UNDERWOOD MITIGATION SITE

Chatham County, NC

DENR Contract No. 003268

Mitigation Plan

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UNDERWOOD MITIGATION SITE
Mitigation Plan

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EXECUTIVE SUMMARY

The Underwood Mitigation Project site is located in northwestern Chatham County approximately 5 miles northeast of Siler City. The project will consist of a combination of restoration and enhancement of streams and non-riparian wetlands and restoration and creation of riparian wetlands. Restoration is proposed for three segments of the South Fork of Cane Creek and portions of three tributaries totaling 4,602 linear feet (LF) of stream restoration. Enhancement I is proposed for 1,182 LF of two unnamed tributaries of the South Fork referred to as UT2 SF4A and a short section of South Fork. Enhancement II is proposed for 3,405 LF of stream including a section of the South Fork called SF2 and the upstream portion of reach SF3 along with portions of tributaries UT1, UT1A and UT1B. A total of 13.76 acres of riparian wetlands will be restored and created adjacent to the streams and 1.54 acres of non-riparian wetlands will be restored and enhanced. A small unnamed tributary to the South Fork (SF1A) will be reconstructed to provide a stable outlet for an existing pond and improve adjacent wetland hydrology. However, no mitigation credit will be claimed for this channel.

The project is located within the North Carolina Ecosystem Enhancement Program (NCEEP) targeted watershed for the Cape Fear River Basin Hydrologic Unit 03030002050050 and North Carolina Division of Water Quality (NCDWQ) Subbasin 03-06-04. The proposed project will provide numerous ecological benefits within the Cape Fear River Basin. While many of these benefits are limited to the Underwood Site project area, others, such as pollutant removal and improved aquatic and terrestrial habitat have more far-reaching effects. Expected improvements to water quality and ecological processes are outlined below in Table ES.1 as project goals.

Table ES.1 Project Goals and Objectives
Underwood Mitigation Project

Primary Goals (Measured)	
Project goal	**How project will seek to reach goal**
Restore and stabilize stream dimensions	Riffle cross sections of the restoration and enhancement reaches will be constructed to remain stable and will show little change in bankfull area, maximum depth ratio and width-to-depth ratio over time.
Restore and stabilize stream pattern and profile	The project will be constructed so that the bedform features of the restoration reaches will remain stable overtime. This will include riffles that remain steeper and shallower than the pools and pools that are deep with flat water surface slopes. The relative percentage of riffles and pools will not change significantly over time. Banks will be constructed so that bank height ratios will remain very near to 1.0 for nearly all of the restoration reaches.
Establish proper substrate distribution throughout stream	Stream substrate will remain coarse in the riffles and finer in the pools.
Establish wetland hydrology for	A free groundwater surface will be present within 12 inches of the

Primary Goals (Measured)	
restored and created wetlands	ground surface for a minimum of 6.5 percent of the growing season measured on consecutive days under typical precipitation conditions.
Restore native vegetation throughout wetlands and riparian buffers	Native vegetation appropriate for the wetland and riparian buffer zones on the site will be planted throughout. The planted trees will become well established and survival criteria will be met.

Secondary Goals (Unmeasured)	
Project goal	**How project will seek to reach goal**
Improve aquatic and benthic habitat	Channel form will include riffle and pool sequences, gravel and cobble zones of macroinvertebrate habitat and deep pool habitat for fish. Introduction of large woody debris, rock structures, root wads, and native stream bank vegetation will substantially increase habitat value.
Decrease nutrient loads	Livestock will be fenced out of the stream and riparian zone. Nutrient input will be absorbed on-site by filtering flood flows through restored floodplain areas and wetlands, where flood flows can disperse through native vegetation and be captured in wetlands. Increased surface water residency time will provide contact treatment time and groundwater recharge potential.
Reduce sediment, bacteria, and other pollutant inputs	Sediment input from eroding stream banks will be reduced by installing bioengineering and in-stream structures while creating a stable channel form using geomorphic design principles. Pollutants from off-site sources will be captured by deposition on restored floodplain areas where native vegetation will slow overland flow velocities. Bacteria pollution from livestock will be reduced.
Decrease water temperature and increase dissolved oxygen concentrations	Gravel bed channel designs will incorporate restored riffle sequences where distinct points of re-aeration can occur will allow for oxygen levels to be maintained in the perennial reaches. Deep pool zones will lower temperature, helping to maintain dissolved oxygen concentrations. The establishment and maintenance of riparian buffers will create long-term shading of the channel flow to minimize thermal heating.
Create appropriate terrestrial habitat	Adjacent buffer areas will be restored by removing invasive vegetation and planting native vegetation. These areas will be allowed to receive more regular inundating flows. Riparian wetland areas will be restored and enhanced to provide wetland habitat.

Table ES.2.a Project Components
Underwood Mitigation Project

Project Reach	Existing Length (LF) or Area (AC)	Mitigation Level	Approach	Proposed Length (LF) or Area (ac)	Stationing	Mitigation Ratio	Mitigation Units (SMUs or WMUs)	Buffer Area* (ac)
Streams								
SF1	773	R	Priority 1	878	100+00 to 108+78	1:1	878	2.0

Project Reach	Existing Length (LF) or Area (AC)	Mitigation Level	Approach	Proposed Length (LF) or Area (ac)	Stationing	Mitigation Ratio	Mitigation Units (SMUs or WMUs)	Buffer Area* (ac)
SF2	302	E II	N/A	302	300+00 to 303+02	2.5:1	121	0.7
SF3	152	E I	N/A	153	419+84 to 421+37	1.5:1	102	0.35
SF3	532	E II	N/A	513	400+00 to 404+87, 405+08 to 405+34	2.5:1	205	1.2
SF3	1,499	R	Priority 1	1,450	405+34 to 419+84	1:1	1,450	3.3
SF4	1,450	R	Priority 1	1,424	800+00 to 814+24	1:1	1,424	3.3
SF4A	0	R	Priority 1	259	906+09 to 908+68	1:1	259	0.6
SF4A	609	E I	N/A	609	900+00 to 906+09	2.5:1	406	1.4
UT1	1,463	E II	N/A	1,406	500+00 to 509+73, 510+30 to 514+63	2.5:1	572	3.3
UT1	452	R	Priority 1	591	514+63 to 520+54	1:1	591	1.2
UT1A	524	E II	N/A	524	700+00 to 705+24	2.5:1	210	1.2
UT1B	660	E II	N/A	660	600+00 to 606+60	2.5:1	264	1.5
UT2	421	E I	N/A	421	0+00 to 4+21	1.5:1	281	1.0
Total	8,837	---	---	9,189	---	---	6,752	21.1
Wetlands								
RW1	1.25	R	N/A	1.25	N/A	1:1	1.3	N/A
RW2	0.45	C	N/A	0.45	N/A	3:1	0.2	N/A
RW2	0.5	R	N/A	0.5	N/A	1:1	0.5	N/A
RW3	2.63	C	N/A	2.63	N/A	3:1	0.9	N/A
RW3	1.33	R	N/A	1.33	N/A	1:1	1.3	N/A
RW4	3.95	C	N/A	3.95	N/A	3:1	1.3	N/A
RW4	3.65	R	N/A	3.65	N/A	1:1	3.7	N/A
NRW1	1.2	R	N/A	1.2	N/A	1:1	1.2	N/A
NRW2	0.34	E	N/A	0.34	N/A	2:1	0.17	---
Total	15.3	---	N/A	15.3	---	---	10.4	---

Table ES.2.b Summary of Mitigation
Underwood Mitigation Project

Mitigation Level	Stream Length (LF)	SMUs	Riparian Wetland (acres)	Riparian WMUs	Non-Riparian Wetland (acres)	Non-Riparian WMUs
Restoration (R)	4,602	4,602	6.7	6.7	1.2	1.2
Enhancement (E)	4,588	2,151	0.0	0.0	0.34	0.2
Preservation (P)	N/A	N/A	N/A	N/A	N/A	N/A
Creation (C)	N/A	N/A	7.03	2.3	N/A	N/A
TOTAL	9,190	6,753	13.8	9.1	1.5	1.4

This document is consistent with the requirements of the federal rule for compensatory mitigation project sites as described in the Federal Register Title 33 Navigation and Navigable Waters Volume 3 Chapter 2 Section 332.8 paragraphs (c) (2) through (c) (14). Specifically the document addresses the following requirements of the federal rule:

(2) *Objectives.* A description of the resource type(s) and amount(s) that will be provided, the method of compensation (i.e., restoration, establishment, enhancement, and/or preservation), and the manner in which the resource functions of the compensatory mitigation project will address the needs of the watershed, Ecoregion, physiographic province, or other geographic area of interest.

(3) *Site selection.* A description of the factors considered during the site selection process. This should include consideration of watershed needs, onsite alternatives where applicable, and the practicability of accomplishing ecologically self-sustaining aquatic resource restoration, establishment, enhancement, and/or preservation at the compensatory mitigation project site. (See §332.3(d))

(4) *Site protection instrument.* A description of the legal arrangements and instrument, including site ownership, that will be used to ensure the long-term protection of the compensatory mitigation project site (see §332.7(a)).

(5) *Baseline information.* A description of the ecological characteristics of the proposed compensatory mitigation project site and, in the case of an application for a DA permit, the impact site. This may include descriptions of historic and existing plant communities, historic and existing hydrology, soil conditions, a map showing the locations of the impact and mitigation site (s) or the geographic coordinates for those sites (s), and other site characteristics appropriate to the type of resource proposed as compensations. The baseline information should also include a delineation of waters of the United States on the proposed compensatory mitigation project site. A prospective permittee planning to secure credits from an approved mitigation bank or in-lieu fee program only needs to provide baseline information about the impact site, not the mitigation bank or in-lieu fee project site.

(6) *Determination of credits.* A description of the number of credits to be provided, including a brief explanation of the rationale for this determination (see §332.3(f)).

(7) *Mitigation work plan.* Detailed written specifications and work descriptions for the compensatory mitigation project; construction methods, timing, and sequence; source(s) of water, including connections to existing waters and uplands; methods for establishing the desired plant community; plans to control invasive plant species; the proposed grading plan, including elevations and slopes of the substrate; soil management; and erosion control measures. For stream compensatory mitigation projects, the mitigation work plan may also include other relevant information, such as plan form geometry, channel form (e.g. typical channel cross sections), watershed size, design discharge, and riparian area plantings.

(8) *Maintenance plan.* A description and schedule of maintenance requirements to ensure the continued viability of the resource once initial construction is completed.

(9) *Performance standards.* Ecologically-based standards that will be used to determine whether the compensatory mitigation project is achieving its objectives (See §332.5).

(10) *Monitoring requirements.* A description of parameters to be monitored in order to determine if the compensatory mitigation project is on track to meet performance standards and if adaptive management is needed. A schedule for monitoring and reporting on monitoring results to the district engineer must be included. (See §332.6)

(11) *Long-term management plan.* A description of how the compensatory mitigation project will be managed after performance standards have been achieved to ensure the long-term sustainability of the resource, including long-term financing mechanisms and the party responsible for long-term management. (See §332.7(d))

(12) *Adaptive management plan.* A management strategy to address unforeseen changes in site conditions or other components of the compensatory mitigation project, including the party or parties responsible for implementing adaptive management measures. The adaptive management plan will guide decisions for management measures. The adaptive management plan will guide decisions for revising compensatory mitigation plans and implementing measures to address both foreseeable and unforeseen circumstances that adversely affect compensatory mitigation success. (See §332.7(c))

(13) *Financial assurances.* A description of financial assurances that will be provided and how they are sufficient to ensure a high level of confidence that the compensatory mitigation project will be successfully completed, in accordance with its performance standards (See §332.3(n))

1.0 Project Site Identification and Location

The North Carolina Ecosystem Enhancement Program (NCEEP) proposes to restore and enhance 9,214 linear feet (LF) of stream, restore and create 13.76 acres of riparian wetlands, and restore and enhance 1.54 acres of non-riparian wetlands in Chatham County, NC. The mitigation site includes two separate areas referred to as the Upstream Area and the Downstream Area which are approximately two miles apart but within the same watershed (Figure 1). The streams proposed for restoration and enhancement include South Fork Cane Creek (South Fork) and five unnamed tributaries: UT1, UT1A, UT1B, UT2, and SF4A. South Fork is broken into 4 reaches (SF1, SF2, SF3, & SF4) based on geographic separation. A small tributary (SF1A) will be reconstructed to stabilize the channel and aid in wetland creation but no credit will be claimed for this reach. The project also includes restoration and enhancement of degraded wetlands located adjacent to South Fork and three of the unnamed tributaries. The project streams ultimately flow into the Haw River which is part of the Cape Fear River Basin. Photographs of the project site are included in Appendix 1.

As a result of the proposed restoration activities, total stream length within the project area will be increased from approximately 8,622 LF to 9,189 LF. The proposed stream restoration designs will primarily be a Priority 1 approach and the stream types for the restored streams will be similar to E or C channels under the Rosgen classification system. Stream enhancements will include restoring riparian buffer and performing bed and bank improvements as needed and, in some cases include raising the channel bed. The wetland restoration and enhancement designs will be based on reference conditions and will restore and enhance Piedmont bottomland hardwood forest. Based on the proposed mitigation effort, the project will result in 6,752 stream mitigation units (SMUs), 9.07 riparian wetland mitigation units (WMUs), and 1.37 non-riparian WMUs. The mitigation activities are summarized in Tables 1a and 1b.

1.1 Directions to Project Site

The two locations of the proposed stream and wetland mitigation sites are located in western Chatham County along Clyde Underwood Road just west of Planfield Church Road (Upstream Area) and southwest of Moon Lindley Road between Johnny Lindley Road and Bob Clark Road (Downstream Area) north of Siler City, North Carolina (Figure 1). The sites are currently used for agriculture and are within the Cape Fear River Basin (HUC 03030002).

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

South Fork Cane Creek and its tributaries are located within North Carolina Division of Water Quality (NCDWQ) Subbasin 03-06-04 of the Cape Fear River Basin (USGS Hydrologic Unit 03030002) as shown in Figure 1. Subbasin 03-06-04 includes the Haw River and the Haw River arm of Jordan Lake. The targeted local watershed within the Cape Fear River Basin is hydrologic Unit Code (HUC) 03030002050050. South Fork flows north into Alamance County where it joins Cane Creek. Cane Creek flows into the Haw River from the south at the Alamance-Orange County line. It should not be confused with the Cane Creek that flows into a water supply reservoir in Orange County and then joins the Hall from the north near the Orange-Alamance County Line.

The NCDWQ assigns best usage classifications to State Waters that reflect water quality conditions and potential resource usage. The South Fork of Cane Creek (NCDWQ AU No. 16-28-5) is the main stream of the project and has been classified as Class WS-V; NSW waters. Class WS-V waters are water supplies which are generally upstream and draining to Class

1.3 Project Components and Structure

Table 1a. Project Components
Underwood Mitigation Project

Project Reach	Existing Length (LF) or Area (AC)	Mitigation Level	Approach	Proposed Length (LF) or Area (ac)	Stationing	Mitigation Ratio	Mitigation Units (SMUs or WMUs)	Buffer Area* (ac)
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UT2	421	E I	N/A	421	200+00 to 204+21	1.5:1	281	20.8
Total	8,837	---	---	9,215	---	---	6,763	41.6
Wetlands								
RW1	1.25	R	N/A	1.25	N/A	1:1	1.3	N/A
RW2	0.45	C	N/A	0.45	N/A	3:1	0.2	N/A

Project Reach	Existing Length (LF) or Area (AC)	Mitigation Level	Approach	Proposed Length (LF) or Area (ac)	Stationing	Mitigation Ratio	Mitigation Units (SMUs or WMUs)	Buffer Area* (ac)
RW2	0.5	R	N/A	0.5	N/A	1:1	0.5	N/A
RW3	2.63	C	N/A	2.63	N/A	3:1	0.9	N/A
RW3	1.33	R	N/A	1.33	N/A	1:1	1.3	N/A
RW4	3.95	C	N/A	3.95	N/A	3:1	1.3	N/A
RW4	3.65	R	N/A	3.65	N/A	1:1	3.7	N/A
NRW1	1.2	R	N/A	1.2	N/A	1:1	1.2	N/A
NRW2	0.34	E	N/A	0.34	N/A	2:1	0.17	---
Total	15.3	---	N/A	15.3	---	---	10.4	---

Table 1b. Summary of Mitigation
Underwood Mitigation Project

Mitigation Level	Stream Length (LF)	SMUs	Riparian Wetland (acres)	Riparian WMUs	Non-Riparian Wetland (acres)	Non-Riparian WMUs
Restoration (R)	4,602	4,602	6.7	6.7	1.2	1.2
Enhancement (E)	4,588	2,151	0.0	0.0	0.34	0.2
Preservation (P)	N/A	N/A	N/A	N/A	N/A	N/A
Creation (C)	N/A	N/A	7.03	2.3	N/A	N/A
TOTAL	9,190	6,753	13.8	9.1	1.5	1.4

WS-IV waters which include waters used by industry to supply their employees with drinking water or as waters formerly used as water supply. These waters are also protected for Class C uses. The Nutrient Sensitive Waters (NSW) classification is a supplemental classification for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation (NCDWQ, 2011).

2.0 Watershed Characterization

2.1 Drainage Area, Project Area, and Easement Acreage

The drainage areas for the Upstream Area and Downstream Area portions of South Fork are 1,051 acres (1.64 square miles) and 3,362 acres (5.25 square miles) respectively. This watershed is located in the Piedmont, northeast of Siler City, NC and is shown in Figure 2. The drainage area of each of the stream project reaches is included in Table 2.

Table 2. Drainage Areas
Underwood Mitigation Project

Project Reach	Existing Length (LF)	Drainage Area (acres)
SF1	682	134
SF2	302	781
SF3	2,165	1,056
SF4	1,350	3,362
SF4A	868	637
UT1	1,843	230
UT1A	524	11
UT1B	660	11
UT2	421	78

The Upstream Area of the Underwood mitigation project is located within three tracts of land. The first is an 84 acre tract owned by Mary Jean Harris (Deed Book 05E, Page Number 0102). A conservation easement has been recorded on 7.68 acres of this tract. The second and third tracts include a 46.4 acre tract owned by William Darrel Harris (Deed Book 673, Page Number 532) and a 47.2-acre tract also owned by William Darrel Harris (Deed Book 972, Page Number 0977). A conservation easement has been recorded on 18.44 acres of these tracts. The Downstream Area of the project is located within two tracts of land. The first is a 150-acre tract owned by James Randall Lindley (Deed Book 06E, Page Number 0098). A conservation easement has been recorded on the 5.34-acre project area within this tract. The second is an 82-acre tract owned by Jonathan Marshall Lindley (Deed Book 716, Page Number 0707). A conservation easement has been recorded on the 6.29-acre project area within this tract. The conservation easements allow for the restoration work to occur and protect the project area in perpetuity.

2.2 Surface Water Classification and Water Quality

On February 19, 2010 and May 6, 2011, Wildlands Engineering, Inc. (WEI) investigated and assessed on-site jurisdictional Waters of the United States using the U.S. Army Corps of Engineers (USACE) Routine On-Site Determination Method. This method is defined in the 1987 Corps of Engineers Wetlands Delineation Manual. Determination methods included stream classification utilizing the NCDWQ Stream Identification Form and the USACE Stream Quality Assessment Worksheet. Potential jurisdictional wetland areas as well as typical upland areas were classified using the USACE Routine Wetland Determination Data Form. On-site jurisdictional wetland areas were also assessed using the North Carolina Wetland Assessment Method (NCWAM). All USACE and NCWAM wetland forms are included in Appendix 2.

The results of the on-site field investigation indicate that there are 11 jurisdictional stream channels on the Upstream Area and Downstream Area properties, nine of which are included in the project. These include South Fork Cane Creek and six unnamed tributaries (Figure 3). Other intermittent tributaries have been identified that will not be included in the project. No jurisdictional wetlands were identified on the site. South Fork is classified as Class WS-V, Nutrient Sensitive Waters (NSW) by the NCDWQ. All NCDWQ Stream Classification Forms are included in Appendix 3. The proposed restoration project includes South Fork and six of the unnamed tributaries. All of these streams are protected under the conservation easement that has been placed on the property. A copy of the Jurisdictional Determination is included in Appendix 2.

2.3 Physiography, Geology, and Soils

The Underwood Mitigation Site is located in the Carolina Slate Belt of the Piedmont Physiographic Province. The Piedmont Province is characterized by gently rolling, well rounded hills with long low ridges, with elevations ranging anywhere from 300 to 1,500 feet above sea level. The Carolina Slate Belt consists of heated and deformed volcanic and sedimentary rocks. Approximately 550 to 650 million years ago, this region was the site of a series of oceanic volcanic islands. The belt is known for its numerous abandoned gold mines and prospects. Specifically, the project site is located in the CZfv formation of the Carolina Slate Belt. This formation consists of light gray to greenish gray, felsic metavolcanic rock interbedded with mafic and intermediate metavolcanic rock, meta-argillite, and metamudstone. (NCGS, 2009).

The floodplain areas of the proposed project are mapped by the Chatham County Soil Survey. Soils along the UT1, UT1A, UT1B, SF2 and SF3 floodplains are primarily mapped as the Nanford-Badin complex. SF1 is primarily mapped as the Cid-Lignum complex. UT2 is located in Georgeville silt loam soil. SF4 and SF4A are mapped in the Chewacla and Wehadkee soils. These soils are described below in Table 3. A soils map is provided in Figure 4. Soil profiles sealed by a NC registered soil scientist are included in Appendix 4. Appendix 4 also includes data for additional borings collected by WEI.

Table 3. Floodplain Soil Types and Descriptions
Underwood Mitigation Project

Soil Name	Location	Description
Chewacla and Wehadkee, 0-2% slopes	Majority of SF4 and SF4A	Chewacla and Wehadkee soils consist of nearly level, very deep, poorly and somewhat poorly drained soils. These are typically floodplain areas. They have a loamy surface layer and subsoil. Permeability is moderate and shrink-swell potential is low. These soils are subject to frequent flooding.
Cid-Lignum complex, 2-6% slopes	Majority of SF1, and portions of SF2, SF3, and UT2	Cid and Lignum soils series are gently sloping, moderately deep to deep, moderately well-drained to somewhat poorly drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is slow and shrink-swell potential is moderate.
Georgeville silt loam, 2-6% slopes	Majority of UT2 and portions of UT2A and SF1	Georgeville soils are gently sloping to strongly sloping, very deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low.
Georgeville-Badin complex, 10-15% slopes	Portion of SF4A	Georgeville and Badin soils are gently sloping to strongly sloping, moderately deep to very deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low to moderate.

Soil Name	Location	Description
Nanford-Badin complex, 2-6% slopes	Portions of UT1A, SF3, and SF4A	These Nanford and Badin soils are gently sloping, moderately deep to deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low to moderate.
Nanford-Badin complex, 6-10% slopes	Majority of UT1, UT1A, UT1B, UT2A, SF2, and SF3, and portions of SF4, and SF4A	These Nanford and Badin soils are gently sloping to steep, moderately deep to deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low to moderate.
Nanford-Badin complex, 10-15% slopes	Portions of UT1 and UT1B	These Nanford and Badin soils are steep, moderately deep to deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low to moderate.
Source: Chatham County Soil Survey, USDA-NRCS, http://efotg.nrcs.usda.gov		

2.4 Historical Land Use and Development Trends

The Cape Fear 0303002 includes developing areas such as the cities of Greensboro, Durham, Burlington, and Chapel Hill as well as the I-40/I-85 transportation corridor. Population growth and the associated development and infrastructure projects create the necessity for mitigation projects in this region. Land in western Chatham County, other than the town of Siler City, is largely forested or used for agriculture. Approximately 60% of the land in the project watershed is forest, 39% is classified as managed herbaceous cover or agricultural, and the remaining 1% is split between unmanaged herbaceous and open water (MRLC, 2001).

2.5 Watershed Planning

The NCEEP follows the Compensation Planning Framework when targeting mitigation sites for implementation. The first planning stage is the development of River Basin Restoration Priority Plans (RBRPs) to prioritize specific watersheds within the 8-digit hydrologic units in which to implement mitigation projects. Through the development of RBRPs, NCEEP develops restoration goals and priorities for 14-digit hydrologic units referred to as “Targeted Local Watersheds.” All Full Delivery Procurement projects must be located within Targeted Local Watersheds. The next phase of planning is the development of Local Watershed Plans to identify and prioritize specific mitigation projects. To date, no local watershed plan has been developed that includes the Cane Creek watershed. The NCDWQ prepares basinwide water quality plans for each of the State’s 17 river basins. The 2005 Cape Fear Basinwide Water Quality Plan does not include any assessment information or recommendations for Cane Creek or South Fork Cane Creek (note: the basinwide plan does include information on a different Cane Creek that is a tributary to the Haw River).

2.6 *Endangered and Threatened Species*

2.6.1 Site Evaluation Methodology

The Endangered Species Act (ESA) of 1973, amended (16 U.S.C. 1531 et seq.), defines protection for species with the Federal Classification of Threatened (T) or Endangered (E). An "Endangered Species" is defined as "any species which is in danger of extinction throughout all or a significant portion of its range" and a "Threatened Species" is defined as "any species which is likely to become an Endangered Species within the foreseeable future throughout all or a significant portion of its range" (16 U.S.C. 1532).

The US Fish and Wildlife Service (USFWS) and NC Natural Heritage Program (NHP) databases were searched for federally listed threatened and endangered plant and animal species for Chatham County, NC. Four federally listed species, the red-cockaded woodpecker (*Picoides borealis*), bald eagle (*Haliaeetus leucocephalus*), Cape Fear shiner (*Notropis mekistocholas*), and harperella (*Ptilimnium nodosum*) are currently listed in Chatham County (Table 4).

Table 4. Listed Threatened and Endangered Species in Chatham County, NC Underwood Mitigation Project

Species	Federal Status	Habitat	Biological Conclusion
Vertebrate			
Red-cockaded woodpecker (*Picoides borealis*)	E	Open stands of mature pines	No effect
Bald eagle (*Haliaeetus leucocephalus*)	BGEPA	Near large open water bodies: lakes, marshes, seacoasts, and rivers	No effect
Cape Fear shiner (*Notropis mekistocholas*)	E	Pools, riffles, and runs of rocky, clean freshwater streams	No effect
Vascular Plants			
Harperella (*Ptilimnium nodosum*)	E	Rocky or gravely shoals of clear swift-moving streams	No effect
E = Endangered; T=Threatened; BGEPA = Bald and Golden Eagle Protection Act			

2.6.2 Threatened and Endangered Species Descriptions

Red-Cockaded Woodpecker

The red-cockaded woodpecker is a medium-sized woodpecker species (8 to 9 inches in length). Distinctive coloration includes black and white feathers with a large white cheek patch and a black back with a white barred pattern. This species is typically found year-round in large open stands of pines with mature trees of 60+ years in age. The foraging habitat for this species may include pine hardwood stands of longleaf and southern pine, 30+ years in age. Occurrences of the red-cockaded woodpecker are listed as historic within Chatham County.

Bald Eagle

The bald eagle is a very large raptor species, typically 28 to 38 inches in length. Adult individuals are brown in color with a very distinctive white head and tail. Bald eagles typically live near large bodies of open water with suitable fish habitat including: lakes, marshes, seacoasts, and rivers. This species generally requires tall, mature tree species for nesting and roosting. Bald eagles were de-listed from the Endangered Species List in June 2007; however, this species remains under the protection of the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act (BGPA). This species is known to occur in every U.S. state except Hawaii.

Cape Fear Shiner

The Cape Fear shiner is a small minnow fish species, typically 6 centimeters in length. This species is pale silvery yellow in color with a black stripe along each side and yellow fins. Water willow beds in flowing areas of creeks and rivers appear to be part of the essential habitat for this species. Individuals can be found in pools, riffles, and slow runs of clean, rocky streams composed of gravel, cobble, and boulder substrates. Critical habitat for this species within Chatham County includes approximately 4.1 miles of the Rocky River from the NC-902 bridge downstream to the County Road 1010 Bridge. Additional critical habitat includes 0.5 mile of Bear Creek from the County Road 2156 bridge downstream to the Rocky River and 4.2 miles downstream within the Rocky River to 2.6 miles of the Deep River.

Harperella

Harperella is an obligate, annual vascular plant ranging in height from 6 to 36 inches. This plant exhibits small white clusters of flowers at the stem tops similar to Queen Anne's lace. This species typically flowers from May until the first frost. Ideal habitat for this species includes pond and riverine areas with gravelly shoals of clear, swift-flowing streams. These areas typically require moderately intensive spring floods to scour gravel bars and rock crevices to remove any competing vegetation. Known population occurrences of harperella have been observed in Chatham County within the past 20 years.

2.6.3 Biological Conclusion

A pedestrian survey of the site was performed on February 18, 2010. On-site habitats include active pastures, successional woodlands, and streamside thickets. The creeks on site provide poor quality potential habitat for Cape Fear shiner. Known populations in the area are in a different river basin (Deep Creek). No shoals of the type utilized by harperella occur on the project site. No habitat for red-cockaded woodpecker occurs on site as they require 60+ year old pine trees. There is no suitable nesting or breeding habitat for bald eagles located within the site, as they require tall, mature trees. Additionally, no suitable feeding habitat for bald eagles is located at the site or within close proximity, such as lakes or large rivers. As a result of the pedestrian survey, no individual species were found to exist on the site.

2.6.4 Federal Designated Critical Habitat

2.6.4.1 Habitat Description

The USFWS has designated Chatham County as exhibiting critical habitat for the Cape Fear shiner. This Critical Habitat includes approximately 4.1 miles of the Rocky River from the NC-902 Bridge downstream to the County Road 1010 Bridge. Additional critical habitat includes 0.5 mile of Bear Creek from the County Road 2156 Bridge downstream to the Rocky River and 4.2 miles downstream within the Rocky River to 2.6 miles of the Deep River. These Critical Habitat locations, however, do not fall within the South Fork Cane Creek watershed. Clean, rocky streams composed of gravel, cobble, and boulder substrates with water willow beds in the flowing areas of creeks and rivers appear to be part of the essential habitat for this species. The results of the pedestrian survey performed on February 18, 2010 indicate that in-stream habitat exhibits poor conditions for the presence of Cape Fear shiner. In-stream habitat includes some gravel and cobble; however these substrates are dominated by finer sands and silts as a result of heavy bank erosion throughout the project reaches. No Critical Habitat for the listed species exists within the project areas.

2.6.4.2 Biological Conclusion

It is determined that the proposed restoration activities will have no impact on the Critical Habitat of the Cape Fear shiner.

2.6.5 USFWS Concurrence

WEI requested review and comment from the USFWS on July 12, 2010, regarding the results of the site investigation of the Underwood Mitigation Site and its potential impacts on threatened or endangered species. Since no response was received from the USFWS within a 30-day time frame, it is assumed that the site determination is correct and that no additional, relevant information is available for this site. A further review of the North Carolina Natural Heritage Program's (NCNHP) element occurrence GIS data layer shows that no natural heritage elements occur within 3.5 miles of the proposed project areas. All correspondence is included in Appendix 5.

2.7 Cultural Resources

2.7.1 Site Evaluation Methodology

The National Historic Preservation Act (NHPA) of 1966, amended (16 U.S.C. 470), defines the policy of historic preservation to protect, restore, and reuse districts, sites, structures, and objects significant in American history, architecture, and culture. Section 106 of the NHPA mandates that federal agencies take into account the effect of an undertaking on any property, which is included in, or eligible for inclusion in, the National Register of Historic Places. A letter was sent to the North Carolina State Historic Preservation Office (SHPO) on July 12, 2010 requesting review and comment for the potential of cultural resources potentially affected by the Underwood Mitigation Project.

2.7.2 SHPO/THPO Concurrence

A request for records search was submitted on July 12, 2010 and to the NC State Historic Preservation Office (SHPO) to determine the presence of any areas of architectural, historic, or archaeological significance that would be affected by the project. In a letter dated July 28, 2010 (see Appendix 5) the SHPO stated that they have reviewed the project and are "aware of no historic resources which would be affected by the project."

2.8 Physical Constraints

2.8.1 Property Ownership, Boundary, and Utilities

The Upstream Area of the project is located on two parcels owned by William Daryl Harris and Mary Jean Harris. A conservation easement, held by the State of North Carolina, has been recorded over 18.44 and 7.68 of these parcels respectively. The Downstream Area of the project is on two adjacent parcels owned by James Randall Lindley and Jonathan Marshall Lindley. A conservation easement, also held by the State of North Carolina, has been recorded over 11.63 acres of these parcels. The stream reaches that are proposed for restoration and enhancement activities are mostly bound on both sides by active agricultural fields, although the upstream portions of SF4A and UT1 are partially bound by forest. The wetland restoration and creation areas are all adjacent to the streams and are within active agricultural fields. There are no known utilities or other easements located on the properties. One road crossing exists on UT1 (it will be relocated to another location on UT1) and one crossing will be constructed on SF2 as well. No mitigation credit is requested for these portions of the streams.

2.8.2 Site Access

The Upstream Area of the project includes three parcels – two north and one south of Clyde Underwood Road. The road will be the primary access point to the all of the project streams and wetland areas on this portion of the site. Farm roads and open fields will allow easy movement of construction equipment within the properties. The Downstream Area is located adjacent to Moon Lindley Road. This site is also open agricultural land, and farm roads and open fields will provide access from the paved road and allow for easy movement around the site.

2.8.3 FEMA and Hydrologic Trespass

SF4 is a FEMA mapped stream (Figure 5). The project will be designed so that any increase in flooding will be contained on the project site and will not extend upstream to adjacent parcels, so hydrologic trespass will not be a concern. The proposed restoration has been designed to transition back to the existing boundary conditions in a gradual manner.

3.0 Project Site Streams – Existing Conditions

3.1 Existing Conditions Survey

The streams located within the Upstream Area of the Underwood Mitigation Site flow through pastures used primarily for grazing livestock. The streams themselves are used as water sources for the animals. As a result, the stream banks are heavily trampled, the channels have over-widened, and the banks remain unstable in most cases. The majority of the riparian buffers were removed decades ago when the sites were cleared for agricultural use. A few sparse trees remain in the riparian zones of some of the channels. There are multiple farm ponds on the site including two that are at the headwaters of project streams and one that is an impoundment on a project stream. Review of historic aerial photos indicates that the land cover patterns have remained essentially the same at least as far back as 1973. However, there was substantial clearing performed between 1951 and 1973 including removal of the buffers along SF2, SF3, UT1, and UT1A. UT1B was cleared after 1973 (historic aerial photos are included in Appendix 6).

The streams located within the Downstream Area of the site flow through open fields used for row crop cultivation. The upstream end of South Fork (SF4) on this portion of the site is wooded on one side and the upstream portion of the unnamed tributary (SF4A) is wooded on both sides. The riparian buffers on the remaining reaches of stream are primarily herbaceous vegetation. These streams have been straightened and deepened and have vertical banks. Some sections are undergoing significant bank erosion.

On-site existing conditions assessments were conducted by WEI between August 2010 and February 2011. The assessments were performed on each of the streams listed in Table 1. All of the streams were determined to be perennial except for UT1B and UT1A which are intermittent. The locations of the project reaches and surveyed cross sections are shown in Figure 6. Existing geomorphic survey data is included in Appendix 7. Tables 5a and 5b summarize the attributes of the overall project and of the project reaches.

Table 5a. Project Attributes
Underwood Mitigation Project

Project County	Chatam County
Physiographic Region	Carolina Slate Belt of the Piedmont Physiographic Province
Ecoregion	Piedmont
River Basin	Cape Fear
USGS HUC (14 digit) NCDWQ Sub-basin	03030002050050 03-06-04
Within NCEEP Watershed Plan?	The project is within an NCEEP Targeted Watershed
WRC Class	Warm
Percent of Easement Fenced or Demarcated	The easement has been recorded but is proposed to be demarcated post construction.
Beaver Activity Observed During Design Phase?	Yes

Table 5b. Mitigation Component Attributes
Underwood Mitigation Project

	SF1	SF2	SF3	UT1	UT1A	UT1B	UT2	SF4	SF4A
Drainage Area (acres)	134	781	1,056	230	11	11	78	3,362	637
Stream Order	2	3	3	2	1	1	2	4	3
Restored Length (LF)	878	302	2,116	1,997	524	660	421	1,424	868
Perennial or Intermittent	P	P	P	P	I	I	P	P	P
Watershed Type	Rural	Rural	Rural	Rural	Rural	Rural	Rural	Rural	Rural
Watershed Land Use									
Developed	5%	0%	0%	0%	0%	0%	0%	0%	0%
Forested/Scrubland	33%	48%	47%	51%	80%	45%	2%	60%	61%
Agriculture/Managed Herb.	57%	52%	52%	45%	20%	55%	98%	39%	38%
Open Water	5%	0%	1%	4%	0%	0%	0%	1%	1%
Watershed Impervious Cover	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
NCDWQ Index Number	16-28-5	16-28-5	16-28-5	N/A	N/A	N/A	N/A	16-28-5	N/A
NCDWQ Classification	WS-V, NSW	WS-V, NSW	WS-V, NSW	C	C	C	C	WS-V, NSW	C
303d Listed	No	No	No	No	No	No	No	No	No
Upstream of a 303d Stream	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reasons for 303d Listing	Chl-a, pH	Chl-a, pH	Chl-a, pH	Chl-a, pH	Chl-a, pH	Chl-a, pH	Chl-a, pH	Chl-a, pH	Chl-a, pH
Total Acreage of Easement	37.75								
Total Vegetated Acreage within Easement	15.2 (existing)								
Total Planted Acreage as part of Restoration	36.53 (does not include streambeds)								
Rosgen Classification of Pre-Existing	E4	E4	E4	E/G5*	Cb4	B4	E4	E5*	E5*
Rosgen Classification of Design	C4	C4	C4	C4	B4	B 4	C4	C4	C4
Valley Type	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Valley Slope (feet/ foot)	0.012	0.008	0.0049	0.012	0.040	0.039	0.0126	0.0039	0.009
Trout Waters Designation	No	No	No	No	No	No	No	No	No
Endangered or Threatened Species	No	No	No	No	No	No	No	No	No
Dominant Soil Series	Nanford-Baden Complex	Nanford-Baden Complex	Nanford-Baden Complex	Nanford-Baden Complex	Nanford-Baden Complex	Nanford-Baden Complex	Georgeville Silt Loam	Chewacla and Wehadkee	Chewacla and Wehadkee

*Reaches UT1, SF4, and SF4a are classified as sand bad channels under the Rosgen classification system based on the D50. However, each of these reaches has a bimodal distribution of gravel and sand including some large gravel.

3.2 Channel Classification

The streams included in the Underwood Mitigation project are all on active farmland and have all been significantly manipulated over the last 35 years. In addition to the channelization and maintenance of the channels, livestock have trampled many sections of the stream banks. Therefore the streams are all in a very unnatural condition and reliable bankfull features were difficult to identify. An estimate of bankfull stage was made for each reach based on potential field indicators and comparison to channel dimensions predicted by the rural Piedmont regional curves. WEI classified the streams based on the Rosgen classification system to the degree possible using these best estimates of bankfull stage. Existing geomorphic conditions for each reach included in the project are summarized below in Tables 6a and 6b and the reaches are mapped on Figure 6.

South Fork (SF) is broken into 4 reaches based primarily on geographic separation. SF1 is 682 LF and located within the upstream area of the project, on the property south of Clyde Underwood Road. This reach drains 0.21 square miles. The reach has been channelized and is essentially straight, except for some areas where lateral erosion has created some minor variation in pattern. The channel is in a fairly tight valley and the floodplain side slopes are relatively steep. The channel has a width to depth ratio of 6.15, an entrenchment ratio of 6.97, and a slope of 0.011 ft/ft. The d_{50} of the bed material is 4.7 mm. The channel classifies as a straightened E4. The bank height ratio is 1.12 indicating that the reach is somewhat incised, however, the most significant problems with this channel are lateral erosion and lack of floodplain vegetation.

SF2 is a short reach (302 LF not including culvert under Clyde Underwood Road) significantly downstream of SF1 on either side of Clyde Underwood Road. This reach is larger with a (drainage area of 1.22 square miles) and has slightly more plan view pattern than SF1 with a sinuosity of 1.20. A few trees are spread around the floodplain and there are bedrock outcroppings in the channel. The valley is not as confining along this reach but there has been more vertical incision of the channel resulting in an apparent bank height ratio of 1.2. The width to depth ratio is 11.91, the entrenchment ratio is 3.29, the channel slope is 0.010 ft/ft, and the channel is most similar to a straightened E4 stream type.

SF3 is 2,132 LF long and flows from the north side of Clyde Underwood Road (immediately downstream of SF2) in a northward direction through active pastures. UT 1 enters from the west approximately 500 LF before the end of the reach. There are a few trees in the riparian zone all along SF3, however cattle graze up to the top of the banks and use the stream as a water source. The banks of this reach have been trampled for much of its length. Some sections of the reach have meander bends while others are relatively straight. Overall the reach has a sinuosity of 1.23. The width to depth ratio is 8.76, the entrenchment ratio is 3.06, and the channel slope is 0.004. The bed material is primarily small to large gravel and sand. The channel classifies as an E4.

Table 6a. Existing Stream Conditions
Underwood Mitigation Project

	Notation	Units		SF1		SF2		SF3 - u/s of UT1		SF3 - d/s of UT1		UT1	
				Min	Max	Min	Max	Min	Max			Min	Max
stream type				E4		E4		E4				E/G5	
drainage area	DA	sq mi		0.21		1.22		1.27		1.65		0.36	
Discharge													
Q- NC Rural Regional Curve	Q_{bkf}	cfs		28.9		103.0		105.8		127.6		42.4	
$Q_{2\text{-}yr}$ NFF regression	$Q_{2\text{-}yr}$	cfs		45.2		155.6		159.7		191.6		65.7	
bankfull design discharge	Q	cfs		20.0		79.1		81.5		99.8		30.3	
Cross-Section Features													
bankfull cross-sectional area	A_{bkf}	SF		9.48		35.44		28.90		---		7.22	
average velocity during bankfull event	v_{bkf}	fps		3.05		2.91		3.66		---		5.87	
width at bankfull	w_{bkf}	feet		7.64		20.54		15.90		---		8.96	
maximum depth at bankfull	d_{max}	feet		2.21		2.04		2.40		---		1.47	
mean depth at bankfull	d_{bkf}	feet		1.24		1.73		1.81		---		0.81	
bankfull width to depth ratio	w_{bkf}/d_{bkf}			6.15		11.91		8.76		---		11.11	
low bank height		feet		3.54		2.43		3.78		---		2.71	
bank height ratio	BHR			1.60		1.19		1.57		---		1.85	
floodprone area width	w_{fpa}	feet		51.90		67.58		48.59		---		14.17	
entrenchment ratio	ER			6.79		3.29		3.06		---		1.58	
Slope & Sinuosity													
valley slope	S_{valley}	feet/ foot		0.012		0.012		0.005		0.007		0.012	
channel slope	$S_{channel}$	feet/ foot		0.011		0.010		0.004		0.004		0.010	
sinuosity	K			1.06		1.20		1.23		1.81		1.22	
Riffle Features													
riffle slope	S_{riffle}	feet/ foot		---		---		0.03	0.05	---		0.01	0.02

	Notation	Units		SF1		SF2		SF3 - u/s of UT1		SF3 - d/s of UT1		UT1	
				Min	Max	Min	Max	Min	Max			Min	Max
riffle slope ratio	$S_{riffle}/S_{channel}$			---		---		6.5	11.4	---		1.5	2.0
Pool Features													
pool slope	S_{pool}	feet/ foot		---		---		0.00	0.01	---		0.00	0.01
pool slope ratio	$S_{pool}l/S_{channel}$			---		---		0.8	2.5	---		0.4	0.9
pool-to-pool spacing	L_{p-p}	feet		---		---		45.98	205.96	---		37.20	54.67
pool spacing ratio	L_{p-p}/w_{bkf}			---		---		2.9	13.0	---		4.2	6.1
Pattern Features													
belt width	w_{blt}	feet		N/A	N/A	49	49	51	106	85		31	59
meander width ratio	w_{blt}/w_{bkf}			---	---	2.4	2.4	3.2	6.7	---		3.4	6.6
meander length	L_m	feet		N/A	N/A	49	49	46	127	272		80	161
meander length ratio	L_m/w_{bkf}			---	---	2.4	2.4	25.6	70.2	---		8.9	17.9
radius of curvature	R_c	feet		N/A	N/A	18	22	27	61	105		10	83
radius of curvature ratio	$R_c/\ w_{bkf}$			---	---	0.9	1.1	7.2	16.0	---		1.1	9.2
Sediment													
Particle Size Distribution from Reachwide Pebble Count													
	d_{16}	mm		NA		---		NA		---		NA	
	d_{35}	mm		0.9		---		6.3		---		NA	
	d_{50}	mm		4.7		---		4.7		---		1.0	
	d_{84}	mm		20.9		---		34.9		---		16.0	
	d_{95}	mm		87.0		---		107.3		---		107.3	
	d_{100}	mm		362.0		---		1024.0		---		256.0	
Particle Size Distribution from Subpavement Analysis													
	d_{16}	mm		---		---		1.55		---		0.72	
	d_{35}	mm		---		---		5.47		---		3.48	
	d_{50}	mm		---		---		9.63		---		8.21	
	d_{84}	mm		---		---		38.8		---		23.91	

	Notation	Units		SF1		SF2		SF3 - u/s of UT1		SF3 - d/s of UT1		UT1	
				Min	Max	Min	Max	Min	Max			Min	Max
	d_{94}	mm		---		---		56.03		---		36.41	
	d_{99}	mm		---		---		>2048		---		>2048	
Particle Size Distribution from Riffle 100 Pebble Count													
	d_{16}	mm		---		---		7.53		---		---	
	d_{35}	mm		---		---		16.66		---		---	
	d_{50}	mm		---		---		40.82		---		---	
	d_{84}	mm		---		---		74.02		---		---	
	d_{95}	mm		---		---		97.42		---		---	
	d_{99}	mm		---		---		180		---		---	

Table 6b. Existing Conditions
Underwood Mitigation Project

	Notation	Units		UT1A		UT1B		UT2		SF4		SF4A	
				Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
stream type				Cb4		B4		E4		E5		E5	
drainage area	DA	sq mi		0.02		0.02		0.12		5.26		1.00	
Discharge													
Q- NC Rural Regional Curve	Q_{bkf}	cfs		4.61		4.83		19.57		295.32		88.76	
$Q_{2\text{-}yr}$ NFF regression	$Q_{2\text{-}yr}$	cfs		7.59		7.95		30.96		432.92		134.59	
bankfull design discharge	Q	cfs		---		---		13.1		247.4		67.3	
Cross-Section Features													
bankfull cross-sectional area	A_{bkf}	SF		1.03		2.2		9.6		49.73		16.89	
average velocity during bankfull event	v_{bkf}	fps		4.48		2.20		2.04		5.94		5.26	
width at bankfull	w_{bkf}	feet		4.94		3.23		7.04		18.55		10.32	
maximum depth at bankfull	d_{max}	feet		0.31		1.04		1.82		3.95		2.15	
mean depth at bankfull	d_{bkf}	feet		0.21		0.67		1.36		2.68		1.64	

	Notation	Units		UT1A		UT1B		UT2		SF4		SF4A	
				Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
bankfull width to depth ratio	w_{bkf}/d_{bkf}			23.63		4.85		5.17		6.92		6.31	
low bank height		feet		0.61		2.03		2.77		5.50		3.89	
bank height ratio	BHR			1.97		1.95		1.52		1.39		1.81	
floodprone area width	w_{fpa}	feet		11.20		6.15		133.21		157.30		29.40	
entrenchment ratio	ER			2.25		1.9		18.91		3.48		2.85	
Slope & Sinuosity													
valley slope	S_{valley}	feet/ foot		0.040		0.039		0.015		0.004		0.009	
channel slope	$S_{channel}$	feet/ foot		0.035		0.035		0.012		0.003		0.008	
sinuosity	K			1.14		1.11		1.02		1.27		1.13	
Riffle Features													
riffle slope	S_{riffle}	feet/ foot		---		---		---		---		---	
riffle slope ratio	$S_{riffle}/S_{channel}$			---		---		---		---		---	
Pool Features													
pool slope	S_{pool}	feet/ foot		---		---		---		---		---	
pool slope ratio	$S_{pool}l/S_{channel}$			---		---		---		---		---	
pool-to-pool spacing	L_{p-p}	feet		---		---		---		---		---	
pool spacing ratio	L_{p-p}/w_{bkf}			---		---		---		---		---	
Pattern Features													
belt width	w_{blt}	feet		---	---	---	---	N/A	N/A	N/A	N/A	26	72
meander width ratio	w_{blt}/w_{bkf}			---	---	---	---	---	---	---	---	2.5	7.0
meander length	L_m	feet		---	---	---	---	N/A	N/A	N/A	N/A	120	231
meander length ratio	L_m/w_{bkf}			---	---	---	---	---	---	---	---	11.6	22.3
radius of curvature	R_c	feet		---	---	---	---	N/A	N/A	36	49	14	40
radius of curvature ratio	R_c/ w_{bkf}			---	---	---	---	---	---	2.0	2.6	1.4	3.9
Sediment													

	Notation	Units		UT1A		UT1B		UT2		SF4		SF4A	
				Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Particle Size Distribution from Reachwide Pebble Count													
	d_{16}	mm		NA		---		NA		NA		NA	
	d_{35}	mm		NA		---		NA		NA		0.1	
	d_{50}	mm		NA		---		6.1		0.3		0.8	
	d_{84}	mm		4.7		---		62.0		17.9		20.4	
	d_{95}	mm		14.8		---		128.0		45.8		62.9	
	d_{100}	mm		90.0		---		256.0		90.0		362.0	
Particle Size Distribution from Subpavement Analysis													
	d_{16}	mm		---		---		---		1.76		---	
	d_{35}	mm		---		---		---		6.44		---	
	d_{50}	mm		---		---		---		13.66		---	
	d_{84}	mm		---		---		---		36.38		---	
	d_{94}	mm		---		---		---		48.07		---	
	d_{99}	mm		---		---		---		76.1		---	
Particle Size Distribution from Riffle 100 Pebble Count													
	d_{16}	mm		---		---		---		19.07		---	
	d_{35}	mm		---		---		---		26.78		---	
	d_{50}	mm		---		---		---		32.84		---	
	d_{84}	mm		---		---		---		44.26		---	
	d_{95}	mm		---		---		---		59.12		---	
	d_{99}	mm		---		---		---		>2048		---	

The downstream end of the project is located on a separate parcel referred to in this report as the Downstream Area. The South Fork reach that runs through this area is called SF4. SF4 is much larger than the other reaches of the South Fork with a drainage area of 5.26 sq. mi. This reach has also been straightened and manipulated for agricultural purposes, but the adjacent fields are used for planting row crops rather than as pastures for livestock. Bank erosion is not as severe on this reach, however it has been dug deep to drain adjacent fields (portions of which were historically wetlands), straightened, and has a riparian zone with few mature trees. The width to depth ratio is 6.92, the entrenchment ratio is 3.48, the slope is 0.003, and the sinuosity is 1.27. Due to a channel bed that is predominantly sand, the reach classifies as an E5 channel.

The project site also includes five smaller tributaries that flow into the South Fork that are proposed for restoration and enhancement. These include UT1, UT1A, UT1B, UT2, and SF4A.

UT1 flows eastward through active pastures and joins SF3 near the end of that reach. UT 1 has a drainage area of 0.36 miles. The riparian buffer has sparse trees throughout. It has a higher sinuosity (1.22) compared to the other reaches in the project. The reach has a width to depth ratio of 8.46, an entrenchment ratio of 1.58, and a channel slope of 0.010. The bed material in the channel is bimodal including significant portions of both sand and gravel; however its D_{50} is 1.0 resulting in a bed material classification of very coarse sand. The channel does not fit exactly into any of the Rosgen system classifications but is most similar to an E5 or G5.

UT1A and UT1B are small intermittent tributaries that flow off of the adjacent hillslope through pasture lands into UT1. Riparian zones of both tributaries are completely devoid of woody vegetation. UT1B has an in-line pond approximately 100 LF above its confluence with UT1. UT1A and UT1B are both nearly straight with sinuosities very near 1. UT1A has a width to depth ratio of 23.63, an entrenchment ratio of 2.25, and a reach-wide D_{50} of 4.7 mm making it most similar to a straightened C4 channel. UT1B has a width to depth ratio of 4.85 and an entrenchment ratio of 1.9 making it most similar to a straightened G channel (with a slightly high entrenchment ratio).

UT2 is a small tributary with drainage area of 0.12 square miles just to the east of SF1 and eventually flows into SF1 downstream of the project reach. It has been straightened and has a sinuosity of nearly 1. UT2 has some trees and woody vegetation in its riparian buffer but is otherwise surrounded by active pasture. It has a width to depth ratio of 5.17, an entrenchment ratio of 18.91, a channel slope of 0.012 ft/ft, and a D_{50} of 6.1 mm. It is most similar to a straightened E4 in the Rosgen classification system.

SF4A is a relatively large tributary with a drainage area of 1.0 square mile that flows northward, mostly through crop fields, into SF4 near the downstream end of the project. Most of the length of SF4A has been channelized although the upstream portion (approximately 475 LF) flows through a wooded area and may have been less manipulated historically. The reach has a width to depth ratio of 6.31, an entrenchment ratio of 2.85, a channel slope of 0.008 ft./ft., a sinuosity of 1.13, and a D50 of 0.8 mm making it most similar to a straightened E5 stream type.

3.3 Valley Classification

The majority of the Underwood project area is bound by broad valleys and gentle elevation relief, typical of the region. The surrounding fluvial and morphological landforms do not fit neatly into any valley type according to the Rosgen classification system (Rosgen, 1996); therefore the valley was not classified according to that system. WEI used GIS tools to analyze topography data in order to describe the valley morphology of each project stream. Characteristics of each project stream valley are summarized in Table 7.

Table 7. Summary of Project Stream Valley Characteristics
Underwood Mitigation Project

	Avg. Valley Floor Width (ft)	Valley Aspect	Typical Valley Side Slopes (ft/ft)
SF1	75	SW to NE	0.04
SF2	180	S to N	0.05
SF3 U/S	230	S to N	0.06
SF3 D/S	195	SW to NE	0.07
SF4	335	W to E	0.075
SF4A	260	SW to NE	0.045
UT1	120	W to E	0.065
UT1A	35	N to S	0.045
UT1B	40	N to S	0.06
UT2	100	S to N	0.04

3.4 Discharge

Multiple methods were used to approximate the bankfull discharge and choose a design discharge for each of the separate design reaches. Due to the agricultural and forest land cover within the watershed, discharge estimates were made using methods intended for rural watersheds.

Regional curves relating bankfull discharge to drainage area for rural watersheds in the Piedmont region of North Carolina (Harman, et al., 1999) were used to estimate the bankfull discharge for each reach. In addition, the U.S. Geological Survey (USGS) flood frequency equations for rural watersheds in the North Carolina Piedmont (USGS, 2009) were used to estimate peak discharges for each reach for floods with a recurrence interval of two years. The two-year discharge provides a reasonable approximation of bankfull discharge, but is generally slightly larger than the discharge predicted by the appropriate regional curve. In addition, historic gauge data were collected from multiple nearby stream gauges operated by the USGS. Two of these gauges with long-term, continuous records of discharge and relatively small drainage areas were selected to assist with developing the design discharge. These two gauges passed the homogeneity test (Dalrymple, 1960) indicating that they are located within a single homogenous region in terms of streamflow characteristics. The river reach near the gauge for one of these sites – Cane Creek near Orange Grove (drainage area = 7.54 square miles) – appeared to have reasonable, consistent bankfull indicators. So a survey of this site was performed to identify the bankfull stage and relate it to the established stage-discharge curve of the gauge to estimate the bankfull discharge for the site. The bankfull recurrence interval for this site was determined to be 1.15 years. Because the other gauge used in the analysis – Rocky River near Crutchfield Crossroads (drainage area = 7.42 square miles) did not appear to have consistent bankfull features, methods described in Bulletin 17 B (Interagency Advisory Committee on Water Data, 1982) were used to determine the discharge associated with a 1.5-year recurrence interval for this gauge. The basin ratio method was then used to estimate a bankfull discharge for each project reach based on the bankfull discharge at the Cane Creek gauge and the 1.5-year discharge for the Rocky River gauge. This method was applied by simply multiplying the ratio of discharge to drainage area of a gauge to the drainage area of the design reaches. Each of the methods described above was used to estimate a bankfull discharge or discharge with recurrence interval approximating bankfull for each design reach.

A design discharge was selected for each reach based on the analyses described above. The design discharges were chosen to be slightly smaller than the bankfull discharges estimated by the regional curve for multiple reasons:

1) Due to wetland mitigation areas adjacent to the project stream reaches, frequent flooding and smaller, more shallow channels are desirable.
2) The bankfull discharge estimates derived from the basin ratio method with the nearby gauges were smaller than the bankfull discharges predicted by the regional curve.
3) When compared to the rural Piedmont regional curve, the estimated bankfull discharge of the two reference reaches and two gauge sites plotted below the curve (Figure 7).

Table 8 summarizes the results of each of the discharge analyses described in this section.

Table 8. Summary of Design Discharge Analysis
Underwood Mitigation Project

Site	Rural Piedmont Regional Curve Qbkf (cfs)	USGS Rural NFF 2-yr Q (cfs)	Rocky River Gauge Ratio 1.5-yr Q (cfs)*	Cane Creek Gauge Ratio Bankfull Q (cfs)*	Design Q (cfs)
SF1	28.9	45.2	11.4	8.82	20.0
SF2	103.0	155.5	66.1	51.28	79.0
SF3 - u/s of UT1	105.8	159.7	68.6	53.23	81.5
SF3 @ outlet	127.6	191.6	88.9	68.99	100.0
SF4	295.3	432.9	284.2	220.41	247.5
SF4A	88.8	134.6	53.8	41.73	67.5
UT1	42.4	65.7	19.3	15.01	30.5
UT1A	4.6	7.6	0.9	0.69	2.75
UT1B	4.8	8.0	1.0	0.74	2.9
UT2	19.6	31.0	6.6	5.14	13.1
UT2A	5.2	8.5	1.1	0.82	3.1

3.5 Channel Morphology

Existing conditions channel morphology surveys were performed to document the current condition of the streams on the Underwood site and to provide a basis for the design. The existing conditions assessment of the project reaches indicated that channelization of the streams and surrounding agricultural land use has led to channel incision and over-widening, severe bank erosion, and loss of aquatic habitat. Based on the morphologic survey data the streams were mostly classified as E or E/GG channels (Tables 6a and 6b). UT1A, classifies as a Cb stream type and UT1B is a B stream. It is likely that all of these streams (with the exception of UT1A and UT1B) were originally E stream types and have either incised to the point at which they now classify as E/G streams (which have a lower entrenchment ratio) or are in the process of transitioning to G streams. It is important to note, however, that reliable bankfull features were difficult to identify in most cases due to erosion and trampling of the stream banks by livestock. Therefore, it is difficult to determine the degree to which these streams have incised. In most cases the planview pattern of the streams is far less sinuous than is normal for E stream types. The sinuosity values of these streams range from 1.02 (nearly perfectly straight) to 1.23 (moderately sinuous) while E channels are typically highly sinuous (>1.5). A short section of SF3 has a high sinuosity which is unusual for the site. Review of historical aerial photos (Appendix 6) indicates that the streams were channelized at least as far back as the early 1970s and have been maintained in a straight condition since.

The bed material of the channels is a bimodal distribution of sand and fine gravel. D_{50} values range from 0.3 (sand) to 6.1 (fine gravel). However, all of the channels have both sand and gravel. While the coarser material predominated in the riffles and runs and the finer material in the pools, particles of both size ranges were found throughout all of the reaches. In some reaches including SF3 and UT1 pool features outnumbered riffles and runs but the opposite was true in SF1, SF4, UT1A, UT2, and UT2A. In other reaches pools and riffles/runs were more evenly distributed.

3.6 Channel Evolution

A review of aerial photos for the project area dating back to 1973 indicates that the streams included in the project were channelized and much of the woody vegetation along the channels was removed prior to that time (but in most cases, after 1951). The surrounding land cover has changed very little since the early 1970's. Channelization usually includes straightening and deepening of streams and is one of the major causes of channel down-cutting, or incision (Simon, 1989; Simon and Rinaldi, 2006). Based on Simon's well-established model of channel evolution (1989), the likely sequence of events that has led to the current state of degradation of the project streams began with channelization sometime prior to 1973. The channelization induced channel incision which led directly to over-steepened banks that subsequently began to fail resulting in channel widening and creation of the current U-shaped channels. Livestock have had access to most of the streams located in the upstream area for decades which has increased the degree of lateral erosion. Bank erosion liberates sediment into the streams which deposits in downstream water bodies. Currently, the project streams appear to be in Stage IV of the Simon model – Channel Widening. In the Rosgen channel evolution model this progression corresponds to the E stream type to G stream type scenario. Most of the streams included in the project have been classified as incised E channels (considering bank height ratios greater than 1) or E/G channels except for UT1A (classified as a Cb stream) and UT1B (classified as a B stream). The next likely stage will be increased widening to an F stream type. However, the next phase of the Simon model, Stage V – Deposition, does not appear to have begun based on the lack of fine sediment accumulations in the channels. Stage V corresponds with creation of a C stream type at a lower base level in the Rosgen system when a channel with more stable geometry is constructed through sediment deposition. UT1 is an exception; there is evidence in some portions of the channel of deposition and on-going creation of a new bankfull channel at a lower base level. It is likely, however, that this channel is still migrating towards a C stream type.

3.7 Channel Stability Assessment

WEI utilized a modified version of the Rapid Assessment of Channel Stability as described in Hydrologic Engineering Circular (HEC)-20 (Lagasse, 2001). The method is semi-quantitative and incorporates thirteen stability indicators that are evaluated in the field. In a 2007 publication, the Federal Highway Administration (FHWA) updated the method for HEC-20 by modifying the metrics included in the assessment and incorporating a stream type determination. The result is an assessment method that can be rapidly applied on a variety of stream types in different physiographic settings with a range of bed and bank materials.

The Channel Stability Assessment protocol was designed to evaluate 12 parameters: watershed land use, status of flow, channel pattern, entrenchment/channel confinement, bed substrate material, bar development, presence of obstructions and debris jams, bank soil texture and coherence, average bank angle, bank vegetation, bank cutting, and mass wasting/bank failure. Once all parameters are scored, the individual scores are totaled and the stability of the stream is then classified as Excellent (score = 12-36), Good (score = 37-72), Fair (score = 73-108), or Poor (score =109-144). As the protocol was designed to assess stream channel stability near bridges, two minor modifications were made to the methodology to make it more applicable to project specific conditions. The first modification involved adjusting the scoring so that naturally meandering streams score lower (better condition) than straight and/or engineered channels. Because straight, engineered channels are hydraulically efficient and necessary for bridge protection, they score low (excellent to good rating) with the original methodology. Secondly, the last assessment parameter – upstream distance to bridge – was removed from the protocol because it relates directly to the potential effects of instability on a bridge and should not influence stability ratings for the streams assessed for this project. The final scores and corresponding ratings were based on the twelve remaining parameters. The rating adjectives were assigned to the streams based on the FHWA guidelines for pool-riffle stream types.

The HEC-20 manual also describes both lateral and vertical components of overall channel stability which can be separated with this assessment methodology. Some of the 13 parameters described above relate specifically to either vertical or horizontal stability. When all parameter scores for the vertical category or all parameter scores for the horizontal category are summed and normalized by the total possible scores for their respective categories, a vertical or horizontal fraction is produced. These fractions may then be compared to one another determine if the channel is more vertically or horizontally unstable.

The assessment results for the streams on the Underwood sites indicate that all of the streams except for UT1A and UT1B are rated in the second to the lowest category – fair. UT1A and

UT1B are relatively stable sites but they rated poor for bank protection. For every stream assessed, the lateral fraction was greater than the vertical fraction. This indicates that lateral instability is a greater problem for these streams than vertical instability. Total scores, stability ratings, and vertical and horizontal fractions are provided in Table 9.

Table 9. Existing Conditions Channel Stability Assessment Results Underwood Mitigation Project

Parameter	SF1	SF2	SF3 U/S	SF3 D/S	SF4	SF4A	UT1 U/S	UT1 D/S	UT1A	UT1B	UT2
1. Watershed characteristics	7	8	8	8	6	5	6	6	6	6	8
2. Flow habit	4	1	2	2	1	1	3	3	2	2	2
3. Channel pattern	7	6	8	8	8	7	6	6	3	4	8
4. Entrenchment	4	4	7	9	6	7	5	8	2	4	7
5. Bed material	8	8	7	8	10	8	8	7	8	7	8
6. Bar development	2	6	10	6	6	7	6	6	2	3	2
7. Obstructions	4	4	4	4	4	5	5	5	2	7	5
8. Bank soil texture and coherence	8	8	8	8	8	8	5	5	5	5	8
9. Average bank slope angle	10	10	11	11	10	10	10	10	7	8	11
10. Bank protection	11	5	9	9	8	7	7	9	10	10	7
11. Bank cutting	6	7	10	10	8	7	7	9	3	4	6
12. Mass wasting or bank failure	8	7	7	7	5	5	9	9	3	3	6
Score	**79**	**74**	**91**	**90**	**80**	**77**	**77**	**83**	**53**	**63**	**78**
Rating	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Good**	**Good**	**Fair**
Lateral Fraction	0.72	0.62	0.75	0.75	0.65	0.62	0.63	0.70	0.47	0.50	0.63
Vertical Fraction	0.39	0.50	0.67	0.64	0.61	0.61	0.53	0.58	0.33	0.39	0.47

3.8 Bankfull Verification

Bankfull stage indicators on the project streams were few and difficult to identify due to incision of the channels and trampling of the banks by livestock. However, during the existing conditions assessment, WEI staff identified the best available bankfull indicators and surveyed cross sections at those locations. Bank features considered to be potential bankfull indicators included flat depositional features and prominent breaks in slope. In addition, a nearby USGS gauging station (station 02096846 – Cane Creek near Orange Grove, NC) was used to develop a calibrated estimate of bankfull discharge and channel geometry at a local site. Bankfull data for the gauge site, the surveyed project reaches, and two nearby reference reaches were compared with the NC rural Piedmont regional curves and are shown overlaid with the rural curves for area and discharge in Figure 7. Analysis of the bankfull cross-sectional areas and discharges for the project reaches reveal that the data consistently plot within the 95% confidence intervals of the area and discharge regional curves in all cases where the points are within the range of drainage area (independent variable) covered by the regional curves. This information indicates that the bankfull indicators identified during the existing conditions assessment provide reasonable estimates of bankfull geometry for the existing conditions. The USGS gauge bankfull discharge was 83% of that predicted by the rural Piedmont regional curve for discharge for a site with a drainage area the same as the gauge site (7.54 sq. mi.) and the cross sectional area was 66% of the regional curve prediction (both well within the lower 95% confidence intervals). The recurrence interval for the bankfull discharge of the gauge site was determined to be 1.15 years. While this recurrence interval is lower than that of many of the gauged sites included on the regional curve, it is reasonable to represent bankfull discharge and provides further support for the use of the regional curves in the project area.

3.9 Vegetation Community Types Descriptions

The existing vegetation communities within the proposed project area are predominately disturbed cattle pasture and row crop agricultural systems dominated by fescue grasses. Based on conversations with the landowners and the age of abandoned farm houses on the properties, row crop agriculture and cattle grazing have been the predominant land use on these farms since at least the early 1900's. Due to heavy agricultural activities and vegetation management over the past century, several major strata are completely absent from this area resulting in a dominant herbaceous layer with few sparse mature trees. Overstory vegetation is thicker and more mature along the UT2 and SF3 tops of bank and within the UT1 floodplain. Dominant herbaceous species within this area include fescue (*Festuca spp.*) and soft stem rush (*Juncus effuses*). Sparse tree species include shagbark hickory (*Carya ovata*), red maple (*Acer rubrum*), green ash (*Fraxinus sylvatica*), hackberry (*Celtis occidentalis*), box elder (*Acer negundo*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), black willow (*Salix nigra*), and sweetgum (*Liquidambar styraciflua*).

4.0 Reference Streams

Two reference reaches were identified near the project area and used to support the design of the project reaches (Figure 8). Reference reaches can be used as a basis for design or, more appropriately, as one source of information on which to base a stream restoration design. Most, if not all, reference reaches identified in the North Carolina Piedmont are in heavily wooded areas and the mature vegetation contributes greatly to their stability. Design parameters for this project were also developed based on the design discharge along with dimensionless ratio values associated with successful restoration designs of streams in the North Carolina Piedmont. Reference reach data for similar streams were obtained from existing data sets and used to verify design parameters. The reference streams considered when developing design parameters for this project include Long Branch and UT to Cane Creek. These reference streams were chosen because of similarities to the project streams including drainage area, valley slope and morphology, bed material, and location within the Carolina Slate Belt region of the Piedmont.

4.1 Reference Streams Channel Morphology and Classification

Long Branch is located in the central portion of Orange County northwest of Chapel Hill. According to the Collins Creek Restoration Plan (KCI Technologies, 2007), the drainage area is 1.49 mi^2 and the land use within the drainage area is low-density residential, agricultural lands, and forest. The Long Branch reference site was classified as a C4 channel type according to the KCI report. The channel has a width to depth ratio ranging from 8.8 to 13.8 and an entrenchment ratio of >2.5. The reach has a valley slope of 0.6% while the channel slope is 0.4%. The bed material D_{50} for the reach is 7.6 mm. WEI visited the reference site to verify the data presented in the KCI report. Two riffles were surveyed during the site visit. These riffles had width to depth ratios of 9.4 and 7.9 and entrenchment ratios of 11.7 and 12.1. Some cross sections are more typical of E stream types while others would classify as a C stream type. This is true of both the sections documented in the KCI report and those surveyed by Wildlands.

The second reference reach investigated for the project, UT to Cane Creek, is located in southern Alamance County approximately seven miles from the Underwood site. This site was classified as an E4 stream type in the Unnamed Tributary to Cane Creek Restoration Plan (URS, 2007) and has a drainage area of 0.28 mi^2. This reach also flows through a mature forest and has a channel slope of 0.46%. The morphological parameters reported for the riffle cross section include a width to depth ratio of 13.1 and an entrenchment ratio of >2.2. WEI conducted a site visit for this reference reach and surveyed an additional cross section typical of the reference reach. The width to depth ratio of this reach was 7.9 and the entrenchment ratio was approximately 25 indicating that the channel would fall into the E classification.

Both of these reference reaches have width to depth ratios in the C to E range depending on the particular cross section considered. For general classification purposes, they are on the cusp between E and narrow C streams. There is often considerable variability of the widths and depths of a stable natural channel – even within a morphologically similar reach. This is very common of smaller Piedmont streams and is representative of the conditions planned for the Underwood site. Summaries of geomorphic parameters for the reference reaches analyzed for this project are included in Table 10.

Table 10. Summary of Reference Reach Geomorphic Parameters
Underwood Mitigation Project

			Long Branch		UT to Cane Creek	
Parameter	**Notation**	**Units**	**min**	**max**	**min**	**max**
stream type			C/E4		C/E4	
drainage area	DA	sq mi	1.49		0.28	
bankfull discharge	Q_{bkf}	cfs	101.0	124.0	20.6	53.2
bankfull cross-sectional area	A_{bkf}	SF	25.0	34.6	8.5	10.7
average velocity during bankfull event	v_{bkf}	fps	3.6	4.0	2.4	5.0
width at bankfull	w_{bkf}	feet	14.8	18.6	8.2	11.8
maximum depth at bankfull	d_{max}	feet	1.9	2.9	1.5	1.7

Parameter	Notation	Units	Long Branch min	Long Branch max	UT to Cane Creek min	UT to Cane Creek max
mean depth at bankfull	d_{bkf}	feet	1.3	2.1	0.9	1.0
bankfull width to depth ratio	w_{bkf}/d_{bkf}		7.9	13.8	7.9	13.1
depth ratio	d_{max}/d_{bkf}		1.4	1.5	1.7	1.7
bank height ratio	BHR		1.2	1.5	1.0	1.0
floodprone area width	w_{fpa}	feet	>50		>40	
entrenchment ratio	ER		>3.4		>4.59	
valley slope	S_{valley}	ft/ft	0.006			
channel slope	$S_{channel}$	ft/ft	0.004		0.005	
sinuosity	K		1.3		1.2	
riffle slope	S_{riffle}	ft/ft	0.013	0.012	0.012	
riffle slope ratio	$S_{riffle}/S_{channel}$		3.3	3.0	2.6	
pool slope	S_{pool}	ft/ft	0.0003	0.0030	0.001	
pool slope ratio	$S_{pool}/S_{channel}$		0.1	0.8	0.3	
pool-to-pool spacing	L_{p-p}	feet	50.0	105.0	1.6	95.0
pool spacing ratio	L_{p-p}/w_{bkf}		3.4	7.1	0.1	8.6
maximum pool depth at bankfull	d_{pool}	feet	2.2		2.6	
pool depth ratio	d_{pool}/d_{bkf}		0.8	1.2	1.7	
pool width at bankfull	w_{pool}	feet	16.2	18.8	12.3	
pool width ratio	w_{pool}/w_{bkf}		0.9	1.3	1.5	
pool cross-sectional area at bankfull	A_{pool}	SF	25.5	33.4	12.5	
pool area ratio	A_{pool}/A_{bkf}		1.0	1.3	1.5	
belt width	w_{blt}	feet	60.0		50.0	77.0
meander width ratio	w_{blt}/w_{bkf}		3.2	4.1	50.0	77.0
meander length	L_m	feet	66	191	29.0	96.0
meander length ratio	L_m/w_{bkf}		4.5	10.3	2.6	8.7
radius of curvature	R_c	feet	16.0	87.0	11.3	27.1
radius of curvature ratio	R_c/ w_{bkf}		1.1	4.7	1.0	2.5

4.2 Reference Streams Vegetation Community Types Descriptions

Stream vegetation communities will be similar to those of Long Branch and UT to Cane Creek. Both of those streams are both surrounded by mature hardwood forests composed of typical Piedmont bottomland riparian forest tree species. The mature trees within the riparian buffers provide significant bank reinforcement to keep the streams from eroding horizontally and maintain channels with small width to depth ratios. The Long Branch site is classified as a combination of Piedmont levee and bottomland forest types (Schafale & Weakley, 1990). The

Levee forest type occurs closer to the creek and grades back to the bottomland forest. Dominant species include river birch (*Betula nigra*), tulip poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), green ash (*Fraxinus pennsylvanica*), and sycamore (*Platanus occidentalis*). Common understory vegetation includes ironwood (*Carpinus caroliniana*), paw paw (*Asimina triloba*), and American silverberry (*Eleagnus commutata*). The UT to Cane Creek site is classified as a Piedmont bottomland forest type (Schafale & Weakley, 1990). Dominant species include southern red oak (*Quercus falcata*), red maple (Acer rubrum), river birch, tulip poplar, sweetgum, green ash, and sycamore. Common understory vegetation includes ironwood and paw paw.

5.0 Project Site Wetlands – Existing Conditions

5.1 Jurisdictional Wetlands

On February 19, 2010, WEI delineated jurisdictional waters of the U.S. within the project easement area. Potential jurisdictional areas were delineated using the USACE Routine On-Site Determination Method. This method is defined by the 1987 Corps of Engineers Wetlands Delineation Manual and subsequent Eastern Mountain and Piedmont Regional Supplement. Routine On-Site Data Forms have been included in Appendix 2. The results of the on-site jurisdictional determination indicate that there are no jurisdictional wetlands located within the project easement.

5.2 Hydrological Characterization

In order to develop a wetland restoration, enhancement, and creation design for the Underwood Site, an analysis of the existing and proposed conditions for groundwater hydrology was necessary. DrainMod (version 6.0) was used to model existing and proposed groundwater hydrology at the site. DrainMod simulates water table depth over time and produces statistics describing long term water table characteristics and an annual water budget. DrainMod was selected for this application because it is a well-documented modeling tool for assessing wetland hydrology (NCSU, 2010) and is commonly used in wetland creation and restoration projects. For more information on DrainMod and its application to high water table soils see Skaggs (1980).

