Privateer Farms Restoration Site

Annual Monitoring Report for 2006 (Year 2)

November 2006

Prepared for:

NC Department of Transportation

Project Development and Environmental Analysis Branch

Office of Natural Environment

1598 Mail Service Center

Raleigh, NC 27699-1598

NC Ecosystem Enhancement Program

1652 Mail Service Center,

Raleigh, NC 27699-1652

Prepared By:

Buck Engineering

A Unit of Michael Baker

8000 Regency Parkway

Suite 200

Cary, North Carolina 27518

Phone: 919.463.5488

Fax: 919.463.5490

EXECUTIVE SUMMARY

The Privateer Farms Stream Restoration Site ("site") was restored through a full-delivery contract with the North Carolina Department of Transportation (NCDOT). Administrative management of the project has been transferred to the North Carolina Ecosystem Enhancement Program (NCEEP). The goals and objectives of this project were as follows:

1. Restore riverine wetlands through stream restoration, filling of agricultural drainage ditches, restoration of a natural topography, and planting
2. Enhance riverine wetlands through stream restoration and supplemental planting
3. Increase stream length across Privateer Farms Restoration Project from 25,000 (LF) to approximately 34,005 LF through dimension, pattern and profile adjustments
4. Restore floodplain and other low-lying areas to their historic wetland ecosystem.

Construction of this project was completed in April 2005. Stability of the project must be annually monitored and documented during a five-year period following construction completion. This report documents the monitoring data collected at the project site during the 2006 growing season (Year 2 of the 5-year monitoring period).

Table 1
Background Information.

Project Name	Privateer Farms
Designer's Name	Buck Engineering, A Unit of Michael Baker Corporation 8000 Regency Parkway, Cary, NC, 27518 (919) 463-5488
Contractor's Name	River Works, Inc.
Project County	Bladen and Cumberland Counties
Directions to Project Site	From Raleigh, follow I-40 east to exit 328 (I- 95). Merge onto I-95 south and proceed to exit 49 (NC 53). Take NC 53 south approximately 12.4 miles to the site. Turn right into site at a blue sign labeled "Privateer Farms Road." From Elizabethtown, follow NC 53 north. Travel through the town of White Oak. From White Oak, travel approximately 5.0 miles to entrance of farm. Turn left into site at a blue sign labeled "Privateer Farms Road."
Drainage Area	6.0 mi^2 (End of Reach 5-end of the project)
USGS Hydro Unit	03030005
NCDWQ Subbasin	03-06-15 and 03-06-16
Project Length	34,005 Linear feet (Restoration)
Restoration Approach	34,005 feet of dimension, pattern, and profile
	402.5 acres of riverine wetland restoration
	25 acres of riverine wetland enhancement
Date of Completion	April 2005
Monitoring Dates	Monthly through each growing season for 5 years.

Table of Contents

Tables and Figures

Appendices (<u>Appendix materials are located on the enclosed CD</u>)

1.0 Background Information

The Privateer Farms Restoration Project is located in Bladen and Cumberland Counties, North Carolina, approximately fourteen miles southeast of Fayetteville (Figure 1). Land use for the restoration site over the past 20 years had been primarily row crop agriculture. Stream and riparian functions on the site had been severely impacted as a result of agricultural conversion. Harrison Creek had historically meandered through the site, but was channelized in the early 1980s to reduce flooding and provide a drainage outlet for the extensive network of ditches carved across the site. Subsequent to channelization, Harrison Creek existed as a large canal running straight through the project site.

Restoration activities for this site involved moving the stream channel back to its historic location and elevation, and filling drainage ditches to raise the local water table and restore wetland and stream hydrology on the site. The plan also included scarification of the fields and breaking of the local plow pan to increase surface water storage and provide a range of hydrologic conditions suitable for a variety of native wetland plant species. The restoration plan for the site predicted the restoration of 405 acres of riverine wetlands, 25 acres of riverine wetland enhancement, and 33,985 linear feet (LF) of stream restoration. Following construction, the as-built data indicated that the total area of restored riverine wetlands was 402.5 acres (excluding 2.5 acres for road accesses), with 25 acres of enhanced riverine wetlands, and 34,005 LF of restored stream channel.

This Annual Monitoring Report presents data from 30 hydrologic monitoring stations and 15 vegetation monitoring stations placed throughout the site, in addition to stream monitoring data, as required by the approved Restoration Plan for the site.

1.1 Goals and Objectives

The goals and objectives of this project were as follows:

- Restore 402.5 acres of riverine wetlands
- Enhance 25 acres of riverine wetlands
- Increase stream length across Privateer Farms Restoration Project from 25,000 LF to approximately 34,005 LF through dimension, pattern and profile adjustments
- Restore Harrison Creek's floodplain and other low lying areas to their historic wetland ecosystem
- Monitor success of the restored and enhanced features during a five-year period following construction.

1.2 Project Location

This project is located approximately fourteen miles southeast of Fayetteville in Bladen and Cumberland Counties. From Raleigh, follow Interstate I-40 east to exit 328 (I-95). Merge onto I-95 south and proceed to exit 49 (NC 53). Take NC 53 south approximately 12.4 miles to the entrance of the site. Turn right into site at a blue road sign that says "Privateer Farms Road."

From Elizabethtown, follow NC 53 north. Travel through the town of White Oak. From White Oak, travel approximately 5.0 miles to entrance of farm. Turn left at a blue road sign that says "Privateer Farms Road."

1.3 Project Description

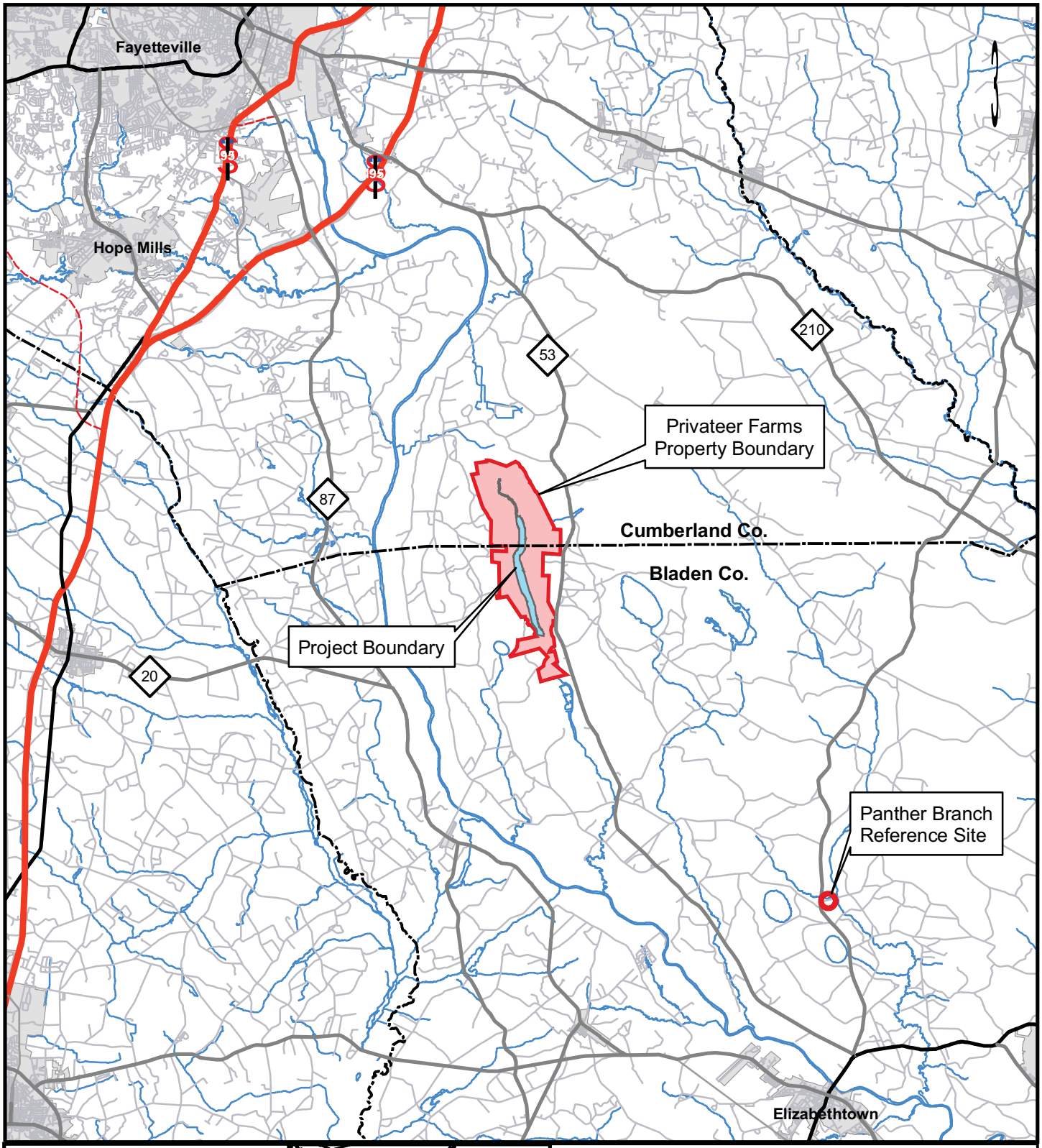
Restoration of site hydrology involved the restoration of natural stream and wetland systems on the site. The stream system that historically flowed through the site was channelized and, as a result, was highly incised ("Gc" type stream – Rosgen classification) prior to restoration. The natural channel design for the restored stream involved the construction of a new meandering channel across the agricultural fields. The furthest upstream portion of the project used sections of the remnant historic channel for Harrison Creek that were still visible within the existing wetland areas. The remaining portion of the restored channel was constructed as a Rosgen "C" stream type with design dimensions based on historic reference parameters for Harrison Creek. These reference parameters were discerned from historic aerial photographs, the topography of the valley, and local reference reach information. The total stream length across the Privateer Farms site was increased from approximately 25,000 to 34,005 LF.

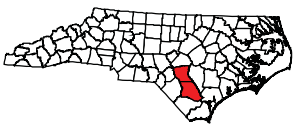
The channel design allows discharges greater than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing stress on streambanks. In-stream structures were used to control streambed grade, reduce stress on streambanks, and promote bedform sequences and habitat diversity. The in-stream structures consisted of root-wads, log vanes, and log weirs that promote a diversity of habitat features in the restored channel. Where grade control was a consideration, constructed riffles were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, and transplants. Transplants provided immediate shading to the restored stream, as well as living root mass to increase streambank stability and create holding areas for fish and aquatic biota.

