the current channel from the baseline data. Tables VII and VIII were compiled from the cross-section and profile raw data and plots located in Appendix B of this report.

Table VII. Baseline Morphology and Hydraulic Summary
Hillsdale Park Stream Restoration/Project No. 177
Reach HR1 (3,037 feet)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-Built		
Dimension	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**
BF Width (ft)				46	59	52	36	44	*	25.6	46	33.5	36	44	*	28	40.2	37.95
BF Cross Sectional Area (ft2)				255	283	269	103	113	*	43.5	122	80	103	113	*	70.7	154.4	117.55
BF Mean Depth (ft)				4.5	6.0	5.2	2.6	2.9	*	1.7	2.6	2.4	2.6	2.9	*	2.5	3.9	3.2
BF Max Depth (ft)							3.7	4.0	*	*	*	*	3.7	4.0	*	3.4	5.9	5
Width/Depth Ratio							12.2	17.3	*	14.0	17.0	15.1	12.2	17.3	*	8.8	14.7	10.9
Entrenchment Ratio							1.5	2.4	*	*	*	*	2.3	2.3	*	1.8	3.3	2.5
Bank Height Ratio (BHR)							*	*	*	*	*	*	*	*	*	*	*	1.0
Wetted Perimeter (ft)							*	*	*	*	*	*	*	*	*	33	47.2	43.35
Hydraulic Radius (ft)							*	*	*	*	*	*	*	*	*	2.14	3.27	2.71
Pattern																		
Channel Beltwidth (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Radius of Curvature (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Wavelength (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Width Ratio							*	*	*	*	*	*	*	*	*	*	*	*
Profile																		
Riffle Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Riffle Slope (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool -to-Pool Spacing (ft)							*	*	*	*	*	*	76	152	*	*	*	*
Substrate																		
d50 (mm)							*	*	*	3.0	64.0	19.1	*	*	*	*	*	*
d84 (mm)							*	*	*	77	180	bedrock	*	*	*	*	*	*
Additional Reach Parameters																		
Valley Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Channel Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Sinuosity							*	*	1.1	*	*	1.1	*	*	1.1	*	*	*
Water Surface Slope (ft/ft)							*	*	0.0016	*	*	*	*	*	0.0016	*	*	*
BF Slope (ft/ft)							*	*	*	*	*	*	*	*	*	*	*	*
Rosgen Classification							*	*	E4/B4c	*	*	B4c	*	*	E4/B4c	*	*	*
*Habitat Index							*	*	*	*	*	*	*	*	*	*	*	*
*Macrobenthos							*	*	*	*	*	*	*	*	*	*	*	*

*Historical documents necessary to provide this information were unavailable at the time of the report submission

Table VII Continued. Baseline Morphology and Hydraulic Summary
Hillsdale Park Stream Restoration/Project No. 177
Reach HR2 (2,265 feet)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-Built		
Dimension	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**
BF Width (ft)				46	59	52	66	66	*	25.6	46	33.5	*	*	66	19.7	52.4	41.1
BF Cross Sectional Area (ft2)				255	283	269	166	166	*	43.5	122	80	*	*	166	72.6	242.3	112.9
BF Mean Depth (ft)				4.5	6.0	5.2	*	*	2.5	1.7	2.6	2.4	*	*	2.5	2.3	5	3.4
BF Max Depth (ft)							*	*	3.6	*	*	*	*	*	3.6	2.9	7.4	4.75
Width/Depth Ratio							*	*	26.4	14.0	17.0	15.1	*	*	26.4	5.3	22.6	10.3
Entrenchment Ratio							*	*	1.1	*	*	*	*	*	2.3	1.5	4.3	2.15
Bank Height Ratio (BHR)							*	*	*	*	*	*	*	*	1.0	*	*	1.0
Wetted Perimeter (ft)							*	*	*	*	*	*	*	*	*	27.1	58.6	48.4
Hydraulic Radius (ft)							*	*	*	*	*	*	*	*	*	2.13	4.13	2.65
Pattern																		
Channel Beltwidth (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Radius of Curvature (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Wavelength (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Width Ratio							*	*	*	*	*	*	*	*	*	*	*	*
Profile																		
Riffle Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Riffle Slope (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool –to-Pool Spacing (ft)							*	*	*	*	*	*	76	152	*	*	*	*
Substrate																		
d50 (mm)							*	*	*	3.0	64.0	19.1	*	*	*	*	*	*
d84 (mm)							*	*	*	77.0	bedrock	157.5	*	*	*	*	*	*
Additional Reach Parameters																		
Valley Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Channel Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Sinuosity							*	*	1.1	*	*	1.1	*	*	1.1	*	*	*
Water Surface Slope (ft/ft)							*	*	0.0035	*	*	*	*	*	0.0035	*	*	*
BF Slope (ft/ft)							*	*	*	*	*	*	*	*	*	*	*	*
Rosgen Classification							*	*	E4/B4c	*	*	B4c	*	*	E4/B4c	*	*	*
*Habitat Index							*	*	*	*	*	*	*	*	*	*	*	*
*Macrobenthos							*	*	*	*	*	*	*	*	*	*	*	*

