As-Built and Monitoring Report

Sandy Creek Stream Enhancement And Wetland Restoration /Creation Project Durham, North Carolina

(SCO ID# 010542301)

Prepared For:

North Carolina Wetlands Restoration Program
Raleigh, North Carolina
September 2003

Prepared By:

Becky L. Ward Consulting
1512 Eglantyne Court
Raleigh, NC 27613
Tel (919) 870-0526 Fax (919) 870-5359
And
The Catena Group
410-B Millstone Drive
Hillsborough, NC 27278
Tel (919) 732-1300 Fax (919) 732-1303

As-Built and Monitoring Report

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Durham North Carolina

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Durham North Carolina

1. INTRODUCTION

1.1 Background

The North Carolina Wetlands Restoration Program (NCWRP) identified Sandy Creek and the adjacent land at the abandoned City of Durham New Hope Creek Waste Water Treatment Facility for a wetland restoration & stream enhancement project. The project site was selected to mitigate impacts to Section 404 jurisdictional areas associated with the extension of the Martin Luther King, Jr. (MLK) Parkway between Cook Road and Hope Valley Road in Durham County North Carolina. The impacts of the MLK Roadway project on jurisdictional wetlands and non-wetland jurisdictional waters totaled 1.73 acres near Third Fork Creek. The Sandy Creek property provides 3.2 acres of wetland restoration/creation as mitigation for the impacts during construction of the MLK Parkway. NCWRP will be using the remaining 1.47 acres for mitigation for other impacts in the Cape Fear River Basin. In addition to the wetlands constructed for this project, Sandy Creek was enhanced with log vanes to create pool features, for habitat and water quality improvement, along 2700 linear feet of stream within the City of Durham property.

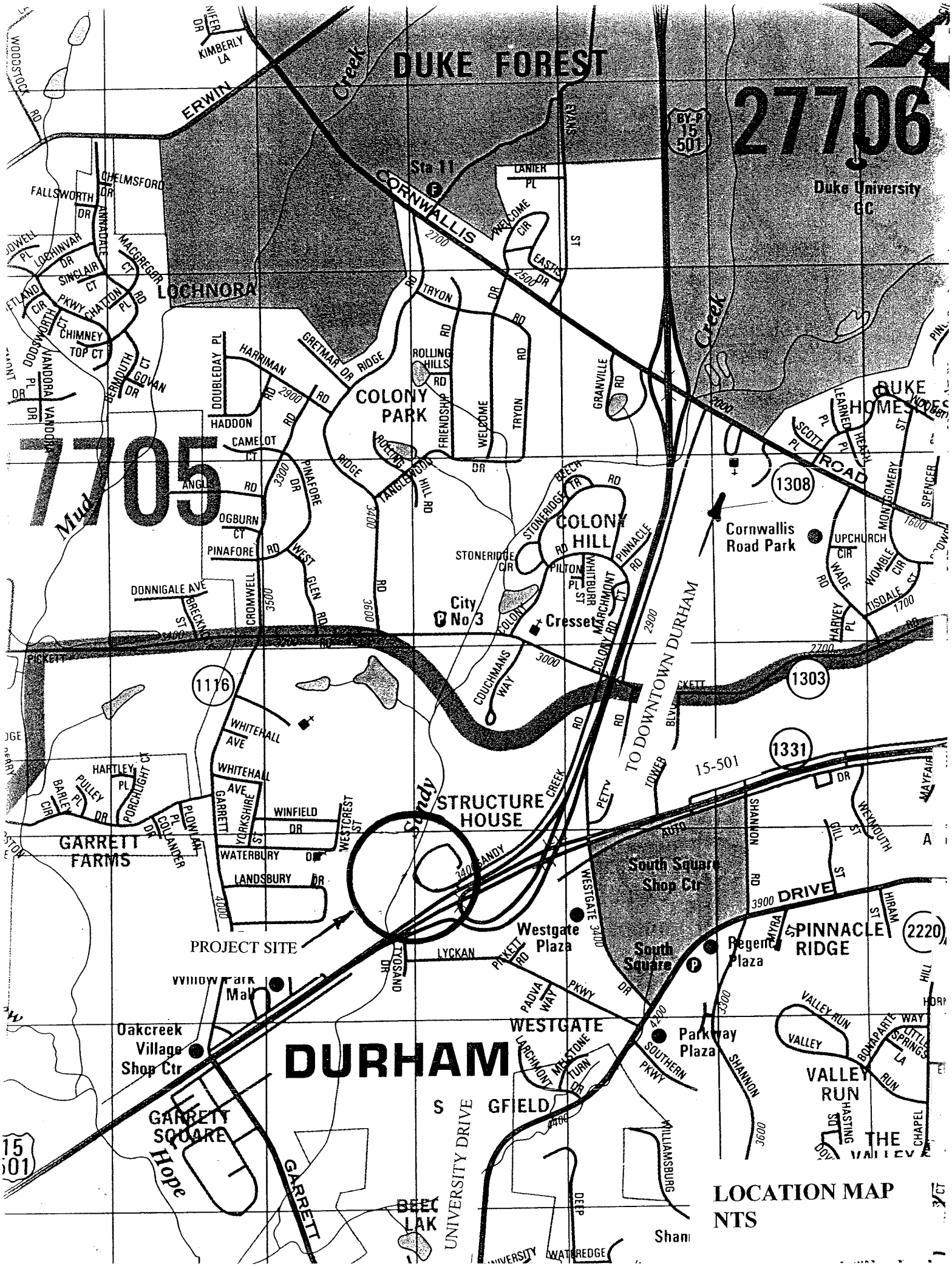
The City of Durham Parks and Recreation Department provided the demolition of the existing concrete, piping, control building, and fencing of the existing sludge drying beds on the wetland site prior to the start of wetlands construction. Remaining demolition of the bed sand, gravel, under drains, manholes, and miscellaneous storm drainage remaining at the sludge drying beds was preformed by the NCWRP wetlands contractor.
The City of Durham had completed phase one of the Sandy Creek Trail, a walking/biking trail on the east side of Sandy Creek from the City property to Pickett Road prior to construction of the NCWRP project. They were also concurrently working on demolition of the abandoned treatment plant on the east side of Sandy Creek and improvements to convert the area into a city park through out the construction of the NCWRP project.

1.2 Location

The Sandy Creek Wetlands Restoration/Creation & Stream Enhancement project site is located in Durham County approximately 1000 feet north of the intersection of Chapel Hill Boulevard (US Business 15/501) and Sandy Creek. A location map has been attached to this report. The site is on the New Hope Creek Waste Water treatment plant facility owned by the City of Durham on Sandy Creek Road. The area is located on the U.S. Geologic Service (USGS) Southwest Durham 7.5 minute topographic quadrangle at latitude 35°58'00" North and longitude 78°57'45" West. The site is in the Cape Fear River Basin in Cataloging Unit 03030002.

1.3 Overview of Project Goals

The goal of this wetland restoration & stream enhancement project was to restore riparian wetlands and improve in stream habitat and water quality in Sandy Creek. In so doing, an abandoned treatment plant facility with waste and spoil areas, overrun with nuisance weeds and trash, was changed into a functioning wetland ecosystem that will provide quality food and habitat for wildlife and improve the water quality within the Sandy Creek drainage basin. The


DUKE FOREST
27706
Duke University GC
Sta 11
CORNWALLIS
ERWIN
BY-P 15 501
LOCHNORA
COLONY PARK
COLONY HILL
DUKE HOMES
Cornwallis Road Park
City No 3
Cresset
STONERIDGE
TO DOWNTOWN DURHAM
1308
1303
1331
1116
7705
Mud
Creek
Sandy
STRUCTURE HOUSE
GARRETT FARMS
PROJECT SITE
Westgate Plaza
South Square Shop Ctr
Regency Plaza
PINNACLE RIDGE
2220
Willowdale Mall
Oakcreek Village Shop Ctr
WESTGATE
Parkway Plaza
DURHAM
VALLEY RUN
GARRETT SQUARE
Hope
UNIVERSITY DRIVE
LOCATION MAP
NTS

stream enhancement will improve the stream water quality, the bed form, and create in stream habitat. These goals were accomplished by the following:

- Removal of existing trash, nuisance weeds and structural treatment plant facilities.
- Establishing wetlands with the removal of unsuitable soils and grading of the site to create a hydrologic regime necessary to further promote and increase hydric soil development.
- Incorporating precipitation as well as the retention of floodwaters from Sandy Creek for hydrologic input.
- Planting a suite of native species that maximize wetland functions.
- Enhancement of bed form in an existing uniform sandy bottom stream.
- Providing opportunities for air induction into the water over log vane structures during low flow conditions.
- Enhancing in stream habitat with the formation of pools on the downstream side of the log vane structures.

2. SUMMARY

2.1 Project Description:

Wetland Restoration/ Creation:

Approximately 9600 cubic yards of soil were removed from the wetland site during construction. The area for the wetland restoration was excavated to act as an extension of the existing wetland. The permanently flooded regime of the reference wetland was replaced with a semi permanently flooded regime in the constructed site. The site was built such that a broad levee set at the elevation of the seasonal high water table of the pond, 262.0 feet, separates the site into two sections. The southern section ties into the grade of the existing wetland and slopes gradually up to the levee. From the levee the site gradually slopes down to the north of the site to an area that stores runoff and floodwaters. In the middle of the ponded area, an elevated wetland "island" was constructed to allow for a different assemblage of vegetation. The following planting zones were established for the project:

Zone 1: Elevation 260.5 – 261.0 Semi permanently Flooded (0.60Ac)
Zone 2: Elevation 261.0 – 262.0 Seasonally Flooded (1.14 Ac)
Zone 3: Elevation 262.0 – 265.0 Temporarily Flooded (1.86 Ac)
Zone 8: Elevation 265.0 feet plus – Buffer (1.12 Ac)

In the wetland zones 1,2, & 3 totaling 3.6 acres, over 2500 plants were initially installed. Eight hundred plants were installed in Buffer zone 8 of the wetland area. The wetland vegetation will be monitored for success in zones 1-3 only. Vegetation plots have been established in these only zones.