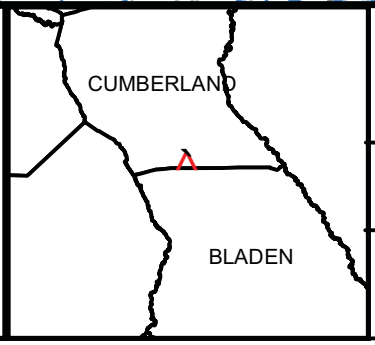
While restoration of the stream channel followed the historic pattern of Harrison Creek, the restored stream would most appropriately be considered a tributary to Harrison Creek. Flow from the headwaters of Harrison Creek has been channelized around the perimeter of the farm. Due to elevation differences between the restored stream and the channelized stream around the perimeter of the farm, flow from the headwaters of Harrison Creek could not be diverted back into the restoration channel without causing significant hydrologic trespass issues beyond the property boundary of Privateer Farms. The restored channel functions as a headwater tributary to Harrison Creek. It has a drainage area of approximately one square mile at the upper limits of the project, increasing to six square miles at the downstream end of the project (Figure 2).

Due to the extensive length of stream restoration and changes in drainage area from the beginning to the end of the project, the project was divided into five stream reaches. Design ratios were the same for each design reach and were based on reference reach information; however, the size of each restored channel reach increased from upstream to downstream to reflect the increasing drainage area.

The large road that ran from north to south through the middle of the project area was graded down to floodplain level to allow spreading of flood flows over the restored floodplain. The excavated road material was used to fill the road-side canals. The two roads that crossed the project area from east to west were left in place to allow access across the restoration site to other parts of the farm.



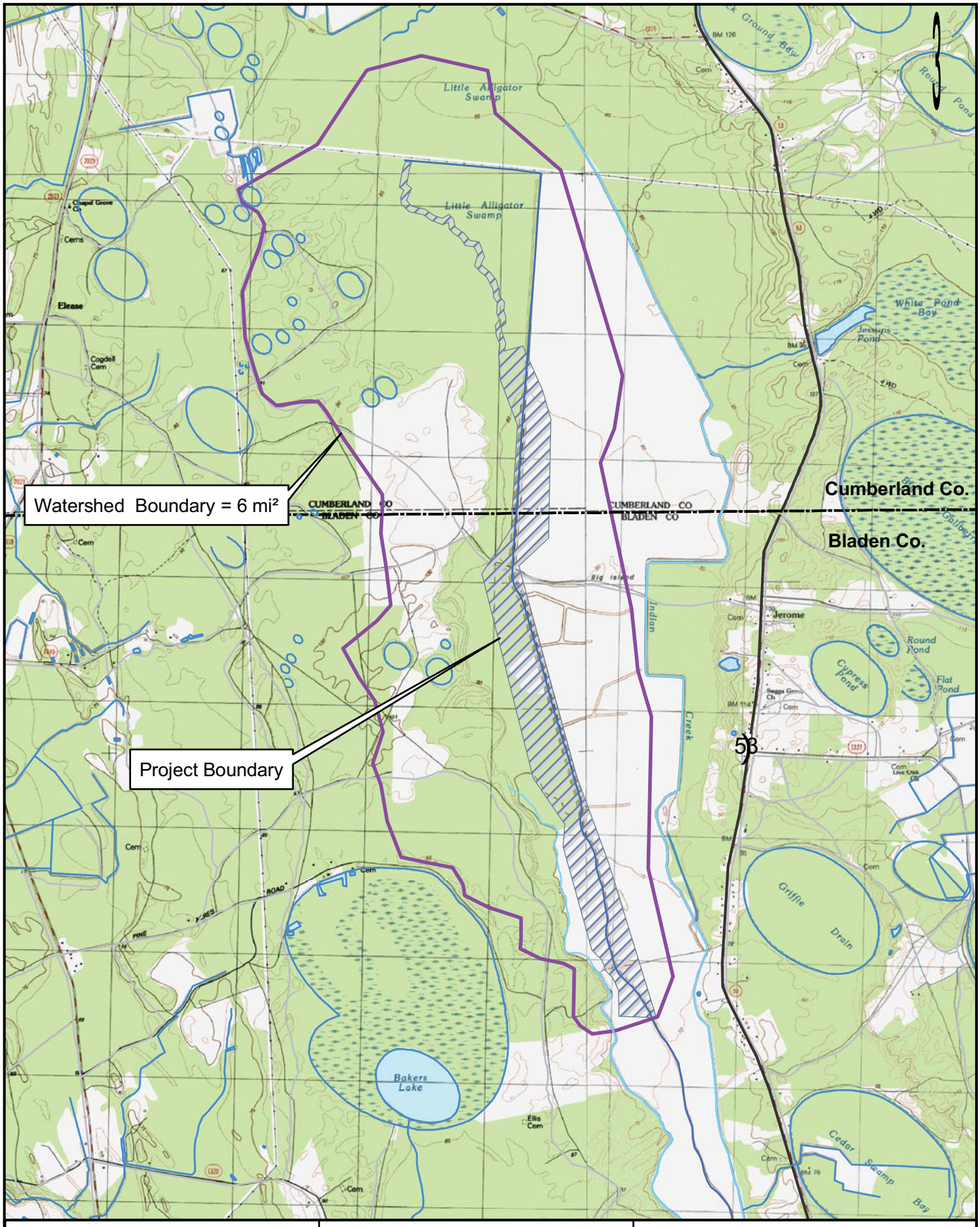




Baker
Buck Engineering
A Unit of Michael Baker
8000 Regency Parkway
Suite 200
Cary, North Carolina 27518
Phone: 919.463.5488
Fax: 919.463.5490

Figure 1. Project Vicinity Map

0 2 4 8 Miles



Baker

Buck Engineering
A Unit of Michael Baker
8000 Regency Parkway
Suite 200
Cary, North Carolina 27518
Phone: 919.463.5488
Fax: 919.463.5490

0 2,000 4,000 Feet

Figure 2. Watershed Map

2.0 Monitoring Results – Year 2 (2006) Data

The five-year monitoring plan for the Privateer Farms site includes criteria to evaluate the success of the wetland hydrology, vegetation components of the project, and stream components of the project. The specific locations of vegetation plots, monitoring wells, permanent cross-sections, crest gauges, and rainfall gauge are shown on the as-built drawing sheets in Figures 3a through 3d. Photo points are located at each of the monitoring wells, and at each of the grade control structures along the restored stream channel. Site photographs are included in Appendix 1.

2.1 Vegetation

Bare root trees were planted within all areas of the conservation easement. A minimum 50-foot buffer was established along all restored stream reaches. In most areas, the final buffer area was more than several hundred feet wide and included restored wetland areas. In general, bare-root vegetation was planted at a target density of 680 stems per acre, or an 8-foot by 8-foot grid. Planting of bare-root trees was conducted during the dormant season, with all trees installed prior to March 20, 2005.

Observations were made during construction of the site regarding the relative wetness of areas to be planted. Planting zones were determined based on these assessments, and planted species were matched according to their wetness tolerance and the anticipated wetness of the planting area. Species planted are summarized in Table 2.

Table 2
Bare-root Tree Species Planted Across the Restoration Site.

Common Name	Scientific Name	Percent Planted by Species	Total Number of Stems	Wetness Tolerance [1]
Willow oak	*Quercus phellos*	8.6%	23,300	weak – moderate
Swamp chestnut	*Quercus michauxii*	8.6%	23,300	weak
Laurel oak	*Quercus laurifolia*	6.0%	16,200	moderate – weak
Overcup oak	*Quercus lyrata*	6.3%	17,000	moderate
Swamp tupelo	*Nyssa biflora*	7.9%	21,300	tolerant
Water tupelo	*Nyssa aquatica*	8.2%	22,000	tolerant
Bald cypress	*Taxodium distichum*	11.6%	31,200	tolerant
Water oak	*Quercus nigra*	8.6%	23,300	weak – moderate
Sycamore	*Platanus occidentalis*	10.8%	29,200	moderate
Green ash	*Fraxinus pennsylvanica*	10.8%	29,200	moderate
Shumard oak	*Quercus shumardii*	6.5%	17,500	weak
Cherrybark oak	*Quercus pagoda*	5.9%	15,900	weak –intolerant

Notes:
1. Based on information from US Army Corps of Engineers (USACE) Wetland Research Program (WRP) Technical Note VN-RS-4.1 (1997).
2. Based on information from other literature sources.

PROJECT: 0157 PRIVATEER FARMS

STATE	PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	0157	1	34

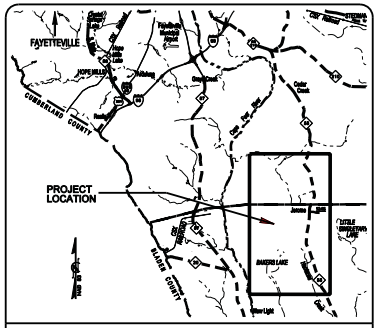
STATE PROJ. NO.	F. A. PROJ. NO.	DESCRIPTION

AS–BUILT

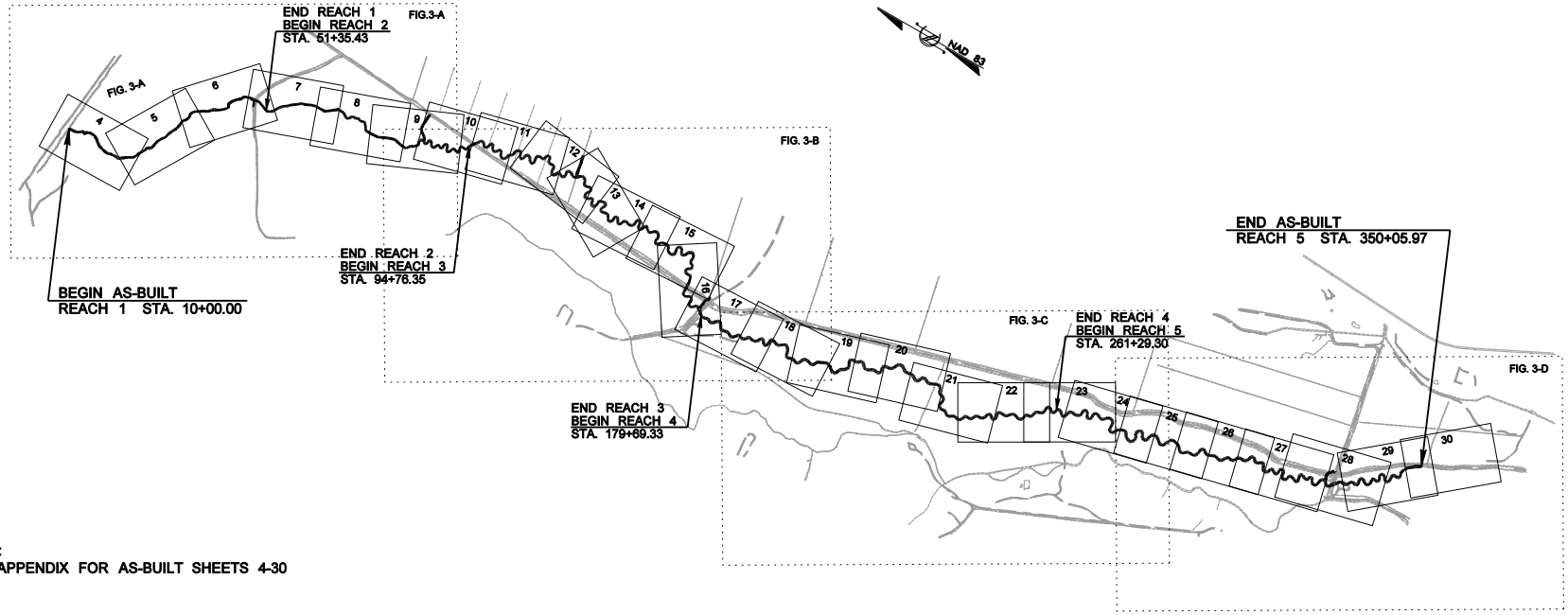
BLADEN /CUMBERLAND COUNTY

LOCATION: *OFF NC 53 NEAR JEROME*
SOUTHEAST OF FAYETTEVILLE

TYPE OF WORK: *WETLAND AND STREAM RESTORATION*



VICINITY MAP



NOTE:
SEE APPENDIX FOR AS-BUILT SHEETS 4-30

GRAPHIC SCALES

50 25 0 50 100
PLANS

50 25 0 50 100
PROFILE (HORIZONTAL)

