MITIGATION PLAN

WELLS CREEK AT SYDNOR PROPERTY

DECEMBER 2004

ARCADIS

Infrastructure, buildings, environment, communications

Mitigation Plan

Wells Creek at Sydnor Property

Prepared for:
North Carolina Department of
Environment and Natural Resources
Ecosystem Enhancement Program

Prepared by:
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Our Ref.:
NC602014.0000

Date:
December 2004

Table of Contents

1. Introduction

1.1 Project Description

ARCADIS was retained by the North Carolina Department of Environment and Natural Resources, Ecosystem Enhancement Program, (EEP), formally the Wetlands Restoration Program (NCWRP) to conduct stream restoration using natural-channel design methodologies on two portions of Wells Creek and an unnamed tributary (UT) to Wells Creek in south-central Alamance County (Figure 1). The site is at the end of Longest Acre Road on Breaburn Farm near the community of Snow Camp. Dr. Charles F. and Ms. Cindy Sydnor own the property.

1.2 Goals and Objectives

The goal of the stream restoration is to improve water quality in the Cape Fear River Basin. An estimated 530 tons of sediment are generated from the project area. This is a conservative estimate, given that fewer than 1,000 linear feet of the over 6,000 feet of stream bank were studied. Wells Creek and its unnamed tributary at this project site are typical of streams within this and surrounding watersheds, exhibiting instability and degradation in response to current and historic land-use practices. The restoration will be accomplished by reestablishing a stream with stable dimension, pattern, and profile and with the capacity to effectively transport water and sediment without aggrading or degrading. Nutrient input should decrease through establishing a permanent, vegetated riparian buffer and excluding cattle from the buffer. The buffer will provide shade to the stream, reducing water temperatures and providing additional wildlife habitat to the site. Stabilization and vegetation development will be monitored.

2. Summary

2.1 Site Description and Land Use

The Wells Creek Restoration Site lies northwest of Snow Camp, North Carolina. Specifically, the project area is located west of Bass Mountain Road (SR 2327), south of Carl Noah Road (SR 2364) and east of Beale Road (SR 2363). The proposed project consists of three separate sections of stream. The northernmost, and longest at approximately 3,730 linear feet (lf), makes up Reach 1 of Wells Creek. Reach 2 is a southern 1,400-linear-foot section of Wells Creek. The UT to Wells Creek is approximately 1,650 linear feet long and lies directly west of Reach 2.

The project valley is characterized by moderately sloping terrain with some bedrock outcrops. The entire Sydnor property drains into Wells Creek and the UT. The drainage area for Reach 1 of Wells Creek is 1.63 square miles. At Reach 2, Wells Creek collects 2.23 square miles of drainage area, and the UT to Wells Creek drainage area is 0.71 square miles. Elevations in the project area range from a high of 690 feet above mean sea level (MSL) on the slopes of Wells Creek on the northernmost portion of the Sydnor property, to a low of approximately 610 feet above MSL in the floodplain of Wells Creek and the UT. The primary land use within the project area is agriculture, specifically, active pasture land for cattle. The riparian areas are limited and are comprised of mature sweet gum (*Liquidambar styraciflua*), red maple (*Acer rubrum*) sycamore (*Platanus occidentalis*) hackberry (*Celtis occidentalis*) redbud (*Cercis canadensis*) and red mulberry (*Morus rubra*).

The watershed of Wells Creek originates in the Cane Creek Mountains and is mostly forested with minor amounts of cleared pastureland. A small portion of the watershed was walked during the reference-reach search. The areas that were walked consist of mature hardwoods and logged areas.

Along both reaches of Wells Creek and the UT, boulder structures and root wads were used in conjunction with the bed and bank work. The structures were installed to reduce stresses in the near-bank regions, to maintain grade, and to increase in-stream habitat. The existing vegetated buffer was maintained where one exists or enhanced as necessary. A vegetated buffer will be established where one does not exist. The buffer will be planted with native vegetation (Piedmont mesic mixed) and fenced to prevent cattle access. At the time of this report, the restoration site was not planted with woody vegetation. Planting will be performed in the winter of 2004/2005.

2.2 Methodology

Monitoring methodology follows Monitoring Level I established by the US Army Corps of Engineers, Stream Mitigation Guidelines (April 2003). The restoration site consists of three separate reaches totaling approximately 6,700. Sections of each restored reach are being monitored. The lengths of each reach being monitored are: 1,213 lf of Reach 1; 1,123 lf of Reach 2 and 1,083 lf of the unnamed tributary. This makes the total length of stream being monitored 3,419 lf. This is within the range established by the Stream Mitigation Guidelines, which state, "If the stream section is greater than 3,000 lf, the profile should be conducted for either 30% of the restored stream or 3,000 lf (whichever is greater)".

Location surveys of the constructed features were conducted to monitor the performance of the stream restoration. These surveys were conducted on June 7, 9 and 10, 2004, using total station survey equipment. A longitudinal profile, four permanent cross sections (two riffle and two pool), and a topographical survey were conducted on portions of each reach to establish baseline conditions. Subsequent surveys will be taken at 12-month intervals and compared with the baseline surveys to determine if the restoration met the designed goal and objectives. Pebble counts, photographs, and vegetation assessments will also be conducted on an annual basis and will provide information to determine the success of the restoration. Baseline, proposed, and reference-reach data are presented in Table 1.

2.2.1 Longitudinal Profile

The longitudinal profile of the restored stream was surveyed for approximately 1,000 lf on each reach. The heads of riffle, run, pool, maximum pool and glide features were surveyed in the longitudinal profile, allowing the calculation of water-surface slope at each feature, average water-surface slope, pool length, and pool-to-pool spacing. At each feature, locations were determined for the thalweg, left and right edges of water, left and right bankfull elevations, and left and right tops of bank. These locations enabled the creation of a plan view of the restored stream. Stream pattern (i.e., meander length, radius of curvature, belt width, and sinuosity) were also measured from the baseline plan view.

Pools constructed downstream of the boulder cross vanes were surveyed in the longitudinal profile. These pools were included in the pool-to-pool spacing and the pool-to-pool-spacing-to-bankfull width ratio calculations.

2.2.2 Permanent Cross Sections

Four permanent cross sections (two riffles and two pools) were surveyed at each reach. One riffle and one pool cross section are located where new channel was constructed. The other set of cross sections is located where the existing stream pattern was maintained. The beginning and end of each permanent cross section were marked using wooden stakes labeled with the cross section number. Cross sections are perpendicular to the stream flow. The cross section survey noted all grade breaks, tops of banks, left and right bankfull, edges of water, and thalweg. The cross sections were plotted and the bankfull cross sectional area calculated. The area was compared with the *Regional Curves for Rural Piedmont North Carolina* (Harmen, et. al. 1999) (Appendix A). The bankfull mean depth was calculated by dividing the bankfull cross sectional area by the bankfull width. The width-to-depth ratio was calculated by dividing the bankfull width by the bankfull mean depth. The stream will be classified using the Rosgen system of stream classification (Rosgen 1994).

2.2.3 Topographical Survey

A topographical survey was conducted to show where the pre-restoration stream channel was filled and the location of new fences. Permanent photo points and benchmarks will also be shown on the topographical survey.

2.2.4 Pebble Count

The stream substrate will be monitored. A modified Wolman pebbled count (Rosgen 1993) was taken at each permanent cross section. Fifty samples were taken below bankfull. The cumulative percent was graphed and the D16, D35, D50, D84, and D95 calculated. During subsequent surveys, pebble counts will be conducted at each location and compared with the baseline pebble count.

2.2.5 Photo-Documentation

Permanent photo points have been established. Photographs will be taken twice a year (summer and fall). Photographs of the site will provide valuable visual information as a complement to the figures and narrative material in the monitoring reports. The photo points were selected to show reaches of the stream, permanent cross sections and vegetation monitoring plots. Additional photographs will be taken to record any events that may have a significant effect on the success of the restoration, such as flood, fire, drought, or vandalism. The locations of the photo points are shown on the plan view.

2.2.6 Vegetation

A survey of woody vegetation during the growing season (August to October) will be conducted annually over the five-year monitoring period to verify survivability of the installed plantings. Stem survival of woody vegetation will be monitored at three permanent 20-foot-by-45-foot plots at each reach. Plots are shown on Sheets 1-3. The corners of the plots are marked so they can be located in future surveys. Baseline data for woody vegetation will be collected following the planting in the winter of 2004/2005. The sample areas and sizes might be slightly increased or decreased after initial data are collected and analyzed. Surviving stems within the plots will be tallied. The stem survival rate per acre will be computed from the plots.

3. Success Criteria

Success criteria need to be established to determine if the restoration project is meeting the designed goals and objectives. These will include changes in the dimension, pattern, profile, bed material, and vegetation over the five-year monitoring period. The monitoring schedule is discussed later in this report.

3.1 Dimension

The stream cross section measurements should not significantly change from the baseline cross section. Minor adjustment in the cross section is expected. The adjustment is due to the lack of precision of large, heavy machinery. The lack of permanent vegetation can also contribute to adjustments in the channel dimension. A change in the width-to-depth ratio of ±5 percent beyond the as-built width-to-depth ratio is tolerable.

3.2 Pattern

The stability of stream pattern will be measured using stream sinuosity (the ratio of stream length divided by valley length or approximated by the ratio of valley slope divided by stream slope). A change of ±5 percent or more from baseline in sinuosity will be considered significant. If there is a significant change in sinuosity, then belt width, radius of curvature, and meander length will be evaluated to determine where the adjustment occurred that affected the sinuosity.

3.3 Profile

The channel profile is not expected to significantly change over the monitoring period. The baseline average water-surface slope will be used as a measure of profile stability. The average water-surface slope will be determined by taking water-surface elevation readings at the beginning and the end of the monitored reach, at the same feature (head of riffle, head of pool, etc.), determining the elevation difference between the two and dividing the difference by the stream length between the two features. A change of ±5 percent or more in average water-surface slope will be considered significant.

Another measure of channel profile stability is pool-to-pool spacing. This is the stream distance between the same features on sequential pools. The measurements are usually taken between heads of pools. Baseline pool-to-pool spacing will be measured and

recorded. Pool-to-pool spacing deviating ±5 percent or more from the designed ranges will be considered significant.

3.4 Material

Usually there is a shift in particle size distribution of the bed material as a result of stream restoration. This is a result of adjusting the shear stress and stabilizing the existing stream banks. The change in the substrate material will be measured over the five-year monitoring period.

3.5 Photo Points

Permanent photo points were established on the site and are shown in Sheets 1 through 3. The photographs should show the succession of vegetation growth and no significant changes in the stream configuration.

3.6 Vegetation

Woody vegetation success will be measured by stem survivability over a five-year monitoring period. Survivability will be based on 320 stems per acre after five years. This survey will track the total mortality on an annual basis and will be used to calculate survivability at the end of three years and five years. Survivability of less than 320 stems per acre at the end of five years will require the installation of replacement plantings. Volunteer and existing woody vegetation will be included in the survivability calculations.

3.7 Discussions

It is possible that some of the above parameters might fail to meet the success criteria. This does not mean that the restoration is a failure. If the dimension, pattern, or profile parameters are not met, further analysis will be required. The goal of the restoration project is to improve water quality by reducing sedimentation. During year four of monitoring, bank erosion rates will be estimated along the stream using bank erosion hazard index (BEHI) methodology (Rosgen 1996), and a modified Pfankuch channel stability evaluation will be conducted. Estimating erosion rates and channel stability during year four will allow time for the vegetation to develop.

An initial concern is that the restoration project will be planted in the winter of 2004/2005. The only vegetation protecting the stream banks over the first year is herbaceous vegetation that was included in the seeding mixture and volunteer species.

4. Monitoring Schedule

4.1 Stream Surveys

Stream surveys will be conducted between May and July of each year. This will provide approximately one year between surveys. Surveys will be conducted each of the five years of monitoring. The same methods that are discussed above will be followed.

4.2 Vegetation Monitoring

Vegetation monitoring will be conducted concurrently with the stream survey. Monitoring during these periods will ensure that woody species will not be dormant. Monitoring will be conducted each of the five years. Monitoring methods described above will be followed. Baseline vegetation monitoring will be conducted in 2005, after planting.

4.3 Reports

Monitoring reports will be prepared within two months of data collection. Six copies of the report will be provided to the EEP. The reports will include the following:

- Introduction
- Summary
- Materials/Methods
- Results
- Discussion
- Recommendations
- References
- Appendices

4.4 Monitoring Procedure Adjustments

The protocol and results of the monitoring will be reviewed annually by the monitoring firm. Adjustment to monitoring procedures or schedules may be required as the site changes over time, or if logistical problems render a procedure unduly difficult to

conduct. Such adjustments would be developed by the monitoring firm and reported to the EEP for approval prior to application. After reviewing the annual reports, the EEP or regulatory agencies may also have suggestions for adjustment to the monitoring. Suggestions will be reviewed, and if appropriate, will be incorporated into the following year's monitoring. The key is to anticipate that the monitoring program may need occasional adjustments to remain accurate, complete, and feasible.

5. Mitigation

See Sheets

6. Maintenance and Contingency Plans

The need for maintenance of the site will be determined during monitoring visits. Maintenance might include litter removal, filling of holes or gullies, removal of large dead trees, etc. Minor maintenance that can be performed by hand either will be performed by the monitoring firm either at the time the need is identified or will be scheduled for a later time. Maintenance that requires the use of specialized equipment will be coordinated with the EEP.