5.2.1 Groundwater Modeling

For the Underwood wetlands, four total models were developed and calibrated to represent the existing and proposed conditions at four different groundwater monitoring gauge locations across the site. Resulting model output was used to validate and refine the proposed grading plan for wetland restoration and creation on site and to develop a water budget for the site. The modeling procedures are described below.

5.2.1.1 Data Collection

DrainMod models are built using site hydrology, soil, climate, and crop data. Prior to building the models, soil cores were taken to validate existing mapped soils across the site. Further explanation of the site soils can be found in Section 5.3 of this report. Rainfall and temperature data were obtained from nearby weather station Siler City 2 N (Station No. 317924) operated by the National Oceanic and Atmospheric Administration (NOAA) National Weather Service. The data set for this station was obtained from the

North Carolina State Climate Office from January of 1960 through April of 2011. These data were used to calibrate the models and perform the long term simulations. Information to develop model inputs for crops previously grown on the site was obtained through interviews with the landowner.

5.2.1.2 Existing Conditions Base Model Set up and Calibration

Models were created to represent four monitoring gauge locations on the site at as shown on Figure 6. The models were developed using the conventional drainage water management option with contributing surface water runoff to best simulate the drainage of the site. Each of the four gauges was installed in July, 2010 and recorded groundwater depth twice per day with In-situ Level TROLL® 100 or 300 pressure transducers through early December 2010. The gauges were reactivated in March, 2011 and collected additional data through early April, 2011. These periods were used as the calibration period for the groundwater models.

The first step in developing the model was to prepare input files from various data sources. A soil input file obtained from N.C. State University, which has similar characteristics to the soils on the site, was used as a base soil input file for each model. The soil files were refined by adjusting certain parameters for each of the mapped soils found on-site from published soil survey data (NRCS, 2006, 2011). Temperature and precipitation data from a nearby weather station, described above, were used to produce weather input files for each model.

Once the necessary input files were created, the project settings were adjusted for this application and then calibration runs were conducted. To calibrate the model, parameters not measured in the field were adjusted within the limits typically encountered under similar soil and geomorphic conditions until model simulation results were similar to observed gauge data. After calibration of each of the models was complete, the calibrated models were used as the basis for the proposed conditions models. Plots showing the calibration results are included in Appendix 8. Trends in the observed data are well-represented by the calibration simulations. Although hydrograph peaks between plots of observed and simulated data do not match exactly, relative changes in water table hydrology as a result of precipitation events correspond well between observed data and model results.

5.2.1.3 Proposed Conditions Model Setup

The proposed conditions models were developed based on the existing conditions models to predict whether wetland criteria would be met over a long period of recorded climate data. Proposed plans for the site include grading portions of the site to lower elevations, raising the inverts of adjacent stream channels, planting native wetland plants, and roughing the surface soil through disking. A ditch that currently drains a riparian wetland restoration area referred to as RW4 will also be filled. These proposed plans were developed to increase the wetland hydrology on site. Settings for the proposed conditions model were altered to reflect these changes to the site. To account for changes to stream alignments, the ditch spacing values in the models were altered. To simulate proposed site grading conditions, the ground surface elevations were decreased by the depth of ground to be graded at gauges 4 and 5. Changes in the vegetation on the site were simulated by altering the rooting depth of plants on the site from variable shallow depths for crops (varying by time of year) to consistent and deeper values for hardwood tree species. Surface storage values were increased at all gauges to account for proposed disking to the site. Once the proposed conditions models were developed, each model was run for a 51-year period from January 1960 through March 2011 using the weather data from the Siler City 2 N weather station to perform the long term simulation.

5.2.1.4 Modeling Results and Conclusions

DrainMod was used to compare calibrated existing conditions models with proposed conditions scenarios to determine the effect of proposed practices on site hydrology. Each gauge location was evaluated to establish how often annual wetland criteria would be met over the 51-year simulation period. The wetland criteria are that the water table must be within 12 inches of the ground surface at each gauge for a minimum of 6.5% of the growing season (April 1 through November 3). The modeling results show that Gauges 2 (representing riparian wetland RW1) and 3 (riparian wetland RW4) would meet the criteria 45 and 39 years respectively out of the 51-year simulation period if in the restored condition. Gauges 4 (riparian wetland RW3) and 5 (riparian wetland RW4) represent wetlands that would not regularly meet criteria without grading the portion of the site represented by that gauge (the wetland creation zone) to a lower elevation. The model results show that if grading is performed to lower the ground surface at each gage by 12 inches, those portions of the site would meet criteria 40 and 43 years respectively out of the out of the 51-year period. Note: gauge 1 was removed and not used in the simulations.

5.2.2 Surface Water Modeling at Restoration Site

The only surface water modeling necessary to support the wetland designs was performed with DrainMod by simulating a contributing area runoff for the hillslope areas adjacent to gauges 3 and 5 (RW4). The runoff simulated for theses hillslopes provided one of the hydrologic inputs for the adjacent wetland areas. No other modeling of surface hydrology, other than the HEC-RAS hydraulic flood study, was performed for this project.

5.2.3 Hydrologic Budget for Restoration Site

DrainMod computes daily water balance information and outputs summaries that describe the loss pathways for rainfall over the model simulation period. Tables 11a, 11b, 11c, and 11d summarize the average annual amount of rainfall, infiltration, drainage, runoff, and evapotranspiration estimated for the three modeled locations on site. Infiltration represents the amount of water that percolates into the soil. Drainage is the loss of infiltrated water that travels through the soil profile and is discharged to the drainage ditches or to underlying aquifers. Runoff is water that flows overland and reaches the drainage ditches before infiltration. Evapotranspiration is water that is lost by the direct evaporation of water from the soil or through the transpiration of plants. From the water balance results provided in Tables 11a, 11b, 11c, and 11d it can be seen that, in most cases evapotranspiration is larger in the proposed condition when compared to the existing condition while runoff is smaller. The evapotranspiration stays essentially the same for gauge 3 because there is a higher existing condition evapotranspiration due to the corn crop planted on the site than would be the case for pastureland. For all gauges except gauge 5, runoff is decreased and infiltration is increased for the proposed condition.

Gauge 5 is unusual because there is a large volume of runon from an existing ditch that will be discharged to the wetland area that currently discharges directly to SF4A and, therefore, does not contribute to the hydrology of the existing site. Some of this additional water will run off the site, increasing the runoff volume for the gauge 5 area.

Table 11a. Summary Water Balance for Gauge 2 for Existing and Proposed Conditions
Underwood Mitigation Project

Hydrologic Parameter	Existing Conditions		Proposed Conditions	
	Average Annual Amount (cm of water)	Average Annual Amount (% of precip + runon)	Average Annual Amount (cm of water)	Average Annual Amount (% of precip + runon)
Precipitation	118.45	100.0%	118.45	100.0%
Runon	0.00	0.0%	0.00	0.0%
Precip + Runon	118.45	100.0%	118.45	100.0%
Infiltration	101.92	86.0%	112.86	95.3%
Evapotranspiration	78.28	66.1%	83.57	70.6%
Drainage	25.29	21.4%	30.39	25.7%
Runoff	16.53	14.0%	5.57	4.7%

Table 11b. Summary Water Balance for Gauge 3 for Existing and Proposed Conditions
Underwood Mitigation Project

Hydrologic Parameter	Existing Conditions		Proposed Conditions	
	Average Annual Amount (cm of water)	Average Annual Amount (% of precip + runon)	Average Annual Amount* (cm of water)	Average Annual Amount * (% of precip + runon)
Precipitation	118.45	70.2%	118.45	100.0%
Runon	50.19	29.8%	50.19	29.8%
Precip + Runon	168.64	100.0%	168.64	100.0%
Infiltration	115.2	68.3%	139.49	82.7%
Evapotranspiration	80.49	47.7%	80.28	47.6%
Drainage	37.92	22.5%	61.21	36.3%
Runoff	53.43	31.7%	29.09	17.2%

Table 11c. Summary Water Balance for Gauge 4 for Existing and Proposed Conditions
Underwood Mitigation Project

Hydrologic Parameter	Existing Conditions		Proposed Conditions	
	Average Annual Amount (cm of water)	Average Annual Amount (% of precip + runon)	Average Annual Amount (cm of water)	Average Annual Amount (% of precip + runon)
Precipitation	118.45	54.1%	218.83	100.0%
Runon	100.38	45.9%	100.38	45.9%
Precip + Runon	218.83	100.0%	319.21	145.9%
Infiltration	148.73	68.0%	157.12	71.8%
Evapotranspiration	70.85	32.4%	84.07	38.4%
Drainage	82.15	37.5%	75.15	34.3%
Runoff	68.82	31.4%	61.65	28.2%

Table 11d. Summary Water Balance for Gauge 5 for Existing and Proposed Conditions
Underwood Mitigation Project

Hydrologic Parameter	Existing Conditions		Proposed Conditions	
	Average Annual Amount (cm of water)	Average Annual Amount (% of precip + runon)	Average Annual Amount (cm of water)	Average Annual Amount (% of precip + runon)
Precipitation	118.45	100.0%	118.45	72.1%
Runon	0.00	0.0%	45.74	27.9%
Precip + Runon	118.45	100.0%	164.19	100.0%
Infiltration	110.68	93.4%	136.14	82.9%
Evapotranspiration	65.02	54.9%	78.31	47.7%
Drainage	48.12	40.6%	59.72	36.4%
Runoff	7.77	6.6%	27.99	17.0%

5.3 Soil Characterization

An investigation of the existing soils within the wetland restoration/enhancement/creation areas was performed by WEI staff between October, 2010 and May, 2011. This investigation supplemented the soils analysis performed by a licensed soil scientist (LSS) on March 1, 2010. Soil cores were collected at locations across the site to provide data to refine NRCS soils mapping units, establish areas suitable for wetland restoration and creation, and aid in developing a wetland grading plan. Fifty-one soil cores were taken at approximately 100- to 200-foot grid spacing in key wetland areas across the site (Figures 9 and 10). Nineteen of the fifty-one soil cores were taken by the licensed soil scientist in March 2010. Soil texture, Munsell chart hue, chroma and value, and hydric soil characteristics were recorded for each core. At each break in soil chroma or texture a new description was recorded and the depth of the change was recorded. The depth to hydric indicators was then measured as well. Detailed soil borings logs are included in Appendix 4.

5.3.1 Taxonomic Classification

Analysis of the soil core samples collected from the project site along with consideration of site topography indicated that soils classifications did not agree with the mapped soil units in many locations. Soil classifications are discussed by wetland zone below. Soil chroma and texture are summarized by zone but Figures 9 and 10 and Appendix 4 contain more detailed information concerning individual soil borings.

5.3.1.1 RW1

Soils within the RW1 area are predominately mapped as Georgeville silt loam which is not listed on the NC Hydric Soil list. This map unit is broad and accurately reflects the surrounding upland soils, however, soil borings throughout the proposed wetland area indicate that the map unit is incorrectly applied to the floodplain area. Soil cores 24-29 (Appendix 4) indicate chroma values of one and two throughout the matrix to a depth of 24 inches with 20%-40% mottling, blackened manganese, and concretions. The soils in this confined floodplain match more closely to the Chewacla and Wehadkee series which are mapped in the downstream floodplains. Monitoring gauge data confirm that the soil in this area is poorly drained.

5.3.1.2 RW2

Soils within the area referred to as RW2 are predominately Cid-Lignum Complex which is listed on the NC Hydric Soil list primarily for inclusions of the Wehadkee soil type. Soil cores indicate chroma values of one and two at a depth of 12-18 inches. The soil mapping unit was confirmed to be correct in this area.

5.3.1.3 NRW1

Soils within the NRW1 area are predominately Cid-Lignum Complex which is listed on the NC Hydric Soil list, primarily for inclusions of the Wehadkee soil type, and Nanford-Badin Complex which is not listed. These map units are broad and accurately reflect the surrounding upland soils; however, soil borings throughout the proposed NRW1 area indicate that the map unit is incorrectly applied to this area which is not associated with a stream channel. Soil cores 30 to 33 indicate chroma values of one to three throughout the matrix to a depth of 24 inches with 20%-30% mottling and blackened manganese. The soils in this confined wetland area match more closely to the Chewacla and Wehadkee series.

5.3.1.4 RW3

Soils within the RW3 area are predominately mapped as Nanford-Badin Complex which is not listed on the NC Hydric Soil list. This broad map unit accurately reflects the surrounding upland soils and portions of the floodplain; however, soil borings throughout and between the proposed wetland areas indicate that the map unit is incorrectly applied at a finer scale. Soil cores 1-20 (Appendix 4) indicate variable conditions within the floodplain of SF3. In the portions of the floodplain proposed for wetland restoration and creation, chroma values of one to three characterized the matrix to a depth of 24 inches with 10%-40% mottling, blackened manganese, and oxidized rhizospheres. Soils in the zones proposed for creation had a higher sand content in the upper 12 inches than soils in the areas proposed for restoration. The soils in this floodplain matched the mapping unit in some locations while matching more closely to the Chewacla and Wehadkee series in other locations.

5.3.1.5 NRW2

Soils within the area referred to as NRW2 are predominately Nanford-Badin Complex which is not listed on the NC Hydric Soil list. This broad map unit accurately reflects the surrounding upland soils. However, soil borings indicate that the map unit is incorrectly applied to this wetland area which is not associated with a stream channel. Soil cores 21 and 22 indicate chroma values of one throughout the matrix to a depth of 24 inches with 10%-30% mottling. Soil core 23 is an adjacent upland point. The soils in this confined wetland area match more closely to the Chewacla and Wehadkee series.

5.3.1.4 RW4

Soils within the RW4 area are predominately mapped as Chewacla and Wehadkee, which is listed on the NC Hydric Soil list, and has margins of Nanford-Badin Complex, which is not listed on the NC Hydric Soil list. This floodplain area was confirmed to be a mix of the two soil types with some areas showing more hydric conditions consistent with Chewacla and Wehadkee and other areas showing higher chroma soils more consistent with Nanford-Badin Complex. Soil cores 34-51 (Appendix 4) indicate these variable conditions within the floodplain of SF4. In the portions of the floodplain proposed for wetland restoration and creation, chroma values of one to three characterized the matrix to a depth of 24 inches with 10%-40% mottling, blackened manganese, and oxidized rhizospheres.

5.3.2 Profile Description

The floodplain areas of the proposed project are mapped by the Chatham County Soil Survey (NRCS, 2006). Soils along the UT1, UT1A, UT1B, UT2A, SF2 and SF3 floodplains are primarily mapped as the Nanford-Badin complex. SF1 is primarily mapped as the Cid-Lignum complex. UT2 is located in the Georgeville silt loam soil. SF4 and SF4A are mapped in the Chewacla and Wehadkee soils. These soils are described below in Table 12. A soils map is provided in Figure 4.

Table 12. Wetland Area Soil Types and Descriptions
Underwood Mitigation Project

Soil Name	Location	Description
Chewacla and Wehadkee, 0-2% slopes	Majority of SF4 and SF4A	Chewacla and Wehadkee soils consist of nearly level, very deep, poorly and somewhat poorly drained soils. These are typically floodplain areas. They have a loamy surface layer and subsoil. Permeability is moderate and shrink-swell potential is low. These soils are subject to frequent flooding.
Cid-Lignum complex, 2-6% slopes	Majority of SF1, and portions of SF2, SF3, and UT2	Cid and Lignum soils series are gently sloping, moderately deep to deep, moderately well-drained to somewhat poorly drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is slow and shrink-swell potential is moderate.
Georgeville silt loam, 2-6% slopes	Majority of UT2 and portions of UT2A and SF1	Georgeville soils are gently sloping to strongly sloping, very deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low.
Georgeville-Badin complex, 10-15% slopes	Portion of SF4A	Georgeville and Badin soils are gently sloping to strongly sloping, moderately deep to very deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low to moderate.
Nanford-Badin complex, 2-6% slopes	Portions of UT1A, SF3, and SF4A	These Nanford and Badin soils are gently sloping, moderately deep to deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low to moderate.
Nanford-Badin complex, 6-10% slopes	Majority of UT1, UT1A, UT1B, UT2A, SF2, and SF3, and portions of SF4, and SF4A	These Nanford and Badin soils are gently sloping to steep, moderately deep to deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low to moderate.
Nanford-Badin complex, 10-15% slopes	Portions of UT1 and UT1B	These Nanford and Badin soils are steep, moderately deep to deep, well-drained soils. They are often found in uplands. The surface layer and subsoil are silt loam. Permeability is moderate and shrink-swell potential is low to moderate.
Notes: Source: Chatham County Soil Survey, USDA-NRCS, http://efotg.nrcs.usda.gov		

5.3.3 Hydraulic Conductivity

The Chewacla-Wehadkee series has a moderate permeability. It consists of somewhat poorly to poorly drained soils. The Cid-Lignum complex is moderately well to somewhat poorly-drained and the permeability is slow to very slow. Georgeville and Georgevill-Baden complex soils are well-drained soils with moderate permeability. Nanford-Baden soils are well-drained with moderate permeability.

5.4 Vegetation Community Types Descriptions and Disturbance History

The existing vegetation communities within the proposed wetland areas are predominately disturbed cattle pasture and row crop agricultural systems dominated by fescue grasses. Based on conversations with the landowners and the age of abandoned farm houses on the properties, row crop agriculture and cattle grazing have been the predominant land use on these farms since at least the early 1900's. Due to heavy agricultural activities and vegetation management over the past century, several major strata are completely absent from this area resulting in a dominant herbaceous layer with few sparse mature trees. Dominant herbaceous species within this area include fescue (*Festuca spp.*) and soft stem rush (*Juncus effuses*). Sparse tree species include shagbark hickory (*Carya ovata*), red maple (*Acer rubrum*), green ash (*Fraxinus sylvatica*), hackberry (*Celtis occidentalis*), box elder (*Acer negundo*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), black willow (*Salix nigra*), and sweetgum (*Liquidambar styraciflua*).

6.0 Reference Wetland

A reference wetland was identified immediately adjacent to RW4. The property is classified as a Piedmont bottomland forest (Shafale & Weakley, 1990). Because the site is immediately adjacent to the project site, it offers the best opportunity to provide reference information on the appropriate natural community to use in restoring and creating wetlands on the project site. The reference wetland is primarily bottomland hardwood forest and the natural community present on the site was used in combination with other sources as a basis to develop the planting plan for the restoration/enhancement/creation project.

6.1 Hydrological Characterization

A groundwater monitoring gauge was installed on July 29, 2010 on the reference site to document the reference wetland hydrology. However, after further analysis during the fall of 2010 it was determined that this particular location represented drier than average conditions for this wetland complex due to its proximity to a drainage feature. The gauge was moved to a more appropriate reference location in March of 2011. The gauge has not been installed for an adequate period to assess hydrologic conditions and determine the appropriateness of this reference location. Other reference sites are currently being evaluated and a permanent reference location will be selected prior to beginning the post-construction monitoring period. This information will be used to provide a comparison for the restored and created wetland hydrology throughout the monitoring period.

6.2 Soil Characterization and Taxonomic Classification

The soils on the reference site are mapped as Chewacla and Wehadkee which are listed on the NC Hydric Soils list. This floodplain area was confirmed to match the mapped soil unit which is described in more detail above.

6.3 Vegetation Community Types Descriptions and Disturbance History

Historical aerials reveal that the reference wetland area was vegetated in 1951 and 1993 to present. In the 1951 photograph, this area was the only vegetated zone within several hundred acres of surrounding cleared agricultural land indicating that it has generally been too wet to use as productive farm land. The existing vegetation communities are typical of a bottomland Hardwood Forest and include semi-mature canopy tree species, moderate subcanopy and shrub species, as well as an herbaceous layer. Dominant canopy species include sweetgum, red maple, sycamore, willow oak, and water oak. Typical subcanopy and shrub species include American elm, box elder, and black willow.

7.0 Project Site Mitigation Plan

A local watershed plan has not been developed at this time for the Cane Creek watershed, the 14-digit HUC in which the project is located. The goals for the Haw River watershed, which includes Cane Creek, discussed in the 2009 NCEEP planning document *Cape Fear River Basin Restoration Priorities* (CFRBRP) are focused on the Jordan Lake nutrient strategy which calls for reductions in nutrient loads to the lake. The lake was designated as nutrient sensitive waters (NSW) by the NC Environmental Management Commission (EMC) in 1983. The NCDWQ determined that the Haw River arm of the lake was failing to meet its designated uses in 2006 due to exceedences of chlorophyll-a (chl-a) and pH standards. Both chl-a and pH can be indicators of eutrophication which is driven by excessive nutrient loads. As a result, the entire reservoir is now on North Carolina's list of impaired waters under Section 303(d) of the federal Clean Water Act. The CFRBRP discusses "a number of stream and wetland restoration projects" which have been completed in the Cane Creek watershed. The specific goals for the watershed are continued restoration and preservation work, promotion of healthy riparian corridors, improvements to "aquatic conditions" and benthic habitats, and, because it is part of the Jordan Lake watershed, reductions in nitrogen and phosphorous loads to help meet established nutrient reductions for the lake. The 51 cattle, dairy, and poultry operations within the watershed are implied to be a major stressor to aquatic resources by the CFRBRP.

The restoration design developed for this project was completed with careful consideration of goals and objectives that were described in the CFRBRP. The goals were established to meet NCEEP's mitigation needs while maximizing the ecological and water quality uplift provided by the project. The goals represent the "ends" that the finer objectives (or "means") were formulated to achieve and were directed by the specific stressors discussed above. The overarching goals of this mitigation plan are broad and similar to those of other mitigation plans. The objectives are more specific in order to replace specific ecological functions and to remain sustainable given watershed trajectory.

7.1 Overarching Goals of Mitigation Plans

The following list provides the intended goals of this mitigation plan:

- The timely, cost effective delivery of sustainable ecological uplift for the purpose of meeting compensatory mitigation requirements.
- Link project specific goals to watershed goals as provided in planning documents.
- Articulate how the proposed approach or levels of intervention are proportional and optimized.
- Demonstrate that the factors of influence and the data streams that are part of the design effort converge (or provide explanation when they don't) to justify the proposed level of intervention.
- Define project level goals and objectives.
- Provide a pre-restoration baseline to which monitoring data can be compared for the purpose of demonstrating attainment of goals and objectives.

- Provide impact and other information necessary to obtain regulatory permits.
- Document whether or not the project will result in a rise in flood elevations.
- Address how project goals and objectives address stressors identified in watershed characterization section of the plan.

7.2 Mitigation Project Goals and Objectives

The Underwood Mitigation Project has been designed to meet the over-arching goals described above. The project will also address multiple watershed stressors that have been documented for both Cane Creek and the Jordan Lake watersheds. The project specific goals include:

- Restore and stabilize stream dimensions, pattern, and profile
- Establish proper substrate distribution throughout restored and enhanced streams
- Improve aquatic and benthic habitat
- Reduce nutrient loads within the watershed and to downstream waters
- Further improve water quality within the watershed through reductions of sediment, bacteria, and other pollutants
- Decrease water temperature and increase dissolved oxygen concentrations
- Establish appropriate hydrology for wetland areas
- Restore native vegetation to wetlands and riparian buffers/improve existing buffers
- Create appropriate terrestrial habitat

The design features of this project were developed to achieve multiple project objectives. The stream restoration elements have been designed to frequently flood the reconnected floodplain and adjacent riparian wetlands. This design will provide more frequent dissipation of energy from higher flows (bankfull and above) to improve channel stability; provide water quality treatment through detention, settling, and biological removal of pollutants; and restore a more natural hydrologic regime. Existing, restored, and created wetlands are key components of the design incorporated to better meet goals described above. The project objectives have been defined as follows:

- Construct stream channels that will remain relatively stable over time and adequately transport their sediment loads without significant erosion or agradation.
- Construct stream channels that maintain riffles with course bed material and pools with finer bed material.
- Provide aquatic and benthic habitat diversity in the form of pools, riffles, woody debris, and in-stream structures.
- Add riffle features and structures and riparian vegetation to decrease water temperatures and increase dissolved oxygen to improve water quality.
- Construct stream reaches so that floodplains and wetlands are frequently flooded to provide energy dissipation, detain and treat flood flows, and create a more natural hydrologic regime.
- Construct fencing to keep livestock out of the streams.

- Raise local groundwater table through raising stream beds and removing agricultural drainage features.
- Grade wetland creation areas as necessary to promote wetland hydrology.
- Plant native tree species to establish appropriate wetland and floodplain communities and retain existing, native trees were possible.

7.2.1 Designed Channel Classification

The design streams and wetlands will be restored to the appropriate type based on the surrounding landscape, climate, and natural vegetation communities but also with strong consideration to existing watershed conditions and trajectory. The project includes stream restoration and enhancement as well as wetland restoration and creation (Figures 11 and 12). The specific proposed stream and wetland types are described below.

7.2.1.1 Designed Channel Classification

The stream restoration portion of this project includes five reaches:

SF1: South Fork from approximately 2,600 LF upstream of Clyde Underwood Road to approximately 1,900 feet upstream of Clyde Underwood Road

SF3: South Fork from approximately 590 feet downstream of Clyde Underwood Road to approximately 2,000 feet downstream of Clyde Underwood Road

SF4: South Fork from approximately 1,400 feet upstream of Moon Lindley Road to Moon Lindley Road

SF4A: Unnamed tributary to South Fork including approximately 600 feet at the downstream end of SF4A to the confluence of SF4A with SF4

UT1: Unnamed tributary to South Fork including approximately 400 feet at the downstream end of UT1 to the confluence of UT1 with SF3

The project also includes stream enhancement on seven reaches classified as either Enhancement I (EI) or Enhancement II (EII):

SF2, EII: South Fork from approximately 320 feet upstream of Clyde Underwood Road to Clyde Underwood Road

SF3, EI: South Fork from 152 LF upstream of the end of the reach to the end of the reach

SF3, EII: South Fork from Clyde Underwood Road to approximately 590 feet downstream of Clyde Underwood Road

SF4A, EI: Tributary to SF4 including approximately 620 feet at the downstream end of SF4A to the confluence of SF4A with SF4

UT1, EII: Unnamed tributary to South Fork from approximately 2000 feet upstream of the confluence of UT1 with SF3 to approximately 400 feet upstream of the confluence

UT1A, EII: Unnamed tributary to UT1 including approximately 520 feet at the downstream end of UT1A to the confluence of UT1A with UT1

UT1B, EII: Unnamed tributary to UT1 including approximately 650 feet at the downstream end of UT1B to the confluence of UT1B with UT1

UT2, EI: Unnamed tributary to SF1 from approximately 850 feet upstream of the confluence of UT2 and SF1 to approximately 390 feet upstream of the confluence

All stream restoration and enhancement I reaches included in the design for this project will be constructed as C type streams according to the Rosgen classification system (Rosgen, 1996). Type C streams are slightly entrenched, meandering streams with well-developed floodplains and gentle gradients of 2% or less. They occur within a wide range of valley types and are appropriate for the project landscape.

The morphologic design parameters for the restoration and enhancement I reaches (Table 13) fall within the ranges specified for C streams (Rosgen, 1996). However, the specific values for the design parameters were selected based on designer experience and judgment and were verified with morphologic data form reference reach data sets. The width to depth ratio for most of the reaches will be approximately 12. The expectation is that the streams will narrow over time and classify as E stream types in some locations and, therefore, resemble the C/E morphology of the references. A width to depth ratio of 14 was used for SF4 to raise the invert of the restored channel and improve adjacent wetland hydrology.

The design channel slopes of the restoration and enhancement I reaches ranged from 0.0034 to 0.0141. Each of the design reaches will be reconnected with the existing floodplain (Priority 1). The restored channels will have entrenchment ratios of greater than 2. The sinuosity for the restored channels will be near 1.2.

Table 13a. Design Morphologic Parameters
Underwood Mitigation Project

	Notation	Units		SF1		SF3 - u/s of UT1		SF3 - d/s of UT1		UT1	
				Min	Max	Min	Max	Min	Max	Min	Max
Stream Type				C4		C4		C4		C5	
Drainage Area	DA	sq mi		0.21		1.27		1.65		0.36	
Discharge											
Q- NC Rural Regional Curve	Q_{bkf}	cfs		28.9		105.8		127.6		42.4	
Bankfull Design Discharge	Q	cfs		20.0		81.5		99.8		30.3	
Cross-Section Features											
Bankfull Cross-Sectional Area	A_{bkf}	SF		6.5		27.5		27.1		9.6	
Average Velocity During Bankfull Event	v_{bkf}	fps		3.1		3.0		3.7		3.2	
Width at Bankfull	w_{bkf}	feet		8.8		18.2		18.0		10.7	
Maximum Depth at Bankfull	d_{max}	feet		1.0		2.1		2.1		1.3	
Mean Depth at Bankfull	d_{bkf}	feet		0.7		1.5		1.5		0.9	
Bankfull Width to Depth Ratio	w_{bkf}/d_{bkf}			12.0		12.0		12.0		12.0	

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	Notation	Units		SF1		SF3 - u/s of UT1		SF3 - d/s of UT1		UT1	
				Min	Max	Min	Max	Min	Max	Min	Max
Low Bank Height				1.0		2.1		2.1		1.3	
Bank Height Ratio	BHR			1.0		1.0		1.0		1.0	
Floodprone Area Width	w_{fpa}	feet		>50		>200		>50		>100	
Entrenchment Ratio	ER			>2.2		>2.2		>2.2		>2.2	
Sinuosity											
Valley Slope	S_{valley}	feet/ foot		0.0122		0.0042		0.0067		0.0100	
Channel Slope	$S_{channel}$	feet/ foot		0.0102		0.0036		0.0056		0.0084	
Sinuosity	K			1.20		1.17		1.19		1.19	
Riffle Features											
Riffle Slope	S_{riffle}	feet/ foot		0.0143	0.0255	0.0050	0.0090	0.0078	0.0140	0.0118	0.0210
Riffle Slope Ratio	$S_{riffle}/S_{channel}$			1.4	2.5	1.4	2.5	1.4	2.5	1.4	2.5
Pool Features											
Pool Slope	S_{pool}	feet/ foot		0.0010	0.0020	0.0004	0.0007	0.0006	0.0011	0.0008	0.0017
Pool Slope Ratio	$S_{pool}l/S_{channel}$			0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.2
Pool-to-Pool Spacing	L_{p-p}	feet		35.0	62.0	73.0	127.0	72.0	126.0	43.0	75.0
Pool Spacing Ratio	L_{p-p}/w_{bkf}			4.0	7.0	4.0	7.0	4.0	7.0	4.0	7.0
Pattern Features											
Belt Width	w_{blt}	feet		26.0	44.0	54.0	91.0	54.0	90.0	32.0	54.0

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	Notation	Units		SF1		SF3 - u/s of UT1		SF3 - d/s of UT1		UT1	
				Min	Max	Min	Max	Min	Max	Min	Max
Meander Width Ratio	w_{blt}/w_{bkf}			3.0	5.0	3.0	5.0	3.0	5.0	3.0	5.0
Meander Length	L_m	feet		62.0	106.0	127.0	218.0	126.0	216.0	75.0	129.0
Meander Length Ratio	L_m/w_{bkf}			7.0	12.0	7.0	12.0	7.0	12.0	7.0	12.0
Radius of Curvature	R_c	feet		15.0	25.0	31.0	51.0	31.0	50.0	21.0	30.0
Radius of Curvature Ratio	R_c/ w_{bkf}			1.7	2.8	1.7	2.8	1.7	2.8	2.0	2.8

Table 13b. Design Morphologic Parameters
Underwood Mitigation Project

	Notation	Units		UT2		SF4		SF4A	
				Min	Max	Min	Max	Min	Max
Stream Type				C4		C5		C5	
Drainage Area	DA	sq mi		0.12		5.26		1.00	
Discharge									
Q- NC Rural Regional Curve	Q_{bkf}	cfs		19.6		295.3		88.8	
Bankfull Design Discharge	Q	cfs		13.1		204.0		67.3	
Cross-Section Features									
Bankfull Cross-Sectional Area	A_{bkf}	SF		4.2		53.0		18.0	

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	Notation	Units		UT2		SF4		SF4A	
				Min	Max	Min	Max	Min	Max
Average Velocity During Bankfull Event	v_{bkf}	fps		3.1		3.9		3.7	
Width at Bankfull	w_{bkf}	feet		7.1		27.3		14.7	
Maximum Depth At Bankfull	d_{max}	feet		0.7		2.3		1.7	
Mean Depth at Bankfull	d_{bkf}	feet		0.6		1.9		1.2	
Bankfull Width to Depth Ratio	w_{bkf}/d_{bkf}			12.0		14.0		12.0	
Low Bank Height				0.7		2.3		1.7	
Bank Height Ratio	BHR			1.0		1.0		1.0	
Floodprone Area Width	w_{fpa}	feet		>200		>200		>200	
Entrenchment Ratio	ER			>2.2		>2.2		>2.2	
Sinuosity									
Valley Slope	S_{valley}	feet/ foot		0.0145		0.0041		0.0080	
Channel Slope	$S_{channel}$	feet/ foot		0.0141		0.0034		0.0077	
Sinuosity	K			1.03		1.21		1.04	
Riffle Features									
Riffle Slope	S_{riffle}	feet/ foot		0.0197	0.0353	0.0048	0.0085	0.0108	0.0193

	Notation	Units		UT2		SF4		SF4A	
				Min	Max	Min	Max	Min	Max
Riffle Slope Ratio	$S_{riffle}/S_{channel}$			1.4	2.5	1.4	2.5	1.4	2.5
Pool Features									
Pool Slope	S_{pool}	feet/ foot		0.0014	0.0042	0.0003	0.0007	0.0008	0.0015
Pool Slope Ratio	$S_{poo}l/S_{channel}$			0.1	0.2	0.1	0.2	0.1	0.2
Pool-to-Pool Spacing	L_{p-p}	feet		29.0	50.0	109.0	191.0	59.0	103.0
Pool Spacing Ratio	L_{p-p}/w_{bkf}			4.0	7.0	4.0	7.0	4.0	7.0
Pattern Features									
Belt Width	w_{blt}	feet		N/A		82.0	136.0	44.0	74.0
Meander Width Ratio	w_{blt}/w_{bkf}			N/A		3.0	5.0	3.0	5.0
Meander Length	L_m	feet		N/A		191.0	327.0	103.0	177.0
Meander Length Ratio	L_m/w_{bkf}			N/A		7.0	12.0	7.0	12.0
Radius of Curvature	R_c	feet		N/A		46.0	76.0	25.0	41.0
Radius of Curvature Ratio	$R_c/\ w_{bkf}$			N/A		1.7	2.8	1.7	2.8

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7.2.1.2 Designed Wetland Type

The proposed stream and wetland restoration project includes six distinct wetland zones. The four riparian wetland restoration/creation zones are labeled as RW1, RW2, RW3, and RW4 (Figures 11 and 12). The two non-riparian wetland restoration/enhancement zones are labeled as NRW1 and NRW2 (Figure 11). Soil investigations for the different wetland areas are described in detail in Section 5.3.1.

RW1 consists of the floodplain adjacent to UT2. Existing bank height ratios on UT2 range from 1.4 to 1.7 which increases the drainage effect on the surrounding historic wetlands. The drainage effect from the incised stream and the lack of surface water retention in the pasture has impaired wetland hydrology and function. RW1 will be restored by raising the bed elevation of UT2 which will decrease the drainage effect on the surrounding historic wetlands and restore a natural flooding regime. In-stream structures will be used to raise the channel grade and any unstable banks will be re-graded, seeded, and matted. Wetland areas will be disked to increase surface roughness and better capture rainfall which will improve connection with the water table for groundwater recharge. Furrows will not exceed 6" to 9" in depth.

RW2 consists of two nearly adjacent areas. One zone is situated downstream of a farm pond and consists of the floodplain adjacent to an intermittent tributary. The second is immediately downstream within the floodplain of SF1. Existing bank height ratios on SF1 range from 1.4 to 1.7 which has increased the drainage effect on the surrounding historic wetlands. The drainage effect from the incised streams and the lack of surface water retention in the pasture has impaired wetland hydrology and function. RW2 will be restored through a combination of grading in the creation zone and raising the bed elevations of SF1. This will decrease the drainage effect on the surrounding historic wetlands and restore a natural flooding regime. SF1 will be restored through a Priority 1 restoration approach with a bankfull elevation that matches the surrounding floodplain grade. Wetland areas will be disked to increase surface roughness and better capture rainfall which will improve connection with the water table for groundwater recharge. Furrows will not exceed 6" to 9" in depth.

RW3 consists of the floodplain adjacent to SF3. Existing bank height ratios on SF3 range from 1.1 at the upstream end to 2.0 at the downstream end. The incised nature of the downstream section increases the drainage effect on the surrounding historic wetlands and non-wetland floodplain. The drainage effect from the incised stream and floodplain drainage ditches and the lack of surface water retention in the pasture has impaired wetland hydrology and function. Vegetation is dominated by fescue and juncus and cattle have access to the entire area. RW3 will be restored and created by a combination of grading in the creation zones and raising the bed elevation of SF3 which will decrease the drainage effect on the surrounding historic wetlands and restore a natural flooding regime. SF3 will be restored through a Priority 1 restoration approach with a bankfull elevation that matches the surrounding floodplain grade. Wetland areas will be disked to increase surface roughness and better capture rainfall which will improve connection with the water table for groundwater recharge. Furrows will not exceed 6" to 9" in depth.

The RW3 restoration zone is an area with confirmed hydric soils. Bedrock seams in this area appear to create a subsurface damming effect that pushes groundwater towards the surface, however the drainage effect from the incised SF3 channel and poor surface retention have impacted hydrology. The RW3 creation zone differed from the restoration zone in that soils appeared to have a higher sand content in the upper 12 inches. Signs of standing water or other indicators of surface water were not noted as frequently in this area indicating that infiltration rates are currently higher. Minor excavation of this area will intercept groundwater movement and encourage storage of surface water in this zone. Note: Bedrock should not have an effect on wetland or stream grading.

RW4 is situated in the floodplain adjacent to SF4 and SF4A. Bank height ratios on SF4 and SF4A range from 1.4 to 1.8. Incision, in combination with several ditches that have been excavated through the floodplain, has increased the drainage effect on the surrounding historic wetlands. The drainage effects from the incised stream, floodplain ditches, and the lack of surface water retention in the field has impaired wetland hydrology and function. The field is actively maintained in row crop agriculture and has been grazed by cattle in the past. RW4 will be restored and created by a combination of grading in the creation zones, plugging and filling several floodplain ditches, and raising the bed elevation of SF4 and SF4A which will decrease the drainage effect on the surrounding historic wetlands and restore a natural flooding regime. SF4 and SF4A will be restored within RW4 through a Priority 1 restoration approach with a bankfull elevation that matches the surrounding floodplain grade. The creation zones include a mix of minor grading in the Chewacla zones and slightly deeper grading in the Nanford-Badin Complex soil mapping unit. Wetland areas will be disked to increase surface roughness and better capture rainfall which will improve connection with the water table for groundwater recharge. Furrows will not exceed 6” to 9” in depth.

NRW1 is comprised of a farm pond and the valley downstream of the pond draining toward SF1. The farm pond creates an open water system. Water retained in the pond is subject to high evaporation rates in the summer months which have decreased hydrologic inputs to the wetland system below. The lack of surface water retention in the pasture has impaired wetland hydrology and function. Widely spaced larger trees exist along most of NRW1. The understory is dominated by fescue and juncus and cattle have access to the entire area. The dam creating the farm pond will be removed, restoring a natural hydrologic regime to the entire wetland area. Wetland areas will be disked to increase surface roughness and better capture rainfall which will improve connection with the water table for groundwater recharge. Furrows will not exceed 6” to 9” in depth.

NRW2 is located at the downstream end of a small valley with an ephemeral drainage channel. The channel form is less apparent at the downstream end where water disperses through the flat wetland area. Hydrology does not appear to be altered or manipulated in this non-riparian wetland. Vegetation is dominated by fescue and juncus with some sparse larger trees and cattle have access to the entire area. This wetland will be enhanced by planting native vegetation and by using agricultural disking equipment to increase surface roughness and better capture rainfall which will improve connection with the water table for groundwater recharge. Furrows will not exceed 6” to 9” in depth.

7.2.2 Target Buffer Communities

The target communities for the restored and created wetlands and riparian buffer zones will be based on reference conditions, existing mature trees throughout the project area, comparison to vegetation listed for these community types in Shafale and Weakley (1990), and through consultation with native tree suppliers. The main reference site is a Piedmont bottomland forest adjacent to RW4. This reference floodplain wetland is described in more detail in Section 6.0. Existing mature trees within the project area are described in Section 5.4. The species to be planted are described in Section 7.4.2.

7.3 Stream Project and Design Justification

Based on assessments of the watershed and existing channels, the designs have been developed to correct incision and lack of pattern caused by channelization, bank instability caused by erosion and livestock access, lack of vegetation in riparian zones, lack of riparian and aquatic habitat, and depletion of hydrology for adjacent wetlands. The existing conditions assessment of the project reaches of South Fork Cane Creek and the tributaries included in the project area indicated that channelization of the streams and livestock operations have resulted in incision and enlargement of the channels. Bank erosion and trampling of the stream banks by livestock is causing lateral erosion and enlargement of the streams. Results from a channel stability assessment indicate that the bank erosion along the project reaches ranges from moderate to severe and results in sediment delivered to downstream waters. The incision and lateral erosion have also resulted in degraded aquatic and benthic habitat, altered hydrology (related to loss of floodplain connection and lowered water table) and reduction of quality and amount of riparian wetlands. The enlargement of the channels has also contributed to water quality problems including lower dissolved oxygen levels (due to wide channels with shallow flow). These conditions exist on many streams throughout the project area including SF1, SF3, portions of UT1, SF4, and SF4A. SF2, the upstream portion of UT1, UT1A, and UT1B have less bed and bank erosion but still have localized areas of scour and generally degraded habitat. The riparian buffers on all of these streams have either been removed completely or are severely degraded.

The restoration reaches – SF1, SF3, portions of UT1, SF4, and SF4A – are all currently unstable. According the Simon channel evolution model (Simon, 1989), the project reaches are at *Stage IV – Channel Widening.* Bank erosion is occurring and has progressed quite far in many locations. If not for continual livestock access to SF1, SF3, and UT1, lateral erosion would eventually decrease and depositional processes would dictate further changes in channel form. Because of the trampling of the banks, it is impossible to determine the degree to which fluvial erosion of the banks has progressed. However, there is little evidence in the streams that depositional processes have taken over. According to the Rosgen channel type succession model, these streams have progressed from E streams which is the likely natural condition of the streams given the size and regional physiography, to more incised E/G streams and are likely moving towards the wider, incised F type.

The next stages in many streams would likely be increased sediment deposition caused by decreased depth of flow and shear stress in the wider channels (*Stage V* according to Simon's model), eventually creating a small C type channel (or potentially a more narrow E type) with a lower floodplain and base level (*Stage VI - Recovery*). However, with continued livestock access, the streams will not stabilize. If the livestock were permanently removed and the streams eventually become stable at a lower base level, the floodplains would remain largely unconnected to the stream and the riparian wetlands wouldl not function due to inadequate hydrology. In this situation, even if the riparian buffers were permitted to regrow, the water quality improvements would be greatly reduced.

The portions of the project that are planned for enhancement activities are not in as poor condition as the restoration reaches and are not as unstable. However, aquatic, benthic, and riparian habitats are degraded in all of these reaches. Intervention will be required to improve the habitat conditions in all of the project reaches. Livestock will also be excluded from the enhancement reaches in order to prevent further degradation and the potential instability.

The objectives described in Section 7.2 were partially developed to deal with the issues described in the paragraphs above. The key factors driving the need for this intervention are:

- Without intervention, it is likely that lateral erosion in all of the project reaches will continue for some time contributing a large volume of sediment to downstream waters.
- Intervention will be required to restore aquatic, benthic, and riparian habitat.
- Treatment of agricultural runoff is needed to reduce nutrient loads and help meet nutrient reduction goals in downstream waters. The restored floodplain and created and restored wetlands will provide both increased flood storage and treatment.
- The project will restore and enhance well over a mile of riparian buffers.
- The project offers the opportunity to meet many goals established in the NCEEP watershed planning documents described in Section 7.0.

7.3.1 Sediment Transport Analysis

A sediment transport analysis was performed for the restoration reaches including UT1, SF1, SF3, and SF4. In general, the analysis was performed to answer two questions:

1) What size bed material particles will become entrained at flows at or near the bankfull discharge (competence) and
2) Does the stream have the ability to pass the sediment load supplied to it (capacity).

The analysis performed for this project addresses both the competence and capacity questions with the information available. Stream competence can be determined through calculations performed with data commonly collected for stream restoration projects. The issue of capacity is much more difficult to analyze due to lack of reliable data on sediment supply for a given stream and, therefore, must often be analyzed qualitatively – unless initial qualitative analysis warrants further field data collection.

Two of the four reaches proposed for restoration (SF1, and SF3) were determined to be gravel bed streams through reach wide pebble counts. UT1 was classified as a sand bed channel because the diameter of the D_{50} was 1.0. However, the reach has a significant gravel component and many riffles with coarse bed material including some cobble. SF4 was also determined to be a sand bed stream through reach wide pebble counts. However, further analysis of the current stream dynamics and underlying bed material indicated that this reach would likely has a substrate with a large gravel component. The slope on this reach is lower than the surrounding valley slope due to channelization and maintenance for agricultural purposes. In recent years, beaver have constructed numerous dams that have created backwater conditions. WEI staff removed these dams to conduct existing conditions surveys and sample bed material. The low slope and flow restrictions have resulted in significant deposition of fine bed material overtop of the native material. Coarse riffles were discovered during site reconnaissance and were used for analyzing native pavement and subpavement material. Furthermore, the bed was excavated in several locations that appeared to have bed material comprised of gravel and sand. The slope will be increased in the restored condition and beaver will be managed. The intent is to return this reach to a gravel bed channel. Due to the reasons discussed above, both UT1 and SF4were analyzed for sediment transport competence.

The existing bed material matrix in all design reaches is comprised of both gravel and sand. Multiple pebble counts and pavement and subpavement samples throughout the project reaches show bimodal distributions of particle size with a larger sand fraction in UT1 and SF4 as discussed above. In gravel bed streams, including bimodal systems, bedload is the dominant component of sediment transport (Wilcock, et al., 2009). Therefore bedload was the focus of this sediment transport analysis.

7.3.1.1 Competence Analysis

A competence analysis was performed for each of the design reaches by comparing shear stresses along the channel at the design bankfull discharge with the size distribution of the bed material. A HEC-RAS model was built to represent the proposed conditions of each restoration reach and bankfull shear stresses were calculated with the model at each pool and riffle cross section throughout each restoration reach. In addition, standard equations were used to calculate the critical dimensionless shear stress needed to move the bed material and the depth and slope combination needed to produce that stress. The equations are:

(1) $\tau_{ci} = 0.0834(d_{50}/ds_{50})^{-0.872}$
(2) $\tau_{ci} = ds/(\gamma s * Di)$
(3) $d = (\tau_{ci} * \gamma s * Di)/S$

where τ_{ci} is critical dimensionless shear stress, d_{50} is median diameter of pavement material, ds_{50} is median diameter of subpavement material, γs is specific weight of sediment, Di is the largest diameter of subpavement material, d is mean bankfull depth of channel, and S is the water surface slope at bankfull stage.

The summary of shear stresses modeled with HEC-RAS shown in Table 14 can be compared with the critical shear stresses obtained from the revised Shields Diagram (Rosgen, 2001), shown in Table 15, to provide a rough estimate of the degree to which shear stress in the proposed stream will be able to move the bed material. As expected, the shear stresses summarized in Table 13 are greater in riffles than pools for each reach. In most cases these ranges of shear stress indicate excess shear stress, or that the largest bed material can be moved at bankfull flow. Note: UT 1 and SF4A were not modeled with HEC-RAS due to the relatively short sections of restoration planned for this tributary.

Table 14. Summary of Shear Stress in Design Reaches by Bed Feature Type
Underwood Mitigation Project

SF1

Shear Stress Statistic (lb/ft^2)	Channel	Riffle	Pool
Minimum	0.06	0.24	0.06
25 Percentile	0.1	0.47	0.08
50 Percentile	0.33	0.56	0.1
75 Percentile	0.56	0.85	0.11
Maximum	0.92	0.92	0.16

SF3

Shear Stress Statistic (lb/ft^2)	Channel	Riffle	Pool
Minimum	0.04	0.2	0.04
25 Percentile	0.06	0.26	0.05
50 Percentile	0.23	0.43	3.24
75 Percentile	0.45	0.57	0.06
Maximum	0.78	0.78	0.09

SF4

Shear Stress Statistic (lb/ft2)	Channel	Riffle	Pool
Minimum	0.02	0.22	0.02
25 Percentile	0.02	0.25	0.02
50 Percentile	0.24	0.31	0.02
75 Percentile	0.315	0.3875	0.03
Maximum	0.48	0.48	0.05

Critical depth and slope combinations were calculated for each design reach using equations 1 through 3 above. The results of this analysis were compared to channel size and slope from hydraulic calculations based on USGS gage and reference reach discharge analyses (See Section 3.4 for a detailed discussion of design discharge analysis). Calculated critical depth and slope matched design channel depth and slope well within the expected range of error from the sediment transport equations. For instance, hydraulic calculations on SF1 provided a design mean depth of 0.7 ft while the competence equations calculated critical depth at 0.5 to 0.7 ft. The results of these two competence analyses for all restoration reaches indicated that no adjustment to channel size or slope as designed based on hydraulics was necessary to adequately move sediment through the systems.

Table 15. Summary of Dimensionless Critical Shear Stress Calculations Underwood Mitigation Project

	UT1	SF1	SF3 – Above UT1	SF3 – Below UT1	SF4
Calculated $D_{critical}$ (ft)	0.7 - 0.9	0.5 - 0.7	1.6 – 2.0	1.1 – 1.3	2.2 – 2.7
Design riffle mean depth (ft)	0.9	0.7	1.5	1.5	1.9
Calculated $S_{critical}$ (ft/ft)	0.0059 - 0.0078	0.0076 – 0.0100	0.0041 - 0.0050	0.0041 - 0.0050	0.0039 – 0.0049
Design channel slope (ft/ft)	0.0078	0.0106	0.0037	0.0056	0.0034
Critical shear stress required to move largest subpavement particle** (lbs/ft2)	0.30	0.30 - 0.40	0.25 - 0.30	0.25 - 0.30	0.25 – 0.40
Bankfull boundary shear stress (lbs/ft^2)[1]	0.37	0.42	0.35	0.52	0.32 – 0.63

[1] From revised Shields Diagram

The results of the competence analyses indicate that the channel will move the bed material at design bankfull flow. While there appears to be excess shear stress, the shear stress values for the riffle features in the design reaches are not uncommonly high. It should be noted that the revised Shields diagram analysis does not directly predict scour but rather provides information that may be used to estimate if and where bed material will be entrained. Secondly, the revised Shields diagram was developed for gravel bed streams that have a consistent bed material particle size (i.e. not bimodal systems with large quantities of sand). Research has shown that bed material that is bimodal with large proportions of both gravel and sand is more difficult to move than bed material that is uniform in size (Wilcock, et al., 2009). Therefore the revised Shields diagram analysis likely under predicts the critical shear stress required to mobilize the bed within the design reaches. However, measures will be taken to prevent significant scour at key locations in the channel, especially riffles. Grade control structures including reinforced constructed riffles, J-hook vanes, and others will be installed during construction at locations were bed scour potential is significant. Natural material revetments such as root wads and brush toe will be used along with bioengineering to prevent bank erosion. In-stream structures and revetments are shown on the design plans.

7.3.1.2 Capacity Analysis

The competence analysis described above only provides an estimate of the necessary shear stress and related slope and flow depth needed to move the existing bed material.

A capacity analysis is necessary to determine if the stream has the ability to pass its sediment load. A capacity analysis is much more difficult to perform and is prone to error. In order to perform the analysis, an estimate of sediment supply must be developed and compared with computation of the stream's ability or capacity to move the load. This analysis was performed for the three main restoration reaches, SF1, SF3, and SF4 as described below.

To begin an analysis of sediment supply a watershed assessment must be performed. WEI staff performed a watershed reconnaissance, reviewed a series of aerial photographs dating back to the 1950's, and reviewed land cover data in order to assess the current condition of the watersheds and identify time periods when the watersheds underwent changes that would affect the sediment load such as development or land clearing. As previously described, land cover within the watersheds has remained essentially the same since sometime prior to the early 1970's. Substantial land clearing was performed between 1951 and 1973, especially affecting the watersheds of SF1 and SF3. The watersheds of the project streams become more forested and less agricultural progressing in the downstream direction. The watershed of SF1 is approximately 57 percent farm land while the watersheds of SF3 and SF4 are 52 percent and 39 percent farm land respectively. The majority of the remaining land area in the watersheds is forest. The percent development within the watersheds is five percent for SF1 and less than 1 percent for SF3 and SF4. There is little sign of recent or ongoing land disturbance in the watersheds. The farm land in the watersheds of SF1 and SF3 are primarily used for grazing livestock. Some of the land in the SF4 watershed is used for row crops (including the fields adjacent to SF4 and SF4A), however, row crops are limited to certain areas. The vast majority of unbuffered streams are located within the watersheds of SF1 and SF3 providing some indication that stream stability may be more of a problem in those two watersheds than in the much larger SF4 watershed. There are no signs that land disturbance is likely in the near future of these rural watersheds, although some recent clearing was observed downstream of SF3. In general the watersheds are stable and vegetated, row cropping and development are limited, and land cover has been largely unchanged for decades.

The results of the watershed assessment indicate generally stable watersheds and no reason to expect unusually high sediment supply. Although stream stability is a concern in terms of sediment contributions of SF1 and SF3, no other major sources of sediment have been observed. Limited sediment deposition was observed in the existing channels (for more detail on exiting stream conditions see Section 3) indicating that the existing channels are moving the sediment supplied to them. There is no indication that the deterioration of these channels has been driven by recent watershed disturbances. A threshold channel design approach will therefore be used for each of the restoration reaches. This design approach is based on the concept that the morphology of the channels is not sensitive to sediment supply and channel migration and changes in slopes are not expected or desired.

To validate the threshold design approach, a sediment monitoring and modeling analysis was performed for a representative reach. SF3 was chosen as the representative reach because:

- The bed material of SF4 (important for the calculations) is expected to coarsen after construction of the restoration project while that of SF3 (and other reaches) is expected to remain the same.
- SF3 is more geographically centered in the watershed and is in between SF1 and SF4 in size.
- SF3 has cross sections appropriate for data collection.

To perform the analysis, an estimate of the sediment supply was developed and compared that to the sediment transport capacity of the channel restoration designs. A bedload and streamflow monitoring station was established on SF3 to represent the general conditions on the project site. Bedload traps described by Bunte et al. (2007) were used to collect bedload and a current meter and staff gauge were used to collect coupled discharge measurements and stage readings. Several attempts were made to collect bedload samples throughout the data collection phase of the project. At streamflows up to 13 cfs no bedload was collected by the samplers (summer baseflow measurements were as low as 0.04 cfs). Two samples were collected during higher flows as shown in Table 16.

Table 16. Summary of SF3 Bedload Data
Underwood Mitigation Project

Discharge (cfs)	Bedload (g/sec.)
19	0.69
27	1.54

In addition, four bedload transport equations for gravel bed streams were used to compute estimates of bedload transport at design (bankfull) discharge for SF3 (81 cfs) in the existing channel. These equations and the results of the computations of bedload transport at design discharge are listed in Table 17. All of the equations use bed material size distributions, channel cross section and slope, and Manning's n (back calculated from discharge measurements) in the calculations. The equations were run in the U.S. Forest Service's (USFS) spreadsheet program called "Bedload Assessment in Gravel Bed Streams" or BAGS (Pitlick et al., 2009).

Table 17. Summary of SF3 Bedload Transport Equation Results
Underwood Mitigation Project

Equation[1]	Bedload Transport Rate (g/sec.)
Parker (1990)	4.82E-03
Parker et al. (1982)	2.72
Klingeman 1982	0.16
Wilcock and Crowe (2003)	0.09

[1]For information on equations see Pitlick et al. (2009)

Bedload equations are known to be prone to error and to produce questionable results (Wilcock, 2009). The results shown in Table 17 cover three orders of magnitude and all, with the possible exception of Parker et al. (1982) appear to under predict transport when compared to the bedload samples. However, the results of the equations and the bedload samples provide the best available estimate of sediment supply, assuming that supply is similar to transport (i.e., the channel is not capacity-limited).

The HEC-RAS model for SF3 was used to perform a sediment transport capacity analysis for the design flow in the proposed SF3 channel. The Hydraulic Design module of HEC-RAS includes tools to perform multiple hydraulic analyses of proposed designs. Included in these tools is a "Sediment Transport Capacity" function that allows the user to input flow data, bed material data, and cross section and slope data and then choose from a variety of transport equations to analyze transport capacity. For this analysis the three equations most appropriate for the sediment sizes transported through SF3 were selected: Meyer-Peter-Mueller (MPM), Toffaleti, and Yang. Again, these equations are not expected to produce precise results but provide an estimate of the proposed channel's capacity that can be compared to the estimated loads in Tables 16 and 17. The results of the HEC-RAS capacity analysis for SF3 are summarized in Table 18. While the transport capacity results vary throughout the channel, each equation predicts capacity that is a minimum of one order of magnitude (and sometimes several) greater than the highest estimate of supply.

Table 18. Summary of SF3 Transport Capacity Analysis
Underwood Mitigation Project

Statistic	MPM (g/sec.)	Toffaletti (g/sec.)	Yang (g/sec.)
Min	19.56	17.92	6.34
Mean	825.08	123.43	1930.71
Max	3238.20	199.71	8008.35

In general, the sediment transport analyses described in this section confirm that the project streams are threshold channels as described Sheilds, et al. (2003). The results validate WEI's initial assessment conclusions that sediment supply is limited in this watershed and channel capacity is not a determining factor in calculating channel dimensions. The proposed channels will move their sediment loads and any bed adjustments will most likely be in the form of scour. Grade control structures will therefore be a key component of the design. For more information on grade control, see Section 7.4.

7.3.2 HEC-RAS Analysis

7.3.2.1 No-rise, LOMR, CLOMR

A flood study for the Underwood project will be completed for the stream restoration work proposed for SF4. This portion of the site includes approximately 1,400 LF of South Fork Cane Creek. This area is mapped as a FEMA Zone AE floodplain on FIRM panel 8784 (Figure 5). The remaining project streams are within Zone X and currently not modeled by FEMA.

South Fork Cane Creek was modeled as a limited detailed study. Base flood elevations have been defined, but no floodway is mapped on the FIRM panel. Non-encroachment widths are published in the Chatham County Community 370299 Flood Insurance Study dated February 2, 2007.

Preliminary modeling of SF4 indicates the proposed action will result in an increase in the 100-year base flood elevations, and further study will be required. The effective hydraulic model has been obtained from the NC Floodplain Mapping Program. WEI will model existing and proposed hydraulic conditions on the site for the 100-year flood event along South Fork. A Conditional Letter of Map Revision (CLOMR) will be prepared for submittal to the Chatham County local floodplain administrator and the NC Floodplain Mapping Program for approval prior to construction to document the increase in base flood elevations. If completed hydraulic modeling indicates that the elevations will not increase, then a no-rise study will be submitted. Following construction completion, if a CLOMR is required, or if it is apparent that flood elevations will drop by more than 0.1 foot, or non-encroachment widths will change, an as-built survey and Letter of Map Revision (LOMR) will be finalized and submitted to the Chatham County local floodplain administrator and the NC Floodplain Mapping Program. The NCEEP Floodplain Requirements Checklist is included in Appendix 9.

7.3.2.2 Hydrologic Trespass

The project will be designed so that any increase in flooding will be contained on the project site and will not extend upstream to adjacent parcels, so hydrologic trespass will not be a concern. The proposed restoration has been designed to transition back to the existing boundary conditions in a gradual manner.

7.4 Site Construction

The stream and wetland restoration will be constructed as described in this section. A full set of preliminary design plans are included with this mitigation plan for review.

7.4.1 Site Grading, Structure Installation and Other Project Related Construction

7.4.1.1

The stream restoration elements of the project will be constructed as Priority 1 restoration in which the stream bed is raised so that the bankfull elevation will coincide with the existing floodplain, the cross sections are sized for the design discharge, and the pattern is reconstructed so that the channel meanders through the floodplain. Due to excavation required for the wetland creation zone, the floodplain for the lower 700 LF of SF4 will be lowered. Enhancement I components of the project will involve raising the channel bed and sizing the cross sections appropriately but will not involve altering the existing channel pattern. Enhancement II construction will include bank treatments and stabilization only.

The stream reconstruction will result in appropriately sized channels that will meander across the floodplain. The cross-sectional dimensions of the design channels will be constructed to flood the adjacent floodplain and wetlands frequently. The reconstructed channel banks will be built with stable side slopes, planted with native materials, matted, and planted for long-term stability. The sinuous planform of the channel will be built to mimic a natural Piedmont stream.

The bedform of the reconstructed gravel bed channels will vary between pools and riffles. Generally the pools will occur in the outside of the meander bends and the riffles in the straight sections of channel between meanders. Riffle-pool sequences such as those that will be built in the new channels are common for gravel bed streams in the Piedmont and provide energy dissipation and aquatic habitat.

As a result of the project, the floodplain will be more frequently inundated. Wetland hydrology will be improved as a byproduct of raising the channel bed. Wetland restoration and creation are proposed in areas adjacent to the stream channels. Grading of the floodplain and wetlands will improve or create wetland functions. Site grading is described below.

7.4.1.2 Scaled Schematic of Grading

The proposed grading is included in the preliminary design plans but is also shown in Figures 13 and 14. Preliminary estimates of grading on the site include approximately 17,265 cubic yards of cut and 9,692 cubic yards of fill, with a net cut of 7,573 cubic yards.

7.4.1.3 In-Stream Structures and Other Construction Elements

Grade control is an important element of the design and many riffles will be constructed with grade control features. These include native gravel/cobble material riffles harvested from the existing channel, native material riffles reinforced with larger quarry stone, boulder and log sills, and cross vanes. Log vanes and log j-hook vanes will be among other in-stream structures constructed along the stream project. These structures will provide additional grade control and will deflect flows away from banks while creating habitat diversity. The channel banks will also be armored with native materials from the site including root wads and brush toe features. These structures and revetments are shown on the preliminary design plans. A mix of log and rock structures will be used on this site due to the occurrence of woody debris and large cobble features found in the existing channels and reference reaches.

Two crossings will be installed along the streams in the Upstream Area (with easement breaks) at the request of the landowner. These include a culvert crossing along UT1 and a ford crossing along SF3. Additionally, two culvert crossings will be installed outside of the easement boundaries and upstream of the restoration reaches to allow landowner access to adjacent parcels. These crossings will be placed on the restoration reach SF3 upstream of UT1, and the enhancement reach UT1 between UT1A and UT1B. Fencing will be installed to keep livestock out of the conservation easements on the Upstream Area properties. There are no livestock on the Downstream Area properties.

7.4.2 Natural Plant Community Restoration

7.4.2.1 Narrative of Plant Community Restoration

As a final stage of construction, riparian stream buffers and wetlands will be planted and restored with native trees and herbaceous plants representative of the natural plant community that exists within the project watershed. The natural community within and adjacent to the project easement can be classified as Piedmont bottomland forest (Schafale and Weakley, 1990). The woody and herbaceous species selected are based on this community type, observations of the occurrence of species in the surrounding area, and best professional judgment on species establishment and anticipated site conditions in the early years following project implementation. Permanent herbaceous seed will be placed on stream banks and bench areas and all disturbed areas within the project easement. The stream banks will be planted with live stakes. The riparian buffers and wetland areas will be planted with bare root seedlings. Proposed permanent herbaceous species are shown in Tables 19 and 20.

Table 19: Permanent Riparian Herbaceous Seed Mix (Applied at 20 lbs acre) Underwood Mitigation Project

Scientific Name	Common Name	Percentage
Elymus virginicus	Virginia Wild Rye	50%
Sorghastrum nutans	Indiangrass	10%
Panicum clandestinum	Deer Tongue	10%
Panicum virgatum	Switchgrass	25%
Rudbeckia hirta	Black Eyed Susan	5%

Table 20: Permanent Wetland Herbaceous Seed Mix (Applied at 20 lbs acre) Underwood Mitigation Project

Scientific Name	Common Name	Percentage
Elymus virginicus	Virginia Wild Rye	50%
Juncus effusus	Soft Rush	10%
Panicum clandestinum	Deer Tongue	20%
Panicum virgatum	Switchgrass	20%

Individual tree and shrub species will be planted throughout the project easement including stream banks, benches, tops of banks, and floodplains zones. These species will be planted as bare root and live stakes and will provide additional stabilization to the outsides of constructed meander bends and side slopes. Species planted as bare roots will be spaced at an initial density of 680 plants per acre (8 feet on center). Live stakes will be planted on channel banks at 2-foot to 3-foot spacing on the outside of meander bends and 6-foot to 8-foot spacing on tangent sections. Point bars will not be planted with live stakes. Targeted densities after monitoring year 3 are 320 woody stems per acre. Proposed tree and shrub species are representative of existing on-site vegetation communities and are typical of Piedmont bottomland forests (Table 21).

Table 21. Riparian Woody Vegetation
Underwood Mitigation Project

Scientific Name	Common Name	Percentage
Live Stakes		
Salix nigra	Black Willow	20%
Salix serecia	Silky Willow	40%
Cornus amomum	Silky Dogwood	40%
Riparian Bare Root Planting		
Alnus serrulata	Tag Alder	10%
Betula nigra	River Birch	15%
Carpinus caroliniana	Ironwood	10%
Fraxinus pennsylvanica	Green Ash	15%
Liriodendron tulipfera	Tulip Poplar	10%
Platanus occidentalis	Sycamore	20%
Quercus michauxii	Swamp Chestnut Oak	5%
Quercus phellos	Willow Oak	10%
Quercus rubra	Red Oak	5%
Wetland Bare Root Planting		
Alnus serrulata	Tag Alder	10%
Betula nigra	River Birch	15%
Cornus amomum	Silky Dogwood	10%
Fraxinus pennsylvanica	Green Ash	20%
Nyssa sylvatica	Blackgum	10%
Platanus occidentalis	Sycamore	20%
Quercus michauxii	Swamp Chestnut Oak	5%
Quercus phellos	Willow Oak	10%

8.0 Monitoring Plan

Using the EEP Baseline Monitoring Plan Template (version 1.0. 11/19/2009), a baseline monitoring plan report and an as-built record drawing of the project documenting the stream and wetland restoration, enhancement, and creation will be developed within 60 days of the planting completion and monitoring installation on the project site. Monitoring reports will be prepared in the fall of each year of monitoring and submitted to NCEEP. These annual monitoring reports will be based on the NCEEP Monitoring Report Template (version 1.2.1, 12/01/2009). The monitoring period will extend five years for stream and wetland hydrology assessments and seven years for wetland vegetation assessments beyond completion of construction or until performance criteria have been met.

8.1 Streams

8.1.1 Dimension

In order to monitor the channel dimension, a total of two permanent cross-sections will be installed along SF1, five on SF3, four on SF4, three on SF4A, two on UT1, and two on UT2. Cross-sections will be located at representative riffle and pool sections on each monitored reach. Each cross-section will be permanently marked with pins to establish its location. Cross-section surveys will be performed annually and will include points measured at all breaks in slope, including top of bank, bankfull, edge of water, and thalweg.

8.1.2 Pattern and Profile

A longitudinal profile will be completed for the 5,784 LF of the restoration and enhancement level I reaches (878 LF on SF1, 1,602 LF on SF3, 1,424 LF on SF4, 868 LF on SF4A, 591 LF on UT1, and 421 LF on UT2) immediately post-construction and annually throughout the five year monitoring period. The initial as-built survey will be used for baseline comparisons. Measurements in the survey will include thalweg, water surface, bankfull, and top of low bank. These profile measurements will be taken at the head of each riffle, run, pool, and glide, as well as at the maximum pool depth. The survey will be tied to a permanent benchmark and NC State Plane coordinates.

8.1.3 Photo Documentation

Approximately 46 permanent photographs will be established within the project stream and wetland areas after construction. Photographs will be taken once a year to visually document stability for five years following construction. Permanent markers will be established so that the same locations and view directions on the site are monitored each year. Photographs will be used to monitor restoration, enhancement, and creation stream and wetland areas as well as vegetation plots. The photographer will make every effort to maintain the same area in each photo over time. Reference photos will also be taken for each of the vegetation plots and cross-sections. The representative digital photo(s) will be taken on the same day surveys are conducted.

8.1.4 Substrate

A reach-wide pebble count will be conducted for classification purposes on each of the restoration and enhancement I reaches (SF1, SF3, SF4, SF4A, UT1, and UT2). Pebble counts will also be conducted on at permanent riffle cross-sections on all restoration and enhancement level I project reaches, for a total of 11 cross-sections. The pebble counts will be done annually and compared with data from previous years. Also, a subpavement sample will be taken at each surveyed riffle to characterize the subpavement particle size distribution.

8.1.5 Bankfull Events

Bankfull events will be documented using a crest gauge, photographs, and visual assessments such as debris lines. Seven crest gauges will be installed; one on SF1, one on SF3, one on SF4, one on SF4A, one on UT1 and the other gauge on UT2. The crest gauges will be installed onsite in a riffle cross-section floodplain of the restored channels at a central site location. The gauges will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition.

8.2 Vegetation

A total of 38 vegetation monitoring plots will be installed and evaluated within the restoration, enhancement, and creation areas to measure the survival of the planted trees. The number of monitoring quadrants required is based on the NCEEP monitoring guidance documents (version 1.0, 11/19/2009). The size of individual quadrants will be 100 square meters for woody tree species and shrubs. Vegetation assessments will be conducted following the Carolina Vegetation Survey (CVS) Level 2 Protocol for Recording Vegetation (2006).

The initial baseline survey will be conducted within 21 days from completion of site planting and used for subsequent monitoring year comparisons. The first annual vegetation monitoring activities will commence at the end of the first growing season, during the month of September. The restoration and enhancement sites will then be evaluated each subsequent year between June 1st and September 31st. Species composition, density, and survival rates will be evaluated on an annual basis by plot and for the entire site. Individual plot data will be provided and will include diameter, height, density, vigor, damage (if any), and survival. Planted woody stems will be marked annually as needed and given a coordinate, based off of a known origin, so they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living planted stems and the current year's living planted stems.

8.3 Wetlands

Groundwater monitoring gauges will be established throughout the wetland restoration, enhancement, and creation areas. Generally, the gauges will be installed at appropriate locations so that the data collected will provide an indication of groundwater levels throughout the wetland project area.

8.4 Schedule

The monitoring program described above will be performed on an annual basis. The estimated reporting schedule is shown below in Table 22.

Table 22. Project Activity and Reporting Schedule
Underwood Mitigation Project

Activity or Report	Completion or Delivery
Mitigation Plan	September 2011
Final Design-Construction Plans	November 2011
Permanent Seed Mix Applied	February 2012
Bare Root Plantings	March 2012

Activity or Report	Completion or Delivery
As-Built Report and Record Drawings	June 2012
Year 1 Monitoring	December 2012
Year 2 Monitoring	December 2013
Year 3 Monitoring	December 2014
Year 4 Monitoring	December 2015
Year 5 Monitoring	December 2016
Year 6 Monitoring	December 2017
Year 7 Monitoring	December 2018

9.0 Performance Criteria

The stream restoration success criteria for the project site will follow approved performance criteria presented in the NCEEP Mitigation Plan Template (version 1.0, 11/20/2009) and the Stream Mitigation Guidelines issued in April 2003 by the USACE and NCDWQ. Annual monitoring and quarterly site visits will be conducted to assess the condition of the finished project for five years, or until success criteria are met. The stream restoration and enhancement level I reaches (SF1, SF3, SF4, SF4A, UT1, and UT2) of the project will be assigned specific performance criteria components for stream morphology, hydrology, and vegetation. The enhancement level II reaches (SF2, SF3, UT1, and UT1A) will be documented through photographs and visual assessments to verify that no significant degradational changes are occurring in the stream channel or riparian corridor. The wetland restoration, enhancement, and creation sections will be assigned specific performance criteria for hydrology and vegetation. These success criteria are covered in detail as follows.

9.1 Streams

9.1.1 Dimension

Riffle cross-sections on the restoration reaches should remain relatively stable; however, due to the sand/silt nature of the substrate throughout the project reaches, fluctuations of the riffle bed elevation over time are expected. These fluctuations should be temporary and will likely correspond to storm events. Riffle cross-sectional ratios (width-to-depth, depth ratio, and bank height ratio) should fall within the parameters defined for channels of the appropriate Rosgen stream type. If persistent changes are observed, these changes will be evaluated to assess whether the stream channel is showing signs of long term instability. Indicators of instability include a vertically incising thalweg or eroding channel banks. Changes in the channel that indicate a movement toward stability or enhanced habitat include a decrease in the width-to-depth ratio in meandering channels or an increase in pool depth. Remedial action would not be taken if channel changes indicate a movement toward stability.

9.1.2 Pattern and Profile

Longitudinal profile data for the stream restoration reaches should show that the bedform features are remaining stable. The riffles should be steeper and shallower than the pools, while the pools should be deep with flat water surface slopes. The relative percentage of riffles and pools should not change significantly from the design parameters. Adjustments in length and slope of run and glide features are expected and will not be considered a sign of instability. The longitudinal profile should show that the bank height ratio remains very near to 1.0 for the majority of the restoration reaches.

9.1.3 Photo Documentation

Photographs should illustrate the site's vegetation and morphological stability on an annual basis. Cross-section photos should demonstrate no excessive erosion or degradation of the banks. Longitudinal photos should indicate the absence of persistent bars within the channel or vertical incision. Grade control structures should remain stable. Deposition of sediment on the bank side of vane arms is preferable. Maintenance of scour pools on the channel side of vane arms is expected. Reference photos will also be taken for each of the vegetation plots.

9.1.4 Substrate

Substrate materials in the restoration reaches should indicate a progression towards or the maintenance of coarser materials in the riffle features and smaller particles in the pool features.

9.1.5 Bankfull Events

Two bankfull flow events in separate years must be documented on the project within the five-year monitoring period. Bankfull events will be documented using a crest gage, photographs, and visual assessments such as debris lines.

9.2 Vegetation

The final vegetative success criteria will be the survival of 260 planted stems per acre in the riparian corridor along restored and enhanced reaches and within the wetland restoration and creation areas at the end of the required monitoring year (year five or seven). The interim measure of vegetative success for the site will be the survival of at least 320 planted stems per acre at the end of the third monitoring year. The extent of invasive species coverage will also be monitored and controlled as necessary throughout the required monitoring period (year five or seven).

9.3 Wetlands

The final performance criteria for wetland hydrology will be a free groundwater surface within 12 inches of the ground surface for 6.5 percent of the growing season, which is measured on consecutive days under typical precipitation conditions. This success criteria was determined through model simulations of post restoration conditions and comparison to an immediately adjacent existing wetland system. If a particular well does not meet this criteria for a given monitoring year, rainfall patterns will be analyzed and the hydrograph will be compared to that of the reference well to assess whether atypical weather conditions occurred during the monitoring period.

10.0 Site Protection and Adaptive Management Strategy

Adaptive measures will be developed or appropriate remedial actions will be implemented in the event that the site or a specific component of the site fails to achieve the success criteria outlined in this report. The project-specific monitoring plan developed during the design phase will identify an appropriate threshold for maintenance intervention based on the monitored items. Any actions implemented will be designed to achieve the success criteria specified previously, and will include a work schedule and updated monitoring criteria.