5 0 5 10
PROFILE (VERTICAL)

PROJECT SUMMARY

PROPOSED DESIGN REACH 1 LENGTH	=	4,135.43 FEET
PROPOSED DESIGN REACH 2 LENGTH	=	4,340.92 FEET
PROPOSED DESIGN REACH 3 LENGTH	=	8,492.98 FEET
PROPOSED DESIGN REACH 4 LENGTH	=	8,159.97 FEET
PROPOSED DESIGN REACH 5 LENGTH	=	8,855.70 FEET
TOTAL DESIGN LENGTH	=	33,985.00 FEET
TOTAL AS–BUILT LENGTH	=	34,005.97 FEET
PROPOSED RESTORED WETLAND AREA	=	402.5 ACRES
PROPOSED ENHANCED WETLAND AREA	=	25 ACRES

PREPARED FOR THE OFFICE OF:

NORTH CAROLINA
ECOSYSTEM ENHANCEMENT PROGRAM

1652 MAIL SERVICE CENTER
RALEIGH, NORTH CAROLINA 27699

CONTACT:

KRISTIN MIGUEZ
PROJECT MANAGER

PREPARED IN THE OFFICE OF:

BUCK ENGINEERING
8000 Regency Parkway Suite 200
Cary, North Carolina 27511
Phone: 919-463-5488
Fax: 919-463-5490

JULY 2004
CONSTRUCTION BEGAN:

MARCH 2005
END OF CONSTRUCTION:

KEVIN L. TWEEDY, PE
PROJECT ENGINEER

PROJECT ENGINEER

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY:

KEVIN L. TWEEDY
027337
JUNE 27, 2005

THIS MEDIA SHALL NOT BE CONSIDERED A CERTIFIED DOCUMENT

P.E.
SIGNATURE:

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

PROJECT REFERENCE NO.	SHEET NO.
0157	31

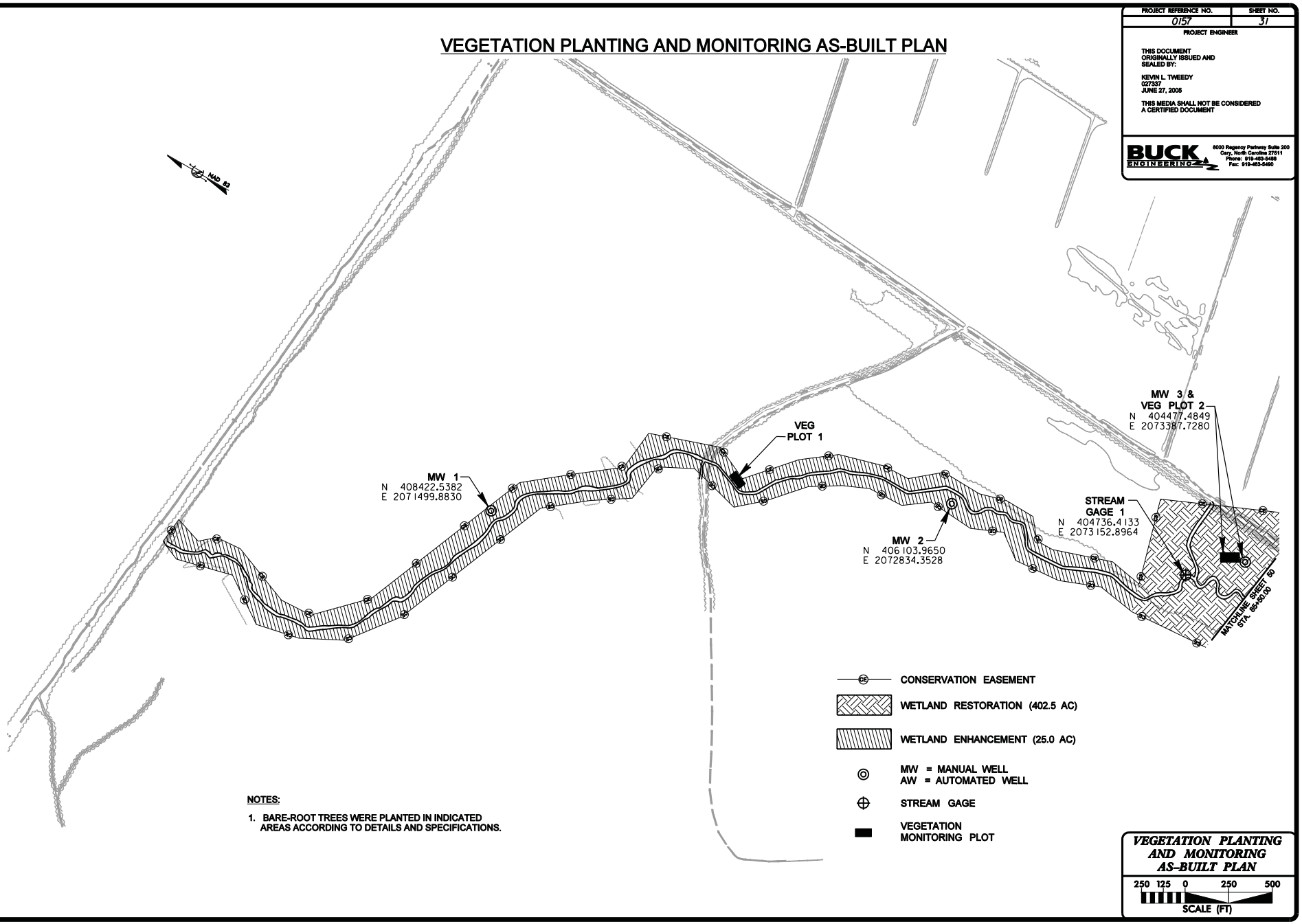
PROJECT ENGINEER

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY:

KEVIN L. TWEEDY
027357
JUNE 27, 2005

THIS MEDIA SHALL NOT BE CONSIDERED A CERTIFIED DOCUMENT

BUCK ENGINEERING
8000 Regency Parkway Suite 200
Cary, North Carolina 27511
Phone: 919-463-5488
Fax: 919-463-5490



NOTES:

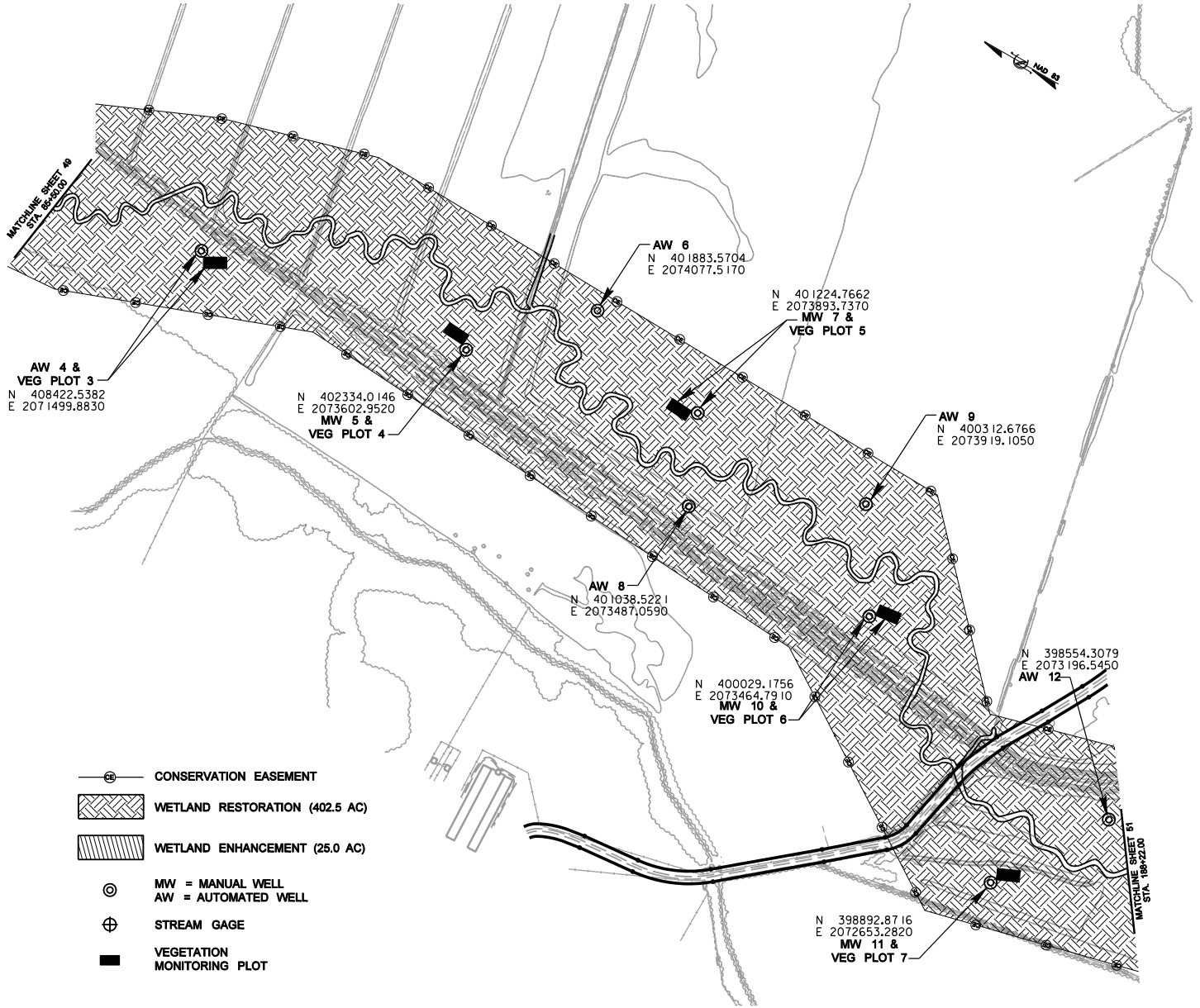
1. BARE-ROOT TREES WERE PLANTED IN INDICATED AREAS ACCORDING TO DETAILS AND SPECIFICATIONS.