Stream Enhancement:

Thirteen log vane structures were constructed along 2700 feet of Sandy Creek. The log vanes consisted of two hardwood trees 24 inches in diameter, 37 feet long, stacked together to form each structure. The logs were secured together with rebar and tied with cables at either end. The logs were anchored with boulders at either end of the structure. Woven fabric was attached to the upstream side of the logs with staples and the upstream side of the logs was backfilled with class I rip rap and #57 stone. The logs were installed at various percent grades along the stream. The as-built construction data for the log vanes are detailed in Exhibit A.

Vegetation was planted on the bank to stabilize the disturbance created with the installation of the log vanes. Therefore this vegetation will not be part of the monitoring plan for this project.

An area just upstream of the culverts under 15-501 was re-graded to repair a blow out and create a bankfull bench. Additionally a narrowed section of the stream, caused by fallen trees and debris, was re-opened to provide improved flow conditions to the existing box culverts. Vegetation was used to protect a newly constructed slope. This vegetation will not be included in the yearly monitoring plan.

2.2 Methodologies:

The as-built data for the wetland site and the constructed log vane structures were developed using a 610 Geodimeter, Total Station. Costal Engineering surveyed the restored wetlands and prepared a contour map. They located all vegetation plots and monitoring wells in the wetland site. In addition to the wetlands topographic information collected, Costal Engineering located all constructed log vanes. They established two elevations on each of the visible ends of the log structures. Becky Ward Consulting placed additional information on the as-built map including photographic locations and the rain gauge location. An LB-100 laser level was utilized to establish the elevations for the monitoring gauges by the Catena Group.

A Wolman Pebble count was made a the permanent cross section. The particle size classification used for the analysis is from the Reference Reach Field Book published by Wildland Hydrology. The pebble count data and plot are located in the Appendix section of this report.

The stream channel permanent cross section was surveyed using a FG 020 Frieberger Automatic level to measure the elevations. The cross sections and pebble counts were field measured & counted by Becky L. Ward Consulting. The distance for each elevation point was located by stretching a cloth tape from one monument to the other and the distance was determined by observing the position of the survey rod along the extended tape. The elevations at each cross section point were established by differential level readings using a benchmark elevation provided by the surveyor on the existing rim of the sanitary sewer system (shown on the plan) to establish the instrument height.

One permanent cross section was located at station 18+50. The cross section is referenced as viewed from left to right looking downstream. The cross section is located north of the existing bridge at station 11+70. Walking north on the asphalt trail adjacent to Sandy Creek the permanent cross section is located approximately 140 feet north of the first manhole. The manhole rim was used for the benchmark for this cross section. The rim elevation was established by Riley Surveying in the design phase of the project. The rim elevation for this manhole is 267.9. The cross section permanent markers are 1 ¼ inch PVC pipe set in concrete. The top of the left permanent marker was established as elevation 265.16 and the right marker at 264.65. The cross section is 47.3 feet in width. This cross section is located in the undisturbed existing channel between log vanes 8 and 9. The cross section data and plot is located in the Appendix of this report.

Five vegetation plots were installed for monitoring in zones 1, 2, and 3 on the wetland site. The plots were set at 10 meters x 10 meters square. The four corners of the plots were marked with 1 ¼ inch PVC piping. A string was tied around all corners of the plot to mark the limits of the 10 meter square space for monitoring. The locations of the plots are shown on the as-built plans and described as follows:

Plot #1: Plot 1 is located in Zone 2 of the wetlands adjacent to the existing pond in the southern end of the project.
Plot #2: Plot 2 is located just east of Plot 1 in zone 3 of the wetland site.
Plot #3: Plot 3 is located in zone 2, on the western side of the site just north of the levee at elevation 262 feet.
Plot #4: Plot 4 is located in the southeastern corner of zone 1.
Plot #5: Plot 5 is located on top of the island feature in zone 3.
The initially plotted vegetation and ground cover data observed in June 2003 can be found in Exhibit C located in the appendix section of this report.

The rain gauge installed at the site was located on top of a 4"x4" treated timber post elevated approximately 9 feet to protect the instrument from vandalism. The gauge was located at the southern end of the site, to approximate the middle of the existing and constructed wetlands. The rain gauge is a Davis instrument Rain collector II. The self-emptying tipping-bucket design measures rainfall in 0.01" increments. An Onset Computer Corporation, HOBO Event Rainfall logger was connected to the rain gauge. The event data logger records momentary closures/openings generated by the tipping-bucket rain gauge. These "events" are recorded with a time stamp that can be viewed as tabular data or exported into spreadsheets to produce detailed graphs. The event stores up to 8000 counts in nonvolatile EEPROM memory for up to 20" of rainfall.

Four Infinities USA Model #138 Pressure Water Level Data Loggers were installed. The loggers are programmed to record the water levels twice a day. They will be downloaded on a monthly basis to ensure proper functioning and that no prolonged lapses in coverage are experienced.

2.3 Watershed Description:
The Sandy Creek watershed extends from the southern most boundary of 15-501 North to Hillsborough Road. The watershed is approximately 6.4 square miles. The Sandy Creek watershed is currently almost completely developed as 35% residential, 10% commercial/office, 25% Duke University campus and Medical Center, 25% Duke Golf Course and other permanent open space and 5% roadways. The watershed drainage area map is included as Exhibit B in the Appendix section of this report.

2.4 Consultant, Contractor & NCWRP Project Manager:
Principal Design Firm: Becky L. Ward Consulting
Contact: Ms. Becky Ward
1512 Eglantyne Court
Raleigh, North Carolina 27613
Phone: (919) 870-0526
Fax: (919) 845-4636

Contractor: ***Shamrock Environmental Corporation***
Contact: Mr. Greg Kiser
Project Manager: Mr. Bill Wright
6106 Corporate Park Drive
Browns Summit, North Carolina 27214
Phone: (336) 375-1989
Fax: (336) 375-1801

NCWRP Project Manager:

North Carolina Wetland Restoration Program
Contact: Ms. Cherri Smith
320 West Jones Street
Raleigh, North Carolina 27603
Phone: (919) 733-5208
Fax: (919) 733-9919

3.0 SUCCESS CRITERIA

3.1 Wetlands Restoration/ Creation:

Hydrology

One data logger was installed on the wetland "island" at an elevation of 263 feet (ground water gauge B), one on the levee at an elevation of 261 feet (ground water gauge A), and the final two were both placed at an elevation of 262 feet, one in the reference wetland (ground water gauge D) and one to right of the entrance road traveling towards the "island" in the mitigation site (ground water gauge C).

Gauge B on the "island" represents the highest elevation that is anticipated to regain wetland hydrology. Success at this elevation assumes success for all areas within the Temporarily Flooded Zone, which runs from 262.1 to 263.5 feet. It needs to be noted that based on the as-built elevations, the amount of area in the mitigation site that falls between 263.0 feet and 263.5 feet is essentially a very narrow strip around the edge of the wetland portion of the site. It would be extremely difficult to locate a gauge in this narrow strip, which totals less than 0.10 acre. Therefore, the decision was made to place the gauge in an area of the site that would be most representative of the highest section of the site that is anticipated to regain wetland hydrology, hence the "island".

Based on the soils, vegetation, and hydrology collected from the reference reach, the success for the Intermittently Exposed and Semipermanently Flooded Zones will be determined. As a minimum, the criteria meeting soil conditions having ponded, flooded, or saturated soils within 12 inches of the surface for 12.5% of the growing season during years of normal precipitation, will be met. The minimum conditions are expected to be exceeded, based on the comparison of the reference wetland to the restored wetlands vegetation, soils, and hydrology. Gauge C was placed at an elevation of 262.0 and success at this level assumes success for all areas within these zones. Gauge D was also placed at this elevation in the reference wetland to be utilized for comparison purposes.

The original mitigation plan called for a gauge to also be placed at the top of the Intermittently Exposed zone, but it was subsequently decided this would be unnecessary since it would be at least as wet as the Semipermanently Flooded Zone, which is a slightly higher elevation. Instead, Gauge A was placed near the levee to help determine the number of times open water connects the existing wetland and the Intermittently Exposed and Semipermanently Flooded zones of the mitigation site as well as supplying additional information on the ground water levels.

Vegetation

The vegetation development should be observed to show progressive growth over the five-year monitoring period. Vegetative success will be determined by the survival of target species within

the sample plots. The minimum survival rate is 260 stems/acre at end of the fifth year. Included in the required survival criteria are planted seedlings and natural recruitment of the same species. At least six different representative species should be present on the entire site.

Five vegetation 30' x 30' vegetation plots were placed within the wetland portion of the sites, which includes Planting Zones 1-3. Vegetation Plot 4 is in Planting Zone 1, Vegetation Plots 1 and 3 are in Zone 2, and Vegetation Plot 2 and 5 are in Zone 3.

The first vegetation monitoring count was performed June 28, 2003 and the results are included in Exhibit C. In addition to the woody vegetation plantings, herbaceous seed mixes were applied throughout the site as detailed in the original plan. However, the majority of the herbaceous seed and seedlings, as well as many of woody plants but to a lesser degree, fell victim to predation. The major culprit being the flock of Canada Geese that inhabit the site and use it for a nesting ground. Despite this setback, many volunteer species have begun to infiltrate the area. It is also worthy to note that the small section that was top dressed with a combination of original top soil and mulch is fairing better with the herbaceous vegetation than the rest of the site.