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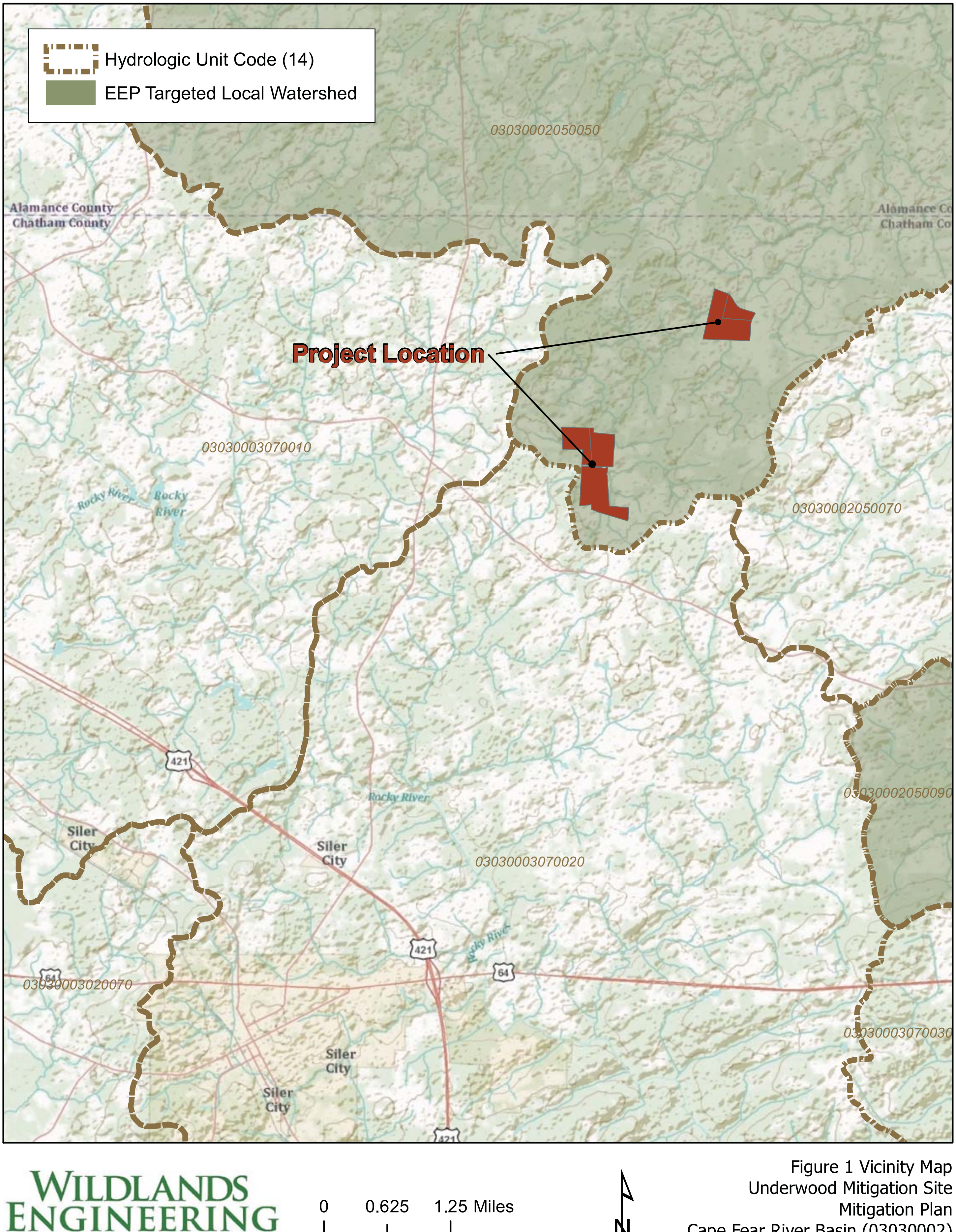
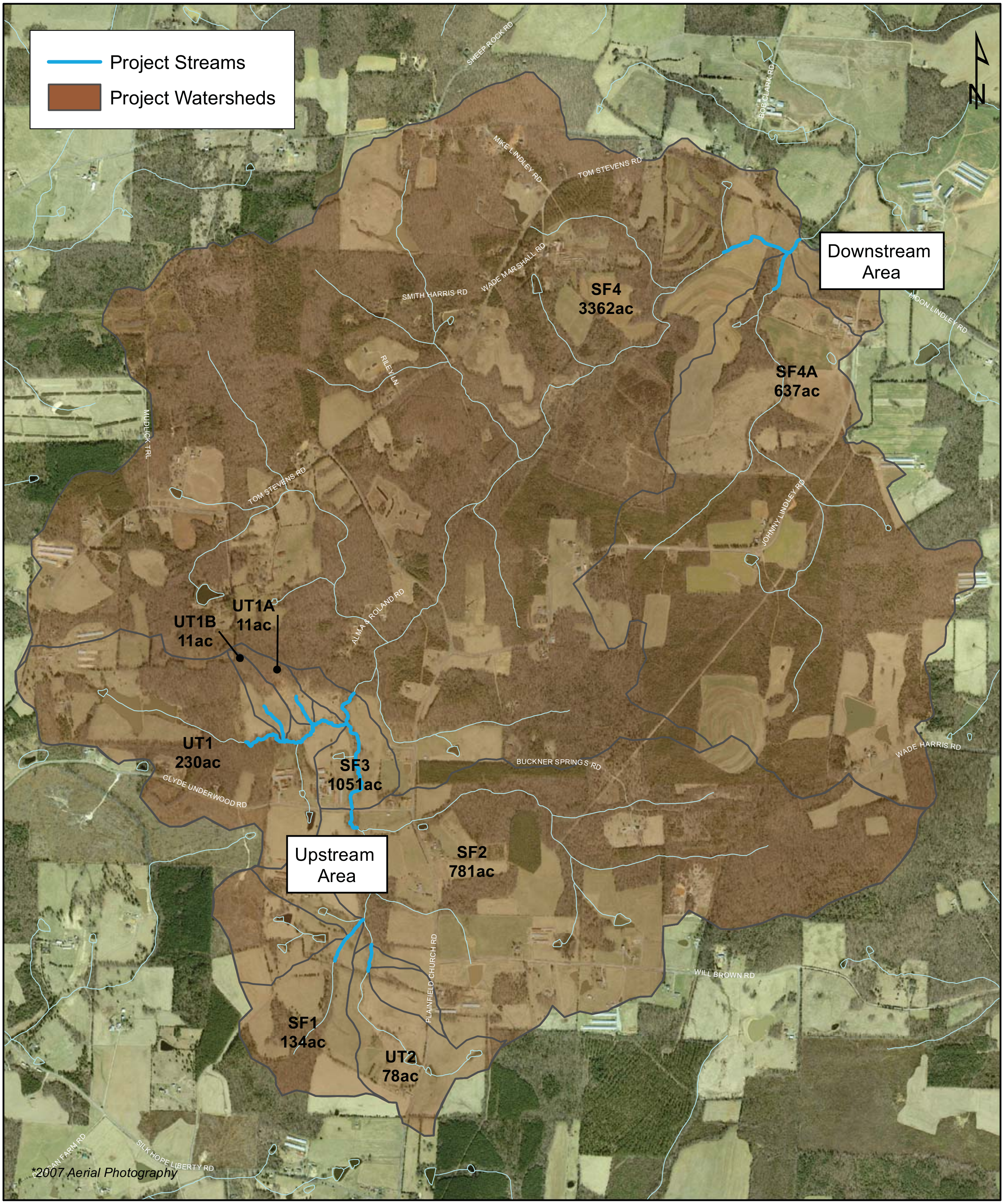
Figures



WILDLANDS ENGINEERING

Figure 1 Vicinity Map
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)
Chatham County, NC



WILDLANDS ENGINEERING

0 1,000 2,000 Feet

Figure 2 Watershed Map
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)
Chatham County, NC

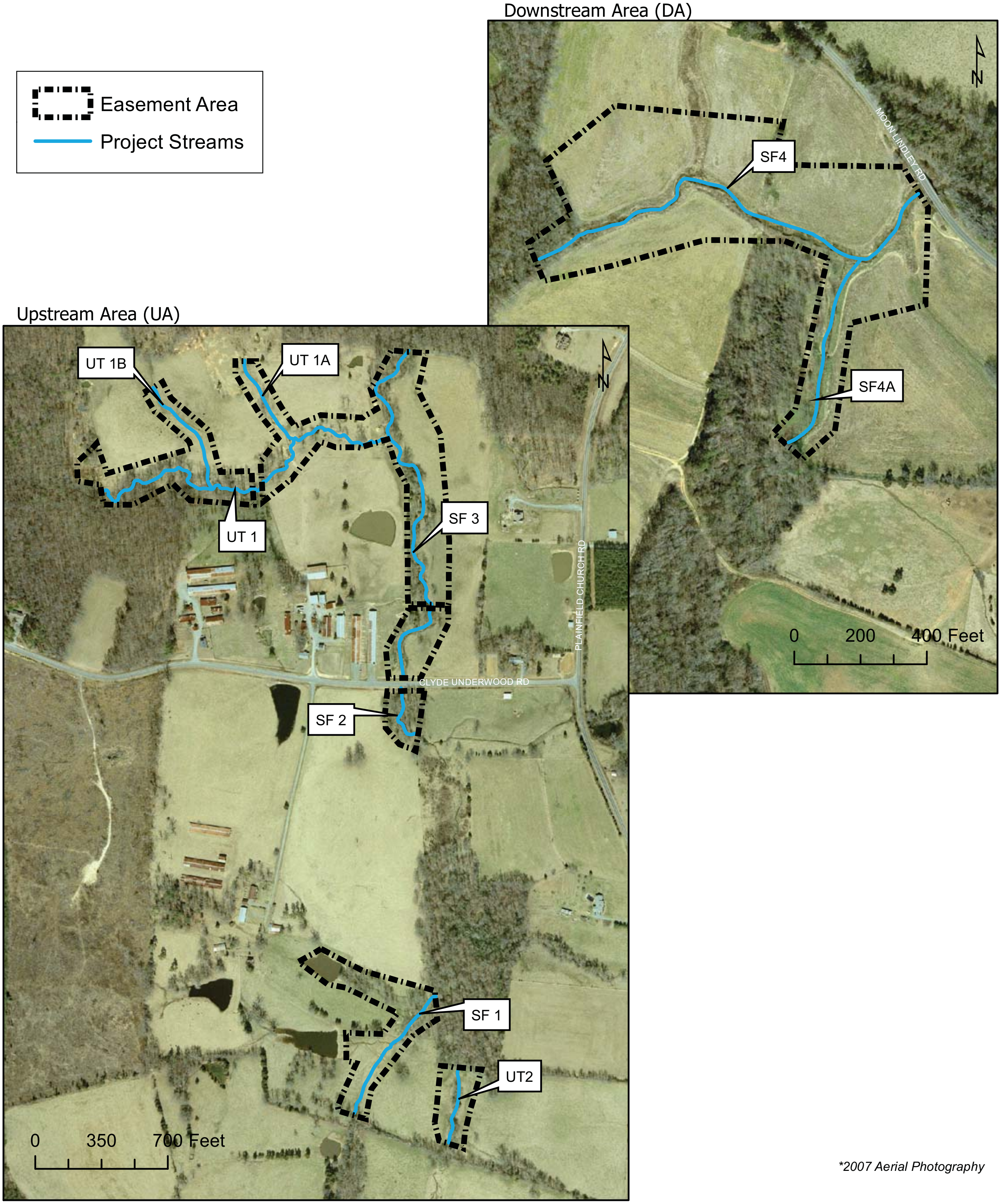
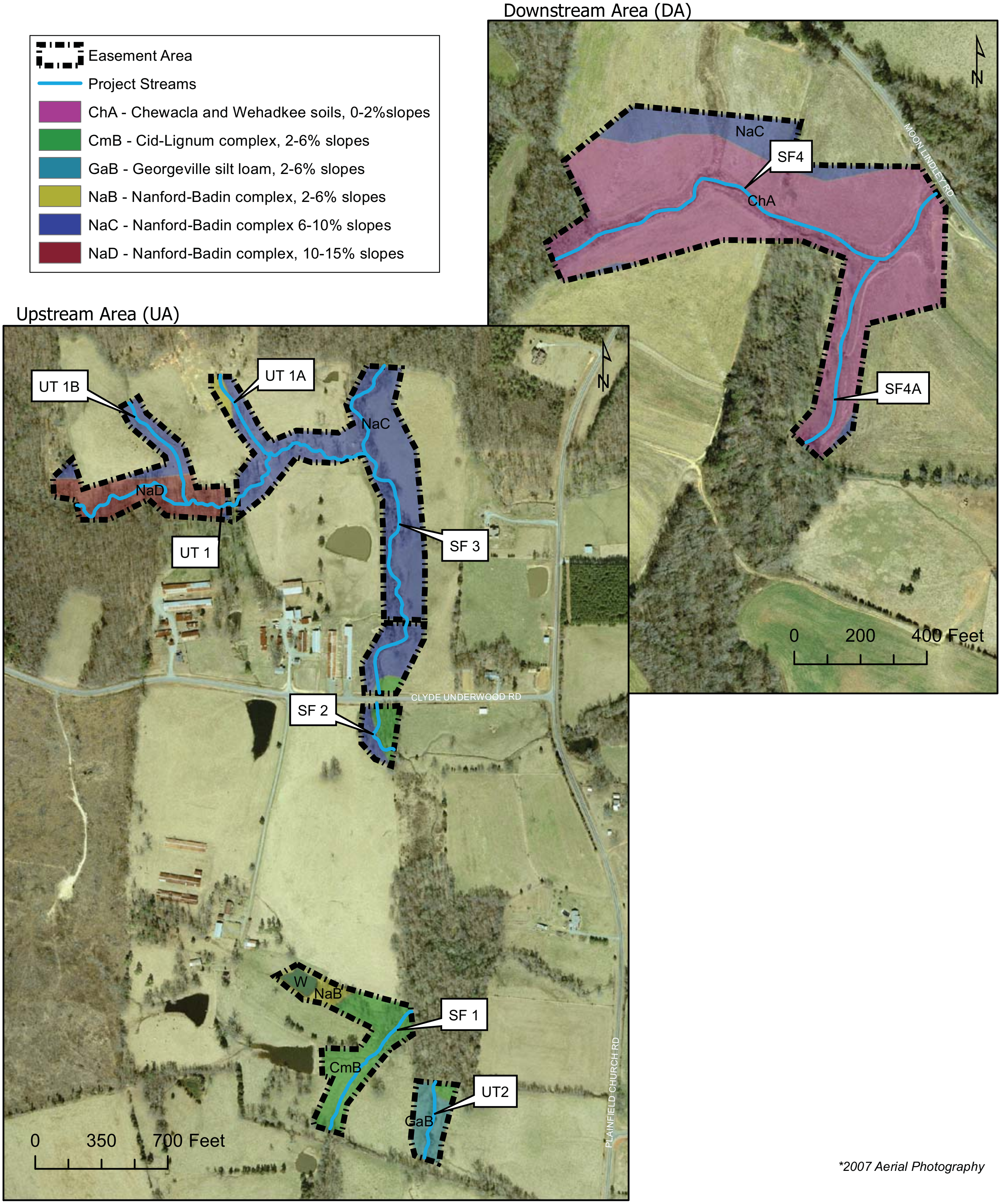


Figure 3 Site Map
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

Chatham County, NC

WILDLANDS
ENGINEERING

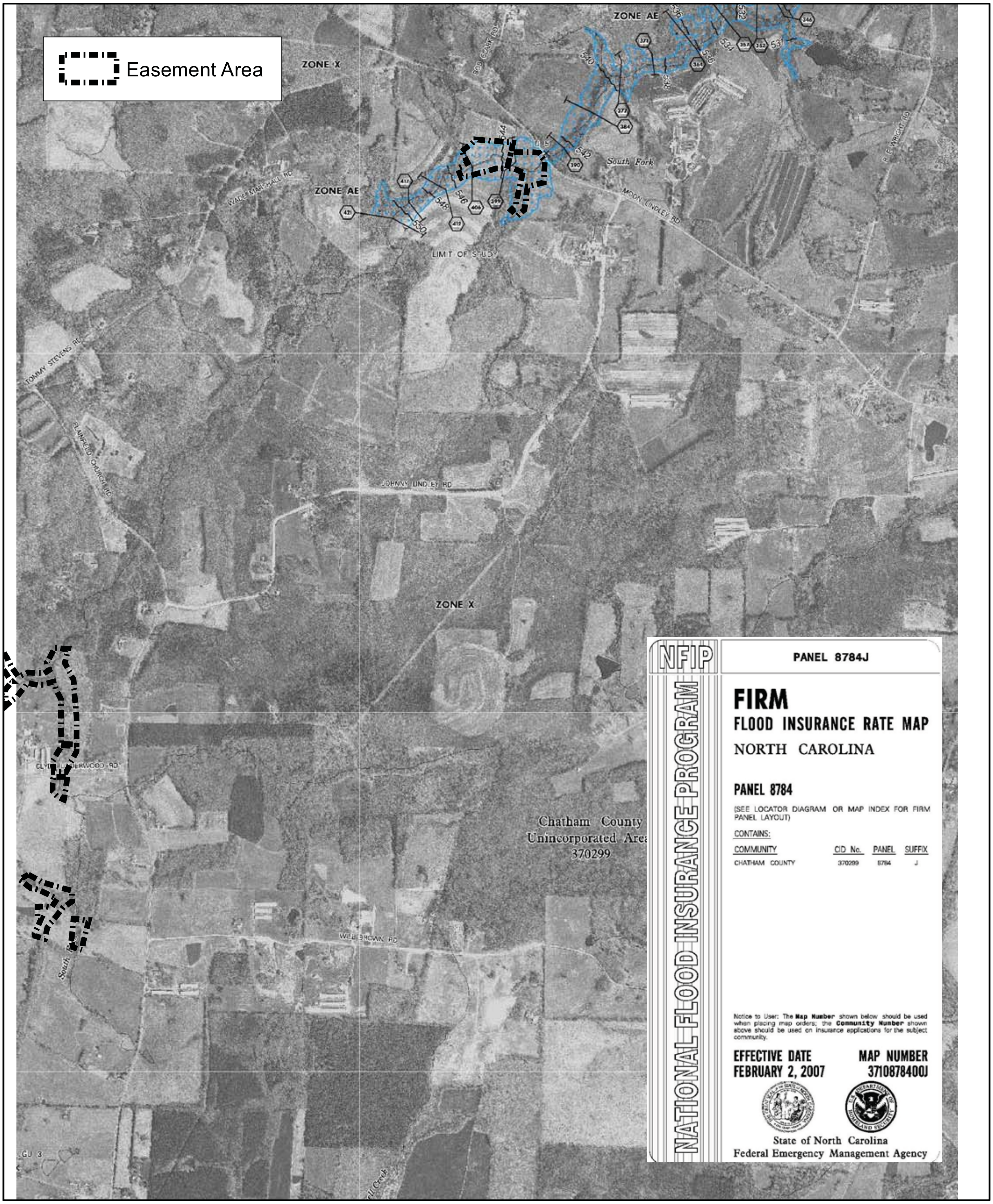


*2007 Aerial Photography

Figure 4 Soils Map
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

Chatham County, NC

WILDLANDS
ENGINEERING



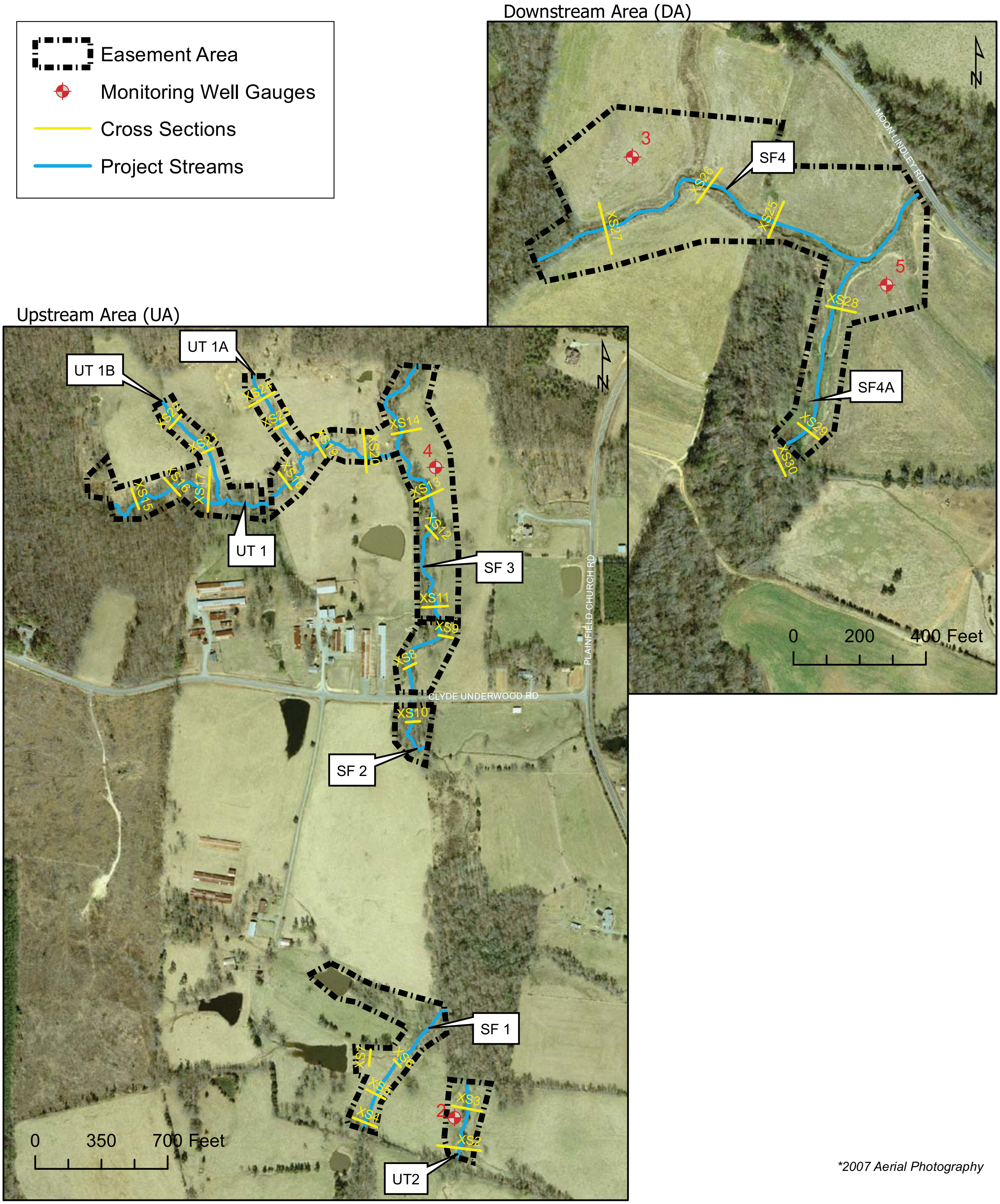
WILDLANDS ENGINEERING

0 1,083 2,166 Feet

N

Figure 5 FEMA Flood Map
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

Chatham County, NC

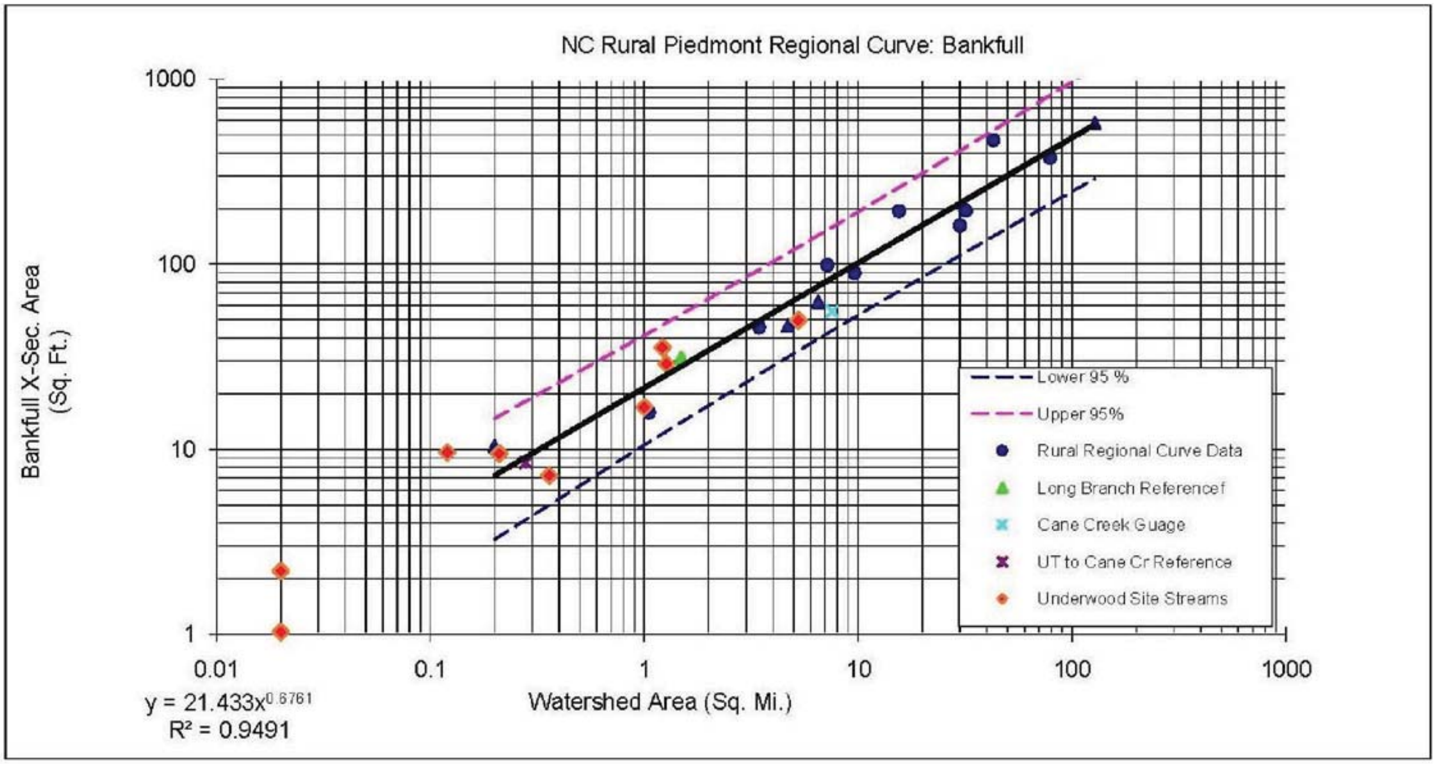


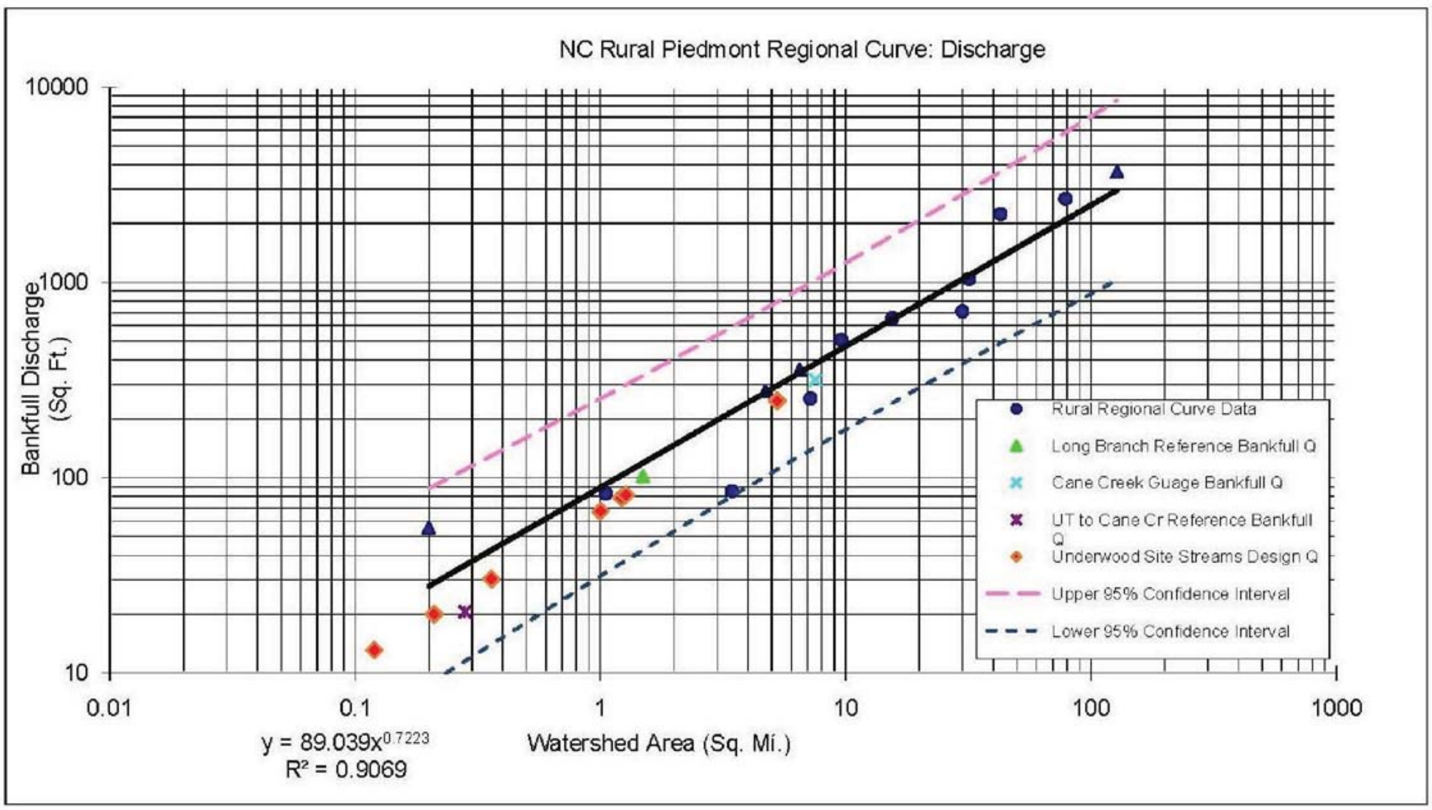
**2007 Aerial Photography*

Figure 6 Hydrologic Features Map
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

Chatham County, NC

WILDLANDS ENGINEERING

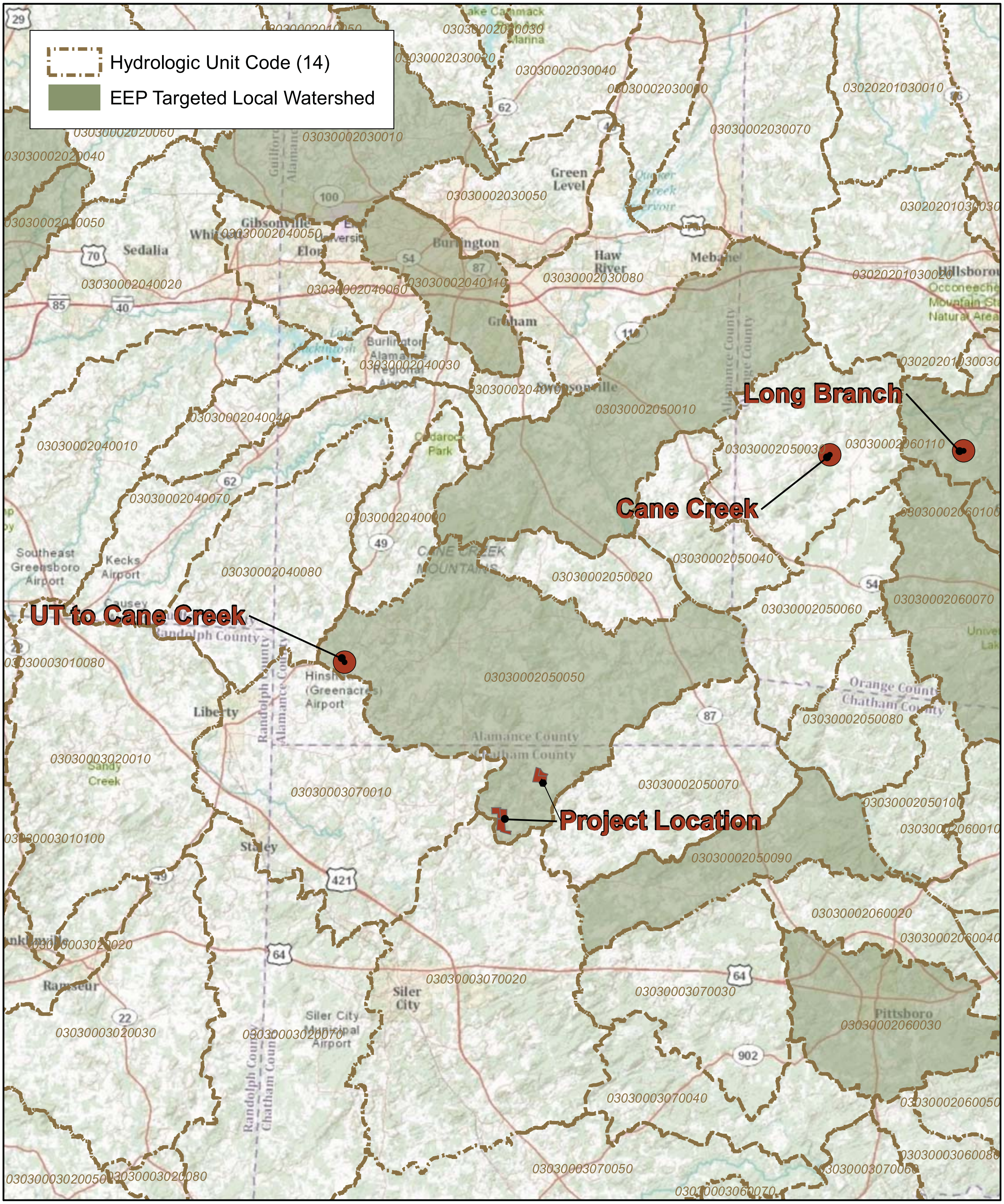




WILDLANDS ENGINEERING

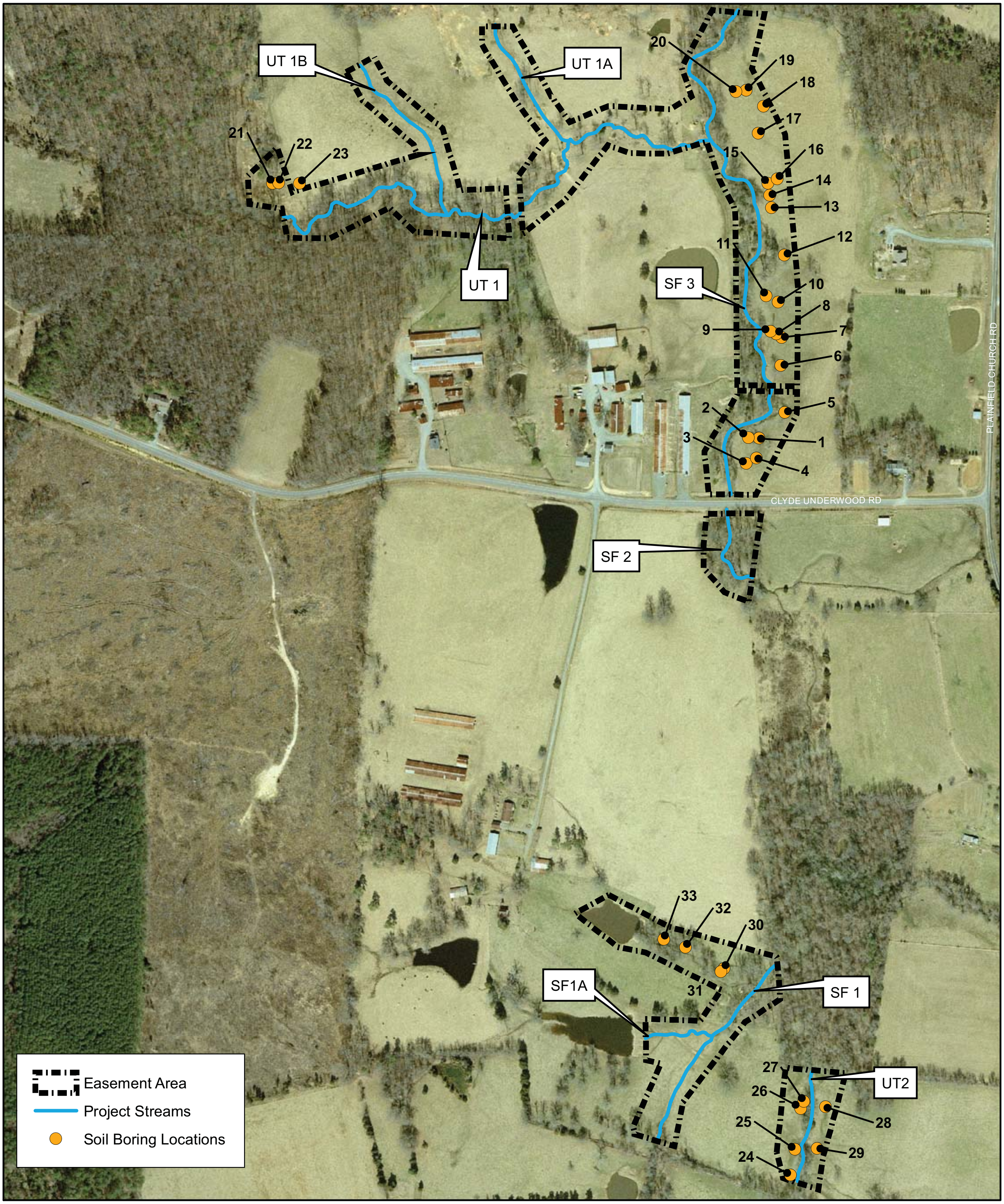
Figure 7 Regional Curve
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

Chatham County, NC



WILDLANDS ENGINEERING

Figure 8 Reference Site Vicinity Map
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)
Chatham County, NC



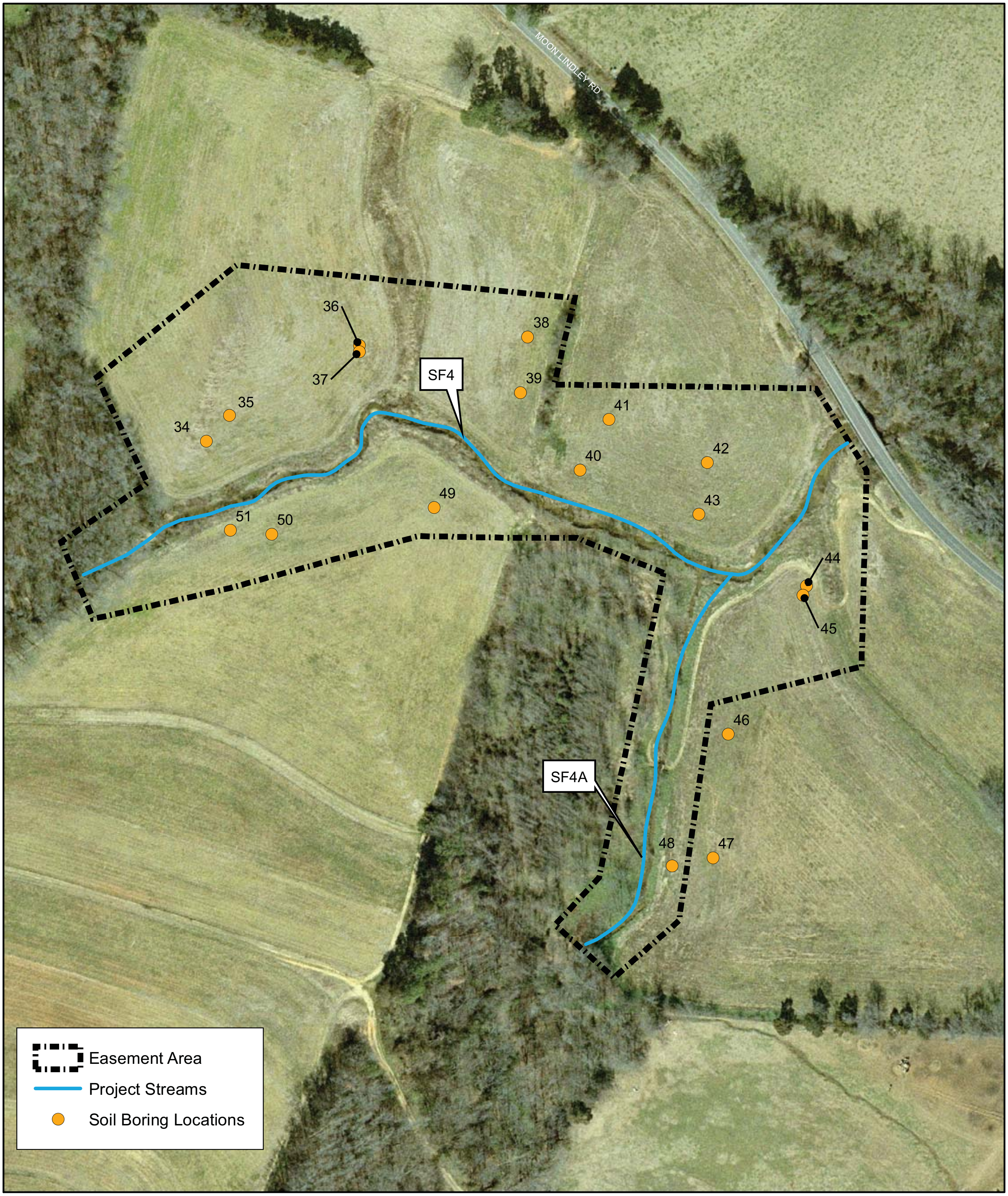
WILDLANDS ENGINEERING

0 237.5 475 Feet

N

Figure 9 Soil Borings - Upstream Area
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

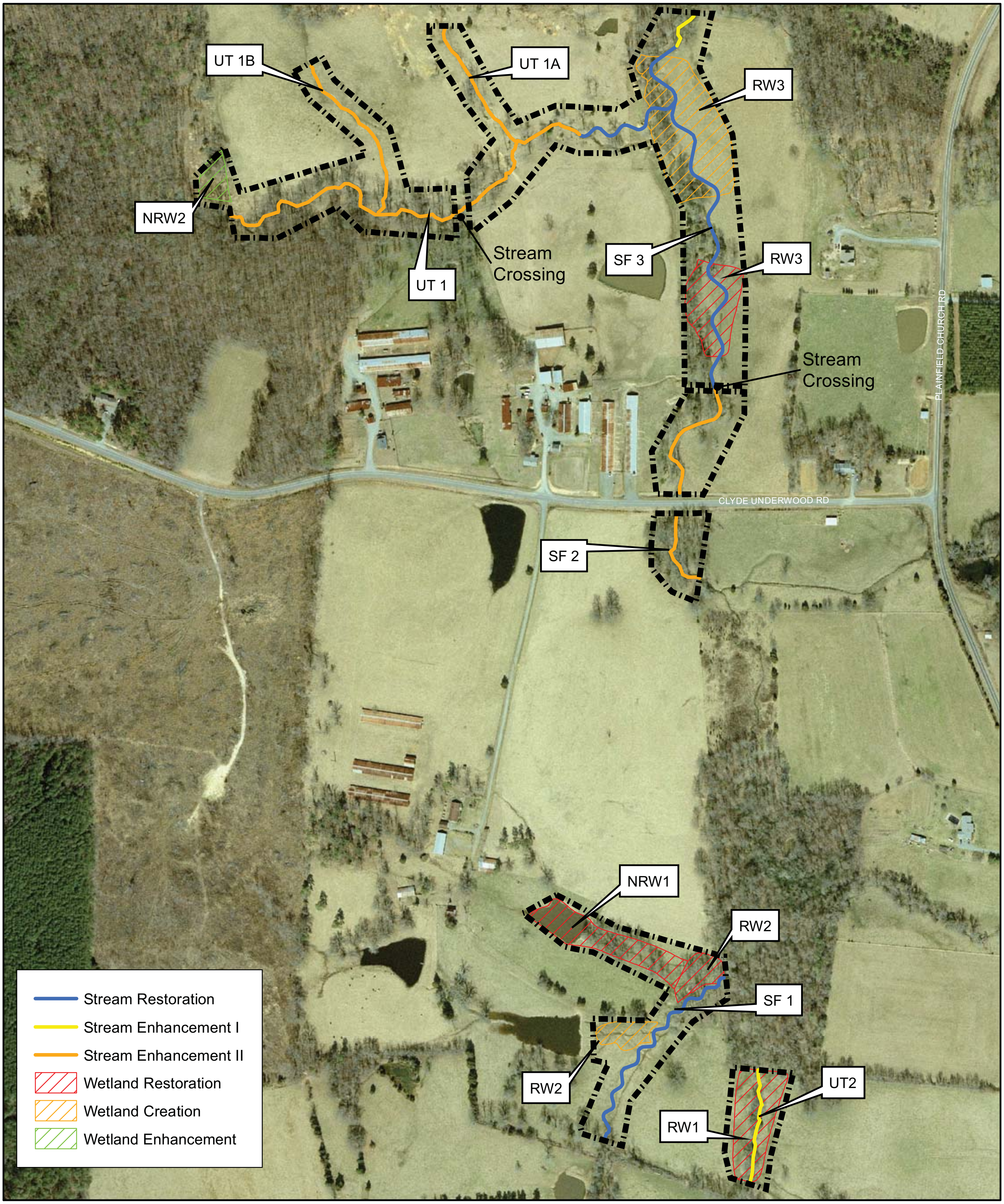
Chatham County, NC



WILDLANDS ENGINEERING

Figure 10 Soil Borings - Downstream Area
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

Chatham County, NC



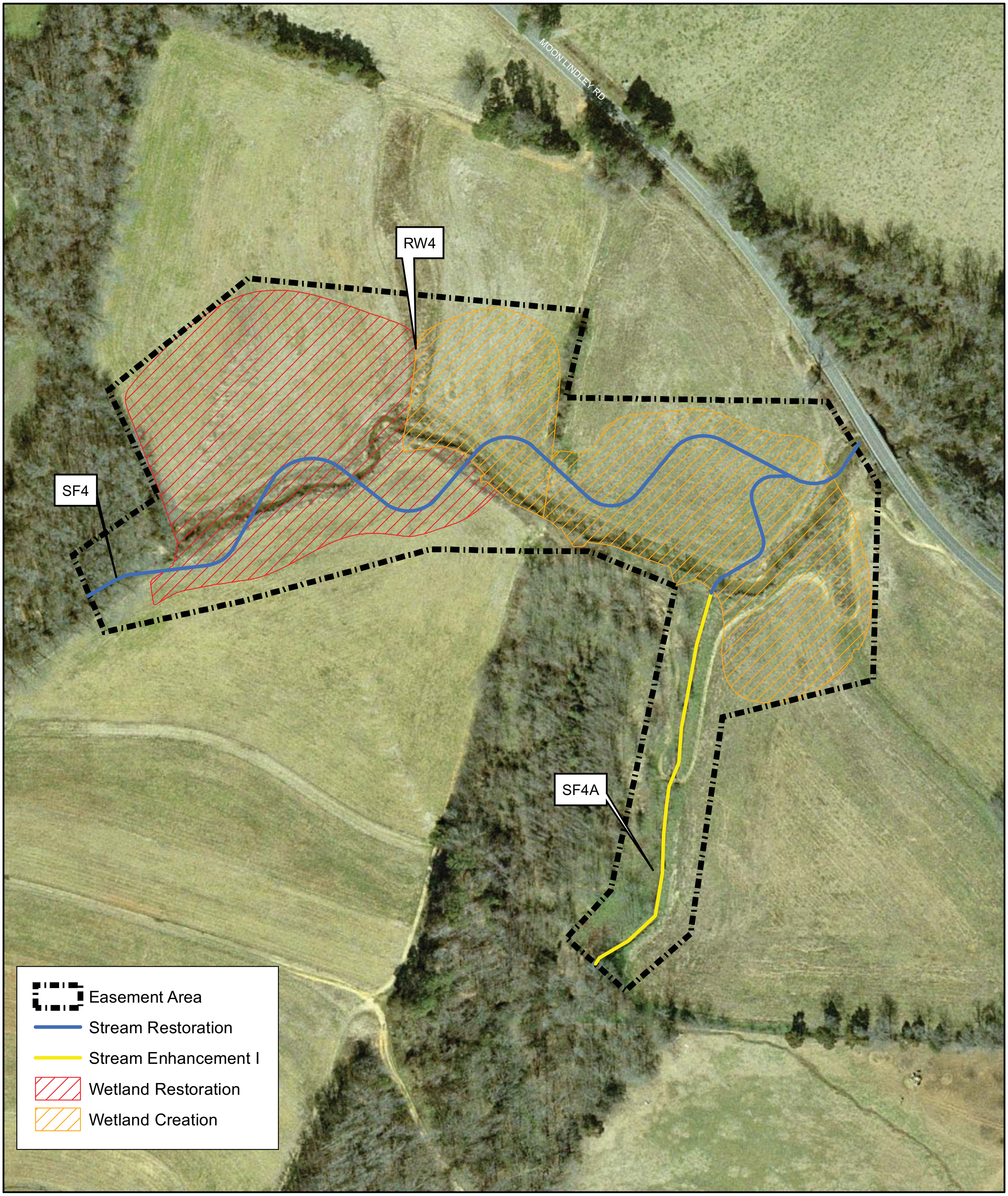
WILDLANDS ENGINEERING

0 237.5 475 Feet

N

Figure 11 Stream and Wetland Design - Upstream Area
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

Chatham County, NC



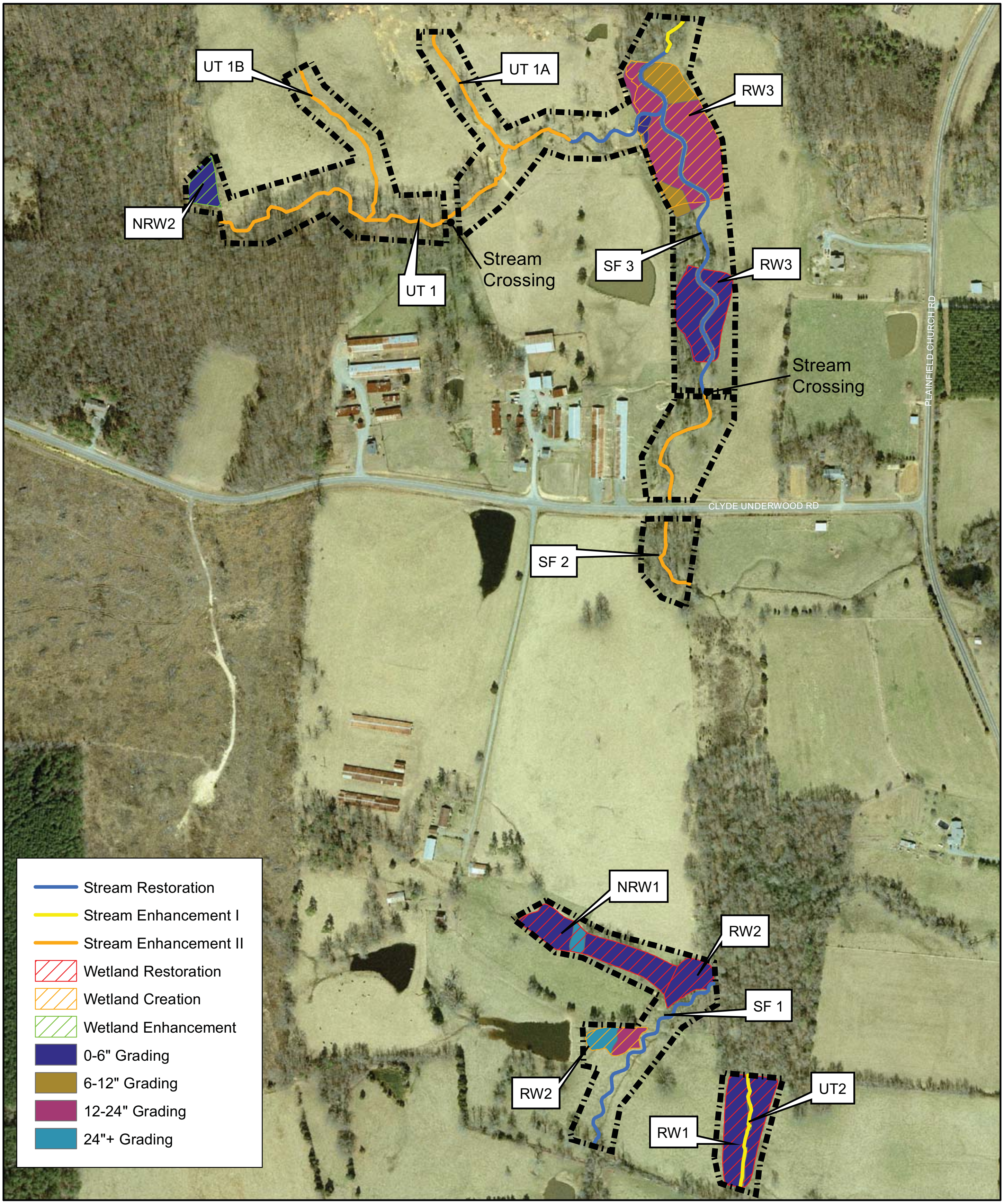
WILDLANDS ENGINEERING

0 100 200 Feet

N

Figure 12 Stream and Wetland Design - Downstream Area
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

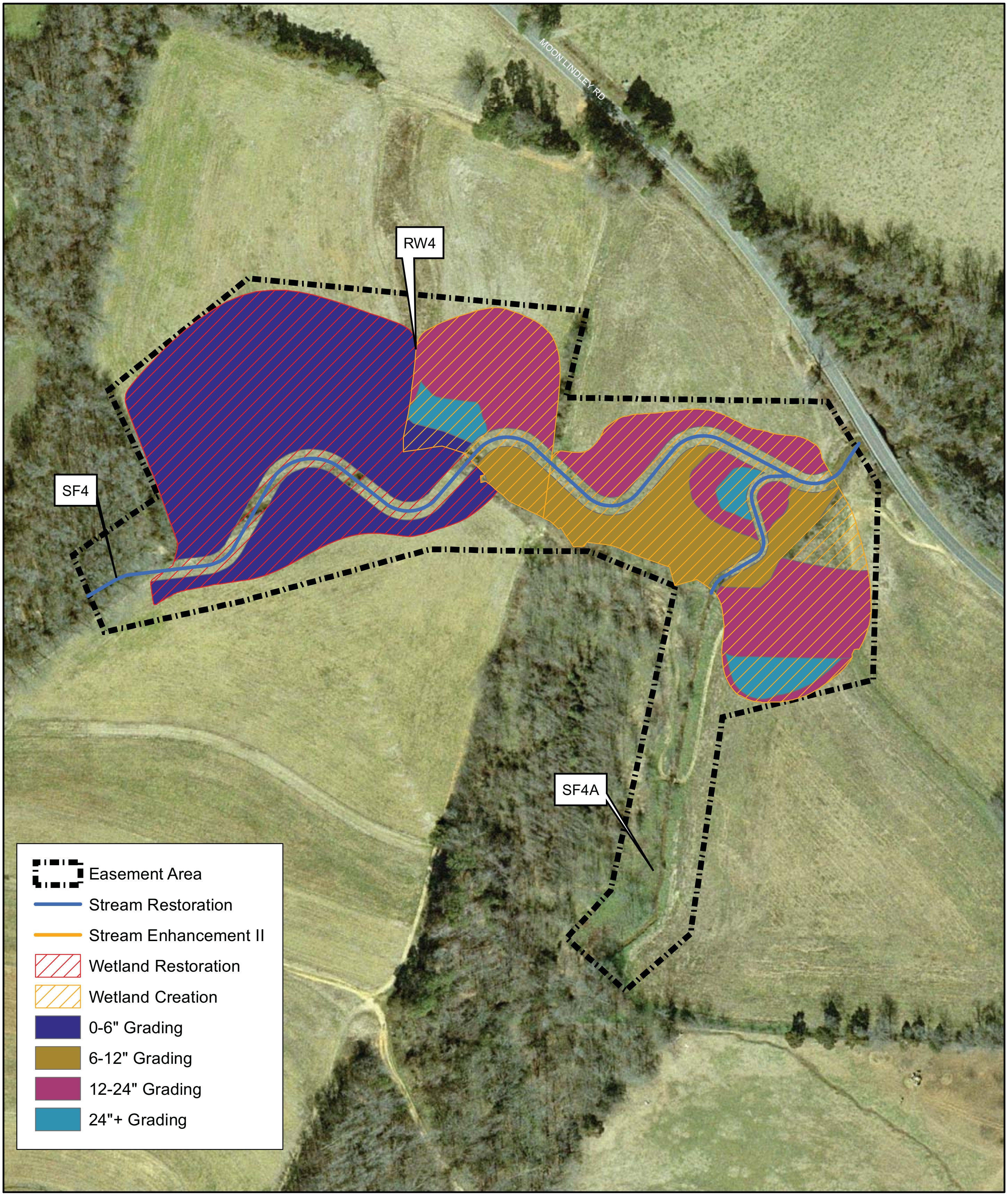
Chatham County, NC



WILDLANDS ENGINEERING

Figure 13 Proposed Wetland Grading - Upstream Area
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

Chatham County, NC



WILDLANDS ENGINEERING

0 100 200 Feet

N

Figure 14 Proposed Wetland Grading - Downstream Area
Underwood Mitigation Site
Mitigation Plan
Cape Fear River Basin (03030002)

Chatham County, NC

Appendix 1 Project Site Photographs


Existing Conditions Reach SF 1


Existing Conditions Reach SF 2


Existing Conditions Reach SF 3


Existing Conditions Reach SF 3


Existing Conditions Reach SF 4


Existing Conditions Reach SF 4


Existing Conditions Reach SF 4A


Existing Conditions Reach SF 4A


Existing Conditions Reach UT 1


Existing Conditions Reach UT 1


Existing Conditions Reach UT 1A


Existing Conditions Reach UT 1A

Existing Conditions UT 1B

Existing Conditions UT 2


Existing Conditions RW1


Existing Conditions RW2


Existing Conditions RW 3


Existing Conditions RW 4


Existing Conditions RW 4


Existing Conditions NRW2

Appendix 2 Project Site USACE Routine Wetland Determination Data Forms and Jurisdictional Determination

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SCP1 – UT2 (Perennial)

STREAM QUALITY ASSESSMENT WORKSHEET

1. Applicant's Name: Wildlands Engineering, Inc.
2. Evaluator's Name: Matt Jenkins
3. Date of Evaluation: 2/19/2010
4. Time of Evaluation: 2:15 pm
5. Name of Stream: UT2 to South Fork Cane Creek
6. River Basin: Cape Fear 03030002
7. Approximate Drainage Area: 78 acres
8. Stream Order: Second
9. Length of Reach Evaluated: 100 lf
10. County: Chatham
11. Location of reach under evaluation (include nearby roads and landmarks): From Greensboro, NC, travel south on US-421 for approximately 20 miles. Take Old Liberty Road exit toward Liberty, turn left at Old Liberty Road and continue on to Swannanoa Avenue. Turn right at S. Greensboro Street and travel approximately 0.5 mile to make a left at Dameron Avenue; continue on to Silk Hope Road and Silk Hope Liberty Road. Travel approximately 8 miles to Clyde Underwood Road.
12. Site Coordinates (if known): N 35.801304°, W 79.401141°
13. Proposed Channel Work (if any): restoration/enhancement
14. Recent Weather Conditions: no rain within the past 48 hours
15. Site conditions at time of visit: sunny, 40°
16. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
17. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area: ~1-2 acres
18. Does channel appear on USGS quad map? YES NO
19. Does channel appear on USDA Soil Survey? YES NO
20. Estimated Watershed Land Use: ____% Residential ____% Commercial ____% Industrial 90 % Agricultural 10 % Forested ____% Cleared / Logged ____% Other (________________________)
21. Bankfull Width: 12-15 feet
22. Bank Height (from bed to top of bank): 3-4 feet
23. Channel slope down center of stream: X Flat (0 to 2%) ____Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
24. Channel Sinuosity: X Straight ____Occasional Bends ____Frequent Meander ____Very Sinuous ____Braided Channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 45 **Comments:**____

Evaluator's Signature ______________________ **Date** 2/19/2010

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STREAM QUALITY ASSESSMENT WORKSHEET
SCP1 – UT2 (Perennial)

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	3
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	2
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	1
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	2
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	3
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	3
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	3
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	1
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	3
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	4
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	2
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	3
	15	**Impact by agriculture or livestock production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	3
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	2
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	3
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	1
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	1
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				45

* These characteristics are not assessed in coastal streams.

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SCP2 – South Fork Cane Creek (Perennial)

STREAM QUALITY ASSESSMENT WORKSHEET

1. Applicant's Name: Wildlands Engineering, Inc.
2. Evaluator's Name: Matt Jenkins
3. Date of Evaluation: 2/19/2010
4. Time of Evaluation: 2:00 pm
5. Name of Stream: South Fork Cane Creek
6. River Basin: Cape Fear 03030002
7. Approximate Drainage Area: 70 acres
8. Stream Order: Second
9. Length of Reach Evaluated: 100 lf
10. County: Chatham
11. Location of reach under evaluation (include nearby roads and landmarks): From Greensboro, NC, travel south on US-421 for approximately 20 miles. Take Old Liberty Road exit toward Liberty, turn left at Old Liberty Road and continue on to Swannanoa Avenue. Turn right at S. Greensboro Street and travel approximately 0.5 mile to make a left at Dameron Avenue; continue on to Silk Hope Road and Silk Hope Liberty Road. Travel approximately 8 miles to Clyde Underwood Road.
12. Site Coordinates (if known): N 35.802778°, W 79.401822°
13. Proposed Channel Work (if any): restoration/enhancement
14. Recent Weather Conditions: no rain within the past 48 hours
15. Site conditions at time of visit: sunny, 40°
16. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
17. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area: 0.6 acre
18. Does channel appear on USGS quad map? YES NO
19. Does channel appear on USDA Soil Survey? YES NO
20. Estimated Watershed Land Use: ____% Residential ____% Commercial ____% Industrial 90 % Agricultural 10 % Forested ____% Cleared / Logged ____% Other (________________________)
21. Bankfull Width: 10-12 feet
22. Bank Height (from bed to top of bank): 3-4 feet
23. Channel slope down center of stream: X Flat (0 to 2%) ____Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
24. Channel Sinuosity: ____Straight X Occasional Bends ____Frequent Meander ____Very Sinuous ____Braided Channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 48 **Comments:**______________________________

Evaluator's Signature______________________ **Date** 2/19/2010

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STREAM QUALITY ASSESSMENT WORKSHEET
SCP2 – South Fork Cane Creek (Perennial)

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	3
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	3
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	2
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	3
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	3
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	3
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	3
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	3
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	3
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	2
	15	**Impact by agriculture or livestock production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	1
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	3
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	3
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	3
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	1
Total Points Possible			100	100	100	
TOTAL SCORE (also enter on first page)						48

* These characteristics are not assessed in coastal streams.

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SCP3 – South Fork Cane Creek (Perennial)

STREAM QUALITY ASSESSMENT WORKSHEET

1. Applicant's Name: Wildlands Engineering, Inc.
2. Evaluator's Name: Matt Jenkins
3. Date of Evaluation: 2/19/2010
4. Time of Evaluation: 1:00 pm
5. Name of Stream: South Fork Cane Creek
6. River Basin: Cape Fear 03030002
7. Approximate Drainage Area: 1,051 acres
8. Stream Order: Third
9. Length of Reach Evaluated: 300 lf
10. County: Chatham
11. Location of reach under evaluation (include nearby roads and landmarks): From Greensboro, NC, travel south on US-421 for approximately 20 miles. Take Old Liberty Road exit toward Liberty, turn left at Old Liberty Road and continue on to Swannanoa Avenue. Turn right at S. Greensboro Street and travel approximately 0.5 mile to make a left at Dameron Avenue; continue on to Silk Hope Road and Silk Hope Liberty Road. Travel approximately 8 miles to Clyde Underwood Road.
12. Site Coordinates (if known): N 35.809256°, W 79.401698°
13. Proposed Channel Work (if any): restoration/ enhancement
14. Recent Weather Conditions: no rain within the past 48 hours
15. Site conditions at time of visit: sunny, 40°
16. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
17. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area: ~5-6 acres
18. Does channel appear on USGS quad map? YES NO
19. Does channel appear on USDA Soil Survey? YES NO
20. Estimated Watershed Land Use: ____% Residential ____% Commercial ____% Industrial 70 % Agricultural 30 % Forested ____% Cleared / Logged ____% Other (______________________)
21. Bankfull Width: 15-20 feet
22. Bank Height (from bed to top of bank): 3-5 feet
23. Channel slope down center of stream: X Flat (0 to 2%) ____Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
24. Channel Sinuosity: ____Straight X Occasional Bends ____Frequent Meander ____Very Sinuous ____Braided Channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 55 **Comments:**

Evaluator's Signature [signature] **Date** 2/19/2010

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STREAM QUALITY ASSESSMENT WORKSHEET
SCP3 – South Fork Cane Creek (Perennial)

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	4
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	3
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	2
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	3
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	4
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	4
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	3
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	3
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	4
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	2
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	1
	15	**Impact by agriculture or livestock production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	5
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	4
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	3
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	1
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	2
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				55

* These characteristics are not assessed in coastal streams.

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SCP4 – UT1 (Perennial)

STREAM QUALITY ASSESSMENT WORKSHEET

1. Applicant's Name: Wildlands Engineering, Inc.
2. Evaluator's Name: Matt Jenkins
3. Date of Evaluation: 2/19/2010
4. Time of Evaluation: 12:30 pm
5. Name of Stream: UT1 to South Fork Cane Creek
6. River Basin: Cape Fear 03030002
7. Approximate Drainage Area: 230 acres
8. Stream Order: Second
9. Length of Reach Evaluated: 200 lf
10. County: Chatham
11. Location of reach under evaluation (include nearby roads and landmarks): From Greensboro, NC, travel south on US-421 for approximately 20 miles. Take Old Liberty Road exit toward Liberty, turn left at Old Liberty Road and continue on to Swannanoa Avenue. Turn right at S. Greensboro Street and travel approximately 0.5 mile to make a left at Dameron Avenue; continue on to Silk Hope Road and Silk Hope Liberty Road. Travel approximately 8 miles to Clyde Underwood Road.
12. Site Coordinates (if known): N 35.811274°, W 79.403625°
13. Proposed Channel Work (if any): restoration/ enhancement
14. Recent Weather Conditions: no rain within the past 48 hours
15. Site conditions at time of visit: sunny, 40°
16. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
17. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area: 8.4 acres
18. Does channel appear on USGS quad map? YES NO 19. Does channel appear on USDA Soil Survey? YES NO
20. Estimated Watershed Land Use: ____% Residential ____% Commercial ____% Industrial 60 % Agricultural 40 % Forested ____% Cleared / Logged ____% Other (________________________)
21. Bankfull Width: 12-15 feet
22. Bank Height (from bed to top of bank): 4-5 feet
23. Channel slope down center of stream: X Flat (0 to 2%) ____Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
24. Channel Sinuosity: ____Straight ____Occasional Bends X Frequent Meander ____Very Sinuous ____Braided Channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 46 **Comments:**

Evaluator's Signature **Date** 2/19/2010

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers in order to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 05/03. To Comment, please call 919-876-8441 x 26.

STREAM QUALITY ASSESSMENT WORKSHEET
SCP4 – UT1 (Perennial)

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	4
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	3
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	1
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	2
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	4
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	3
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	4
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	2
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	3
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	1
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	2
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	1
	15	**Impact by agriculture or livestock production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	5
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	3
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	2
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	2
BIOLOGY	20	**Presence of stream invertebrates** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	1
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	1
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				46

* These characteristics are not assessed in coastal streams.

OFFICE USE ONLY:	USACE AID#______________________	DWQ #__________________________

SCP5 – UT1A (Intermittent)

STREAM QUALITY ASSESSMENT WORKSHEET

1. Applicant's Name: Wildlands Engineering, Inc.
2. Evaluator's Name: Matt Jenkins
3. Date of Evaluation: 2/19/2010
4. Time of Evaluation: 12:15 pm
5. Name of Stream: UT1A to South Fork Cane Creek
6. River Basin: Cape Fear 03030002
7. Approximate Drainage Area: 11 acres
8. Stream Order: First
9. Length of Reach Evaluated: 100 lf
10. County: Chatham

11. Location of reach under evaluation (include nearby roads and landmarks): From Greensboro, NC, travel south on US-421 for approximately 20 miles. Take Old Liberty Road exit toward Liberty, turn left at Old Liberty Road and continue on to Swannanoa Avenue. Turn right at S. Greensboro Street and travel approximately 0.5 mile to make a left at Dameron Avenue; continue on to Silk Hope Road and Silk Hope Liberty Road. Travel approximately 8 miles to Clyde Underwood Road.

12. Site Coordinates (if known): N 35.812115°, W 79.404562°

13. Proposed Channel Work (if any): restoration/enhancement

14. Recent Weather Conditions: no rain within the past 48 hours

15. Site conditions at time of visit: sunny, 40°

16. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)

17. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:___________

18. Does channel appear on USGS quad map? YES NO 19. Does channel appear on USDA Soil Survey? YES NO

20. Estimated Watershed Land Use: ____% Residential ____% Commercial ____% Industrial 80 % Agricultural 20 % Forested ____% Cleared / Logged ____% Other (________________________)

21. Bankfull Width: 5-6 feet
22. Bank Height (from bed to top of bank): 1-2 feet

23. Channel slope down center of stream: ____Flat (0 to 2%) X Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)

24. Channel Sinuosity: ____Straight X Occasional Bends ____Frequent Meander ____Very Sinuous ____Braided Channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 23 **Comments:**

Evaluator's Signature ______________ **Date** 2/19/2010

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STREAM QUALITY ASSESSMENT WORKSHEET
SCP5 – UT1A (Intermittent)

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	2
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	0
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	0
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	0
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	2
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	1
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	1
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	2
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	1
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	3
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	1
	15	**Impact by agriculture or livestock production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	2
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	2
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	1
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	1
BIOLOGY	20	**Presence of stream invertebrates** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	0
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				23

* These characteristics are not assessed in coastal streams.

OFFICE USE ONLY:	USACE AID#______________________	DWQ #__________________________

SCP6 – UT1B (Intermittent)

STREAM QUALITY ASSESSMENT WORKSHEET

1. Applicant's Name: Wildlands Engineering, Inc.
2. Evaluator's Name: Matt Jenkins
3. Date of Evaluation: 2/19/2010
4. Time of Evaluation: 12:00 pm
5. Name of Stream: UT to South Fork Cane Creek
6. River Basin: Cape Fear 03030002
7. Approximate Drainage Area: 15 acres
8. Stream Order: First
9. Length of Reach Evaluated: 100 lf
10. County: Chatham
11. Location of reach under evaluation (include nearby roads and landmarks): From Greensboro, NC, travel south on US-421 for approximately 20 miles. Take Old Liberty Road exit toward Liberty, turn left at Old Liberty Road and continue on to Swannanoa Avenue. Turn right at S. Greensboro Street and travel approximately 0.5 mile to make a left at Dameron Avenue; continue on to Silk Hope Road and Silk Hope Liberty Road. Travel approximately 8 miles to Clyde Underwood Road.
12. Site Coordinates (if known): N 35.811499°, W 79.405879°
13. Proposed Channel Work (if any): restoration/enhancement
14. Recent Weather Conditions: no rain within the past 48 hours
15. Site conditions at time of visit: sunny, 40°
16. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
17. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:___________
18. Does channel appear on USGS quad map? YES NO
19. Does channel appear on USDA Soil Survey? YES NO
20. Estimated Watershed Land Use: ____% Residential ____% Commercial ____% Industrial 80 % Agricultural 20 % Forested ____% Cleared / Logged ____% Other (______________________)
21. Bankfull Width: 5-8 feet
22. Bank Height (from bed to top of bank): 1-2 feet
23. Channel slope down center of stream: ____Flat (0 to 2%) X Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
24. Channel Sinuosity: ____Straight X Occasional Bends ____Frequent Meander ____Very Sinuous ____Braided Channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 22 **Comments:**

Evaluator's Signature ______________ **Date** 2/19/2010

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STREAM QUALITY ASSESSMENT WORKSHEET
SCP6 – UT1B (Intermittent)

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	2
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	0
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	0
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	0
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	2
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	1
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	1
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	2
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	2
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	3
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	0
	15	**Impact by agriculture or livestock production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	2
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	2
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	0
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	1
BIOLOGY	20	**Presence of stream invertebrates** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	0
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				22

* These characteristics are not assessed in coastal streams.

OFFICE USE ONLY: USACE AID#____________ DWQ #____________

SCP7 – South Fork Cane Creek (Perennial)

STREAM QUALITY ASSESSMENT WORKSHEET

1. Applicant's Name: Wildlands Engineering, Inc.
2. Evaluator's Name: John Hutton
3. Date of Evaluation: 3/1/2010
4. Time of Evaluation: 1:00 pm
5. Name of Stream: South Fork Cane Creek
6. River Basin: Cape Fear 03030002
7. Approximate Drainage Area: 5.3 square miles
8. Stream Order: Third
9. Length of Reach Evaluated: 300 lf
10. County: Chatham
11. Location of reach under evaluation (include nearby roads and landmarks): From Greensboro, NC, travel south on US-421 for approximately 20 miles. Take Old Liberty Road exit toward Liberty, turn left at Old Liberty Road and continue on to Swannanoa Avenue. Turn right at S. Greensboro Street and travel approximately 0.5 mile to make a left at Dameron Avenue; continue on to Silk Hope Road and Silk Hope Liberty Road. Travel approximately 8 miles and turn left onto Siler City Snow Camp Road and take an immediate right onto Tom Stevens Road. Travel approximately 3.5 miles and turn right onto Moon Lindley Road, site will be ½ mile on the right.
12. Site Coordinates (if known): N 35.811383°, W 79.409065°
13. Proposed Channel Work (if any): restoration/ enhancement
14. Recent Weather Conditions: no rain within the past 48 hours
15. Site conditions at time of visit: sunny, 40°
16. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
17. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area: ~5-6 acres
18. Does channel appear on USGS quad map? YES NO
19. Does channel appear on USDA Soil Survey? YES NO
20. Estimated Watershed Land Use: 5 % Residential ____% Commercial ____% Industrial 45 % Agricultural 50 % Forested ____% Cleared / Logged ____% Other (____________)
21. Bankfull Width: 18-23 feet
22. Bank Height (from bed to top of bank): 4-6 feet
23. Channel slope down center of stream: X Flat (0 to 2%) ____Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
24. Channel Sinuosity: ____Straight X Occasional Bends ____Frequent Meander ____Very Sinuous ____Braided Channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 61 **Comments:**____________

Evaluator's Signature ____________ **(for John Hutton)** **Date** 3/1/2010

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STREAM QUALITY ASSESSMENT WORKSHEET
SCP7 – South Fork Cane Creek (Perennial)

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	4
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	3
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	2
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	2
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	4
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	4
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	3
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	4
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	2
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	2
	15	**Impact by agriculture or livestock production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	5
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	3
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	3
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	3
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	4
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	1
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	3
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				61

* These characteristics are not assessed in coastal streams.

OFFICE USE ONLY: USACE AID#______________________ DWQ #__________________________

SCP8 – SF4A (Perennial)

STREAM QUALITY ASSESSMENT WORKSHEET

1. Applicant's Name: Wildlands Engineering, Inc.
2. Evaluator's Name: John Hutton
3. Date of Evaluation: 3/1/2010
4. Time of Evaluation: 1:30 pm
5. Name of Stream: UT SF4A to South Fork Cane Creek
6. River Basin: Cape Fear 03030002
7. Approximate Drainage Area: 650 acres
8. Stream Order: Second
9. Length of Reach Evaluated: 100 lf
10. County: Chatham
11. Location of reach under evaluation (include nearby roads and landmarks): From Greensboro, NC, travel south on US-421 for approximately 20 miles. Take Old Liberty Road exit toward Liberty, turn left at Old Liberty Road and continue on to Swannanoa Avenue. Turn right at S. Greensboro Street and travel approximately 0.5 mile to make a left at Dameron Avenue; continue on to Silk Hope Road and Silk Hope Liberty Road. Travel approximately 8 miles and turn left onto Siler City Snow Camp Road and take an immediate right onto Tom Stevens Road. Travel approximately 3.5 miles and turn right onto Moon Lindley Road, site will be ½ mile on the right.
12. Site Coordinates (if known): N 35.811383°, W 79.409065°
13. Proposed Channel Work (if any): restoration/ enhancement
14. Recent Weather Conditions: no rain within the past 48 hours
15. Site conditions at time of visit: sunny, 40°
16. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
17. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:__________
18. Does channel appear on USGS quad map? YES NO
19. Does channel appear on USDA Soil Survey? YES NO
20. Estimated Watershed Land Use: ____% Residential ____% Commercial ____% Industrial 60 % Agricultural 40 % Forested ____% Cleared / Logged ____% Other (________________________)
21. Bankfull Width: 10-12 feet
22. Bank Height (from bed to top of bank): 2-4 feet
23. Channel slope down center of stream: X Flat (0 to 2%) ____Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
24. Channel Sinuosity: ____Straight X Occasional Bends ____Frequent Meander ____Very Sinuous ____Braided Channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 46 **Comments:**______________________________

Evaluator's Signature ________ **(for John Hutton)** **Date** 3/1/2010

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STREAM QUALITY ASSESSMENT WORKSHEET
SCP8 – SF4A (Perennial)

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	3
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	3
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	2
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	3
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	2
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	2
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	3
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	2
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	3
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	2
	15	**Impact by agriculture or livestock production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	3
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	3
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	2
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	2
BIOLOGY	20	**Presence of stream invertebrates** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	1
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	2
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	2
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				46

* These characteristics are not assessed in coastal streams.