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

250 125 0 250 500
SCALE (FT)

2/26/03
11/10/2005
n:\0157R\Design\Plans\0157R_BUCK_PSH_eb_31veg.dgn

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN



PROJECT REFERENCE NO.	SHEET NO.
0157	32

PROJECT ENGINEER

THIS DOCUMENT
ORIGINALLY ISSUED AND
SEALED BY:

KEVIN L. TWEEDY
027357
JUNE 27, 2005

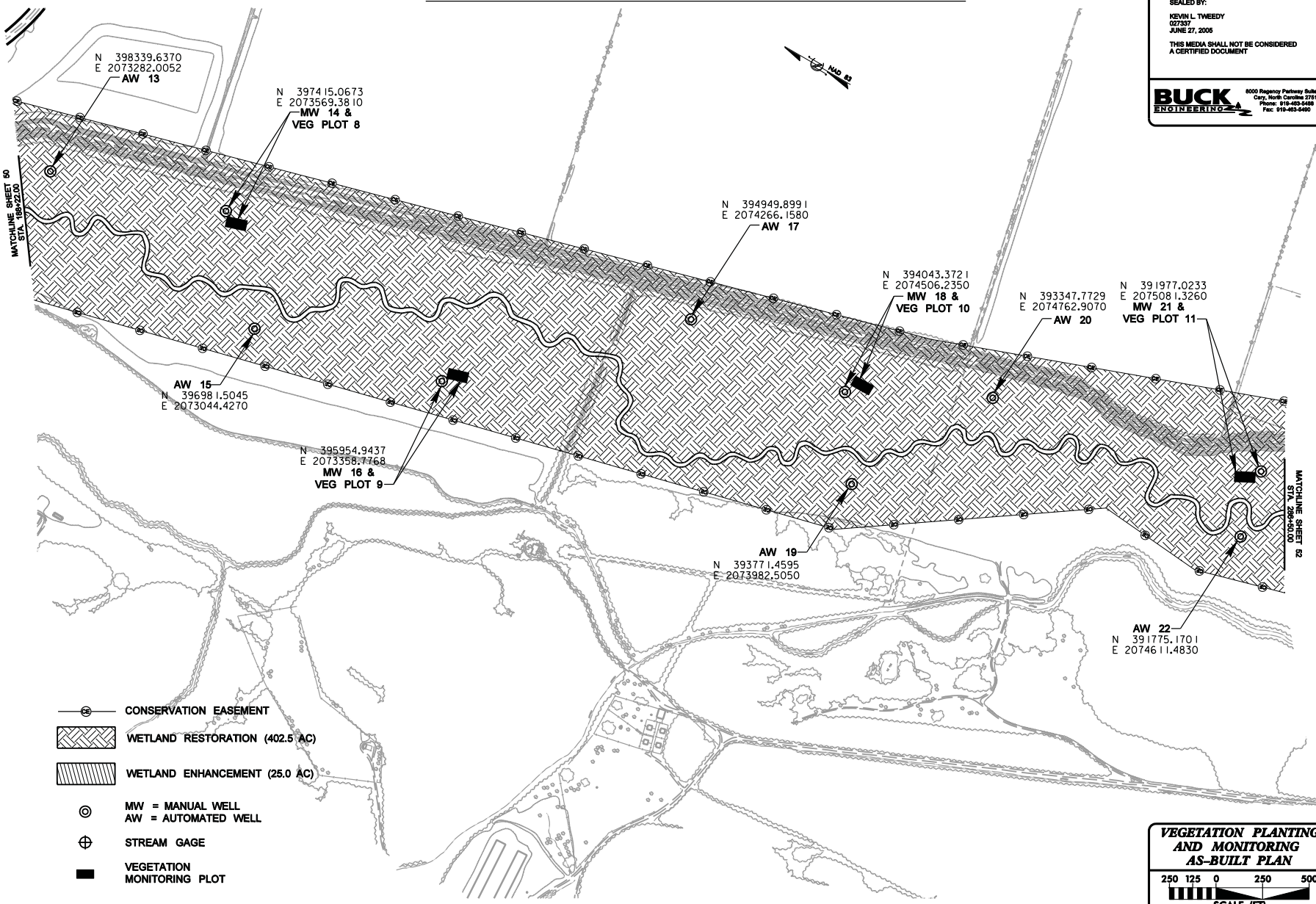
THIS MEDIA SHALL NOT BE CONSIDERED
A CERTIFIED DOCUMENT

BUCK ENGINEERING
8000 Regency Parkway Suite 200
Cary, North Carolina 27511
Phone: 919-463-5488
Fax: 919-463-5490

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

250 125 0 250 500
SCALE (FT)

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN



PROJECT REFERENCE NO.	SHEET NO.
0157	33

PROJECT ENGINEER

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY:

KEVIN L. TWEEDY
027357
JUNE 27, 2005

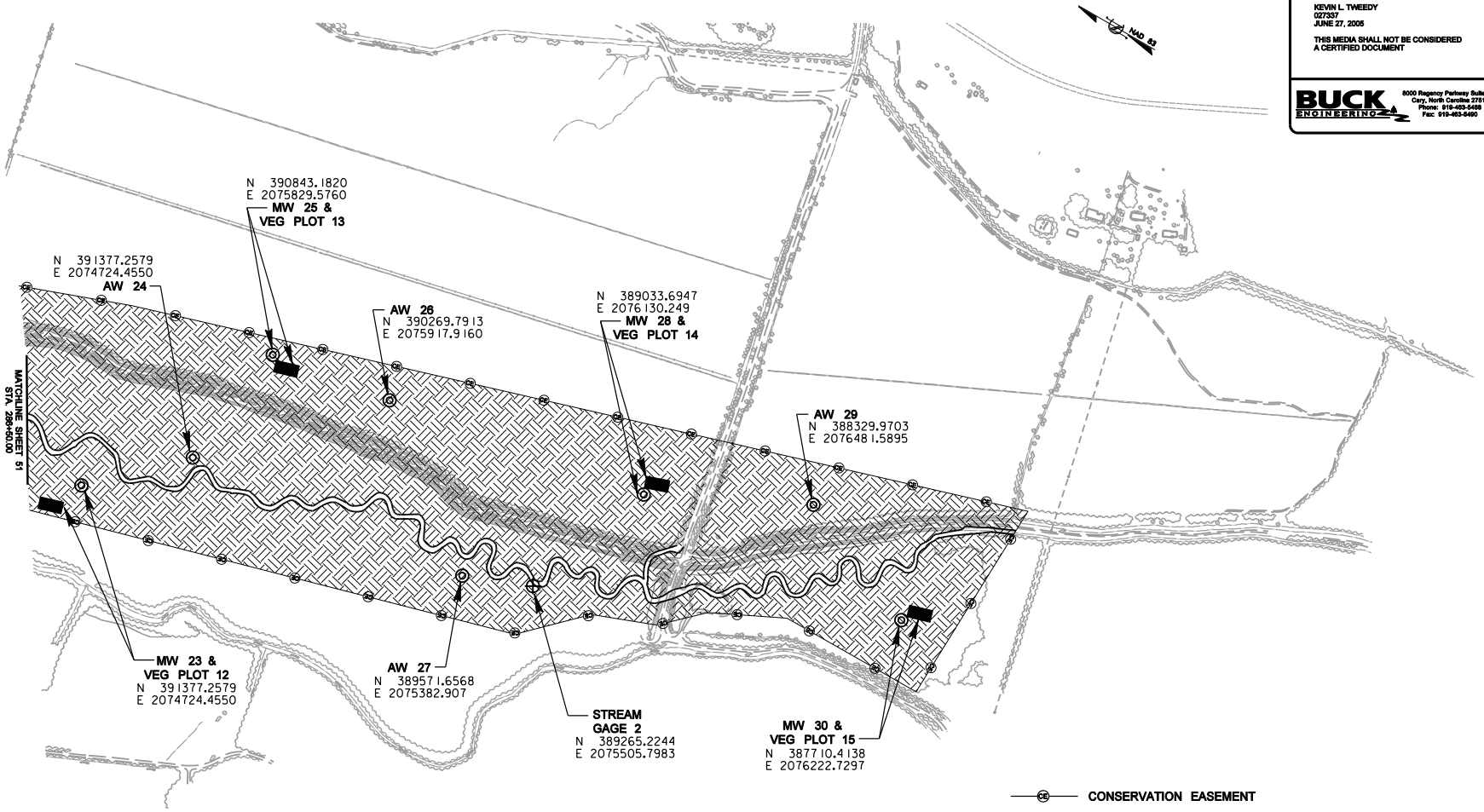
THIS MEDIA SHALL NOT BE CONSIDERED A CERTIFIED DOCUMENT

BUCK ENGINEERING
8000 Regency Parkway Suite 200
Cary, North Carolina 27511
Phone: 919-463-5488
Fax: 919-463-5490

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

250 125 0 250 500
SCALE (FT)

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN



CONSERVATION EASEMENT

WETLAND RESTORATION (402.5 AC)

WETLAND ENHANCEMENT (25.0 AC)

MW = MANUAL WELL
AW = AUTOMATED WELL

STREAM GAGE

VEGETATION
MONITORING PLOT

PROJECT REFERENCE NO.	SHEET NO.
0157	34

PROJECT ENGINEER

THIS DOCUMENT
ORIGINALLY ISSUED AND
SEALED BY:

KEVIN L. TWEEDY
027357
JUNE 27, 2005

THIS MEDIA SHALL NOT BE CONSIDERED
A CERTIFIED DOCUMENT

BUCK ENGINEERING
8000 Regency Parkway Suite 200
Cary, North Carolina 27511
Phone: 919-463-5488
Fax: 919-463-5490

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

250 125 0 250 500
SCALE (FT)

2/26/03

11/10/2005
r:\0157R\Design\Plans\0157R_BUCK_PSH_sb_34veg.dgn

The restoration plan for the Privateer Farms site specified that 15 vegetation plots, each 25 feet by 100 feet in size would be established across the restored site. The initial planted density within each of the vegetation monitoring plots is given in Table 3. The average initial density of planted bare root stems, based on the data from the 15 monitoring plots, was 670 stems/ acre. The data from the end of the second growing season are presented in Table 3. The locations of the vegetation plots are shown in figure 3a-3d..

Table 3
Initial Planted Density of Trees for the 15 Vegetation Sampling Plots.

Sampling Plot No.	Counted Stems per Plot		Stems per Acre (extrapolated)	
	Initial	Year 2	Initial	Year 2
1	38	33	662	575
2	40	38	697	662
3	39	37	680	645
4	33	31	575	540
5	42	42	732	732
6	37	33	645	575
7	43	40	749	697
8	31	31	540	540
9	35	27	610	470
10	35	30	610	523
11	39	18	680	314
12	36	29	627	505
13	35	16	610	279
14	49	16	854	279
15	45	37	784	645

2.1.1 Results and Discussion

Fifteen monitoring plots, each 0.057 acre in size, were used to predict survivability of the woody vegetation planted on-site. The vegetation monitoring for 2006 (Year 2) indicated an average survivability of over 532 stems per acre, which is on a trajectory to achieve an average vegetation survival criteria of 320 stems per acre surviving after the fifth growing season.