7. References

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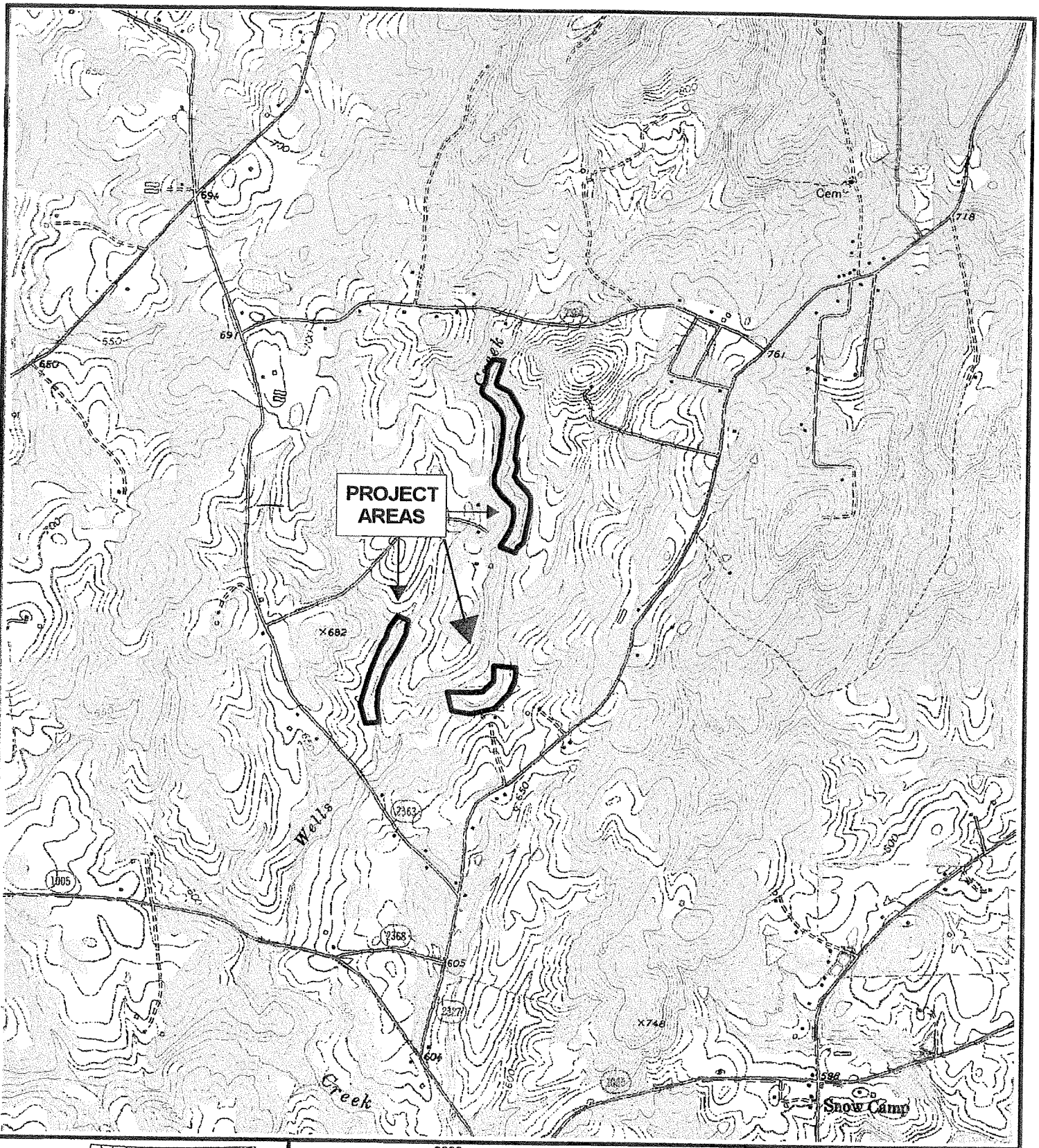
Rosgen, D. L. 1993. Applied Fluvial Geomorphology, Training Manual. River Short Course, Wildland Hydrology, Pagosa Springs, Colorado. 450 pp.

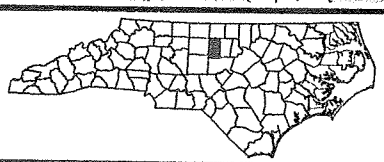
Schafale, M. P.,. and A. S. Weakley. 1990. Classification of the Natural Communities of North Carolina, A Third Approximation. North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health and Natural Resources, Raleigh, North Carolina.

United States Geological Survey. 7-5 Minute topographical quadrangle map, Snow Camp, North Carolina.

Wells Creek Mitigation Plan

Figures





2000 0 2000 Feet

0.5 0 0.5 Miles

SCALE: 1:24,000 (1"= 2,000')

USGS 7.5 Minute Topographic Map: SNOW CAMP, NC

N

Prepared By: ARCADIS

Prepared For: NCDENR

VICINITY MAP

WELLS CREEK & UT TO WELLS CREEK

ALAMANCE COUNTY, NORTH CAROLINA

Figure No. 1

Wells Creek Mitigation Plan

Sheets

NC DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

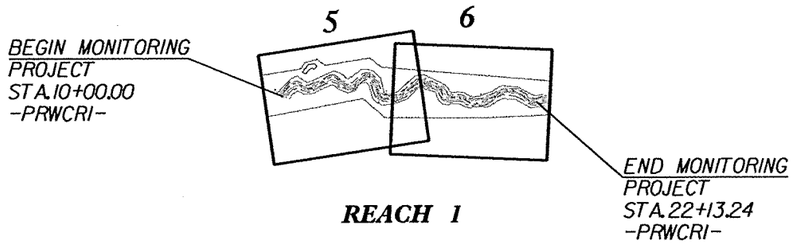
DIVISION OF WATER QUALITY

NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

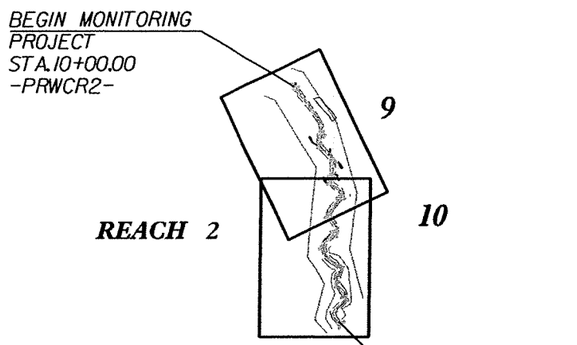
NATURAL CHANNEL DESIGN STREAM RESTORATION PROJECT

WELLS CREEK

ALAMANCE COUNTY, NORTH CAROLINA

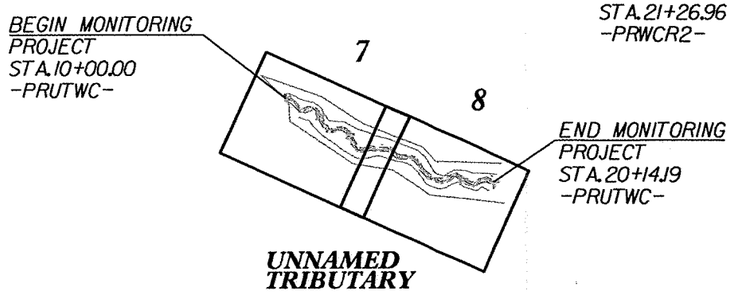


REACH 1

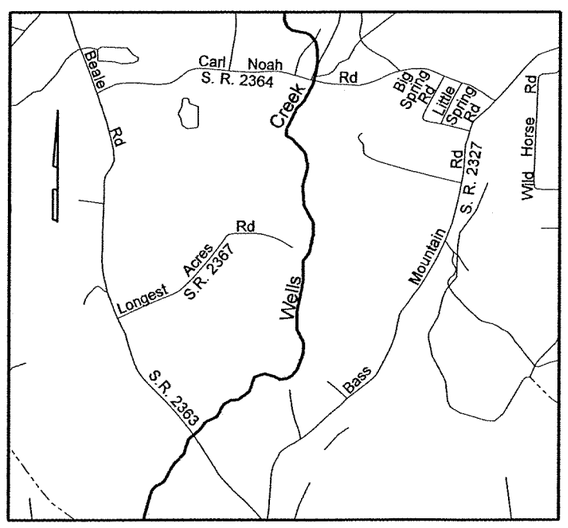


REACH 2

ASSUMED NORTH



UNNAMED TRIBUTARY



VICINITY MAP

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INDEX OF SHEETS

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11/16/2004

LEGEND

ROADS & RELATED ITEMS

- Prop. Woven Wire Fence
- Prop. Chain Link Fence
- Prop. Barbed Wire Fence
- Existing Fence
- Exist. Guardrail
- Prop. Guardrail
- Equality Symbol

RIGHT OF WAY

- Right of Way Marker
- Exist. Right of Way Line w/Marker
- Prop. Right of Way Line (by others)
- Prop. Right of Way Line (by contract)
- Exist. Control of Access Line
- Prop. Control of Access Line
- Exist. Easement Line
- Prop. Temp. Construction Easement Line
- Prop. Temp. Drainage Easement Line
- Prop. Perm. Drainage Easement Line

BOUNDARIES & PROPERTIES

- Property Line Surveyed
- Property Line Not Surveyed
- Exist. Iron Pin
- Property Corner
- Property Monument
- Property Number
- Parcel Number
- Fence Line
- Existing Wetland Boundaries
- Proposed Wetland Boundaries
- Buildings
- Foundations
- Proposed 50' Buffer Boundary

HYDROLOGY

- Stream or Body of Water
- Flow Arrow
- Disappearing Stream
- Spring
- Shoreline
- Falls, Rapids

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UTILITIES

- Exist. Pole
- Exist. Power Pole
- Exist. Telephone Pole
- Exist. Joint Use Pole
- Telephone Pedestal
- Cable TV Pedestal
- Hydrant
- Exist. Water Valve
- Sewer Clean Out
- Power Manhole
- Water Manhole
- Light Pole
- H-Frame Pole
- Power Line Tower
- Pole with Base
- Gas Valve
- Gas Meter
- Telephone Manhole
- Power Transformer
- Guy Wire Anchor
- Sanitary Sewer Manhole
- Storm Sewer Manhole
- Tank; Water, Gas, Oil
- Recorded Water Line
- Sanitary Sewer
- Recorded Sanitary Sewer Force Main
- Recorded Gas Line
- Storm Sewer
- Recorded Power Line
- Recorded Telephone Cable
- Recorded U/G Telephone Conduit
- Unknown Utility
- Recorded Television Cable
- Recorded Fiber Optics Cable
- Exist. Water Meter
- Exist. Overhead Power Line
- Exist. Underground Utilities

STRUCTURES

MAJOR

- Bridge, Tunnel, or Box Culvert
- Bridge Wing Wall, Head Wall and End Wall

MINOR

- Head & End Wall
- Pipe Culvert
- Footbridge
- Drainage Boxes

TOPOGRAPHY

- Loose Surface
- Hard Surface
- Change in Road Surface
- Curb
- Right of Way Symbol
- Paved Walk
- Guard Post
- Bridge
- Box Culvert or Tunnel
- Ferry
- Culvert
- Footbridge
- Trail, Footpath

STREAM IMPROVEMENTS

- Approx. Location of Proposed Boulder Cross Vane (See Detail)
- Approx. Location of Proposed Boulder J-Hook Vane (See Detail)
- Approx. Location of Proposed Rootwad (See Detail)
- Approx. Location of Proposed Stream Plug (See Detail)
- Proposed Oxbox Pond/Wetland (See Detail)
- Boulder Vane
- Log Vane
- Existing Thalweg
- Existing Top of Bank
- Proposed Thalweg
- Proposed Bankfull
- Slope Stake Line
- Approximate limits of Buffer

VEGETATION

- Existing Woods Line
- Existing Tree
- Existing Ash
- Existing Beech
- Existing Birch
- Existing Box Elder
- Existing Cedar
- Existing Cherry
- Existing Dead Tree
- Existing Elm
- Existing Hackberry
- Existing Hickory
- Existing Holly
- Existing Hornbeam
- Existing Ironwood
- Existing Maple
- Existing Mulberry
- Existing Oak
- Existing Persimmon
- Existing Pine
- Existing Poplar
- Existing Redbud
- Existing Sweet Gum
- Existing Sycamore
- Existing Walnut
- Existing Willow

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1	REB	11/17/04	MONITORING BASELINE

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NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

WELLS CREEK
ALAMANCE COUNTY, NORTH CAROLINA

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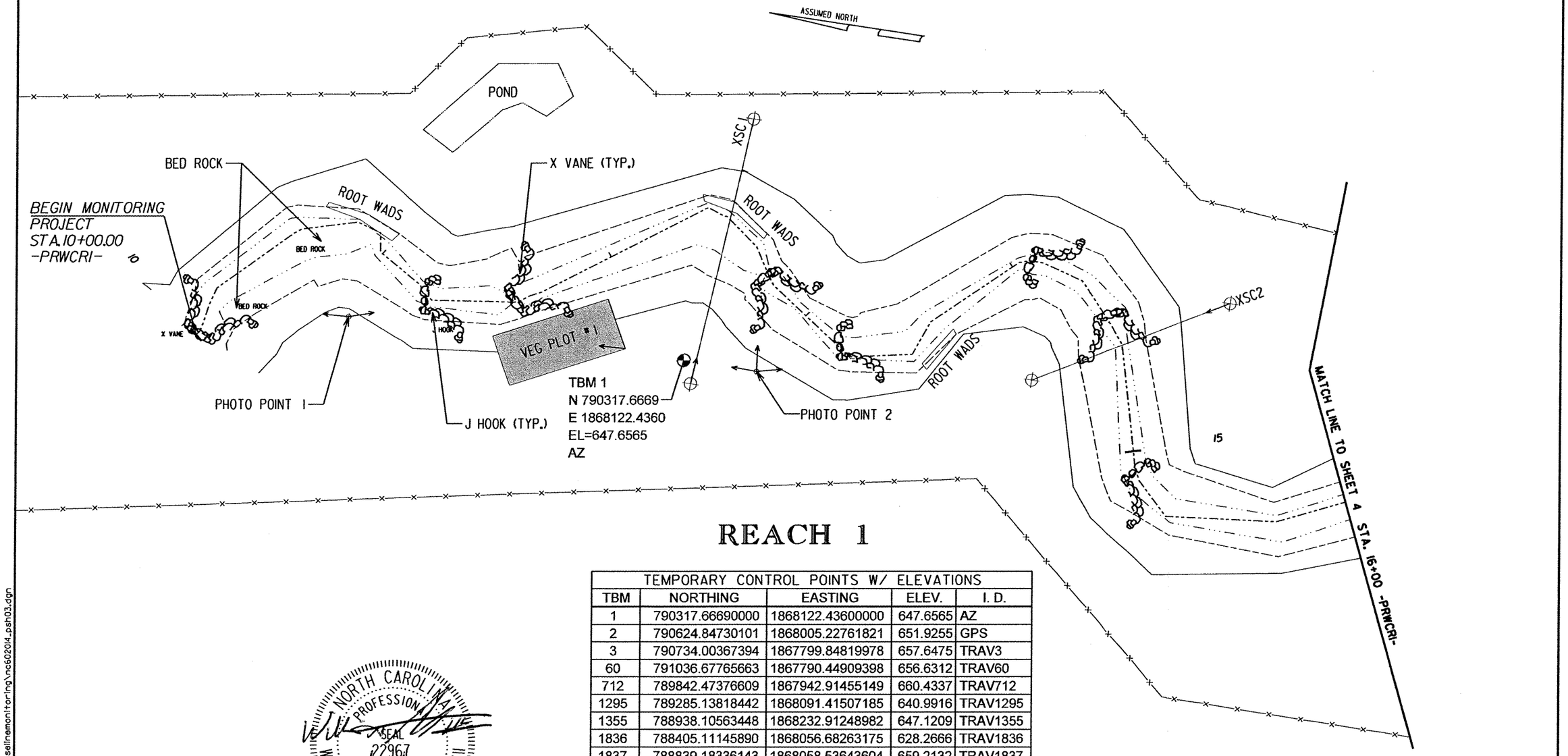

REACH 1

TEMPORARY CONTROL POINTS W/ ELEVATIONS				
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1	790317.66690000	1868122.43600000	647.6565	AZ
2	790624.84730101	1868005.22761821	651.9255	GPS
3	790734.00367394	1867799.84819978	657.6475	TRAV3
60	791036.67765663	1867790.44909398	656.6312	TRAV60
712	789842.47376609	1867942.91455149	660.4337	TRAV712
1295	789285.13818442	1868091.41507185	640.9916	TRAV1295
1355	788938.10563448	1868232.91248982	647.1209	TRAV1355
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1837	788839.18336143	1868058.53643604	659.2132	TRAV1837
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2577	786161.36562698	1867162.36317027	603.9194	TRAV2577
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NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III 11/22/04

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KEY

- CONSTRUCTED THALWEG
- WATER SURFACE
- BANKFULL
- DIRECTION OF PHOTOGRAPHS

10' 0 20'
SCALE

NOTE: ALL COORDINATES AND ELEVATIONS ARE BASED ON AN ASSUMED DATUM. SEE TBM2.