OFFICE USE ONLY: USACE AID#________________________ DWQ #____________________________

SCP9 – SF2A (Intermittent)

STREAM QUALITY ASSESSMENT WORKSHEET

1. Applicant's Name: Wildlands Engineering, Inc.
2. Evaluator's Name: Matt Jenkins
3. Date of Evaluation: 2/19/2010
4. Time of Evaluation: 1:45 pm
5. Name of Stream: UT to South Fork Cane Creek
6. River Basin: Cape Fear 03030002
7. Approximate Drainage Area: 44 acres
8. Stream Order: First
9. Length of Reach Evaluated: 100 lf
10. County: Chatham
11. Location of reach under evaluation (include nearby roads and landmarks): From Greensboro, NC, travel south on US-421 for approximately 20 miles. Take Old Liberty Road exit toward Liberty, turn left at Old Liberty Road and continue on to Swannanoa Avenue. Turn right at S. Greensboro Street and travel approximately 0.5 mile to make a left at Dameron Avenue; continue on to Silk Hope Road and Silk Hope Liberty Road. Travel approximately 8 miles to Clyde Underwood Road.
12. Site Coordinates (if known): N 35.80248°, W 79.402701°
13. Proposed Channel Work (if any): restoration/enhancement
14. Recent Weather Conditions: no rain within the past 48 hours
15. Site conditions at time of visit: sunny, 40°
16. Identify any special waterway classifications known: ____Section 10 ____Tidal Waters ____Essential Fisheries Habitat ____Trout Waters ____Outstanding Resource Waters ____ Nutrient Sensitive Waters ____Water Supply Watershed ____(I-IV)
17. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area: 0.3 acre
18. Does channel appear on USGS quad map? YES NO
19. Does channel appear on USDA Soil Survey? YES NO
20. Estimated Watershed Land Use: ____% Residential ____% Commercial ____% Industrial 100 % Agricultural ____% Forested ____% Cleared / Logged ____% Other (________________________)
21. Bankfull Width: 6-8 feet
22. Bank Height (from bed to top of bank): 1-2 feet
23. Channel slope down center of stream: ____Flat (0 to 2%) X Gentle (2 to 4%) ____Moderate (4 to 10%) ____Steep (>10%)
24. Channel Sinuosity: ____Straight ____Occasional Bends X Frequent Meander ____Very Sinuous ____Braided Channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 32 **Comments:**____________________________

Evaluator's Signature______________________________ **Date**__________________

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STREAM QUALITY ASSESSMENT WORKSHEET
SCP9 – SF2A (Intermittent)

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	2
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	2
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	0
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	3
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	2
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	2
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	3
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	2
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	2
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	2
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	2
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	1
	15	**Impact by agriculture or livestock production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	3
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	2
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	0
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	2
BIOLOGY	20	**Presence of stream invertebrates** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	0
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				32

* These characteristics are not assessed in coastal streams.

WETLAND DETERMINATION DATA FORM – Eastern Mountains and Piedmont

Project/Site: Underwood Mitigation Site City/County: Chatham Sampling Date: 2/19/10

Applicant/Owner: Wildands Engineering State: NC Sampling Point: DP1

Investigator(s): Matt Jenkins, PWS Section, Township, Range: Albright Township

Landform (hillslope, terrace, etc.): floodplain Local relief (concave, convex, none): None Slope (%): 0.5%

Subregion (LRR or MLRA): MLRA 136 Lat: N 35.810119 Long: W 79.401341 Datum: ____

Soil Map Unit Name: Nanford-Badin complex (NaC) NWI classification: ____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ___ No ✔	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** ✔
Hydric Soil Present?	Yes ___ No ✔	
Wetland Hydrology Present?	Yes ___ No ✔	

Remarks:

Sampling point is representative of a non-jurisdictional upland area.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No ✔ Depth (inches): ____

Water Table Present? Yes ___ No ✔ Depth (inches): ____

Saturation Present? (includes capillary fringe) Yes ___ No ✔ Depth (inches): ____

Wetland Hydrology Present? Yes ___ **No** ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: DP1

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Platanus occidentalis	5	Yes	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	5 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15')			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	0 = Total Cover		
Herb Stratum (Plot size: 5')			
1. Festuca paradoxa	95	Yes	FAC
2. Juncus effusus	5	No	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: 30')			
1.			
2.			
3.			
4.			
5.			
6.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ___ **No** ✔

Remarks: (Include photo numbers here or on a separate sheet.)

Site is an active pasture/floodplain.

SOIL

Sampling Point: DP1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-12	10YR 5/3	95	10YR 3/3	5	C	PL	silt loam	
12-24	10YR 4/3	90	10YR 5/6	10	C	PL	silt loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Stratified Layers (A5)
___ 2 cm Muck (A10) **(LRR N)**
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1) **(LRR N, MLRA 147, 148)**
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Dark Surface (S7)
___ Polyvalue Below Surface (S8) **(MLRA 147, 148)**
___ Thin Dark Surface (S9) **(MLRA 147, 148)**
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)
___ Iron-Manganese Masses (F12) **(LRR N, MLRA 136)**
___ Umbric Surface (F13) **(MLRA 136, 122)**
___ Piedmont Floodplain Soils (F19) **(MLRA 148)**

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10) **(MLRA 147)**
___ Coast Prairie Redox (A16) **(MLRA 147, 148)**
___ Piedmont Floodplain Soils (F19) **(MLRA 136, 147)**
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ________

Depth (inches): ________

Hydric Soil Present? Yes ____ **No** ✔

Remarks:

WETLAND DETERMINATION DATA FORM – Eastern Mountains and Piedmont

Project/Site: Underwood Mitigation Site City/County: Chatham Sampling Date: 2/19/10

Applicant/Owner: Wildands Engineering State: NC Sampling Point: DP2

Investigator(s): Matt Jenkins, PWS Section, Township, Range: Albright Township

Landform (hillslope, terrace, etc.): floodplain Local relief (concave, convex, none): None Slope (%): 0%

Subregion (LRR or MLRA): MLRA 136 Lat: N 35.831427 Long: W 79.38243 Datum: ____

Soil Map Unit Name: Chewacla soils (ChA) NWI classification: ____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes ____ No ✔

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✔	No ____
Hydric Soil Present?	Yes ____	No ✔
Wetland Hydrology Present?	Yes ____	No ✔

Is the Sampled Area within a Wetland? **Yes** ____ **No** ✔

Remarks:

Sampling point is representative of a non-jurisdictional upland area. Data point is located within an active agricultural crop field.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No ✔	Depth (inches): ____
Water Table Present?	Yes ____	No ✔	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No ✔	Depth (inches): ____

Wetland Hydrology Present? Yes ____ **No** ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: DP2

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15')			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	0 = Total Cover		
Herb Stratum (Plot size: 5')			
1. Festuca paradoxa	50	Yes	FAC
2. Xanthium strumarium	30	Yes	FAC
3. Polygonum pensylvanicum	5	No	FACW
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: 30')			
1.			
2.			
3.			
4.			
5.			
6.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ✔ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ✔ **No** ___

Remarks: (Include photo numbers here or on a separate sheet.)

Site is an active agricultural crop field.

SOIL

Sampling Point: DP2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-24	10YR 5/3	90	7.5YR 4/6	10	C	PL	silt loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10) **(LRR N)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1) **(LRR N, MLRA 147, 148)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) **(MLRA 147, 148)**
- ___ Thin Dark Surface (S9) **(MLRA 147, 148)**
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Iron-Manganese Masses (F12) **(LRR N, MLRA 136)**
- ___ Umbric Surface (F13) **(MLRA 136, 122)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 148)**

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) **(MLRA 147)**
- ___ Coast Prairie Redox (A16) **(MLRA 147, 148)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 136, 147)**
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____________

Depth (inches): ____________

Hydric Soil Present? Yes ______ **No** ✔

Remarks:

WETLAND DETERMINATION DATA FORM – Eastern Mountains and Piedmont

Project/Site: Underwood Mitigation Site City/County: Chatham Sampling Date: 5/6/11

Applicant/Owner: Wildands Engineering State: NC Sampling Point: DP3

Investigator(s): Matt Jenkins, PWS Section, Township, Range: Albright Township

Landform (hillslope, terrace, etc.): hillslope Local relief (concave, convex, none): None Slope (%): 1%

Subregion (LRR or MLRA): MLRA 136 Lat: N 35.810833 Long: W 79.407538 Datum: ____

Soil Map Unit Name: Nanford-Badin complex (NaC) NWI classification: PEM1

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✔ No ____	Is the Sampled Area within a Wetland?	Yes ✔ No ____
Hydric Soil Present?	Yes ✔ No ____		
Wetland Hydrology Present?	Yes ✔ No ____		

Remarks:

Sampling point is representative of a jurisdictional wetland area. Data point is located down slope of an old breached farm pond.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ✔ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ✔ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No ✔	Depth (inches): ____
Water Table Present?	Yes ____	No ✔	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ✔	No ____	Depth (inches): <12"

Wetland Hydrology Present? Yes ✔ No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: DP3

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 = Total Cover		

Sapling/Shrub Stratum (Plot size: 15')	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	0 = Total Cover		

Herb Stratum (Plot size: 5')	Absolute % Cover	Dominant Species?	Indicator Status
1. Festuca paradoxa	70	Yes	FAC
2. Juncus effusus	30	Yes	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	100 = Total Cover		

Woody Vine Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ✔ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ✔ **No** ___

Remarks: (Include photo numbers here or on a separate sheet.)

Site is an active agricultural pasture, downstream of breached farm pond.

SOIL

Sampling Point: DP3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-4	7.5YR 3/1	100					organic	
4-20	7.5YR 6/1	90	7.5YR 5/6	10	C	M	sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10) **(LRR N)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1) **(LRR N, MLRA 147, 148)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) **(MLRA 147, 148)**
- ___ Thin Dark Surface (S9) **(MLRA 147, 148)**
- ___ Loamy Gleyed Matrix (F2)
- ✔ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Iron-Manganese Masses (F12) **(LRR N, MLRA 136)**
- ___ Umbric Surface (F13) **(MLRA 136, 122)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 148)**

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) **(MLRA 147)**
- ___ Coast Prairie Redox (A16) **(MLRA 147, 148)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 136, 147)**
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ✔ **No** ______

Remarks:

WETLAND DETERMINATION DATA FORM – Eastern Mountains and Piedmont

Project/Site: Underwood Mitigation Site City/County: Chatham Sampling Date: 5/6/11

Applicant/Owner: Wildands Engineering State: NC Sampling Point: DP4

Investigator(s): Matt Jenkins, PWS Section, Township, Range: Albright Township

Landform (hillslope, terrace, etc.): hillslope Local relief (concave, convex, none): None Slope (%): 1%

Subregion (LRR or MLRA): MLRA 136 Lat: N 35.810833 Long: W 79.407538 Datum: ______

Soil Map Unit Name: Nanford-Badin complex (NaC) NWI classification: PEM1

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✔ No ___	Is the Sampled Area within a Wetland? Yes ✔ No ___
Hydric Soil Present?	Yes ✔ No ___	
Wetland Hydrology Present?	Yes ✔ No ___	

Remarks:

Sampling point is representative of a jurisdictional wetland area. Data point is located down slope of an old breached farm pond.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ✔ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ✔ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ✔ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No ✔ Depth (inches): ______

Water Table Present? Yes ___ No ✔ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ✔ No ___ Depth (inches): <12"

Wetland Hydrology Present? Yes ✔ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: DP4

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15')			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	0 = Total Cover		
Herb Stratum (Plot size: 5')			
1. Festuca paradoxa	70	Yes	FAC
2. Juncus effusus	30	Yes	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: 30')			
1.			
2.			
3.			
4.			
5.			
6.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ✔ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ✔ **No** ___

Remarks: (Include photo numbers here or on a separate sheet.)

Site is an active agricultural pasture, downstream of breached farm pond.

SOIL

Sampling Point: DP4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-24	7.5YR 5/1	90	7.5YR 5/6	10	C	PL	sandy loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10) **(LRR N)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1) **(LRR N, MLRA 147, 148)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) **(MLRA 147, 148)**
- ___ Thin Dark Surface (S9) **(MLRA 147, 148)**
- ___ Loamy Gleyed Matrix (F2)
- ✔ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Iron-Manganese Masses (F12) **(LRR N, MLRA 136)**
- ___ Umbric Surface (F13) **(MLRA 136, 122)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 148)**

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) **(MLRA 147)**
- ___ Coast Prairie Redox (A16) **(MLRA 147, 148)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 136, 147)**
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ✔ **No** ______

Remarks:

WETLAND DETERMINATION DATA FORM – Eastern Mountains and Piedmont

Project/Site: Underwood Mitigation Site City/County: Chatham Sampling Date: 5/6/11

Applicant/Owner: Wildands Engineering State: NC Sampling Point: DP5

Investigator(s): Matt Jenkins, PWS Section, Township, Range: Albright Township

Landform (hillslope, terrace, etc.): hillslope Local relief (concave, convex, none): None Slope (%): 1%

Subregion (LRR or MLRA): MLRA 136 Lat: N 35.810833 Long: W 79.407538 Datum: ____

Soil Map Unit Name: Nanford-Badin complex (NaC) NWI classification: ____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✔	No ____	**Is the Sampled Area within a Wetland?** **Yes** ____ **No** ✔
Hydric Soil Present?	Yes ____	No ✔	
Wetland Hydrology Present?	Yes ____	No ✔	

Remarks:

Sampling point is representative of a non-jurisdictional upland area. Data point is located in an active agricultural pasture.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Aquatic Fauna (B13)
- ___ True Aquatic Plants (B14)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres on Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Moss Trim Lines (B16)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Stunted or Stressed Plants (D1)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ Microtopographic Relief (D4)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ____	No ✔	Depth (inches): ____
Water Table Present?	Yes ____	No ✔	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No ✔	Depth (inches): ____

Wetland Hydrology Present? Yes ____ **No** ✔

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: DP5

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15')			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	0 = Total Cover		
Herb Stratum (Plot size: 5')			
1. Festuca paradoxa	70	Yes	FAC
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: 30')			
1.			
2.			
3.			
4.			
5.			
6.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- __ 1 - Rapid Test for Hydrophytic Vegetation
- ✔ 2 - Dominance Test is >50%
- __ 3 - Prevalence Index is ≤3.0[1]
- __ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- __ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ✔ **No** ___

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features				Texture	Remarks
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]		
0-20	7.5YR 5/4	100					loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5)
- ___ 2 cm Muck (A10) **(LRR N)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1) **(LRR N, MLRA 147, 148)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Dark Surface (S7)
- ___ Polyvalue Below Surface (S8) **(MLRA 147, 148)**
- ___ Thin Dark Surface (S9) **(MLRA 147, 148)**
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Iron-Manganese Masses (F12) **(LRR N, MLRA 136)**
- ___ Umbric Surface (F13) **(MLRA 136, 122)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 148)**

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10) **(MLRA 147)**
- ___ Coast Prairie Redox (A16) **(MLRA 147, 148)**
- ___ Piedmont Floodplain Soils (F19) **(MLRA 136, 147)**
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____________

Depth (inches): ____________

Hydric Soil Present? **Yes** ______ **No** ✔

Remarks:

NC WAM WETLAND ASSESSMENT FORM
Accompanies User Manual Version 3.0
Rating Calculator Version 3.0

Wetland Site Name Underwood Mitigation Site: Wetland AA
Date 05/06/11
Wetland Type Bottomland Hardwood Forest
Assessor Name/Organization Matt Jenkins, PWS
Level III Ecoregion Piedmont
Nearest Named Water Body South Fork
River Basin Cape Fear
USGS 8-Digit Catalogue Unit 03030002
[ ] **Yes** [x] **No** **Precipitation within 48 hrs?**
Latitude/Longitude (deci-degrees) 35.810833°N, 79.407538°W

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.

- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? [x] Yes [ ] No

Describe effects of stressors that are present.
Wetland located within an actively agricultural pasture. Vegetation is regularly mowed, soils are driven on and occansionally compacted.

Regulatory Considerations
Select all that apply to the assessment area.

[ ] Anadromous fish
[ ] Federally protected species or State endangered or threatened species
[ ] NCDWQ riparian buffer rule in effect
[ ] Abuts a Primary Nursery Area (PNA)
[ ] Publicly owned property
[ ] N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
[ ] Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
[ ] Designated NCNHP reference community
[ ] Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)
[ ] Blackwater
[x] Brownwater
[ ] Tidal (if tidal, check one of the following boxes) [ ] Lunar [ ] Wind [ ] Both

Is the assessment area on a coastal island? [ ] Yes [x] No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? [ ] Yes [x] No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
[ ] A	[ ] A	Not severely altered
[x] B	[x] B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
[ ] A	[x] A	Water storage capacity and duration are not altered.
[x] B	[ ] B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
[ ] C	[ ] C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
[ ] A	[ ] A	Majority of wetland with depressions able to pond water > 1 foot deep
[ ] B	[ ] B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
[ ] C	[ ] C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
[x] D	[x] D	Depressions able to pond water < 3 inches deep

[ ] A Evidence that maximum depth of inundation is greater than 2 feet
[ ] B Evidence that maximum depth of inundation is between 1 and 2 feet
[x] C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.

- [ ] A Sandy soil
- [x] B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- [ ] C Loamy or clayey soils not exhibiting redoxymorphic features
- [ ] D Loamy or clayey gleyed soil
- [ ] E Histosol or histic epipedon

- [x] A Soil ribbon < 1 inch
- [ ] B Soil ribbon ≥ 1 inch

- [x] A No peat or muck presence
- [ ] B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
[x] A	[x] A	Little or no evidence of pollutants or discharges entering the assessment area
[ ] B	[ ] B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
[ ] C	[ ] C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles and within the watershed draining to the assessment area (5M), and within 2 miles and within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
[ ] A	[ ] A	[ ] A	≥ 10% impervious surfaces
[x] B	[x] B	[x] B	< 10% impervious surfaces
[x] C	[x] C	[x] C	Confined animal operations (or other local, concentrated source of pollutants)
[x] D	[ ] D	[ ] D	≥ 20% coverage of pasture
[ ] E	[x] E	[ ] E	≥ 20% coverage of agricultural land (regularly plowed land)
[x] F	[x] F	[x] F	≥ 20% coverage of maintained grass/herb
[ ] G	[ ] G	[ ] G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
[ ] H	[ ] H	[ ] H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic alterations that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
7a. Is assessment area within 50 feet of a tributary or other open water?
[x] Yes [ ] No If Yes, continue to 7b. If No, skip to Metric 8.
Wetland buffer need only be present on one side of the water body. Make buffer judgment based on the average width of the wetland. Record a note if a portion of the buffer has been removed or disturbed.
7b. How much of the first 50 feet from the bank is weltand? Descriptor E should be selected if ditches effectively bypass the buffer.

- [x] A ≥ 50 feet
- [ ] B From 30 to < 50 feet
- [ ] C From 15 to < 30 feet
- [ ] D From 5 to < 15 feet
- [ ] E < 5 feet or buffer bypassed by ditches

7c. Tributary width. If the tributary is anastomosed, combine widths of channels/braids for a total width.
[x] ≤ 15-feet wide [ ] > 15-feet wide [ ] Other open water (no tributary present)
7d. Do roots of assessment area vegetation extend into the bank of the tributary/open water?
[ ] Yes [x] No
7e. Is tributary or other open water sheltered or exposed?

- [x] Sheltered – adjacent open water with width < 2500 feet and no regular boat traffic.
- [ ] Exposed – adjacent open water with width ≥ 2500 feet or regular boat traffic.

8. **Wetland Width at the Assessment Area – wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT) and the wetland complex at the assessment areas (WC). See User Manual for WT and WC boundaries.

WT	WC	
[ ] A	[ ] A	≥ 100 feet
[x] B	[x] B	From 80 to < 100 feet
[ ] C	[ ] C	From 50 to < 80 feet
[ ] D	[ ] D	From 40 to < 50 feet
[ ] E	[ ] E	From 30 to < 40 feet
[ ] F	[ ] F	From 15 to < 30 feet
[ ] G	[ ] G	From 5 to < 15 feet
[ ] H	[ ] H	< 5 feet

9. Inundation Duration – assessment area condition metric

Answer for assessment area dominant landform.

☐ A Evidence of short-duration inundation (< 7 consecutive days)
☒ B Evidence of saturation, without evidence of inundation
☐ C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. Indicators of Deposition – assessment area condition metric

Consider recent deposition only (no plant growth since deposition).

☒ A Sediment deposition is not excessive, but at approximately natural levels.
☐ B Sediment deposition is excessive, but not overwhelming the wetland.
☐ C Sediment deposition is excessive and is overwhelming the wetland.

11. Wetland Size – wetland type/wetland complex condition metric

Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the wetland complex (WC), and the size of the forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
☐ A	☐ A	☐ A	≥ 500 acres
☐ B	☐ B	☐ B	From 100 to < 500 acres
☐ C	☐ C	☐ C	From 50 to < 100 acres
☐ D	☐ D	☐ D	From 25 to < 50 acres
☐ E	☐ E	☐ E	From 10 to < 25 acres
☐ F	☐ F	☐ F	From 5 to < 10 acres
☐ G	☐ G	☐ G	From 1 to < 5 acres
☐ H	☐ H	☐ H	From 0.5 to < 1 acre
☒ I	☒ I	☐ I	From 0.1 to < 0.5 acre
☐ J	☐ J	☐ J	From 0.01 to < 0.1 acre
☐ K	☐ K	☒ K	< 0.01 acre or assessment area is clear-cut

12. Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)

☐ A Pocosin is the full extent (≥ 90%) of its natural landscape size.
☐ B Pocosin is < 90% of the full extent of its natural landscape size.

13. Connectivity to Other Natural Areas – landscape condition metric

13a. **Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment.** This metric evaluates whether the wetland is well connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
☐ A	☐ A	≥ 500 acres
☐ B	☐ B	From 100 to < 500 acres
☐ C	☐ C	From 50 to < 100 acres
☐ D	☐ D	From 10 to < 50 acres
☐ E	☐ E	< 10 acres
☒ F	☒ F	Wetland type has a poor or no connection to other natural habitats

13b. **Evaluate for marshes only**.

☐ Yes ☐ No Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands.

14. Edge Effect – wetland type condition metric

May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.

☐ A No artificial edge within 150 feet in all directions
☐ B No artificial edge within 150 feet in four (4) to seven (7) directions
☒ C An artificial edge occurs within 150 feet in more than four (4) directions or assessment area is clear-cut

15. Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)

☐ A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
☐ B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
☒ C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)

☐ A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
☐ B Vegetation diversity is low or has > 10% to 50% cover of exotics.
☐ C Vegetation is dominated by exotic species (>50% cover of exotics).

☐

17. Vegetative Structure – assessment area/wetland type condition metric

17a. Is vegetation present?

☒ Yes ☐ No If Yes, continue to 17b. If No, skip to Metric 18.

17b. Evaluate percent coverage of vegetation **for all marshes only**. Skip to 17c for non-marsh wetlands.

☐ A ≥ 25% coverage of vegetation
☐ B < 25% coverage of vegetation

17c. **Check a box in each column for each stratum**. Evaluate this portion of the metric **for non-marsh wetlands**. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

AA	WT	
☐ A	☐ A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
☐ B	☐ B	Canopy present, but opened more than natural gaps
☒ C	☒ C	Canopy sparse or absent
☐ A	☐ A	Dense mid-story/sapling layer
☐ B	☐ B	Moderate density mid-story/sapling layer
☒ C	☒ C	Mid-story/sapling layer sparse or absent
☐ A	☐ A	Dense shrub layer
☐ B	☐ B	Moderate density shrub layer
☒ C	☒ C	Shrub layer sparse or absent
☐ A	☐ A	Dense herb layer
☒ B	☒ B	Moderate density herb layer
☐ C	☐ C	Herb layer sparse or absent

18. Snags – wetland type condition metric

☐ A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
☒ B Not A

19. Diameter Class Distribution – wetland type condition metric

☐ A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
☐ B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
☒ C Majority of canopy trees are < 6 inches DBH or no trees.

20. Large Woody Debris – wetland type condition metric

Include both natural debris and man-placed natural debris.

☐ A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
☒ B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

☐ A ☐ B ☐ C ☐ D

22. Hydrologic Connectivity – assessment area condition metric

Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.

☒ A Overbank and overland flow are not severely altered in the assessment area.
☐ B Overbank flow is severely altered in the assessment area.
☐ C Overland flow is severely altered in the assessment area.
☐ D Both overbank and overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet
Accompanies User Manual Version 3.0
Rating Calculator Version 3.0

Wetland Site Name	Underwood Mitigation Site: Wetland AA	Date	05/06/11
Wetland Type	Bottomland Hardwood Forest	Assessor Name/Organization	Matt Jenkins, PWS

Presence of stressor affecting assessment area (Y/N)	YES
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	NO
Wetland is intensively managed (Y/N)	YES
Assessment area is located within 50 feet of a natural tributary or other open water (Y/N)	YES
Assessment area is substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**LOW**
	Sub-Surface Storage and Retention	Condition	**MEDIUM**
Water Quality	Pathogen Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Particulate Change	Condition	**LOW**
		Condition/Opportunity	**LOW**
		Opportunity Presence? (Y/N)	**YES**
	Soluble Change	Condition	**MEDIUM**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Physical Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	**LOW**
	Landscape Patch Structure	Condition	**LOW**
	Vegetation Composition	Condition	**LOW**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**LOW**
Water Quality	Condition	**HIGH**
	Condition/Opportunity	**HIGH**
	Opportunity Presence? (Y/N)	**YES**
Habitat	Conditon	**LOW**

Overall Wetland Rating **LOW**

Appendix 3 Project Site NCDWQ Stream Classification Forms

NC DWQ Stream Identification Form Version 4.11

Date: 2/19/2010	**Project/Site:** Underwood	**Latitude:** 35.801304° N
Evaluator: MLJ	**County:** Chatham	**Longitude:** 79.401141° W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 38	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** SCP1 - UT2 *e.g. Quad Name:*

A. Geomorphology (Subtotal = 22.5)	Absent	Weak	Moderate	Strong
1[a] Continuity of channel bed and bank	0	1	2	3
2. Sinuosity of channel along thalweg	0	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	2	3
4. Particle size of stream substrate	0	1	2	3
5. Active/relict floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Recent alluvial deposits	0	1	2	3
8. Headcuts	0	1	2	3
9. Grade control	0	0.5	1	1.5
10. Natural valley	0	0.5	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 8)				
12. Presence of Baseflow	0	1	2	3
13. Iron oxidizing bacteria	0	1	2	3
14. Leaf litter	1.5	1	0.5	0
15. Sediment on plants or debris	0	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 7.5)				
18. Fibrous roots in streambed	3	2	1	0
19. Rooted upland plants in streambed	3	2	1	0
20. Macrobenthos (note diversity and abundance)	0	1	2	3
21. Aquatic Mollusks	0	1	2	3
22. Fish	0	0.5	1	1.5
23. Crayfish	0	0.5	1	1.5
24. Amphibians	0	0.5	1	1.5
25. Algae	0	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 2/19/2010	**Project/Site:** Underwood	**Latitude:** 35.802778° N
Evaluator: MLJ	**County:** Chatham	**Longitude:** 79.401822° W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 36	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	**Other** SCP2 - South Fork *e.g. Quad Name:* Cane Creek

A. Geomorphology (Subtotal = 22)	Absent	Weak	Moderate	Strong
1[a] Continuity of channel bed and bank	0	1	2	3
2. Sinuosity of channel along thalweg	0	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	2	3
4. Particle size of stream substrate	0	1	2	3
5. Active/relict floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Recent alluvial deposits	0	1	2	3
8. Headcuts	0	1	2	3
9. Grade control	0	0.5	1	1.5
10. Natural valley	0	0.5	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 8)				
12. Presence of Baseflow	0	1	2	3
13. Iron oxidizing bacteria	0	1	2	3
14. Leaf litter	1.5	1	0.5	0
15. Sediment on plants or debris	0	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 6)				
18. Fibrous roots in streambed	3	2	1	0
19. Rooted upland plants in streambed	3	2	1	0
20. Macrobenthos (note diversity and abundance)	0	1	2	3
21. Aquatic Mollusks	0	1	2	3
22. Fish	0	0.5	1	1.5
23. Crayfish	0	0.5	1	1.5
24. Amphibians	0	0.5	1	1.5
25. Algae	0	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 2/19/2010	Project/Site: Underwood	Latitude: 35.809256 ° N
Evaluator: MLJ	County: Chatham	Longitude: 79.401698° W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 43.25	**Stream Determination (circle one)** Ephemeral Intermittent Perennial	Other *e.g. Quad Name:* SCP3 - South Fork Cane Creek

A. Geomorphology (Subtotal = 26)	Absent	Weak	Moderate	Strong
1[a]. Continuity of channel bed and bank	0	1	2	3
2. Sinuosity of channel along thalweg	0	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	2	3
4. Particle size of stream substrate	0	1	2	3
5. Active/relict floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Recent alluvial deposits	0	1	2	3
8. Headcuts	0	1	2	3
9. Grade control	0	0.5	1	1.5
10. Natural valley	0	0.5	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 9)				
12. Presence of Baseflow	0	1	2	3
13. Iron oxidizing bacteria	0	1	2	3
14. Leaf litter	1.5	1	0.5	0
15. Sediment on plants or debris	0	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 8.25)				
18. Fibrous roots in streambed	3	2	1	0
19. Rooted upland plants in streambed	3	2	1	0
20. Macrobenthos (note diversity and abundance)	0	1	2	3
21. Aquatic Mollusks	0	1	2	3
22. Fish	0	0.5	1	1.5
23. Crayfish	0	0.5	1	1.5
24. Amphibians	0	0.5	1	1.5
25. Algae	0	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 2/19/2010	Project/Site: Underwood	Latitude: 35.811274° N
Evaluator: MLJ	County: Chatham	Longitude: 79.403655° W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 40	**Stream Determination (circle one)** **Ephemeral Intermittent Perennial**	**Other** SCP4 - UT1 *e.g. Quad Name:*

A. Geomorphology (Subtotal = 24.5)	Absent	Weak	Moderate	Strong
1[a.] Continuity of channel bed and bank	0	1	2	3
2. Sinuosity of channel along thalweg	0	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	2	3
4. Particle size of stream substrate	0	1	2	3
5. Active/relict floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Recent alluvial deposits	0	1	2	3
8. Headcuts	0	1	2	3
9. Grade control	0	0.5	1	1.5
10. Natural valley	0	0.5	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 8.5)	Absent	Weak	Moderate	Strong
12. Presence of Baseflow	0	1	2	3
13. Iron oxidizing bacteria	0	1	2	3
14. Leaf litter	1.5	1	0.5	0
15. Sediment on plants or debris	0	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 7)	Absent	Weak	Moderate	Strong
18. Fibrous roots in streambed	3	2	1	0
19. Rooted upland plants in streambed	3	2	1	0
20. Macrobenthos (note diversity and abundance)	0	1	2	3
21. Aquatic Mollusks	0	1	2	3
22. Fish	0	0.5	1	1.5
23. Crayfish	0	0.5	1	1.5
24. Amphibians	0	0.5	1	1.5
25. Algae	0	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 2/19/2010	**Project/Site:** Underwood	**Latitude:** 35.812115° N
Evaluator: MLJ	**County:** Chatham	**Longitude:** 79.404562° W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 22.75	**Stream Determination (circle one)** **Ephemeral Intermittent Perennial**	**Other** SCPS - UTIA *e.g. Quad Name*:

A. Geomorphology (Subtotal = 11)	Absent	Weak	Moderate	Strong
1[a] Continuity of channel bed and bank	0	1	2	3
2. Sinuosity of channel along thalweg	0	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	2	3
4. Particle size of stream substrate	0	1	2	3
5. Active/relict floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Recent alluvial deposits	0	1	2	3
8. Headcuts	0	1	2	3
9. Grade control	0	0.5	1	1.5
10. Natural valley	0	0.5	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 7)				
12. Presence of Baseflow	0	1	2	3
13. Iron oxidizing bacteria	0	1	2	3
14. Leaf litter	1.5	1	0.5	0
15. Sediment on plants or debris	0	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 4.75)				
18. Fibrous roots in streambed	3	2	1	0
19. Rooted upland plants in streambed	3	2	1	0
20. Macrobenthos (note diversity and abundance)	0	1	2	3
21. Aquatic Mollusks	0	1	2	3
22. Fish	0	0.5	1	1.5
23. Crayfish	0	0.5	1	1.5
24. Amphibians	0	0.5	1	1.5
25. Algae	0	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 2/19/2010	Project/Site: Underwood	Latitude: 35.811499° N
Evaluator: MLJ	County: Chatham	Longitude: 79.405879°W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 24.25	**Stream Determination (circle one)** **Ephemeral Intermittent Perennial**	**Other** SCPG - UT1B *e.g. Quad Name*:

A. Geomorphology (Subtotal = 12.5)	Absent	Weak	Moderate	Strong
1[a] Continuity of channel bed and bank	0	1	2	3
2. Sinuosity of channel along thalweg	0	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	2	3
4. Particle size of stream substrate	0	1	2	3
5. Active/relict floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Recent alluvial deposits	0	1	2	3
8. Headcuts	0	1	2	3
9. Grade control	0	0.5	1	1.5
10. Natural valley	0	0.5	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 7)				
12. Presence of Baseflow	0	1	2	3
13. Iron oxidizing bacteria	0	1	2	3
14. Leaf litter	1.5	1	0.5	0
15. Sediment on plants or debris	0	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 4.75)				
18. Fibrous roots in streambed	3	2	1	0
19. Rooted upland plants in streambed	3	2	1	0
20. Macrobenthos (note diversity and abundance)	0	1	2	3
21. Aquatic Mollusks	0	1	2	3
22. Fish	0	0.5	1	1.5
23. Crayfish	0	0.5	1	1.5
24. Amphibians	0	0.5	1	1.5
25. Algae	0	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 3/1/2010	Project/Site: Underwood	Latitude: 35.811383° N
Evaluator: JWH	County: Chatham	Longitude: 79.409065°W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 50.5	Stream Determination (~~circle one~~) Ephemeral Intermittent Perennial	Other SCP7 - South Fork *e.g. Quad Name:* Cane Creek

A. Geomorphology (Subtotal = 27.5)	Absent	Weak	Moderate	Strong
1[a] Continuity of channel bed and bank	0	1	2	3
2. Sinuosity of channel along thalweg	0	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	2	3
4. Particle size of stream substrate	0	1	2	3
5. Active/relict floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Recent alluvial deposits	0	1	2	3
8. Headcuts	0	1	2	3
9. Grade control	0	0.5	1	1.5
10. Natural valley	0	0.5	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 9.5)				
12. Presence of Baseflow	0	1	2	3
13. Iron oxidizing bacteria	0	1	2	3
14. Leaf litter	1.5	1	0.5	0
15. Sediment on plants or debris	0	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 13.5)				
18. Fibrous roots in streambed	3	2	1	0
19. Rooted upland plants in streambed	3	2	1	0
20. Macrobenthos (note diversity and abundance)	0	1	2	3
21. Aquatic Mollusks	0	1	2	3
22. Fish	0	0.5	1	1.5
23. Crayfish	0	0.5	1	1.5
24. Amphibians	0	0.5	1	1.5
25. Algae	0	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

NC DWQ Stream Identification Form Version 4.11

Date: 3/1/2010	Project/Site: Underwood	Latitude: 35.811383° N
Evaluator: JWH	County: Chatham	Longitude: 79.409065° W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30** 34.5	**Stream Determination (~~circle one~~)** Ephemeral Intermittent Perennial	**Other** SCP8 - SF4A *e.g. Quad Name:*

A. Geomorphology (Subtotal = 20.5)	Absent	Weak	Moderate	Strong
1[a] Continuity of channel bed and bank	0	1	2	3
2. Sinuosity of channel along thalweg	0	1	2	3
3. In-channel structure: ex. riffle-pool, step-pool, ripple-pool sequence	0	1	2	3
4. Particle size of stream substrate	0	1	2	3
5. Active/relict floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Recent alluvial deposits	0	1	2	3
8. Headcuts	0	1	2	3
9. Grade control	0	0.5	1	1.5
10. Natural valley	0	0.5	1	1.5
11. Second or greater order channel	No = 0		Yes = 3	

[a] artificial ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 7)				
12. Presence of Baseflow	0	1	2	3
13. Iron oxidizing bacteria	0	1	2	3
14. Leaf litter	1.5	1	0.5	0
15. Sediment on plants or debris	0	0.5	1	1.5
16. Organic debris lines or piles	0	0.5	1	1.5
17. Soil-based evidence of high water table?	No = 0		Yes = 3	

C. Biology (Subtotal = 7)				
18. Fibrous roots in streambed	3	2	1	0
19. Rooted upland plants in streambed	3	2	1	0
20. Macrobenthos (note diversity and abundance)	0	1	2	3
21. Aquatic Mollusks	0	1	2	3
22. Fish	0	0.5	1	1.5
23. Crayfish	0	0.5	1	1.5
24. Amphibians	0	0.5	1	1.5
25. Algae	0	0.5	1	1.5
26. Wetland plants in streambed	FACW = 0.75; OBL = 1.5 Other = 0			

*perennial streams may also be identified using other methods. See p. 35 of manual.

Notes:

Sketch:

North Carolina Division of Water Quality – Stream Identification Form; Version 3.1

Date:	02/19/2010	Project:	Underwood Site	Latitude:	N 35.80248°
Evaluator:	MLJ	Site:	SCP9	Longitude:	W 79.402701°
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30*	23.50	County:	Chatham	Other *e.g. Quad Name:*	SF2A - Intermittent

A. Geomorphology (Subtotal = 12.0)		Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	2.0	0	1	2	3
2. Sinuosity	2.0	0	1	2	3
3. In-channel structure: riffle-pool sequence	1.0	0	1	2	3
4. Soil texture or stream substrate sorting	2.0	0	1	2	3
5. Active/relic floodplain	2.0	0	1	2	3
6. Depositional bars or benches		0	1	2	3
7. Braided channel		0	1	2	3
8. Recent alluvial deposits	1.0	0	1	2	3
9[a] Natural levees		0	1	2	3
10. Headcuts	1.0	0	1	2	3
11. Grade controls	0.5	0	0.5	1	1.5
12. Natural valley or drainageway	0.5	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.		No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.0)		Absent	Weak	Moderate	Strong
14. Groundwater flow/discharge	2.0	0	1	2	3
15. Water in channel and > 48 hrs since rain, or Water in channel -- dry or growing season	1.0	0	1	2	3
16. Leaflitter	1.5	1.5	1	0.5	0
17. Sediment on plants or debris		0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)		0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	1.5	No = 0		Yes = 1.5	

C. Biology (Subtotal = 5.50)		Absent	Weak	Moderate	Strong
20[b]. Fibrous roots in channel	2.0	3	2	1	0
21[b]. Rooted plants in channel	3.0	3	2	1	0
22. Crayfish		0	0.5	1	1.5
23. Bivalves		0	1	2	3
24. Fish		0	0.5	1	1.5
25. Amphibians		0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)		0	0.5	1	1.5
27. Filamentous algae; periphyton		0	1	2	3
28. Iron oxidizing bacteria/fungus.		0	0.5	1	1.5
29[b]. Wetland plants in streambed	0.50	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

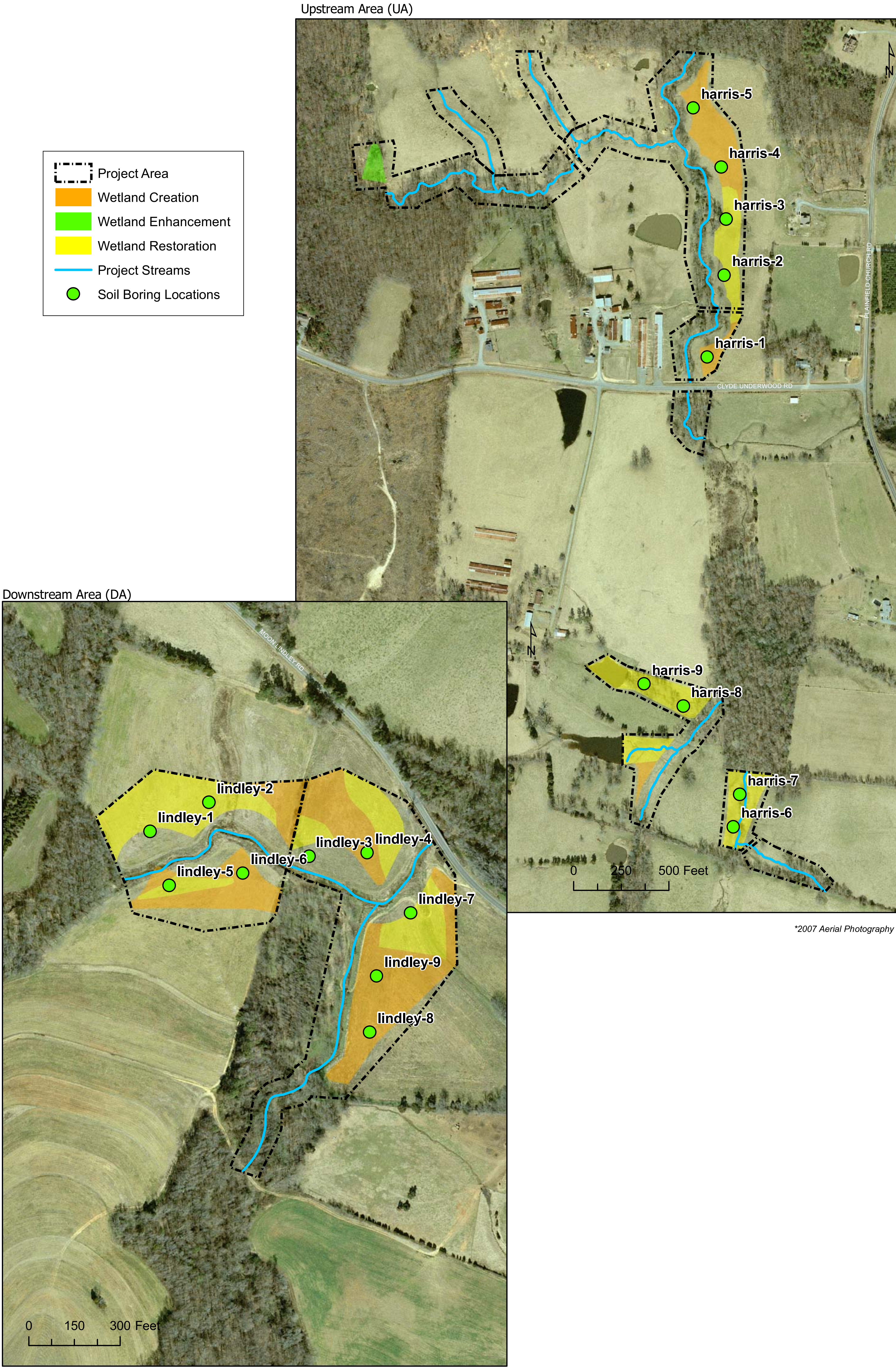
Notes: (use back side of this form for additional notes.)

Sketch:

Appendix 4 Soil Boring Data

Old Number	New Number	Depth (in)	Munsell Color	Texture	Mottle %	Munsell Color	Mottle %	Munsell Color	Notes
1	1	0-10	7.5YR 5/2	clay loam		7.5YR 6/3			
		10-24	7.5YR 5/6	clay loam	40%	7.5YR 4/1			
		24+		gravel					
2	2	0-16	10YR 5/3	silt loam	10%	7.5YR 5/6			
		16+	2.5Y 7/4	silt loam					
3	3	0-4	10YR 5/3	silt loam	10%	7.5YR 5/6			
		4-14	2.5Y 7/4	silt loam					
Harris 1	4	0-12	2.5Y 5/3	silt loam	20%	7.5YR 5/6			
		12-20	10YR 5/3	silt loam	20%	10YR 5/6			
		20-24	2.5Y 5/4	silt loam					
4	5	0-20	7.5YR 6/2	clay loam	25%	7.5YR 5/6	10%	7.5YR 4/1	edge of drainage swale, water moving through swale in top 20" but drier below
		20+	7.5YR 6/6	clay loam	20%	7.5YR 6/2	10%	7.5YR 4/1	
5	6	0-8	10YR 5/2	loam	20%	7.5YR 6/3	20%	10YR 6/3	
		8-24	2.5Y 6/4	loam	20%	7.5YR 5/6			
		24+		bedrock					
Harris 2	7	0-12	10YR 5/2	silt loam	30%	10YR 5/6			
		12-24	2.5Y 5/4	silt loam					
6	8	0-14	7.5YR 5/2	clay loam	10%	7.5YR 4/1	10%	7.5YR 5/6	
		14-24	5YR 5/4	clay loam	40%	7.5YR 4/1			
7	9	0-24	7.5YR 5/1	clay loam	10%	7.5YR 5/6			blackened manganese, oxidized rhizospheres
		24+		bedrock					
8	10	0-14	7.5YR 5/1	sandy clay loam	30%	7.5YR 5/6			
		14-24	10YR 7/4	sandy clay loam	40%	10YR 4/1			
9	11	0-24	7.5YR 5/2	clay loam	10%	7.5YR 5/6			
Harris 3	12	0-12	10YR 5/3	silt loam	30%	10YR 3/3			
		12-24	10YR 4/3	silt loam	20%	10YR 5/6			
10	13	0-16	7.5YR 5/3	clay loam					no mottles
11	14	0-24	7.5YR 6/2	clay loam	10%	7.5YR 5/6			blackened manganese
12	15	0-16	7.5YR 6/3	clay loam	20%	7.5YR 4/1			
		16-24	7.5YR 5/2	clay loam	50%	7.5YR 6/6			
Harris 4	16	0-22	2.5Y 5/3	silt loam	30%	10YR 4/4			Concretions
		22-24	10YR 5/6	silt loam					
13	17	0-14	7.5YR 5/3	clay loam	10%	7.5YR 5/1	20%	7.5YR 5/6	
		14-24	7.5YR 6/6	clay loam	40%	7.5YR 5/2			
14	18	0-14	7.5YR 5/2						oxidized rhizospheres
		14-24	7.5YR 5/2	gravel	40%	7.5YR 6/6			
15	19	0-14	7.5YR 5/2						
		14-24	7.5YR 6/6		40%	7.5YR 5/2			
Harris 5	20	0-18	10YR 5/3	silt loam	30%	7.5YR 3/4			
		18-24	10YR 5/2	silt loam	20%	10YR 5/6			
16	21	0-4	7.5YR 3/1	organic layer					NRW2
		4-20	7.5YR 6/1	sandy loam	10%	7.5YR 5/6	10%	7.5YR 4/1	
17	22	0-24	7.5YR 5/1	sandy loam	10%	7.5YR 5/6			oxidized rhizospheres
18	23	0-20	7.5YR 5/4	loam					upland point
29	24	0-9	7.5YR 5/2	clay loam	10%	7.5YR 5/6			blackened manganese
		9-20	7.5YR 6/1	clay loam	40%	7.5YR 6/6	10%	7.5YR 5/2	
Harris 6	25	0-12	7.5YR 5/2	silt loam	30%	7.5YR 4/6			
		12-24	7.5YR 5/2	silty clay loam	20%	10YR 5/6			
28	26	0-9	7.5YR 5/2	clay loam	10%	7.5YR 5/6			blackened manganese
		9-20	7.5YR 6/1	clay loam	40%	7.5YR 6/6	10%	7.5YR 5/2	
Harris 7	27	0-12	2.5Y 5/2	silt loam	30%	7.5YR 4/6			Concretions
		12-24	7.5YR 5/2	silt loam	20%	10YR 5/6			
31	28	0-24	7.5YR 5/1	clay loam	20%	7.5YR 5/6			
30	29	0-10	7.5YR 5/1	clay loam	10%	7.5YR 5/6			free water at 10in
		10-16	7.5YR 5/2	clay loam	20%	7.5YR 6/1	40%	7.5YR 5/6	
32	30	0-24	7.5YR 5/1	clay loam	20%	7.5YR 5/6			blackened manganese
Harris 8	31	0-18	10YR 5/3	silt loam	30%	7.5YR 3/4			
		18-24	2.5Y 6/2	silt loam	20%	10YR 3/4			
33	32	0-24	7.5YR 5/1	clay loam	20%	7.5YR 5/6			blackened manganese
Harris 9	33	0-2	2.5Y 5/3	silt loam	30%	5YR 4/6			

Old Number	New Number	Depth (in)	Munsell Color	Texture	Mottle %	Munsell Color	Mottle %	Munsell Color	Notes
Harris 9	33	2-24	2.5Y 6/3	silt loam	20%	10YR 3/4			
24	34	0-20	7.5YR 5/2	sandy loam	10%	7.5YR 5/6			saturated at surface
Lindley 1	35	0-24	10YR 5/3	silt loam	10%	7.5YR 4/6			
23	36	0-16	7.5YR 5/2	sandy loam	10%	7.5YR 5/6			saturated at surface
Lindley 2	37	0-24	7.5YR 6/3	sandy silt loam	20%	7.5YR 5/6			
22	38	0-10	7.5YR 5/1		40%	7.5YR 5/3	10%	7.5YR 4/1	blackened manganese, saturated at surface
		10-25	7.5YR 5/4		20%	7.5YR 5/2			
		25+	7.5YR 6/1		20%	7.5YR 4/1	30%	7.5YR 5/6	
21	39	0-20	7.5YR 5/2	sandy loam	10%	7.5YR 4/1	10%	7.5YR 5/6	saturated at surface
Lindley 3	40	0-24	2.5Y 6/3	silt loam	20%	5YR 4/6			
20	41	0-20	7.5YR 5/2	loam	15%	7.5YR 5/6			
Lindley 4	42	0-20	10YR 5/4	silt loam					
		20-24	10YR 5/3	silt loam	20%	7.5YR 4/6			
19	43	0-30	7.5YR 4/4	sandy loam					
27	44	0-20	7.5YR 5/3	clay loam	20%	7.5YR 5/6			
Lindley 7	45	0-18	10YR 4/4	silt loam					
		18-24	10YR 5/3	silt loam	20%	7.5YR 4/4			
Lindley 9	46	0-24	7.5YR 4/4	sandy silt loam					
Lindley 8	47	0-18	7.5YR 4/3	silt loam					
		18-24	10YR 4/3	silt loam	20%	7.5YR 4/4			
26	48	0-20	7.5YR 5/4						
Lindley 6	49	0-20	7.5YR 4/4	silt loam					
		20-24	10YR 4/2	silt loam	20%	7.5YR 5/8			
Lindley 5	50	0-18	10YR 5/3	silt loam	20%	7.5YR 4/6			
		18-24	10YR 6/2	silt loam	30%	7.5YR 5/6			
25	51	0-20	7.5YR 5/2		50%	7.5YR 5/6			recently disked, juncus nearby



WILDLANDS

Soil Boring Locations
Underwood Mitigation Site
Cape Fear River Basin (03030002)

Chatham County, NC

Soils Descriptions performed by **Mike Ortosky** (NC Licensed Soil Scientist # 1075)

Harris Property - 1/28/10

Profile #1

Depth	Color (Munsell)	Mottles	Texture	Notes
0-8	10 YR 4/3	C2D 10YR 5/2	Loam	Manganese bodies
8-24	10 YR 5/5	C2D 10YR 5/2	Clay Loam	Manganese bodies

Profile #2

Depth	Color (Munsell)	Mottles	Texture	Notes
0-8	10 YR 4/4	F2D 10YR 5/2	Loam	
8-24	10 YR 5/5	C2D 10YR 5/2	Clay Loam	

Profile #3

Depth	Color (Munsell)	Mottles	Texture	Notes
0-8	10 YR 4/2		Loam	Manganese bodies
8-24	10 YR 5/2		Clay Loam	Manganese bodies

Profile #4

Depth	Color (Munsell)	Mottles	Texture	Notes
0-8	10 YR 4/2		Loam	Manganese bodies
8-24	10 YR 5/1		Clay Loam	Manganese bodies

Profile #5

Depth	Color (Munsell)	Mottles	Texture	Notes
0-24	10 YR 5/4		Loam	

Profile #6

Depth	Color (Munsell)	Mottles	Texture	Notes
0-12	10 YR 4/3	F2D 10YR 5/2	Loam	Manganese bodies
8-24	10 YR 5/5	C2D 10YR 5/2	Loam	Manganese bodies

Soils Descriptions performed by **Mike Ortosky** (NC Licensed Soil Scientist # 1075)

James Property - 1/28/10

Profile #1

Depth	Color (Munsell)	Mottles	Texture	Notes
0-8	10 YR 4/5	C2D 10YR 5/2	Loam	
8-24	10 YR 4/2		Clay Loam	

Profile #2

Depth	Color (Munsell)	Mottles	Texture	Notes
0-14	10 YR 4/4	F2D 10YR 5/2	Loam	
14-24	10 YR 5/2		Clay Loam	Relic low-chroma colors

Profile #3

Depth	Color (Munsell)	Mottles	Texture	Notes
0-8	10 YR 4/3	C2D 10 YR 5/2	Loam	
8-12	10 YR 5/2		Loam	

Profile #4

Depth	Color (Munsell)	Mottles	Texture	Notes
0-12	10 YR 4/3	C2D 10 YR 5/2	Loam	Manganese bodies
12-30	10 YR 5/2	C2D 10 YR 5/3	Clay Loam	Manganese bodies

Profile #5

Depth	Color (Munsell)	Mottles	Texture	Notes
0-24	10 YR 4/2		Loam	

Profile #6

Depth	Color (Munsell)	Mottles	Texture	Notes
0-12	10 YR 5/3	C2D 10 YR 5/2	Loam	

Soils Descriptions performed by **Mike Ortosky** (NC Licensed Soil Scientist # 1075)

Underwood Property - 3/1/10

Profile #1

Depth	Color (Munsell)	Mottles	Texture	Notes
0-10	10 YR 6/2	F2D 10 YR 5/3	Sandy Loam	
10-16	10 YR 6/2	C2D 7.5 YR 4/4	Sandy CL	

Profile #2

Depth	Color (Munsell)	Mottles	Texture	Notes
0-3	10 YR 5/2		Fine SL	
3-15	10 YR 5/3	C2D 10 YR 5/2 & 7.5 YR 4/4	Loam	

Profile #3

Depth	Color (Munsell)	Mottles	Texture	Notes
0-24	10 YR 5/4		Loam	

Profile #4

Depth	Color (Munsell)	Mottles	Texture	Notes
0-12	10 YR 4/4		Loam	
12-24	10 YR 4/4	C2D 10 YR 4/2	Sandy CL	

Profile #5

Depth	Color (Munsell)	Mottles	Texture	Notes
0-10	10 YR 5/3		Loam	
10-18	10 YR 5/2	M2D 10 YR 5/6	Sandy CL	

Profile #6

Depth	Color (Munsell)	Mottles	Texture	Notes
0-6	10 YR 4/2 & 5/3		Loam	50% - 50% color mix
6-20	10 YR 5/2		Loam	

Profile #7

Depth	Color (Munsell)	Mottles	Texture	Notes
0-10	10 YR 5/4		Loam	Alluvial deposit - Manganese
10-20	10 YR 4/2		Loam	

Appendix 5 Resource Agency Correspondence

North Carolina Department of Cultural Resources

State Historic Preservation Office

Peter B. Sandbeck, Administrator

Beverly Eaves Perdue, Governor
Linda A. Carlisle, Secretary
Jeffrey J. Crow, Deputy Secretary

Office of Archives and History
Division of Historical Resources
David Brook, Director

July 28, 2010

Andrea Spangler
Wildlands Engineering, Inc.
1430 South Mint Street, #104
Charlotte, NC 28203

Re: Underwood Mitigation Project, Chatham County, ER 10-1313

Dear Ms. Spangler:

Thank you for your letter of July 12, 2010, concerning the above project.

We have conducted a review of the project and are aware of no historic resources which would be affected by the project. Therefore, we have no comment on the project as proposed.

The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

Thank you for your cooperation and consideration. If you have questions concerning the above comment, please contact Renee Gledhill-Earley, environmental review coordinator, at 919-807-6579. In all future communication concerning this project, please cite the above-referenced tracking number.

Sincerely,

Renee Gledhill-Earley

for Peter Sandbeck

North Carolina Wildlife Resources Commission

Gordon Myers, Executive Director

28 July 2010

Matt L. Jenkins, PWS
Wildlands Engineering, Inc.
1430 South Mint Street
Suite 104
Charlotte, NC 28203

Subject: Underwood Mitigation Site – Chatham County, North Carolina.

Dear Mr. Jenkins:

Biologists with the North Carolina Wildlife Resources Commission have reviewed the subject information. Our comments are provided in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-667d) and North Carolina General Statutes (G.S. 113-131 et seq.).

The proposed project includes restoration of a degraded stream channel and wetland creation and restoration along South Fork Cane Creek and its tributaries. South Fork Cane Creek is a tributary to Cane Creek in the Cape Fear River basin. There are records for the federal species of concern and state endangered Carolina creekshell (*Villosa vaughaniana*), the state special concern notched rainbow (*Villosa constricta*), and the state significantly rare Eastern creekshell (*Villosa delumbis*) in Cane Creek.

Stream and wetland restoration projects often improve water quality and aquatic habitat. We recommend establishing native, forested buffers in riparian areas to protect water quality, improve terrestrial habitat, and provide a travel corridor for wildlife species. Provided natural channel design methods are used and measures are taken to minimize erosion and sedimentation from construction/restoration activities, we do not anticipate the project to result in significant adverse impacts to aquatic and terrestrial wildlife resources.

Thank you for the opportunity to review this proposed project. If we can provide further assistance, please contact our office at (336) 449-7625.

Sincerely,

Shari L Bryant

Shari L. Bryant
Piedmont Region Coordinator
Habitat Conservation Program

Mailing Address: Division of Inland Fisheries • 1721 Mail Service Center • Raleigh, NC 27699-1721
Telephone: (919) 707-0220 • **Fax:** (919) 707-0028

Appendix 6 Historic Aerial Photographs


INQUIRY #: 2827723.4
YEAR: 1983
= 1000'
N
EDR Environmental Data Resources Inc


INQUIRY #: 2827723.4
YEAR: 1993
= 750'
N
EDR Environmental Data Resources Inc


INQUIRY #: 2827723.4
YEAR: 1999
= 750'
N


INQUIRY #: 2827723.4
YEAR: 2006
= 604'
N
EDR Environmental Data Resources Inc


INQUIRY #: 2827723.8
YEAR: 1973
= 500'
N
EDR Environmental Data Resources Inc

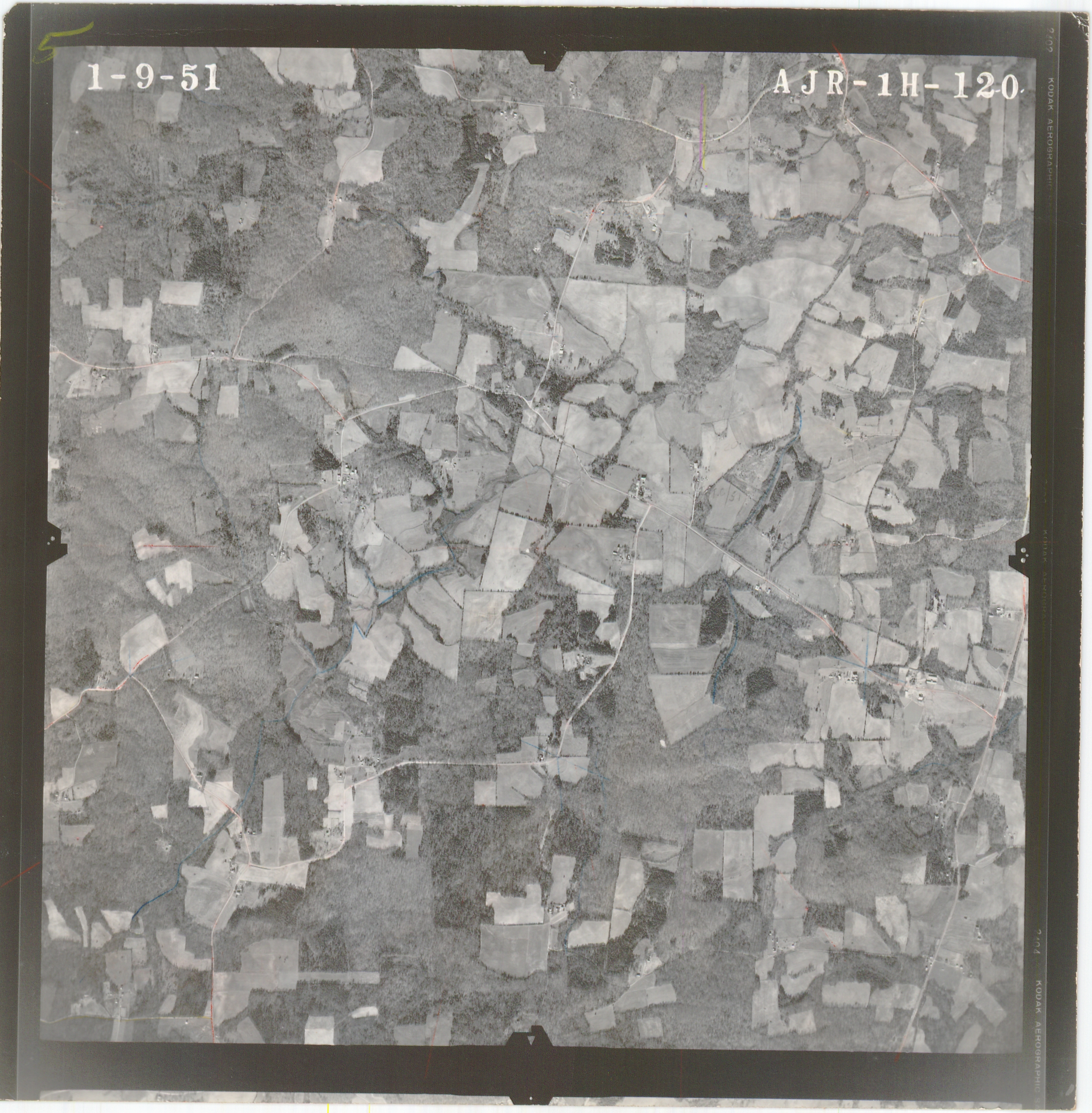

INQUIRY #: 2827723.8
YEAR: 1983
= 1000'
N
EDR Environmental Data Resources Inc


INQUIRY #: 2827723.8
YEAR: 1993
= 750'
N
EDR Environmental Data Resources Inc


INQUIRY #: 2827723.8
YEAR: 1999
= 750'
N
EDR Environmental Data Resources Inc


INQUIRY #: 2827723.8
YEAR: 2006
= 604'
N


1-9-51
AJR-1H-113


5
1-9-51
AJR-1H-120
KODAK AEROGRAPHIC

Appendix 7 Existing Morphologic Survey Data

RIVERMORPH CROSS SECTION SUMMARY

River Name: Upstream Area South
Reach Name: SF 1
Cross Section Name: XS 6
Survey Date: 09/21/10

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	596.233549	
11.48	0	595.855614	
15.92	0	595.505928	
19.33	0	594.174299	BKF
21.01	0	593.389687	
21.84	0	592.305062	LEW
23.32	0	591.961387	TW
24.86	0	592.176775	REW
25.77	0	593.626585	
28.42	0	594.820598	
37.35	0	596.117528	
52.22	0	596.384791	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	596.38	596.38	596.38
Bankfull Elevation (ft)	594.17	594.17	594.17
Floodprone Width (ft)	51.88	-----	-----
Bankfull Width (ft)	7.64	3.8	3.84
Entrenchment Ratio	6.79	-----	-----
Mean Depth (ft)	1.24	1.15	1.33
Maximum Depth (ft)	2.21	2.17	2.21
Width/Depth Ratio	6.15	3.31	2.88
Bankfull Area (sq ft)	9.48	4.37	5.11
Wetted Perimeter (ft)	9.32	6.71	6.94
Hydraulic Radius (ft)	1.02	0.65	0.74
Begin BKF Station	19.34	19.34	23.14
End BKF Station	26.98	23.14	26.98

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope			
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

RIVERMORPH CROSS SECTION SUMMARY

River Name: Upstream Area North
Reach Name: SF 2
Cross Section Name: XS 10
Survey Date: 09/27/10

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	580.310902	
11.22	0	579.201798	
18.21	0	578.563962	
20.81	0	578.109025	BKF
21.67	0	576.069961	LEW
25.76	0	576.101953	TW
29.82	0	576.201078	
31.65	0	576.565883	
37.6	0	576.263807	
39.65	0	576.405762	REW
42.28	0	579.049436	RB
48.19	0	579.785514	
55.6	0	580.149241	
65.37	0	579.929737	
73.57	0	580.40061	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	580.15	580.15	580.15
Bankfull Elevation (ft)	578.11	578.11	578.11
Floodprone Width (ft)	67.58	-----	-----
Bankfull Width (ft)	20.54	10.27	10.28
Entrenchment Ratio	3.29	-----	-----
Mean Depth (ft)	1.73	1.88	1.57
Maximum Depth (ft)	2.04	2.04	1.85
Width/Depth Ratio	11.91	5.45	6.56
Bankfull Area (sq ft)	35.44	19.34	16.1
Wetted Perimeter (ft)	22.65	13.3	12.67
Hydraulic Radius (ft)	1.56	1.45	1.27
Begin BKF Station	20.8	20.8	31.07
End BKF Station	41.35	31.07	41.35

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope			
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

RIVERMORPH CROSS SECTION SUMMARY

River Name: Upstream Area North
Reach Name: SF 3
Cross Section Name: XS 9
Survey Date: 09/27/10

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	576.060781	
12.46	0	576.129954	
18.74	0	574.910033	
23.68	0	574.7376	BKF
25.43	0	573.095374	LEW
29.13	0	572.599035	
30.49	0	572.342842	
33.76	0	572.530653	
38.3	0	573.079962	REW
40.77	0	576.464212	RB
55.51	0	577.731898	
74.93	0	578.46657	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	577.14	577.14	577.14
Bankfull Elevation (ft)	574.74	574.74	574.74
Floodprone Width (ft)	48.59	-----	-----
Bankfull Width (ft)	15.9	7.95	7.95
Entrenchment Ratio	3.06	-----	-----
Mean Depth (ft)	1.81	1.77	1.86
Maximum Depth (ft)	2.4	2.4	2.34
Width/Depth Ratio	8.76	4.49	4.27
Bankfull Area (sq ft)	28.85	14.06	14.79
Wetted Perimeter (ft)	17.49	10.99	11.17
Hydraulic Radius (ft)	1.65	1.28	1.32
Begin BKF Station	23.61	23.61	31.56
End BKF Station	39.51	31.56	39.51

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope			
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

RIVERMORPH CROSS SECTION SUMMARY

River Name: Downstream Area
Reach Name: SF 4
Cross Section Name: XS 27
Survey Date: 09/21/10

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	540.516132	
24.17	0	540.557823	
42.35	0	540.741362	
51.77	0	541.14924	
58.29	0	541.352592	LB
64.83	0	539.742895	BKF
68.46	0	536.783319	LEW
71.41	0	536.266929	
74.35	0	535.794817	TW
76.34	0	536.29395	
79.87	0	536.785617	REW
81.78	0	538.311822	
85.13	0	541.288536	
100.47	0	540.730927	
130.91	0	540.230367	
157.31	0	540.514334	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	543.69	543.69	543.69
Bankfull Elevation (ft)	539.74	539.74	539.74
Floodprone Width (ft)	157.31	-----	-----
Bankfull Width (ft)	18.55	7.01	11.55
Entrenchment Ratio	8.48	-----	-----
Mean Depth (ft)	2.68	2.33	2.89
Maximum Depth (ft)	3.95	3.54	3.95
Width/Depth Ratio	6.92	3	3.99
Bankfull Area (sq ft)	49.73	16.35	33.38
Wetted Perimeter (ft)	20.86	11.65	16.29
Hydraulic Radius (ft)	2.38	1.4	2.05
Begin BKF Station	64.83	64.83	71.84
End BKF Station	83.39	71.84	83.39

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope			
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

RIVERMORPH CROSS SECTION SUMMARY

River Name:	Downstream Area
Reach Name:	SF 4A
Cross Section Name:	XS 29
Survey Date:	09/21/10

Cross Section Data Entry

BM Elevation:	0 ft
Backsight Rod Reading:	0 ft

TAPE	FS	ELEV	NOTE
0	0	541.980498	
18.75	0	542.011765	
26.66	0	541.721211	
30.41	0	541.40856	LB
33.63	0	539.725003	BKF
35.71	0	537.805416	LEW
39.47	0	537.573278	TW
42.23	0	537.80111	REW
45.89	0	541.87025	RB
53.1	0	541.873644	
68.52	0	541.862049	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	541.87	541.87	541.87
Bankfull Elevation (ft)	539.72	539.72	539.72
Floodprone Width (ft)	29.4	-----	-----
Bankfull Width (ft)	10.32	5.16	5.16
Entrenchment Ratio	2.85	-----	-----
Mean Depth (ft)	1.64	1.59	1.69
Maximum Depth (ft)	2.15	2.11	2.15
Width/Depth Ratio	6.31	3.25	3.06
Bankfull Area (sq ft)	16.89	8.2	8.69
Wetted Perimeter (ft)	11.94	8.02	8.13
Hydraulic Radius (ft)	1.41	1.02	1.07
Begin BKF Station	33.64	33.64	38.8
End BKF Station	43.96	38.8	43.96

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope			
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

RIVERMORPH CROSS SECTION SUMMARY

River Name: Upstream Area North
Reach Name: UT 1
Cross Section Name: XS 15
Survey Date: 09/21/10

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	591.488739	
16.35	0	590.731728	
22.49	0	590.95998	
24.02	0	591.313888	
30.32	0	592.285778	
35.54	0	591.44712	
43.43	0	589.924136	
54.23	0	589.056774	
61.33	0	588.821219	
69.23	0	588.875569	
74.7	0	588.839013	LB
76.87	0	587.052846	
78.58	0	585.81693	LEW
80.21	0	585.545872	TW
82.25	0	585.899342	REW
84.04	0	586.807817	
85.87	0	587.01879	BKF
88.2	0	588.295338	
90.24	0	588.667393	
94.35	0	589.29686	
100.89	0	590.337884	
105.41	0	591.357406	
113.27	0	592.432297	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	588.49	588.49	588.49
Bankfull Elevation (ft)	587.02	587.02	587.02
Floodprone Width (ft)	14.17	-----	-----
Bankfull Width (ft)	8.96	4.48	4.47
Entrenchment Ratio	1.58	-----	-----
Mean Depth (ft)	0.81	1.07	0.54
Maximum Depth (ft)	1.47	1.47	1.27
Width/Depth Ratio	11.11	4.18	8.31
Bankfull Area (sq ft)	7.22	4.81	2.4
Wetted Perimeter (ft)	9.63	6.18	5.98
Hydraulic Radius (ft)	0.75	0.78	0.4
Begin BKF Station	76.92	76.92	81.4
End BKF Station	85.87	81.4	85.87

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope			
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

RIVERMORPH CROSS SECTION SUMMARY

River Name: Upstream Area North
Reach Name: UT 1A
Cross Section Name: XS 24
Survey Date: 09/21/10

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	597.198583	
23.26	0	596.147864	
35.75	0	594.792082	
47.01	0	594.129928	
53.66	0	593.544332	LB
54.55	0	593.231984	
56.52	0	593.28698	bkf
57.15	0	593.004641	LEW
59.07	0	592.979829	TW
62.93	0	593.48045	
66.19	0	593.800693	
68.89	0	593.855361	REW
70.29	0	594.458096	
72.22	0	595.038285	RB
78.15	0	595.643374	
107.73	0	597.526207	
131.79	0	601.315126	
156.33	0	603.842325	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	593.6	593.6	593.6
Bankfull Elevation (ft)	593.29	593.29	593.29
Floodprone Width (ft)	11.12	-----	-----
Bankfull Width (ft)	4.94	1.86	3.08
Entrenchment Ratio	2.25	-----	-----
Mean Depth (ft)	0.21	0.24	0.19
Maximum Depth (ft)	0.31	0.3	0.31
Width/Depth Ratio	23.63	7.66	16.3
Bankfull Area (sq ft)	1.03	0.45	0.58
Wetted Perimeter (ft)	5.03	2.22	3.4
Hydraulic Radius (ft)	0.21	0.2	0.17
Begin BKF Station	56.52	56.52	58.38
End BKF Station	61.46	58.38	61.46

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope			

Shear Stress (lb/sq ft)
Movable Particle (mm)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Upstream Area North
Reach Name: UT 1B
Cross Section Name: XS 22
Survey Date: 09/21/10

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	603.457087	
24.17	0	601.9216	
42.14	0	600.871401	LB
44.2	0	599.245239	LEW
45.4	0	598.874322	TW
46.05	0	598.808501	REW
46.66	0	599.845353	BKF
48.02	0	600.953243	RB
58.01	0	601.047462	
73.34	0	601.964867	
95.76	0	602.830283	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	600.89	600.89	600.89
Bankfull Elevation (ft)	599.85	599.85	599.85
Floodprone Width (ft)	6.15	-----	-----
Bankfull Width (ft)	3.23	1.62	1.62
Entrenchment Ratio	1.9	-----	-----
Mean Depth (ft)	0.67	0.53	0.8
Maximum Depth (ft)	1.04	0.87	1.04
Width/Depth Ratio	4.85	3.05	2.01
Bankfull Area (sq ft)	2.15	0.86	1.3
Wetted Perimeter (ft)	4.1	2.73	3.1
Hydraulic Radius (ft)	0.53	0.31	0.42
Begin BKF Station	43.43	43.43	45.05
End BKF Station	46.67	45.05	46.67

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope			
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

RIVERMORPH CROSS SECTION SUMMARY

River Name: Upstream Area South
Reach Name: UT 2
Cross Section Name: XS 3
Survey Date: 09/21/10

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	601.076034	
50.3	0	599.402516	
68.93	0	600.052792	
79.63	0	599.770653	RB
81.23	0	598.6869	BKF
82.5	0	597.187287	LEW
84.63	0	596.868668	TW
86.96	0	597.053305	REW
88.99	0	599.592667	RB
94.69	0	600.060645	
100.54	0	599.536109	
113.46	0	599.704145	
146.26	0	599.937119	
159.62	0	601.89479	