2.1.2 Areas of Concern

Three monitoring plots had lower than expected survivability rates for Year 2. The survivability rates for Plots 11, 13, and 14 ranged from 33 to 46 percent and densities ranging from 279 to 314. The plots will be monitored closely during the 2007 growing season to determine if some tree which were recorded as dead were actually green at the base and will re-sprout. The prevalence of volunteer species will also be assessed to determine if natural recolonization is compensating for lower planted stem densities.

2.2 Morphology

Drainage area strongly influences channel morphology. Watershed areas for the reconstructed channel increase from 1.0 square mile at the beginning of the project to 6.0 square miles at its downstream end (southern limit of the project site). The project was divided into five stream reaches, and the size of each restored channel reach was increased from upstream to downstream to reflect the increasing drainage area. Design ratios were kept the same for each design reach and were based on reference reach information.

Year 2 monitoring data for stream stability of each channel reach were collected during April and May 2006. This effort included data on 67 permanent cross-sections, and data from two streamflow gauges installed at the site: one near the upstream limit of the project (stream gauge # 1) and one near the downstream limit of the project (stream gauge # 2). The location of the permanent cross-sections and the stream gauges are shown in Figures 3a though 3d.

Permanent cross-sections are used to monitor channel dimension and bank erosion over time. Two permanent cross-sections were established per 1,000 LF of restored stream, with equal proportion of sections across riffles and pools. Each cross-section was marked on both banks with permanent pins and they were all survey-located relative to a common benchmark. This ensures use of the same transects through the entire monitoring period, facilitating easy comparison of year-to-year data. A complete longitudinal survey was completed in 2005 for the restored stream channel to provide a base-line for evaluating changes in bed conditions over time. A longitudinal survey was not performed this growing season. A complete longitudinal survey will be completed in 2007 (Year 3).

The annual cross-section surveys include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg. The longitudinal profile includes the elevations of all grade control structures. The permanent cross-section and longitudinal profile data are provided in Appendix 2 and 3.

The stream gauges were installed on-site to document continuous water level in the restored channel and record the occurrence of bankfull events. The gauges automatically record water depth every six hours, and have a continuous period of record extending from end of construction to present. The gauges are inspected and their water level data is retrieved every month.

Photographs were taken to visually document restoration success during Year 2 of monitoring. Each reference photograph station was marked with wooden stakes and bench-marked using a Global Positioning System (GPS). Reference photos of both streambanks were taken at each permanent cross-section. On each streambank photograph, the survey tape is centered and the water line is located along the lower edge of the frame, showing as much of the bank as possible.

2.2.1 Morphology Success Criteria

The stream restoration success criteria for the site include the following:

- *Cross-Sections*: There should be little change in as-built cross-sections. Cross-sections shall be classified using the Rosgen stream classification method and all monitored cross-sections should fall within the quantitative parameters defined for “C” type channels.
- *Longitudinal Profiles*: The longitudinal profiles should show that the bedform features are remaining stable, e.g. they are not aggrading or degrading. Bedforms observed should be consistent with those observed in “C” type channels.
- *Photo Reference Stations*: Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Longitudinal photos should indicate the absence of developing bars within the channel or of excessive increases in channel depth.

2.2.2 Results and Discussion

On-site streamflow gauges documented the occurrence of at least two bankfull flow events during the second year of the monitoring period (2006). The largest stream flow documented by the on-site crest gauge occurred during the beginning of the month of May 2006 and was approximately 1.0 foot above the bankfull stage at stream gauge #2. The on-site streamflow gauges also registered a continuous out-of-bank flow through the lower end of the site for a period of 9 days, from May 6 to May 15, 2006.

Visual evidence of the out-of-bank flows observed during a subsequent site visit helped confirm the bankfull flow gauge readings. Based on observations of ponded water, debris lines, and deposited sediment on the floodplain, this bankfull event spread over a substantial portion of the restored wetland areas adjacent to the stream.

In-stream structures installed within the restored stream included constructed riffles, log vanes, log weirs, and root wads. Visual observations of structures throughout the past growing season have indicated that the structures are functioning as designed.

Photographs have been taken throughout the Year 2 (2006) growing season to document the evolution of the restored stream channel (see Appendix 1). Restored pools have maintained a variety of depths and habitat qualities, depending on the location and type of scour features (logs, root wads, etc.). Permanent vegetation seeded on the restored stream banks was noted.

2.2.3 Areas of Concern

No areas of concern have been identified for the restored stream channel segments.

2.3 Hydrology

The restoration plan for the Privateer Farms site specified that 30 monitoring wells (15 automated and 15 manual) would be established across the restored site. Thirty wells (15 automated and 15 manual) were installed initially during mid-March 2005 to document water table hydrology in all required monitoring locations throughout the site. The locations of monitoring wells are shown on the as-built plan sheets in Figures 3a through 3d.

The reference wetland site identified for this project and described in the Monitoring Plan is also being monitored. Three automated monitoring wells were installed at the reference site during late April 2005 to document variation in water table depth across the reference site. Data from these wells provide a base of comparison for water table hydrology between the project site and the established wetland areas.

Monthly photographs were taken during the Year 2 (2006) growing season to document vegetation growth throughout the restored wetland areas (see Appendix 1). The monitoring well locations will serve as the reference points from which photographs of vegetation growth will be taken over time.

As per the approved Privateer Farms Monitoring Plan, historic rainfall for Cumberland County was used to determine average rainfall and growing season dates for the site. The automated weather station William O. Huske L&D (UCAN: 14405, COOP: 319427) in Bladen County, located within five miles of the project site, was used to determine rainfall over the site during the 2006 growing season. Missing data were supplemented with data from the next closest weather station, Elizabethtown Lock 2 gauge (UCAN: 14082, COOP: 312732) in Bladen County.

A manual rainfall gauge on the Privateer Site was used to validate observations made at the automated weather stations. Data collected on-site correlated fairly well with the data from the weather stations. There was a difference of 0.57 inches between the data collected on-site and observations made at the automated weather stations for the 2006 growing season.

2.3.1 Success Criteria

Successful restoration of wetland hydrology is defined in the project's Restoration Plan as achieving continuous inundation of the site or continuous saturation of its soil within 12 inches of soil surface for a minimum of 12.5 percent of the growing season, or 30 consecutive days. The day counts are based on the growing season for Cumberland County, which is 242 days long, beginning on March 18 and ending November 15, as calculated from National Weather Service Wetlands Determination Tables (WETS) for Johnston County. Data on inundation height or depth of soil saturation line were obtained from the 15 automated monitoring wells and 15 manual monitoring wells in place throughout the site. Data defining successful hydrologic conditions must demonstrate that wetland conditions are present in normal or dryer than normal conditions.

If rainfall data for any given year during the monitoring period are not normal, and if the desired hydrology for the project site is not on a trajectory to achieve success, then data from the pre-defined reference wetland site for this project can be assessed to determine if there is a positive correlation between the underperformance of the restoration site and the natural hydrology of the reference site.

If the restored site is inundated or saturated within 12 inches of the soil surface for less than 12.5 percent of the growing season, but the post-restoration monitoring data reflect that the site meets applicable USACE criteria for wetlands and the site is performing with similar hydrology as the monitored reference site, then the regulatory agencies may consider the site for mitigation of in-kind impacts on a case-by-case basis.

2.3.2 Results and Discussion

March and October of the 2006 growing season was unusually dry, with total monthly rainfall noticeably below the approximated long-term average for the area. However the months of May through September 2006 experienced wetter conditions, with monthly rainfall depths over an inch above the estimated long-term average for these months.

Total rainfall for the 2006 growing season was more than eight inches above the long-term average for total growing season rainfall. Most rain fell during the hottest summer months when evapotranspiration leads to significant losses of water to the atmosphere. Year 2 may be considered a relatively wet year, since monthly total rainfall fell above the long-term average for over half of the growing season. Table 4 and Figure 4 compare historic rainfall over the area with those observed during the 2006 growing season.

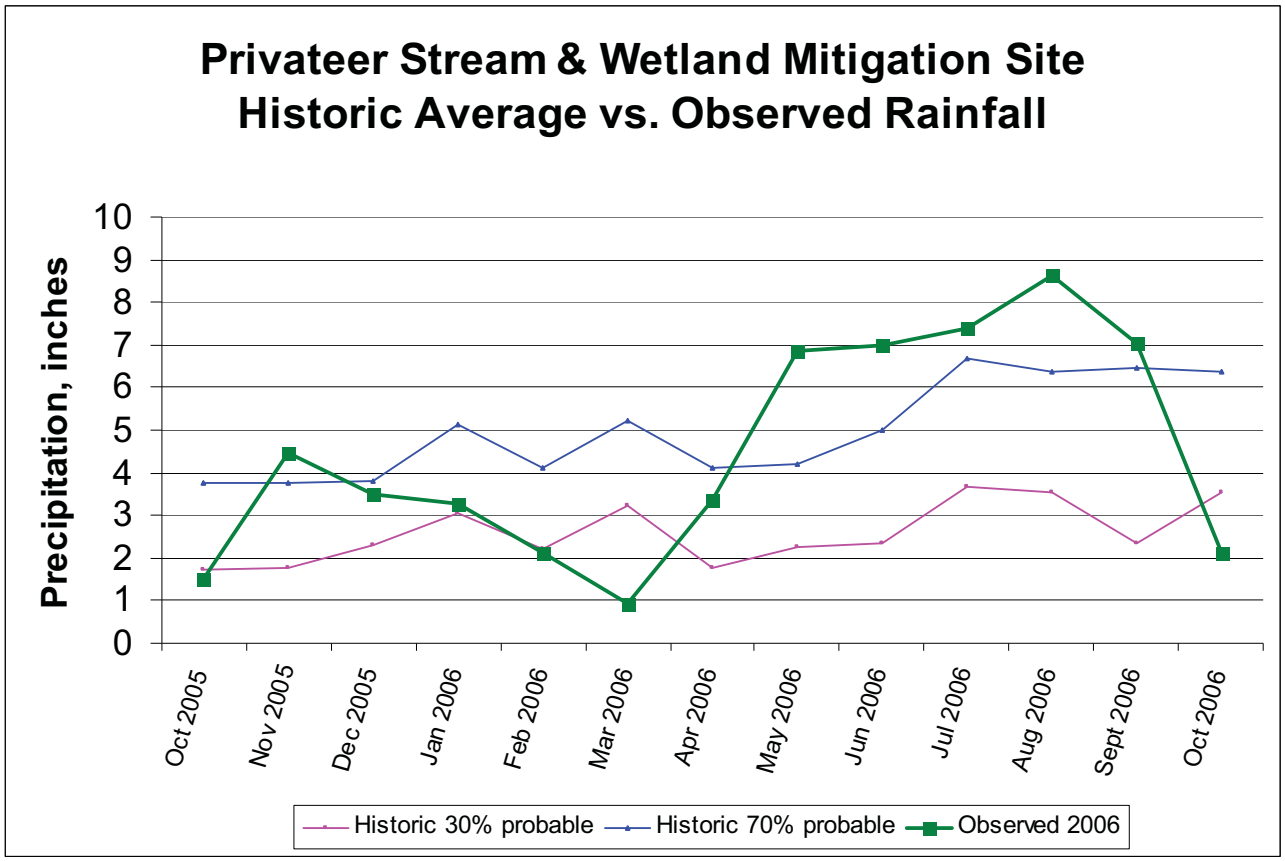
Data collected during the 2006 growing season by the fifteen automatic monitoring well gauges at the Privateer site showed that groundwater levels met hydrologic success criteria for fourteen of the wells. The one gage (AW27) that did not meet the success criteria, exhibited a continuous hydroperiod of 7.5%. However, gage AW27 did exhibit a cumulative hydroperiod of 108 days or 45% of the 2006 growing season, indicating that the location experiences significant wetness, but the water table fluctuates very rapidly and does not experience surface saturated conditions for long periods of time. This is due to the close proximity to the restored channel. The drainage effect of the restored stream causes the local water table to drop quickly after wetting. This phenomenon is also evident on the reference site where the wells located closest to the reference stream indicate shorter periods of saturation. Data collected from onsite gauges are presented in Appendix 4.