*Historical documents necessary to provide this information were unavailable at the time of the report submission

Table VIII. Morphology and Hydraulic Monitoring Summary
Hillsdale Park Stream Restoration/Project No. 177
Reach HR1 CS 1-6 (3,037 feet)

Parameter	Cross-Section 1 12+01 Pool				Cross-Section 2 14+61 Riffle				Cross-Section 3 16+31 Pool				Cross-Section 4 20+31 Riffle				Cross-Section 5 25+43 Riffle				Cross-Section 6 25+82 Pool			
Dimension	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3
BF Width (ft)	33.5	32.8	38.3	36.4	38.0	37.5	38.5	38.0	33.8	36.9	37.3	41.3	37.9	40.1	41.7	38.9	40.2	41.1	44.5	38.7	39.4	38.4	47.8	36.1
Floodprone Width (ft)	95	95	>85	**	68	68	74.4	84	110	110	**	**	75	75	89	99	73	73	*	82	110	110	**	**
BF Cross Sectional Area (ft2)	127.0	125.5	177.8	165.9	104.7	102.6	108.6	114.7	114.2	138.6	165.5	156.4	97.8	104.2	110.2	109.2	120.9	128.0	133.0	120.0	154.4	159.5	223.9	168.4
BF Mean Depth (ft)	3.8	3.8	4.6	4.6	2.8	2.7	2.8	3.0	3.4	3.8	4.4	3.8	2.6	2.6	2.6	2.8	3	3.1	3.0	3.1	3.9	4.2	4.7	4.7
BF Max Depth (ft)	5.8	5.7	7.1	6.9	3.8	4.1	3.9	4.6	5.5	6.4	7.2	7.4	3.4	3.7	3.7	3.8	4.5	4.7	5.5	5.0	5.5	6.0	7.8	6.2
Width/Depth Ratio	8.8	8.6	8.3	8.0	13.8	13.7	13.7	12.6	10.0	9.8	8.4	10.9	15.4	15.8	15.8	13.9	13.4	13.2	14.9	12.5	10.1	9.2	10.2	7.7
Entrenchment Ratio	2.8	2.9	>2.2	**	1.8	1.8	1.9	2.2	3.3	3.0	**	**	1.9	2.1	2.1	2.5	1.8	1.8	*	2.1	2.8	2.9	**	**
Bank Height Ratio (BHR)	1.0	1.0	*	1.0	1.0	1.0	1.0	*	1.0	1.0	*	1.0	1.0	1.0	*	1.0	1.0	1.0	*	1.0	1.0	1.0	*	1.0
Wetted Perimeter (ft)	41.1	*	47.58	41.1	43.6	*	44.14	39.8	40.6	*	46.17	44.0	*	46.99	46.99	41.0	46.2	*	50.48	41.2	47.2	*	57.17	40.1
Hydraulic Radius (ft)	3.09	*	3.74	4.0	2.40	*	2.46	2.9	2.81	*	3.58	3.6	*	2.35	2.35	2.7	2.62	*	2.63	2.9	3.27	*	3.92	4.2
Substrate																								
d50 (mm)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
d84 (mm)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Parameter	MY-01 (2005)				MY-02 (2005)				MY-03 (2006)				MY-04 (2007)				MY-05 (2008)				MY+ (2009)			
Pattern	Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med	
Channel Beltwidth (ft)	*	*	*		*	*	*		22	69	39													
Radius of Curvature (ft)	*	*	*		*	*	*		6	22	12													
Meander Wavelength (ft)	*	*	*		*	*	*		33	74	49													
Meander Width Ratio	*	*	*		*	*	*		0.59	1.85	1.05													
Profile																								
Riffle Length (ft)	*	*	*		6	434	26		11	421	34													
Riffle Slope (ft)	*	*	*		0	0.0197	0.0003		0	0.0220	0.0005													
Pool Length (ft)	*	*	*		10	140	28		12	155	37													
Pool –to-Pool Spacing (ft)	*	*	*		25	613	144		23	712	168													
Additional Reach Parameters																								
Valley Length (ft)	NA				2720				2720															
Channel Length (ft)	NA				3045				3045															
Sinuosity	NA				1.12				1.12															
Water Surface Slope (ft/ft)	NA				0.00199				0.0017															
BF Slope (ft/ft)	NA				0.00181				0.0018															
Rosgen Classification	NA				B4c				B4c															
*Habitat Index	NA				NA				NA															
*Macrobenthos	NA				NA				NA															