Cross Sectional Geometry

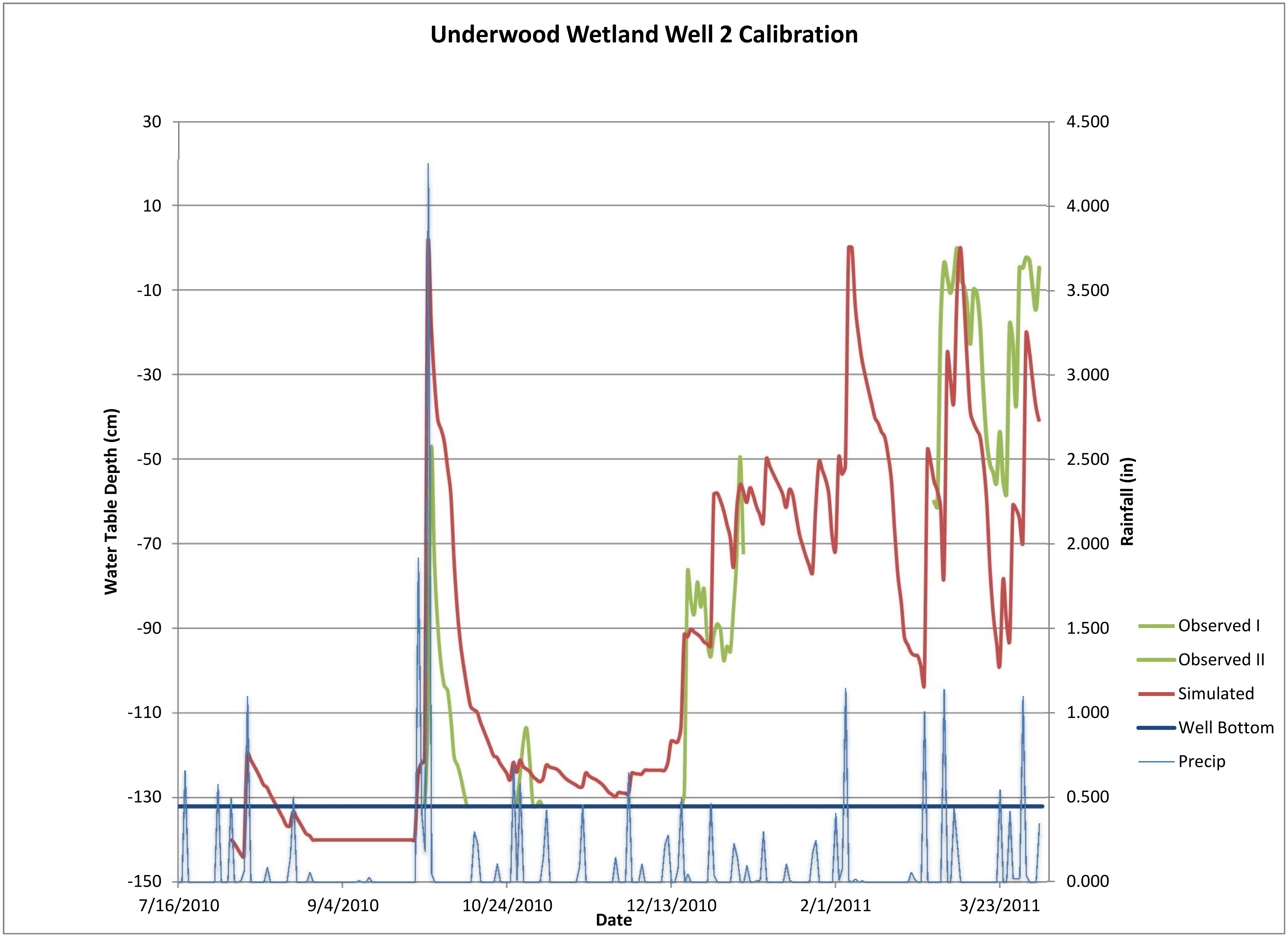
	Channel	Left	Right
Floodprone Elevation (ft)	600.51	600.51	600.51
Bankfull Elevation (ft)	598.69	598.69	598.69
Floodprone Width (ft)	133.21	-----	-----
Bankfull Width (ft)	7.04	3.52	3.52
Entrenchment Ratio	18.91	-----	-----
Mean Depth (ft)	1.36	1.34	1.39
Maximum Depth (ft)	1.82	1.82	1.81
Width/Depth Ratio	5.17	2.64	2.54
Bankfull Area (sq ft)	9.6	4.71	4.88
Wetted Perimeter (ft)	8.56	6.06	6.12
Hydraulic Radius (ft)	1.12	0.78	0.8
Begin BKF Station	81.23	81.23	84.75
End BKF Station	88.27	84.75	88.27

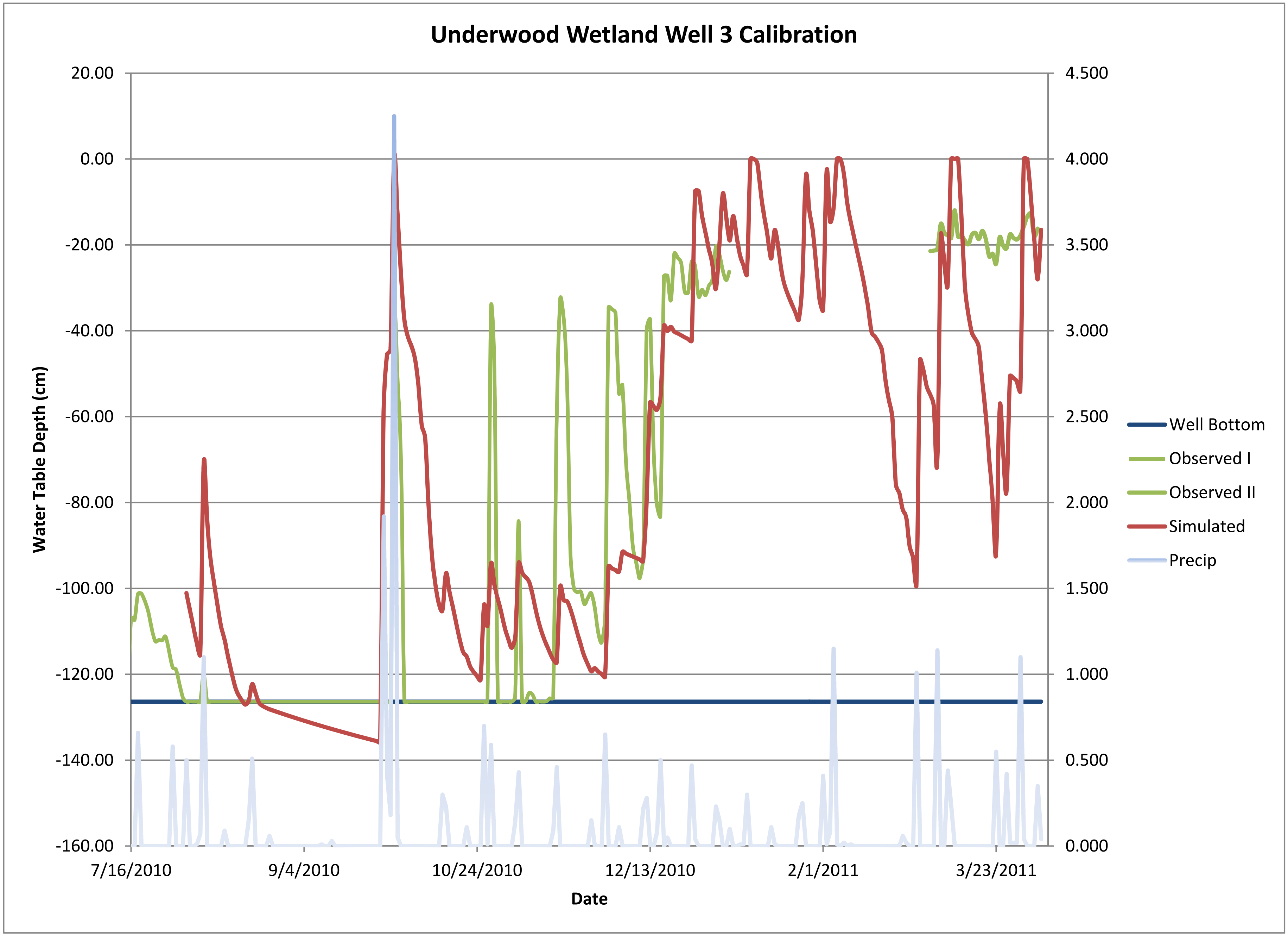
Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

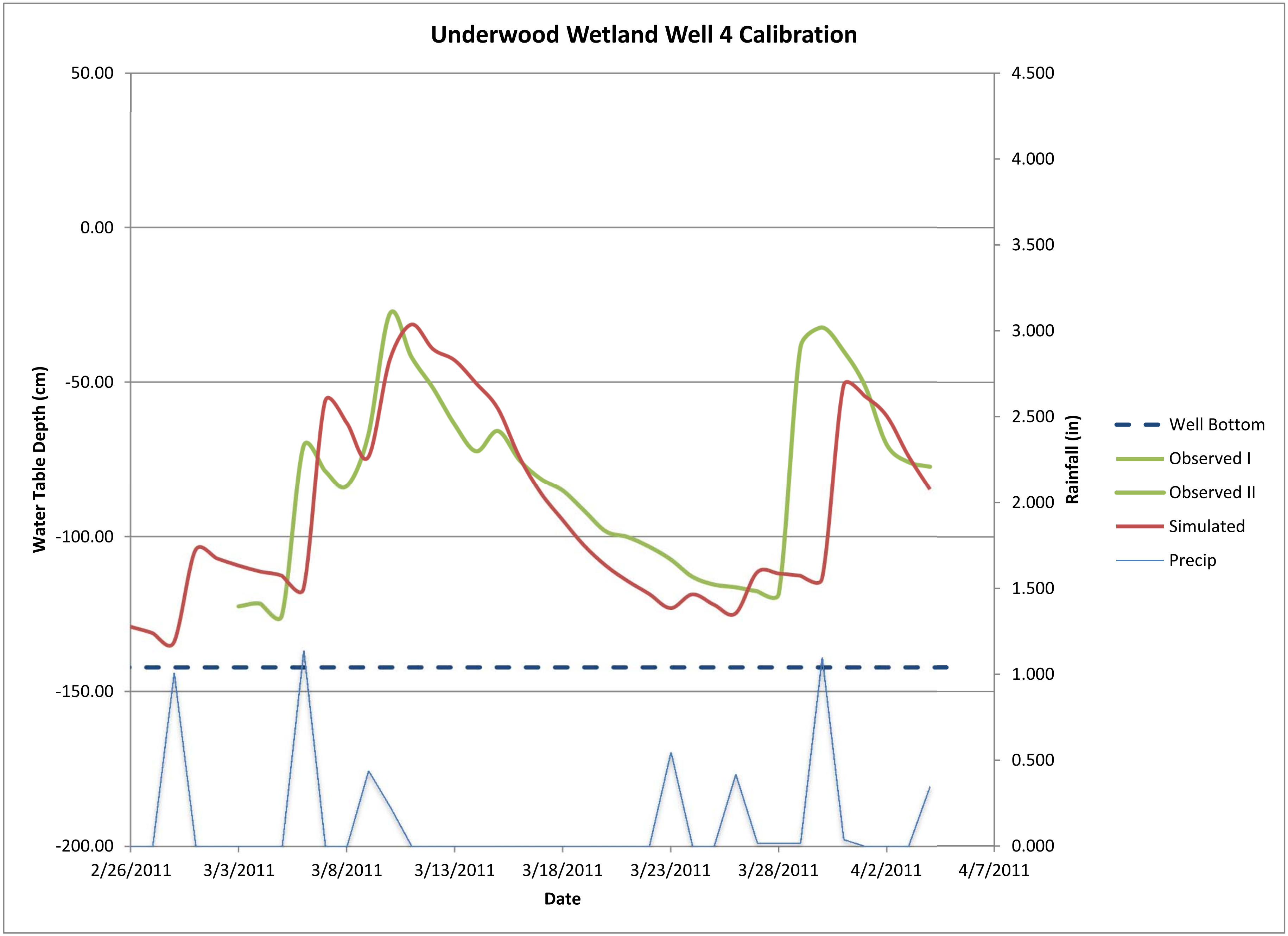
	Channel	Left Side	Right Side
Slope			
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

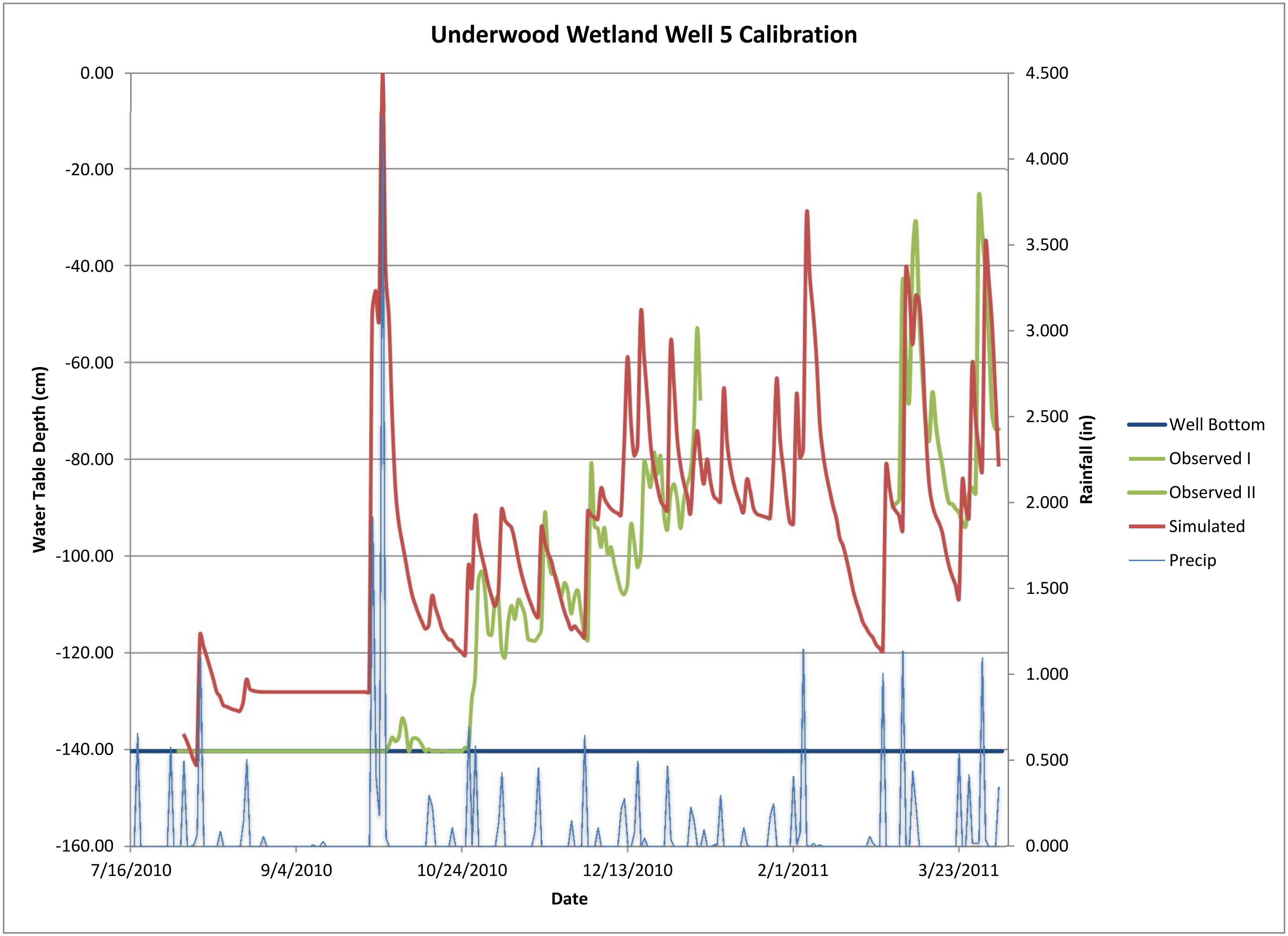
Appendix 8 Drainmod Calibration Plots


Underwood Wetland Well 2 Calibration
Water Table Depth (cm)
30
10
-10
-30
-50
-70
-90
-110
-130
-150
Rainfall (in)
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
7/16/2010
9/4/2010
10/24/2010
12/13/2010
2/1/2011
3/23/2011
Date
Observed I
Observed II
Simulated
Well Bottom
Precip



Underwood Wetland Well 3 Calibration
Water Table Depth (cm)
20.00
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
-120.00
-140.00
-160.00
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
7/16/2010
9/4/2010
10/24/2010
12/13/2010
2/1/2011
3/23/2011
Date
Well Bottom
Observed I
Observed II
Simulated
Precip


Underwood Wetland Well 4 Calibration
Water Table Depth (cm)
Rainfall (in)
Date
50.00
0.00
-50.00
-100.00
-150.00
-200.00
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
2/26/2011
3/3/2011
3/8/2011
3/13/2011
3/18/2011
3/23/2011
3/28/2011
4/2/2011
4/7/2011
Well Bottom
Observed I
Observed II
Simulated
Precip



Underwood Wetland Well 5 Calibration
Water Table Depth (cm)
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
-120.00
-140.00
-160.00
Rainfall (in)
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
7/16/2010
9/4/2010
10/24/2010
12/13/2010
2/1/2011
3/23/2011
Date
Well Bottom
Observed I
Observed II
Simulated
Precip

EEP Floodplain Requirements Checklist

This form was developed by the National Flood Insurance program, NC Floodplain Mapping program and Ecosystem Enhancement Program to be filled for all EEP projects. The form is intended to summarize the floodplain requirements during the design phase of the projects. The form should be submitted to the Local Floodplain Administrator with three copies submitted to NFIP (attn. Edward Curtis), NC Floodplain Mapping Unit (attn. John Gerber) and NC Ecosystem Enhancement Program.

Project Location

Name of project:	Underwood Stream & Wetland Mitigation Site
Name if stream or feature:	Unnamed Tributary to South Fork
County:	Chatham County, NC
Name of river basin:	Cape Fear River Basin
Is project urban or rural?	Rural
Name of Jurisdictional municipality/county:	Chatham County, NC
DFIRM panel number for entire site:	Firm Panels 8764 and 8784 Community No.: 370299 Map Numbers: 3710876400J and 3710878400J Effective Map Date: February 2, 2007
Consultant name:	Wildlands Engineering, Inc. Nicole Macaluso, PE
Phone number:	(919) 851-9986
Address:	5605 Chapel Hill Road, Suite 122 Raleigh, NC 27607

Design Information

Provide a general description of project (one paragraph). Include project limits on a reference orthophotograph at a scale of 1" = 500".

Wildlands Engineering is designing a stream and wetland restoration project to provide stream and wetland mitigation units (SMUs and WMUs) for the NC Ecosystem Enhancement Program. The stream restoration work includes channel and floodplain grading for approximately 9,200LF of South Fork and its unnamed tributaries. A total of 13.76 acres of riparian wetlands will be restored and created adjacent to the streams and 1.54 acres of non-riparian wetlands will be restored and enhanced.

Stream Reaches			
Reach	Type of Mitigation	Length (LF)	Priority
UT1	Enhancement II	1,406	4
UT1	Restoration	591	1
UT1A	Enhancement II	524	4
UT1B	Enhancement II	660	4
	Total	3,181	

Non-riparian Wetland Areas		
Reach	Type of Mitigation	Area (acres)
NRW2	Enhancement	0.34

Floodplain Information

Is project located in a Special Flood Hazard Area (SFHA)?

○ Yes ● No

If project is located in a SFHA, check how it was determined:

☐ Redelineation

☐ Detailed Study

☐ Limited Detail Study

☐ Approximate Study

☐ Don't know

List flood zone designation: Zone X

Check if applies:

☐ AE Zone

- ○ Floodway
- ○ Non-Encroachment
- ● None

☐ A Zone

- ○ Local Setbacks Required

○ No Local Setbacks Required
If local setbacks are required, list how many feet: N/A
Does proposed channel boundary encroach outside floodway/non-encroachment/setbacks? N/A ○ Yes ● No
Land Acquisition (Check) ☐ State owned (fee simple) ☐ Conservation easment (Design Bid Build) ☑ Conservation Easement (Full Delivery Project)
Note: if the project property is state-owned, then all requirements should be addressed to the Department of Administration, State Construction Office (attn: Herbert Neily, (919) 807-4101)
Is community/county participating in the NFIP program? ● Yes ○ No
Note: if community is not participating, then all requirements should be addressed to NFIP (attn: Edward Curtis, (919) 715-8000 x369)
Name of Local Floodplain Administrator: Dan LaMontagne Phone Number: (919) 542-0945

Floodplain Requirements

This section to be filled by designer/applicant following verification with the LFPA

☑ No Action

☐ No Rise

☐ Letter of Map Revision

☐ Conditional Letter of Map Revision

☐ Other Requirements

List other requirements:

Comments:

Name: Nicole Macaluso, PE Signature: [signature]

Title: Water Resources Engineer Date: 9/14/2011

EEP Floodplain Requirements Checklist

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Project Location

Name of project:	Underwood Stream & Wetland Mitigation Site
Name if stream or feature:	South Fork
County:	Chatham County, NC
Name of river basin:	Cape Fear River Basin
Is project urban or rural?	Rural
Name of Jurisdictional municipality/county:	Chatham County, NC
DFIRM panel number for entire site:	Firm Panel 8784 Community No.: 370299 Map Number: 3710878400J Effective Map Date: February 2, 2007
Consultant name:	Wildlands Engineering, Inc. Nicole Macaluso, PE
Phone number:	(919) 851-9986
Address:	5605 Chapel Hill Road, Suite 122 Raleigh, NC 27607

Design Information

Provide a general description of project (one paragraph). Include project limits on a reference orthophotograph at a scale of 1" = 500".

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Stream Reaches			
Reach	Type of Mitigation	Length (LF)	Priority
SF2	Enhancement II	302	4
SF3	Enhancement I	152	3
SF3	Enhancement II	513	4
SF3	Restoration	1,450	1
	Total	2,417	

Riparian Wetland Areas		
Reach	Type of Mitigation	Area (acres)
RW3	Creation	2.63
RW3	Restoration	1.33
	Total	13.76

Floodplain Information

Is project located in a Special Flood Hazard Area (SFHA)?

○ Yes ◉ No

If project is located in a SFHA, check how it was determined:

☐ Redelineation

☐ Detailed Study

☐ Limited Detail Study

☐ Approximate Study

☐ Don't know

List flood zone designation: Zone X

Check if applies:

☐ AE Zone

○ Floodway

○ Non-Encroachment

◉ None

☐ A Zone

○ Local Setbacks Required ○ No Local Setbacks Required	
If local setbacks are required, list how many feet: N/A	
Does proposed channel boundary encroach outside floodway/non-encroachment/setbacks? N/A ○ Yes ◉ No	
Land Acquisition (Check) ☐ State owned (fee simple) ☐ Conservation easment (Design Bid Build) ☑ Conservation Easement (Full Delivery Project)	
Note: if the project property is state-owned, then all requirements should be addressed to the Department of Administration, State Construction Office (attn: Herbert Neily, (919) 807-4101)	
Is community/county participating in the NFIP program? ◉ Yes ○ No	
Note: if community is not participating, then all requirements should be addressed to NFIP (attn: Edward Curtis, (919) 715-8000 x369)	
Name of Local Floodplain Administrator: Dan LaMontagne Phone Number: (919) 542-0945	

Floodplain Requirements

This section to be filled by designer/applicant following verification with the LFPA

☑ No Action

☐ No Rise

☐ Letter of Map Revision

☐ Conditional Letter of Map Revision

☐ Other Requirements

List other requirements:

Comments:

Name: Nicole Macaluso, PE   Signature: [signature]

Title: Water Resources Engineer   Date: 9/14/2011

EEP Floodplain Requirements Checklist

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Project Location

Name of project:	Underwood Stream & Wetland Mitigation Site
Name if stream or feature:	South Fork and Unnamed Tributary to South Fork
County:	Chatham County, NC
Name of river basin:	Cape Fear River Basin
Is project urban or rural?	Rural
Name of Jurisdictional municipality/county:	Chatham County, NC
DFIRM panel number for entire site:	Firm Panel 8784 Community No.: 370299 Map Number: 3710878400J Effective Map Date: February 2, 2007
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Stream Reaches			
Reach	Type of Mitigation	Length (LF)	Priority
SF1	Restoration	878	1
UT2	Enhancement I	421	3
	Total	1,299	

Riparian Wetland Areas		
Reach	Type of Mitigation	Area (acres)
RW1	Restoration	1.25
RW2	Creation	0.45
RW2	Restoration	0.50
	Total	2.2

Non-riparian Wetland Areas		
Reach	Type of Mitigation	Area (acres)
NRW1	Restoration	1.20

Floodplain Information

Is project located in a Special Flood Hazard Area (SFHA)?

- [ ] Yes
- [x] No

If project is located in a SFHA, check how it was determined:

- [ ] Redelineation
- [ ] Detailed Study
- [ ] Limited Detail Study
- [ ] Approximate Study
- [ ] Don't know

List flood zone designation: Zone X

Check if applies:

- [ ] AE Zone
    - [ ] Floodway
    - [ ] Non-Encroachment

◉ None ☐ A Zone ○ Local Setbacks Required ○ No Local Setbacks Required
If local setbacks are required, list how many feet: N/A
Does proposed channel boundary encroach outside floodway/non-encroachment/setbacks? N/A ○ Yes ◉ No
Land Acquisition (Check) ☐ State owned (fee simple) ☐ Conservation easment (Design Bid Build) ☑ Conservation Easement (Full Delivery Project)
Note: if the project property is state-owned, then all requirements should be addressed to the Department of Administration, State Construction Office (attn: Herbert Neily, (919) 807-4101)
Is community/county participating in the NFIP program? ◉ Yes ○ No Note: if community is not participating, then all requirements should be addressed to NFIP (attn: Edward Curtis, (919) 715-8000 x369)
Name of Local Floodplain Administrator: Dan LaMontagne Phone Number: (919) 542-0945

Floodplain Requirements

This section to be filled by designer/applicant following verification with the LFPA

☑ No Action

☐ No Rise

☐ Letter of Map Revision

☐ Conditional Letter of Map Revision

☐ Other Requirements

List other requirements:

Comments:

Name: Nicole Macaluso, PE Signature: [signature]

Title: Water Resources Engineer Date: 9/14/2011

EEP Floodplain Requirements Checklist

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Project Location

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Name if stream or feature:	South Fork and Unnamed Tributary to South Fork
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Stream Reaches			
Reach	Type of Mitigation	Length (LF)	Priority
SF4	Restoration	1,424	1
SF4A	Restoration	259	1
SF4A	Enhancement I	609	3
	Total	2,292	

Riparian Wetland Areas		
Reach	Type of Mitigation	Area (acres)
RW4	Creation	3.95
RW4	Restoration	3.65
	Total	7.6

Floodplain Information

Is project located in a Special Flood Hazard Area (SFHA)?

(•) Yes ( ) No

If project is located in a SFHA, check how it was determined:

- [ ] Redelineation
- [ ] Detailed Study
- [x] Limited Detail Study
- [ ] Approximate Study
- [ ] Don't know

List flood zone designation:

Check if applies:

- [x] AE Zone
  - ( ) Floodway
  - (•) Non-Encroachment
  - ( ) None
- [ ] A Zone
  - ( ) Local Setbacks Required

◯ No Local Setbacks Required
If local setbacks are required, list how many feet: N/A
Does proposed channel boundary encroach outside floodway/non-encroachment/setbacks? ◉ Yes ◯ No
Land Acquisition (Check) ☐ State owned (fee simple) ☐ Conservation easment (Design Bid Build) ☑ Conservation Easement (Full Delivery Project)
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Name of Local Floodplain Administrator: Dan LaMontagne Phone Number: (919) 542-0945

Floodplain Requirements

This section to be filled by designer/applicant following verification with the LFPA

☐ No Action

☐ No Rise

☐ Letter of Map Revision

☑ Conditional Letter of Map Revision

☐ Other Requirements

List other requirements:

Comments:

Name: Nicole Macaluso, PE Signature: [signature]

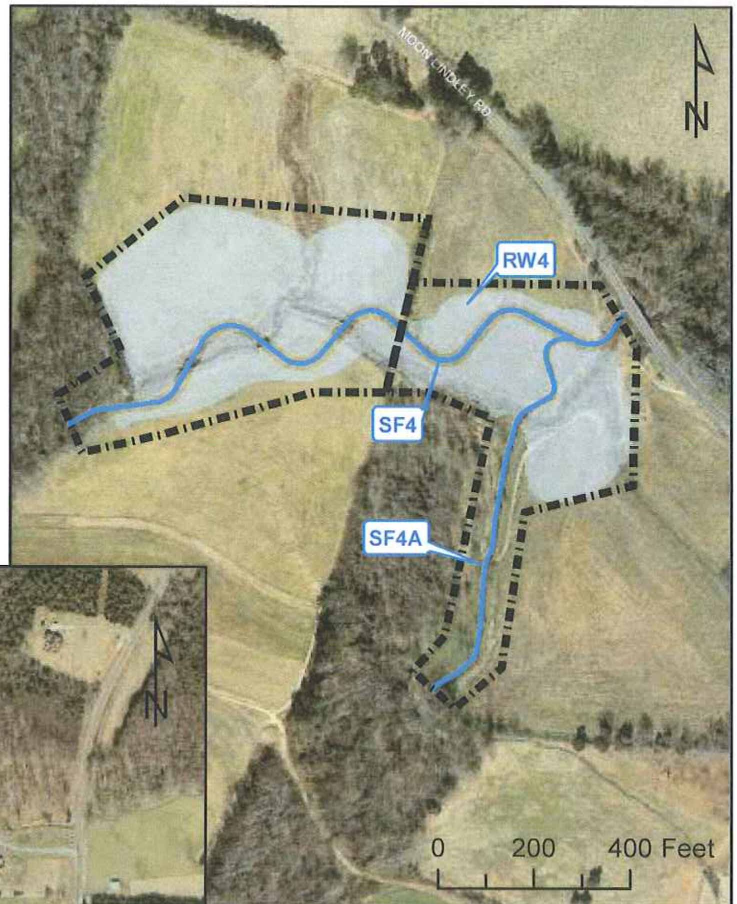
Title: Water Resources Engineer Date: 9/14/2011

Legend

Proposed Easement

Project Streams

All Wetlands



**2007 Aerial Photography*

WILDLANDS

Site Map
Underwood Mitigation Site
Cape Fear River Basin (03030002)
Chatham County, NC

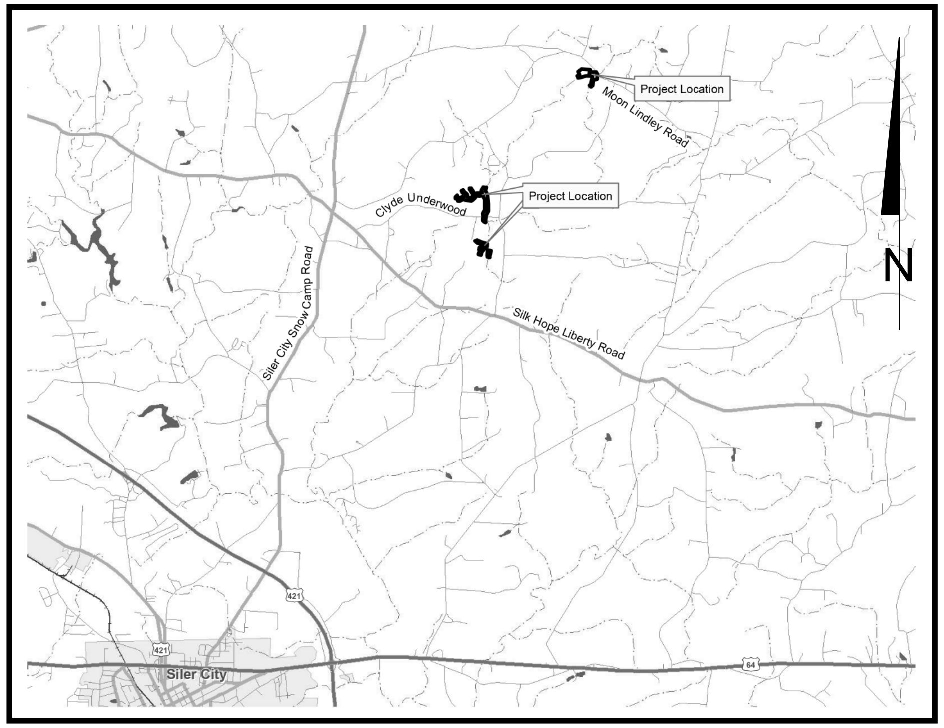
Underwood Mitigation Site

Chatham County, NC

for

North Carolina Ecosystem Enhancement Program

Ecosystem Enhancement PROGRAM



Vicinity Map
Not to Scale

BEFORE YOU DIG!
CALL 1-800-632-4949
N.C. ONE-CALL CENTER
IT'S THE LAW!

Sheet Index

Project Directory

Engineering:
Wildlands Engineering, Inc
License No. F-0831
5605 Chapel Hill Road
Suite 122
Raleigh, NC 27607
Nicole Macaluso, PE
919-851-9986

Owner:
Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, NC 27699-1652
Guy Pearce
919-715-1157

Project Summary

Stream Restoration Length	4602 LF
Stream Enhancement I Length	1182 LF
Stream Enhancement II Length	3405 LF
Wetland Restoration	7.93 Acres
Wetland Enhancement	0.34 Acres
Wetland Creation	7.03 Acres
Disturbed Area	TBD
River Basin	Cape Fear
HUC	03030002

Preliminary Plans - Not For Construction

WILDLANDS ENGINEERING

WILDLANDS ENGINEERING, INC.
Ecological Restoration Services

5605 Chapel Hill Road, Suite 122
Raleigh, NC 27607
Tel: 919.851.9986
Fax: 919.851.9987
Firm License No. F-0831

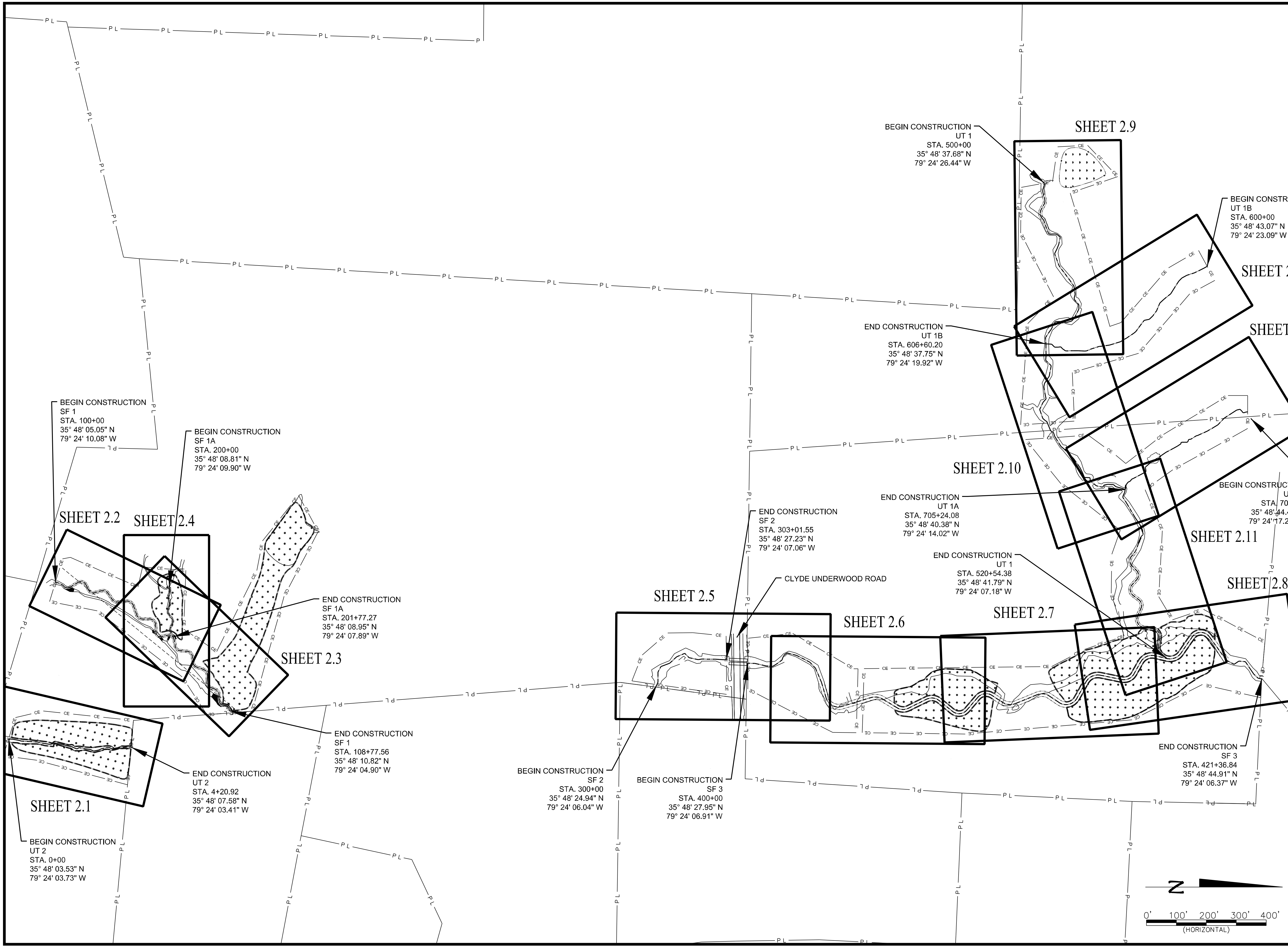
Underwood Mitigation Site
Chatham County, NC
Title Sheet

Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

TITLE SHEET

Sheet
0.1



Preliminary Plans - Not For Construction

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Underwood Mitigation Site
Chatham County, NC

Stream Overview

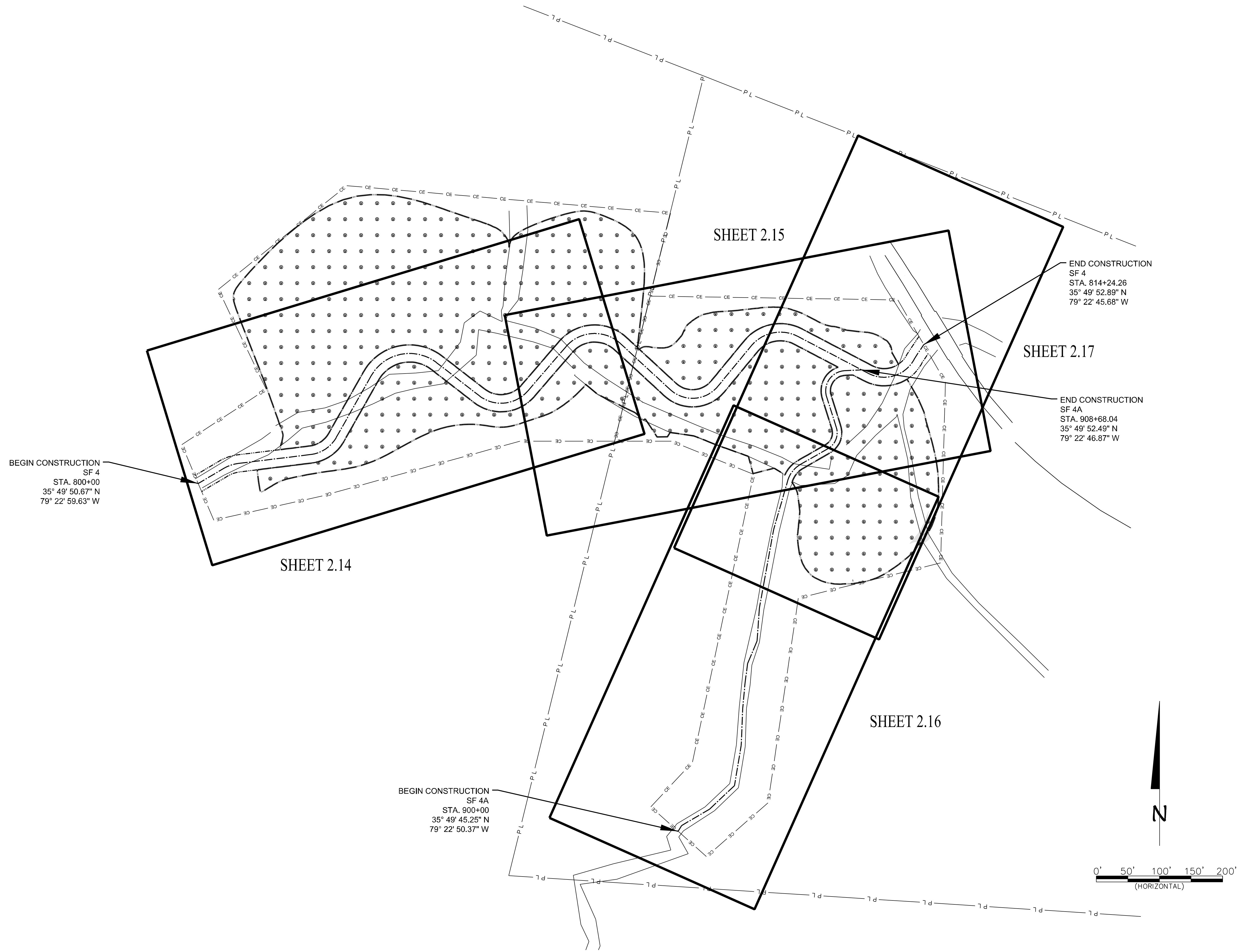
Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM OVERVIEW

Sheet

0.2



Preliminary Plans - Not For Construction

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Underwood Mitigation Site
Chatham County, NC

Stream Overview

Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM OVERVIEW

Sheet

0.3

GENERAL NOTES

1. Various types of constructed riffles are specified in this plan set per details and constructed riffle tables on plan sheets. Contractor will build the specific types of constructed riffles at locations shown on the plans. Changes in constructed riffle type must be approved by the engineer.
2. Contractor is to make every effort to avoid removing trees from the present site. The tree protection measures included in these plans are to be followed at all times.

P L	Existing Property Line
100	Existing Major Contour
	Existing Minor Contour
	Existing Tree/Shrub Line
	Existing Tree
WL	Existing Wetland
	Existing Power Pole
	Existing Bedrock
CE CE CE	Conservation Easement
10+00	Proposed Channel Centerline
	Proposed Bankfull
540	Proposed Major Contour
538	Proposed Minor Contour
	Proposed Wetlands
	Proposed Root Wads See Detail 1, Sheet 6.3
	Proposed Log Vane See Detail 2, Sheet 6.1
	Proposed Constructed Riffle Varies per details on Sheets 6.1 & 6.2. Coordinate with designer in the field.
	Proposed Log Sill See Detail 4, Sheet 6.1
	Proposed Log J-Hook See Detail 1, Sheet 6.1
	Proposed Drainage Berm See Detail 2, Sheet 6.4
4	Proposed Structure Number
	Proposed Brush Toe Protection See Detail 3, Sheet 6.3
	Proposed Stream Plug See Detail 2, Sheet 6.3
	Proposed Ephemeral Pool See Detail 1, Sheet 6.4
	Proposed Sod Mat See Detail 3, Sheet 6.5
	Zone 1 - Stream Bank Planting Zone
	Zone 2 - Floodplain Planting Zone
	Zone 3 - Wetland Planting Zone

Preliminary Plans - Not For Construction

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Underwood Mitigation Site
Chatham County, NC

General Notes and Symbols

Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

GENERAL NOTES AND SYMBOLS

Sheet

0.4

Constructed Riffle Table

Structure Number	Type	SF 1 (Design)		SF 1 (Construction)	
		Beginning Elevation	Ending Elevation	Beginning Elevation	Ending Elevation
CR-1	B	597.90	597.44		
CR-2	A	597.39	597.07		
CR-3	A	597.03	596.67		
CR-4	A	596.62	596.28		
CR-5	A	596.24	595.79		
CR-6	D	595.74	595.50		
CR-7	A	595.26	594.85		
CR-8	C	594.80	594.29		
CR-9	B	594.23	593.73		
CR-10	A	593.66	593.20		
CR-11	C	593.15	592.85		
CR-12	A	592.57	592.14		
CR-13	A	592.10	591.47		
CR-14	B	591.38	590.89		
CR-15	A	590.82	590.35		
CR-16	B	590.28	590.06		

Constructed Riffle Table

Structure Number	Type	UT 2 (Design)		UT 2 (Construction)	
		Beginning Elevation	Ending Elevation	Beginning Elevation	Ending Elevation
CR-17	B	601.09	600.94		
CR-18	A	600.59	600.46		
CR-19	B	600.09	599.96		
CR-20	A	599.67	599.53		
CR-21	A	599.23	599.09		
CR-22	A	598.82	598.65		
CR-23	B	598.10	597.93		
CR-24	A	597.44	597.28		
CR-25	C	597.16	596.75		
CR-26	C	596.24	595.90		

Constructed Riffle Table

Structure Number	Type	SF 3 (Design)		SF 3 (Construction)	
		Beginning Elevation	Ending Elevation	Beginning Elevation	Ending Elevation
CR-27	C	574.94	574.88		
CR-28	A	574.73	574.67		
CR-29	A	574.53	574.37		
CR-30	D	574.35	574.14		
CR-31	A	574.13	573.80		
CR-32	B	573.77	573.40		
CR-33	A	573.37	573.00		
CR-34	D	572.96	572.60		
CR-35	A	572.56	572.27		
CR-36	D	572.24	571.83		
CR-37	A	571.80	571.49		
CR-38	A	571.44	571.09		
CR-39	D	571.05	570.68		
CR-40	B	570.64	570.25		
CR-41	B	570.19	569.72		
CR-42	D	569.67	568.98		
CR-43	C	568.90	568.10		
CR-44	C	567.67	567.48		
CR-45	C	567.22	566.87		

Constructed Riffle Table

Structure Number	Type	UT 1 (Design)		UT 1 (Construction)	
		Beginning Elevation	Ending Elevation	Beginning Elevation	Ending Elevation
CR-46	B	586.34	586.04		
CR-47	D	581.08	580.87		
CR-48	C	576.60	575.92		
CR-49	A	574.18	574.75		
CR-50	A	573.95	573.85		
CR-51	A	573.70	573.46		
CR-52	A	573.42	573.16		
CR-53	A	573.13	572.84		
CR-54	B	572.80	572.28		
CR-55	C	572.21	571.80		
CR-56	B	571.37	570.68		
CR-57	C	570.60	570.30		
CR-58	A	570.00	569.72		

Constructed Riffle Table

Structure Number	Type	UT 1B (Design)		UT 1B (Construction)	
		Beginning Elevation	Ending Elevation	Beginning Elevation	Ending Elevation
CR-59	B	582.45	582.07		

Constructed Riffle Table

Structure Number	Type	UT 1A (Design)		UT 1A (Construction)	
		Beginning Elevation	Ending Elevation	Beginning Elevation	Ending Elevation
CR-60	B	572.95	572.03		

Constructed Riffle Table

Structure Number	Type	SF 4 (Design)		SF 4 (Construction)	
		Beginning Elevation	Ending Elevation	Beginning Elevation	Ending Elevation
CR-61	B	538.90	538.77		
CR-62	A	538.71	538.25		
CR-63	A	538.27	537.72		
CR-64	B	537.65	537.25		
CR-65	C	537.20	536.51		
CR-66	A	536.44	535.74		
CR-67	C	535.67	535.10		
CR-68	D	535.03	534.28		

Constructed Riffle Table

Structure Number	Type	SF 4A (Design)		SF 4A (Construction)	
		Beginning Elevation	Ending Elevation	Beginning Elevation	Ending Elevation
CR-69	A	540.60	540.48		
CR-70	B	539.49	539.43		
CR-71	A	538.92	538.87		
CR-72	A	538.45	538.37		
CR-73	A	537.99	537.95		
CR-74	B	537.56	537.46		
CR-75	B	537.31	536.70		
CR-76	C	535.87	535.62		
CR-77	A	535.42	535.05		
CR-78	C	535.00	534.51		
CR-79	A	534.45	534.28		

Preliminary Plans - Not For Construction

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Tel: 919.851.9986
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Underwood Mitigation Site
Chatham County, NC

Structure Tables

Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

STRUCTURE TABLES

Sheet

0.5

Structure Table

Structure Number	Structure Type	Thalweg Elevation	Bankfull Elevation	SF 1 (Construction) Constructed Invert Elevation	Constructed Arm Angle	Constructed Arm Slope
S1	Log Vane	594.85	596.07			
S2	Log Vane	591.47	592.82			
S3	Log Vane	590.89	582.15			
S4	Log Vane	590.35	591.61			

Structure Table

Structure Number	Structure Type	Thalweg Elevation	Bankfull Elevation	SF 1A (Construction) Constructed Invert Elevation	Constructed Arm Angle	Constructed Arm Slope
S5	Log Weir	593.97	594.97			
S6	Log Weir	593.93	594.93			
S7	Log Weir	593.88	594.88			
S8	Log Weir	593.82	594.82			
S9	Log Weir	593.76	594.76			
S10	Log Weir	593.70	594.70			

Structure Table

Structure Number	Structure Type	Thalweg Elevation	Bankfull Elevation	SF 2 (Construction) Constructed Invert Elevation	Constructed Arm Angle	Constructed Arm Slope
S11	Log Vane	577.67	579.47			
S12	Log Vane	577.47	579.27			
S13	Log Vane	576.35	578.15			
S14	Log Vane	576.35	578.15			

Structure Table

Structure Number	Structure Type	Thalweg Elevation	Bankfull Elevation	SF 3 (Construction) Constructed Invert Elevation	Constructed Arm Angle	Constructed Arm Slope
S15	Log Vane	574.78	576.94			

Structure Table

Structure Number	Structure Type	Thalweg Elevation	Bankfull Elevation	UT1 (Construction) Constructed Invert Elevation	Constructed Arm Angle	Constructed Arm Slope
S16	Log Vane	586.68	587.98			
S17	Log Vane	586.50	587.80			
S18	Log Vane	586.20	587.50			
S19	Log Vane	586.00	587.30			
S20	Log Vane	585.38	586.68			
S21	Log Vane	585.20	586.50			
S22	Log Vane	584.60	585.90			
S23	Log Vane	582.97	584.27			
S24	Log Vane	582.59	583.89			
S25	Log Vane	580.74	582.04			
S26	Log Vane	579.90	581.20			
S27	Log Vane	578.62	579.92			
S28	Log Vane	577.18	578.48			
S29	Log Vane	576.72	578.02			
S30	Log Vane	575.60	576.90			

Structure Table

Structure Number	Structure Type	Thalweg Elevation	Bankfull Elevation	UT1A (Construction) Constructed Invert Elevation	Constructed Arm Angle	Constructed Arm Slope
S31	Log Vane					
S32	Log Vane					
S33	Log Vane					
S34	Log Vane					
S35	Log Vane					
S36	Log Vane					
S37	Log Vane					
S38	Log Vane					

Structure Table

Structure Number	Structure Type	Thalweg Elevation	Bankfull Elevation	UT1B (Construction) Constructed Invert Elevation	Constructed Arm Angle	Constructed Arm Slope
S39	Log Vane					
S40	Log Vane					
S41	Log Vane					
S42	Log Vane					
S43	Log Vane					
S44	Log Vane					
S45	Log Vane					
S46	Log Vane					
S47	Log Vane					
S48	Log Vane					

NOTE:
LOCATION AND QUANTITIES OF LOGS ON UT1A & UT1B
WILL BE DETERMINED IN THE FIELD BY THE ENGINEER.

Preliminary Plans - Not For Construction

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Underwood Mitigation Site
Chatham County, NC

Structure Tables

Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

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STRUCTURE TABLES

Sheet

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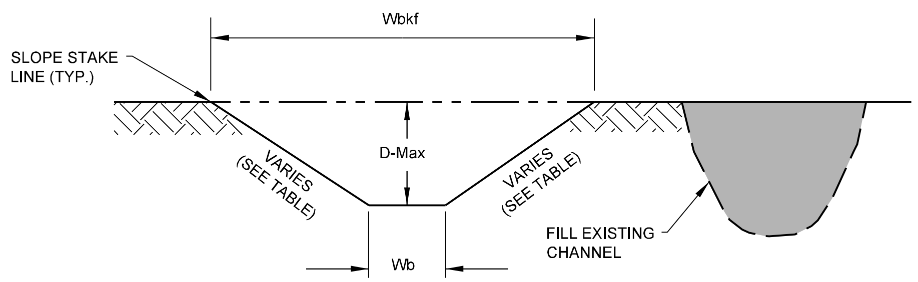
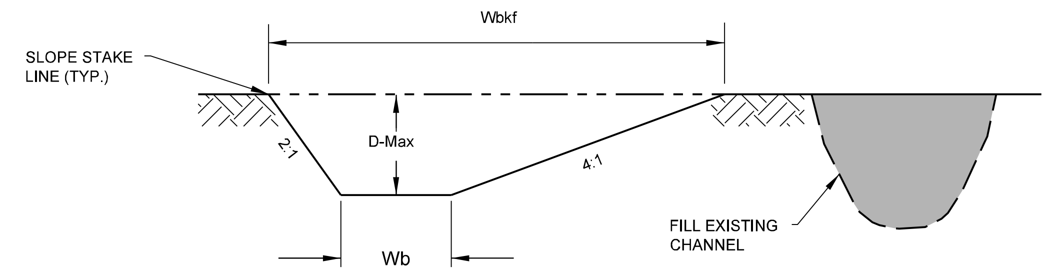
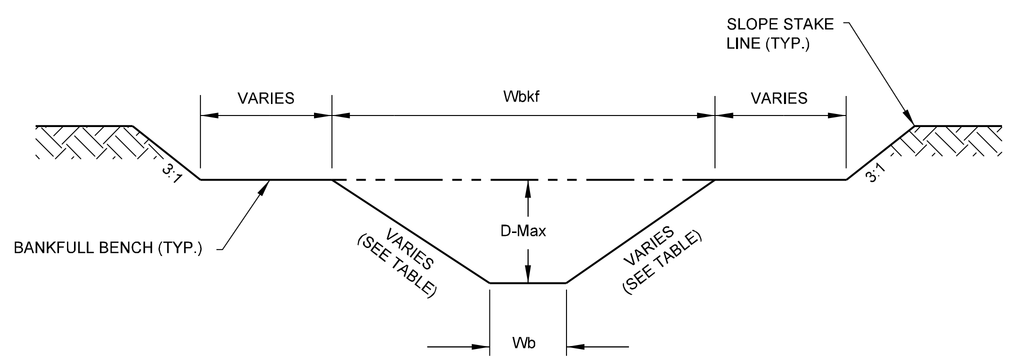


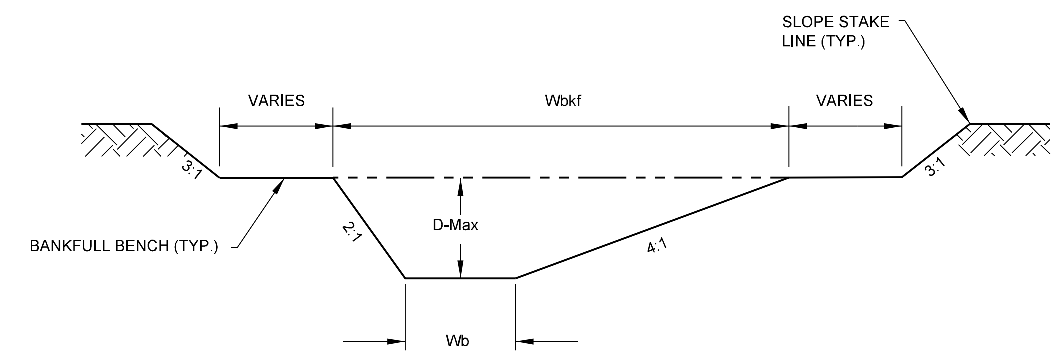
RIFFLE WITHOUT BANKFULL BENCH



POOL WITHOUT BANKFULL BENCH



RIFFLE WITH BANKFULL BENCH



POOL WITH BANKFULL BENCH

NOTES:

1. DURING CONSTRUCTION CORNERS OF DESIGN CHANNEL WILL BE ROUNDED AND A THALWEG WILL BE SHAPED PER DIRECTION OF ENGINEER.
2. POOLS SHOWN ABOVE ARE LEFT POOLS ONLY.
3. SEE PLANS FOR BANKFULL BENCH LIMITS.
4. ENHANCEMENT REACHES WILL UTILIZE STRUCTURES TO ADJUST GRADE AND CREATE STREAMBED FEATURES BUT ARE NOT DESIGNED TO SPECIFIC DESIGN PARAMETERS.

DESIGN PARAMETER	SF 1		SF 1A		SF 3		UT 1		SF 4		SF 4A	
	RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL
BANKFULL AREA (Abkf)	6.5 ft^2	11.4 ft^2	3.3 ft^2	5.7 ft^2	27.5 ft^2	48.0 ft^2	9.6 ft^2	16.7 ft^2	53.0 ft^2	101.4 ft^2	18.0 ft^2	31.5 ft^2
BANKFULL WIDTH (Wbkf)	8.8'	11.9'	6.2'	8.4'	18.2'	24.5'	10.7'	14.5'	27.3'	36.8'	14.7'	19.9'
MAXIMUM DEPTH (D-Max)	1.0'	1.6'	0.7'	1.1'	2.1'	3.3'	1.3'	1.9'	2.3'	4.2'	1.7'	2.6'
WIDTH TO DEPTH RATIO (Wbkf/D)	12.0	12.5	12.0	12.5	12.0	12.5	12.0	12.5	14.0	13.3	12.0	12.5
BOTTOM WIDTH (Wb)	3.2'	2.4'	2.2'	1.7'	5.4'	5.0'	4.5'	2.9'	13.2'	11.7'	6.1'	4.0'
SIDE SLOPE (SS)	3:1	—	2.5:1	—	3:1	—	2.5:1	—	3:1	—	2.5:1	—

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Typical Sections

Date: August 31, 2011
Job Number: 005-02125
Project Engineer: NMM
Drawn By: JTL
Checked By: JWH

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TYPICAL SECTIONS

Sheet
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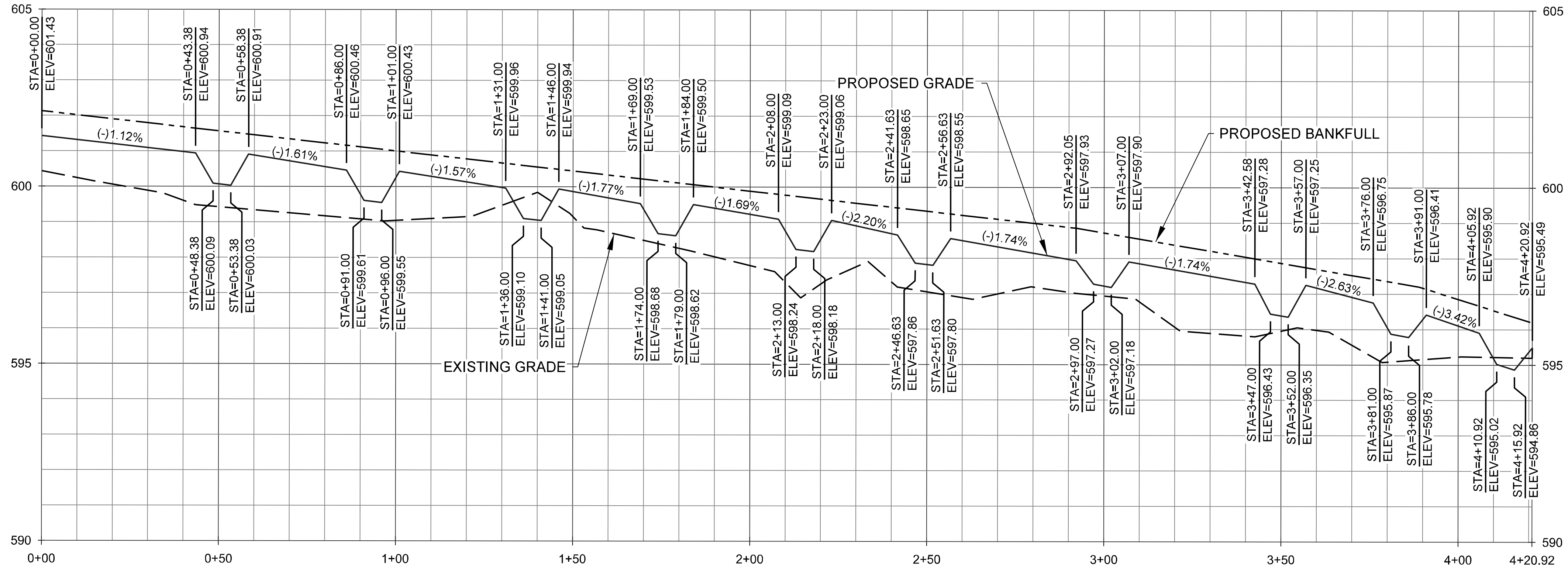

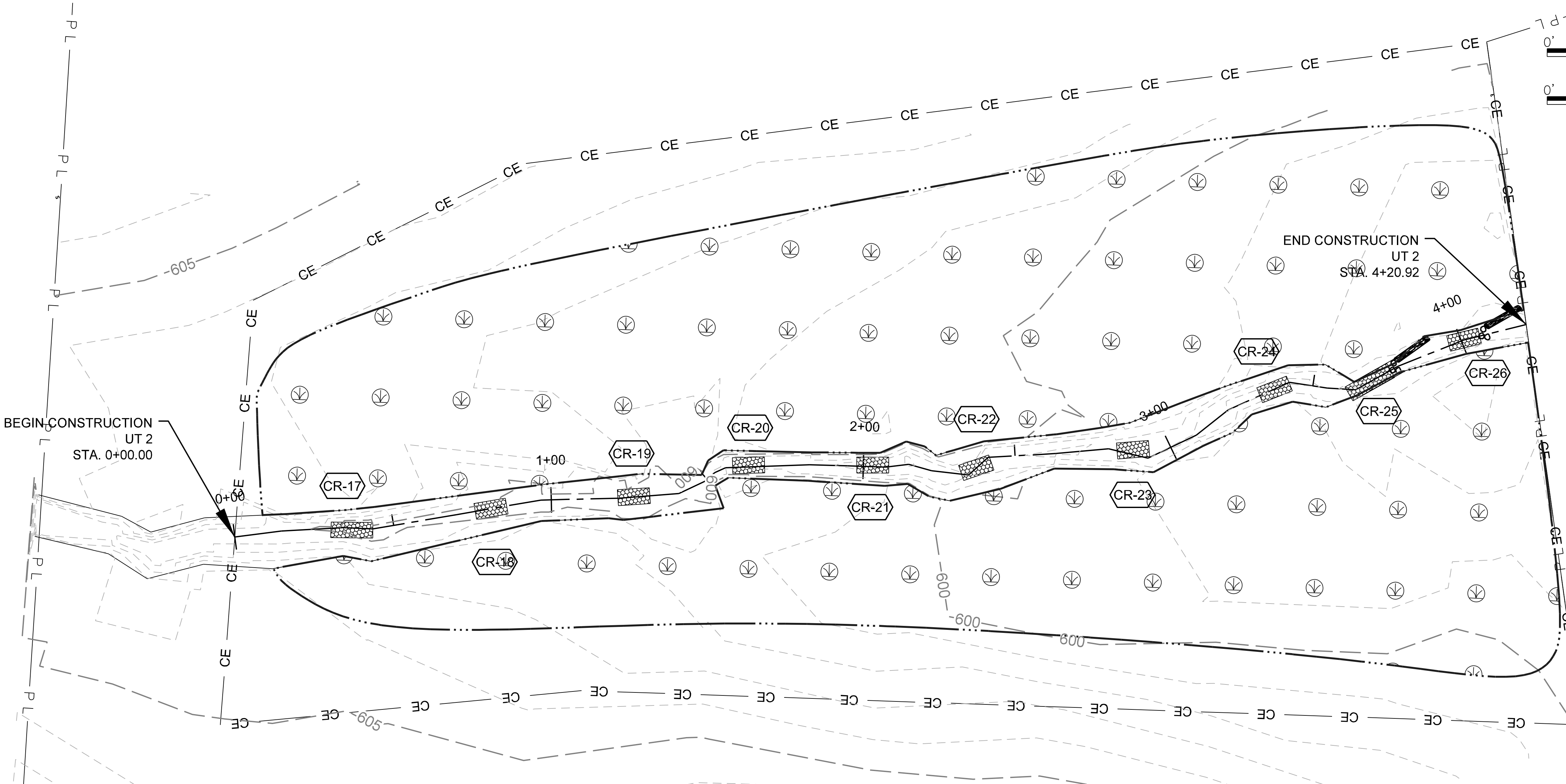

Constructed Riffle Table	
UT 2	
Structure Number	Type
CR-17	B
CR-18	A
CR-19	B
CR-20	A
CR-21	A
CR-22	A
CR-23	B
CR-24	A
CR-25	C
CR-26	C

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Underwood Mitigation Site
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UT 2
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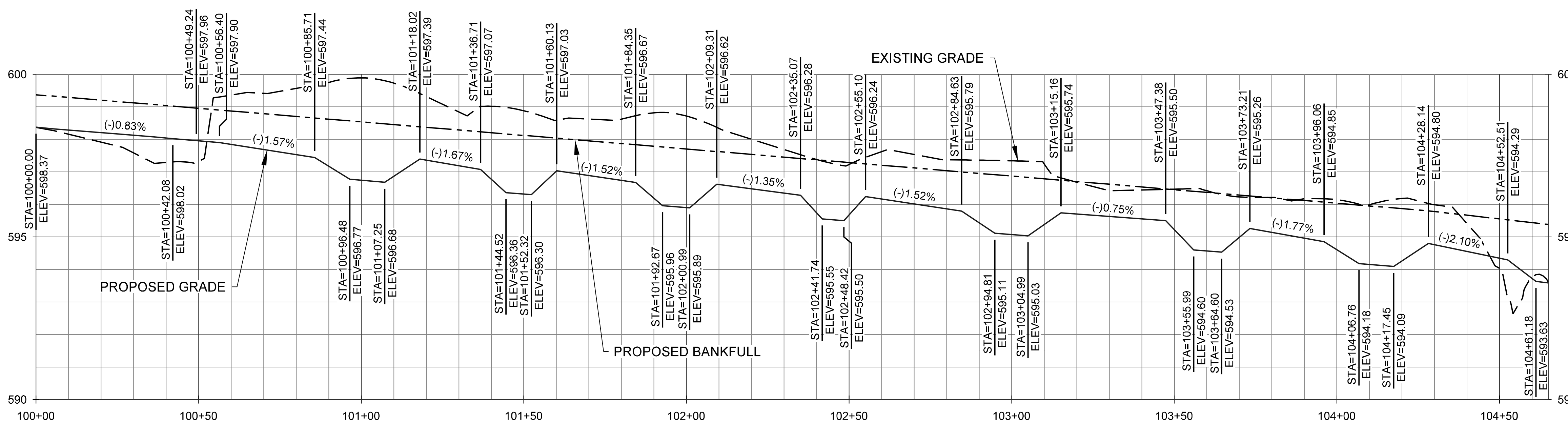
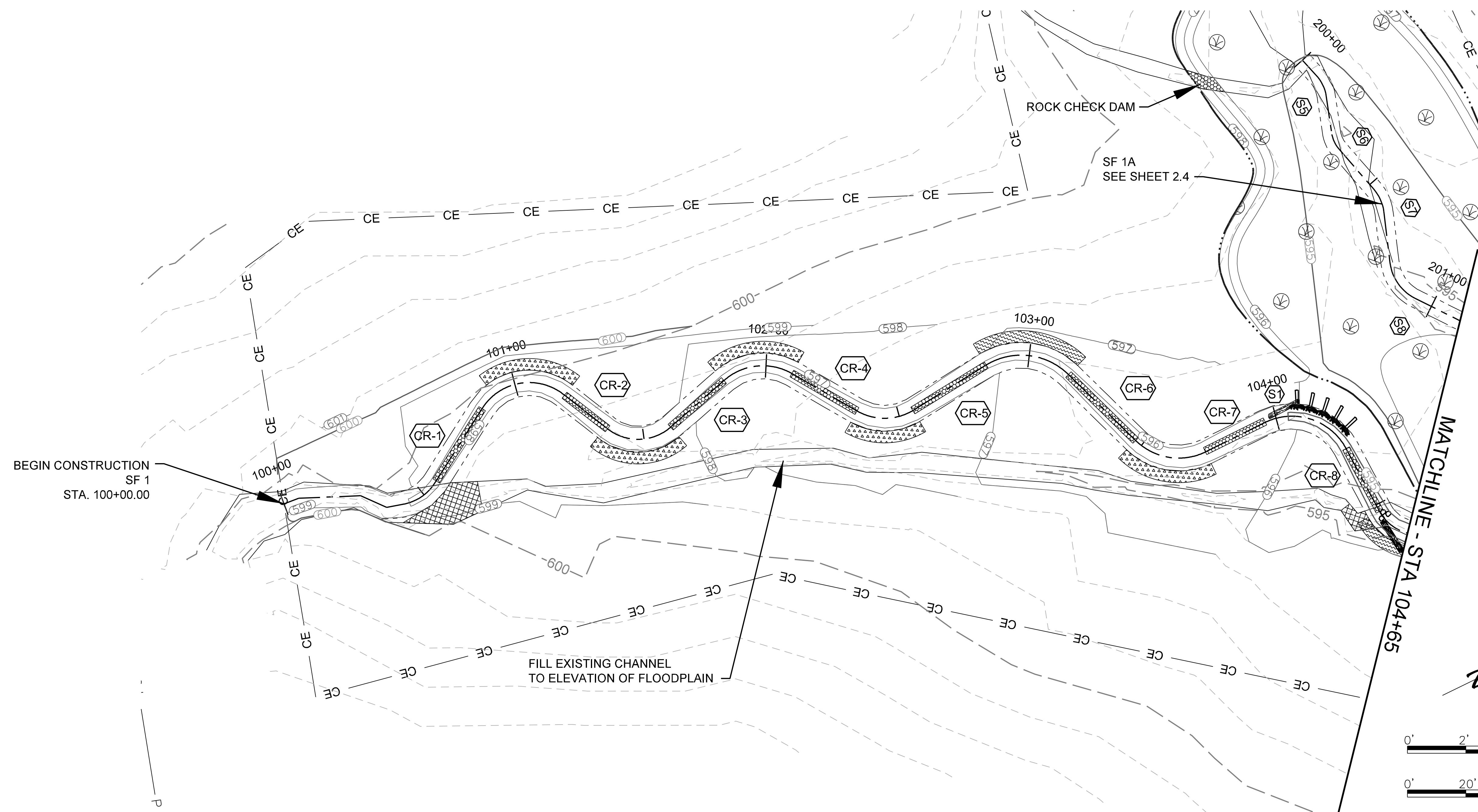
PLAN AND PROFILE

Sheet

2.1





Constructed Riffle Table	
SF 1	
Structure Number	Type
CR-1	B
CR-2	A
CR-3	A
CR-4	A
CR-5	A
CR-6	D
CR-7	A
CR-8	C

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SF 1
Plan and Profile

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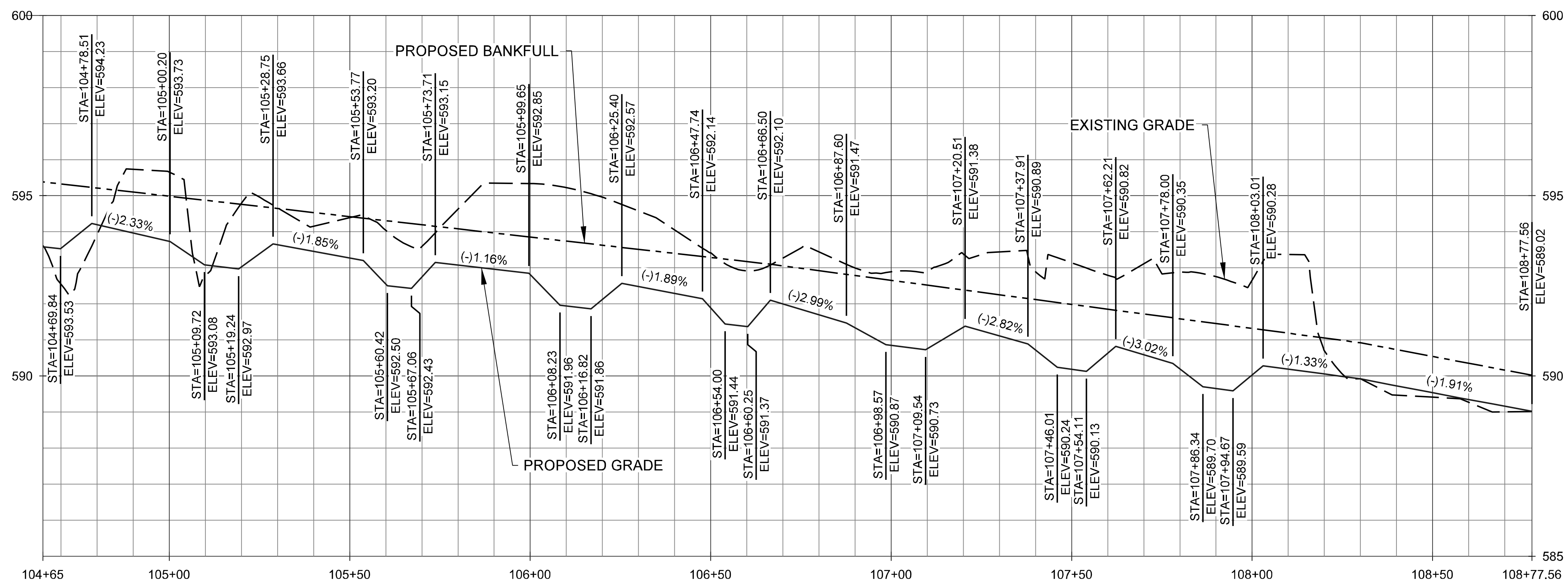
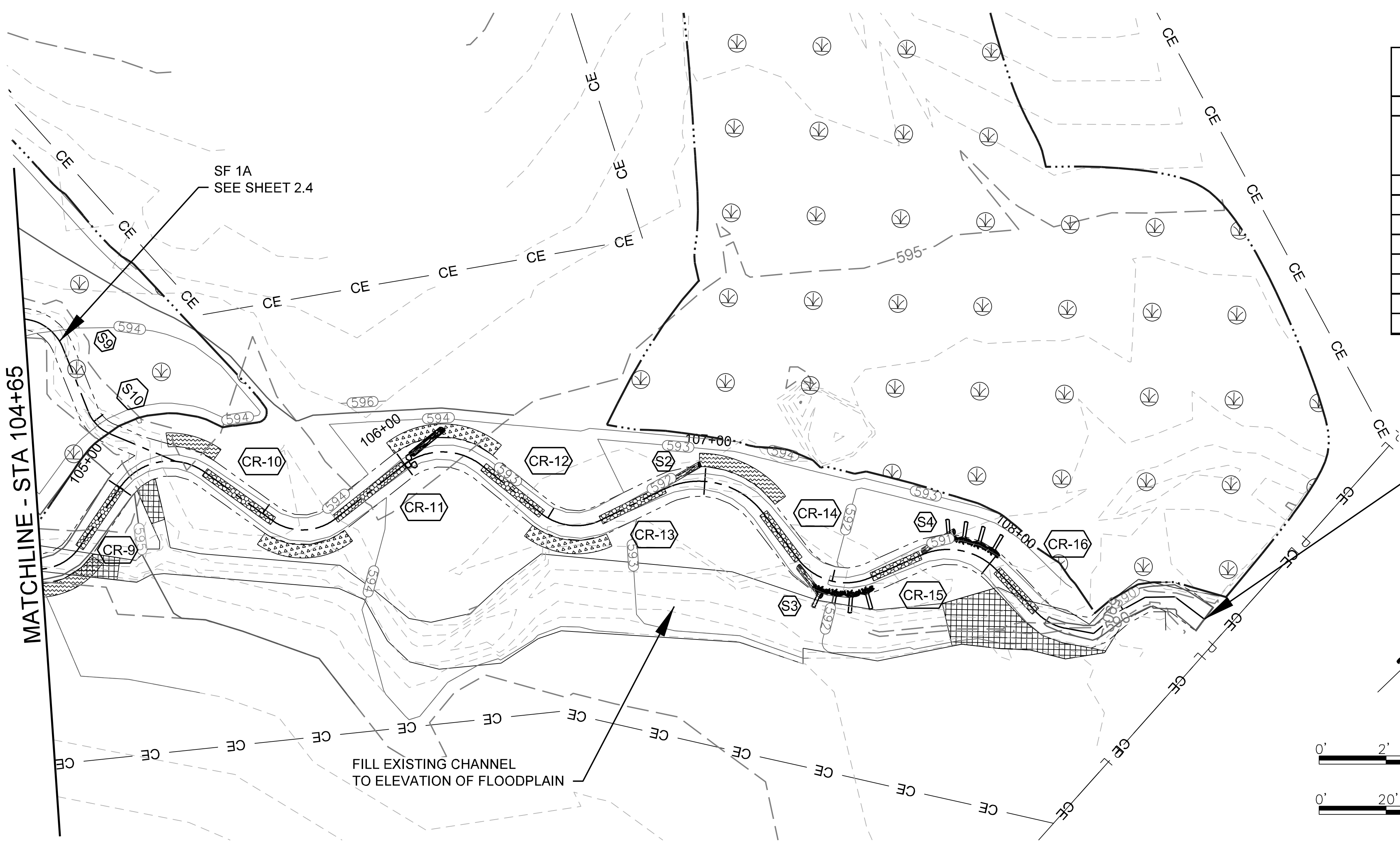
PLAN AND PROFILE