The three wells located in the reference site indicated drier than expected conditions at the reference site for 2006. Well Ref-3 documented similar hydrologic conditions to areas of the restoration site, with a continuous hydroperiod of approximately 12%. The other two reference wells documented drier conditions, and it is suspected that these locations are experiencing a significant drainage effect from the nearby stream channel. Data collected from onsite gauges are summarized in Table 5.

Table 4
Comparison of Historic Average Rainfall to Observed Rainfall (Inches).

Month	Average	30%	70%	Observed 2006 Precipitation
January	4.16	3.06	5.13	3.27
February	3.43	2.22	4.11	2.13
March	4.37	3.24	5.22	0.91
April	3.06	1.77	4.13	3.38
May	3.29	2.25	4.2	6.86
June	4.18	2.36	5.02	6.99
July	5.21	3.69	6.7	7.37
August	5.21	3.54	6.36	8.63
September	4.77	2.36	6.46	7.05
October	3.15	1.73	3.76	2.12
November	2.88	1.75	3.76	N/A
December	3.24	2.3	3.81	N/A

Figure 4. Comparison of Observed Rainfall and Historic Average Rainfall.



Monitoring well data are shown in Figures 5 through 11. A separate graph is presented for monitoring wells in each of the five reaches that comprise the project, except for data from Reach 1 which are included with Reach 2 data. Wherever there were more than 5 monitoring wells in a single reach, data for that reach are presented in two separate graphs: one for the upstream half of the reach and another for the downstream half of the same reach. Reference site well data are presented in Figure 12.

Table 5
Hydrologic Monitoring Results for 2006 (Year 2).

Monitoring Station	Most Consecutive Days Meeting Criteria[1]	Cumulative Days Meeting Criteria[2]	Number of Instances Meeting Criteria[3]
MW1[4]	116 (48.3%)	168 (70.0%)	2
MW2[5]	204 (85.0%)	204 (85.0%)	1
MW3[5]	204 (85.0%)	204 (85.0%)	1
AW4	204 (85.0%)	204 (85.0%)	1
MW5[5]	204 (85.0%)	204 (85.0%)	1
AW6	116 (48.3%)	168 (70.0%)	2
MW7[6]	204 (85.0%)	204 (85.0%)	1
AW8	204 (85.0%)	204 (85.0%)	1
AW9	117 (48.8%)	203 (84.6%)	2
MW10[6]	204 (85.0%)	204 (85.0%)	1
MW11[7]	86 (35.8%)	198 (82.5%)	3
AW12	86 (35.8%)	198 (82.5%)	3
AW13	86 (35.8%)	197 (82.1%)	3
MW14[8]	86 (35.8%)	197 (82.1%)	3
AW15	69 (28.8%)	145 (60.4%)	14
MW16[7]	86 (35.8%)	198 (82.5%)	3
AW17	37 (15.4%)	158 (65.8%)	11
MW18[9]	87 (36.3%)	193 (80.4%)	4
AW19	35 (14.6%)	123 (51.3%)	15
AW20	87 (36.3%)	193 (80.4%)	4
MW21[9]	87 (36.3%)	193 (80.4%)	4
AW22	44 (18.3%)	183 (76.3%)	7
MW23[9]	87 (36.3%)	193 (80.4%)	4
AW24	42 (17.5%)	147 (61.3%)	11
MW25[9]	87 (36.3%)	193 (80.4%)	4
AW26	34 (14.2%)	123 (51.3%)	13
AW27	18 (7.5%)	108 (45.0%)	16
MW28[9]	87 (36.3%)	193 (80.4%)	4

AW29	116 (48.3%)	195 (81.3%)	5
MW30[10]	116 (48.3%)	195 (81.3%)	5
REF1	6 (2.5%)	21 (8.8%)	6
REF2	8 (3.3%)	27 (11.3%)	6
REF3	29 (12.1%)	57 (23.8%)	6

[1] Indicates the most consecutive number of days within the monitored growing season with a water table less than 12 inches from the soil surface.

[2] Indicates the cumulative number of days within the monitored growing season with a water table less than 12 inches from the soil surface.

[3] Indicates the number of instances within the monitored growing season when the water table rose to less than 12 inches from the soil surface.

[4] Groundwater gauge MW1 is a manual gauge. Hydrologic parameters are estimated based on data from gauge AW6.

[5] Groundwater gauges MW2, MW3, and MW5 are manual gauges. Hydrologic parameters are estimated based on data from gauge AW4.

[6] Groundwater gauges MW7 and MW10 are manual gauges. Hydrologic parameters are estimated based on data from gauge AW9.

[7] Groundwater gauges MW11 and MW16 are manual gauges. Hydrologic parameters are estimated based on data from gauge AW12.

[8] Groundwater gauge MW14 is a manual gauge. Hydrologic parameters are estimated based on data from gauge AW13.

[9] Groundwater gauges MW18, MW21, MW23, MW25, and MW28 are manual gauges. Hydrologic parameters are estimated based on data from gauge AW19.

[10] Groundwater gauge MW30 is a manual gauge. Hydrologic parameters are estimated based on data from gauge AW29.

Figure 5. Well Data for Reach 1 and Reach 2 of the Privateer Restoration Project.

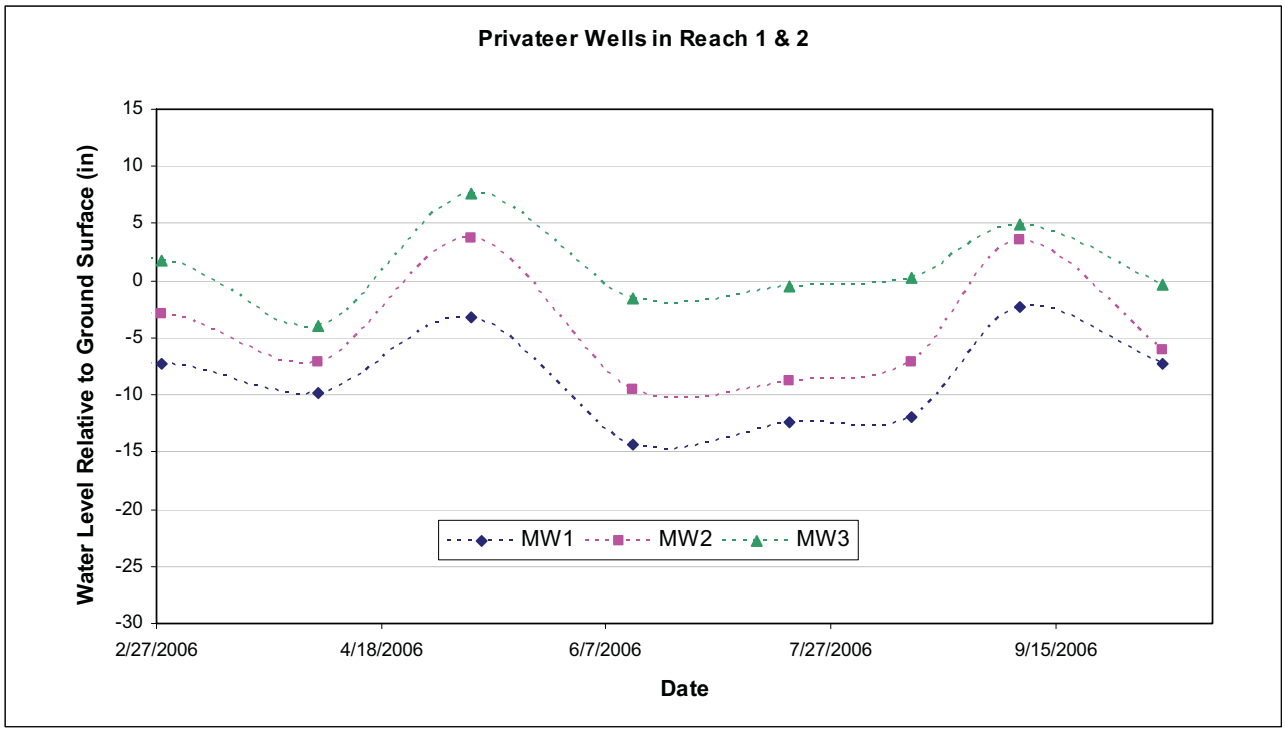


Figure 6. Well Data for Upstream Half of Reach 3 of the Privateer Restoration Project.

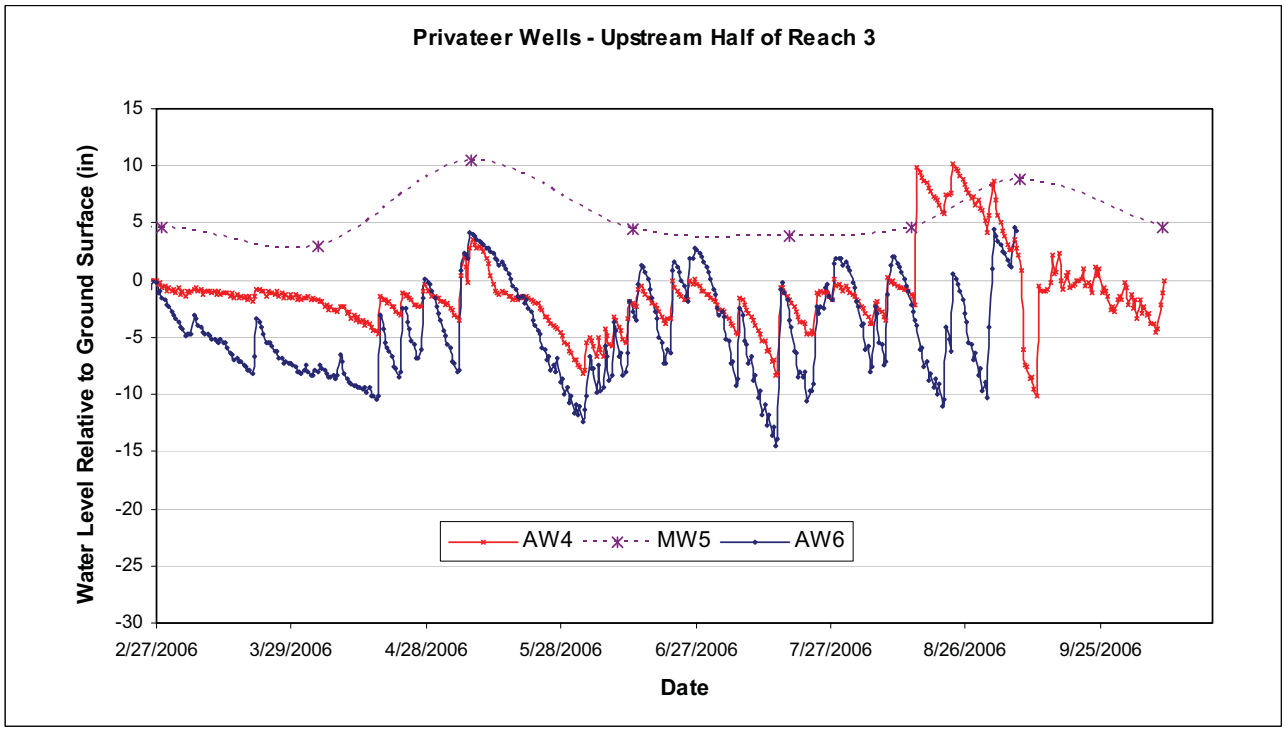


Figure 7. Well Data for Downstream Half of Reach 3 of the Privateer Restoration Project.