Vegetation Plot Photo Reference

Photographs should show growth in woody vegetation and ground cover. The photo locations for the vegetation plots are shown on the as-built plans and described as follows:

Plot #1: The photograph for this plot was taken viewing the north east corner of the plot looking south towards the pond. The ground cover was also viewed in this line of site just at a closer distance.

Plot #2: The photo for plot 2 was taken viewing the south east corner of the plot looking north. The ground cover for this plot was also in this same direction, viewed at a closer distance.

Plot #3: The photograph at this location was taken viewing the north side of the plot looking south.

Plot #4: The photograph of this plot was taken viewing the east side of the plot and looking west.

Plot #5: The photo of plot 5 was taken viewing the north side of the plot on the island and looking south at the existing pond.

3.2 Stream Enhancement:

Structures

The structures should not show any breaching. The water should flow over the log vane or the rocks placed at the end of the vane. The structures should not show any erosion along the arms or evidence of water bypassing the structure. The stream banks should show evidence of vegetation stabilization. The banks disturbed by the installation of the log vane should not show any signs of erosion.

Stream Cross Section & Log Vane Photo Reference Points

Photographs should show no change in physical location of channel. Log vanes shall show no evidence of breaching.

Photo Reference Locations:

1. The photograph for the permanent cross section was taken upstream of the section looking downstream.
2. All log vane pictures were taken standing upstream of the log vane looking downstream at the structures.

4. MONITORING SCHEDULE & METHODS

The project will be monitored once each year for a period of five (5) years with the first year monitoring to be completed in October of 2004 by the principal design consultant, *Becky L. Ward Consulting.*

As previously noted, the ground water gauges will be downloaded on a monthly basis to ensure proper functioning and that no prolonged lapses in coverage are experienced. Rainfall data will also be collected monthly to produce a record of the actual rainfall received at the site. The rainfall data will be analyzed to determine if the annual rainfall is within the realm of a "normal" year. The gauge data will be analyzed to determine if each hydrologic zone is meeting the success criteria as well as compared to the reference wetland ground water data.

Stream enhancement monitoring will consist of reviewing the structures periodically or after large storm events to look for structure integrity. The pool downstream of each log structure will be monitored yearly to determine overall pool depths. The permanent cross section will be surveyed yearly to determine any changes in the channel geometry, location or elevations. Photographic documentation of each log structure will be taken yearly.

5. MITIGATION

The mitigation plan, Exhibit "E", is located in the Appendix section of this report.

6. MAINTENANCE & CONTINGENCY PLANS

The State of North Carolina Wetland Restoration Program (NCWRP) will be responsible for the maintenance of this project, for a period of five (5), years after project completion. During the first year of monitoring by the design consultant, if a problem that requires an immediate corrective action or a flaw in the site is noted at any point, it will be brought immediately to the attention of the NCWRP. After the first year, repairs will be made as necessary by NCWRP.

7. REFERENCES

7.1 Applied River Morphology, Rosgen Dave, 1996 Wildland Hydrology

7.2 The Reference Reach Field Book, 1998 Wildland Hydrology

7.3 As-built surveys by: Costal Engineering 934 West Kitty Hawk Road, Kitty Hawk North Carolina 27949 (252) 261-4151

7.4 As-built Cross Section by Becky L. Ward Consulting 1512 Eglantyne Court, Raleigh North Carolina 27613 (919)870-0526

7.5 Monitoring well installation by The Catena Group, 410-B Millstone Drive Hillsborough, NC 27278 (919) 732-1300.

7.6 Base project map prepared by Hayes, Seay, Mattern & Mattern, Inc. for Sandy Creek Life Long Learning Center Trail Phase One, August 2000.

7.7 Flood Insurance Study Durham County, North Carolina & Incorporated Areas Effective Date February 2, 1996

7.8 Sandy Creek Conservation Easement Triangle Township, Durham county, North Carolina August , 2001

7.9 Wetland Delineation survey, Sandy Creek Wastewater Treatment Facility by Barbara H. Mulkey Engineering Inc. dated 12/1/1997, revised 12/5/1997, delineation by Ecological consultants.

7.10 Surveys for proposed design and easements by Phil Riley Surveying, 636 Gary Street Durham, NC 27703 (919) 667-0742.

APPENDIX

EXHIBIT A

Vane No	Fin Rod At bank	Fin Rod At chann	Distance btw rod	Final El At bank	Final El At channel	Final % Grade	Comments
13	9.00	10.92		263.00	261.08	8.0%	2 bkt rip rap 2bkt 57 stone
12	8.90 7.78	9.96 9.85	20.00 26.00	262.5? 263.51	261.44	8.0%	1 bkt rip rap 1bkt 57 stone
11	8.00	9.74	16.00	263.25	261.50	8.6%	10% based on upper 1/2 of log , Forked end of tree on bottom End elev 260.4, length bank to end 33', overall slope 8.64%
10	8.17	10.35	20.00	262.31	260.13	11.0%	1 load each 57 % rip rap
9	9.00	10.83	20.00	261.66	259.83	9.8%	overall slope 11.41-7.9/36= 9.75 Q=inv sin 12.5/36= 20.3 deg missed seeing toe rocks 9&10, 1load 57 & rip rap#9
8	7.70	9.66	20.00	262.25	260.30	9.3%	Q=inv sin 12/31 = 23 deg, length rom bnk to end top log 31', 1 load 57 stone 10.59at end el=259.36, overall slope 262.25-259.36/31=9.3% 2 load rip rap
7	7.12	9.55	20.00	262.26	259.83	12.0%	Q=inv sin 11/31= 21 deg, ttl gog length =31' exposed, end elev= 259.0 overall slope 262.26-259/31=10.5%
6	7.15	8.98	20.00	261.80	259.97	8.0%	End log elev= 259.29, ttl length=31' overall slope = 261.8-259.29/31=8% Q=inv sin 9/31=17 deg 1.5 loads of 57, 1 load rip rap
5	9.06	10.80	20.00	261.37	259.63	8.7%	Q=inv sin 8/17 = 28 deg
4	6.67	8.86	20.00	261.21	259.02	11.0%	end log top 257.89 Total length =32' Q=inv sin 8/26 = 18 deg
3	6.09	7.65	20.00	260.81	259.25	7.8%	Q=inv sin 10/29=20 deg
2	6.15	8.16	20.00	262.07	260.06	10.0%	end log Q=inv sin 9/31=17 deg, overall length 31' overall slope 10.3% End shot 9.35 EL = 258.87
1	7.02	8.49	20.00	260.62	259.15	7.4%	Q+ sin 6/20=17 deg, end shot = 9.0, El = 258.64 Length log =32'

Sandy Creek Stream Enhancement Log Vane Installation

EXHIBIT A

Vane No	Target % Grade	BM	Rod Reading	HI	Stream Elevation	Target Bank EL.	Target @ 1/3 Chan	Target Bnk Rod Read	Target ch Rod Read	Vane Degree	Distance From Bnk	Distance along log	Channel Width
13	8%	268.60 sta 23+80	3.40	272.00	261.00	263.40	261.50	8.80	20.00	20	9.50	24.00	29.00
12	12%	268.60 sta 23+80	2.69	271.29	bnk 260.8 str 260.9	263.90	261.50	7.40	9.80	30	10.00	20.00	25.00
11	8%	280.80 sta 21+80	2.45	271.25	260.60	263.80	261.70	7.50	9.60	24	8.00	24.00	24.00
10	12%	268.80 sta 21+80	1.68	270.48	260.33	263.60	261.50	6.90			9.00	25.00	25.00
9	8%	267.90 sta 16+90	2.76	270.66	259.60	263.00	260.60	7.70	10.00	20	9.00	24.00	25.00
8	12%	267.90 sta 16+90	2.05	269.95	259.80	263.00	261.00	6.95	8.90	23	9.00	24.00	25.00
7	8%	267.90 16.90	1.48	269.38	259.50	263.00	260.50	6.40	8.90	21	11.00	31.00	25.00
6	12%	267.90 sta 16+90	1.05	268.95	259.10	262.45	260.80	6.50	8.10	17	8.00	24.00	22.00
5	8%	266.00 sta 11+60	4.43	270.43	258.70	262.20	260.50	8.40	10.00	28	8.00	17.00	26.00
4	12%	264.00 tbm2-stk	3.88	267.88	258.40	261.90	259.50	6.00	8.40	18	8.00	26.00	22.00
3	8%	264.00 tbm2-stk	2.90	266.90	259.00	261.50	259.90	5.40	7.00	20	10.00	29.00	21.00
2	12%	263.90 tbm3-stk	4.32	268.22	259.26	262.80	260.40	5.42	7.82	17	9.00	31.00	21.00
1	8%	263.98 tbm4-stk	3.66	267.64	258.73	262.23	260.60	5.40	7.00	17	6.00	20.00	17.00

Exhibit C- Vegetation Plot Data June 2003

Survival of plantings in the Sandy Creek Mitigation Site were evaluated on June 28, 2003 by personnel from The Catena Group. Living stems were counted and their respective species was recorded within the boundary of each plot. It should be noted that there were living stems of species within a designated plot that were not listed for the vegetative zone in which the plots resided. These species were included in the counts and will be noted with an asterisk "*" in the tables below.