Sheet
2.2





Constructed Riffle Table	
SF 1	
Structure Number	Type
CR-9	B
CR-10	A
CR-11	C
CR-12	A
CR-13	A
CR-14	B
CR-15	A
CR-16	B

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SF 1
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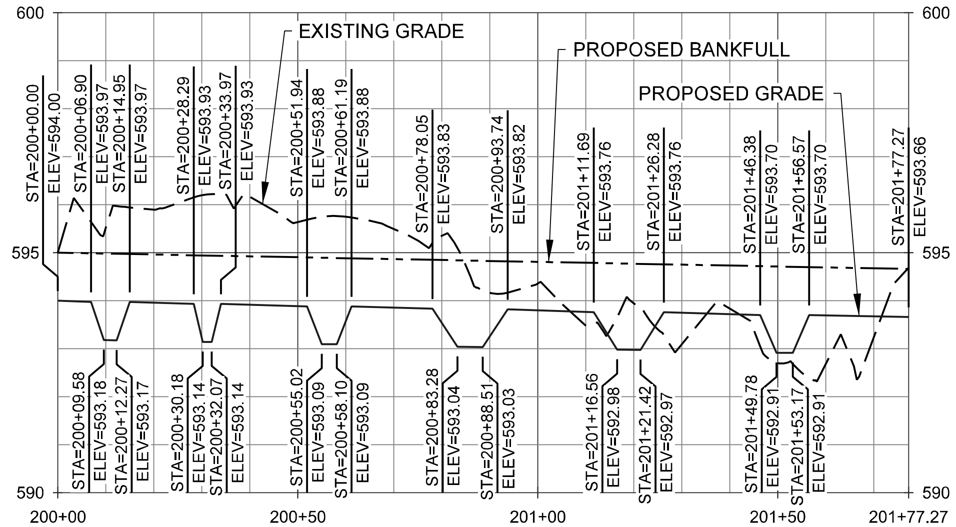
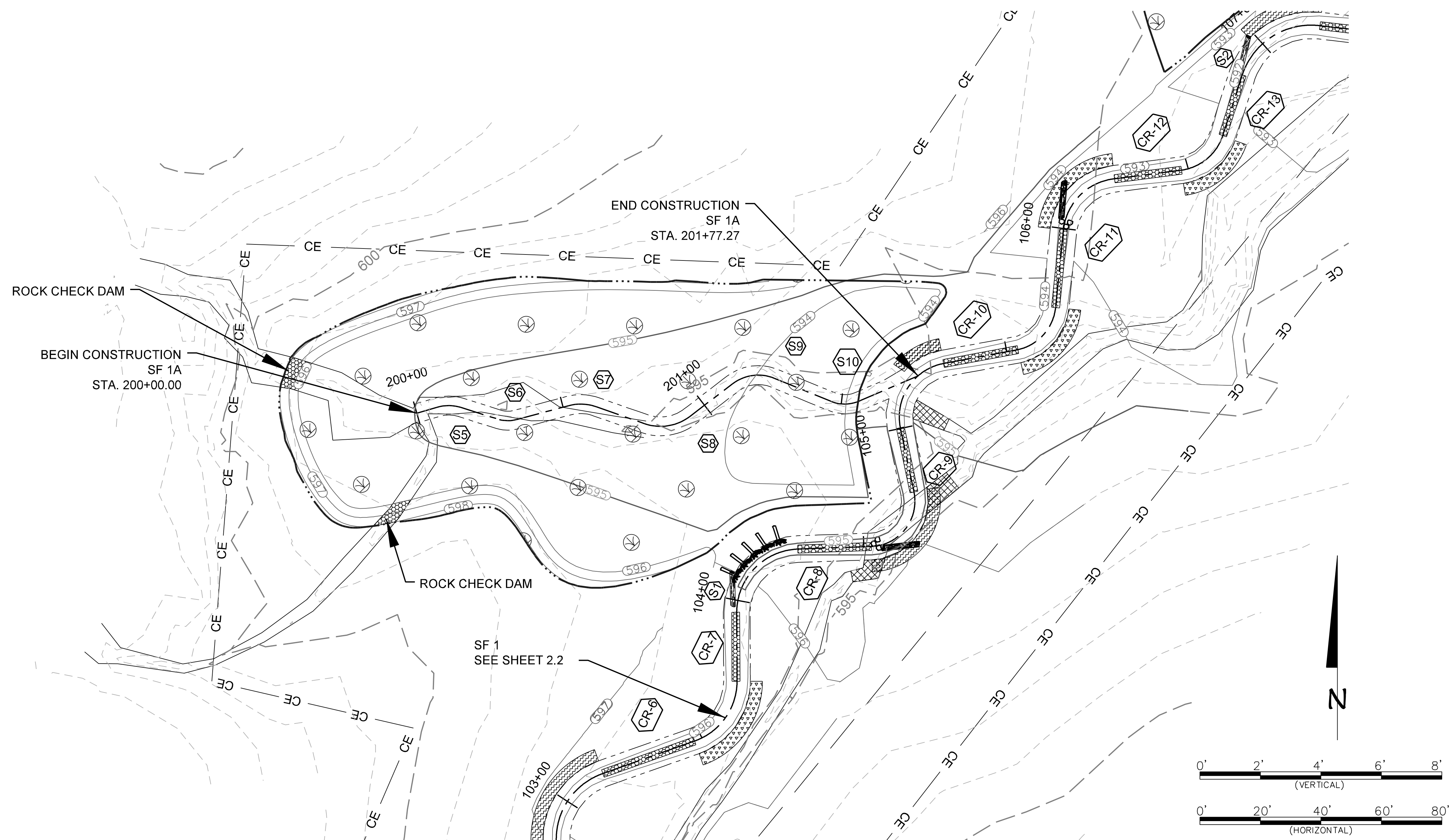
2.3





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Underwood Mitigation Site
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SF 1A
Plan and Profile

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PLAN AND PROFILE

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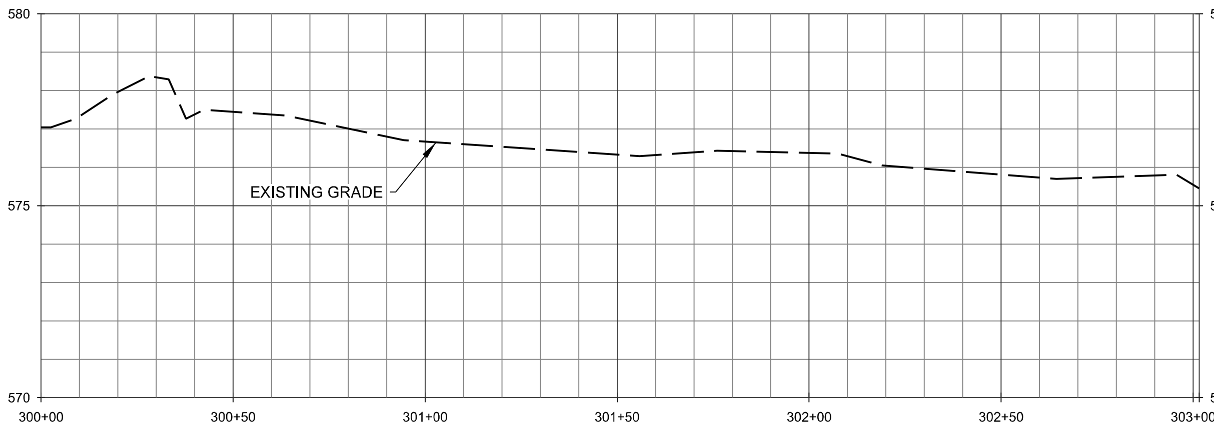

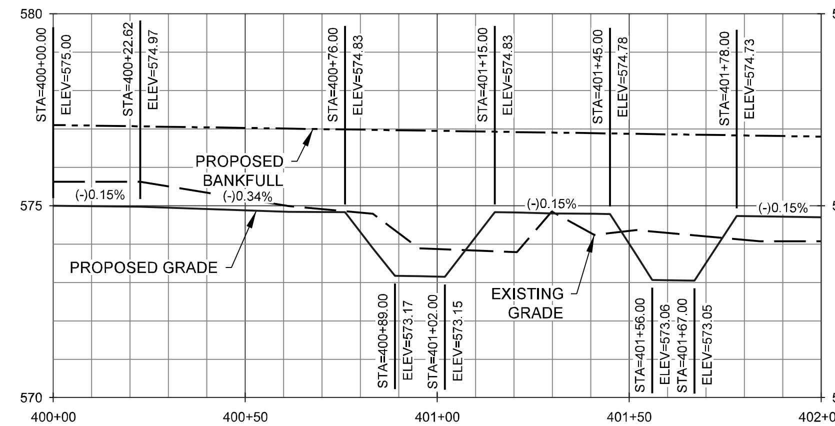

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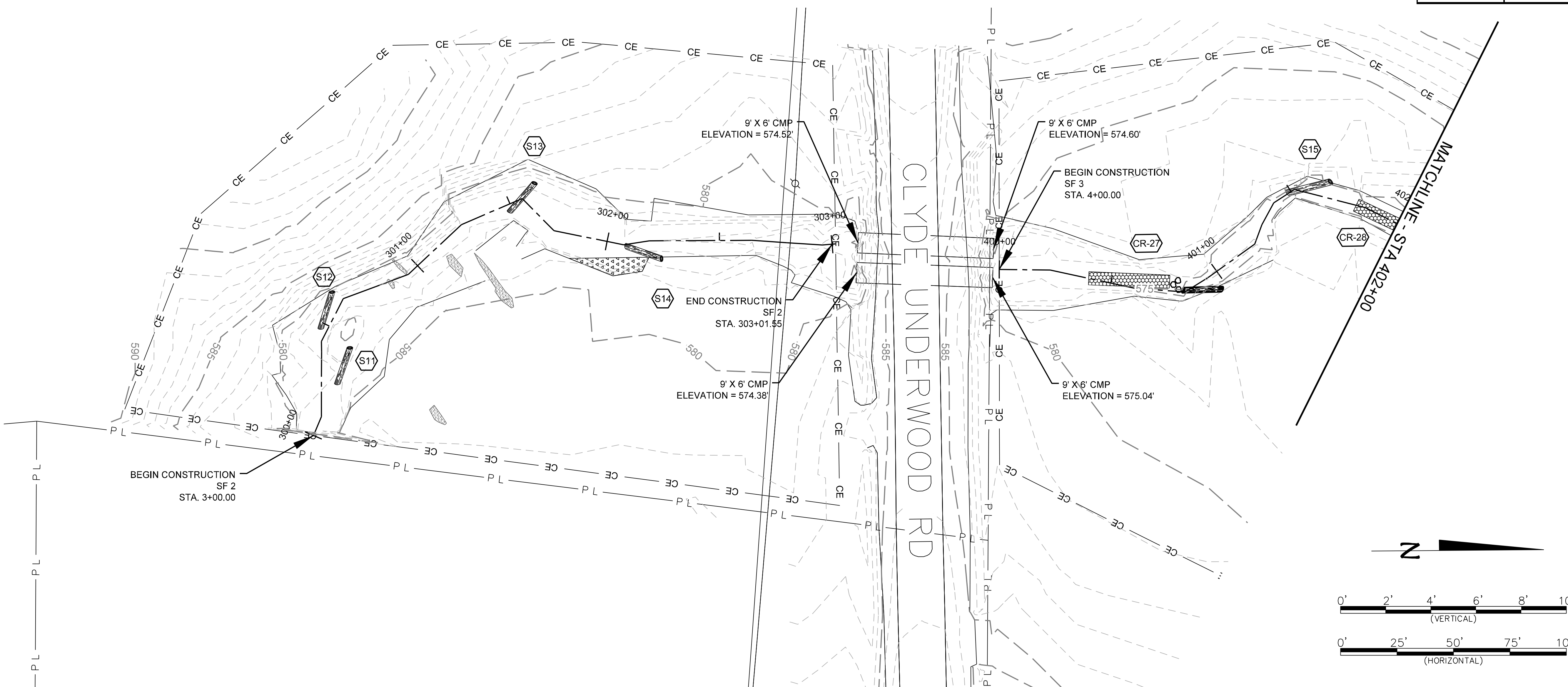
SF 3	
Structure Number	Type
CR-27	C
CR-28	A



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Underwood Mitigation Site
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SF 2 & SF 3
Plan and Profile

Date:	August 31, 2011
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PLAN AND PROFILE

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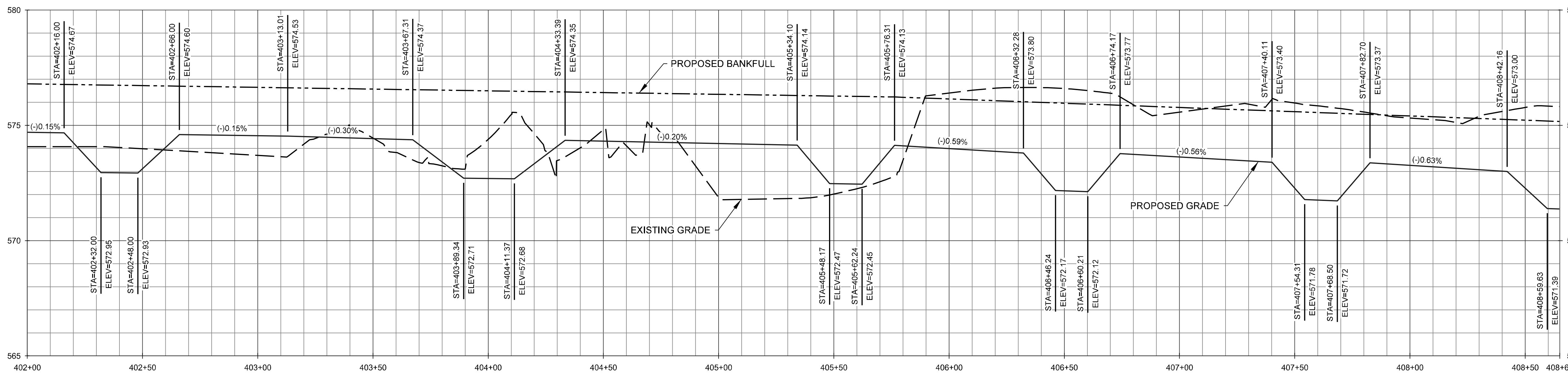

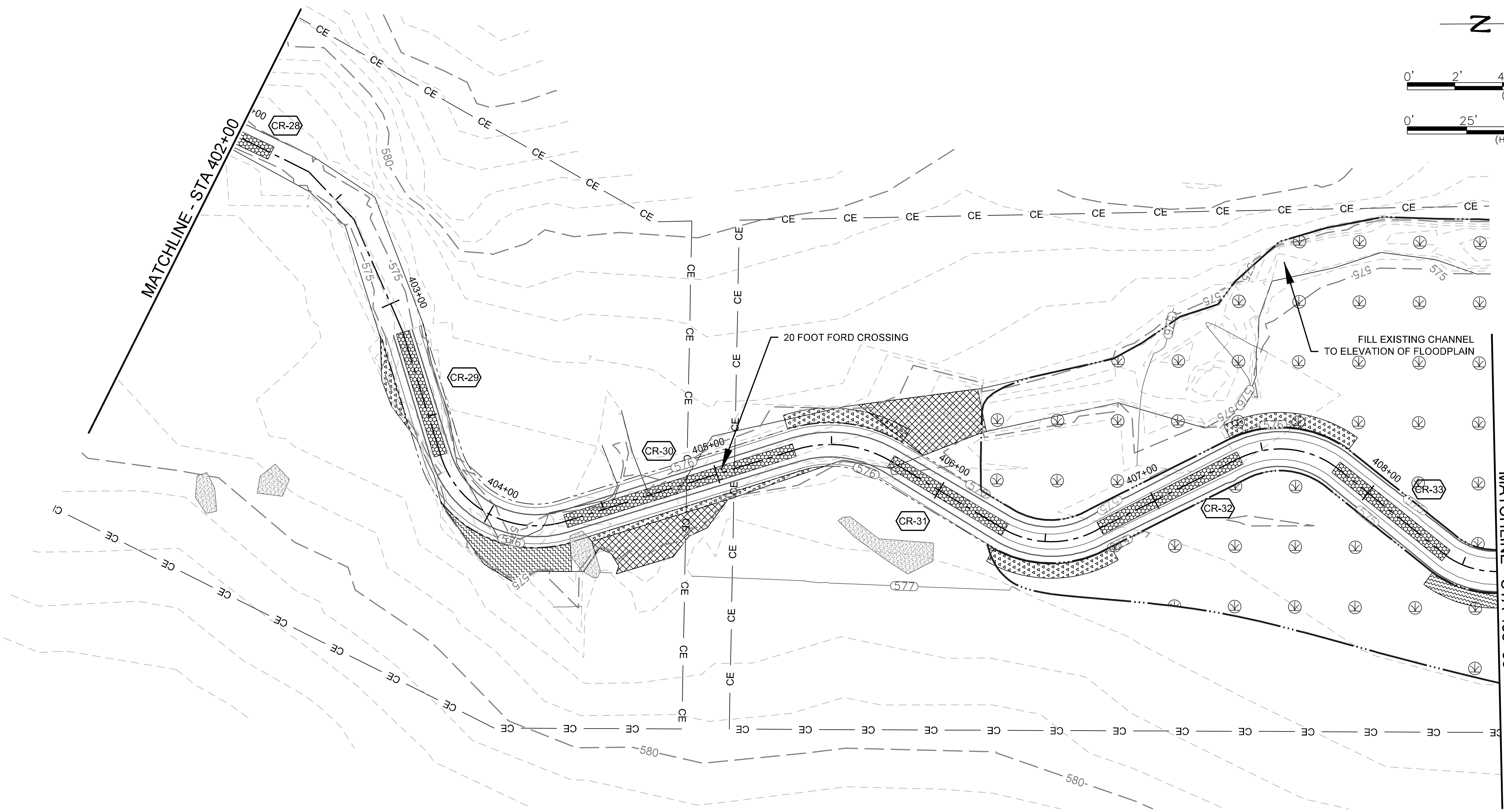

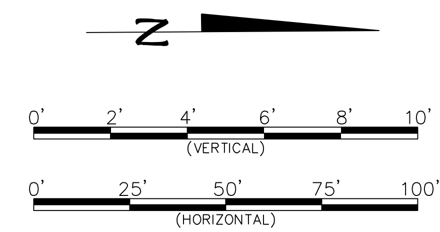

Constructed Riffle Table

SF 3

Structure Number	Type
CR-28	A
CR-29	A
CR-30	D
CR-31	A
CR-32	B
CR-33	A

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Underwood Mitigation Site
Chatham County, NC

SF 3
Plan and Profile

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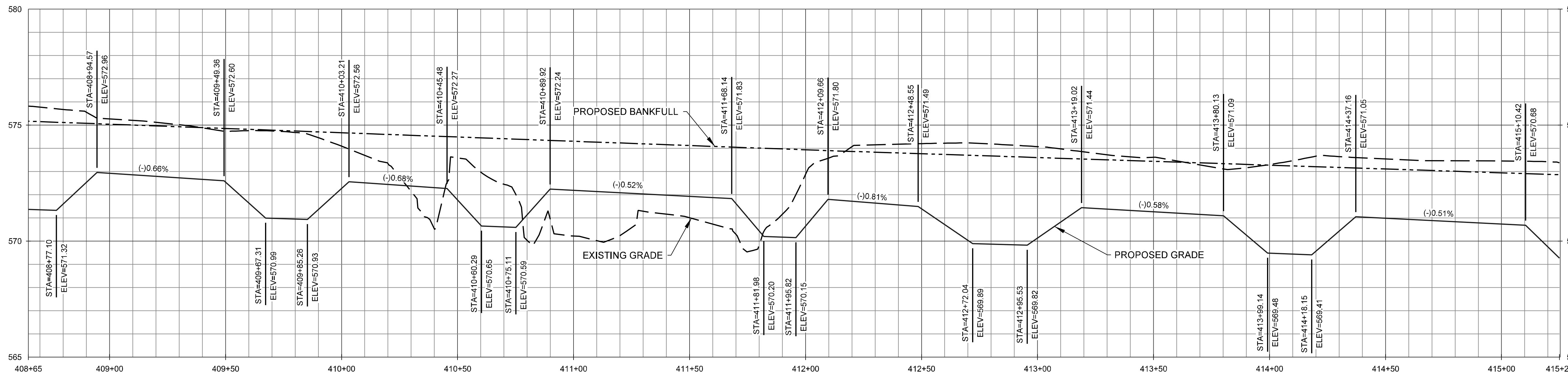
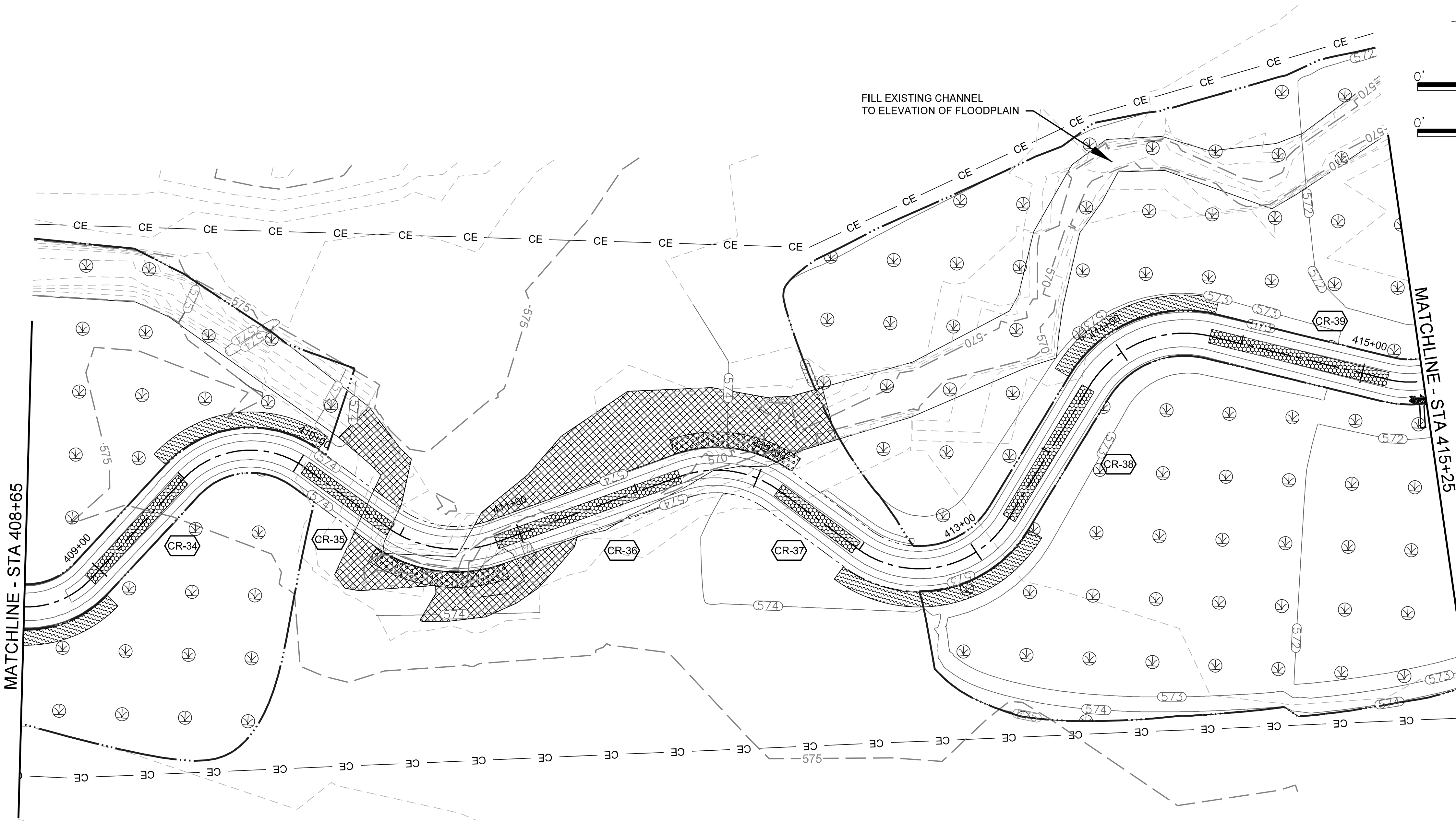
PLAN AND PROFILE

Sheet

2.6





Constructed Riffle Table	
SF 3	
Structure Number	Type
CR-34	D
CR-35	A
CR-36	D
CR-37	A
CR-38	A
CR-39	D

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Underwood Mitigation Site
Chatham County, NC

SF 3
Plan and Profile

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PLAN AND PROFILE

Sheet

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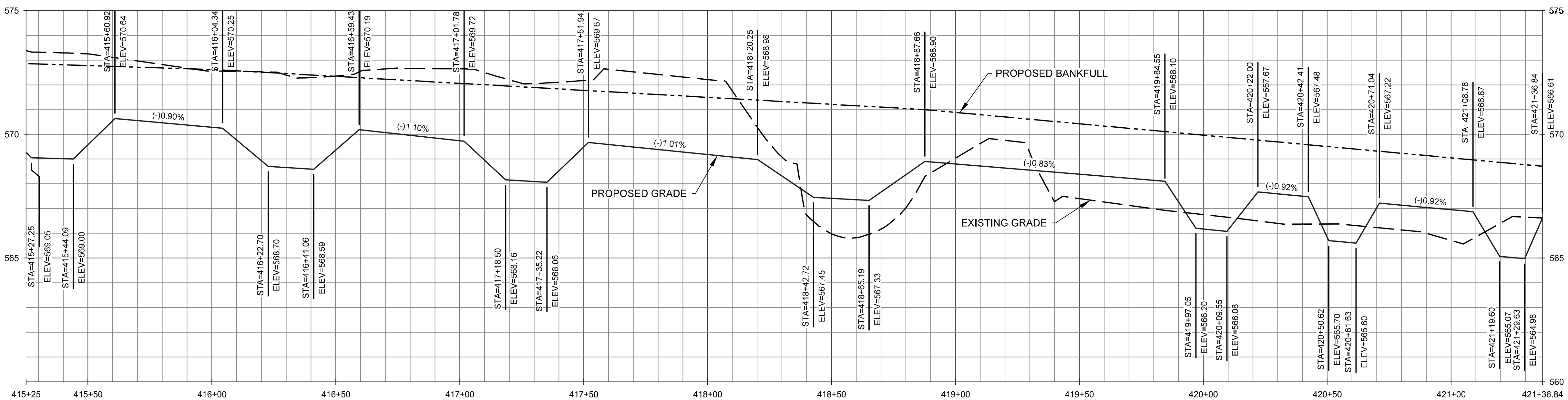

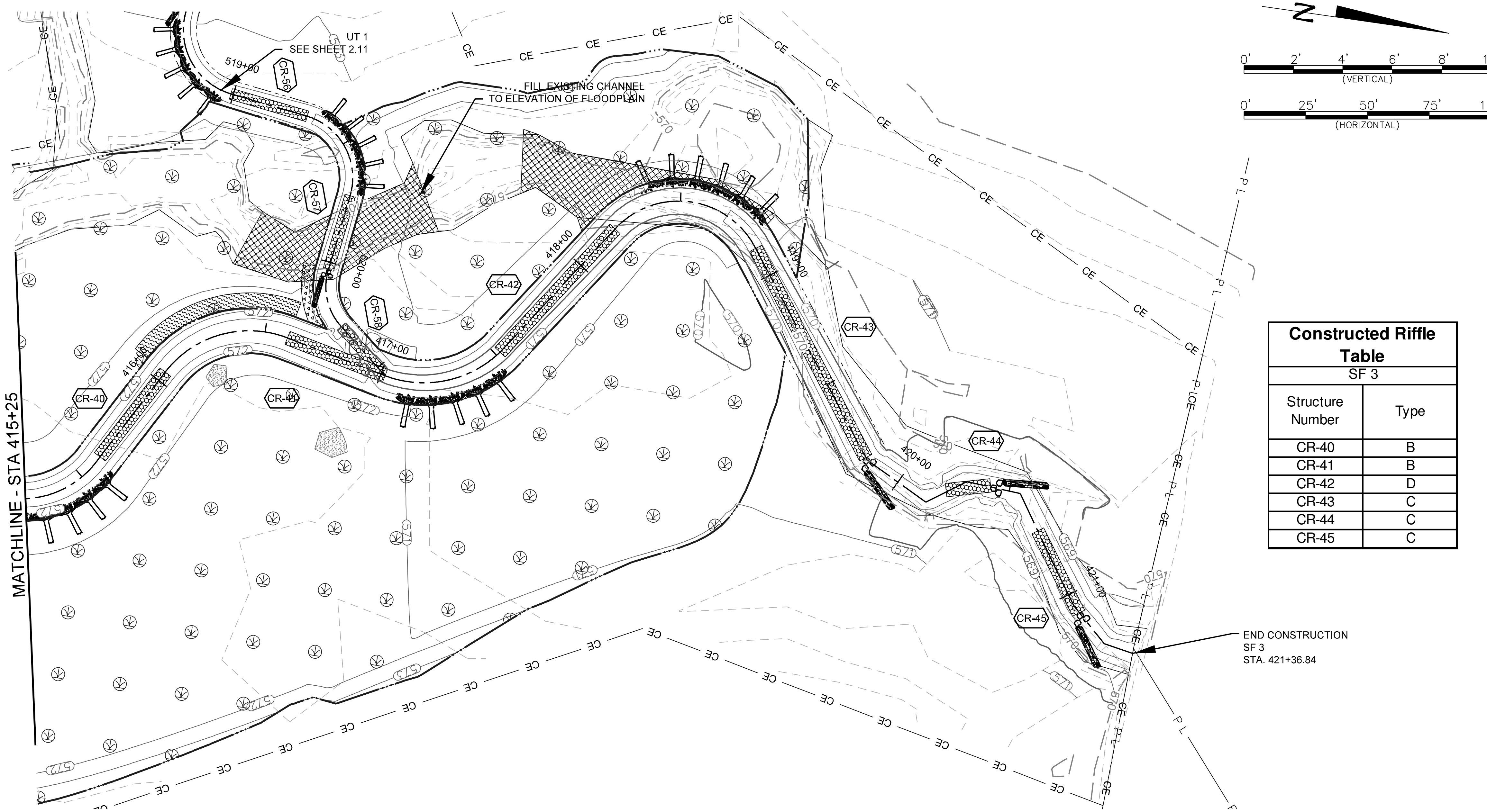

Constructed Riffle Table	
SF 3	
Structure Number	Type
CR-40	B
CR-41	B
CR-42	D
CR-43	C
CR-44	C
CR-45	C

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Underwood Mitigation Site
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SF 3
Plan and Profile

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PLAN AND PROFILE

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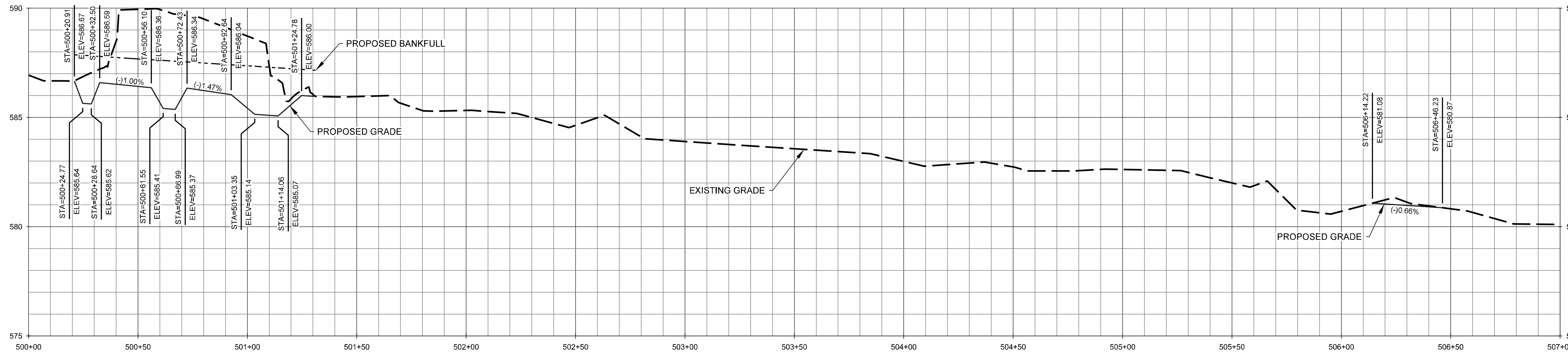
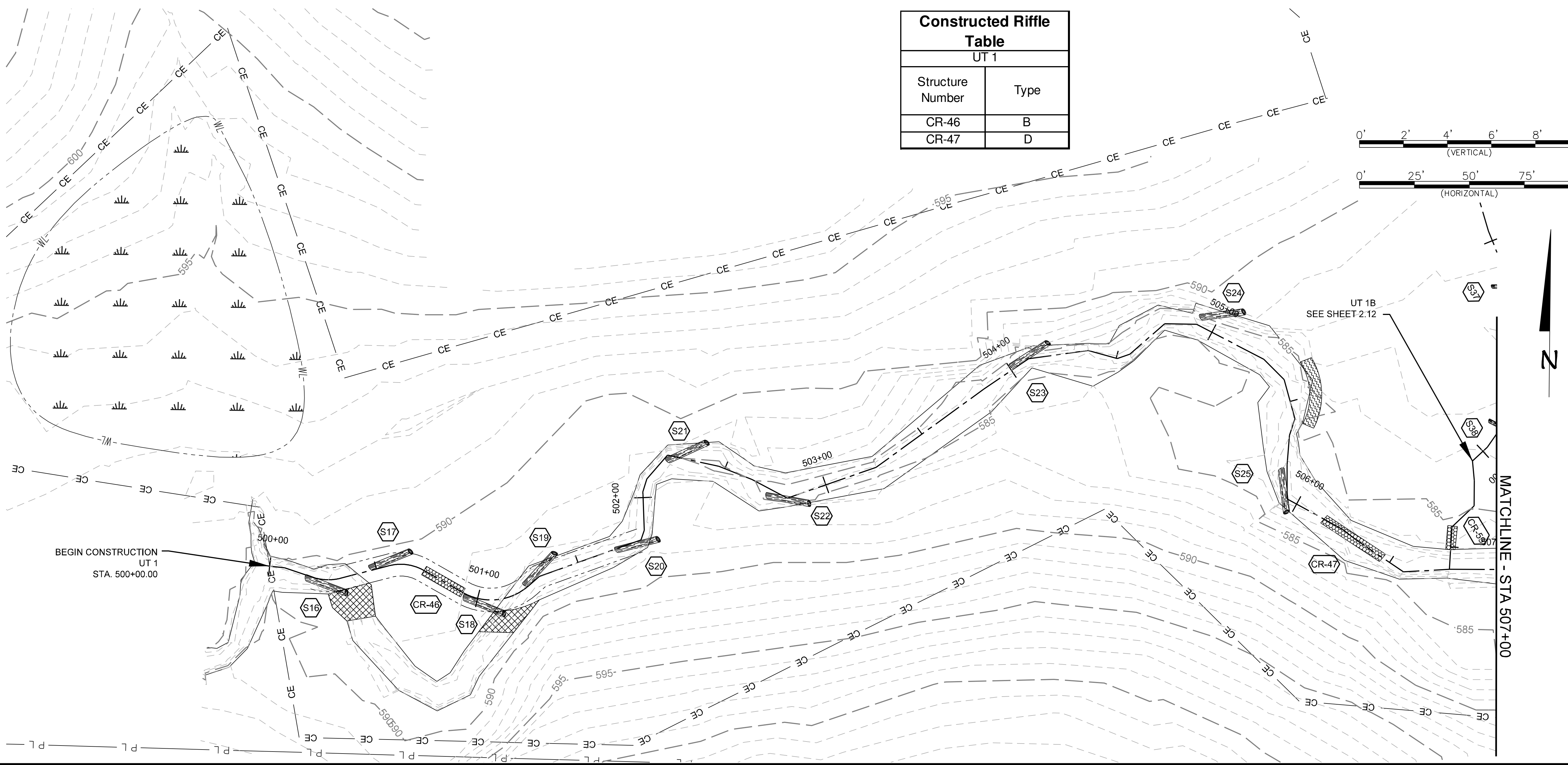


Constructed Riffle Table	
UT 1	
Structure Number	Type
CR-46	B
CR-47	D



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Underwood Mitigation Site
Chatham County, NC

UT 1
Plan and Profile

Date:	August 31, 2011
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PLAN AND PROFILE

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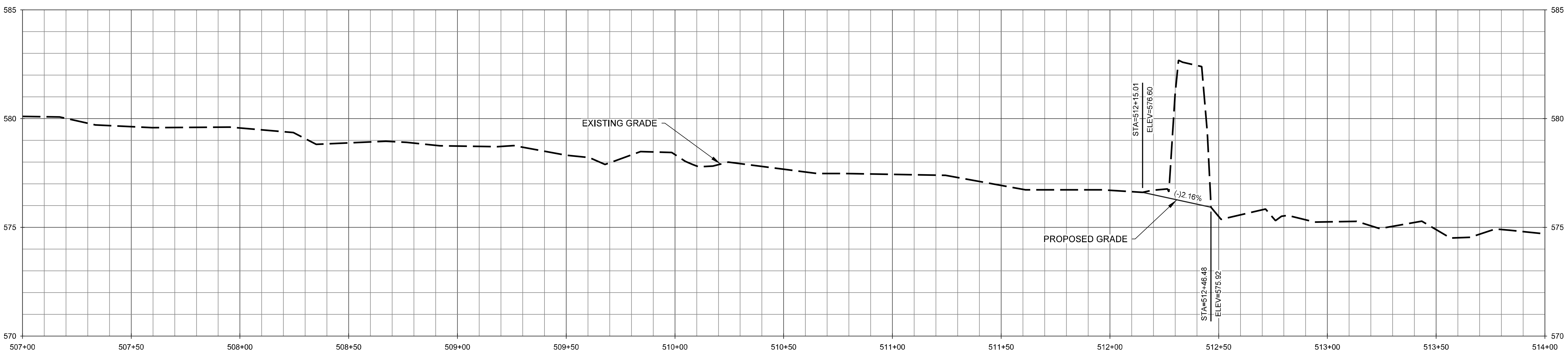

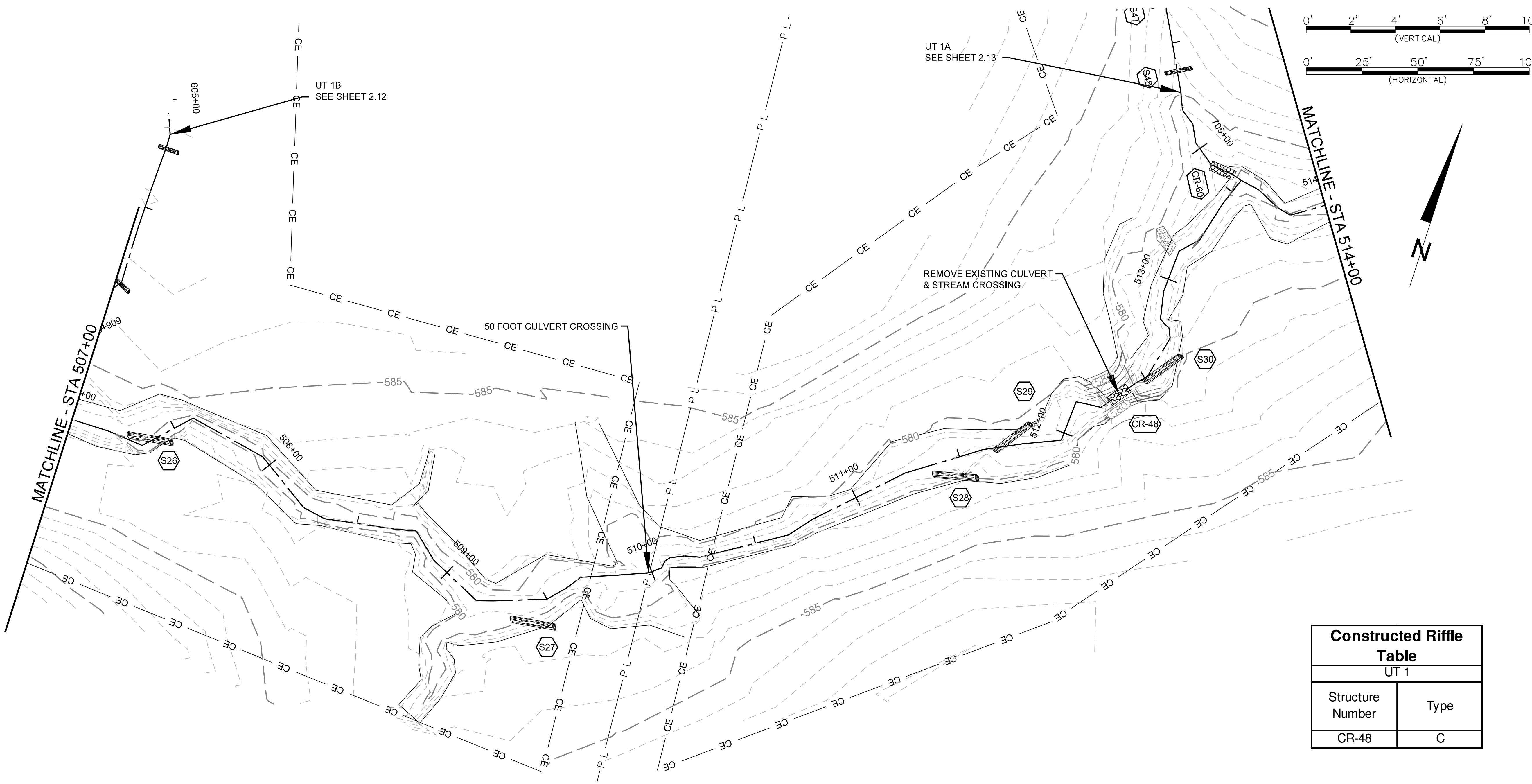

Constructed Riffle Table

UT 1	
Structure Number	Type
CR-48	C

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Underwood Mitigation Site
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UT 1
Plan and Profile

Date:	August 31, 2011
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Drawn By:	JTL
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PLAN AND PROFILE

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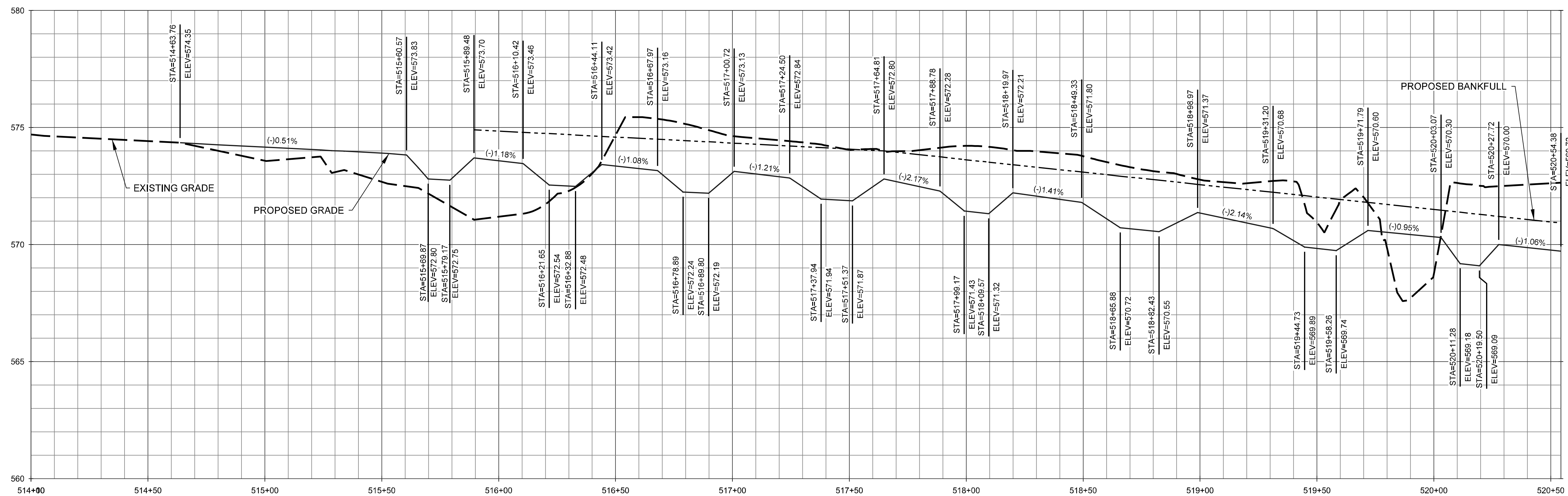
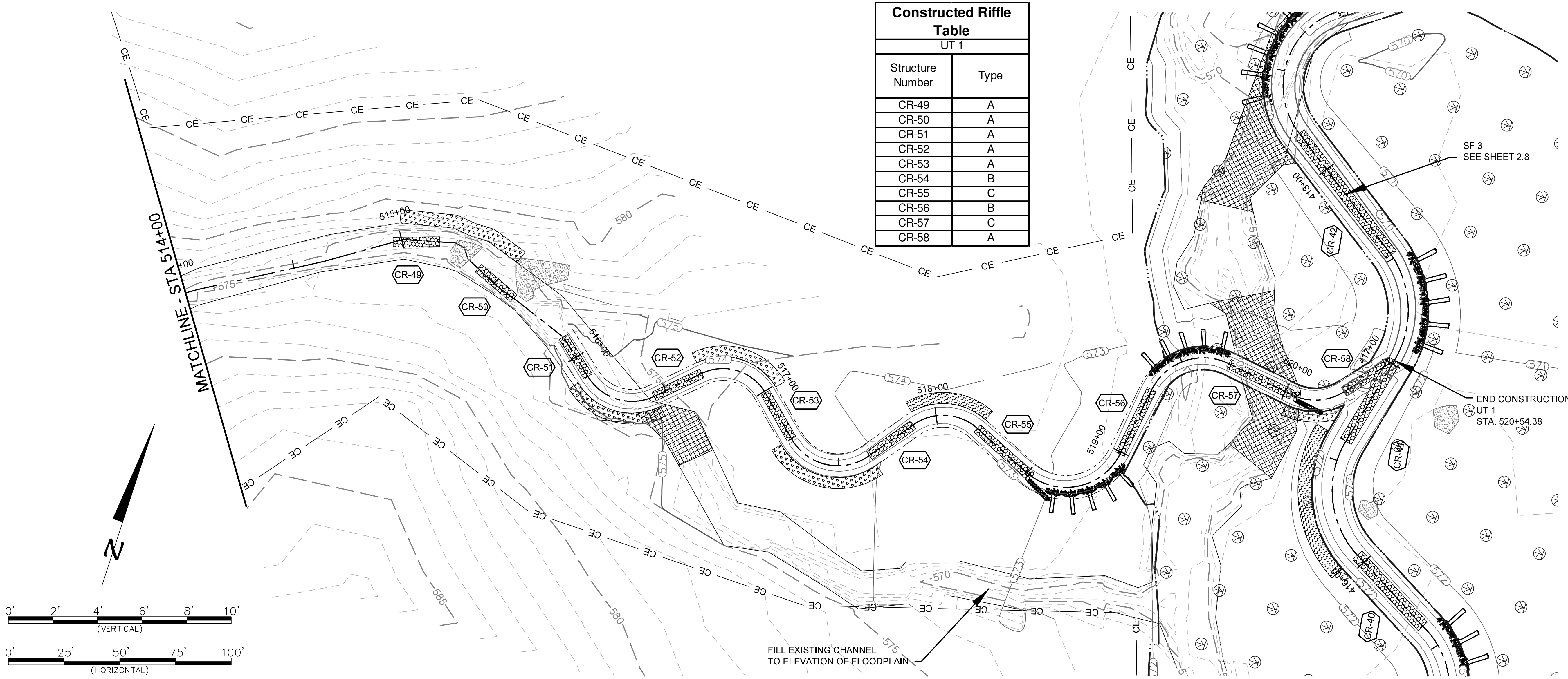


Constructed Riffle Table	
UT 1	
Structure Number	Type
CR-49	A
CR-50	A
CR-51	A
CR-52	A
CR-53	A
CR-54	B
CR-55	C
CR-56	B
CR-57	C
CR-58	A



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Underwood Mitigation Site
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UT 1
Plan and Profile

Date:	August 31, 2011
Job Number:	005-02125
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PLAN AND PROFILE

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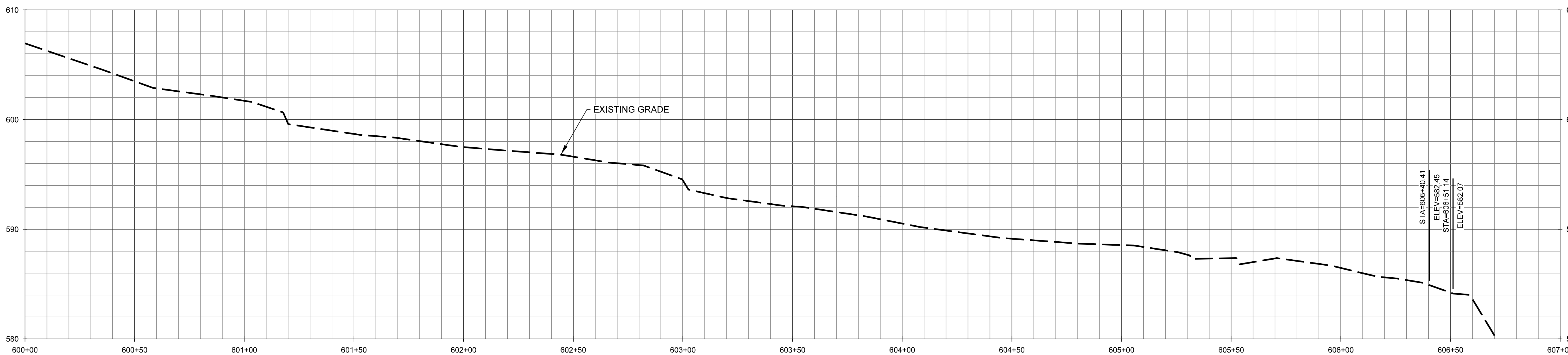
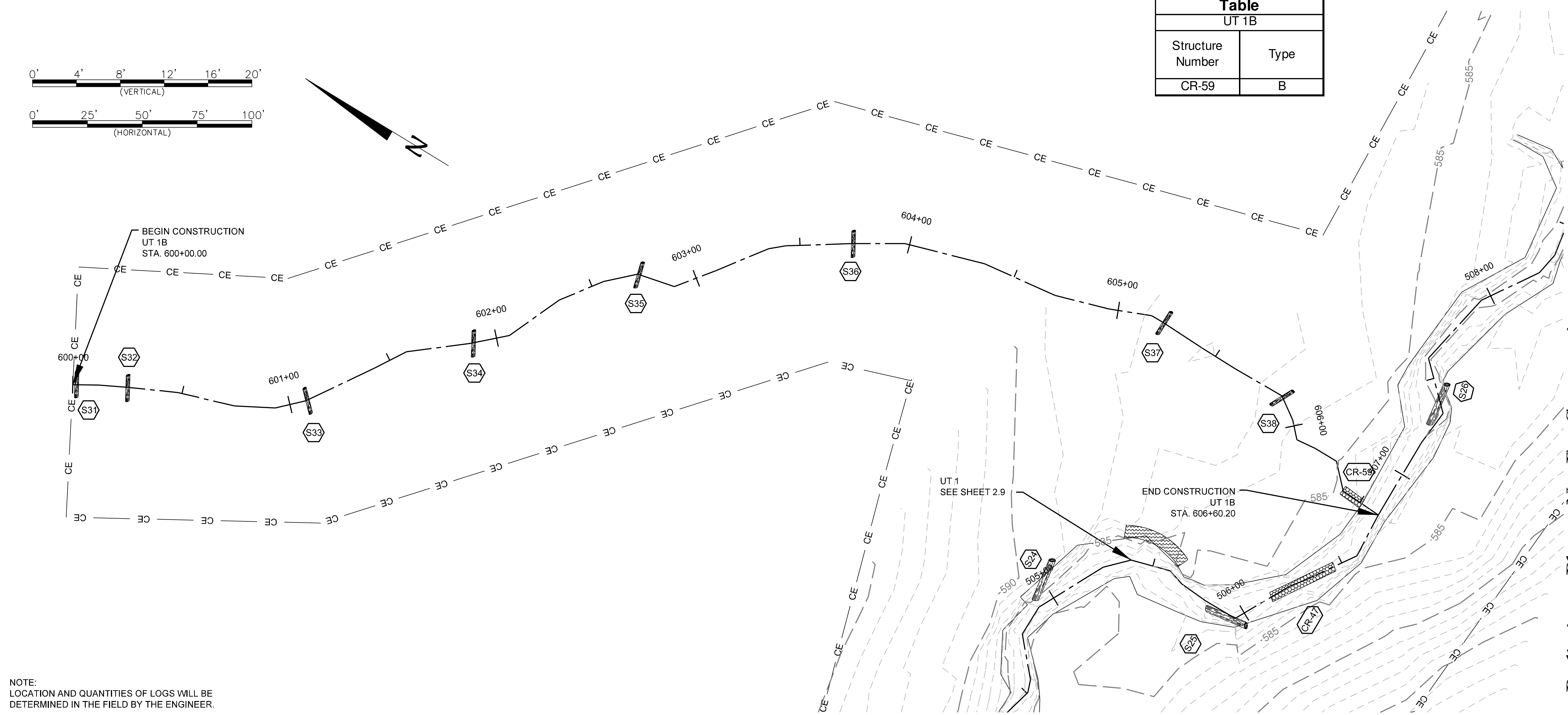
2.11



Constructed Riffle Table	
UT 1B	
Structure Number	Type
CR-59	B



NOTE:
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Underwood Mitigation Site
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UT 1B
Plan and Profile

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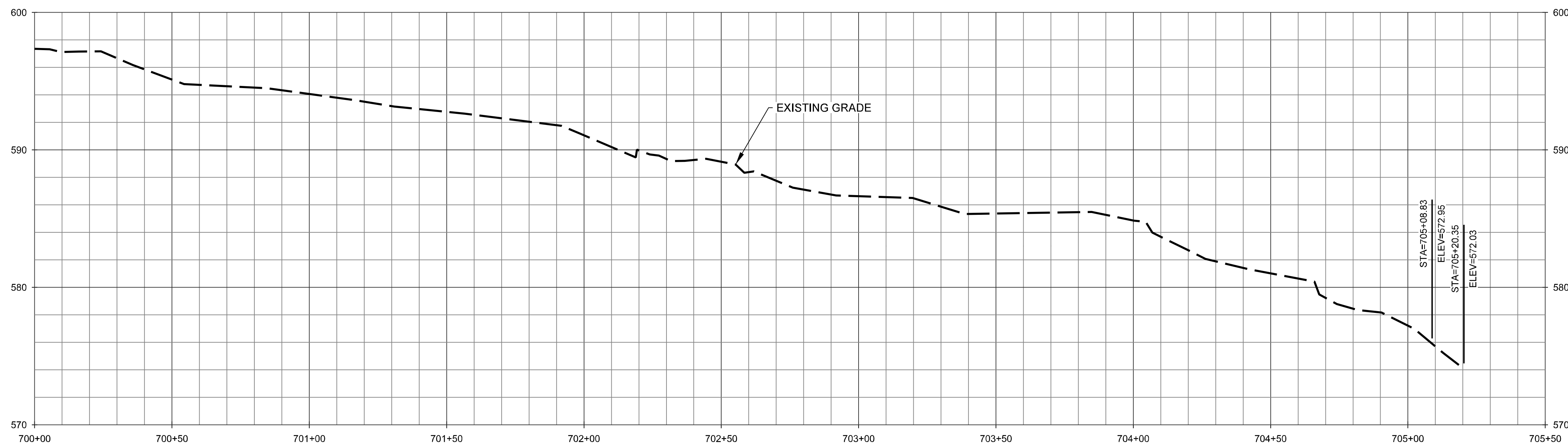
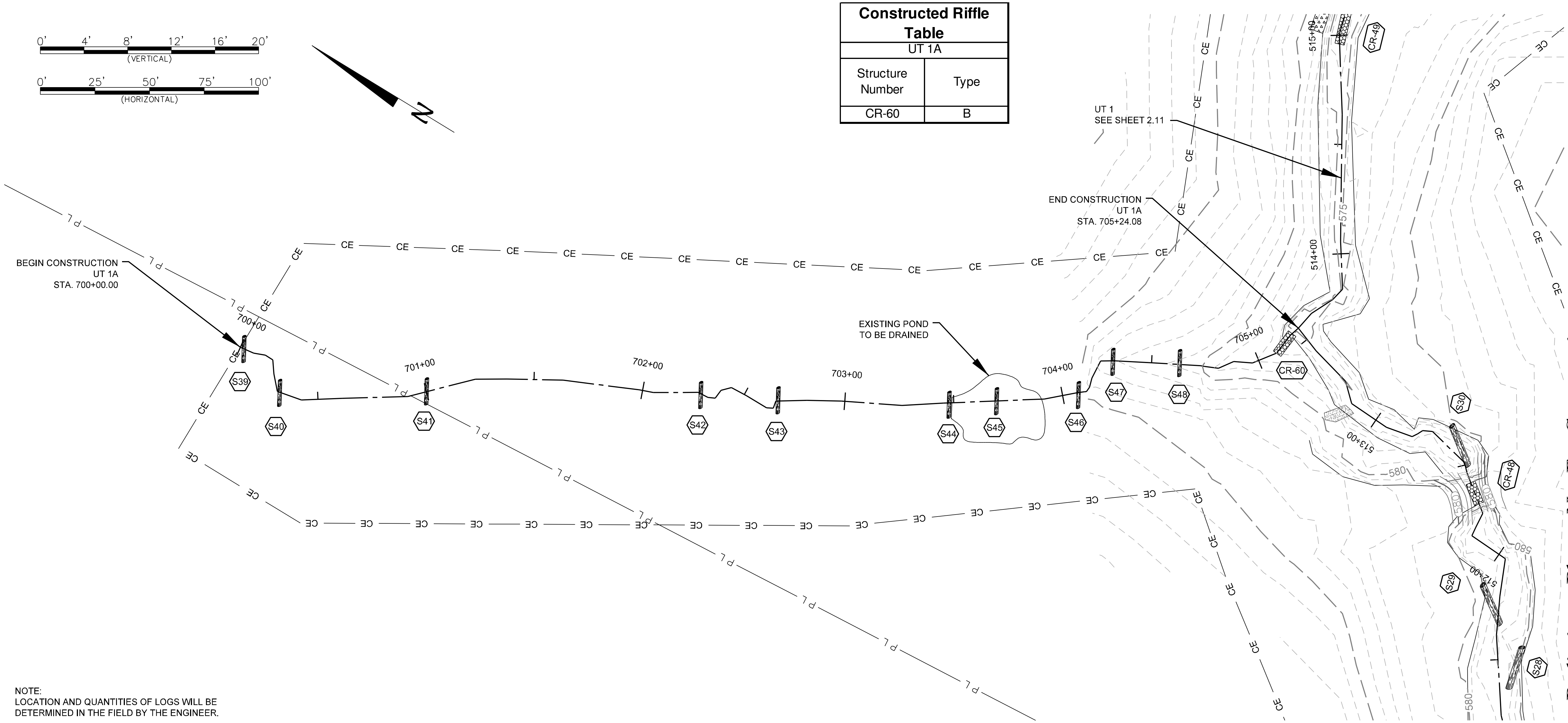
2.12



Constructed Riffle Table	
UT 1A	
Structure Number	Type
CR-60	B



NOTE:
LOCATION AND QUANTITIES OF LOGS WILL BE
DETERMINED IN THE FIELD BY THE ENGINEER.

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Underwood Mitigation Site
Chatham County, NC

UT 1A
Plan and Profile

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Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

PLAN AND
PROFILE

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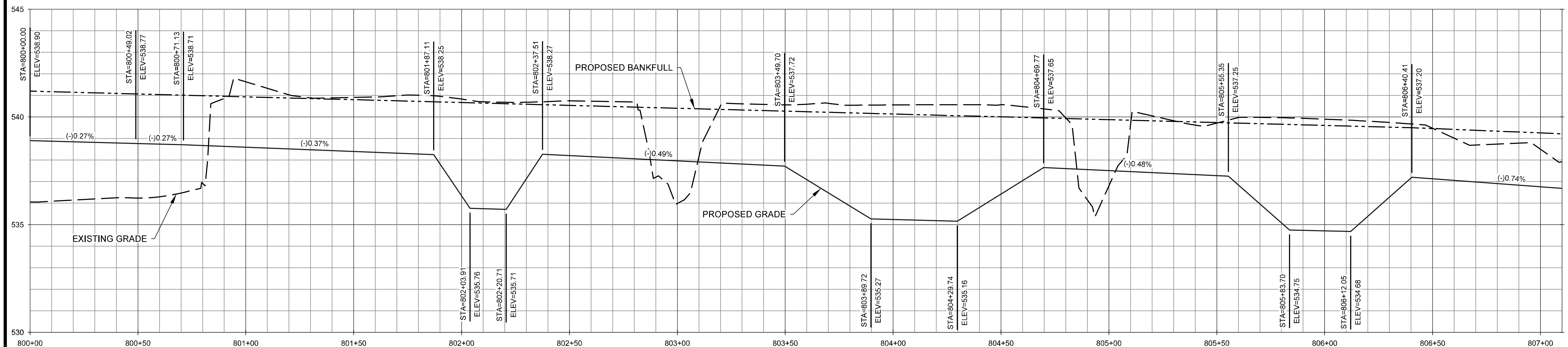
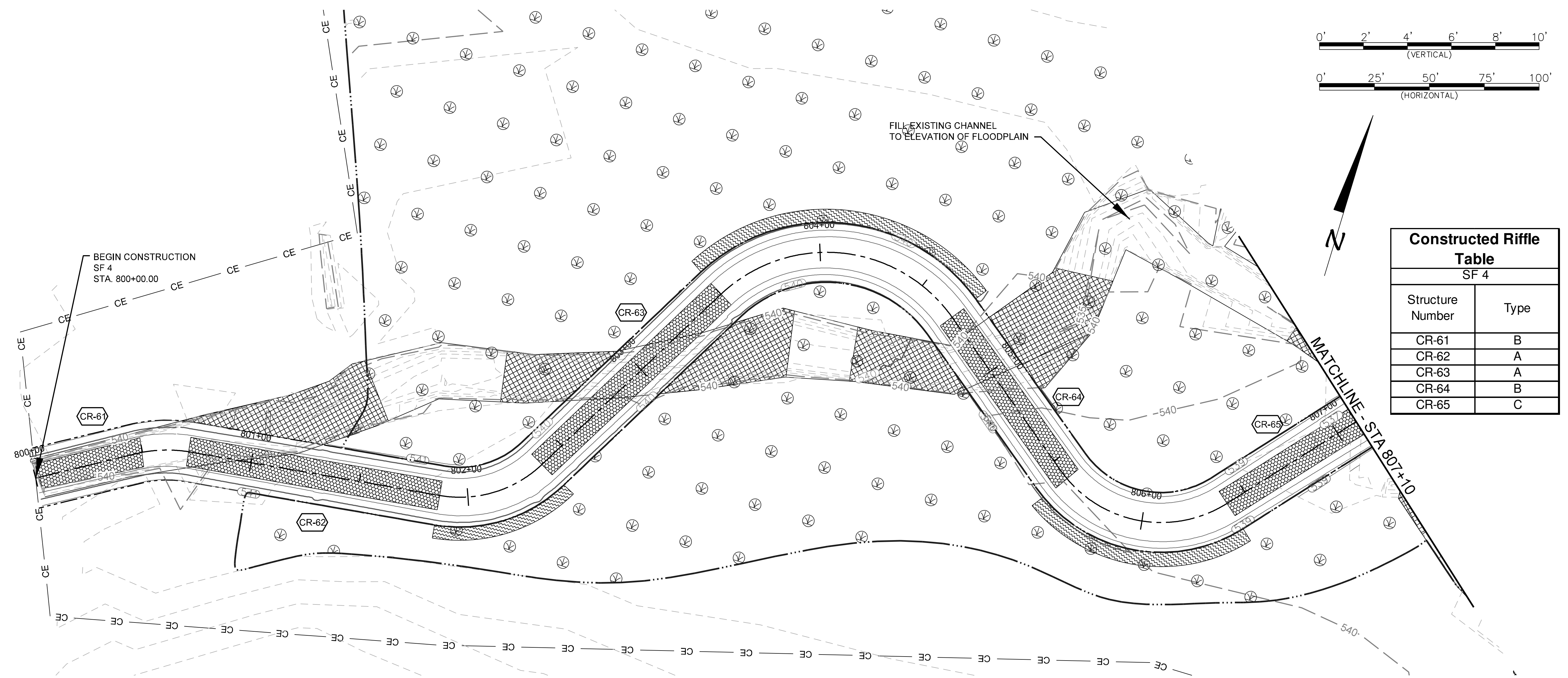
2.13





Constructed Riffle Table

SF 4

Structure Number	Type
CR-61	B
CR-62	A
CR-63	A
CR-64	B
CR-65	C

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SF 4
Plan and Profile

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PLAN AND PROFILE

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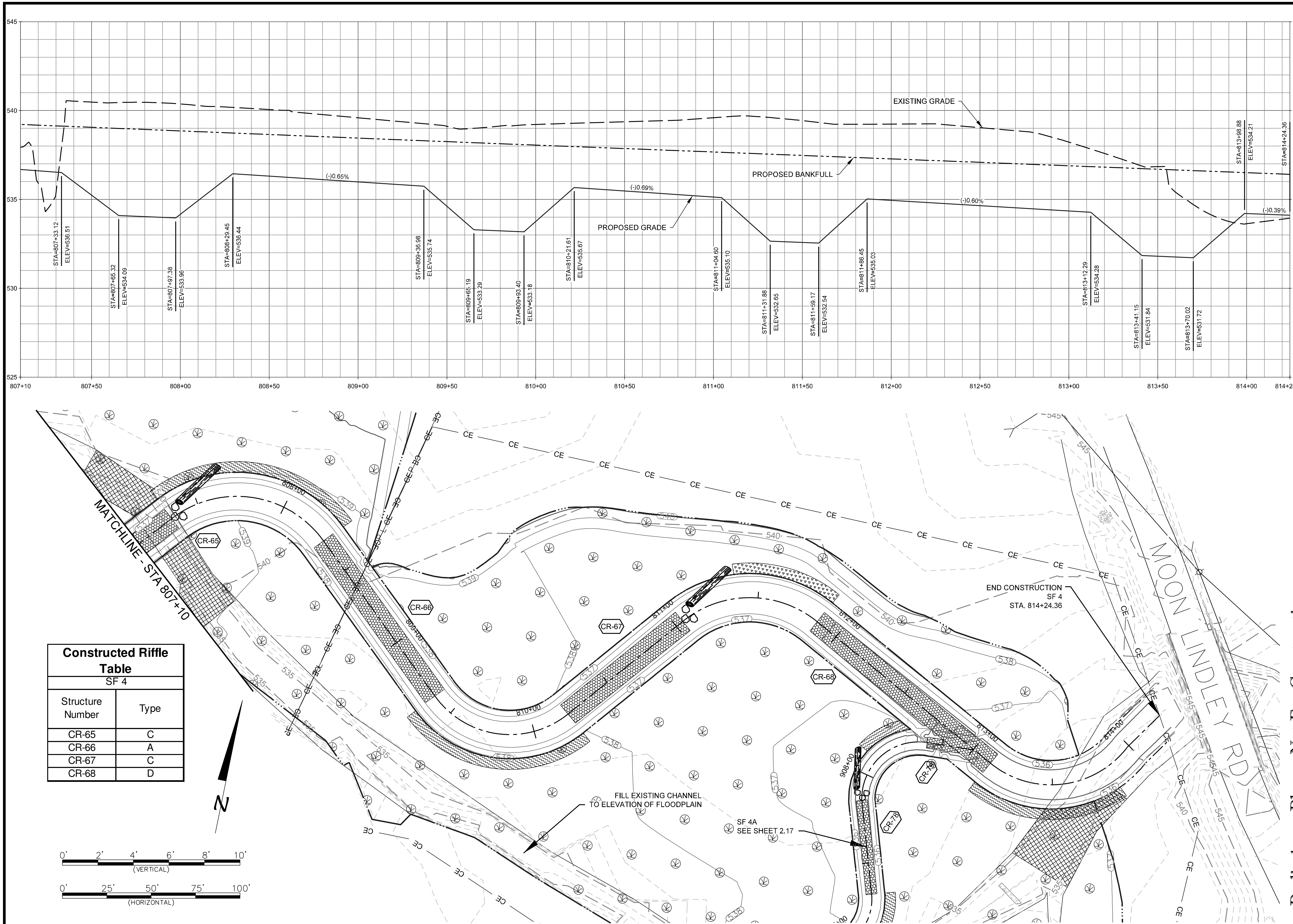
2.14



Constructed Riffle Table	
SF 4	
Structure Number	Type
CR-65	C
CR-66	A
CR-67	C
CR-68	D

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SF 4
Plan and Profile

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Project Engineer:	NMM
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PLAN AND PROFILE

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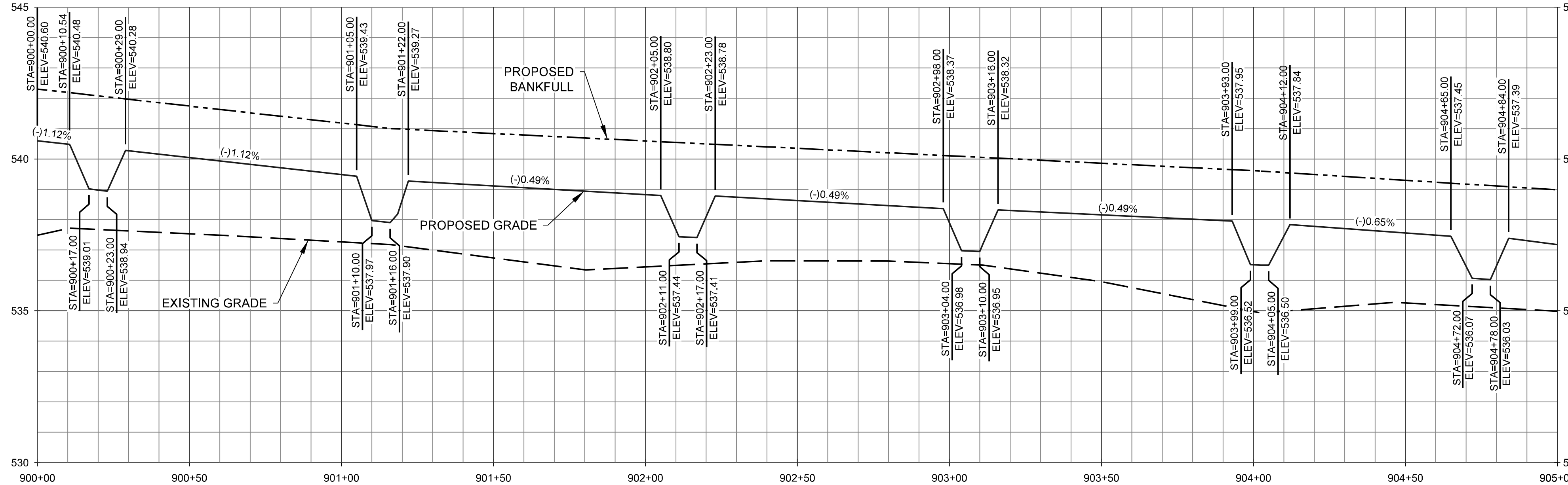
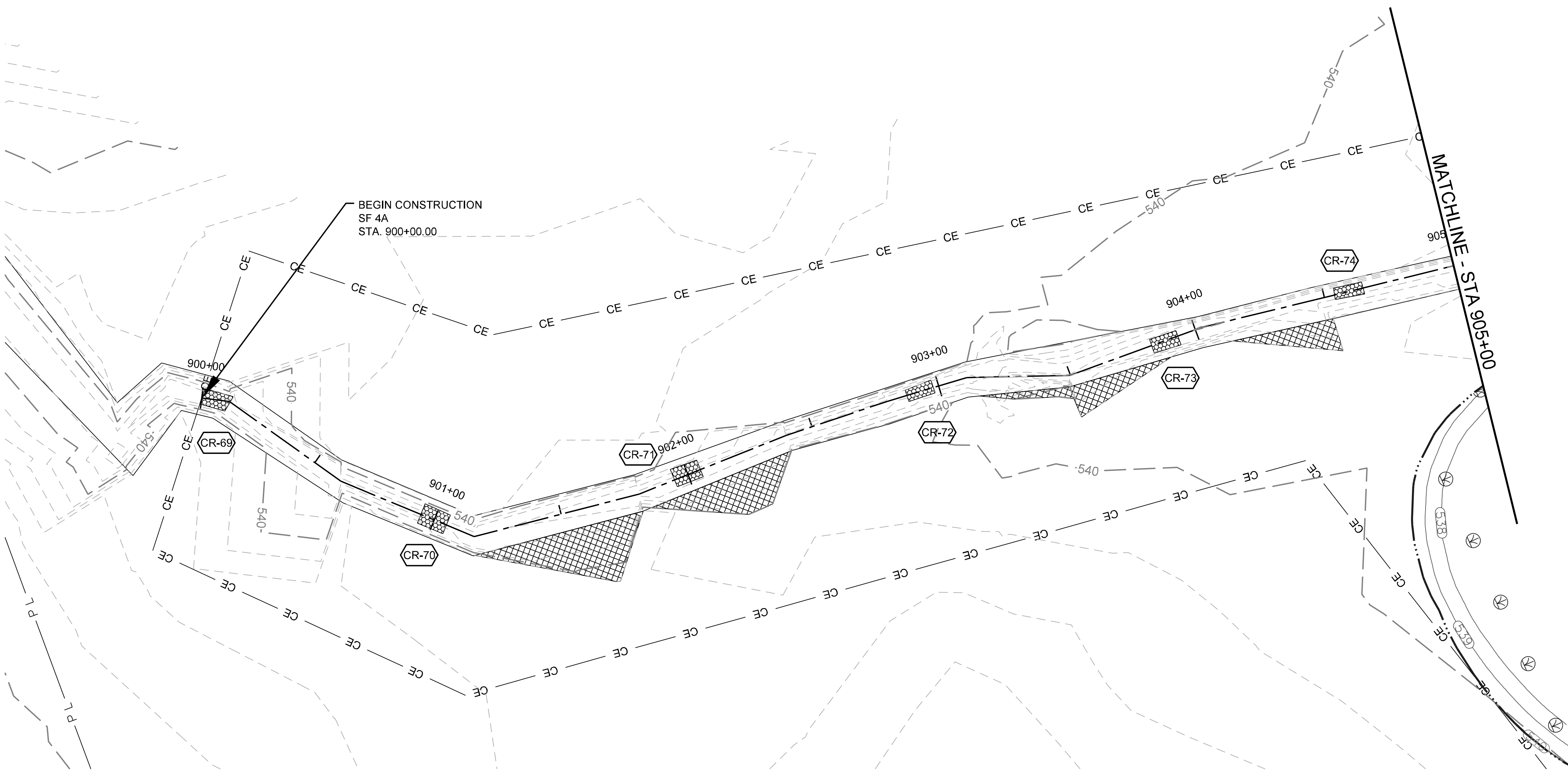
2.15