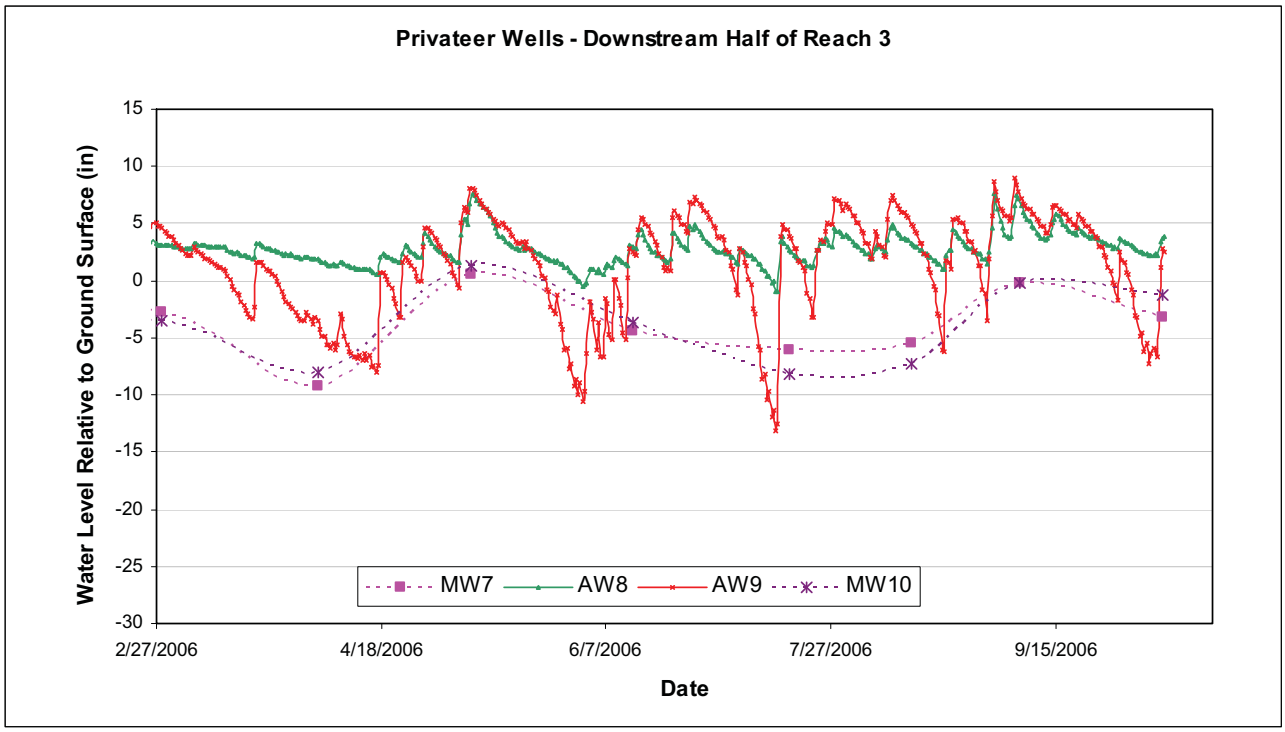


Figure 8. Well Data for Upstream Half of Reach 4 of the Privateer Restoration Project.

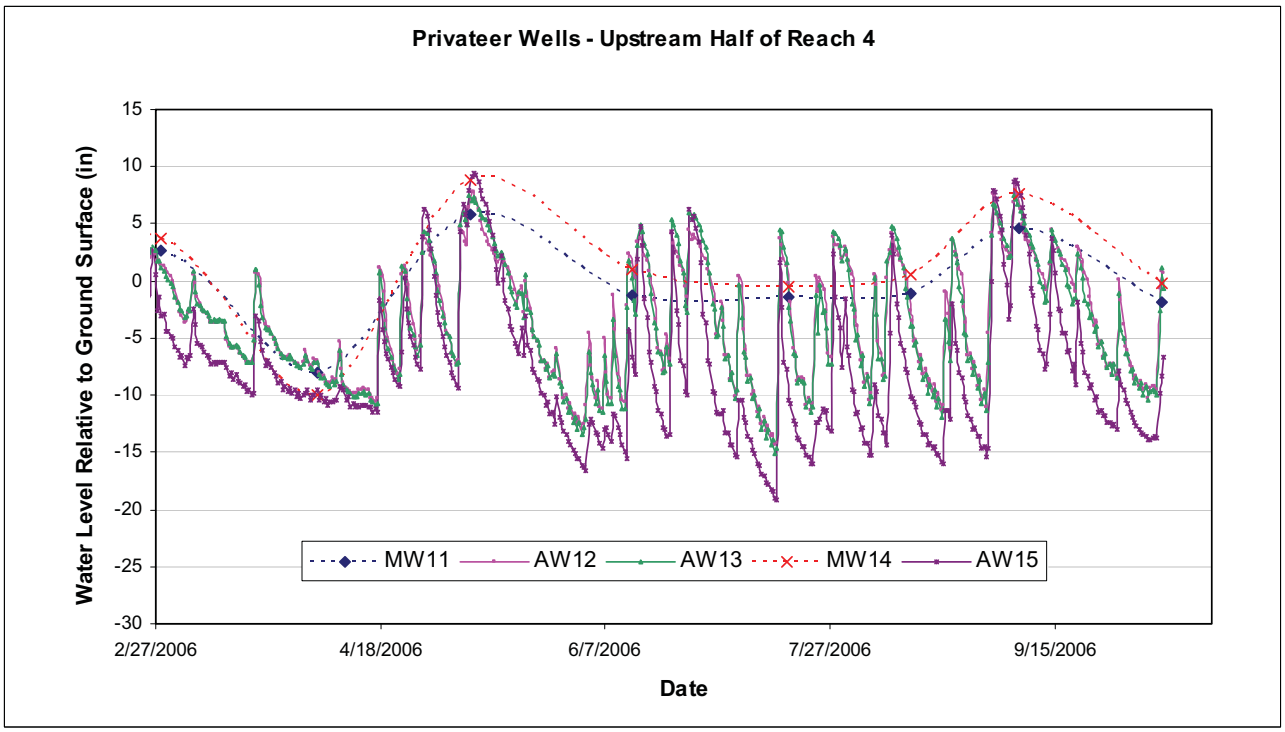


Figure 9. Well Data for Downstream Half of Reach 4 of the Privateer Restoration Project.

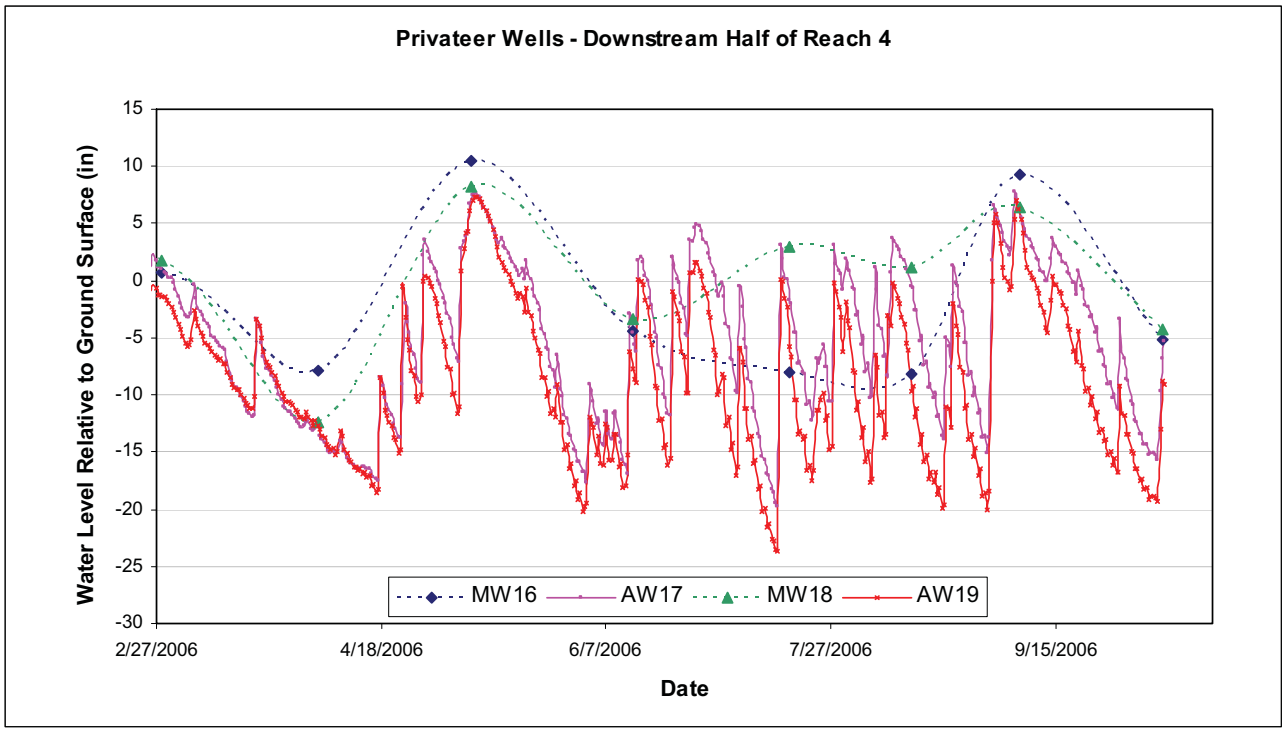


Figure 10. Well Data for Upstream Half of Reach 5 of the Privateer Restoration Project.