*Historical documents necessary to provide this information were unavailable at the time of the report submission
**Typically a flood prone width and entrenchment ratio are not calculated for a pool cross section.

Table VIII Continued. Morphology and Hydraulic Monitoring Summary
Hillsdale Park Stream Restoration/Project No. 177
Reach HR1 CS 7-8 (3,037 feet)

Parameter	Cross-Section 7 30+89 Riffle				Cross-Section 8 31+81 Pool																			
Dimension	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3
BF Width (ft)	28.0	28.1	33.4	29.4	38.9	35.7	42	33.8																
Floodprone Width (ft)	62	62	70.5	64	130	130	**	**																
BF Cross Sectional Area (ft2)	70.7	71.3	82.0	74.3	142.1	128.0	171.7	198.2																
BF Mean Depth (ft)	2.5	2.5	2.5	2.5	3.7	3.6	4.1	5.9																
BF Max Depth (ft)	3.8	3.8	4.0	3.9	5.9	5.6	6.6	9.6																
Width/Depth Ratio	11.1	11.1	13.6	11.6	10.7	10.0	10.3	5.8																
Entrenchment Ratio	2.2	2.2	2.1	2.2	3.3	3.6	**	**																
Bank Height Ratio (BHR)	1.0	1.0	*	1.0	1.0	1.0	*	1.0																
Wetted Perimeter (ft)	33	*	38.31	32.2	46.3	*	50.18	41.7																
Hydraulic Radius (ft)	2.14	*	2.14	2.3	3.07	*	3.42	4.8																
Substrate																								
d50 (mm)	*	*	*	*	*	*	*	*																
d84 (mm)	*	*	*	*	*	*	*	*																

Parameter	MY-01 (2005)				MY-02 (2005)				MY-03 (2006)				MY-04 (2007)				MY-05 (2008)				MY+ (2009)			
Pattern	Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med	
Channel Beltwidth (ft)																								
Radius of Curvature (ft)																								
Meander Wavelength (ft)																								
Meander Width Ratio																								
Profile																								
Riffle Length (ft)																								
Riffle Slope (ft)																								
Pool Length (ft)																								
Pool -to-Pool Spacing (ft)																								
Additional Reach Parameters																								
Valley Length (ft)																								
Channel Length (ft)																								
Sinuosity																								
Water Surface Slope (ft/ft)																								
BF Slope (ft/ft)																								
Rosgen Classification																								
*Habitat Index																								
*Macrobenthos																								

*Historical documents necessary to provide this information were unavailable at the time of the report submission.
**Typically a flood prone width and entrenchment ratio are not calculated for a pool cross section.

Table VIII Continued. Morphology and Hydraulic Monitoring Summary
Hillsdale Park Stream Restoration/Project No. 177
Reach HR2 CS 9-12 (2,265 feet)