Constructed Riffle Table

SF 4A

Structure Number	Type
CR-69	A
CR-70	B
CR-71	A
CR-72	A
CR-73	A
CR-74	B

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SF 4A
Plan and Profile

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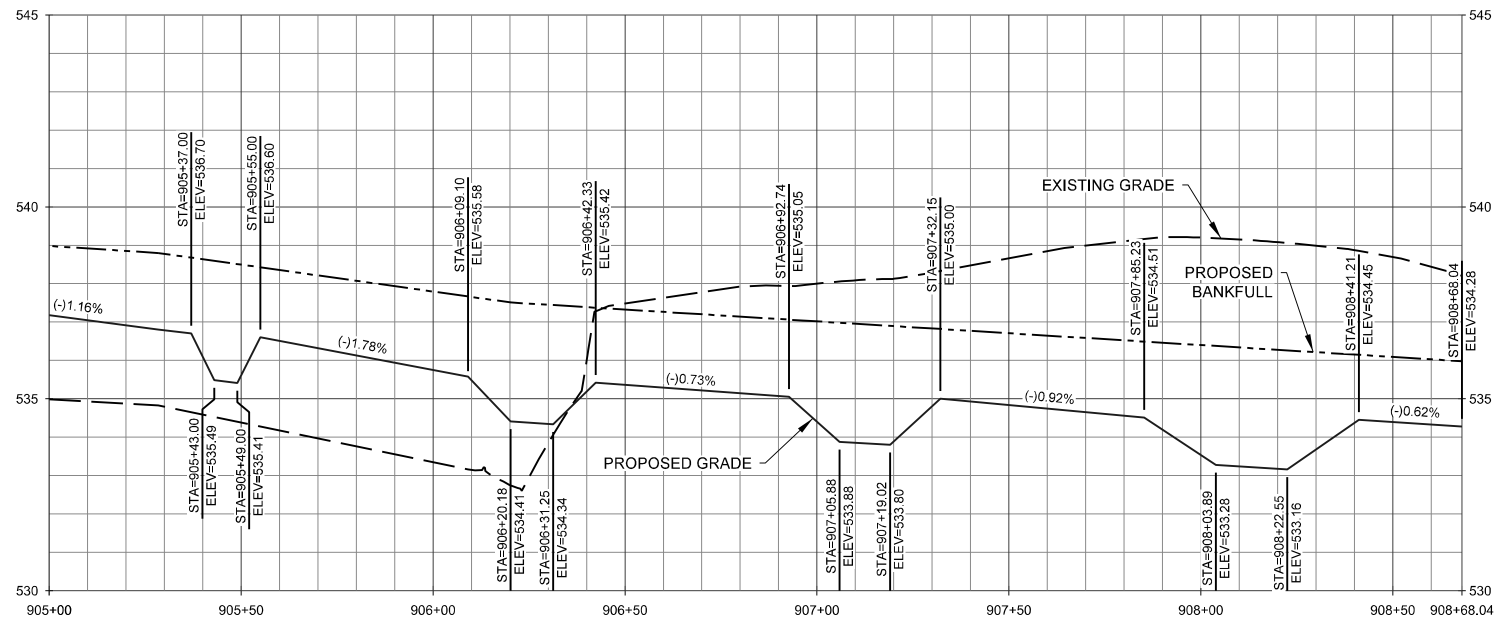
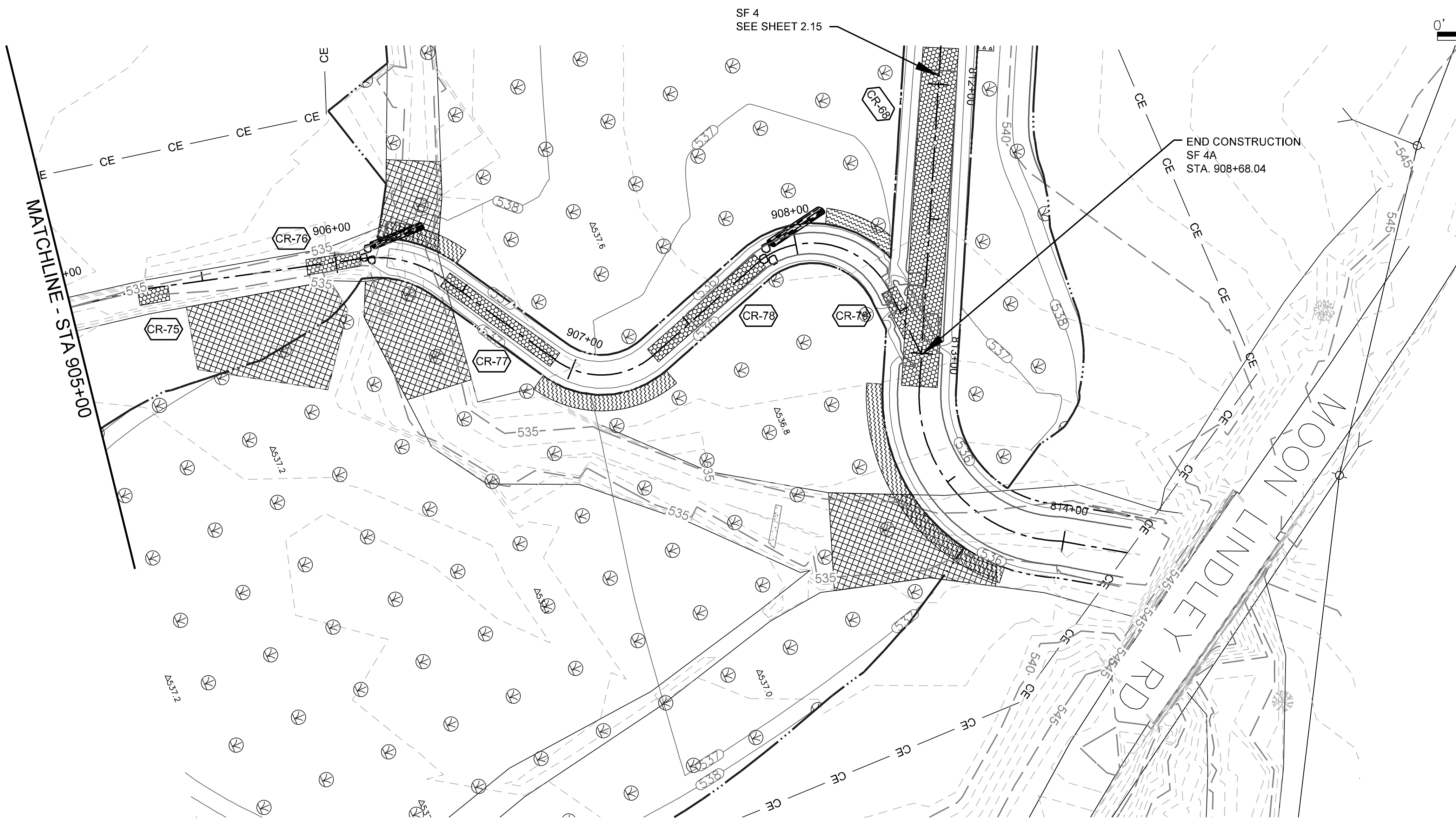
2.16



0' 2' 4' 6' 8' 10' (VERTICAL)

0' 25' 50' 75' 100' (HORIZONTAL)



Constructed Riffle Table	
SF 4A	
Structure Number	Type
CR-75	B
CR-76	C
CR-77	A
CR-78	C
CR-79	A

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SF 4A
Plan and Profile

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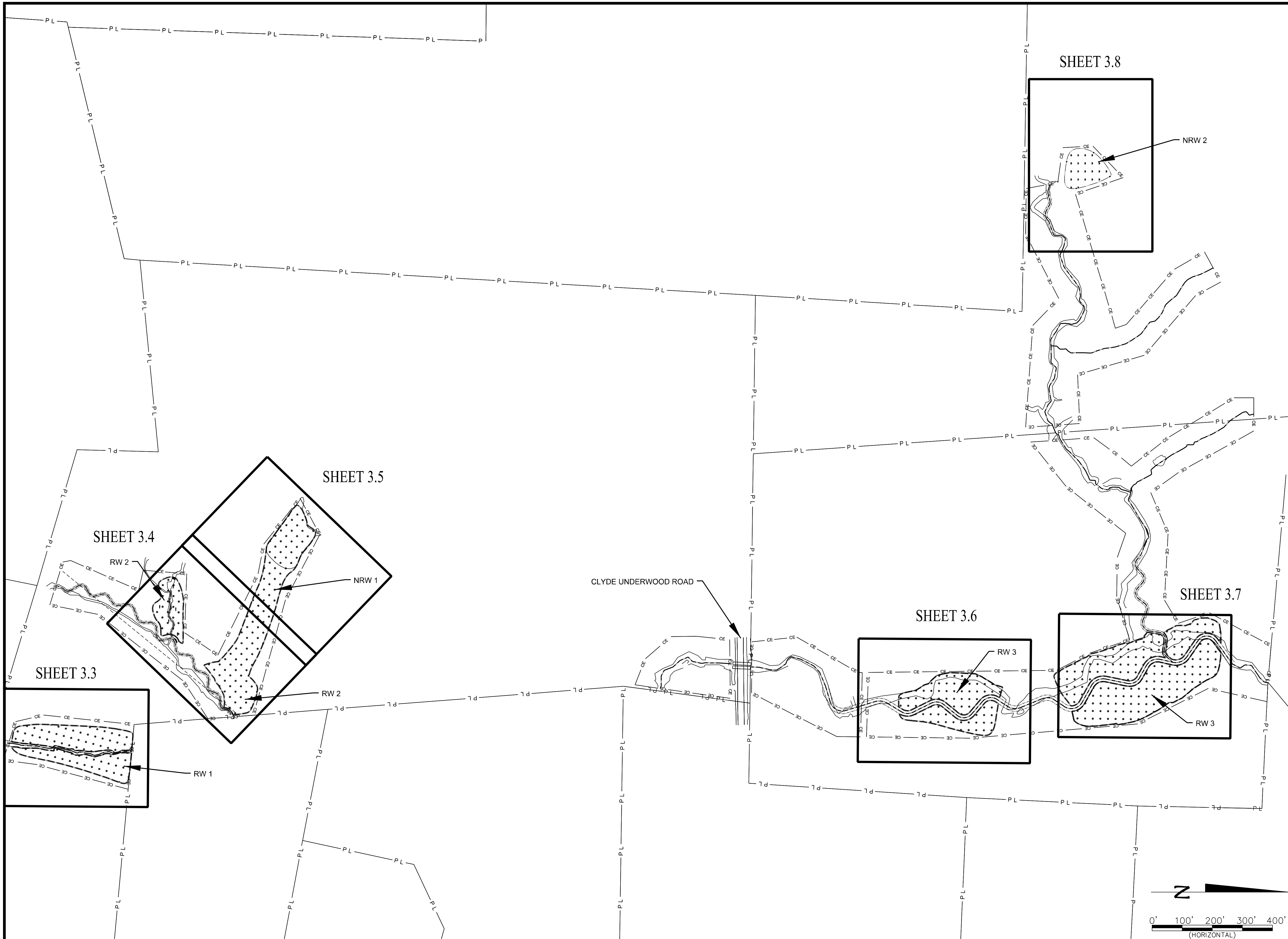
2.17



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Underwood Mitigation Site
Chatham County, NC
Wetland Overview

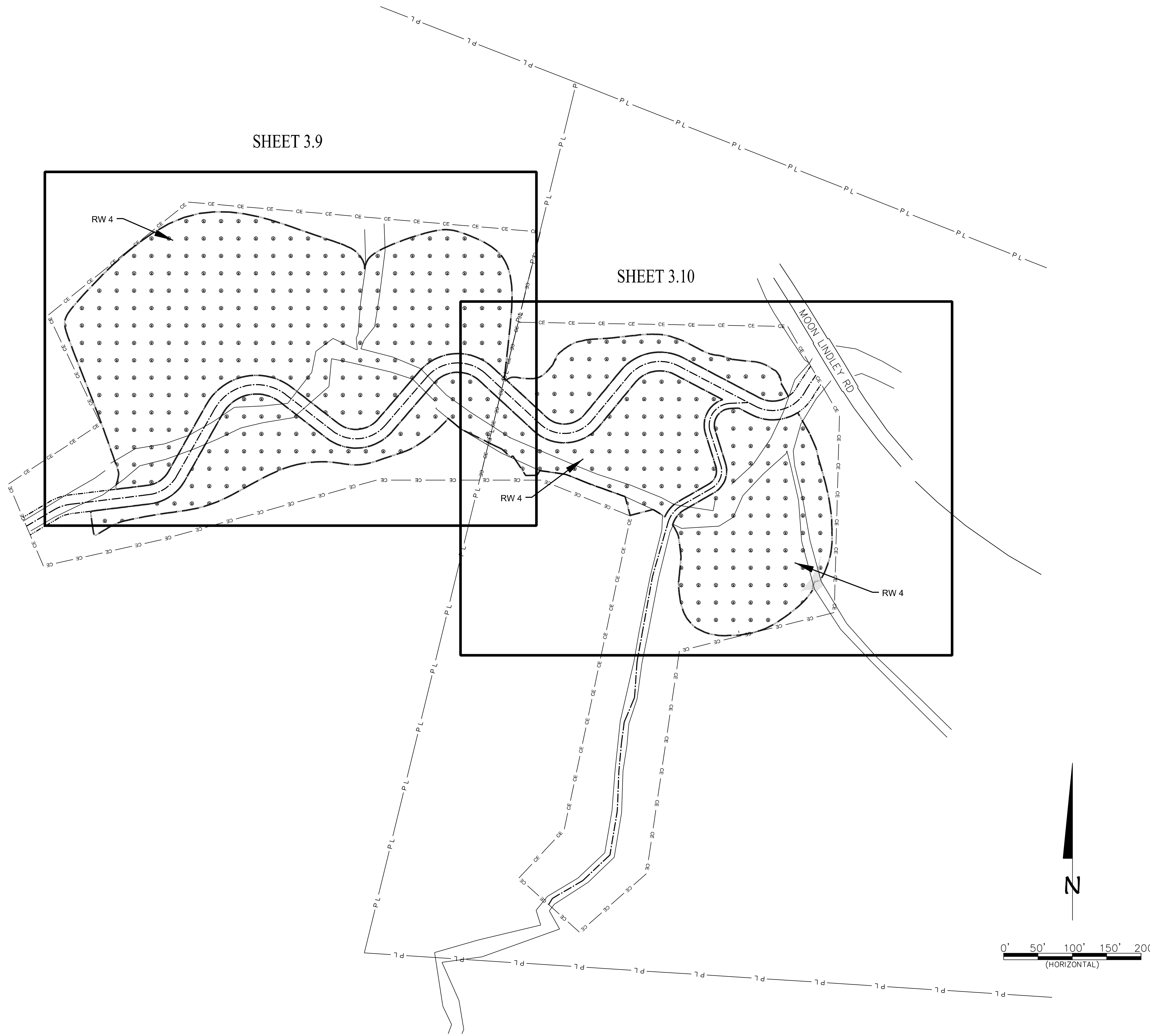
Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

WETLAND OVERVIEW

Sheet

3.1



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Chatham County, NC

Wetland Overview

Date:	August 31, 2011
Job Number:	005-02125
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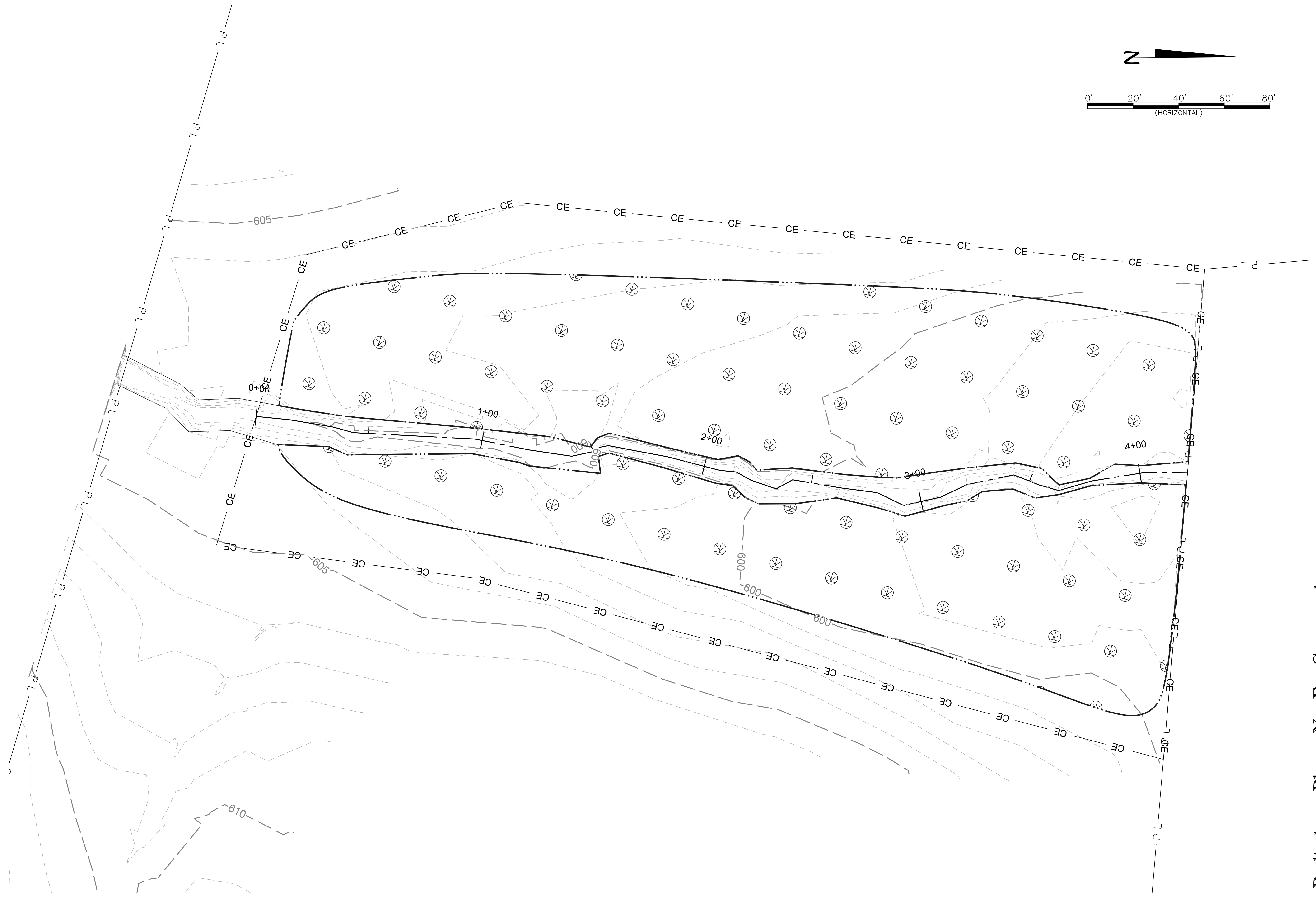
WETLAND OVERVIEW

Sheet

3.2



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Underwood Mitigation Site
Chatham County, NC

RW1
Wetland Grading

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Job Number:	005-02125
Project Engineer:	NMM
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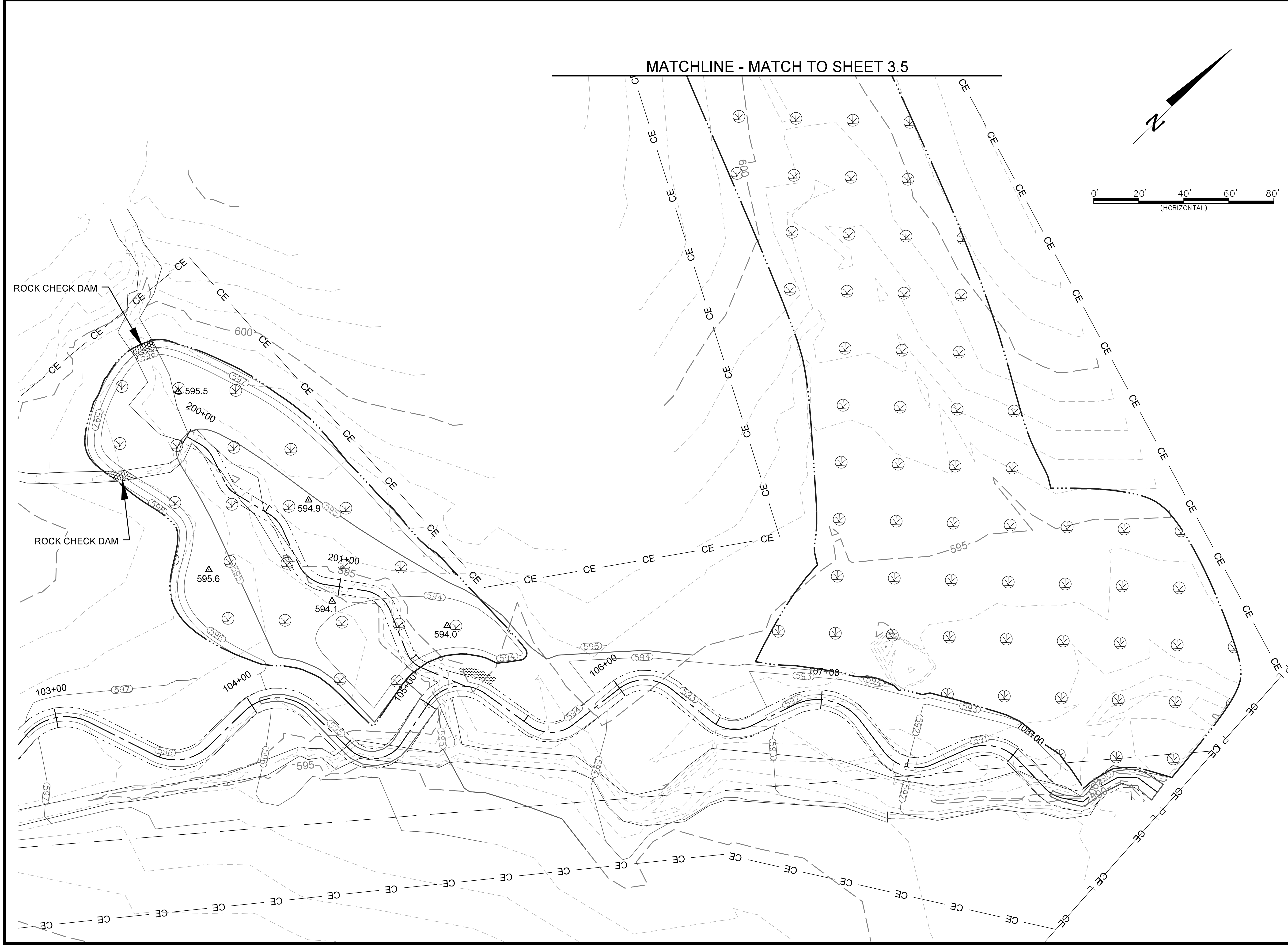
WETLAND GRADING

Sheet

3.3



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Underwood Mitigation Site
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RW 2 & NRW 1
Wetland Grading

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Project Engineer:	NMM
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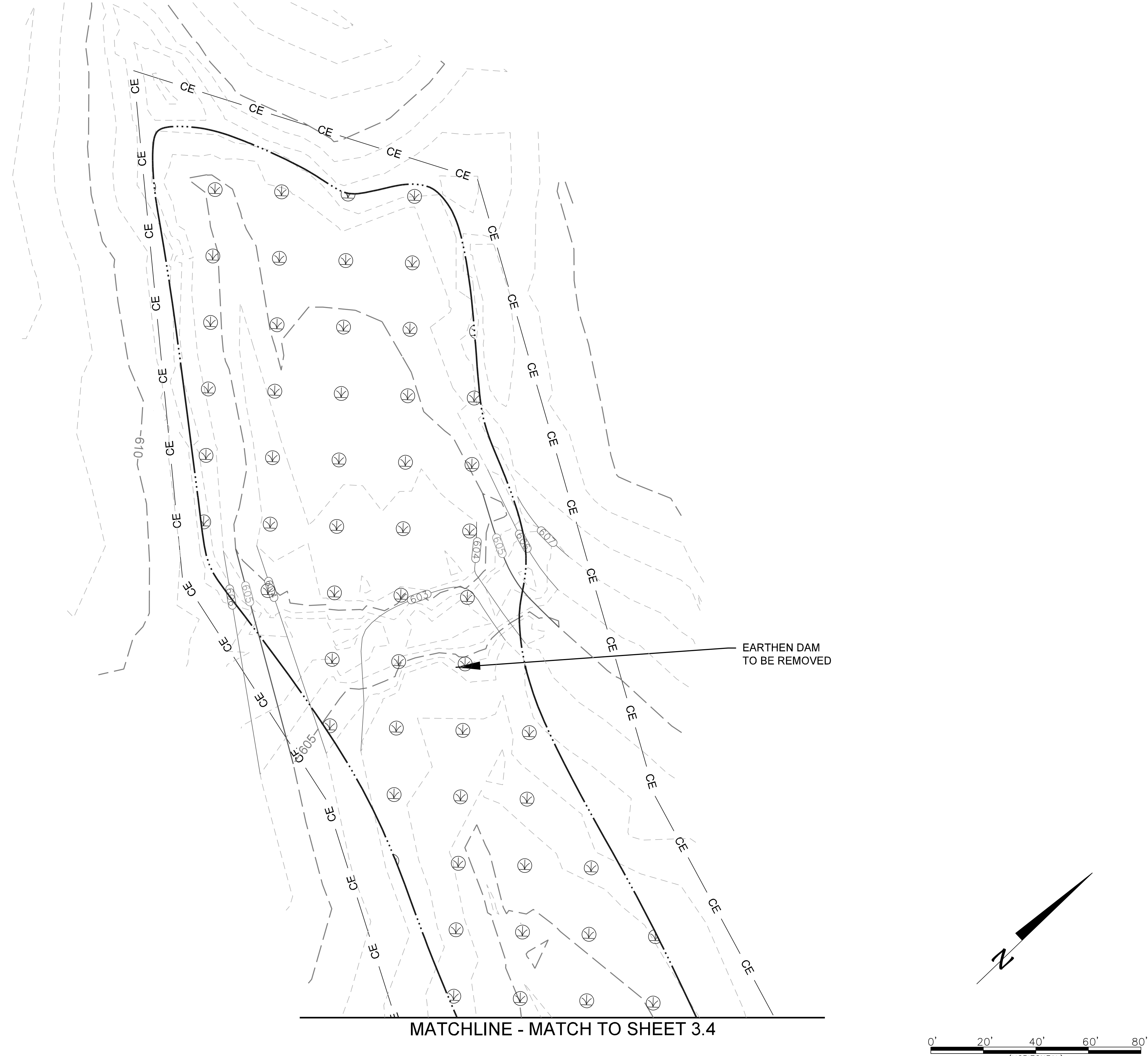
Revisions

WETLAND GRADING

Sheet

3.4



MATCHLINE - MATCH TO SHEET 3.4

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NRW 1
Wetland Grading

Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
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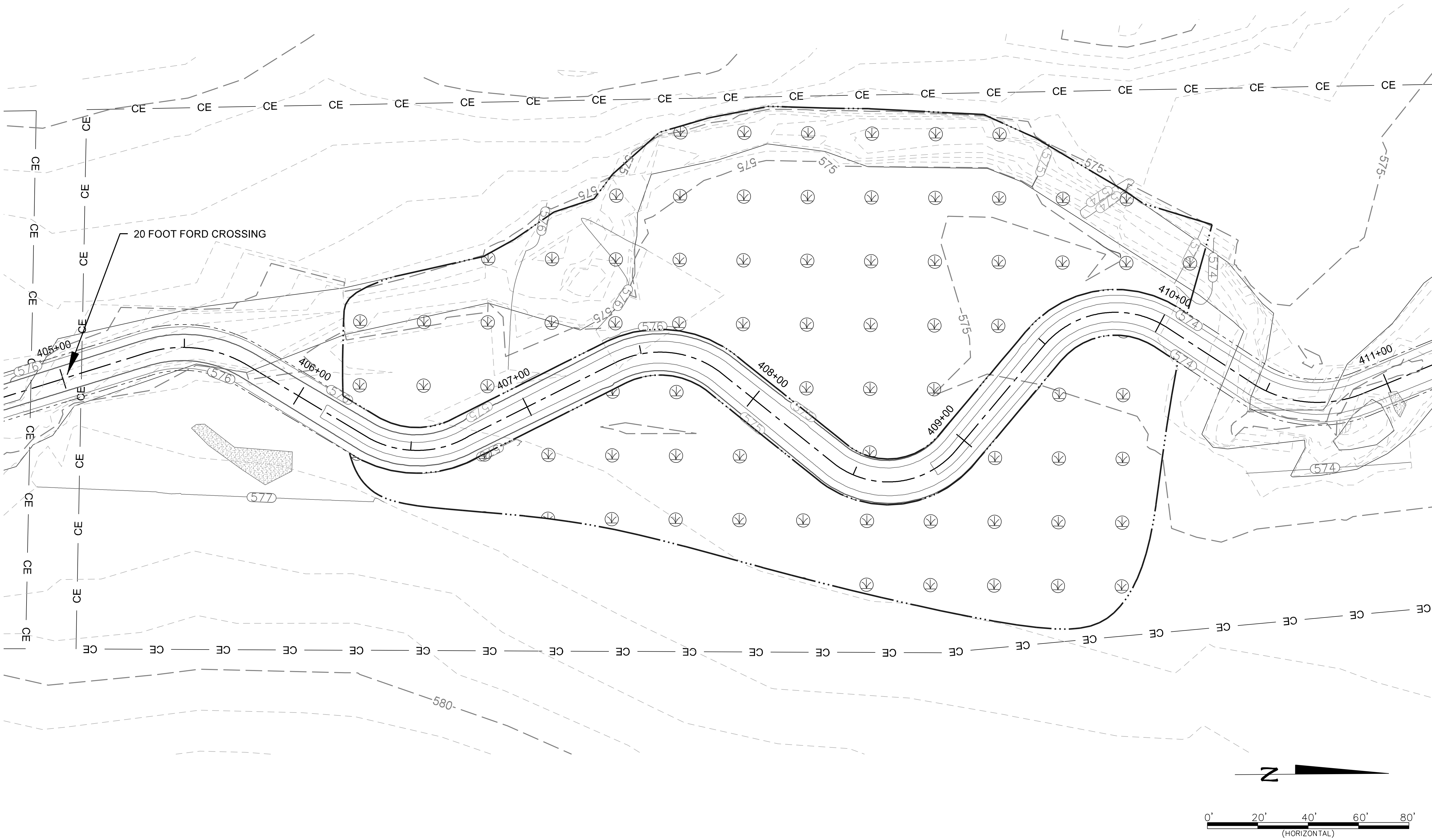
WETLAND GRADING

Sheet

3.5



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RW 3
Wetland Grading

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3.6

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RW 3
Wetland Grading

Date:	August 31, 2011
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Drawn By:	JTL
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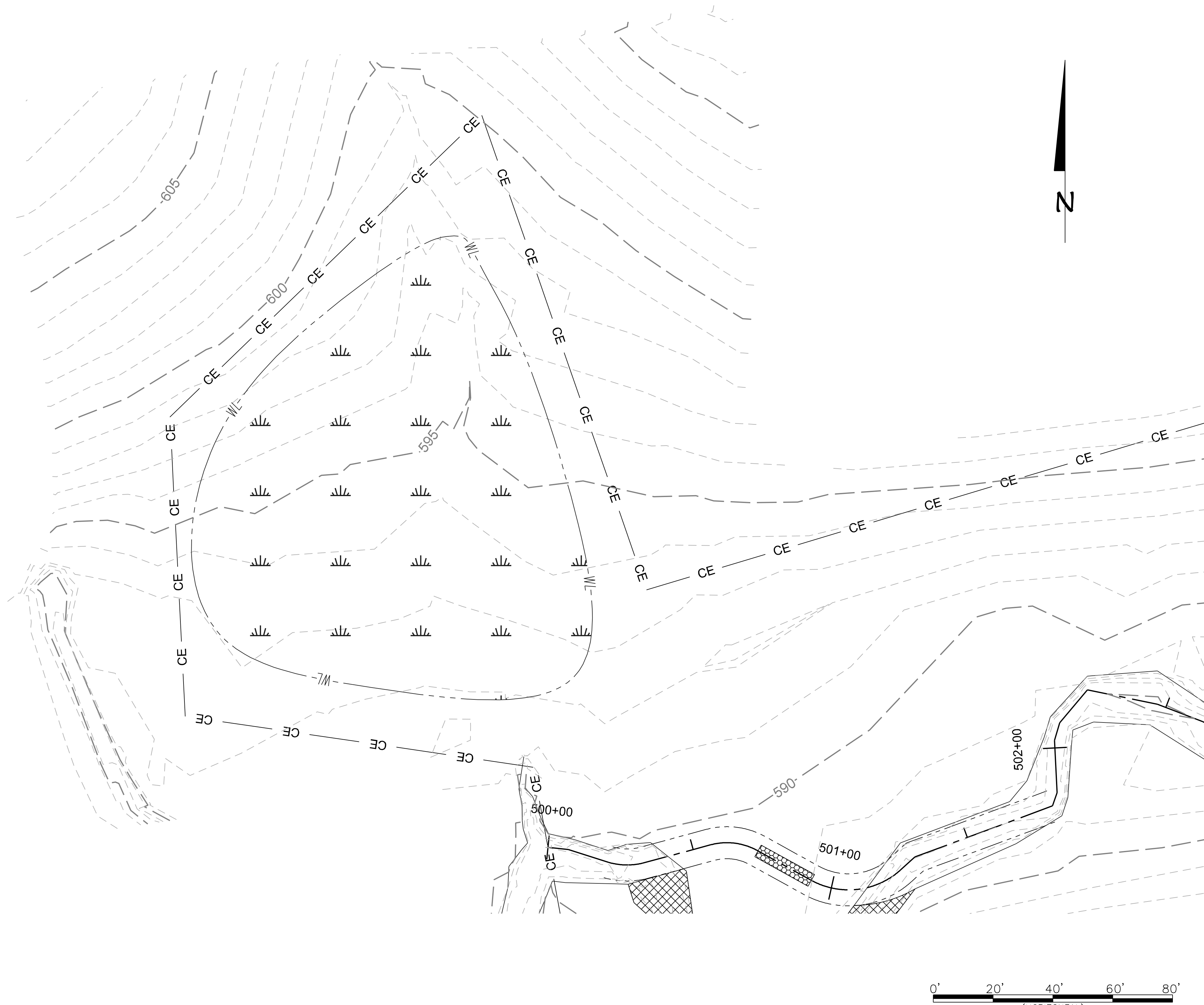
WETLAND GRADING

Sheet

3.7



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Underwood Mitigation Site
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NRW 2
Wetland Grading

Date:	August 31, 2011
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Project Engineer:	NMM
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WETLAND GRADING

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RW 4
Wetland Grading

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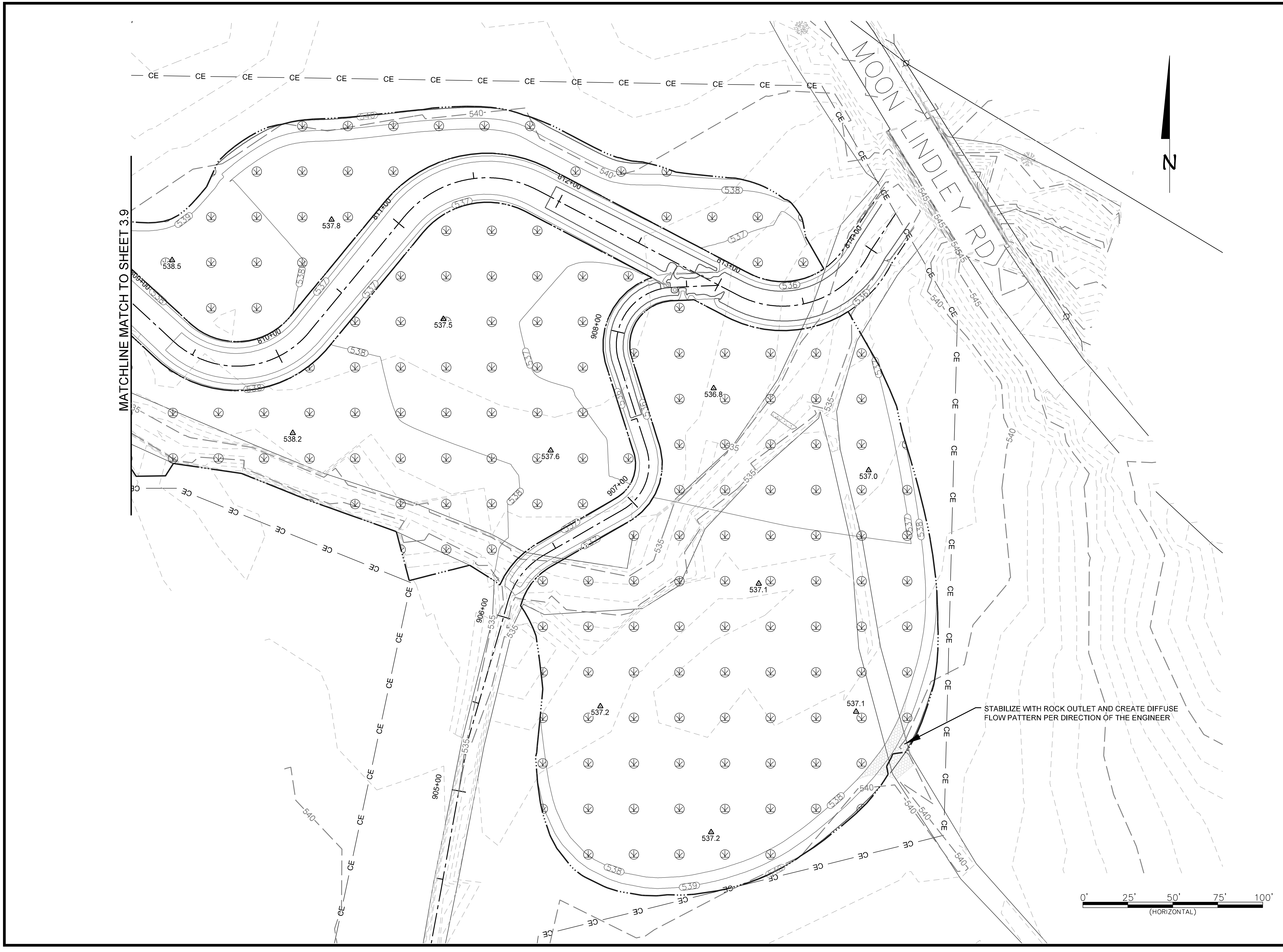
WETLAND GRADING

Sheet

3.9



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RW 4
Wetland Grading

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WETLAND GRADING

Sheet
3.10

PLANTING PLAN GENERAL NOTES

PLANTING ZONES:

Zone 1 - Stream Bank Planting Zone

Zone 2 - Floodplain Planting Zone

Zone 3 - Wetland Planting Zone

VEGETATION TABLES

Permanent Riparian Seeding

Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)	
				Acres	22.8
All Year	*Elymus virginicus*	Herb	Virginia wild rye	10	
All Year	*Panicum virgatum*	Herb	Switchgrass	5	
All Year	*Rudbeckia hirta NC ecotype*	Herb	Black-eyed susan	1	
All Year	*Panicum clandestinum*	Herb	Deer tongue	2	
All Year	*Sorghastrum nutans*	Herb	Indian grass	2	
			Subtotal	**20**	

Permanent Wetland Seeding

Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)	
				Acres	13.9
All Year	*Elymus virginicus*	Herb	Virginia wild rye	10	
All Year	*Panicum virgatum*	Herb	Switchgrass	4	
All Year	*Panicum clandestinum*	Herb	Deer tongue	4	
All Year	*Juncus effusus*	Herb	Soft rush	2	
			Subtotal	**20**	

Temporary Seeding

Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)	
				Acres	34.7
Nov 1 - Apr 30	*Lolium multiflorum*	Herb	Rye Grain	140	
May 1 - October 31	*Panicum ramosum*	Herb	Browntop Millet	45	

NOTE: APPLY MULCH AT 130 BALES/ ACRE AND TEMPORARY SEED ACCORDING TO THE TABLE ON ALL AREAS SUSCEPTIBLE TO EROSION INCLUDING, BUT NOT LIMITED TO, STREAM BANKS, ACCESS AREAS, STEEP SLOPES, AREAS OF INVASIVE SPECIES REMOVAL, STOCKPILES, AND STAGING AREAS.

Planting Summary Table

Streambank Planting

Species	Common Name	Max Spacing	Unit Type*	Min. Caliper Size	Stratum	Indiv. Spacing	# of Stems	Total lbs	
								Acres	2.0
Salix nigra	Black Willow	8 ft.	L	0.5”-1.0”	Shrub	2-8 ft.	697		
Cornus amomum	Silky Dogwood	8 ft.	L	0.5”-1.0”	Shrub	2-8 ft.	697		
Salix sericea	Silky Willow	8 ft.	L	0.5”-1.0”	Shrub	2-8 ft.	1428		
						Subtotal	**2,822**	**0**	

Planting Summary Table

Buffer Planting

Species	Common Name	Max Spacing	Unit Type*	Min. Caliper Size	Stratum	Indiv. Spacing	# of Stems	Total lbs	
								Acres	20.8
Alnus serrulata	Tag Alder	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	1414		
Liriodendron tulipifera	Tulip Poplar	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	1414		
Quercus phellos	Willow Oak	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	1414		
Plantus occidentalis	Sycamore	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	2829		
Betula nigra	River Birch	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	2122		
Carpinus caroliniana	Ironwood	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	1414		
Quercus michauxii	Swamp Chestnut Oak	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	707		
Fraxinus pennsylvanica	Green Ash	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	2122		
Quercus rubra	Southern Red Oak	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	707		
						Subtotal	**14,144**	**0**	

Planting Summary Table

Wetland Planting

Species	Common Name	Max Spacing	Unit Type*	Min. Caliper Size	Stratum	Indiv. Spacing	# of Stems	Total lbs	
								Acres	13.9
Alnus serrulata	Tag Alder	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	945		
Cornus ammomum	Silky Dogwood	8 ft.	R	0.25”-1.0”	Shrub	6-8 ft.	644		
Quercus phellos	Willow Oak	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	644		
Plantus occidentalis	Sycamore	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	1288		
Betula nigra	River Birch	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	966		
Nyssa sylvatica	Blackgum	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	644		
Quercus michauxii	Swamp Chestnut	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	322		
Fraxinus pennsylvanica	Green Ash	8 ft.	R	0.25”-1.0”	Canopy	6-8 ft.	1288		
						Subtotal	**6,741**	**0**	

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Chatham County, NC

Planting Notes & Vegetation Tables

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Job Number:	005-02125
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Drawn By:	JTL
Checked By:	JWH

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PLANTING NOTES & VEGETATION TABLES

Sheet

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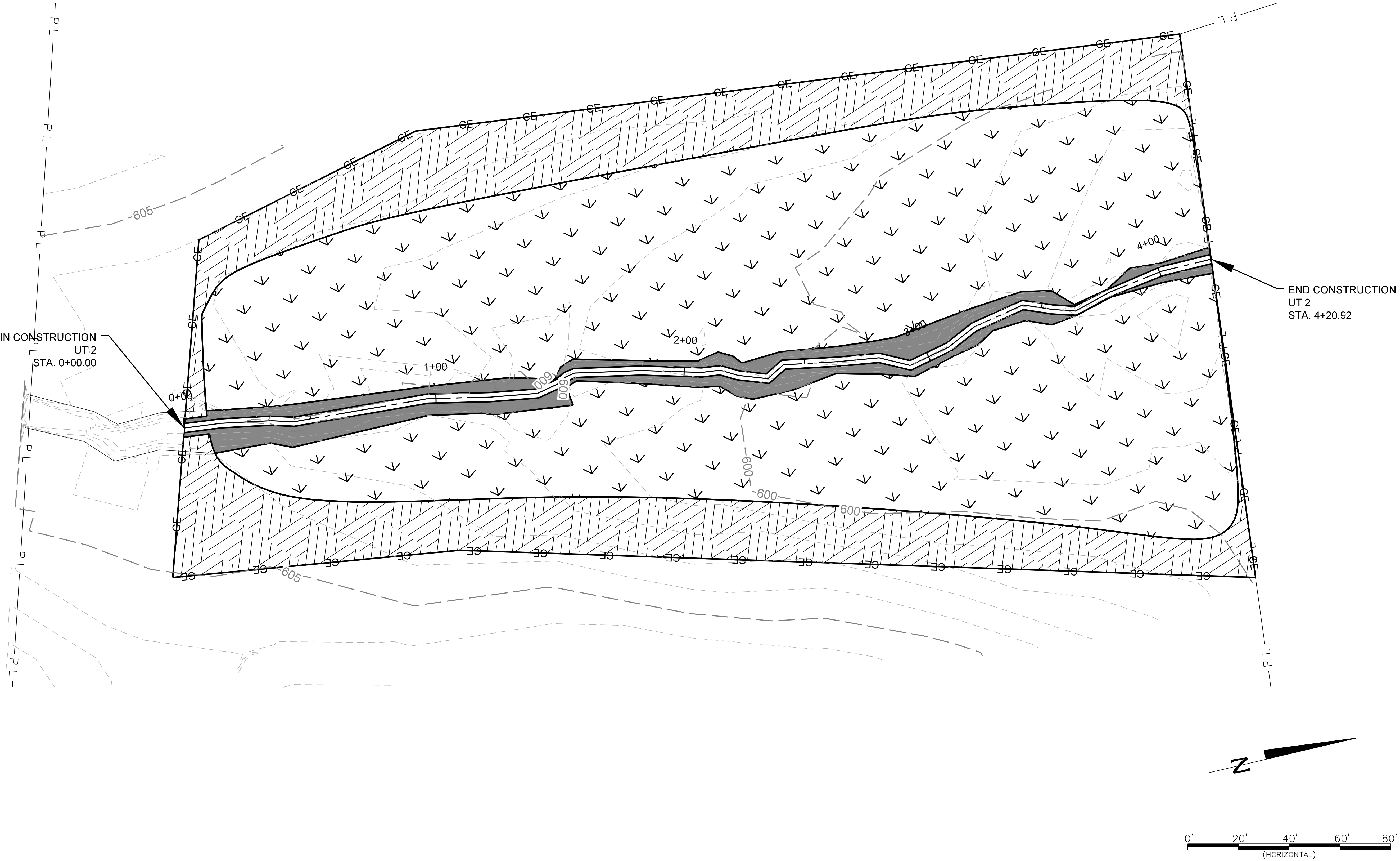

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Chatham County, NC

UT 2 & RW 1
Planting

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PLANTING

Sheet

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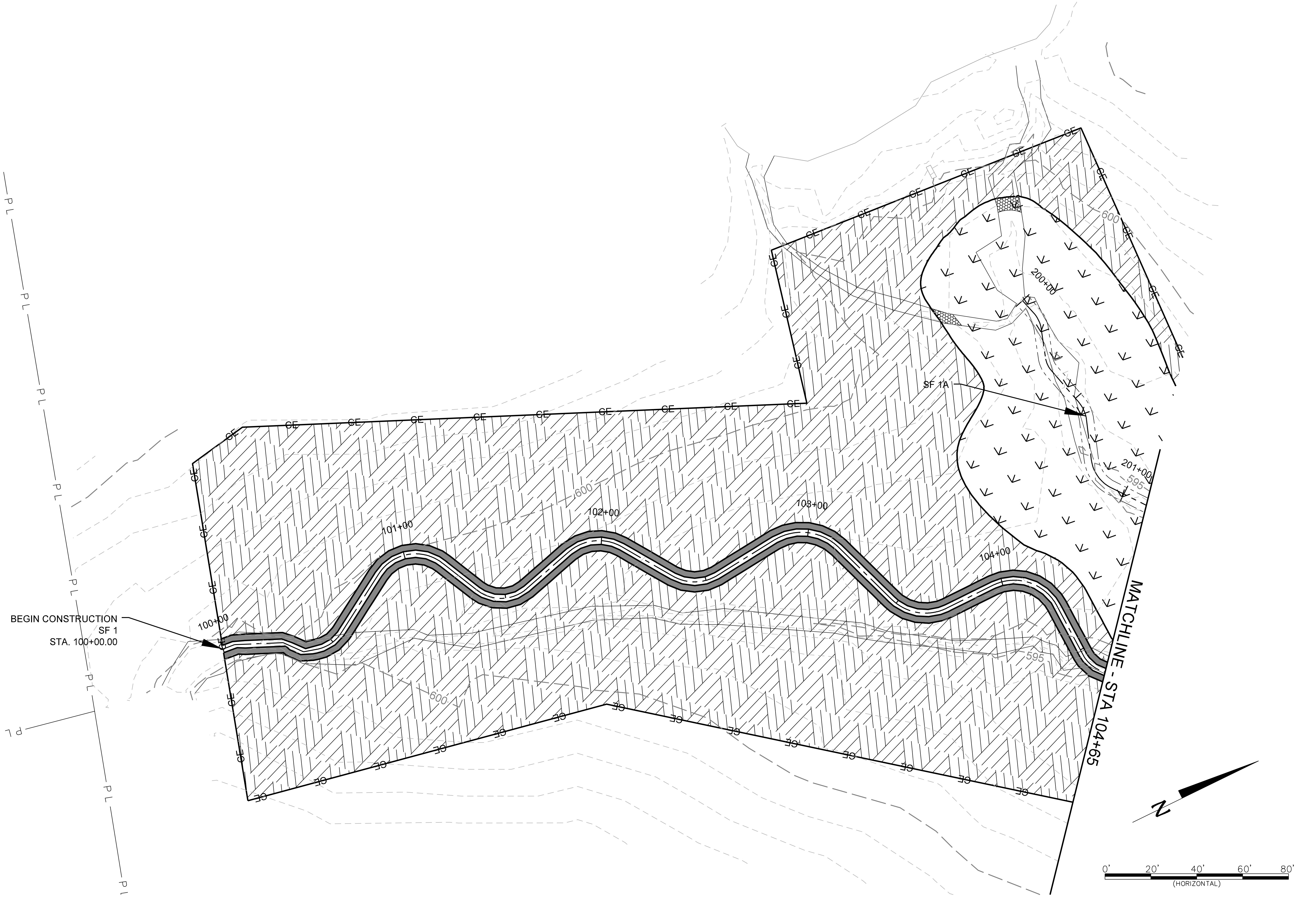

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SF 1, SF 1A, & RW 2
Planting

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Project Engineer:	NMM
Drawn By:	JTL
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PLANTING

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4.2

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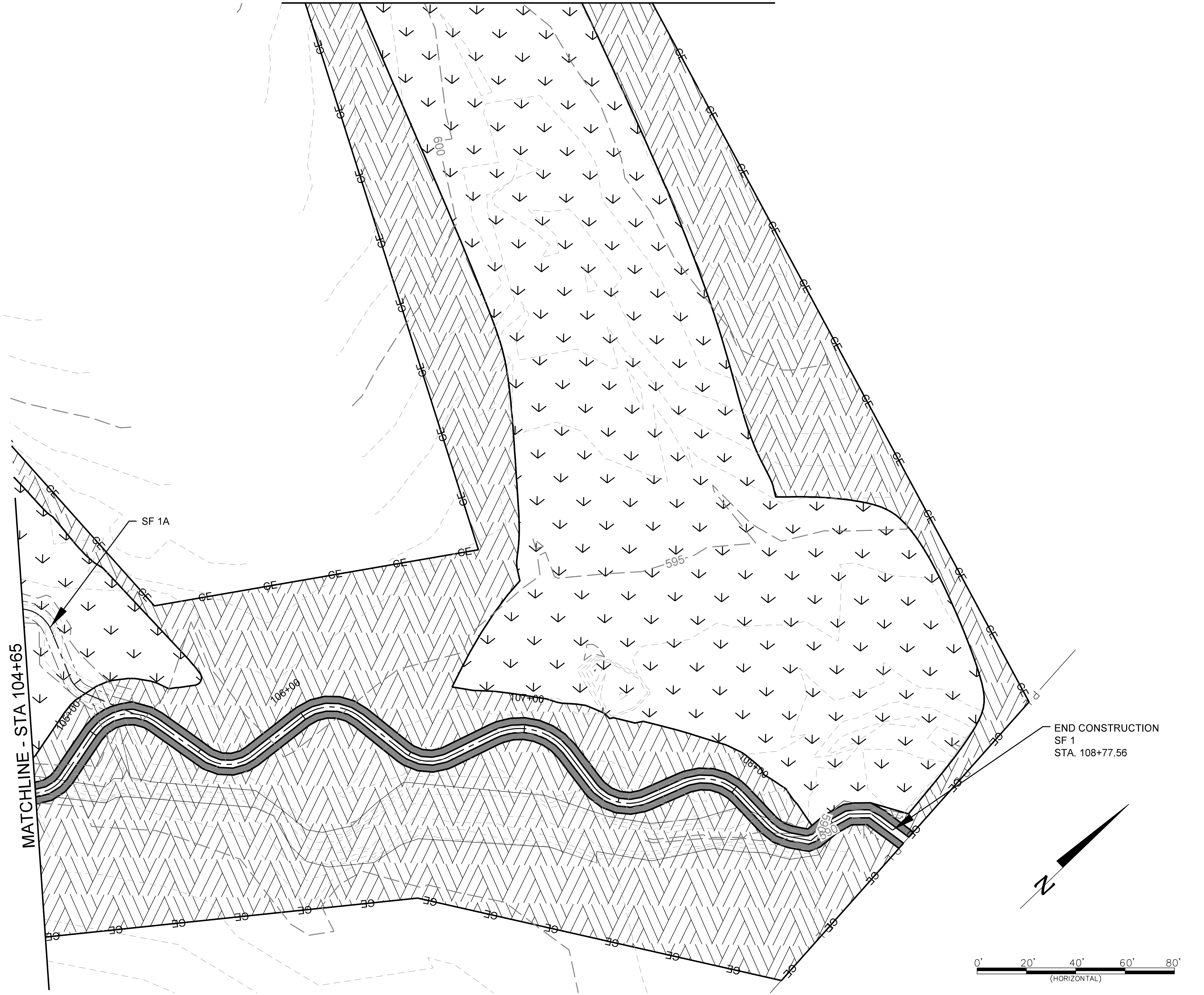

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Underwood Mitigation Site
Chatham County, NC

SF 1, SF 1A, RW 2, & NRW1
Planting

Date:	August 31, 2011
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Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

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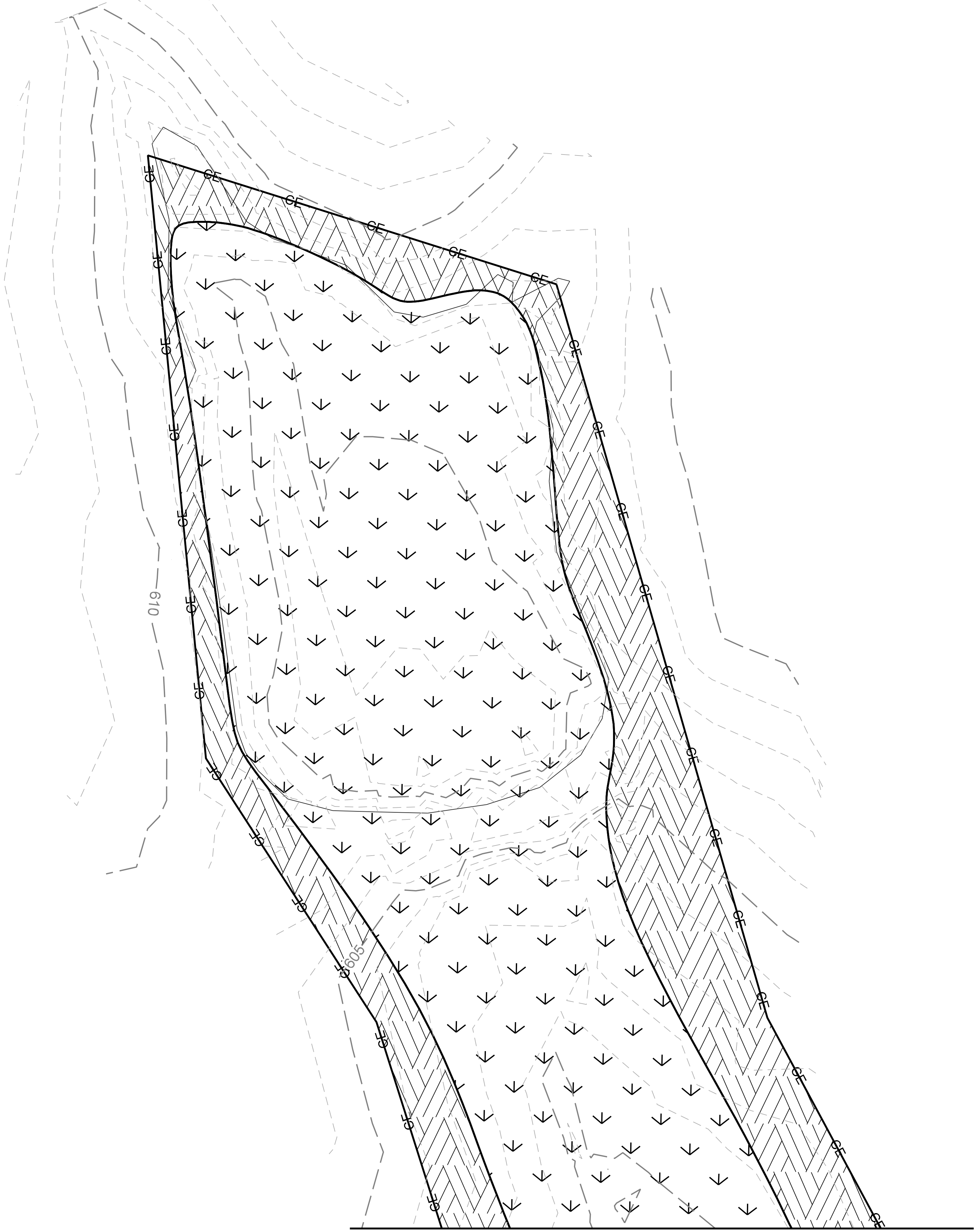
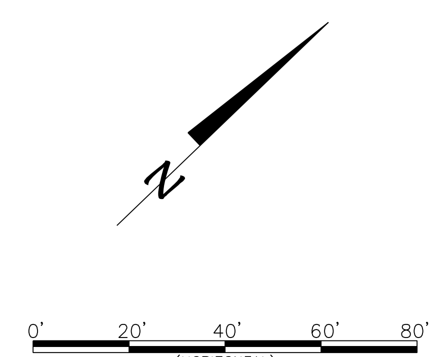
PLANTING

Sheet

4.3



MATCHLINE - MATCH TO SHEET 4.3



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Underwood Mitigation Site
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NRW1
Planting

Date:	August 31, 2011
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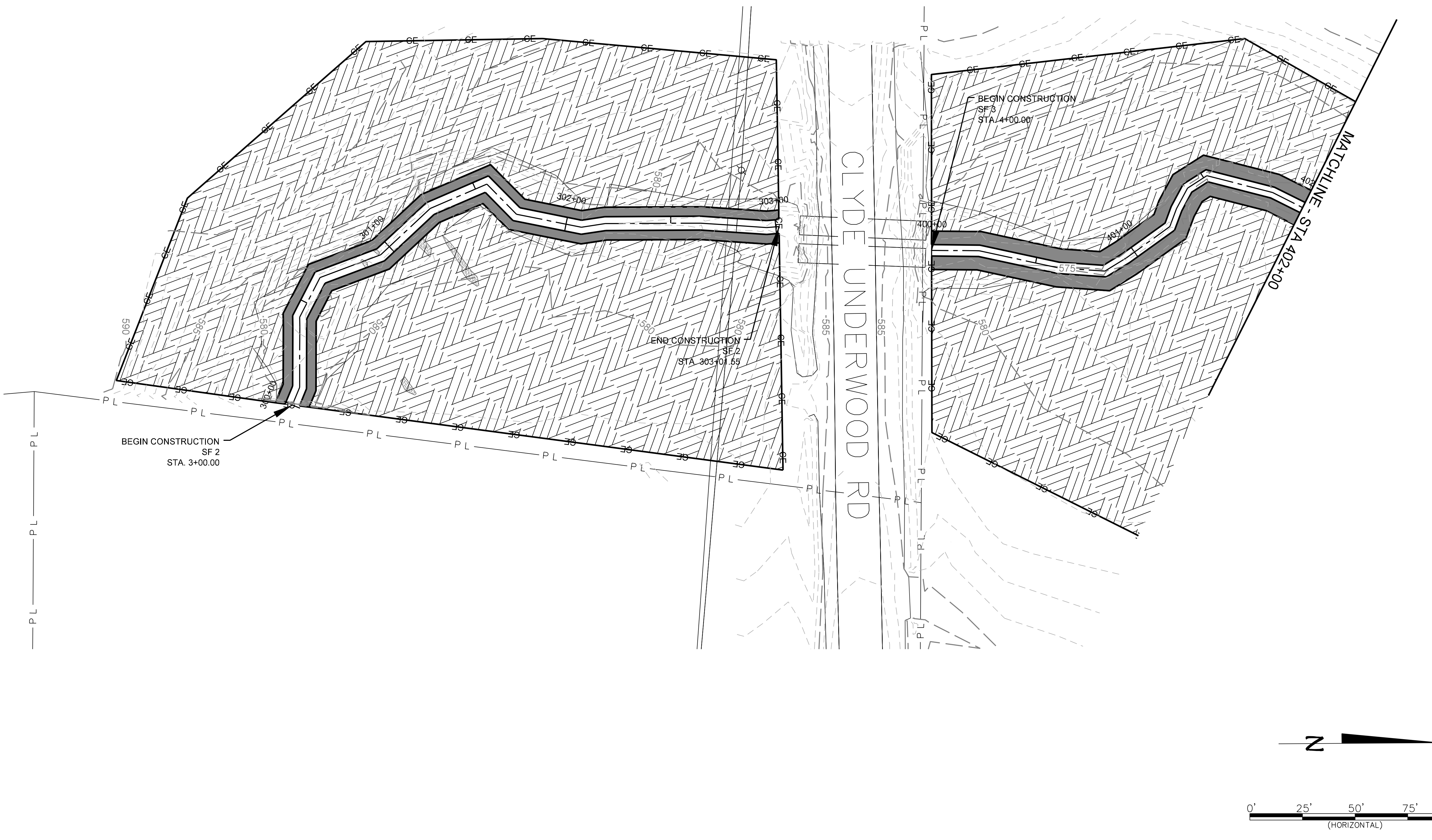
4.4



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Underwood Mitigation Site
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SF 2 & SF 3
Planting

Date:	August 31, 2011
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Drawn By:	JTL
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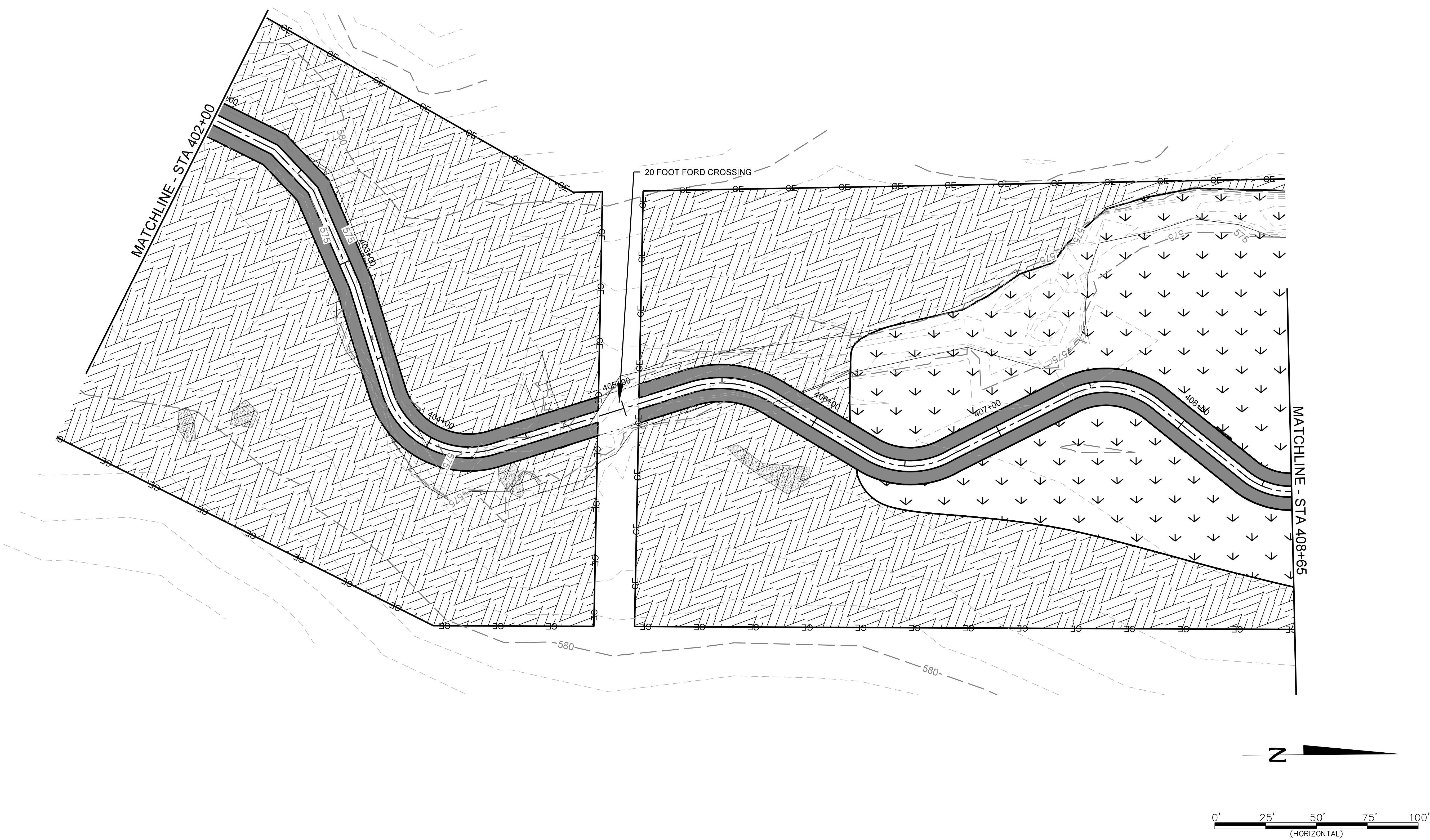
Sheet

4.5



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Ecological Restoration Services

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Firm License No. F-0831

Underwood Mitigation Site
Chatham County, NC

SF 3 & RW 3
Planting

Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

PLANTING

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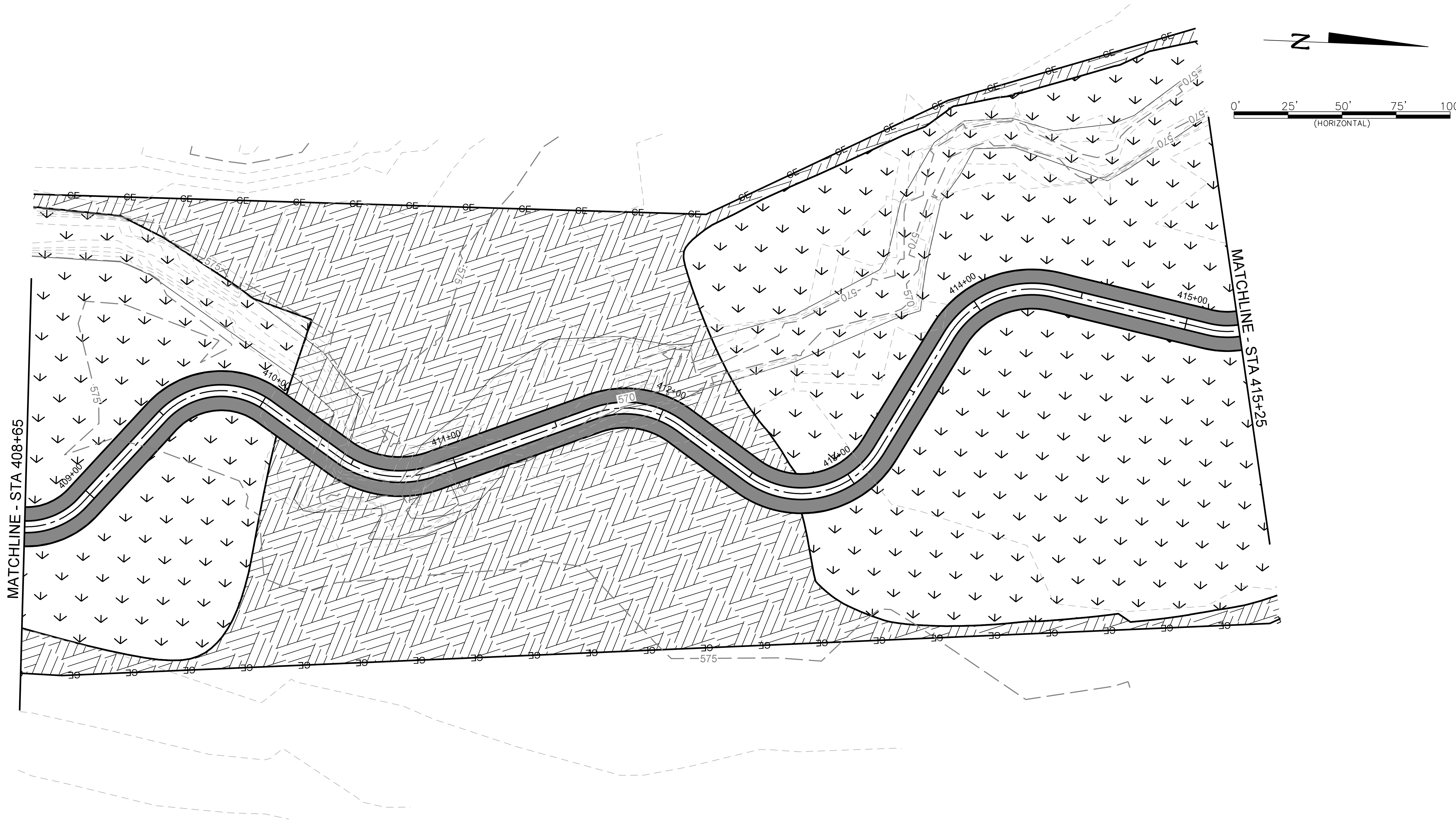
4.6



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SF 3 & RW 3
Planting

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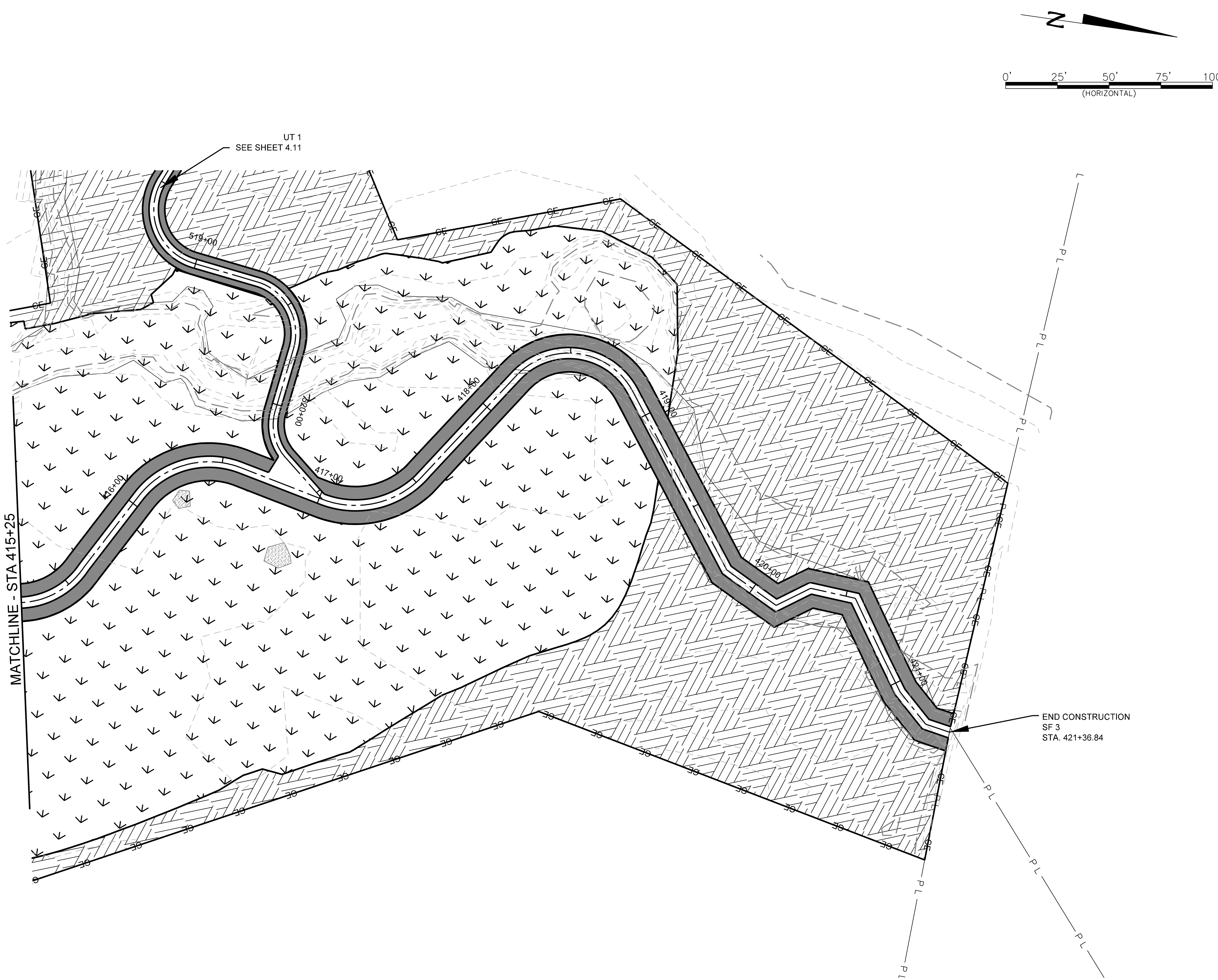

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SF 3 & RW 3
Planting

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PLANTING

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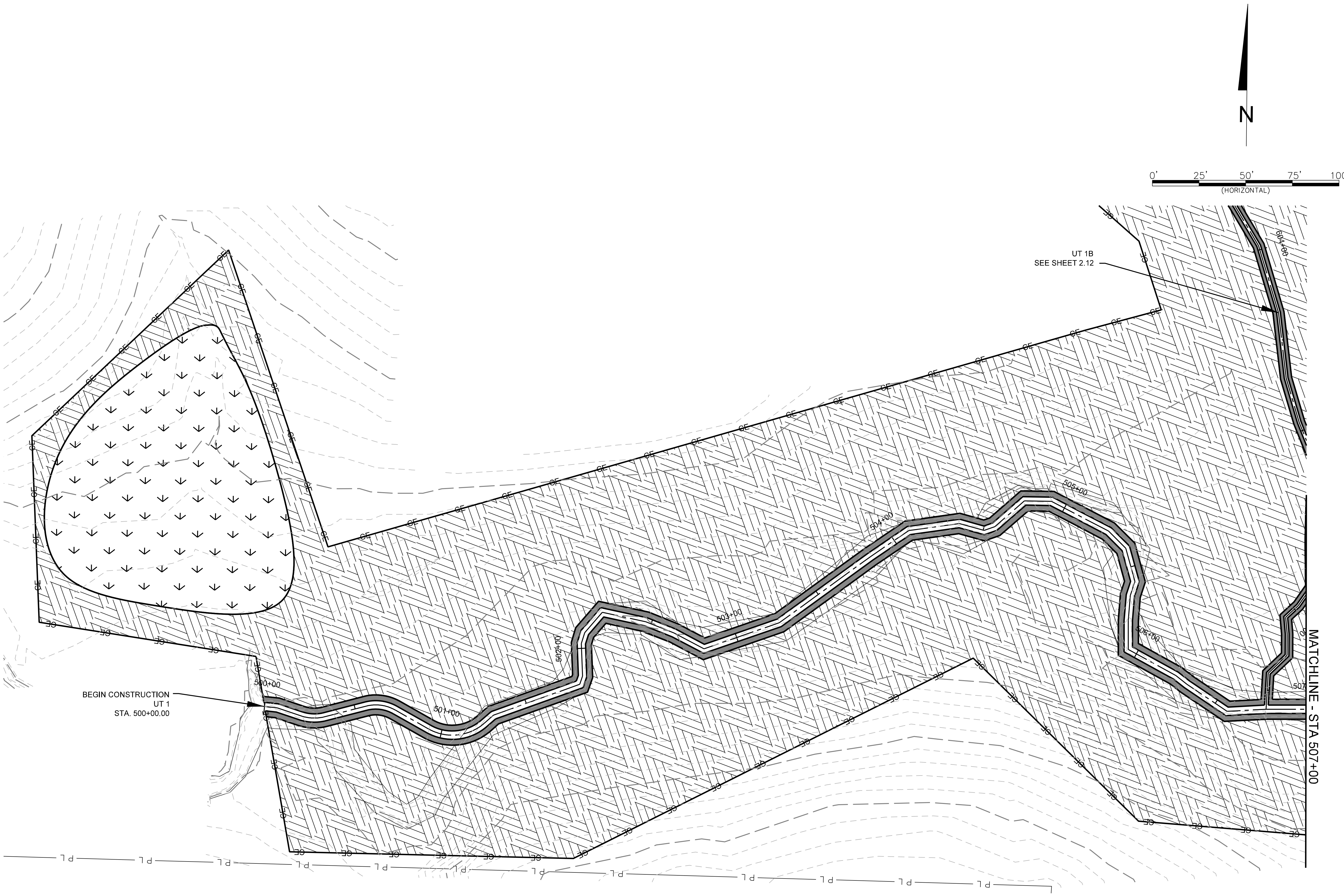