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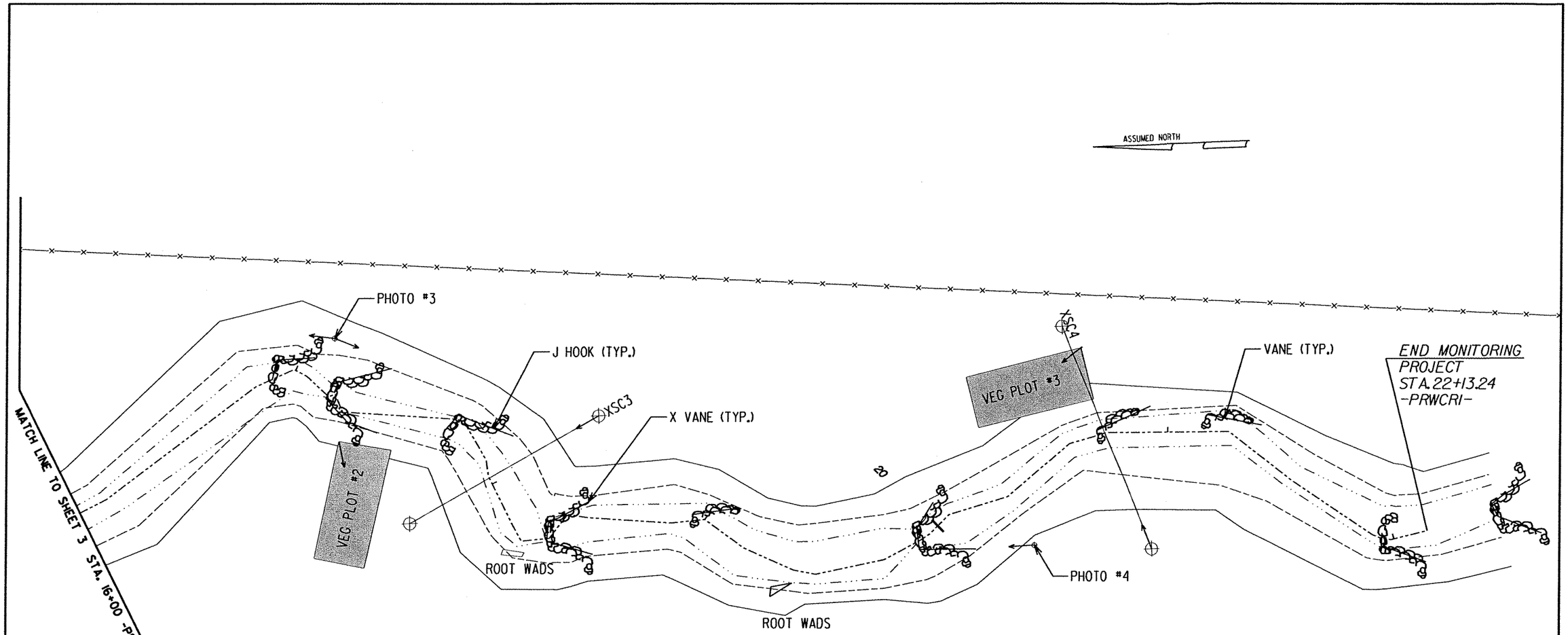

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EL=660.4337
TRAV712

REACH 1

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SHEET NO. 4

Date:11/16/2004
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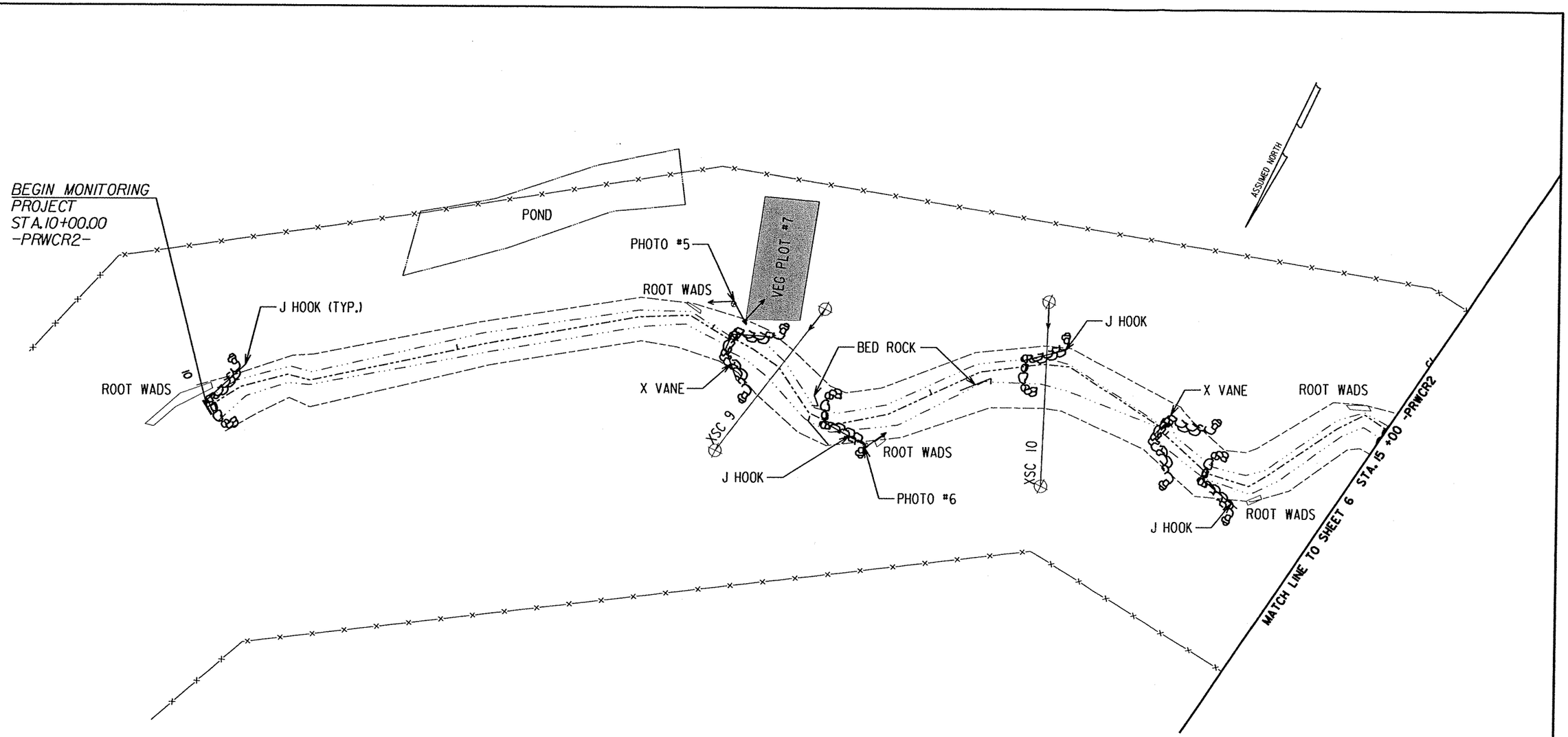

REACH 2

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III 11/22/04

SEAL NOT VALID UNLESS SIGNED AND DATED

KEY

- CONSTRUCTED THALWEG
- WATER SURFACE
- BANKFULL
- DIRECTION OF PHOTOGRAPHS

10' 0 20'
SCALE

NOTE: ALL COORDINATES AND ELEVATIONS ARE BASED ON AN ASSUMED DATUM. SEE TBM2.

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1	REB	11/17/04	MONITORING BASELINE
	BY	DATE	DESCRIPTION OF REVISION

NC DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF WATER QUALITY
NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

WELLS CREEK
ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 5

Date:11/16/2004
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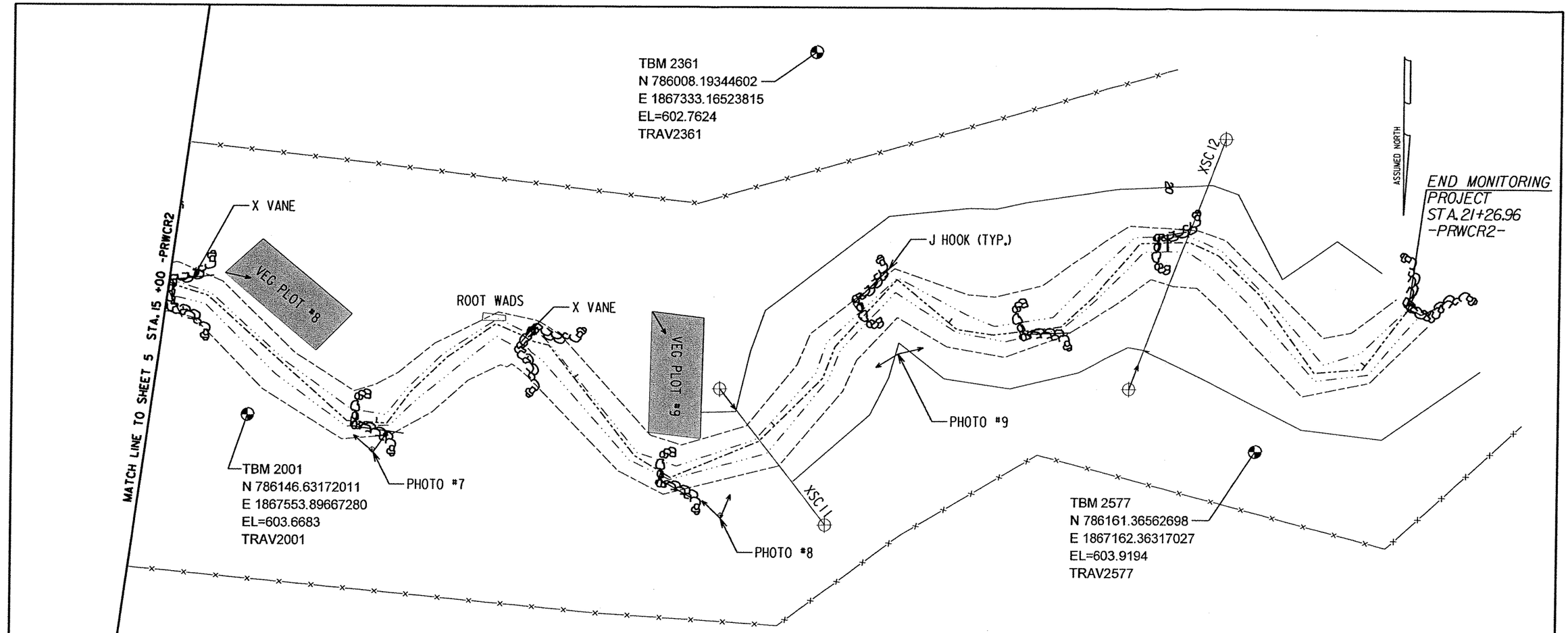

REACH 2

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III
11/22/04

SEAL NOT VALID UNLESS SIGNED AND DATED

KEY

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NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

WELLS CREEK
ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 6

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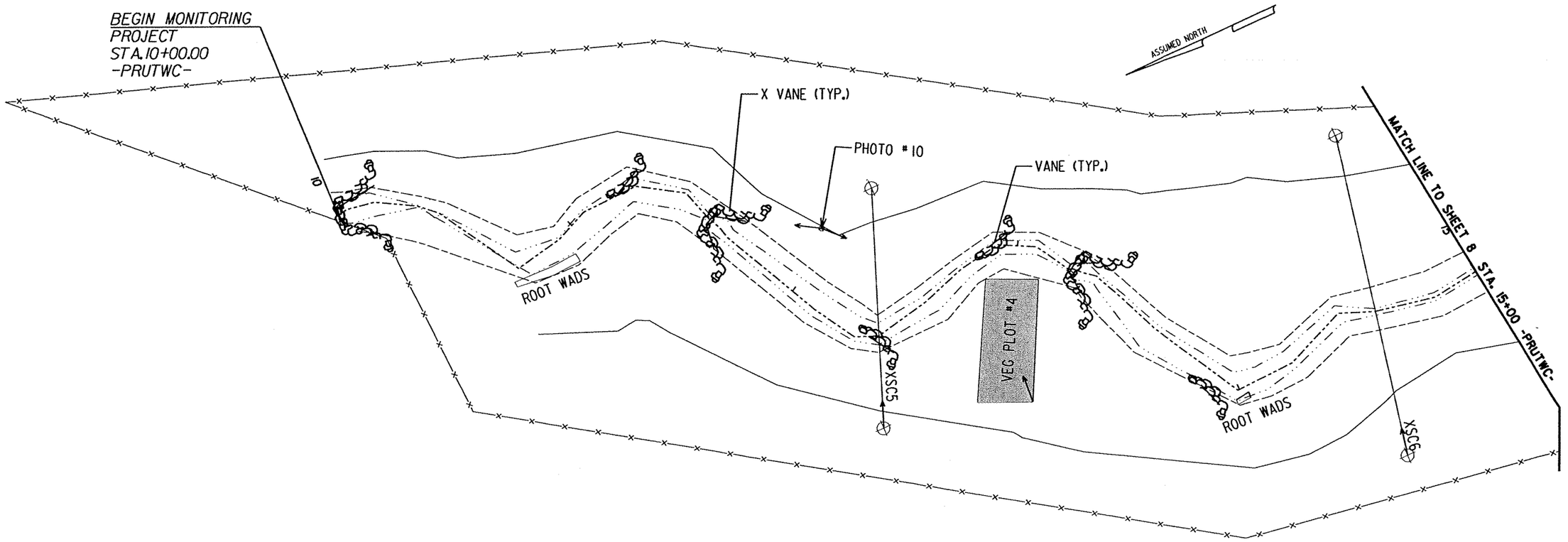

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1	REB	11/17/04	MONITORING BASELINE

NC DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF WATER QUALITY
NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