Vegetation Plot 1

Species	# of living stems
Sambucus canadensis	7
Cornus amomum	2
Fraxinus pennsylvanica	10
Quercus phellos	6

Vegetation Plot 2

Species	# of living stems
Nyssa sylvatica	2
Liriodendron tulipifera	0
Betula nigra	0
Quercus laurifolia	0
**Acer negundo*	2

Note: The *Acer negundo* listed above may be volunteers with in plot 2 since the species is not listed on the planting list

Vegetation Plot 3

Species	# of living stems
Sambucus canadensis	3
Cornus amomum	4
Fraxinus pennsylvanica	6
Quercus phellos	7

Vegetation Plot 4

Species	# of living stems
Salix nigra	3
Alnus serrulata	1
Cephalanthus occidenatalis	2
Quercus lyrata	5
**Cornus amomum*	2
**Carya ovata*	4
**Quercus phellos*	1
**Sambucus canadensis*	1

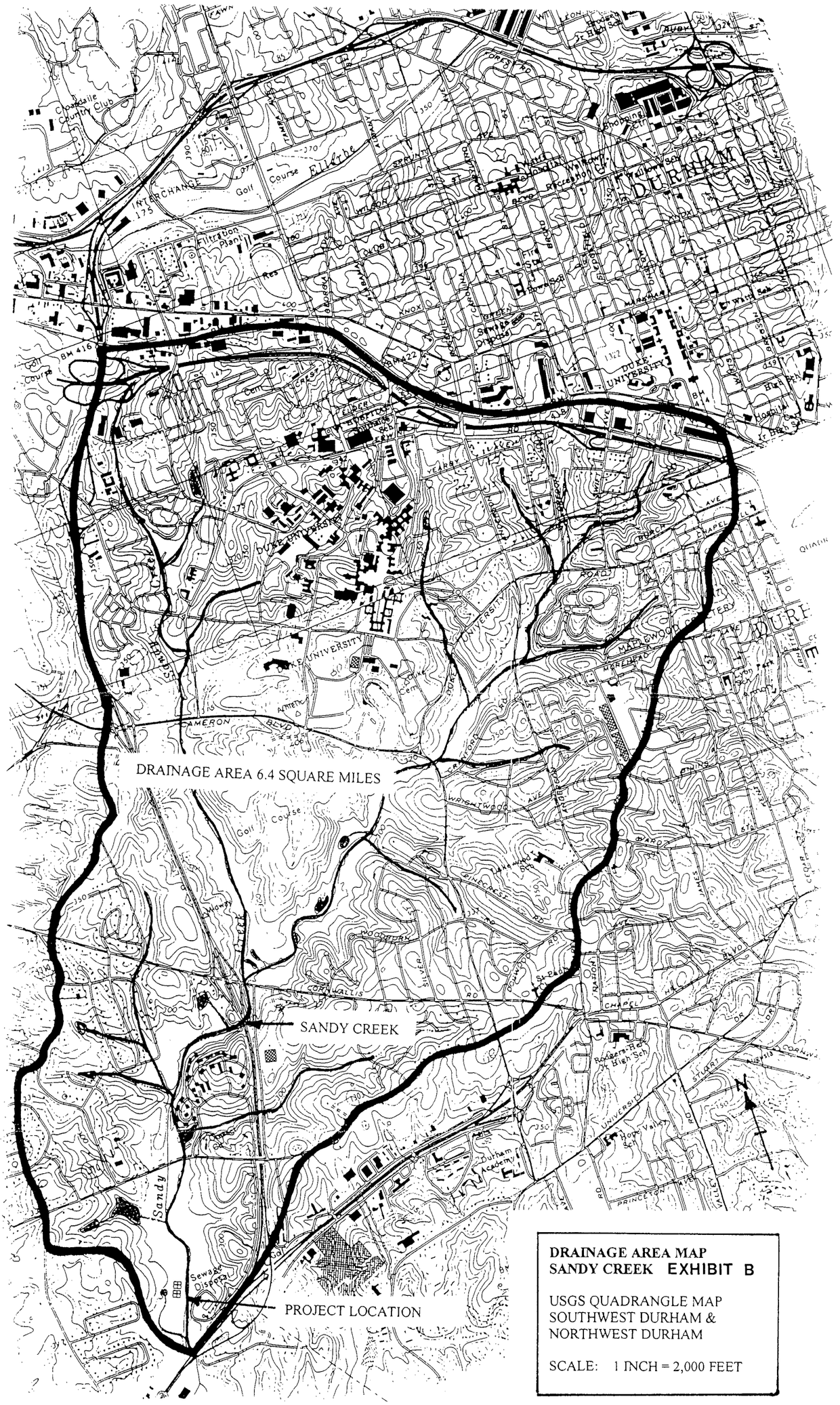
Vegetation Plot 5

Species	# of living stems
Nyssa sylvatica	3
Liriodendron tulipifera	9
Betula nigra	0
Quercus laurifolia	0
* *Salix nigra*	1

EXHIBIT D - LOG VANE POOL DATA

Monitoring Date	7/12/2003					
Log Vane Number	Pool Depth (in)	Comments	Pool Depth (in)	Comments	Pool Depth (in)	Comments
1	19					
2	12					
3	12					
4	8					
5	28					
6	12					
7	13					
8	15					
9	5	log burried 2/3 length				
10	2	log burried point bar forming				
11	16	check washing top end				
12	12.5					
13	6	1st log set low				

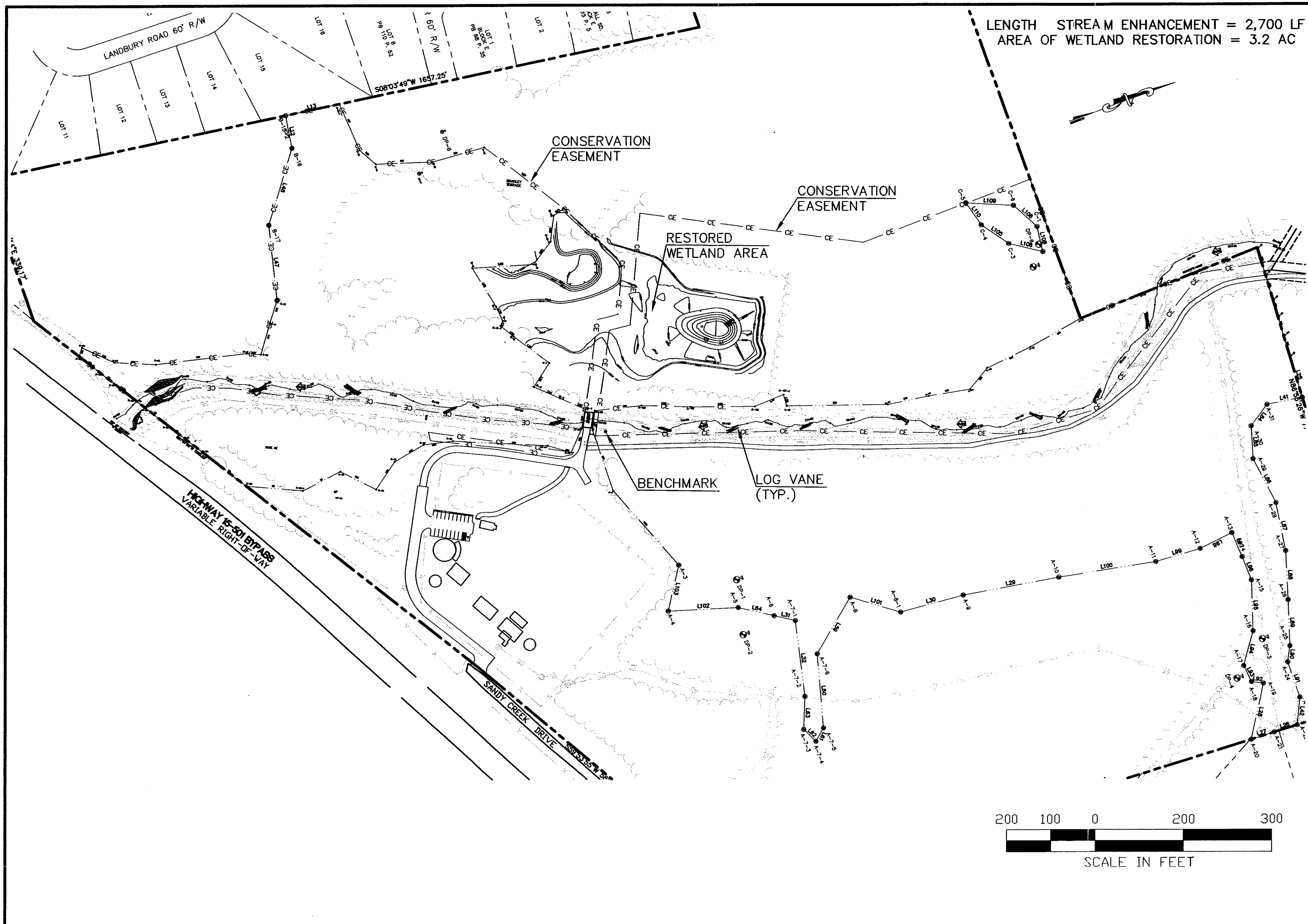
PHOTO LOG



DRAINAGE AREA MAP
SANDY CREEK **EXHIBIT B**

USGS QUADRANGLE MAP
SOUTHWEST DURHAM &
NORTHWEST DURHAM

SCALE: 1 INCH = 2,000 FEET



Becky Ward Consulting
Water Management Engineering

108 Sturbridge Road
Raleigh, NC 27615
(919) 870-0526
FAX (919) 870-5359

SANDY CREEK MITIGATION PLAN

STATE OF NC WETLANDS RESTORATION PROGRAM

DATE: 10-03-03

REVISIONS:

PROJECT NAME: SANDY CREEK

DWG NAME: ab-mitigation

SCALE: 1"=200'

SHEET NO.

LEGEND

CE — CONSERVATION EASEMENT

AS-BUILT CONTOURS

TREE LINE

GROUND WATER GAUGE LOCATION

VEGETATION PLOT AREA

1 — PHOTO LOCATION

REFERENCE SITE
GROUND WATER GAUGE
ADJ. GROUND EL.=261.81

LIMITS OF WETLANDS
AS MAPPED BY ECOLOGICAL
CONSULTANTS 12-18-1997
INCLUDED WITH CONTRACT
DOCUMENTS.