Parameter	Cross-Section 9 44+41 Riffle				Cross-Section 10 45+39 Pool				Cross-Section 11 54+96 Riffle				Cross-Section 12 55+43 Pool											
Dimension	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3
BF Width (ft)	52.4	53.6	49.1	53.7	48.6	47.8	53.3	47.0	33.6	36.9	34.0	31.1	19.7	20.3	21.1	20.5								
Floodprone Width (ft)	80	80	67.6	76	210	210	**	**	55	55	>53	52	53	53	**	**								
BF Cross Sectional Area (ft2)	121.5	122.1	93.8	131.7	242.3	240.6	256.2	277.6	104.3	107.2	103.3	92.2	72.6	87.1	89.1	84.3								
BF Mean Depth (ft)	2.3	2.3	1.9	2.5	5.0	5.0	4.8	5.9	3.1	2.9	3.0	3.0	3.7	4.3	4.2	4.1								
BF Max Depth (ft)	2.9	2.9	2.2	3.1	7.4	7.0	7.4	7.7	4.4	4.4	4.2	7.6	5.1	5.6	5.4	5.6								
Width/Depth Ratio	22.6	23.6	25.7	21.9	9.8	9.5	11.1	7.9	10.8	12.7	11.2	10.5	5.3	4.7	5.0	5.0								
Entrenchment Ratio	1.5	1.5	1.4	1.4	4.3	4.4	**	**	1.6	1.5	*	1.7	2.7	2.6	**	**								
Bank Height Ratio (BHR)	1.0	1.0	*	1.0	1.0	1.0	*	1.0	1.0	1.0	*	1.0	1.0	1.0	*	1.0								
Wetted Perimeter (ft)	57	*	52.92	55.7	58.6	*	62.91	53.0	39.8	*	40.07	42.9	27.1	*	29.55	26.1								
Hydraulic Radius (ft)	2.13	*	1.77	2.4	4.13	*	4.07	5.2	2.62	*	2.58	2.2	2.68	*	3.02	3.2								
Substrate																								
d50 (mm)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*								
d84 (mm)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*								

Parameter	MY-01 (2005)				MY-02 (2005)				MY-03 (2006)				MY-04 (2007)				MY-05 (2008)				MY+ (2009)			
Pattern	Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med	
Channel Beltwidth (ft)	*	*	*		*	*	*		24	66	46													
Radius of Curvature (ft)	*	*	*		*	*	*		9	21	12													
Meander Wavelength (ft)	*	*	*		*	*	*		34	81	60													
Meander Width Ratio	*	*	*		*	*	*		0.63	1.73	1.21													
Profile																								
Riffle Length (ft)	*	*	*		11	194	50		15	234	75													
Riffle Slope (ft)	*	*	*		0	0.014792	0.004292		0	0.0163	0.0074													
Pool Length (ft)	*	*	*		8	104	67		10	125	80													
Pool -to-Pool Spacing (ft)	*	*	*		108	443	180		105	438	205													
Additional Reach Parameters																								
Valley Length (ft)	NA				2115				2115															
Channel Length (ft)	NA				2167				2167															
Sinuosity	NA				1.025				1.025															
Water Surface Slope (ft/ft)	NA				0.00392				0.0037															
BF Slope (ft/ft)	NA				0.00364				0.0022															
Rosgen Classification	NA				B4c				B4c															
*Habitat Index	NA				NA				NA															
*Macrobenthos	NA				NA				NA															

*Historical documents necessary to provide this information was unavailable at the time of the report submission.
**Typically a flood prone width and entrenchment ratio are not calculated for a pool cross section.

C. Wetland Assessment

There is no wetland restoration associated with this site. Table X is not applicable to this project.

IV. METHODOLOGY SECTION

The methodology used for vegetative monitoring is described in the "CVS-EEP Protocol for Recording Vegetation." The only exceptions to this protocol that were made was that it was determined that Green Ash was a volunteer species found in each plot. Also, per the procedure as discussed with Steve Roberts of NC EEP, only species that measured above 2m were to be considered a planted species. No additional deviations from the established procedures were performed in collecting data for this report.

V. RECOMMENDATIONS

It is highly recommended that crest gauges be installed at Hillsdale Park in order to measure bankfull flows if they occur onsite.

References:

USACOE (2003) *Stream Mitigation Guidelines*. USACOE, USEPA, NCWRC, NCDENR-DWQ

USACOE (1987) *Corps of Engineers Wetlands Delineation Manual*. Tech report Y-87-1. AD/A176.

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Lee, Michaeal T., Peet, Robert K., Roberts, Steven D., Wentworth, Thomas R. (2006). CVS-EEP Protocol for Recording Vegetation Version 4.0. Retrieved October 30, 2006, from: http://www.nceep.net/business/monitoring/veg/datasheets.htm

Click on the Desired Link Below

Appendix A

Appendix B