WELLS CREEK
ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 7

Date:11/16/2004
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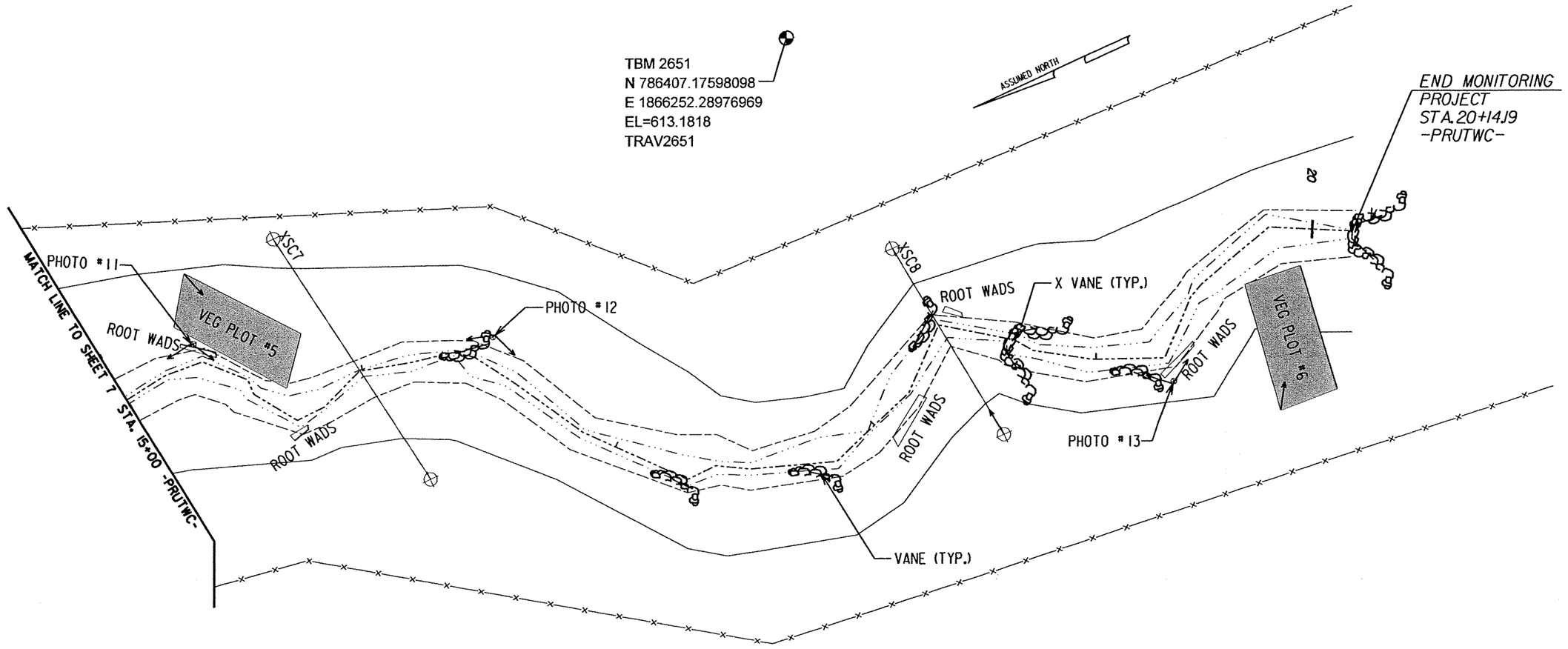

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- DIRECTION OF PHOTOGRAPHS

10' 0 20'
SCALE

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1	REB	11/17/04	MONITORING BASELINE

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WELLS CREEK
ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 8

Date:11/16/2004
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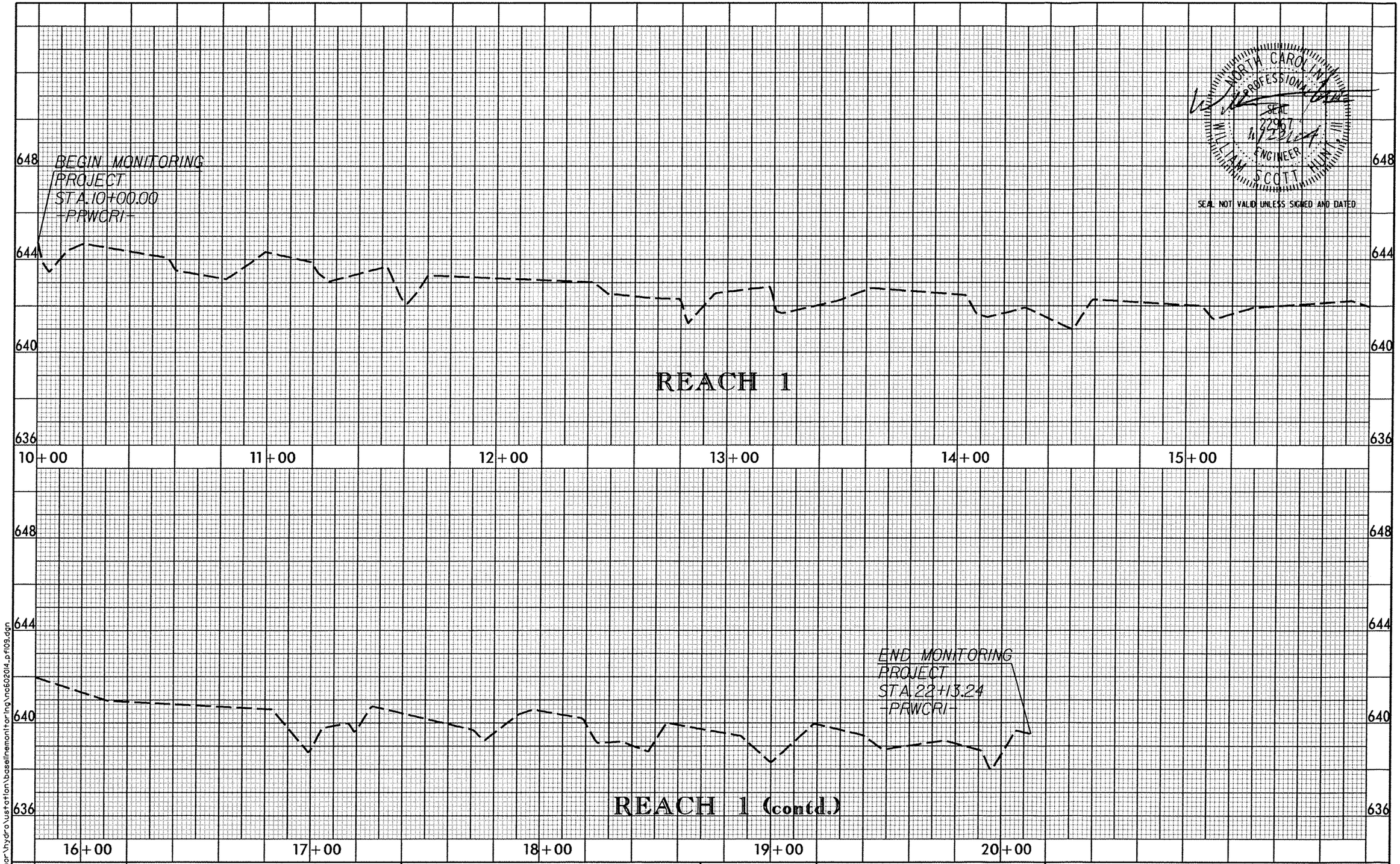

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10' 0 20'
HORIZON. SCALE

1' 0 2'
VERTICAL SCALE

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	BY	DATE	DESCRIPTION OF REVISION

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NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

WELLS CREEK
ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 9

Date:11/16/2004
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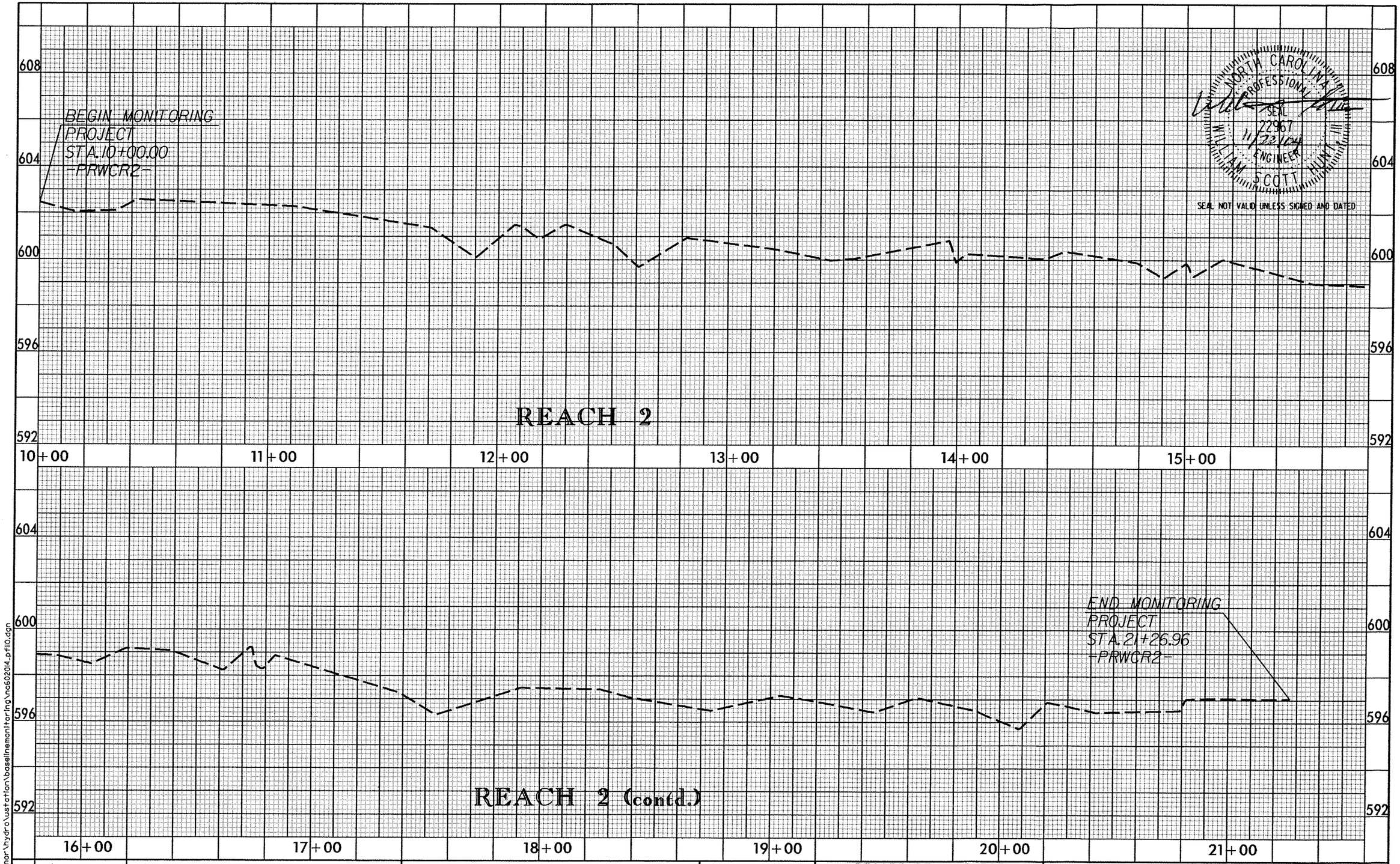

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT III
11/22/04
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10' 0 20'
HORIZON. SCALE

1' 0 2'
VERTICAL SCALE

Date:11/16/2004
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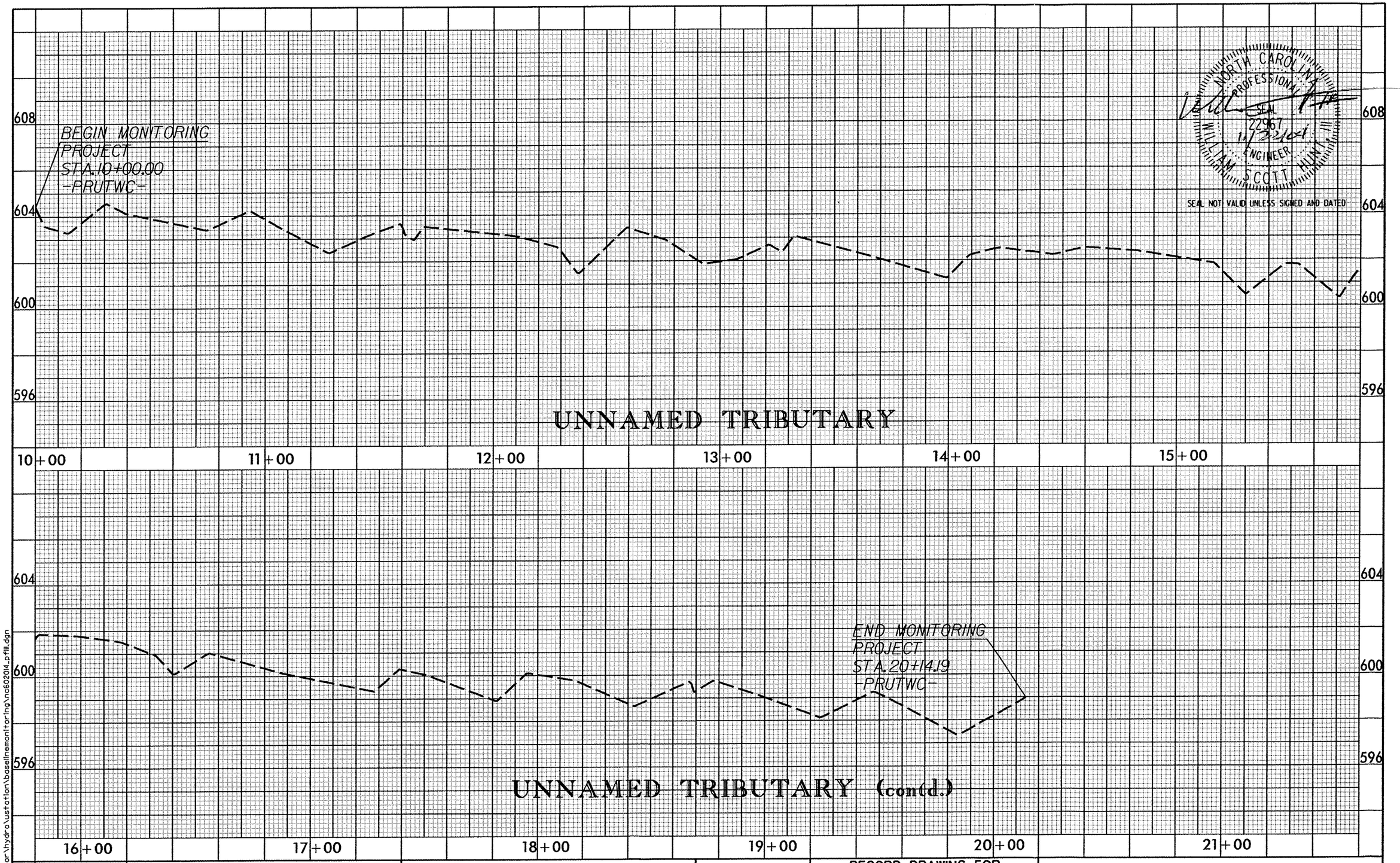
WELLS CREEK
ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 10



NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT III

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HORIZON. SCALE

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WELLS CREEK
ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 11