VEGETATION PLOT #1

VEGETATION PLOT #2

VEGETATION PLOT #3
(TYP.)

VEGETATION PLOT #4

VEGETATION PLOT #5

GROUND WATER GAUGE
"A"
ADJ. GROUND EL.=260.69

GROUND WATER GAUGE
"B"
ADJ. GROUND EL.=262.93

GROUND WATER GAUGE
"C"
ADJ. GROUND EL.=261.84

EXISTING
POND

TIPPING BUCKET RAIN
GAUGE LOCATION

TREE LINE
(TYP.)

SITE BENCHMARK
60d NAIL IN 8" RIVER BIRCH
33' NORTH OF BRIDGE @ TOP
OF CREEK BANK ELEVATION = 264.81

BRIDGE

RIM=266.6

ASPHALT TRAIL

FLOW

B-10, B-9, B-8, B-7, B-6, B-5-1, B-5, B-4, B-3, B-2, B-1, B-40, B-38, B-39

A-47-1, A-47, A-48, A-49, A-50, A-51, A-1

L52, L53, L54, L55, L70, L72, L73, L74, L14, L15, L33, L34, L35, L37, L38, L69, L75, L76, L78

8+00, 9+00, 10+00, 11+00, 12+00, 13+00, 14+00, 15+00, 16+00

AS-BUILTS SURVEYED BY,
COASTAL ENGINEERING & SURVEYING
P.O. BOX 1129
KITTY HAWK, NC 27949
252-261-4151

WETLAND DESIGN & MONITORING
GROUND WATER GAUGES INSTALLED BY,
THE CATENA GROUP
410-B MILLSTONE DRIVE
HILLSBOROUGH, NC 27278
919-732-1300

60 30 0 60
SCALE IN FEET

Becky Ward Consulting
Water Management Engineering
1512 Eglantyne Ct. (919) 870-0526
Raleigh, NC 27613 FAX (919) 870-5359

SANDY CREEK
AS-BUILTS

STATE OF NC WETLANDS
RESTORATION PROGRAM

DATE: 08-22-03

REVISIONS:

PROJECT NAME: SANDY CREEK

DWG NAME: ab-wetland

SCALE: 1"=60'

SHEET NO.

LEGEND

L1 PICTURE LOCATION

LOG VANE

LOG #1
STA=2+04.35
TOP OF LOG
VANE IN
CREEK=257.58'

STA=1+82.52
TOP OF LOG
VANE @ TOP
OF BANK=259.26'

STA=3+77.03
TOP OF LOG
VANE @ TOP
OF BANK=261.06'

LOG #2
STA=4+11.86
TOP OF LOG
VANE IN
CREEK=257.86'

STA=6+32.23
TOP OF LOG
VANE @ TOP
OF BANK=259.76'

LOG #3
STA=6+54.73
TOP OF LOG
VANE IN
CREEK=257.91'

0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00

FLOW

TOP OF CULVERT
= 262.0

STREAM BANK
REPAIR AREA

RIM=267.4

S57°57'55"W 1283.23'

ZONE AE

HIGHWAY 15-501 BYPASS
VARIABLE RIGHT-OF-WAY

50 25 0 50
SCALE IN FEET

Becky Ward Consulting
Water Management Engineering
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SANDY CREEK AS-BUILTS

STATE OF NC WETLANDS RESTORATION PROGRAM

DATE: 08-22-03

REVISIONS:

PROJECT NAME: SANDY CREEK

DWG NAME: ob-creek1

SCALE: 1"=50'

SHEET NO.

LEGEND

L1 PICTURE LOCATION

LOG VANE

LOG #4
STA=8+87.55
TOP OF LOG
VANE IN
CREEK=258.08'

STA=8+62.54
TOP OF LOG
VANE @ TOP
OF BANK=260.61'

LOG #5
STA=10+99.37
TOP OF LOG
VANE @ TOP
OF BANK=261.02'

STA=11+21.20
TOP OF LOG
VANE IN
CREEK=258.36'

LOG #6
STA=13+56.68
TOP OF LOG
VANE @ TOP
OF BANK=261.04'

STA=13+82.68
TOP OF LOG
VANE IN
CREEK=258.93'

SITE BENCHMARK
60d NAIL IN 8" RIVER BIRCH
33' NORTH OF BRIDGE @ TOP
OF CREEK BANK ELEVATION = 264.81

ASPHALT DRIVE

ASPHALT TRAIL

BRIDGE

FLOW

RIM=267.4

RIM=266.0

50 25 0 50

SCALE IN FEET

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Water Management Engineering
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Raleigh, NC 27613 FAX (919) 870-5359

SANDY CREEK AS-BUILTS

STATE OF NC WETLANDS RESTORATION PROGRAM

DATE: 08-22-03

REVISIONS:

PROJECT NAME: SANDY CREEK

DWG NAME: ob-creek1

SCALE: 1"=50'

SHEET NO.

LEGEND

L1 PICTURE LOCATION

LOG VANE

260.5

263.5

260.5

261.0

260.5

261.5

A-47-1

STA=17+17.76
TOP OF LOG
VANE @ TOP
OF BANK=261.49'

LOG #8
STA=17+44.64
TOP OF LOG
VANE IN
CREEK=259.51'

PERMANENT
CROSS SECTION
LOCATION

L76 L77 L78 L79 L80 L81 L82 L83

A-48 A-47 A-46 A-45 A-44 A-43

STA=20+68.75
TOP OF LOG
VANE @ TOP
OF BANK=261.68'

LOG #11
STA=22+38.78
TOP OF LOG
VANE @ TOP
OF BANK=26

15+00 16+00 17+00 18+00 19+00 20+00 21+00 22+00

L7 L8 L9 L10

FLOW

N

RIM=267.9

RIM=268.8

140.00'

68
G
93'

STA=15+11.35
TOP OF LOG
VANE @ TOP
OF BANK=261.60'

LOG #7
STA=15+38.68
TOP OF LOG
VANE IN
CREEK=259.55'

LOG #9
STA=19+53.25
TOP OF LOG
VANE @ TOP
OF BANK=261.67'

STA=19+71.77
TOP OF LOG
VANE IN
CREEK=259.71'

LOG #10
STA=20+91.40
TOP OF LOG
VANE IN
CREEK=259.84'

50 25 0 50

SCALE IN FEET

Becky Ward Consulting
Water Management Engineering
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Raleigh, NC 27613 FAX (919) 870-5359

SANDY CREEK AS-BUILTS

STATE OF NC WETLANDS RESTORATION PROGRAM

DATE: 08-22-03

REVISIONS:

PROJECT NAME: SANDY CREEK

DWG NAME: ob-creek1

SCALE: 1"=50'

SHEET NO. 4 OF 5

LEGEND

L1 PICTURE LOCATION

LOG VANE

LOG #11
STA=22+38.78
TOP OF LOG
VANE @ TOP
OF BANK=262.53'

STA=22+66.52
TOP OF LOG
VANE IN
CREEK=260.06'

LOG #12
STA=23+97.43
TOP OF LOG
VANE @ TOP
OF BANK=262.02'

STA=24+19.92
TOP OF LOG
VANE IN
CREEK=260.02'

LOG #13
STA=25+96.34
TOP OF LOG
VANE @ TOP
OF BANK=262.41'

STA=26+12.37
TOP OF LOG
VANE IN
CREEK=260.55'

A-42 L16 A-41 L17 A-40 L18 A-39 L19 A-38 L20 A-37 L21 A-36 L22 A-35 L23 A-34 L24 A-33

22+00 23+00 24+00 25+00 26+00 27+00 28+00 29+00

RIM=268.8 RIM=268.6 RIM=270.8 RIM=271.2

N01°47'21"W 432.35'

FLOW

CLEAN-OUT

SS

50 25 0 50

SCALE IN FEET

Becky Ward Consulting
Water Management Engineering
1512 EGLANTYNE CT. (919) 870-0526
Raleigh, NC 27613 FAX (919) 870-5359

SANDY CREEK AS-BUILTS

STATE OF NC WETLANDS RESTORATION PROGRAM

DATE: 08-22-03

REVISIONS:

PROJECT NAME: SANDY CREEK

DWG NAME: ab-creek1

SCALE: 1"=50'