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Underwood Mitigation Site
Chatham County, NC

UT 1 & NRW 2
Planting

Date:	August 31, 2011
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Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

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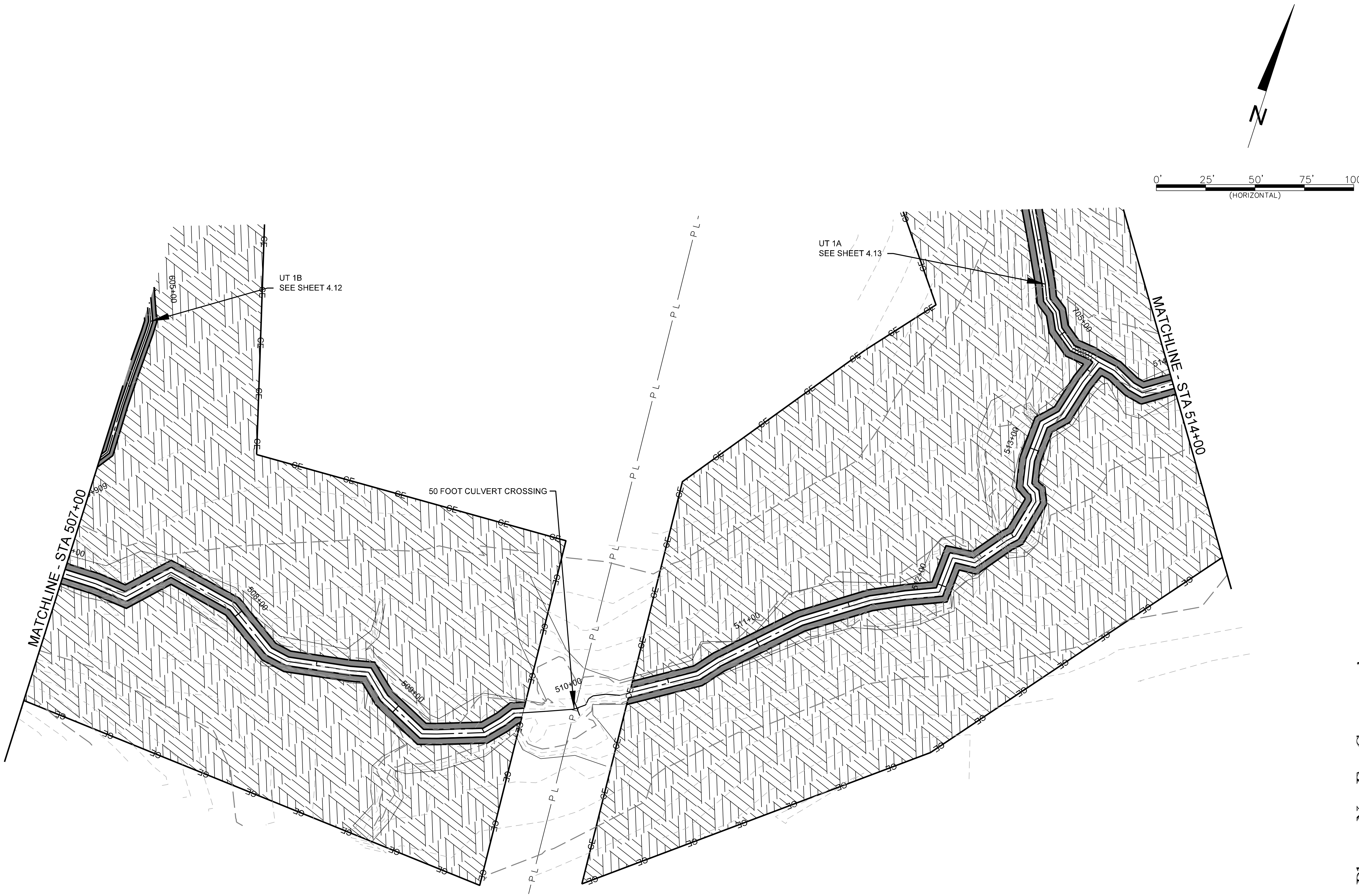

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Underwood Mitigation Site
Chatham County, NC

UT 1
Planting

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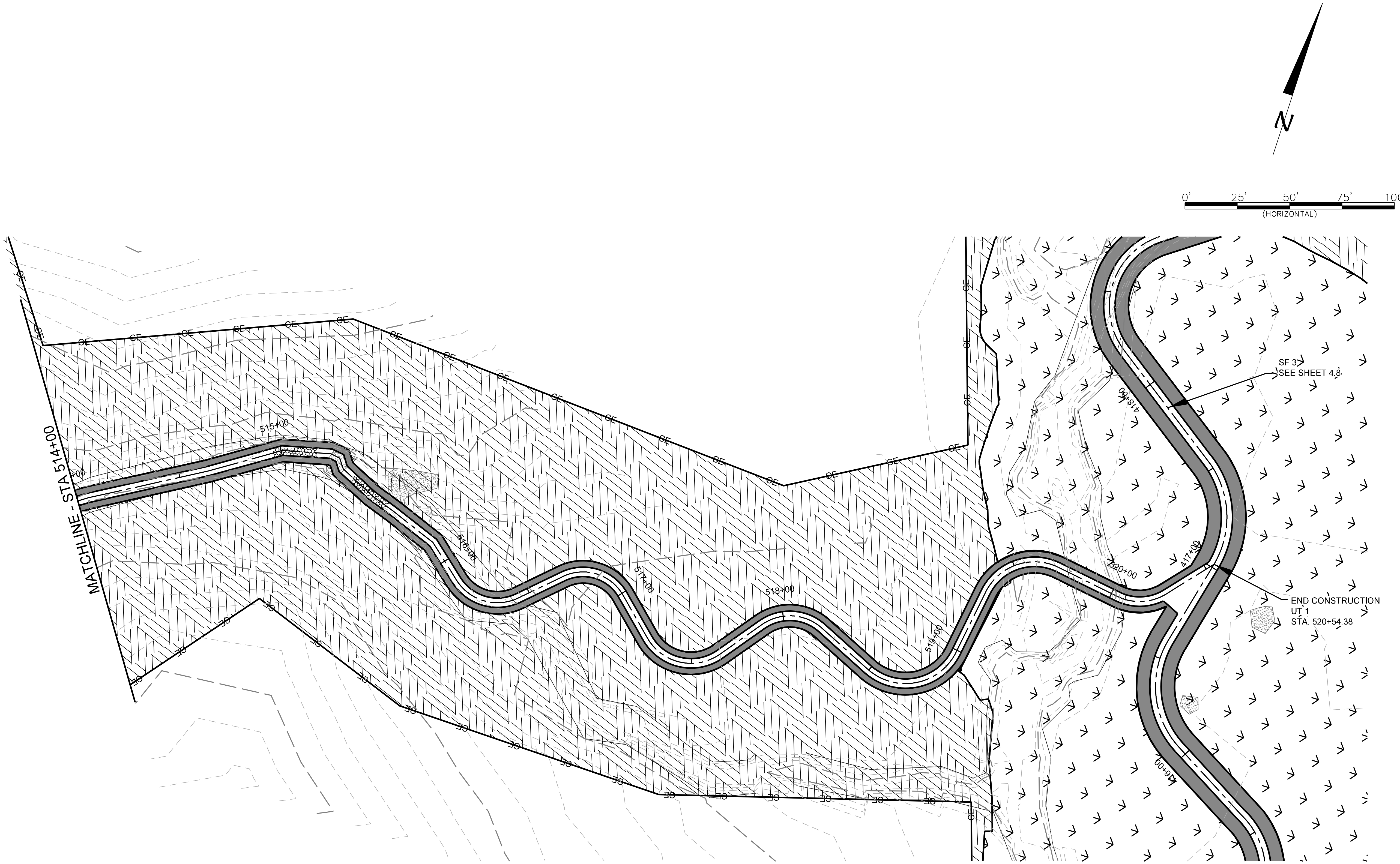

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UT 1
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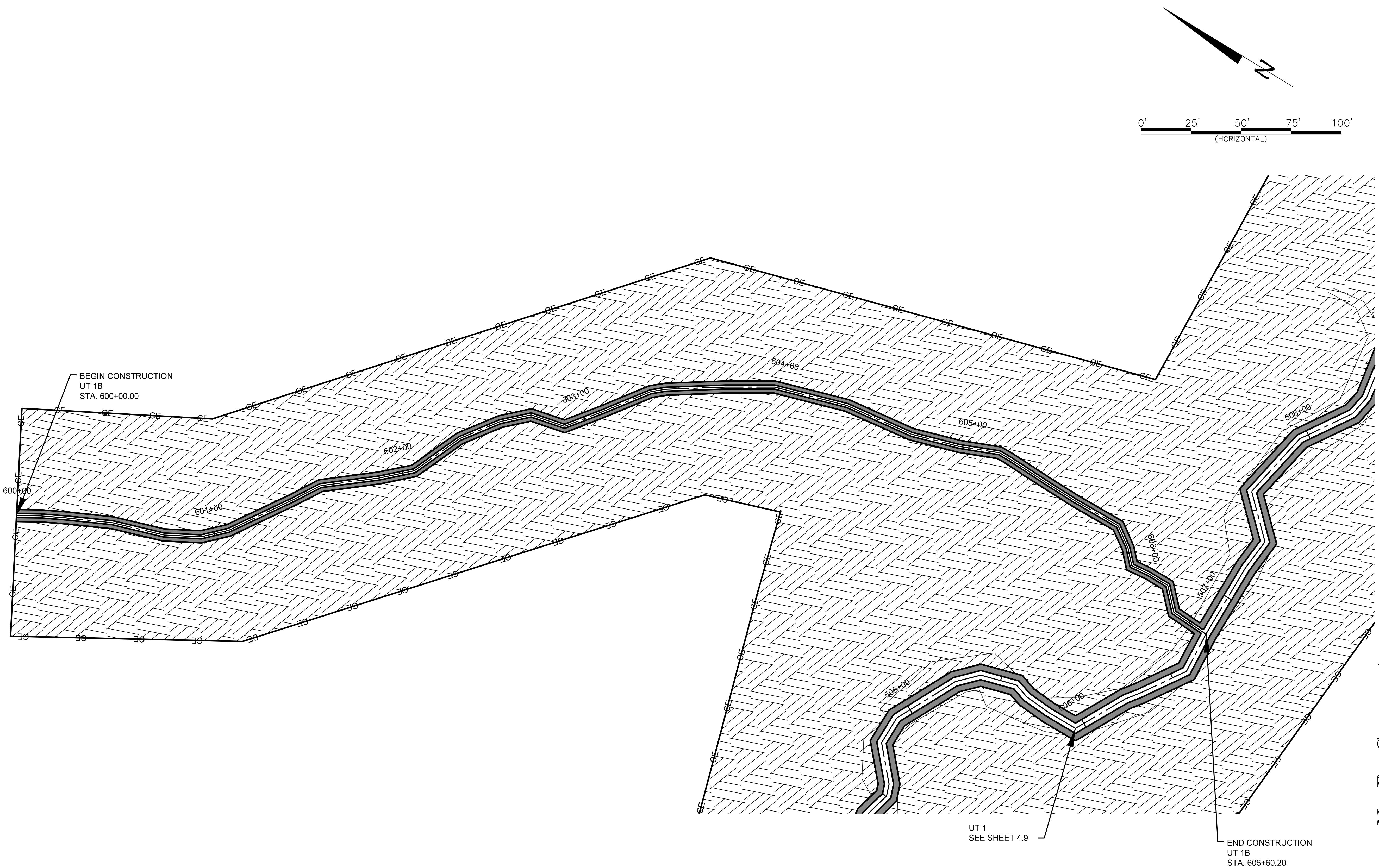

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Underwood Mitigation Site
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UT 1B
Planting

Date:	August 31, 2011
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Drawn By:	JTL
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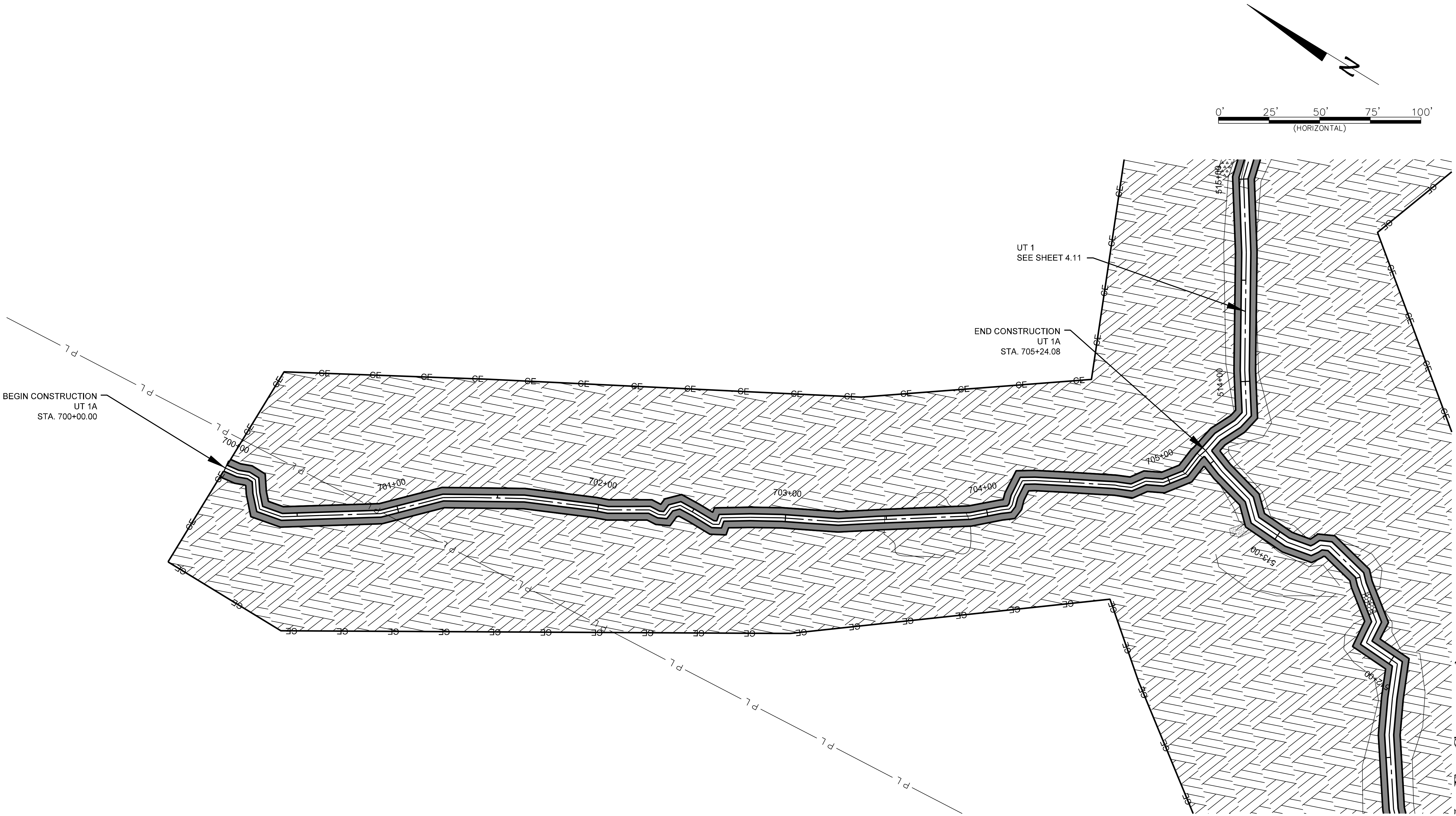

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Underwood Mitigation Site
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UT 1A
Planting

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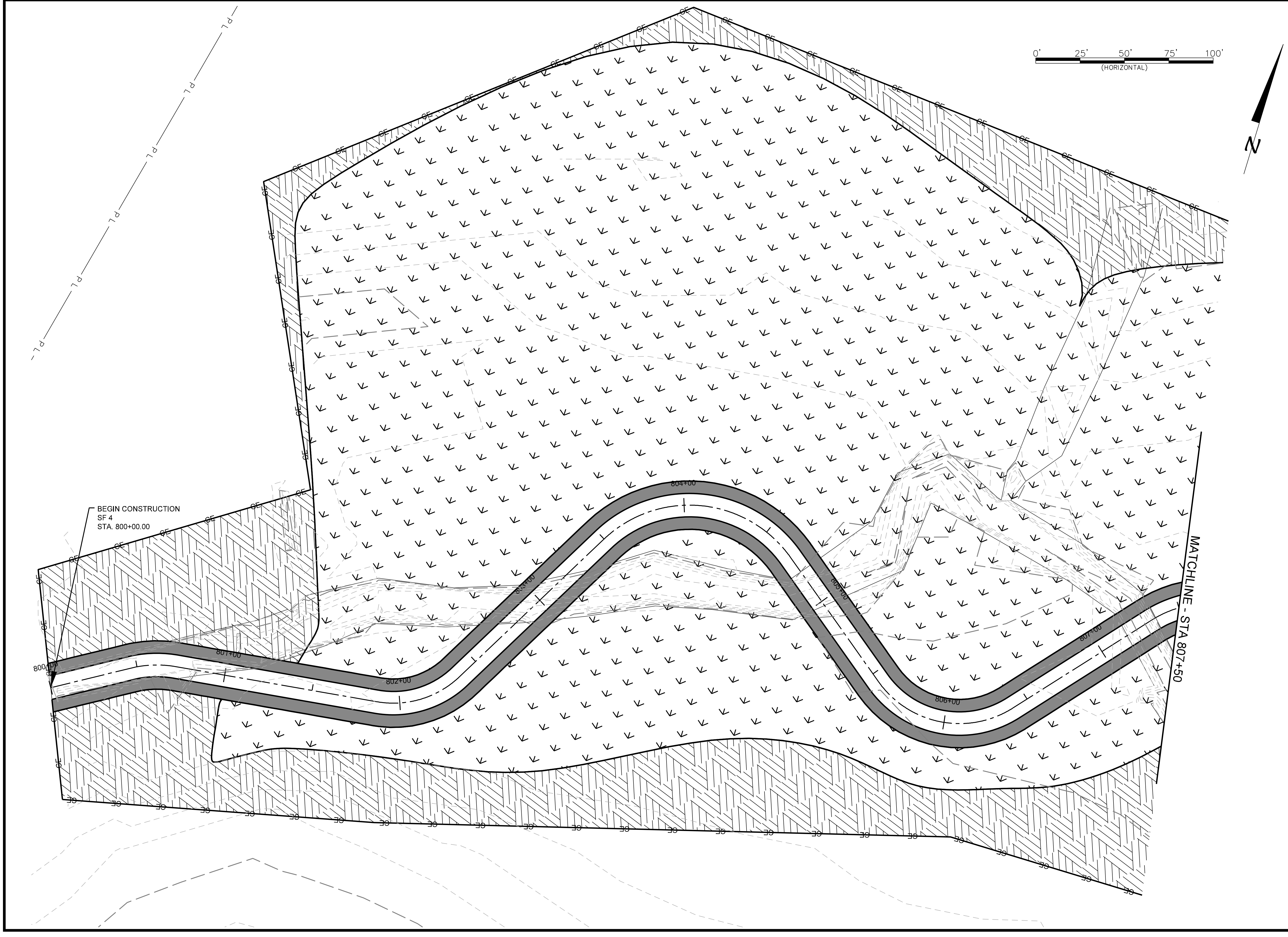

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SF 4 & RW 4
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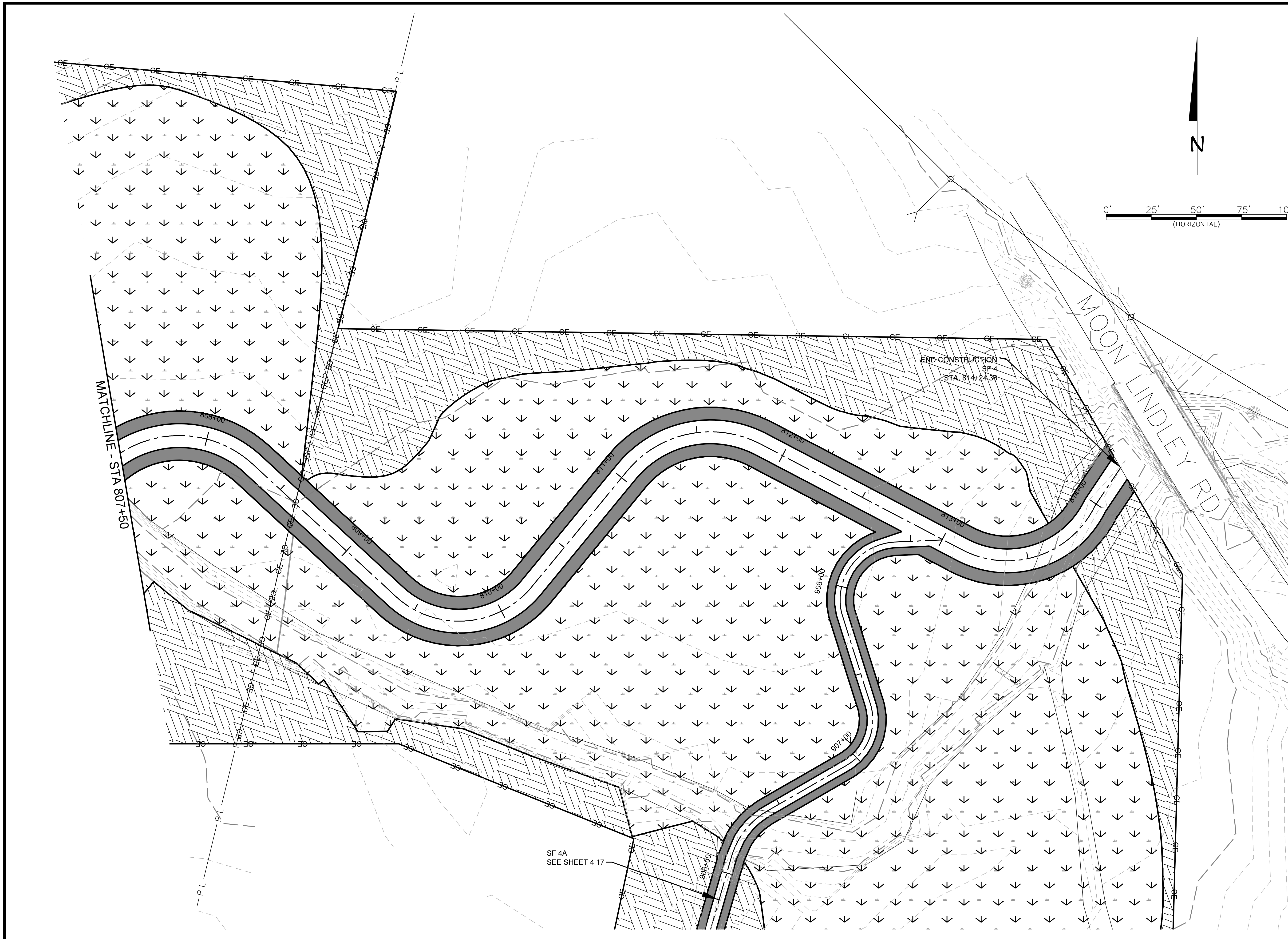

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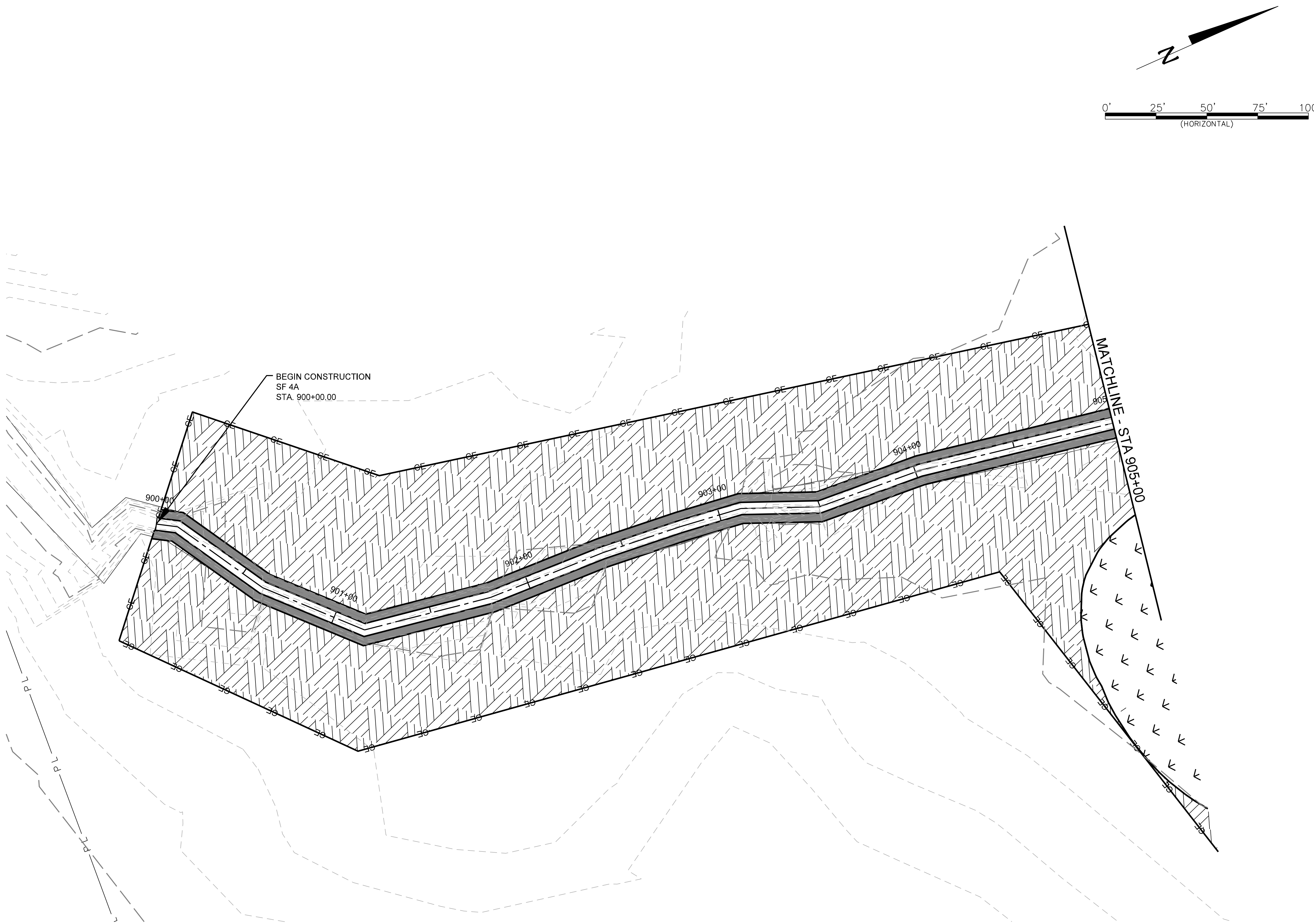

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Underwood Mitigation Site
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SF 4A
Planting

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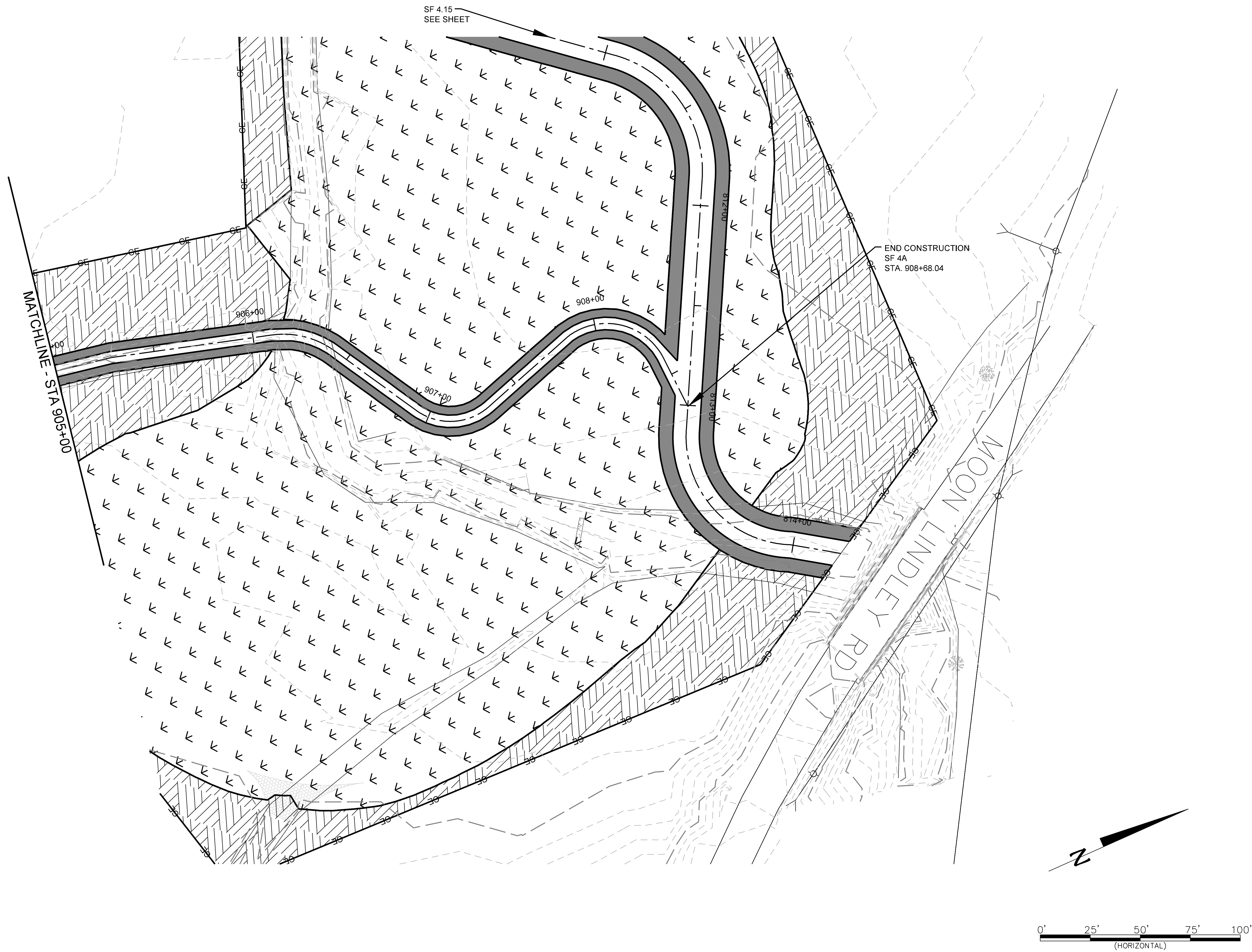

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Underwood Mitigation Site
Chatham County, NC

SF 4A
Planting

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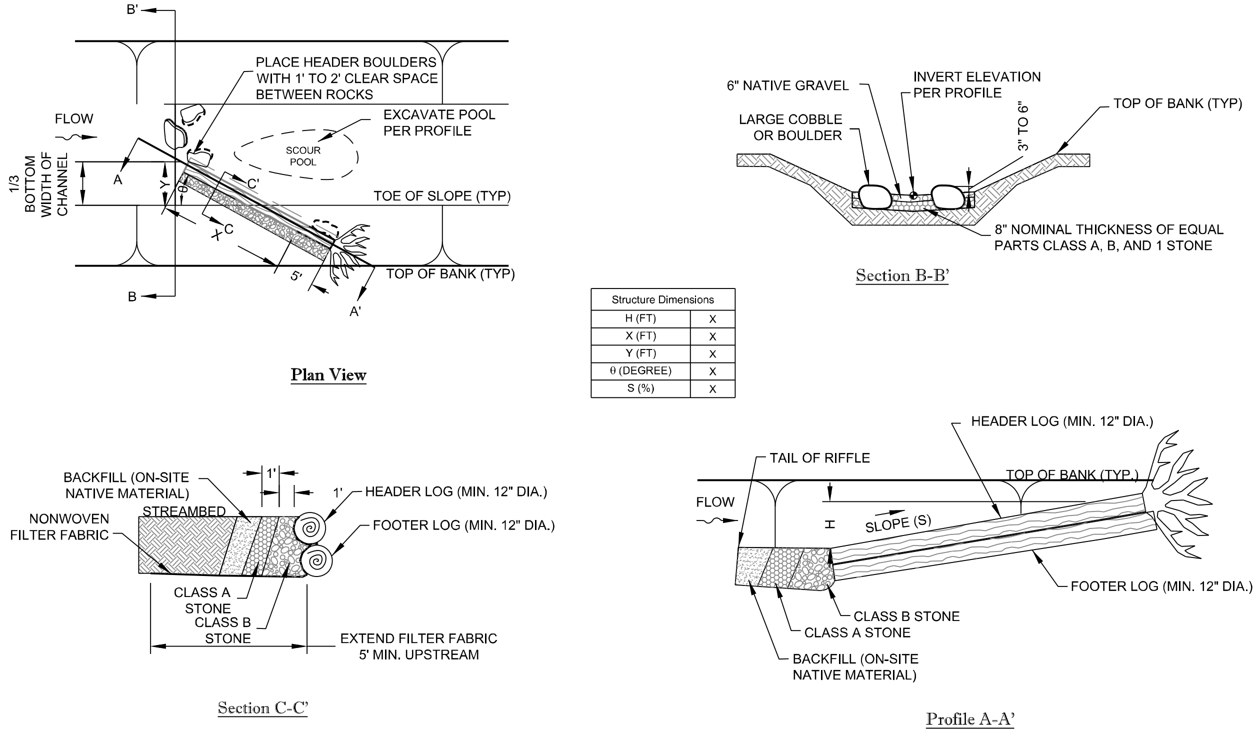
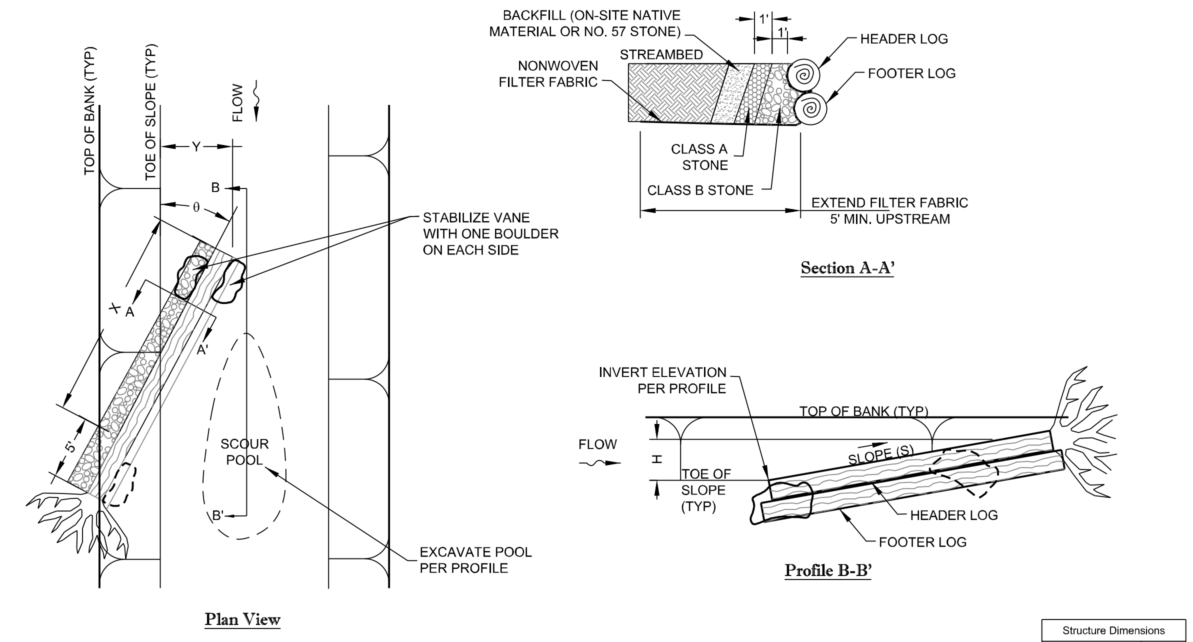


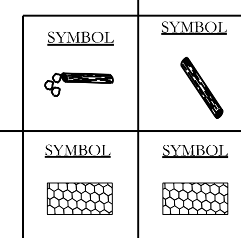
Structure Dimensions	
H (FT)	X
X (FT)	X
Y (FT)	X
θ (DEGREE)	X
S (%)	X

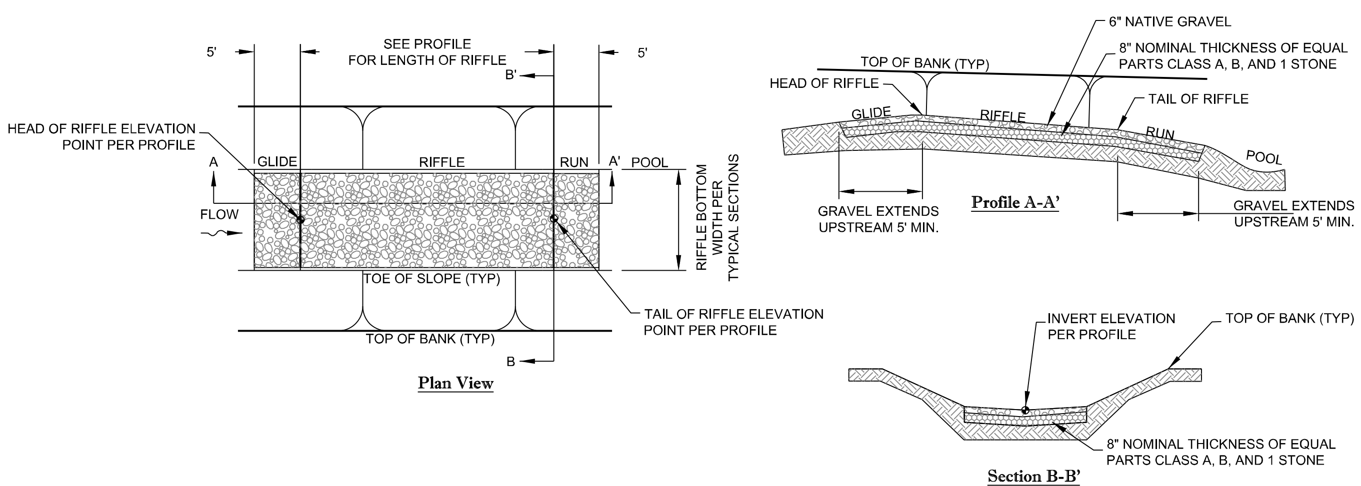
Log J-Hook
1 / 6.1 Not to Scale



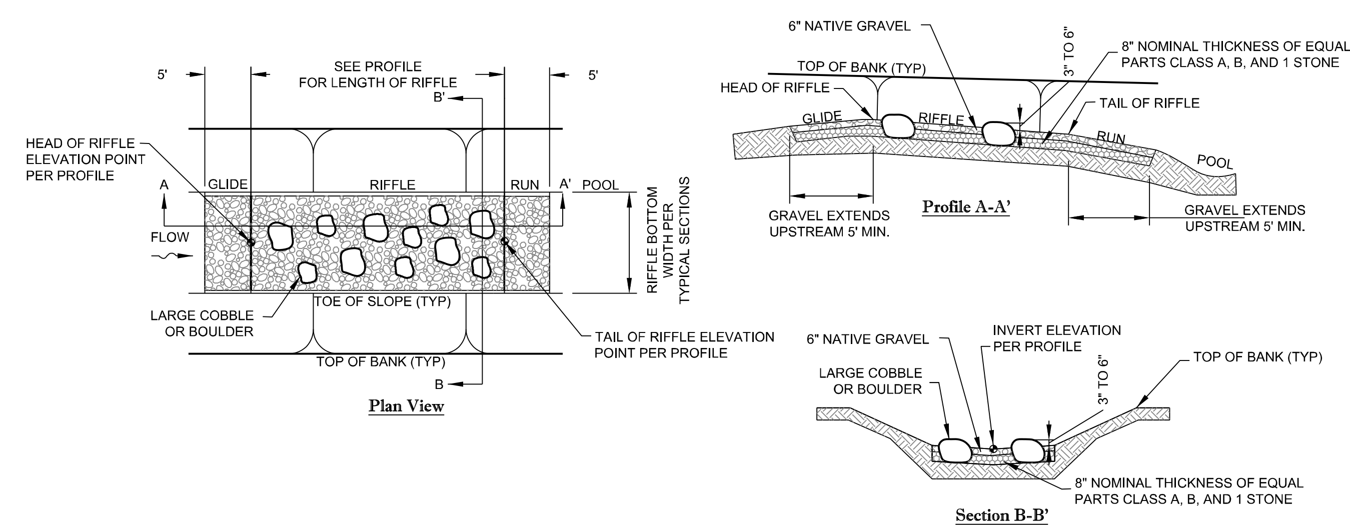
Structure Dimensions	
H (FT)	X
X (FT)	X
Y (FT)	X
θ (DEGREE)	X
S (%)	X

Log Vane
2 / 6.1 Not to Scale





Constructed Riffle with Native Gravel - Type A
3 / 6.1 Not to Scale



Chunky Riffle - Type B
4 / 6.1 Not to Scale

Preliminary Plans - Not For Construction

Underwood Mitigation Site
Chatham County, NC

Details

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DETAILS

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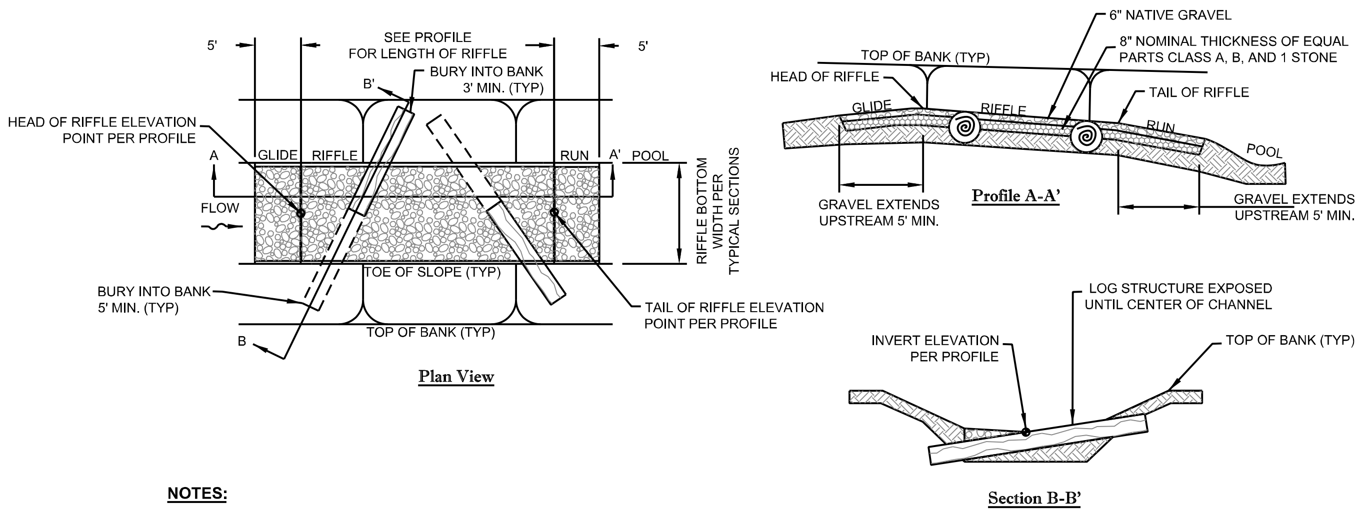
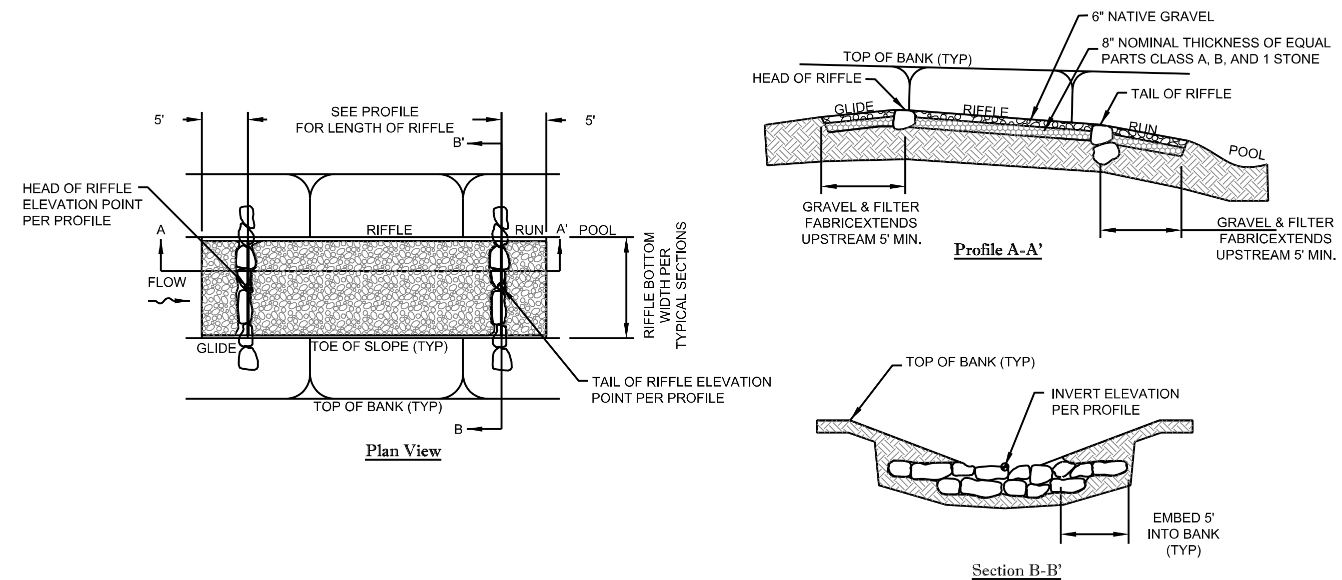
6.1



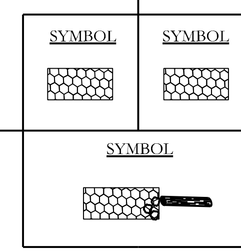
NOTES:

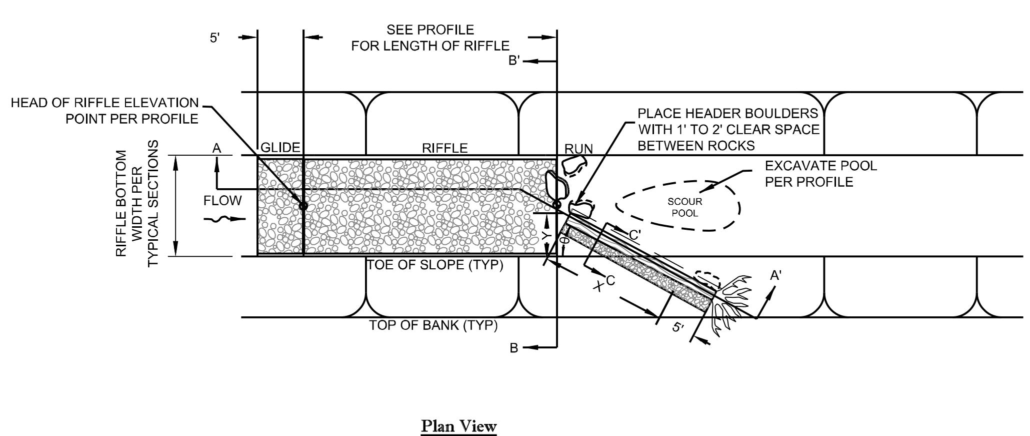
1. STRUCTURES SHOULD VARY IN SIZE AND TYPE WITHIN EACH RIFFLE.
2. LOGS MAY BE SUBSTITUTED BY ROCK AT ENGINEERS DISCRETION.

1/6.2 Jazz Riffle Structure - Type D
Not to Scale

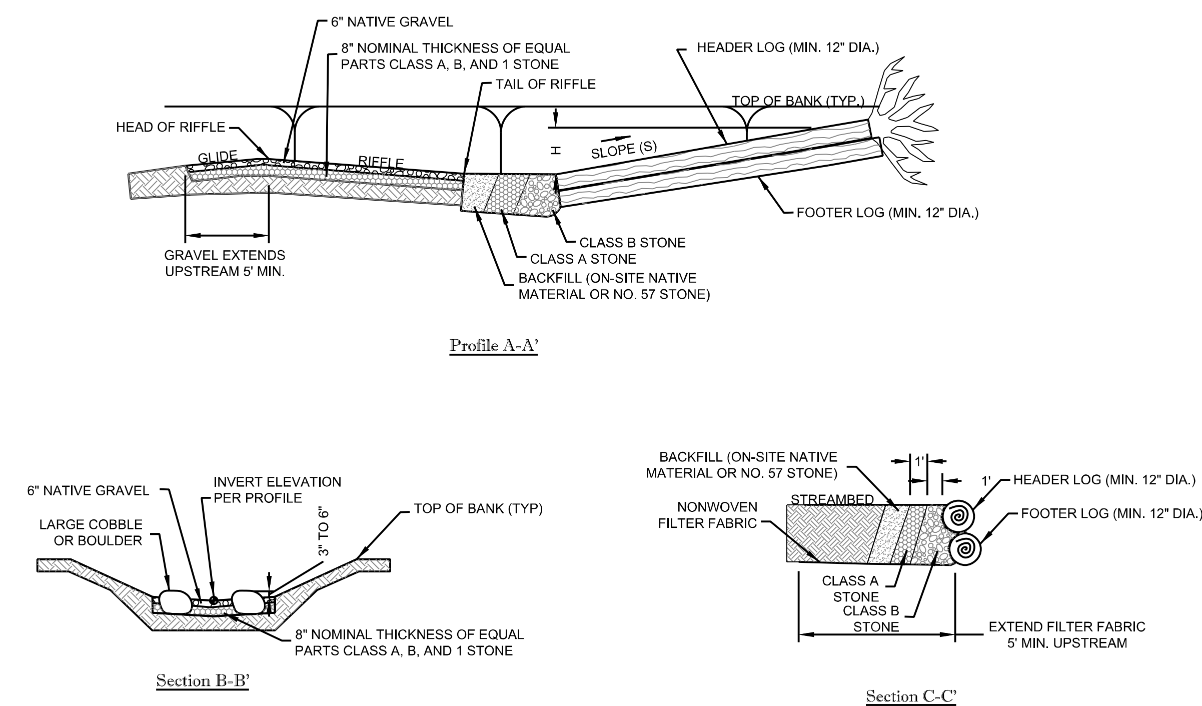


2/6.2 Constructed Riffle with Boulder Sills - Type E
Not to Scale





Structure Dimensions	
H (FT)	X
W (FT)	X
X (FT)	X
Y (FT)	X
θ (DEGREE)	X
S (%)	X



3/6.2 Constructed Riffle to J-Hook - Type C
Not to Scale

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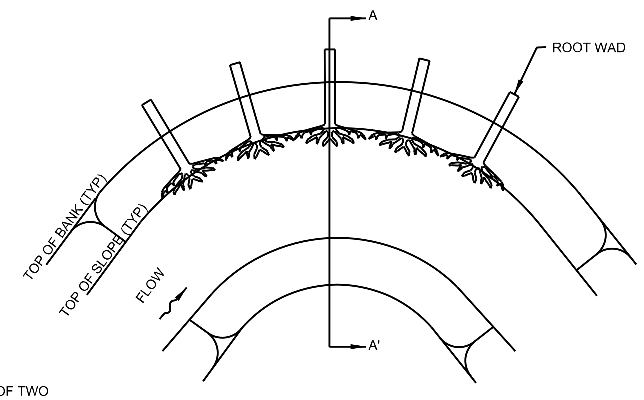
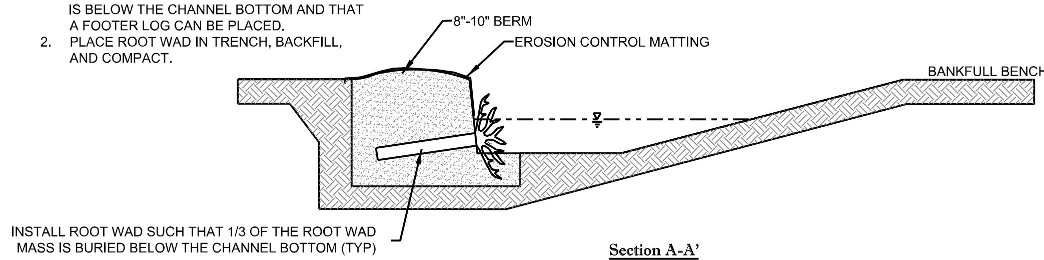
6.2



Plan View

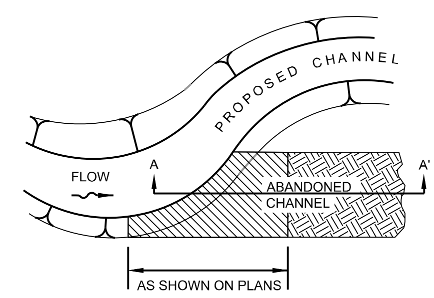
ROOT WAD INSTALLATION:

1. EXCAVATE A TRENCH A MINIMUM OF TWO TIMES THE WIDTH OF THE TRUNK AND DEEP ENOUGH SUCH THAT ⅓ OF THE ROOTMASS IS BELOW THE CHANNEL BOTTOM AND THAT A FOOTER LOG CAN BE PLACED.
2. PLACE ROOT WAD IN TRENCH, BACKFILL, AND COMPACT.

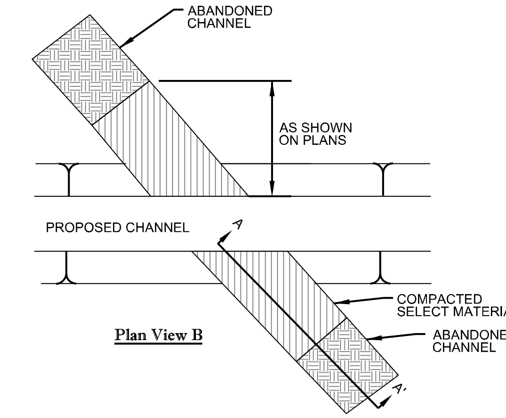


Section A-A'

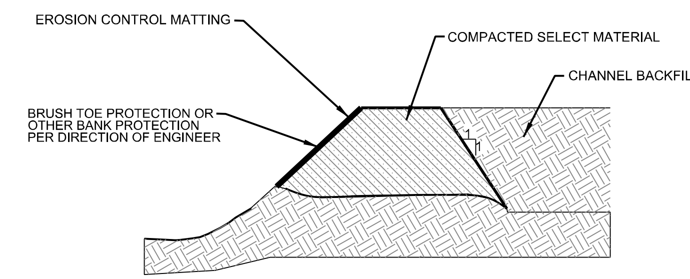
1 / 6.3 Root Wad
Not to Scale



Plan View A



Plan View B

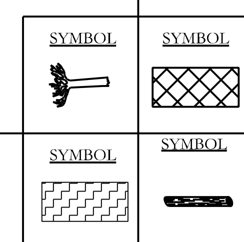


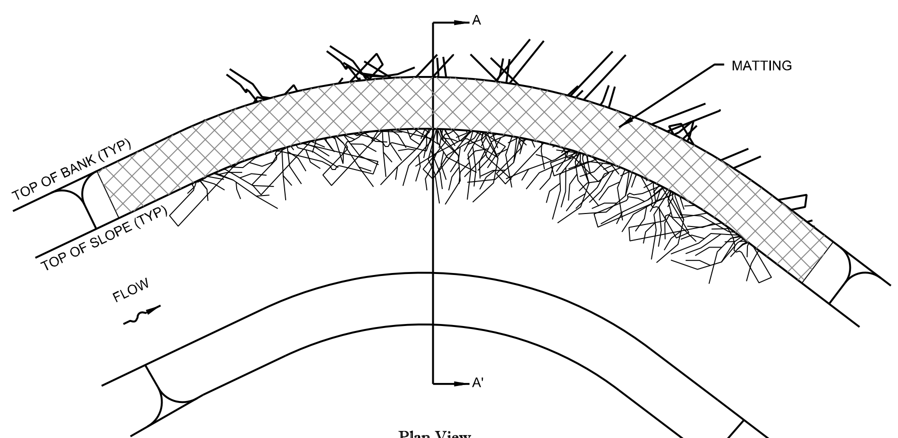
Section A-A'

NOTE:

1. COMPACTED SELECT MATERIAL SHALL BE A SUBSURFACE CLAY MATERIAL. THIS MATERIAL SHALL BE COMPACTED INTO THE EXISTING CHANNEL AS DIRECTED BY THE DESIGNER TO CREATE AN IMPERVIOUS PLUG AFTER WATER IS TURNED INTO THE NEW CHANNEL.

2 / 6.3 Channel Plug
Not to Scale

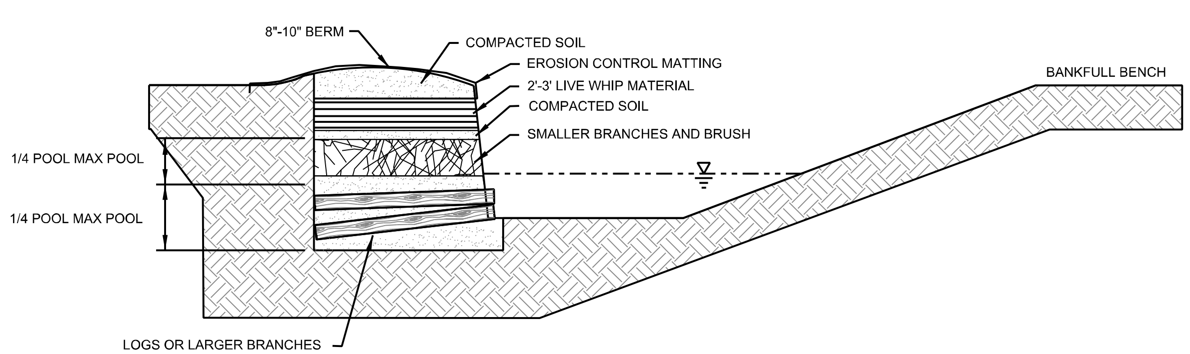




Plan View

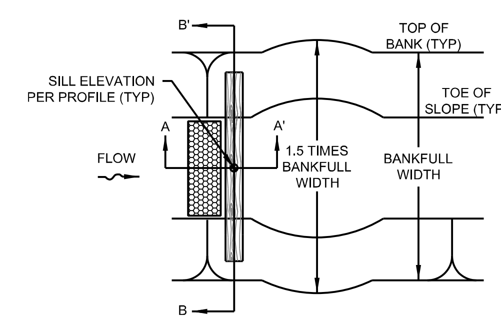
NOTES:

1. OVER-EXCAVATE THE OUTSIDE BEND OF THE CHANNEL, LAY LARGER LOGS AND BRANCHES IN A CRISS-CROSS FASHION, LOCK IN PLACE WITH FILL COVERING 1'-2' OF THE LARGER LOGS.
2. LAY SMALLER BRANCHES AND BRUSH OVER LARGER LOGS, PRESS TIGHTLY TOGETHER. BACKFILL TO LOCK IN PLACE.
3. LAY LIVE WHIP MATERIAL OVER SOIL COVERING SMALLER BRANCH MATERIAL AND COVER WITH SOIL.
4. LAY EROSION CONTROL MATTING OVER SOIL COVERING LIVE WHIP MATERIAL WITH 1/2 OF LENGTH OF MATTING EXTENDING INTO CHANNEL. PLACE SOIL OVER MATTING TO A HEIGHT OF 6" - 10" ABOVE TOP OF BANK ELEVATION. WRAP EROSION CONTROL MATTING OVER SOIL LAYER AND STAKE IN PLACE ACCORDING TO EROSION CONTROL MATTING DETAIL.

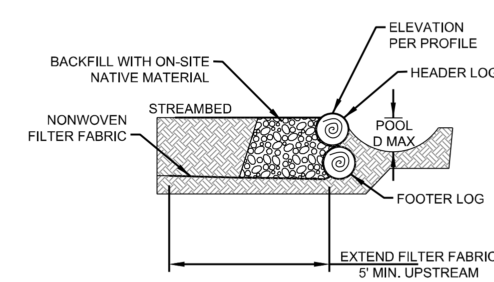


Section A-A'

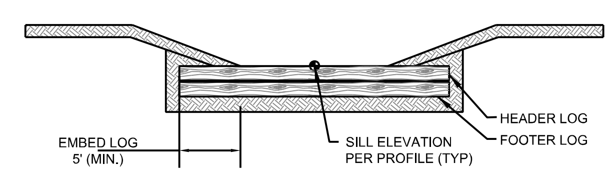
3 / 6.3 Brush Toe
Not to Scale



Plan View



Profile A-A'



Section B-B'

4 / 6.3 Log Sill
Not to Scale

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Underwood Mitigation Site
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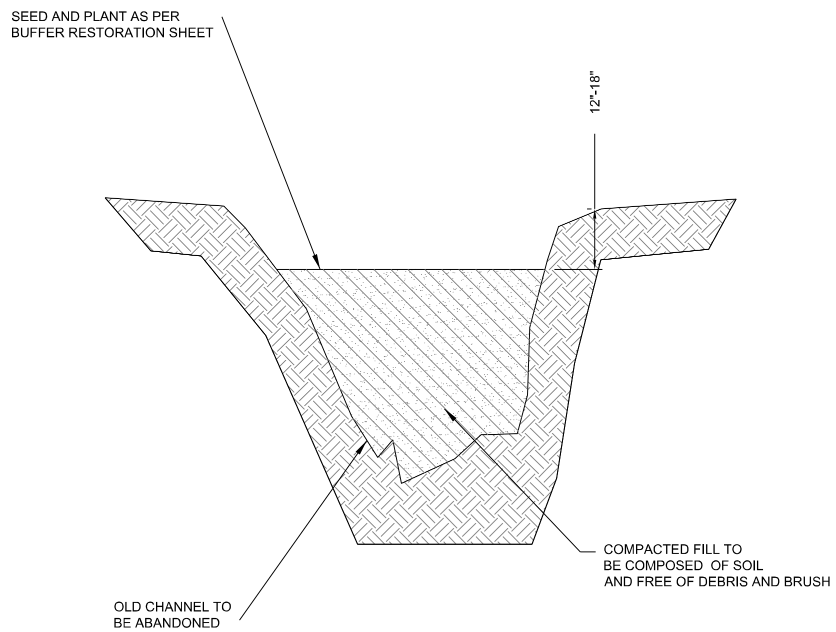
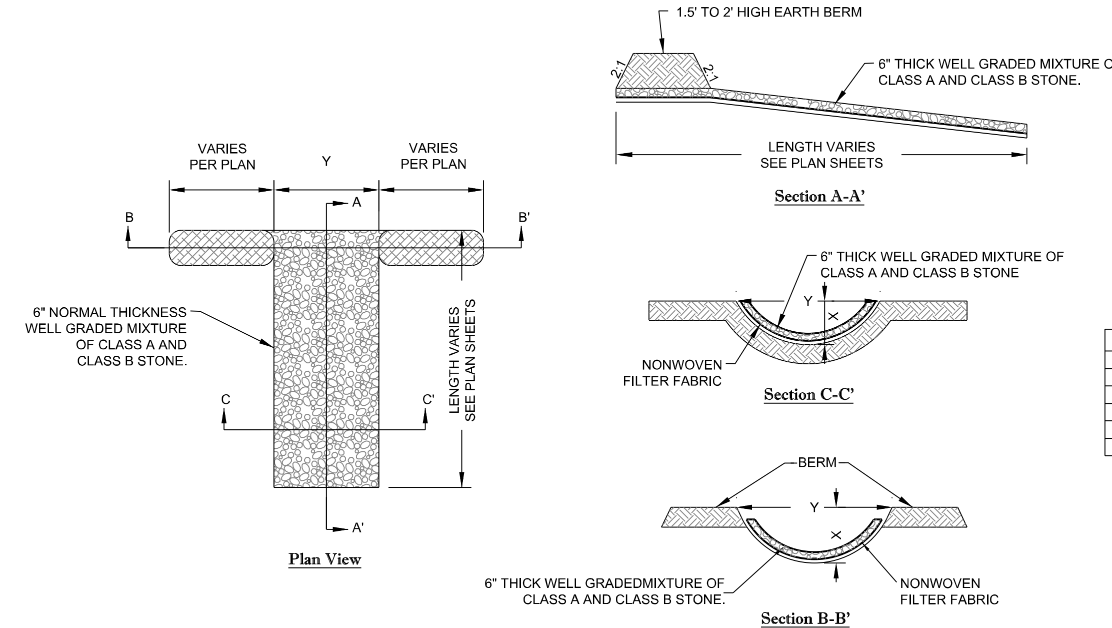
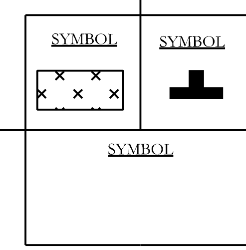


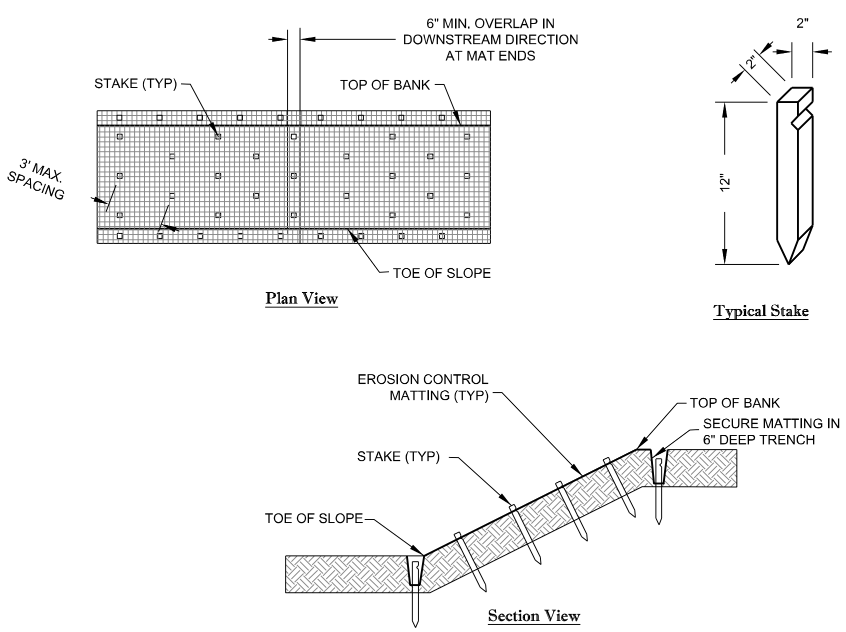
1 6.4 Ephemeral Pool
Not to Scale

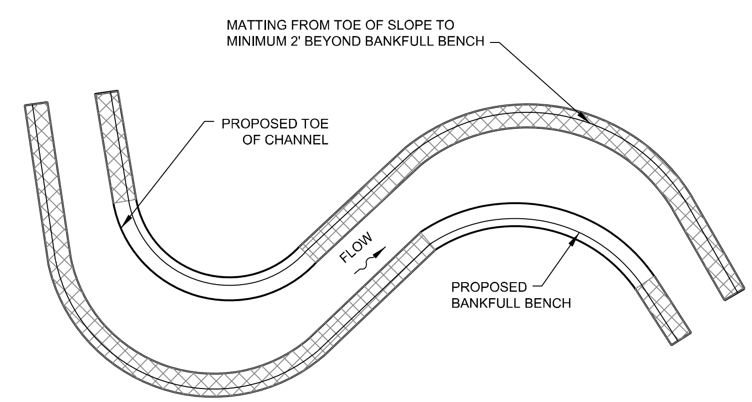


Structure Dimensions	
H (FT)	X
W (FT)	X
X (FT)	X
Y (FT)	X
θ (DEGREE)	X
S (%)	X

2 6.4 Drainage Berm
Not to Scale







NOTES:

1. MATTING SHALL BE PLACED ON BOTH BANKS ALONG THE ENTIRE LENGTH OF THE CHANNEL, WITH THE EXCEPTION OF POINT BARS.

3 6.4 Erosion Control Matting
Not to Scale

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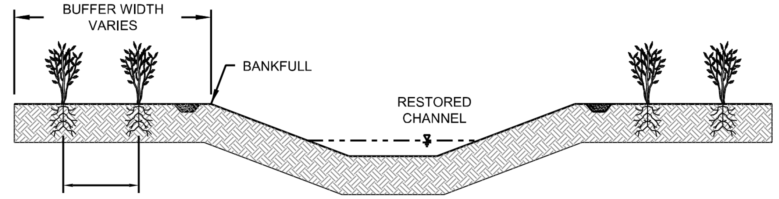
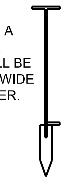


Section View

DIBBLE BAR

PLANTING BAR SHALL HAVE A BLADE WITH A TRIANGULAR CROSS-SECTION, AND SHALL BE 12 INCHES LONG, 4 INCHES WIDE AND 1 INCH THICK AT CENTER.

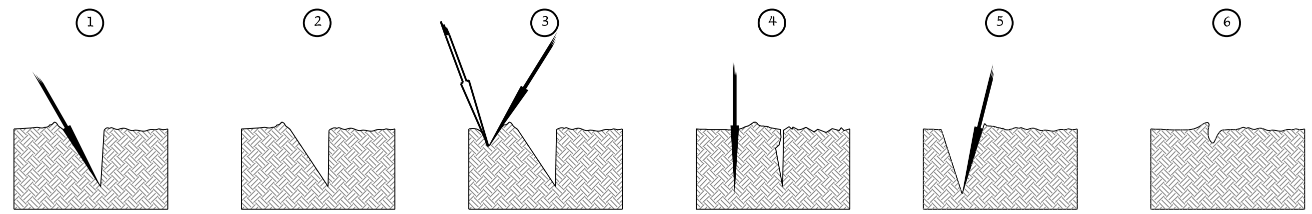


ROOTING PRUNING

ALL ROOTS SHALL BE PRUNED TO AN APPORIATE LENGTH TO PREVENT J-ROOTING.

NOTES:

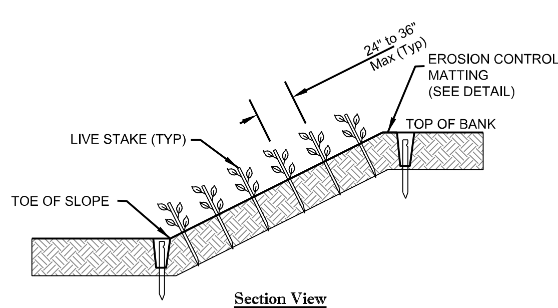
1. ALL SOILS WITHIN THE BUFFER PLANTING AREA SHALL BE DISKED, AS REQUIRED, PRIOR TO PLANTING.
2. ALL PLANTS SHALL BE PROPERLY HANDLED PRIOR TO INSTALLATION TO INSURE SURVIVAL.



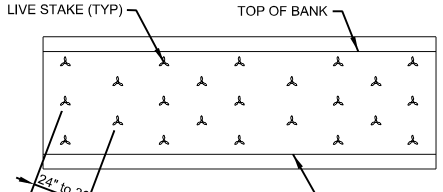
1. INSERT THE DIBBLE, OR SHOVEL, STRAIGHT DOWN INTO THE SOIL TO THE FULL DEPTH OF THE BLADE AND PULL BACK ON THE HANDLE TO OPEN THE PLANTING HOLE. (DO NOT ROCK THE SHOVEL BACK AND FORTH AS THIS CAUSES SOIL IN THE PLANTING HOLE TO BE COMPACTED, INHIBITING ROOT GROWTH.
2. REMOVE THE DIBBLE, OR SHOVEL, AND PUSH THE SEEDLING ROOTS DEEP INTO THE PLANTING HOLE. PULL THE SEEDLING BACK UP TO THE CORRECT PLANTING DEPTH (THE ROOT COLLAR SHOULD BE 1 TO 3 INCHES BELOW THE SOIL SURFACE). GENTLY SHAKE THE SEEDLING TO ALLOW THE ROOTS TO STRAIGHTEN OUT. DO NOT TWIST OR SPIN THE SEEDLING OR LEAVE THE ROOTS J-ROOTED.
3. INSERT THE DIBBLE, OR SHOVEL, SEVERAL INCHES IN FRONT OF THE SEEDLING AND PUSH THE BLADE HALFWAY INTO THE SOIL. TWIST AND PUSH THE HANDLE FORWARD TO CLOSE THE TOP OF THE SLIT TO HOLD THE SEEDLING IN PLACE.
4. PUSH THE DIBBLE, OR SHOVEL, DOWN TO THE FULL DEPTH OF THE BLADE.
5. PULL BACK ON THE HANDLE TO CLOSE THE BOTTOM OF THE PLANTING HOLD. THEN PUSH FORWARD TO CLOSE THE TOP, ELIMINATING AIR POCKETS AROUND THE ROOT.
6. REMOVE THE DIBBLE, OR SHOVEL, AND CLOSE AND FIRM UP THE OPENING WITH YOUR HEEL. BE CAREFUL TO AVOID DAMAGING THE SEEDLING.

1/6.5 Bare Root Planting
Not to Scale

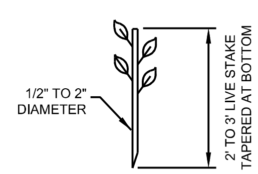
SYMBOL



Section View



Plan View

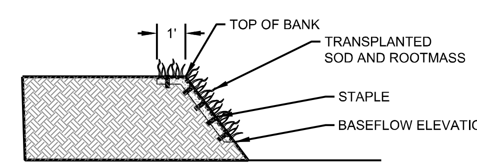


Live Stake Detail

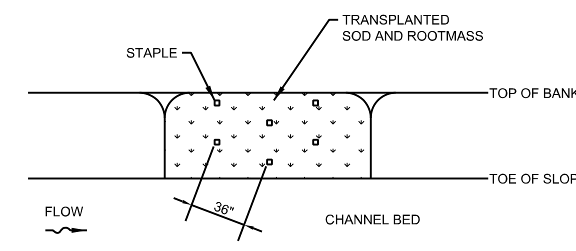
NOTE:

1. LIVE STAKES TO BE PLANTED IN AREAS AS SHOWN ON PLANS AND DIRECTED BY THE ENGINEER.

2/6.5 Live Staking
Not to Scale



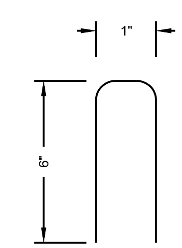
Section View



Typical Plan View

NOTES:

1. PREPARE THE BANK WHERE THE SOD MAT WILL BE TRANSPLANTED BY RAKING AS DIRECTED BY ENGINEER.
2. EXCAVATE TRANSPLANT SOD MATS WITH A WIDE BUCKET AND AS MUCH ADDITIONAL SOIL MATERIAL AS POSSIBLE.
3. PLACE TRANSPLANT ON THE BANK TO BE STABILIZED.
4. SECURE WITH SOD STAPLES.
5. FILL IN ANY HOLES AROUND THE TRANSPLANT AND COMPACT.
6. ANY LOOSE SOIL LEFT IN THE STREAM SHOULD BE REMOVED.
7. PLACE MULTIPLE TRANSPLANTS CLOSE TOGETHER SUCH THAT THEY TOUCH.



Typical Staple

3/6.5 Transplanted Sod Mats
Not to Scale

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Preliminary Plans - Not For Construction

Underwood Mitigation Site
Chatham County, NC
Planting Details

Date:	August 31, 2011
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

PLANTING DETAILS

Sheet
6.5