Date: 11/15/2004
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SHEET NO.	TOTAL SHEETS
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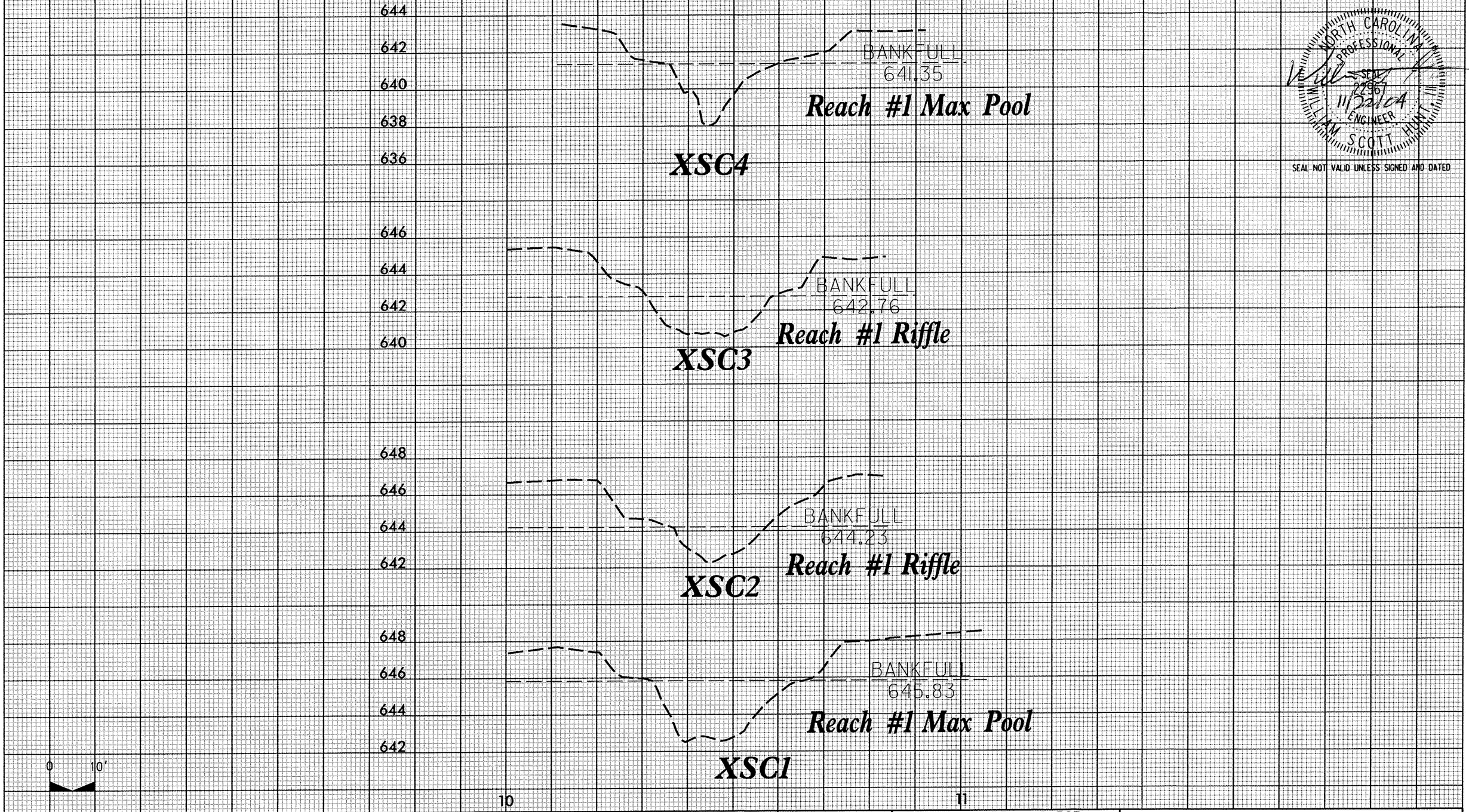

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1	REB	11/17/04	BASELINE MONITORING

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WELLS CREEK

ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 12

-PRWCR1-

SHEET NO.	TOTAL SHEETS
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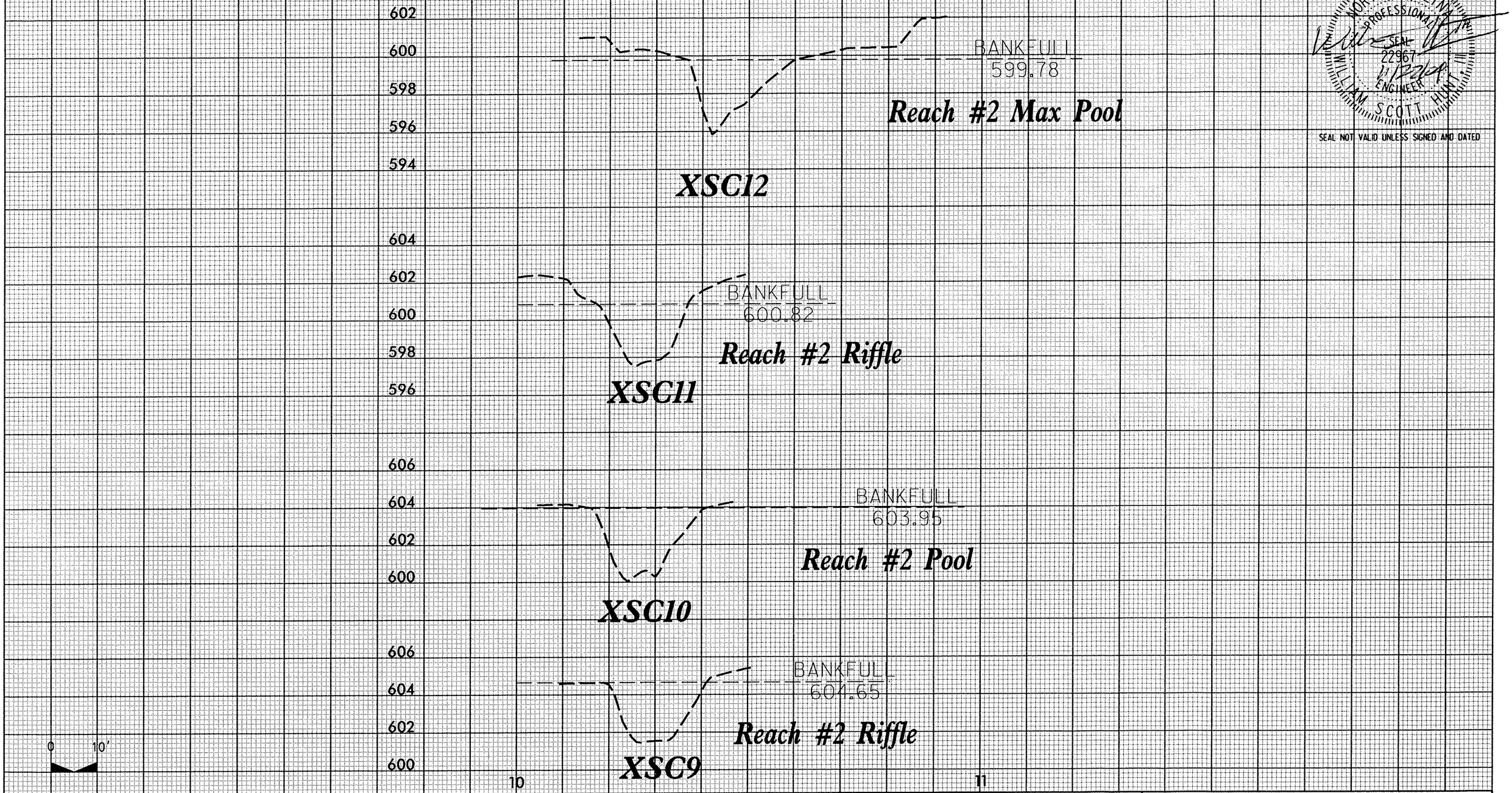

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT III

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1	REB	11/17/04	BASELINE MONITORING

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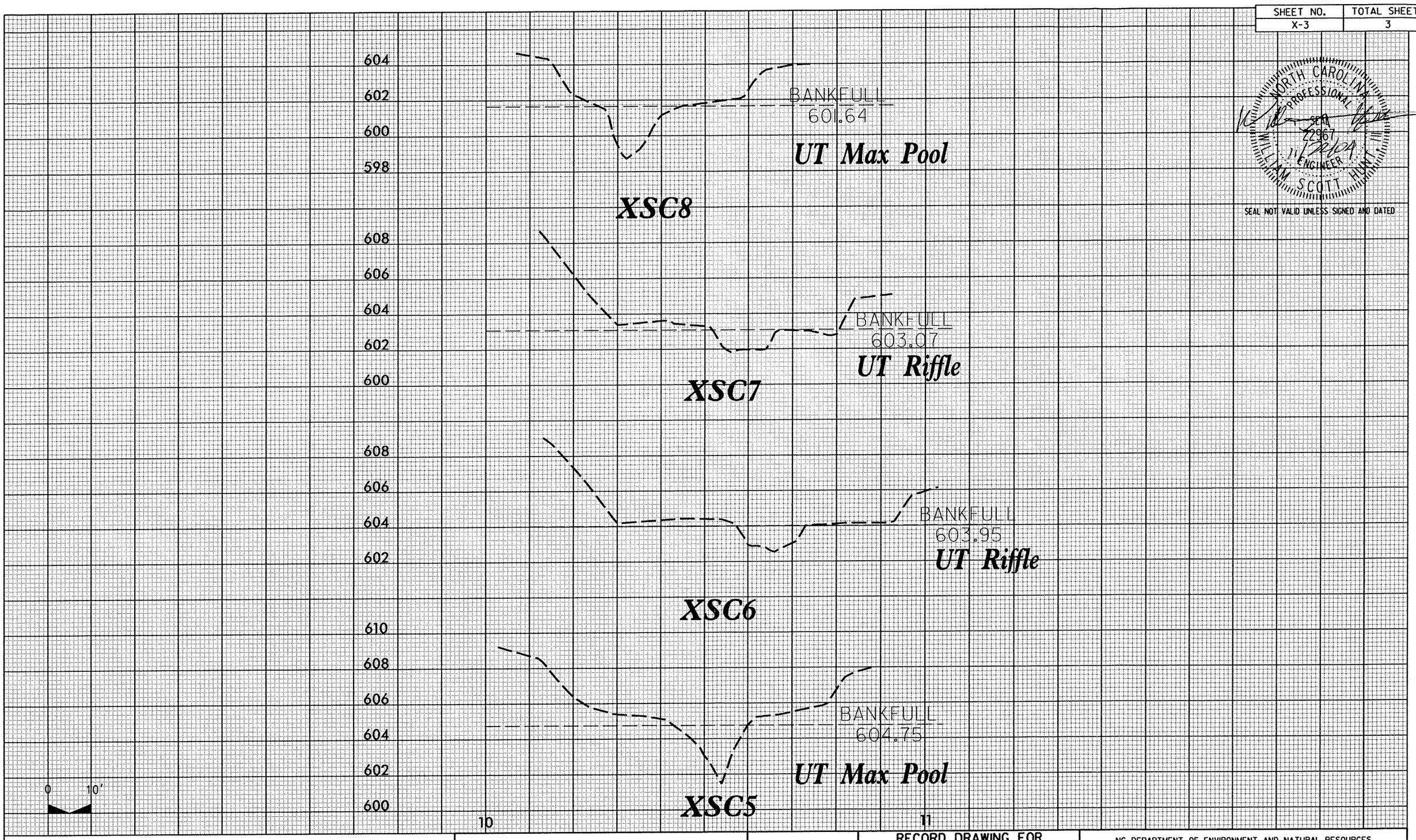
WELLS CREEK

ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 13

-PRWCR2-

SHEET NO.	TOTAL SHEETS
X-3	3



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NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

WELLS CREEK

ALAMANCE COUNTY, NORTH CAROLINA

SHEET NO. 14

-PRUTWC-

Wells Creek Mitigation Plan

Tables

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA
(Adapted from Rosgen, 1996)

TABLE 1

Restoration Site: Wells Creek, Reach #1, Sydnor Property, Alamance County
USGS Gage Station: 0210166029 Rocky River @ SR 1300 Near Crutchfield Crossroads, NC
Reference Reach: UT to Wells Creek, Cane Creek Mountains, Alamance County

Variables	Existing Constructed Channel	Proposed Reach	Reference Reach	USGS Gage Station
1. Stream Type	C 5/1	C 4/1	C 4/1	B/C
2. Drainage Area (sq. mi)	1.6	1.6	0.13	7.42
3. Bankfull Width (Wbkf) ft	Mean: 23.7 Range: 20.1 - 27.4	Mean: 25.0 Range:	Mean: 8.0 Range: 6.5 - 10.0	Mean: 29.0 Range: 28.0 - 30.0
4. Bankfull Mean Depth (dbkf) ft	Mean: 1.4 Range: 1.3 - 1.6	Mean: 1.3 Range:	Mean: 0.7 Range: 0.4 - 1.0	Mean: 2 Range: 2.0 - 2.1
5. Width/Depth Ratio (Wbkf/dbkf)	Mean: 16.8 Range: 16.1 - 17.6	Mean: 19.0 Range:	Mean: 13.5 Range: 7.0 - 26.0	Mean: 14 Range: 13.0 - 15.0
6. Bankfull Cross-Sectional Area (Abkf) sq ft	Mean: 34 Range: 25.2 - 42.8	Mean: 33.0 from Range: regional curve	Mean: 5.3 Range: 3.9 - 6.3	Mean: 58.8 Range: 28.6 - 58.9
7. Bankfull Mean Velocity (Vbkf) fps	Mean: 4.6 Range: 3.7 - 5.7	Mean: 3.4 Range: 2.6 - 4.1	Mean: 5.3 Range: 3.7 - 7.9	Mean: Range:
8. Bankfull Discharge (Qbkf) cfs	Mean: 156.4 Range: 125.8 - 193.8	Mean: 112.2 Range: 85.8 - 135.3	Mean: 25.2 Range: 19.6 - 41.9	Mean: Range:
9. Maximum Bankfull Depth (dmax) ft	Mean: 2.3 Range: 1.6 - 3.1	Mean: 2.1 Range: 1.7 - 2.6	Mean: 1.1 Range: 0.9 - 1.4	Mean: 2.9 Range: 2.7 - 3.0
10. Ratio of Low Bank Height to Max. Bankfull	Mean: 1.0 Range:	Mean: 1.0 Range:	Mean: 1.8 Range: 1.4 - 2.5	Mean: Range:
11. Width of Flood Prone Area (Wfpa) ft	Mean: 57.0 Range: 48.0 - 66.0	Mean: > 55.0 Range:	Mean: 18.8 Range: 16.0 - 22.0	Mean: 70 Range: 40.0 - 100.0
12. Entrenchment Ratio (Wfpa/Wbkf)	Mean: 2.4 Range:	Mean: > 2.2 Range:	Mean: 2.4 Range: 2.0 - 3.4	Mean: 2.4 Range: 1.3 - 3.6
13. Meander Length (Lm) ft	Mean: 137.5 Range: 49.3 - 232.4	Mean: 157.0 Range: 110.0 - 220.0	Mean: 50.0 Range: 35.0 - 70.0	Mean: Range:
14. Ratio of Meander Length to Bankfull Width (Lm/Wbkf)	Mean: 5.8 Range: 2.1 - 9.8	Mean: 6.3 Range: 4.4 - 8.8	Mean: 6.3 Range: 4.4 - 8.8	Mean: Range:
15. Raduis of Curvature (Rc) ft	Mean: 44.6 Range: 10.0 - 80.0	Mean: 40.0 Range: 8.0 - 100.0	Mean: 13.5 Range: 2.3 - 31.8	Mean: Range:
16. Ratio of Radius of Curvature to Bankfull Width	Mean: 1.9 Range: 0.4 - 3.4	Mean: 1.6 Range: 0.3 - 4.0	Mean: 1.6 Range: 0.3 - 4.0	Mean: Range:
17. Belt Width (Wblt) ft	Mean: 55.9 Range: 29.5 - 105.6	Mean: 65.0 Range: 33.0 - 110.0	Mean: 20.9 Range: 10.0 - 35.0	Mean: Range:
18. Meander Width Ratio (Wblt/Wbkf)	Mean: 2.3 Range: 1.2 - 4.4	Mean: 2.6 Range: 1.3 - 4.4	Mean: 2.6 Range: 1.3 - 4.4	Mean: Range:
19. Sinuosity (Stream length/valley distance) (k)	Mean: 1.25 Range:	Mean: 1.30 Range:	Mean: 1.4 Range:	Mean: Range:
20. Valley Slope (ft/ft)	Mean: 0.0061 Range:	Mean: 0.00597 Range:	Mean: 0.028 Range:	Mean: Range:
21. Average Water Surface Slope or Bankful Slope for	Mean: 0.0049 Range:	Mean: 0.0047 Range:	Mean: 0.0197 Range:	Mean: 0.0016 Range:
22. Pool Slope (Spool) ft / ft	Mean: 0.0016 Range: 0.0 - 0.0071	Mean: 0.0009 Range: 0.0 - 0.0019	Mean: 0.0031 Range: 0.0 - 0.078	Mean: Range:
23. Ratio of Pool Slope to Average Slope (Spool/Sbkf)	Mean: 0.3 Range: 0.0 - 1.4	Mean: 0.2 Range: 0.0 - 0.4	Mean: 0.2 Range: 0.0 - 0.4	Mean: Range:
24. Maximum Pool Depth (dpool) ft	Mean: 3.4 Range: 2.6 - 4.4	Mean: 3.1 Range: 3.1 - 3.5	Mean: 1.7 Range: 1.6 - 1.9	Mean: Range:
25. Ratio of Maximum Pool Depth to Bankfull Mean	Mean: 2.4 Range: 1.8 - 3.1	Mean: 2.4 Range: 2.3 - 2.7	Mean: 2.4 Range: 2.3 - 2.7	Mean: Range:
26. Pool Width (Wpool) ft	Mean: 26.5 Range: 23.0 - 30.1	Mean: 27.5 Range: 17.5 - 30.0	Mean: 8.7 Range: 6.0 - 10.0	Mean: Range:

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA
(Adapted from Rosgen, 1996)

TABLE 1

Restoration Site: Wells Creek, Reach #1, Sydnor Property, Alamance County
USGS Gage Station: 0210166029 Rocky River @ SR 1300 Near Crutchfield Crossroads, NC
Reference Reach: UT to Wells Creek, Cane Creek Mountains, Alamance County

Variables	Existing Constructed Channel	Proposed Reach	Reference Reach	USGS Gage Station
27. Ratio of Pool Width to Bankfull Width	Mean: 1.1 Range: 1.0 - 1.3	Mean: 1.1 Range: 0.7 - 1.2	Mean: 1.1 Range: 0.7 - 1.2	Mean: Range:
28. Bankfull Cross-sectional Area at Pool (Apool) sq ft	Mean: 49.2 Range: 35.0 - 63.5	Mean: 49.5 Range: 39.6 - 56.1	Mean: 7.8 Range: 6.2 - 8.9	Mean: Range:
29. Ratio of Pool Area to Bankfull Area (Apool/Abkf)	Mean: 1.4 Range: 1.0 - 1.9	Mean: 1.5 Range: 1.2 - 1.7	Mean: 1.5 Range: 1.2 - 1.7	Mean: Range:
30. Pool to Pool Spacing (p-p) ft	Mean: 66.2 Range: 31.0 - 176.5	Mean: 115.0 Range: 30.0 - 197.5	Mean: 36.5 Range: 17.0 - 63.0	Mean: Range:
31. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-	Mean: 2.8 Range: 1.3 - 7.4	Mean: 4.6 Range: 2.1 - 7.9	Mean: 4.6 Range: 2.1 - 7.9	Mean: Range:
32. Pool Length (Lp) ft	Mean: 27.2 Range: 7.4 - 93.9	Mean: 45.0 Range: 22.5 - 85.0	Mean: 14.5 Range: 7.0 - 27.0	Mean: Range:
33. Ratio of Pool Length to Bankfull Width (Lp/Wbkf)	Mean: 1.1 Range: 0.3 - 4.0	Mean: 1.8 Range: 0.9 - 3.4	Mean: 1.8 Range: 0.9 - 3.4	Mean: Range:
34. Riffle Slope (Sriff) ft / ft	Mean: 0.0072 Range: 0.0020 - 0.0190	Mean: 0.0113 Range: 0.0042 - 0.0188	Mean: 0.0389 Range: 0.0173 - 0.0783	Mean: Range:
35. Ratio of Riffle Slope to Average Slope (Sriff/Sbkf)	Mean: 1.4 Range: 0.4 - 3.9	Mean: 2.4 Range: 0.9 - 4.0	Mean: 2.4 Range: 0.9 - 4.0	Mean: Range:
36. Maximum Riffle Depth (driff) ft	Mean: 2.3 Range: 1.6 - 3.1	Mean: 2.1 Range: 1.7 - 2.6	Mean: 1.1 Range: 0.9 - 1.4	Mean: Range:
37. Ratio of Riffle Depth to Bankfull Mean Depth	Mean: 1.6 Range: 1.1 - 2.2	Mean: 1.6 Range: 1.3 - 2.0	Mean: 1.6 Range: 1.3 - 2.0	Mean: Range:
38. Run Slope (Srun) ft / ft	Mean: 0.0088 Range: 0.0004 - 0.0162	Mean: 0.0075 Range: 0.0019 - 0.0169	Mean: 0.0307 Range: 0.008 - 0.0712	Mean: Range:
39. Ratio of Run Slope to Average Slope (Srun/Sbkf)	Mean: 1.8 Range: 0.1 - 3.3	Mean: 1.6 Range: 0.4 - 3.6	Mean: 1.6 Range: 0.4 - 3.6	Mean: Range:
40. Maximum Run Depth (drun) ft	Mean: 2.3 Range: 1.7 - 2.6	Mean: 2.3 Range:	Mean: 1.3 Range:	Mean: Range:
41. Ratio of Run Depth to Bankfull Mean Depth	Mean: 1.6 Range: 1.2 - 1.8	Mean: 1.8 Range:	Mean: 1.8 Range:	Mean: Range:
42. Slope of Glide (Sgl) ft / ft	Mean: 0.0066 Range: 0.0003 - 0.0125	Mean: 0.0028 Range: 0.0 - 0.0075	Mean: 0.0114 Range: 0.0 - 0.0325	Mean: Range:
43. Ratio of Glide Slope to Average Water Surface Slope	Mean: 1.3 Range: 0.1 - 2.6	Mean: 0.6 Range: 0.0 - 1.6	Mean: 0.6 Range: 0.0 - 1.6	Mean: Range:
44. Maximum Glide Depth (dgl) ft	Mean: 2.8 Range: 1.4 - 3.3	Mean: 2.2 Range:	Mean: 1.2 Range:	Mean: Range:
45. Ratio of Glide Depth to Bankfull Mean Depth	Mean: 2.0 Range: 1.0 - 2.3	Mean: 1.7 Range:	Mean: 1.7 Range:	Mean: Range:
46. Step Slope (Sst)	Mean: N/A Range:	Mean: N/A Range:	Mean: 0.2112 Range: 0.1375 - 0.285	Mean: Range:
47. Ratio of Step Slope to Average Water Surface Slope	Mean: N/A Range:	Mean: N/A Range:	Mean: 10.7 Range: 7.0 - 14.5	Mean: Range:
48. Maximum Step Depth (dst)	Mean: N/A Range:	Mean: N/A Range:	Mean: 1.1 Range: 1.0 - 1.1	Mean: Range:
49. Ratio of Step Depth to Bankfull Mean Depth	Mean: N/A Range:	Mean: N/A Range:	Mean: 1.5 Range: 1.4 - 1.6	Mean: Range:

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA
(Adapted from Rosgen, 1996)

TABLE 1

Restoration Site: Wells Creek, Reach #1, Sydnor Property, Alamance County
USGS Gage Station: 0210166029 Rocky River @ SR 1300 Near Crutchfield Crossroads, NC
Reference Reach: UT to Wells Creek, Cane Creek Mountains, Alamance County

Variables	Existing Constructed Channel	Proposed Reach	Reference Reach	USGS Gage Station
Materials:				
Particle Size Distribution of Channel Material (mm)				
D16	N/A	Expected to	0.1	
D35	N/A	Coarsen	0.6	
D50	0.1		4.5	
D84	9.0		53.0	
D95	31.0		96.0	
Particle Size Distribution of Bar Material (mm)				
D16	Sample not	Expected to	0.1	
D35	Collected	Coarsen	0.3	
D50			0.7	
D84			7.0	
D95			12.0	
Largest Size Particle on Bar			20.0	

Sediment Transport:		
Sediment Transport Validation (Based on Bankfull Shear Stress)	**Existing**	**Proposed**
Calculated value (mm) from curve	30	100
Calculated Shear Stress (lb/ft2)	0.41	0.35
Critical dimensionless shear stress	Not Calculated. No bar sample collected.	0.009
Minimal mean dbkf (ft) calculated using critical dimensionless shear stress equations	Not Calculated. No bar sample collected.	1.1

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA
(Adapted from Rosgen, 1996)

TABLE 2

Restoration Site: Wells Creek, Reach #2, Sydnor Property, Alamance County
USGS Gage Station: 0210166029 Rocky River @ SR 1300 Near Crutchfield Crossroads, NC
Reference Reach: UT to Wells Creek, Cane Creek Mountains, Alamance County

Variables	Existing Constructed Channel	Proposed Reach	Reference Reach	USGS Gage Station
1. Stream Type	C/E 4/1	C 4/1	C 4/1	B/C
2. Drainage Area (sq. mi)	2.23	2.23	0.13	7.42
3. Bankfull Width (Wbkf) ft	Mean: 25.4 Range: 19.3 - 31.6	Mean: 20.0 Range:	Mean: 8.0 Range: 6.5 - 10.0	Mean: 29.0 Range: 28.0 - 30.0
4. Bankfull Mean Depth (dbkf) ft	Mean: 1.9 Range: 1.5 - 2.3	Mean: 1.8 Range:	Mean: 0.7 Range: 0.4 - 1.0	Mean: 2 Range: 2.0 - 2.1
5. Width/Depth Ratio (Wbkf/dbkf)	Mean: 14.8 Range: 8.4 - 21.2	Mean: 11.0 Range:	Mean: 13.5 Range: 7.0 - 26.0	Mean: 14 Range: 13.0 - 15.0
6. Bankfull Cross-Sectional Area (Abkf) sq ft	Mean: 45.6 Range: 44.2 - 47.1	Mean: 34.1 Range: 32.2 - 36.0	Mean: 5.3 Range: 3.9 - 6.3	Mean: 58.8 Range: 28.6 - 58.9
7. Bankfull Mean Velocity (Vbkf) fps	Mean: 5.3 Range: 3.5 - 6.5	Mean: 4.4 Range:	Mean: 5.3 Range: 3.7 - 7.9	Mean: Range:
8. Bankfull Discharge (Qbkf) cfs	Mean: 241.7 Range: 159.6 - 296.4	Mean: 159.0 Range:	Mean: 25.2 Range: 19.6 - 41.9	Mean: Range:
9. Maximum Bankfull Depth (dmax) ft	Mean: 3.0 Range: 2.5 - 3.5	Mean: 2.9 Range: 2.3 - 3.6	Mean: 1.1 Range: 0.9 - 1.4	Mean: 2.9 Range: 2.7 - 3.0
10. Ratio of Low Bank Height to Max. Bankfull	Mean: 1.0 Range:	Mean: 1.0 Range:	Mean: 1.8 Range: 1.4 - 2.5	Mean: Range:
11. Width of Flood Prone Area (Wfpa) ft	Mean: 100.0 Range:	Mean: >50 Range:	Mean: 18.8 Range: 16.0 - 22.0	Mean: 70 Range: 40.0 - 100.0
12. Entrenchment Ratio (Wfpa/Wbkf)	Mean: 4.2 Range: 3.2 - 5.2	Mean: >2.2 Range:	Mean: 2.4 Range: 2.0 - 3.4	Mean: 2.4 Range: 1.3 - 3.6
13. Meander Length (Lm) ft	Mean: 129.5 Range: 113.1 - 151.3	Mean: 126.0 Range: 88.0 - 176.0	Mean: 50.0 Range: 35.0 - 70.0	Mean: Range:
14. Ratio of Meander Length to Bankfull Width (Lm/Wbkf)	Mean: 5.1 Range: 4.4 - 5.9	Mean: 6.3 Range: 4.4 - 8.8	Mean: 6.3 Range: 4.4 - 8.8	Mean: Range:
15. Raduis of Curvature (Rc) ft	Mean: 69.2 Range: 40.0 - 130.0	Mean: 32.0 Range: 6.0 - 80.0	Mean: 13.5 Range: 2.3 - 31.8	Mean: Range:
16. Ratio of Radius of Curvature to Bankfull Width	Mean: 2.7 Range: 1.6 - 5.1	Mean: 1.6 Range: 0.3 - 4.0	Mean: 1.6 Range: 0.3 - 4.0	Mean: Range:
17. Belt Width (Wblt) ft	Mean: 57.2 Range: 32.5 - 81.8	Mean: 52.0 Range: 26.0 - 88.0	Mean: 20.9 Range: 10.0 - 35.0	Mean: Range:
18. Meander Width Ratio (Wblt/Wbkf)	Mean: 2.2 Range: 1.3 - 3.2	Mean: 2.6 Range: 1.3 - 4.4	Mean: 2.6 Range: 1.3 - 4.4	Mean: Range:
19. Sinuosity (Stream length/valley distance) (k)	Mean: 1.24 Range:	Mean: 1.40 Range:	Mean: 1.4 Range:	Mean: Range:
20. Valley Slope (ft/ft)	Mean: 0.0077 Range:	Mean: 0.00950 Range:	Mean: 0.028 Range:	Mean: Range:
21. Average Water Surface Slope or Bankful Slope for	Mean: 0.0062 Range:	Mean: 0.0065 Range:	Mean: 0.0197 Range:	Mean: 0.0016 Range:
22. Pool Slope (Spool) ft / ft	Mean: 0.0007 Range: 0.0 - 0.0025	Mean: 0.0013 Range: 0.0 - 0.0026	Mean: 0.0031 Range: 0.0 - 0.078	Mean: Range:
23. Ratio of Pool Slope to Average Slope (Spool/Sbkf)	Mean: 0.1 Range: 0.0 - 0.4	Mean: 0.2 Range: 0.0 - 0.4	Mean: 0.2 Range: 0.0 - 0.4	Mean: Range:
24. Maximum Pool Depth (dpool) ft	Mean: 3.9 Range: 2.9 - 4.9	Mean: 4.3 Range: 4.1 - 4.9	Mean: 1.7 Range: 1.6 - 1.9	Mean: Range:
25. Ratio of Maximum Pool Depth to Bankfull Mean	Mean: 2.0 Range: 1.5 - 2.5	Mean: 2.4 Range: 2.3 - 2.7	Mean: 2.4 Range: 2.3 - 2.7	Mean: Range:
26. Pool Width (Wpool) ft	Mean: 23.5 Range: 23.5 - 23.6	Mean: 22.0 Range: 14.0 - 24.0	Mean: 8.7 Range: 6.0 - 10.0	Mean: Range:

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA
(Adapted from Rosgen, 1996)

TABLE 2

Restoration Site: Wells Creek, Reach #2, Sydnor Property, Alamance County
USGS Gage Station: 0210166029 Rocky River @ SR 1300 Near Crutchfield Crossroads, NC
Reference Reach: UT to Wells Creek, Cane Creek Mountains, Alamance County