SHEET NO. 5 OF 5

Sandy Creek Stream Enhancement Log Vanes
July 12, 2003

Log Vane #1, Station 2+04

Log Vane #2, Station 4+12

Sandy Creek Stream Enhancement Log Vanes
July 12, 2003

Log # 3, Station 6 + 55

Log # 4, Station 8 + 88

Sandy Creek Stream Enhancement Log Vanes
July 12, 2003

Log Vane # 5, Station 10 + 99

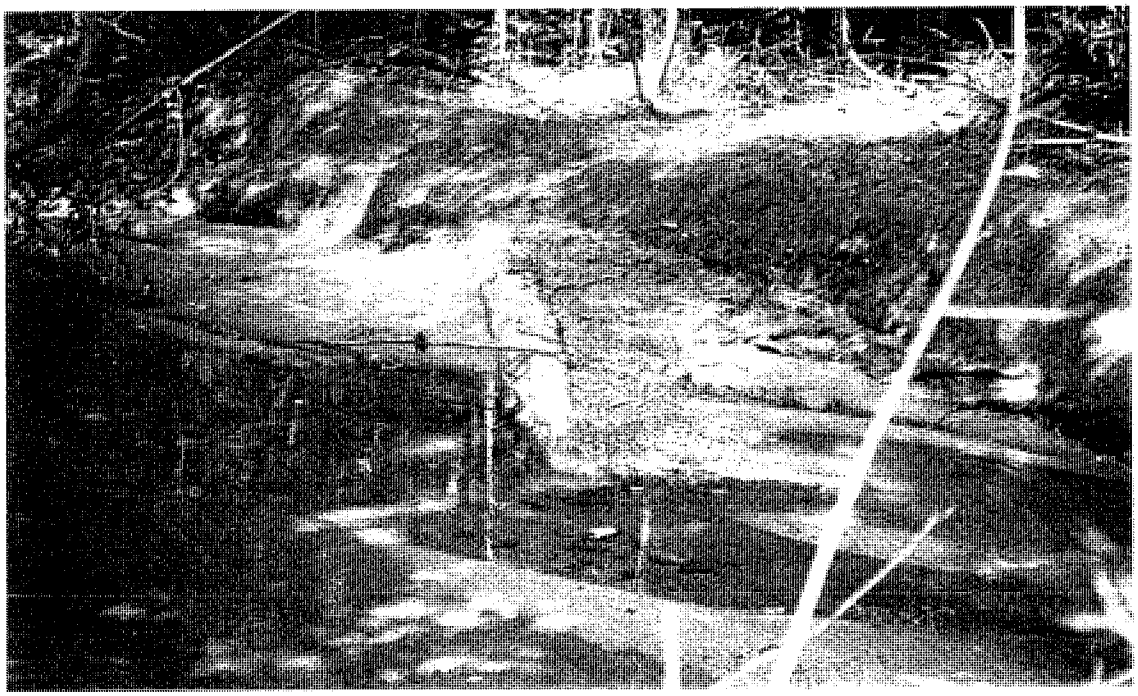
Log Vane # 6, Station 13 + 83

Sandy Creek Stream Enhancement Log Vanes
July 12, 2003

Log Vane #7, Station 15 + 39

Log Vane # 8, Station 17 + 45

Sandy Creek Stream Enhancement Log Vanes
July 12, 2003

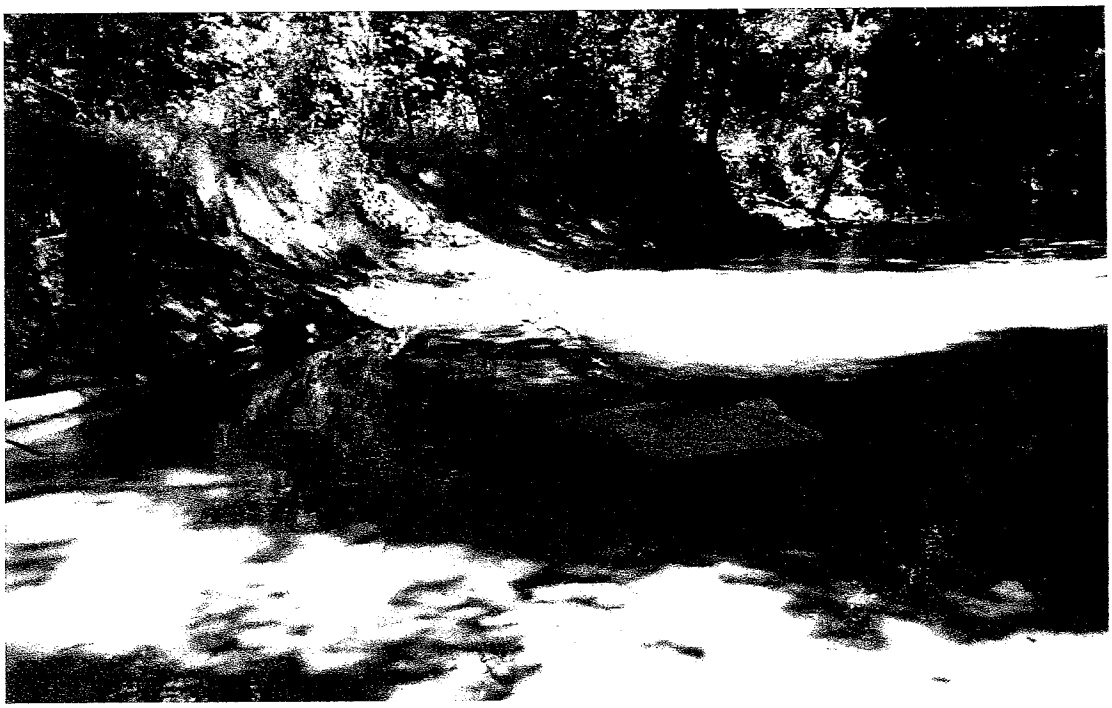


Log Vane # 9, Station 19 +72

Log Vane #10, Station 20 + 91

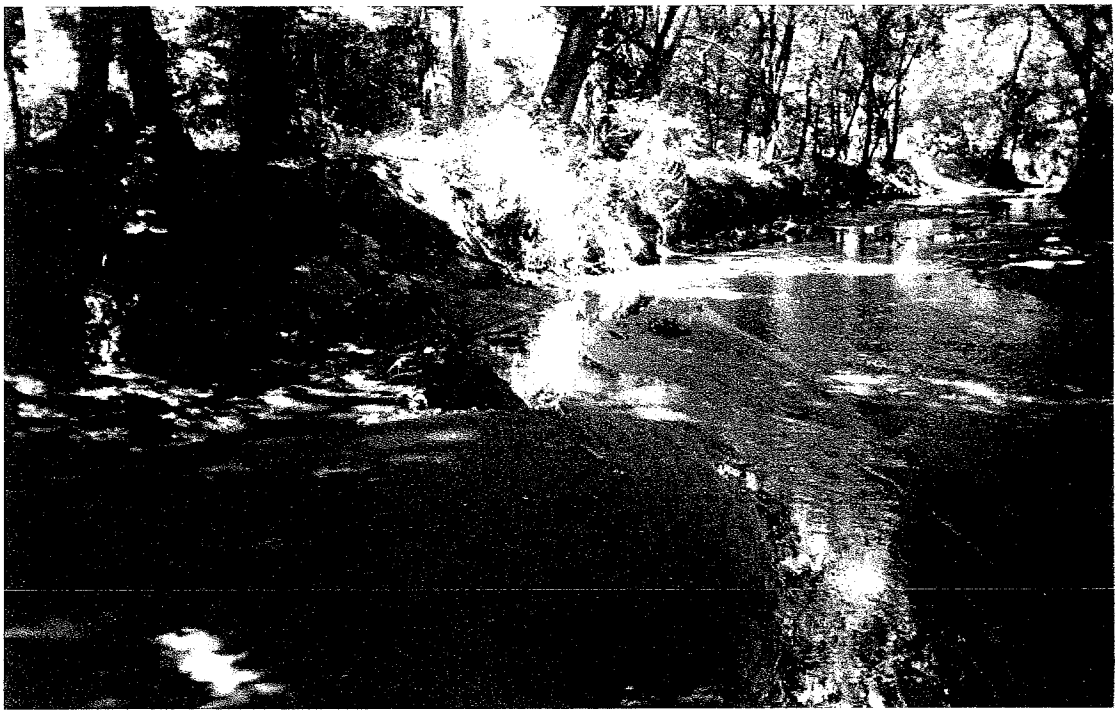
Sandy Creek Stream Enhancement Log Vanes
July 12, 2003

Log Vane # 11, Station 22 + 66



Log Vane #12, Station 24 + 20

Sandy Creek Stream Enhancement Log Vane & Permanent Cross Section
July 12, 2003



Log Vane # 13, Station 26 +12

Permanent Cross-Section, Station 18 + 25, Viewed Looking Downstream

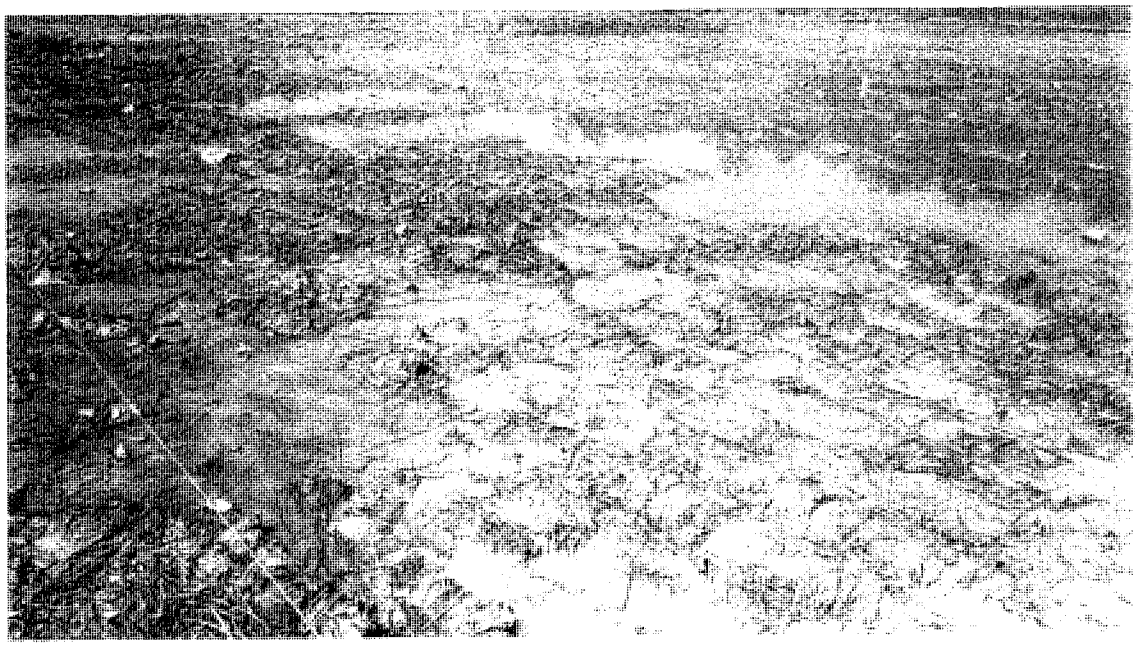
Vegetation Plot 1 – Sandy Creek Wetland Site
July 12, 2003