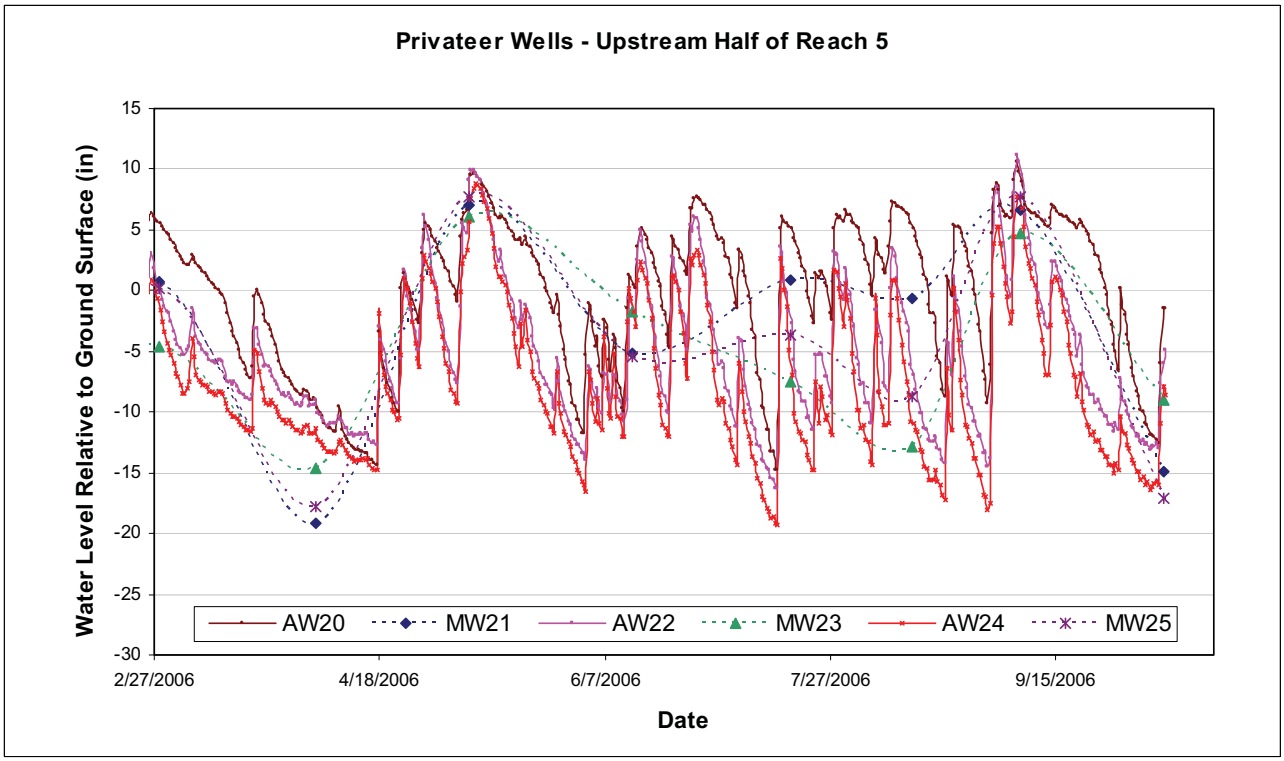


Figure 11. Well Data for Downstream Half of Reach 5 of the Privateer Restoration Project.

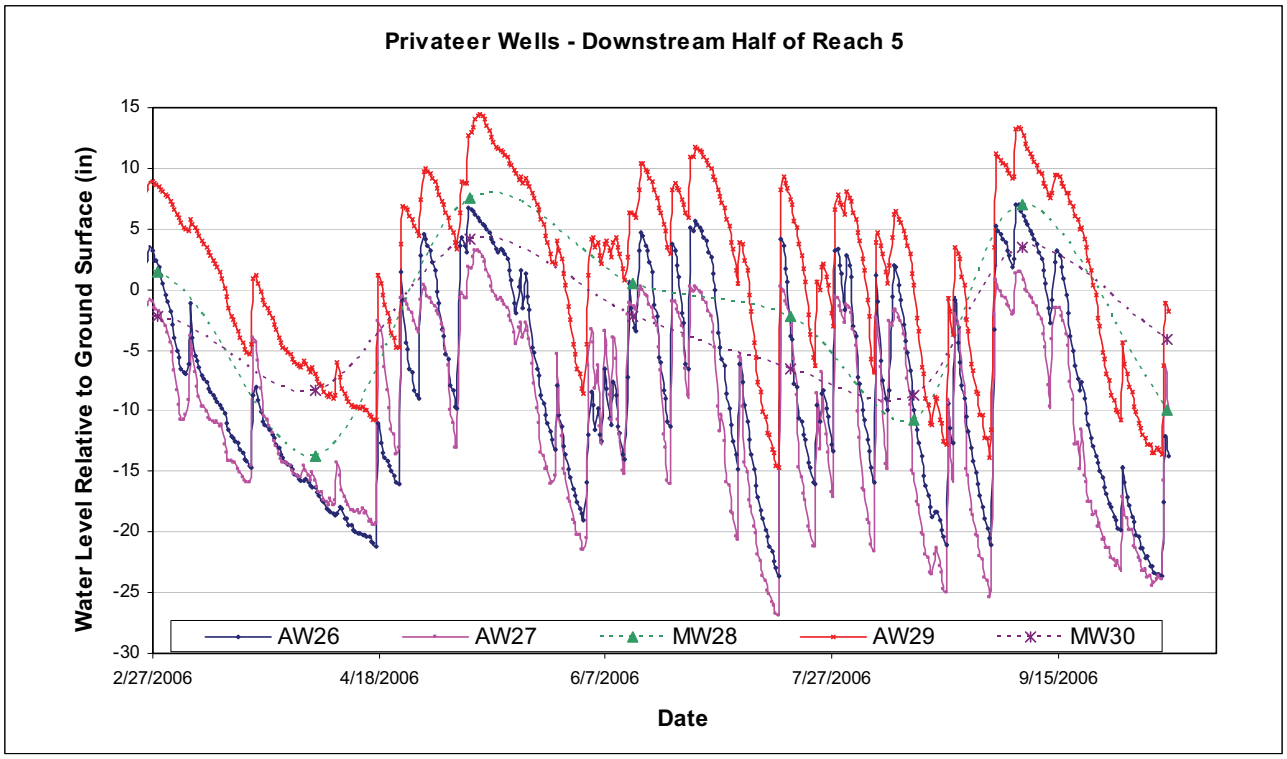
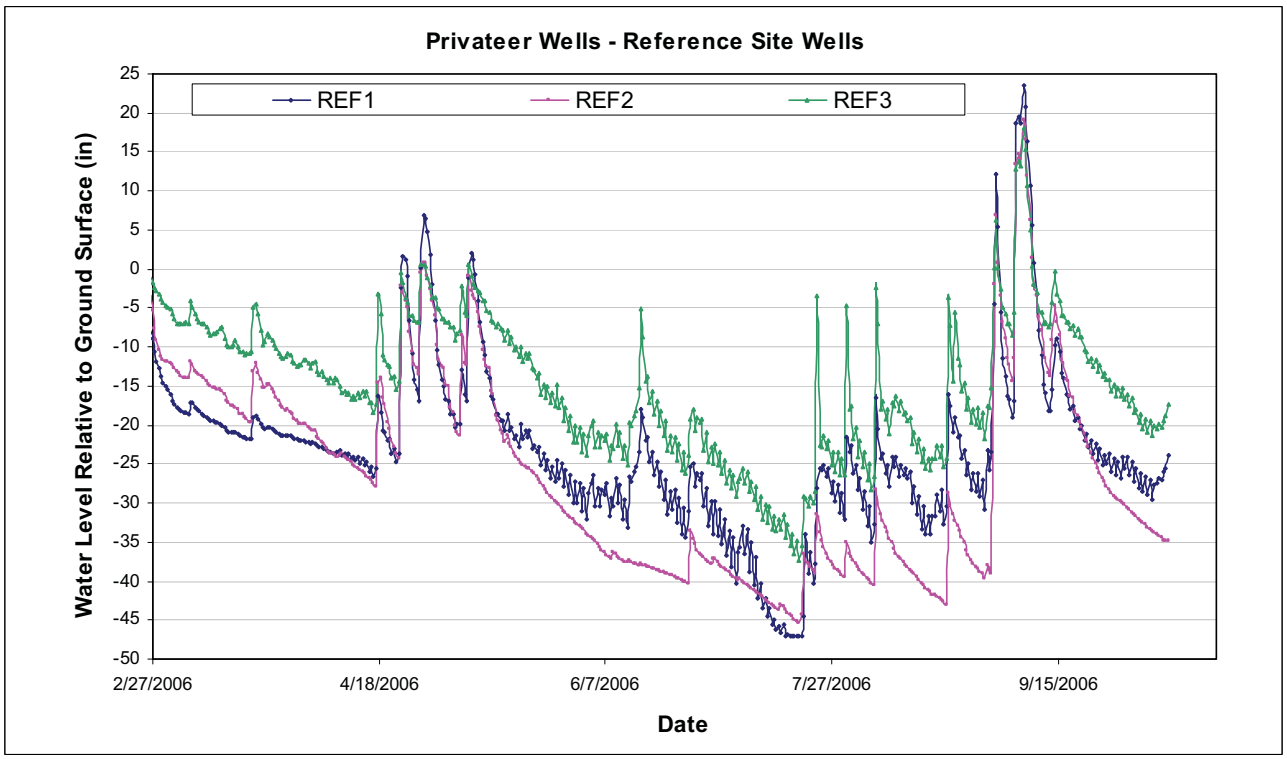


Figure 12. Well Data for Reference Site Wells - Privateer Restoration Project.



Although hydrologic success criteria was not met for all wells at the site, the data show that 2006 hydrologic conditions at the site were more favorable than those occurring at the reference site for the same year. The data correlates well with the type of wetland systems that are targeted in this project. Based on these results, it was concluded that the site is performing as designed and conditions are expected to improve.

Monitoring data from the reference site demonstrate positive correlations between the restoration site and the natural hydrology of the target system.

2.3.3 Areas of Concern

Only one well did not meet the success criteria. However, hydrology at the restored site is still rebounding from the restoration activities. The site is performing as designed and conditions are expected to improve.

Three monitoring plots had lower than expected survivability rates for Year 2. The survivability rates for Plots 11, 13, and 14 ranged from 33 to 46 percent and densities ranging from 279 to 314. Due to the low densities in plots 11, 13, and 14 supplemental planting in these affected areas is scheduled to be completed by February 2007.

2.4 Site Observations

Many different animal species were observed throughout the site. White tail deer, wild turkey, blue herons, many other birds, turtles, and small fish in the stream were commonly observed on-site. Occasionally, black bear and several snake species were observed throughout the site. Bobcat tracks were also commonly observed. .

Thick, herbaceous vegetation covered nearly the entire site. Observed species included rush (*Juncus* sp.), goldenrod (*Solidago* sp.), switchgrass (*Panicum virgatum*), lespedeza (*Lespedeza*), fennel (*Foeniculum vulgare*), tearthumb (*Polygonum sagittatum*), and various other grasses.