Variables	Existing Constructed Channel	Proposed Reach	Reference Reach	USGS Gage Station
27. Ratio of Pool Width to Bankfull Width	Mean: 0.9 Range: 0.9 - 1.0	Mean: 1.1 Range: 0.7 - 1.2	Mean: 1.1 Range: 0.7 - 1.2	Mean: Range:
28. Bankfull Cross-sectional Area at Pool (Apool) sq ft	Mean: 50.7 Range: 46.0 - 55.4	Mean: 51.2 Range: 40.9 - 58.0	Mean: 7.8 Range: 6.2 - 8.9	Mean: Range:
29. Ratio of Pool Area to Bankfull Area (Apool/Abkf)	Mean: 1.1 Range: 1.0 - 1.2	Mean: 1.5 Range: 1.2 - 1.7	Mean: 1.5 Range: 1.2 - 1.7	Mean: Range:
30. Pool to Pool Spacing (p-p) ft	Mean: 79.9 Range: 22.4 - 170.6	Mean: 92.0 Range: 42.0 - 158.0	Mean: 36.5 Range: 17.0 - 63.0	Mean: Range:
31. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-	Mean: 3.1 Range: 0.9 - 6.7	Mean: 4.6 Range: 2.1 - 7.9	Mean: 4.6 Range: 2.1 - 7.9	Mean: Range:
32. Pool Length (Lp) ft	Mean: 43.6 Range: 4.6 - 84.8	Mean: 36.0 Range: 18.0 - 68.0	Mean: 14.5 Range: 7.0 - 27.0	Mean: Range:
33. Ratio of Pool Length to Bankfull Width (Lp/Wbkf)	Mean: 1.7 Range: 0.2 - 3.3	Mean: 1.8 Range: 0.9 - 3.4	Mean: 1.8 Range: 0.9 - 3.4	Mean: Range:
34. Riffle Slope (Sriff) ft / ft	Mean: 0.0107 Range: 0.0016 - 0.0228	Mean: 0.0156 Range: 0.0058 - 0.0221	Mean: 0.0389 Range: 0.0173 - 0.0783	Mean: Range:
35. Ratio of Riffle Slope to Average Slope (Sriff/Sbkf)	Mean: 1.7 Range: 0.3 - 3.7	Mean: 2.4 Range: 0.9 - 4.0	Mean: 2.4 Range: 0.9 - 4.0	Mean: Range:
36. Maximum Riffle Depth (driff) ft	Mean: 3.0 Range: 2.5 - 3.5	Mean: 2.9 Range: 2.3 - 3.6	Mean: 1.1 Range: 0.9 - 1.4	Mean: Range:
37. Ratio of Riffle Depth to Bankfull Mean Depth	Mean: 1.6 Range: 1.3 - 1.8	Mean: 1.6 Range: 1.3 - 2.0	Mean: 1.6 Range: 1.3 - 2.0	Mean: Range:
38. Run Slope (Srun) ft / ft	Mean: N/A Range:	Mean: 0.0104 Range: 0.0026 - 0.0234	Mean: 0.0307 Range: 0.008 - 0.0712	Mean: Range:
39. Ratio of Run Slope to Average Slope (Srun/Sbkf)	Mean: N/A Range:	Mean: 1.6 Range: 0.4 - 3.6	Mean: 1.6 Range: 0.4 - 3.6	Mean: Range:
40. Maximum Run Depth (drun) ft	Mean: N/A Range:	Mean: 3.2 Range:	Mean: 1.3 Range:	Mean: Range:
41. Ratio of Run Depth to Bankfull Mean Depth	Mean: N/A Range:	Mean: 1.8 Range:	Mean: 1.8 Range:	Mean: Range:
42. Slope of Glide (Sgl) ft / ft	Mean: 0.005 Range: 0.0020 - 0.0080	Mean: 0.0039 Range: 0.0 - 0.0104	Mean: 0.0114 Range: 0.0 - 0.0325	Mean: Range:
43. Ratio of Glide Slope to Average Water Surface Slope	Mean: 0.8 Range: 0.3 - 1.3	Mean: 0.6 Range: 0.0 - 1.6	Mean: 0.6 Range: 0.0 - 1.6	Mean: Range:
44. Maximum Glide Depth (dgl) ft	Mean: 3.6 Range: 3.3 - 3.9	Mean: 3.1 Range:	Mean: 1.2 Range:	Mean: Range:
45. Ratio of Glide Depth to Bankfull Mean Depth	Mean: 1.9 Range: 1.7 - 2.0	Mean: 1.7 Range:	Mean: 1.7 Range:	Mean: Range:
46. Step Slope (Sst)	Mean: N/A Range:	Mean: N/A Range:	Mean: 0.2112 Range: 0.1375 - 0.285	Mean: Range:
47. Ratio of Step Slope to Average Water Surface Slope	Mean: N/A Range:	Mean: N/A Range:	Mean: 10.7 Range: 7.0 - 14.5	Mean: Range:
48. Maximum Step Depth (dst)	Mean: N/A Range:	Mean: N/A Range:	Mean: 1.1 Range: 1.0 - 1.1	Mean: Range:
49. Ratio of Step Depth to Bankfull Mean Depth	Mean: N/A Range:	Mean: N/A Range:	Mean: 1.5 Range: 1.4 - 1.6	Mean: Range:

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA
(Adapted from Rosgen, 1996)

TABLE 2

Restoration Site: Wells Creek, Reach #2, Sydnor Property, Alamance County
USGS Gage Station: 0210166029 Rocky River @ SR 1300 Near Crutchfield Crossroads, NC
Reference Reach: UT to Wells Creek, Cane Creek Mountains, Alamance County

Variables	Existing Constructed Channel	Proposed Reach	Reference Reach	USGS Gage Station
Materials:				
Particle Size Distribution of Channel Material (mm)				
D16	N/A	Expected to	0.1	
D35	0.4	Coarsen	0.6	
D50	0.5		4.5	
D84	17.0		53.0	
D95	32.0		96.0	
Particle Size Distribution of Bar Material (mm)				
D16	Sample not	Expected to	0.1	
D35	Collected	Coarsen	0.3	
D50			0.7	
D84			7.0	
D95			12.0	
Largest Size Particle on Bar			20.0	

Sediment Transport:		
Sediment Transport Validation (Based on Bankfull Shear Stress)	**Existing**	**Proposed**
Calculated value (mm) from curve	54	55
Calculated Shear Stress (lb/ft2)	0.68	0.72
Critical dimensionless shear stress	Not Calculated. No bar sample collected.	0.027
Minimal mean dbkf (ft) calculated using critical dimensionless shear stress equations	Not Calculated. No bar sample collected.	1.8

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA
(Adapted from Rosgen, 1996)

TABLE 3

Restoration Site: Wells Creek, UT, Sydnor Property, Alamance County
USGS Gage Station: 0210166029 Rocky River @ SR 1300 Near Crutchfield Crossroads, NC
Reference Reach: UT to Wells Creek, Cane Creek Mountains, Alamance County

Variables	Existing Constructed Channel	Proposed Reach	Reference Reach	USGS Gage Station
1. Stream Type	C 5/1	C 4/1	C 4/1	B/C
2. Drainage Area (sq. mi)	0.71	0.71	0.13	7.42
3. Bankfull Width (Wbkf) ft	Mean: 14.9 Range: 13.5 - 16.0	Mean: 15.0 Range:	Mean: 8.0 Range: 6.5 - 10.0	Mean: 29.0 Range: 28.0 - 30.0
4. Bankfull Mean Depth (dbkf) ft	Mean: 1.0 Range:	Mean: 1.1 Range:	Mean: 0.7 Range: 0.4 - 1.0	Mean: 2 Range: 2.0 - 2.1
5. Width/Depth Ratio (Wbkf/dbkf)	Mean: 15.0 Range: 14.8 - 15.3	Mean: 12.5 Range:	Mean: 13.5 Range: 7.0 - 26.0	Mean: 14 Range: 13.0 - 15.0
6. Bankfull Cross-Sectional Area (Abkf) sq ft	Mean: 14.7 Range: 13.5 - 16.0	Mean: 17.0 Range:	Mean: 5.3 Range: 3.9 - 6.3	Mean: 58.8 Range: 28.6 - 58.9
7. Bankfull Mean Velocity (Vbkf) fps	Mean: 4.0 Range: 3.1 - 4.7	Mean: 4.1 Range:	Mean: 5.3 Range: 3.7 - 7.9	Mean: Range:
8. Bankfull Discharge (Qbkf) cfs	Mean: 58.8 Range: 45.6 - 69.1	Mean: 68.9 Range:	Mean: 25.2 Range: 19.6 - 41.9	Mean: Range:
9. Maximum Bankfull Depth (dmax) ft	Mean: 1.6 Range: 1.4 - 2.1	Mean: 1.8 Range: 1.4 - 2.2	Mean: 1.1 Range: 0.9 - 1.4	Mean: 2.9 Range: 2.7 - 3.0
10. Ratio of Low Bank Height to Max. Bankfull	Mean: 1.0 Range:	Mean: 1.0 Range:	Mean: 1.8 Range: 1.4 - 2.5	Mean: Range:
11. Width of Flood Prone Area (Wfpa) ft	Mean: 63.5 Range: 50.0 - 77.0	Mean: >33 Range:	Mean: 18.8 Range: 16.0 - 22.0	Mean: 70 Range: 40.0 - 100.0
12. Entrenchment Ratio (Wfpa/Wbkf)	Mean: 4.2 Range: 3.5 - 4.9	Mean: >2.2 Range:	Mean: 2.4 Range: 2.0 - 3.4	Mean: 2.4 Range: 1.3 - 3.6
13. Meander Length (Lm) ft	Mean: 116.5 Range: 55.0 - 184.3	Mean: 94.5 Range: 66.0 - 132.0	Mean: 50.0 Range: 35.0 - 70.0	Mean: Range:
14. Ratio of Meander Length to Bankfull Width (Lm/Wbkf)	Mean: 7.8 Range: 3.7 - 12.4	Mean: 6.3 Range: 4.4 - 8.8	Mean: 6.3 Range: 4.4 - 8.8	Mean: Range:
15. Raduis of Curvature (Rc) ft	Mean: 70.7 Range: 20.0 -150.0	Mean: 24.0 Range: 4.5 - 60.0	Mean: 13.5 Range: 2.3 - 31.8	Mean: Range:
16. Ratio of Radius of Curvature to Bankfull Width	Mean: 4.7 Range: 1.3 - 10.1	Mean: 1.6 Range: 0.3 - 4.0	Mean: 1.6 Range: 0.3 - 4.0	Mean: Range:
17. Belt Width (Wblt) ft	Mean: 45.4 Range: 17.8 - 71.7	Mean: 39.0 Range: 19.5 - 66.0	Mean: 20.9 Range: 10.0 - 35.0	Mean: Range:
18. Meander Width Ratio (Wblt/Wbkf)	Mean: 3.0 Range: 1.2 - 4.8	Mean: 2.6 Range: 1.3 - 4.4	Mean: 2.6 Range: 1.3 - 4.4	Mean: Range:
19. Sinuosity (Stream length/valley distance) (k)	Mean: 1.27 Range:	Mean: 1.20 Range:	Mean: 1.4 Range:	Mean: Range:
20. Valley Slope (ft/ft)	Mean: 0.0067 Range:	Mean: 0.00770 Range:	Mean: 0.028 Range:	Mean: Range:
21. Average Water Surface Slope or Bankful Slope for	Mean: 0.0053 Range:	Mean: 0.0064 Range:	Mean: 0.0197 Range:	Mean: 0.0016 Range:
22. Pool Slope (Spool) ft / ft	Mean: 0.0004 Range: 0.0 - 0.0013	Mean: 0.0013 Range: 0.0 - 0.0026	Mean: 0.0031 Range: 0.0 - 0.078	Mean: Range:
23. Ratio of Pool Slope to Average Slope (Spool/Sbkf)	Mean: 0.1 Range: 0.0 - 0.2	Mean: 0.2 Range: 0.0 - 0.4	Mean: 0.2 Range: 0.0 - 0.4	Mean: Range:
24. Maximum Pool Depth (dpool) ft	Mean: 2.7 Range: 1.7 - 3.4	Mean: 2.6 Range: 2.5 - 3.0	Mean: 1.7 Range: 1.6 - 1.9	Mean: Range:
25. Ratio of Maximum Pool Depth to Bankfull Mean	Mean: 2.7 Range: 1.7 - 3.4	Mean: 2.4 Range: 2.3 - 2.7	Mean: 2.4 Range: 2.3 - 2.7	Mean: Range:
26. Pool Width (Wpool) ft	Mean: 15.1 Range: 13.5 - 16.7	Mean: 16.5 Range: 10.5 - 18.0	Mean: 8.7 Range: 6.0 - 10.0	Mean: Range:

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA
(Adapted from Rosgen, 1996)

TABLE 3

Restoration Site: Wells Creek, UT, Sydnor Property, Alamance County
USGS Gage Station: 0210166029 Rocky River @ SR 1300 Near Crutchfield Crossroads, NC
Reference Reach: UT to Wells Creek, Cane Creek Mountains, Alamance County