Picture 1

Picture 1A

Vegetation Plot 2 – Sandy Creek Wetland Site
July 12, 2003

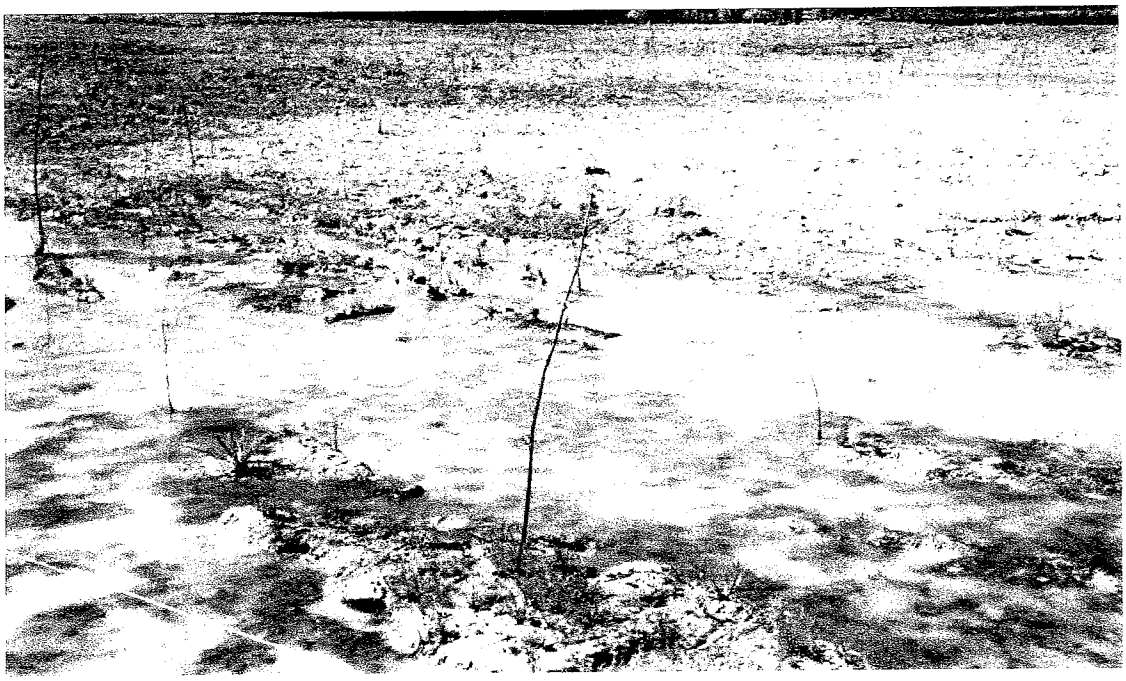
Picture 2



Picture 2A

Vegetation Plot 3 – Sandy Creek Wetland Site
July 12,2003

Picture 3

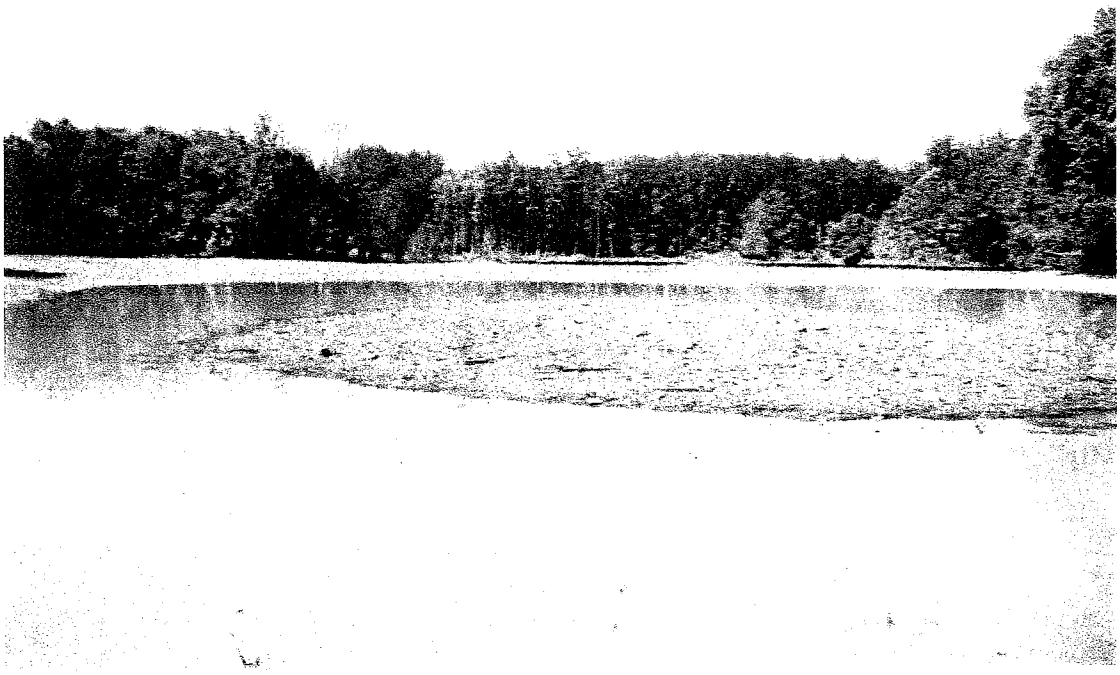


Picture 3A

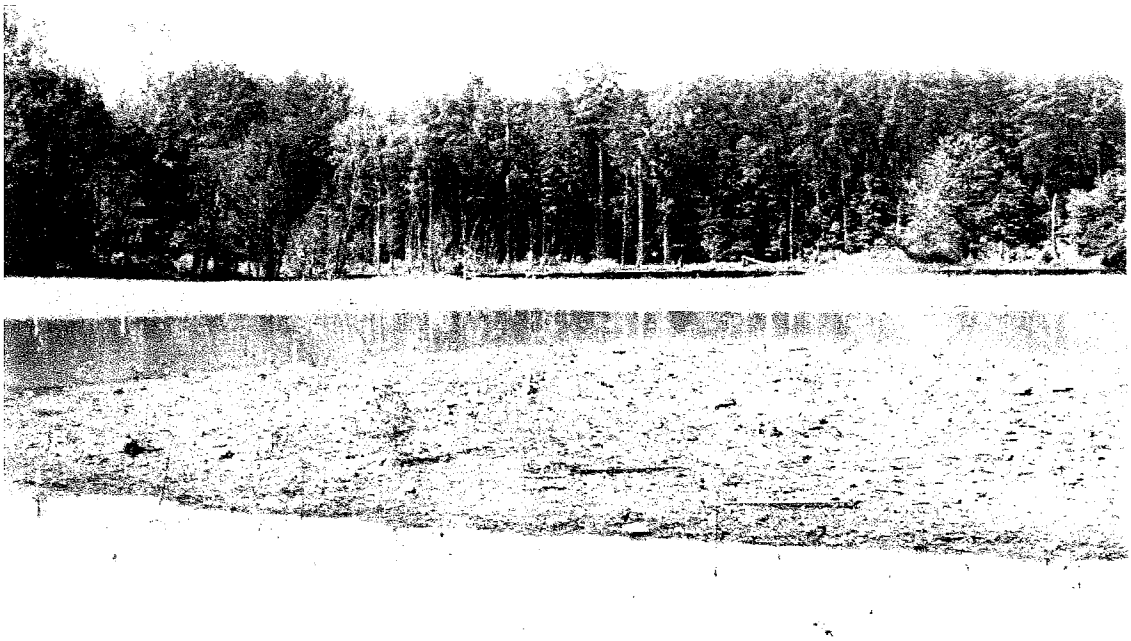
Vegetation Plot 4 – Sandy Creek Wetland Site
July 12, 2003

Picture 4

Vegetation Plot 5 – Sandy Creek Wetland Site
July 12, 2003



Picture 5



Picture 5A

Project: Sandy Creek Stream Enhancement

Location: Permanent Cross Section at approx station 18+50 - 140 feet north of benchmark man hole

Date: 7/12/2003

			USGS Grid Coordinates North	USGS Grid Coordinates East	Plan Sheet Ref. No.
Top of Left Permanent Marker Elevation:	265.16				5
Top of Right Permanent Marker Elevation:	264.65				5

Benchmark description: Top of Existing Sanitary sewer rim at station 16+80 — Benchmark El. 267.9

Note: Cross Section taken from left to right looking downstream

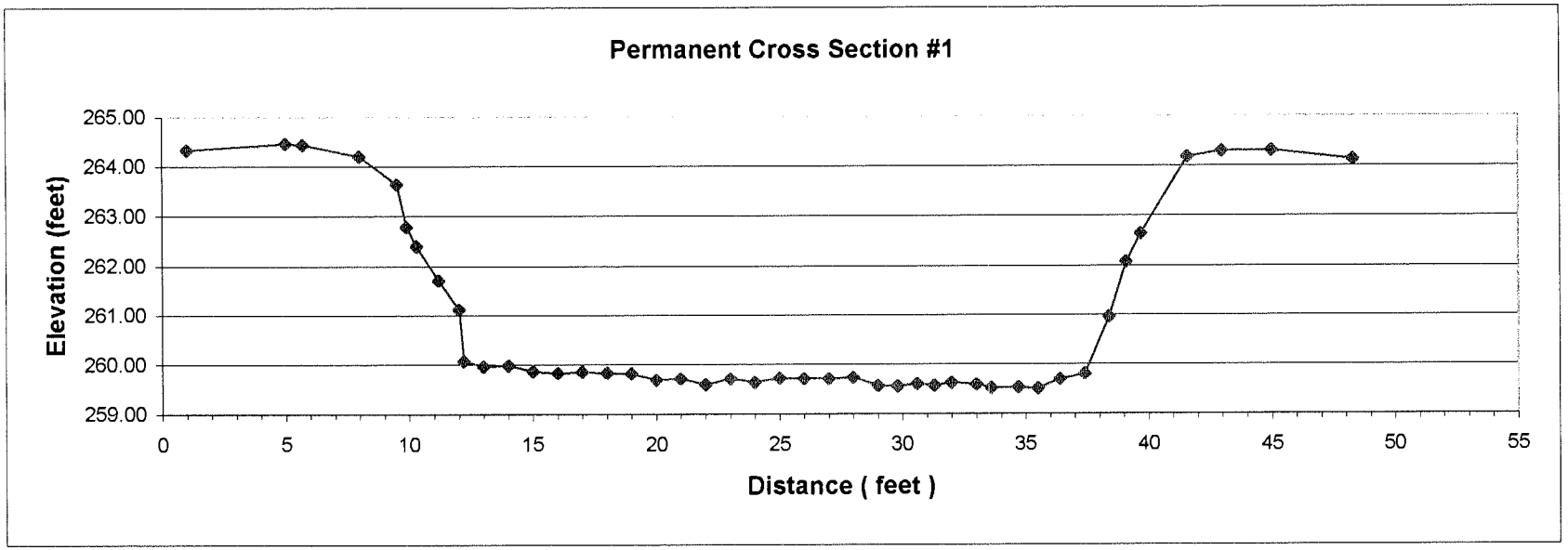
Photo Reference Location:

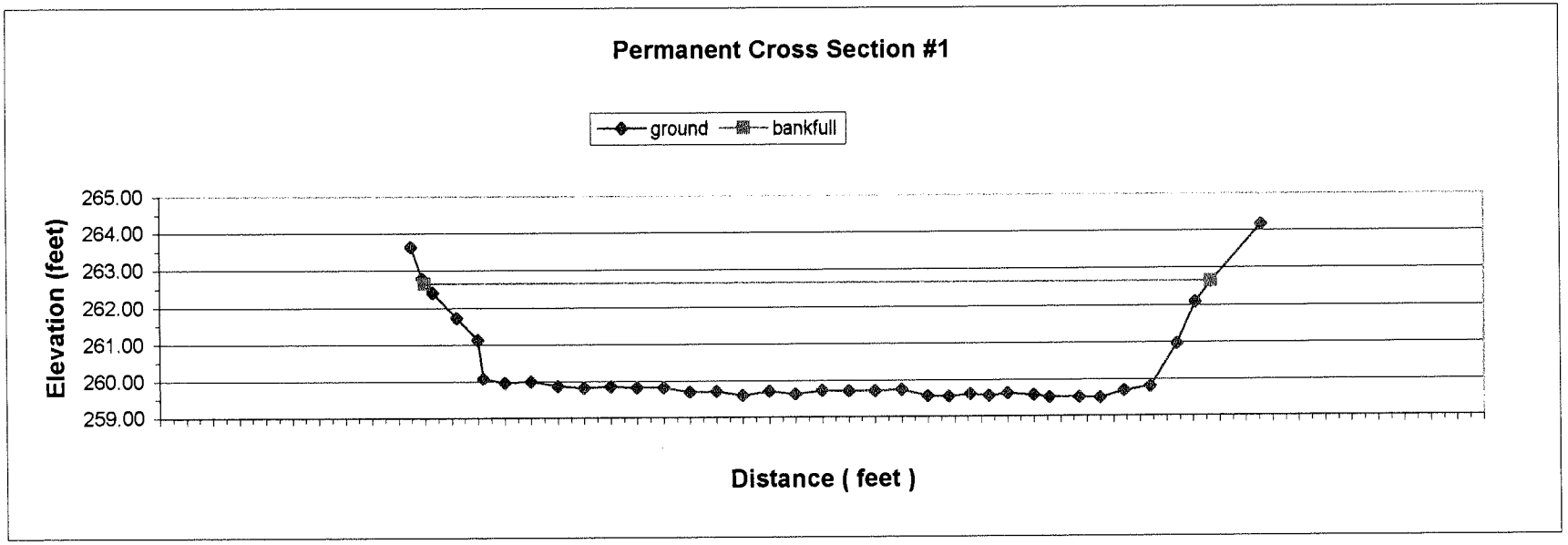
	Back-Sight	Height of Instrument	Fore-Sight	Height	Notes Comments Remarks
Station	**BS**	**HI**	**FS**	**Elevation**	
Feet	Feet	Feet	Feet	Feet	
	1.7	269.60			
1			5.27	264.33	
5			5.14	264.46	
5.7			5.16	264.44	
8			5.4	264.20	
9.5			5.96	263.64	TOB
9.9			6.81	262.79	
10.3			7.2	262.40	bankfull
11.2			7.88	261.72	
12			8.48	261.12	
12.2			9.53	260.07	Toe
13			9.63	259.97	
14			9.61	259.99	
15			9.73	259.87	
16			9.77	259.83	
17			9.74	259.86	
18			9.77	259.83	
19			9.78	259.82	
20			9.91	259.69	
21			9.89	259.71	
22			10	259.60	WS at 7.2 = elev 262.40
23			9.88	259.72	
24			9.96	259.64	
25			9.87	259.73	
26			9.89	259.71	

Stream Morphology

Wbkf =	29.7
dbkf =	2.65
Abkf =	78.8
dmbkf =	3.13
Wfpa =	480
ER =	16.2
D50 =	0.74
Qbkf=	2600
DA =	6.4
Slope =	0.0017
Sinuosity =	1.08

27			9.88	259.72	
28			9.86	259.74	
29			10.03	259.57	
29.8			10.04	259.56	
30.6			9.99	259.61	
31.3			10.03	259.57	
32			9.97	259.63	
33			10.01	259.59	
33.6			10.08	259.52	
34.7			10.07	259.53	
35.5			10.09	259.51	
36.4			9.9	259.70	
37.4			9.79	259.81	Toe
38.4			8.64	260.96	
39.1			7.52	262.08	
39.7			6.96	262.64	bankfull
41.6			5.42	264.18	Top of Bank
43			5.3	264.30	
45			5.29	264.31	
48.3			5.47	264.13	





Bankfull Cross Section

Width= 29.8

Bankfull Elevation 262.64

Station	Elevation	Elevation from Bankfull	Incremental Avg.Height Ft.	Incremental Distance Ft.	Incremental Area Sq.Ft.
10	262.64	0			
			0.12	0.3	0.036
10.3	262.4	0.24			
			0.58	0.9	0.522
11.2	261.72	0.92			
			1.22	0.8	0.976
12	261.12	1.52			
			2.045	0.2	0.409
12.2	260.07	2.57			
			2.62	0.8	2.096
13	259.97	2.67			
			2.66	1	2.66
14	259.99	2.65			
			2.71	1	2.71
15	259.87	2.77			
			2.79	1	2.79

16	259.83	2.81	2.795	1	2.795
17	259.86	2.78	2.795	1	2.795
18	259.83	2.81	2.815	1	2.815
19	259.82	2.82	2.885	1	2.885
20	259.69	2.95	2.94	1	2.94
21	259.71	2.93	2.985	1	2.985
22	259.6	3.04	2.98	1	2.98
23	259.72	2.92	2.96	1	2.96
24	259.64	3	2.955	1	2.955
25	259.73	2.91	2.92	1	2.92
26	259.71	2.93	2.925	1	2.925
27	259.72	2.92	2.91	1	2.91
28	259.74	2.9	2.985	1	2.985
29	259.57	3.07	3.075	0.8	2.46
29.8	259.56	3.08	3.055	0.8	2.444
30.6	259.61	3.03	3.05	0.7	2.135
31.3	259.57	3.07	3.04	0.7	2.128
32	259.63	3.01	3.03	1	3.03
33	259.59	3.05	3.085	0.6	1.851
33.6	259.52	3.12	3.115	1.1	3.4265

34.7	259.53	3.11			
			3.12	0.8	2.496
35.5	259.51	3.13			
			3.035	0.9	2.7315
36.4	259.7	2.94			
			2.885	1	2.885
37.4	259.81	2.83			
			2.255	1	2.255
38.4	260.96	1.68			
			1.12	0.7	0.784
39.1	262.08	0.56			
			0.28	0.6	0.168
39.7	262.64	0			

Total Area 78.843 Sq. Feet

PEBBLE COUNT								
Project: Sandy Creek Post Construction						**Date:** 07/12/03		
Location: At Permanenet cross Section station 18+50, Ripple								
				Particle Counts				
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0		0	0%	0%
	Very Fine	.062 - .125	S	7	0	7	7%	7%
	Fine	.125 - .25	A	4	0	4	4%	11%
	Medium	.25 - .50	N	26	0	26	26%	37%
	Coarse	.50 - 1.0	D	24	0	24	24%	61%
.04 -.08	Very Coarse	1.0 - 2.0	S	6	0	6	6%	67%
.08 - .16	Very Fine	2.0 - 4.0		8	0	8	8%	75%
.16 - .22	Fine	4.0 - 5.7	G	11	0	11	11%	86%
.22 - .31	Fine	5.7 - 8.0	R	12	0	12	12%	98%
.31 - .44	Medium	8.0 - 11.3	A	0	0	0	0%	98%
.44 - .63	Medium	11.3 - 16.0	V	2	0	2	2%	100%
.63 - .89	Coarse	16.0 - 22.6	E	0	0	0	0%	100%
.89 - 1.26	Coarse	22.6 - 32.0	L	0	0	0	0%	100%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	0	0	0	0%	100%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0	0	0	0%	100%
2.5 - 3.5	Small	64 - 90	C	0	0	0	0%	100%
3.5 - 5.0	Small	90 - 128	O	0	0	0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0	0	0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0	0%	100%
	Bedrock		BDRK	0	0	0	0%	100%
			Totals	**100**	**0**	**100**	**100%**	**100%**