Variables	Existing Constructed Channel		Proposed Reach		Reference Reach		USGS Gage Station
27. Ratio of Pool Width to Bankfull Width	Mean: Range:	1.0 0.9 - 1.1	Mean: Range:	1.1 0.7 - 1.2	Mean: Range:	1.1 0.7 - 1.2	Mean: Range:
28. Bankfull Cross-sectional Area at Pool (Apool) sq ft	Mean: Range:	21.3 18.5 - 24.1	Mean: Range:	25.5 20.4 - 28.9	Mean: Range:	7.8 6.2 - 8.9	Mean: Range:
29. Ratio of Pool Area to Bankfull Area (Apool/Abkf)	Mean: Range:	1.4 1.2 - 1.6	Mean: Range:	1.5 1.2 - 1.7	Mean: Range:	1.5 1.2 - 1.7	Mean: Range:
30. Pool to Pool Spacing (p-p) ft	Mean: Range:	59.9 29.8 - 139.6	Mean: Range:	69.0 31.5 - 118.5	Mean: Range:	36.5 17.0 - 63.0	Mean: Range:
31. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-	Mean: Range:	4.0 2.0 - 9.4	Mean: Range:	4.6 2.1 - 7.9	Mean: Range:	4.6 2.1 - 7.9	Mean: Range:
32. Pool Length (Lp) ft	Mean: Range:	36.8 8.0 - 61.1	Mean: Range:	27.0 13.5 - 51.0	Mean: Range:	14.5 7.0 - 27.0	Mean: Range:
33. Ratio of Pool Length to Bankfull Width (Lp/Wbkf)	Mean: Range:	2.5 0.5 - 4.1	Mean: Range:	1.8 0.9 - 3.4	Mean: Range:	1.8 0.9 - 3.4	Mean: Range:
34. Riffle Slope (Sriff) ft / ft	Mean: Range:	0.0200 0.0027 - 0.0483	Mean: Range:	0.0154 0.0058 - 0.0256	Mean: Range:	0.0389 0.0173 - 0.0783	Mean: Range:
35. Ratio of Riffle Slope to Average Slope (Sriff/Sbkf)	Mean: Range:	3.8 0.5 - 9.1	Mean: Range:	2.4 0.9 - 4.0	Mean: Range:	2.4 0.9 - 4.0	Mean: Range:
36. Maximum Riffle Depth (driff) ft	Mean: Range:	1.6 1.4 - 2.1	Mean: Range:	1.8 1.4 - 2.2	Mean: Range:	1.1 0.9 - 1.4	Mean: Range:
37. Ratio of Riffle Depth to Bankfull Mean Depth	Mean: Range:	1.6 1.4 - 2.1	Mean: Range:	1.6 1.3 - 2.0	Mean: Range:	1.6 1.3 - 2.0	Mean: Range:
38. Run Slope (Srun) ft / ft	Mean: Range:	N/A	Mean: Range:	0.0038 0.0026 - 0.0230	Mean: Range:	0.0307 0.008 - 0.0712	Mean: Range:
39. Ratio of Run Slope to Average Slope (Srun/Sbkf)	Mean: Range:	N/A	Mean: Range:	1.6 0.4 - 3.6	Mean: Range:	1.6 0.4 - 3.6	Mean: Range:
40. Maximum Run Depth (drun) ft	Mean: Range:	N/A	Mean: Range:	2.0	Mean: Range:	1.3	Mean: Range:
41. Ratio of Run Depth to Bankfull Mean Depth	Mean: Range:	N/A	Mean: Range:	1.8	Mean: Range:	1.8	Mean: Range:
42. Slope of Glide (Sgl) ft / ft	Mean: Range:	0.0007	Mean: Range:	0.0038 0.0 - 0.0102	Mean: Range:	0.0114 0.0 - 0.0325	Mean: Range:
43. Ratio of Glide Slope to Average Water Surface Slope	Mean: Range:	0.1	Mean: Range:	0.6 0.0 - 1.6	Mean: Range:	0.6 0.0 - 1.6	Mean: Range:
44. Maximum Glide Depth (dgl) ft	Mean: Range:	2.6 2.1 - 2.8	Mean: Range:	1.9	Mean: Range:	1.2	Mean: Range:
45. Ratio of Glide Depth to Bankfull Mean Depth	Mean: Range:	2.6 2.1 - 2.8	Mean: Range:	1.7	Mean: Range:	1.7	Mean: Range:
46. Step Slope (Sst)	Mean: Range:	N/A	Mean: Range:	N/A	Mean: Range:	0.2112 0.1375 - 0.285	Mean: Range:
47. Ratio of Step Slope to Average Water Surface Slope	Mean: Range:	N/A	Mean: Range:	N/A	Mean: Range:	10.7 7.0 - 14.5	Mean: Range:
48. Maximum Step Depth (dst)	Mean: Range:	N/A	Mean: Range:	N/A	Mean: Range:	1.1 1.0 - 1.1	Mean: Range:
49. Ratio of Step Depth to Bankfull Mean Depth	Mean: Range:	N/A	Mean: Range:	N/A	Mean: Range:	1.5 1.4 - 1.6	Mean: Range:

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA
(Adapted from Rosgen, 1996)

TABLE 3

Restoration Site: Wells Creek, UT, Sydnor Property, Alamance County
USGS Gage Station: 0210166029 Rocky River @ SR 1300 Near Crutchfield Crossroads, NC
Reference Reach: UT to Wells Creek, Cane Creek Mountains, Alamance County

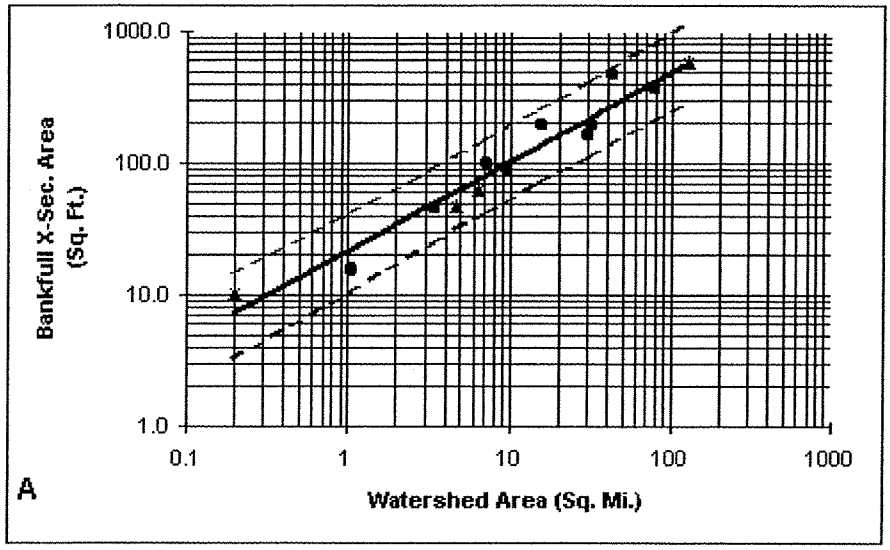
Variables	Existing Constructed Channel	Proposed Reach	Reference Reach	USGS Gage Station
Materials:				
Particle Size Distribution of Channel Material (mm)				
D16	N/A	Expected to	0.1	
D35	N/A	Coarsen	0.6	
D50	0.6		4.5	
D84	13.0		53.0	
D95	25.0		96.0	
Particle Size Distribution of Bar Material (mm)				
D16	Sample not	Expected to	0.1	
D35	Collected	Coarsen	0.3	
D50			0.7	
D84			7.0	
D95			12.0	
Largest Size Particle on Bar			20.0	

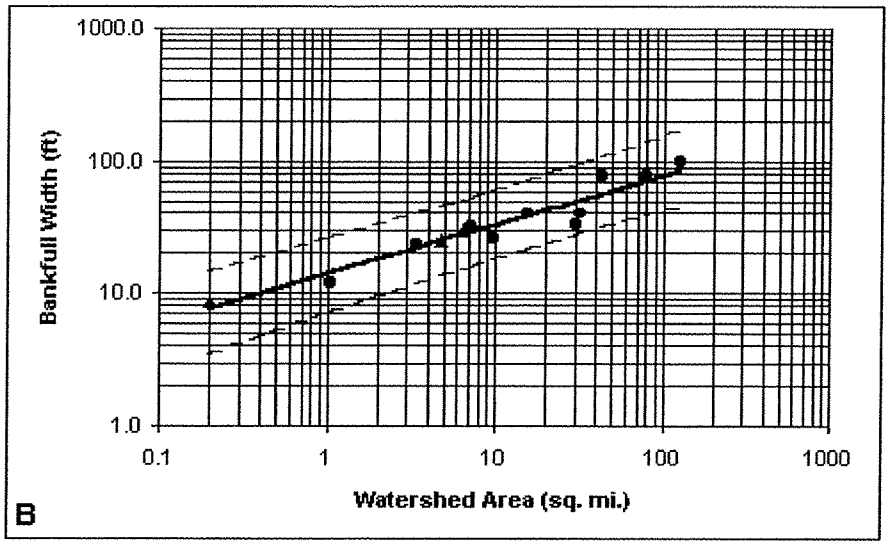
Sediment Transport:		
Sediment Transport Validation (Based on Bankfull Shear Stress)	**Existing**	**Proposed**
Calculated value (mm) from curve	24	55
Calculated Shear Stress (lb/ft2)	0.314	0.72
Critical dimensionless shear stress	Not Calculated. No bar sample collected.	0.027
Minimal mean dbkf (ft) calculated using critical dimensionless shear stress equations	Not Calculated. No bar sample collected.	1.8

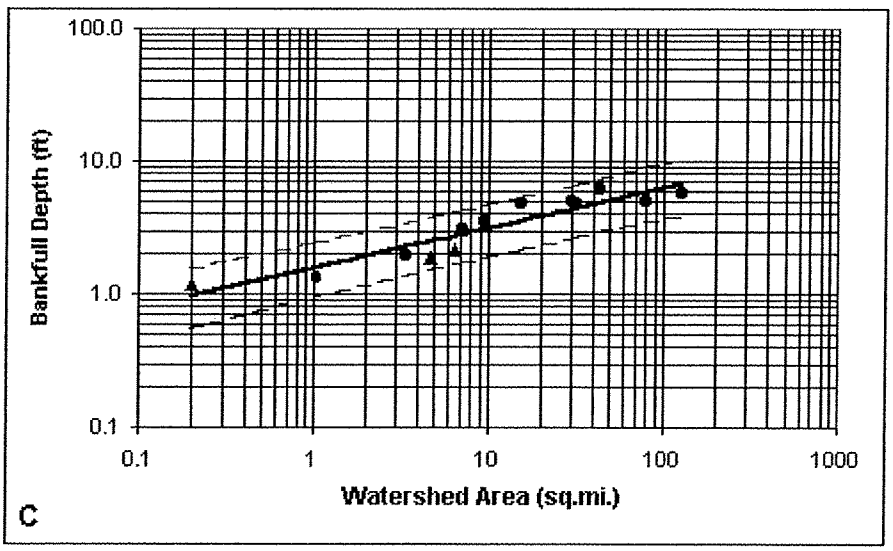
Appendix A

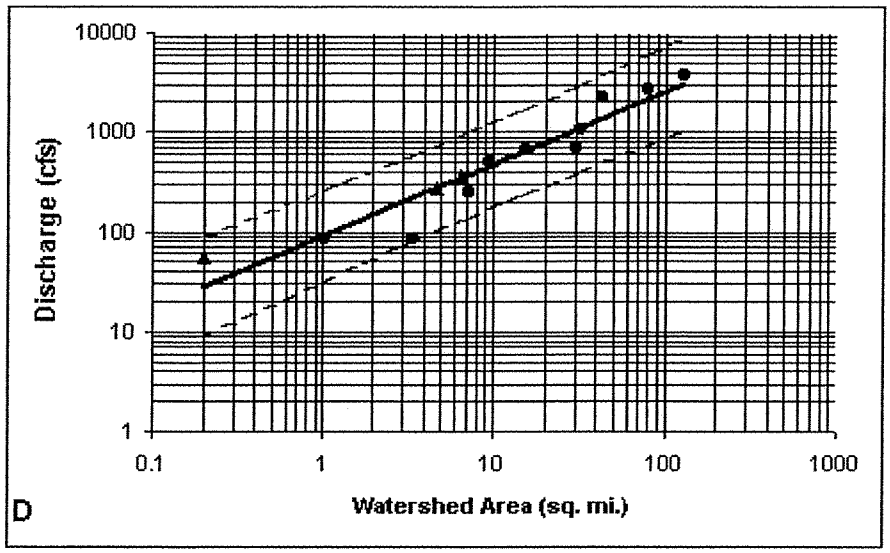
Regional Curves

Bankfull hydraulic geometry relationships for rural Piedmont North Carolina Streams. The four graphs represent:
a) cross sectional area, b) width, c) depth, and d) discharge. The circles represent gage stations and the triangles represent ungaged streams. The outside dashed lines are the 95% confidence intervals for all the data points.








10000
1000
100
10
1
Discharge (cfs)
0.1
1
10
100
1000
Watershed Area (sq. mi.)
D

Appendix B

Project Contacts

Project Contacts
Wells Creek at Sydnor Property
Baseline Monitoring

ARCADIS G&M of North Carolina, Inc. designed the restoration project. Contact Mr. Robert Lepsic, 801 Corporate Center Drive, Suite 300, Raleigh, NC 27607-5073. Phone (919) 854-1282.

A&D Environmental and Industrial Services, Inc. constructed the restoration project. Contact Mr. Dave Farmer, 2718 Uwharrie Road, Archdale, NC 27263. Phone (336) 434-7750.

Ecosystem Enhancement Program project manager is Mr. Jason Guidry, 1652 Mail Center, Raleigh, NC 27699-1652. Phone (919) 715-1061.

Appendix C

Photographs

Reach #1. Photograph Point #1. Looking upstream. 06/15/04 37

Reach #1. Photograph Point #1. Looking downstream. 06/15/04 38

Reach #1. Vegetation Plot #1. View from southeast corner looking to northeast corner. 06/15/04 39

Reach #1. Photograph Point #2. Looking downstream. 06/15/04 40

Reach #1. Photograph Point #2. Looking upstream. 06/15/04 41

Reach #1. Photograph Point #2. Looking north. 06/15/04 42

Reach #1. Cross Section #1. Maximum Pool. Looking west to east. 06/15/04 43

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Reach #1. Photograph Point #3. Looking upstream. 06/15/04 46

Reach #1. Photograph Point #3. Looking downstream. 06/15/04 47

Reach #1. Cross Section #3. Riffle. Looking east to west. 06/15/04 49

Reach #1. Vegetation Plot #3. View from southeast corner looking to northwest corner. 06/15/04 50

Reach #1. Photograph Point #4. Looking upstream. 06/15/04 51

Reach #1. Cross Section #4. Maximum Pool. Looking west to east. 06/15/04 52

Reach #2. Photograph Point #5. Looking upstream. 06/15/04 9

Reach #2. Photograph Point #5. Looking downstream. 06/15/04 10

Reach #2. Vegetation Plot #7. View from northeast corner looking to southwest corner. 06/15/04 11

Reach #2. Cross Section #9. Riffle. Looking south to north. 06/15/04 12

Reach #2. Photograph Point #6. Looking upstream. 06/15/04 7

Reach #2. Photograph Point #6. Looking downstream. 06/15/04 8

Reach #2. Cross Section #10. Maximum Pool. Looking south to north. 06/15/04 13

Reach #2. Vegetation Plot #8. View from east corner looking to west corner. 06/15/04 14

Reach #2. Photograph Point #7. Looking upstream. 06/15/04 5

Reach #2. Photograph Point #7. Looking downstream. 06/15/04 6

Reach #2. Vegetation Plot #9. View from southeast corner looking to northwest corner. 06/15/04 15

Reach #2. Photograph Point #8. Looking upstream. 06/15/04 4

Reach #2. Photograph Point #8. Looking downstream. 06/15/04 3

Reach #2. Cross Section #11. Riffle. Looking south to north. 06/15/04 16

Reach #2. Photograph Point #9. Looking upstream. 06/15/04 1

Reach #2. Photograph Point #9. Looking downstream. 06/15/04 2

Reach #2. Cross Section #12. Maximum Pool. Looking north to south. 06/15/04 17

UT. Photograph Point #10. Looking upstream. 06/15/04 33

UT. Photograph Point #10. Looking downstream. 06/15/04 34

UT. Cross Section #5. Maximum Pool. Looking east to west. 06/15/04 32

UT. Vegetation Plot #4. View from southwest corner looking to northeast corner. 06/15/04 31

UT. Cross Section #6. Riffle. Looking west to east. 06/15/04 30

UT. Photograph Point #11. Looking upstream. 06/15/04 28

UT. Photograph Point #11. Looking downstream. 06/15/04 29

UT. Vegetation Plot #5. View from northeast corner looking to southwest corner. 06/15/04 36

UT. Cross Section #7. Riffle. Looking east to west. 06/15/04 35

UT. Photograph Point #12. Looking upstream. 06/15/04 26

UT. Photograph Point #12. Looking downstream. 06/15/04 25

UT. Cross Section #8. Maximum Pool. Looking west to east. 06/15/04 24

UT. Photograph Point #13. Looking upstream. 06/15/04 22

UT. Photograph Point #13. Looking downstream. 06/15/04 23

UT. Vegetation Plot #6. View from northwest corner looking to southeast corner. 06/15/04 21