AS-BUILT MITIGATION PLAN
LLOYD STREAM AND WETLAND RESTORATION SITE
ONSLOW COUNTY, NORTH CAROLINA

(CONTRACT #16-D06003-1)
FULL DELIVERY PROJECT
CAPE FEAR/WHITE OAK RIVER BASIN
CATALOGING UNIT 03030001

Prepared for:

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
RALEIGH, NORTH CAROLINA

Prepared by:

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

And

Axiom Environmental, Inc.

Restoration Systems, LLC
1101 Haynes Street, Suite 107
Raleigh, North Carolina 27604

Axiom Environmental, Inc.
2126 Rowland Pond Drive
Willow Springs, North Carolina 27592

May 2007
Amended July 2007

LLOYD STREAM AND WETLAND RESTORATION SITE
AS-BUILT MITIGATION PLAN
ONSLOW COUNTY

EXECUTIVE SUMMARY

Restoration Systems, LLC. (Restoration Systems) has completed the restoration of stream, riverine wetlands, and nonriverine wetlands at the Lloyd Stream and Wetland Restoration Site (hereafter referred to as the "Site") to assist the North Carolina Ecosystem Enhancement Program (EEP) in fulfilling stream and wetland mitigation goals in the region. The Site is located approximately 1 mile southeast of Richlands and 5 miles northwest of Jacksonville, in Onslow County. The Site encompasses 24.3 acres, which contains 22.5 acres of hydric soil, two unnamed tributaries (UTs) to the New River, riparian buffer, and upland slopes. The project consists of 5858 linear feet of constructed stream channel, 3.3 acres of riverine wetland restoration, 3.1 acres of nonriverine wetland restoration, and approximately 23.1 acres of reforestation, with benefits to water quality and wildlife.

The Site is located in United States Geological Survey (USGS) Hydrologic Unit (HU) 03030001010030 (North Carolina Division of Water Quality [NCDWQ] Subbasin 03-05-02) of the White Oak River Basin and will service the USGS 8-digit Cataloging Unit 03030001. This subbasin of the White Oak River Basin is entirely contained within Onslow County and consists of the New River and its tributaries, several small Coastal Plain streams, and the Intracoastal Waterway.

A Detailed Stream and Wetland Restoration Plan was completed for the Site in June 2006. The plan outlined methods to restore pastureland used for livestock grazing. Site alterations including removal of riparian vegetation and straightening and rerouting of stream channels resulted in degraded water quality, unstable channel characteristics (stream entrenchment, erosion, and bank collapse), and decreased wetland function. Prior to implementation, the 24.3-acre Site was underlain by approximately 22.0 acres of hydric soil that had been effectively drained and 0.5 acres of hydric soil with jurisdictional wetland hydrology. The Detailed Stream and Wetland Restoration Plan outlined restoration procedures including 1) belt-width preparation and grading, 2) floodplain bench excavation, 3) channel excavation, 4) installation of channel and ditch plugs, 5) backfilling of the abandoned channel and ditches, 6) ditch rerouting, 7) installation of in-stream structures and a Terracell drop structure at the Site outfall, 8) construction of a piped channel crossing, 9) floodplain soil scarification, and 10) plant community restoration.

The primary goals of this stream and wetland restoration project focused on improving water quality, enhancing flood attenuation, and restoring aquatic and riparian habitat and were accomplished by:

- Removing nonpoint sources of pollution associated with agricultural production including a) removal of livestock from streams, stream banks, and floodplains; b) cessation of broadcasting fertilizer, pesticides, and other agricultural materials into and adjacent to Site streams and wetlands; and c) provide a vegetative buffer adjacent to streams and wetlands to treat surface runoff.
- Reducing sedimentation within onsite and downstream receiving waters through a) a reduction of bank erosion associated with hoof shear, vegetation maintenance, and agricultural plowing to Site streams and b) providing a forested vegetative buffer adjacent to Site streams and wetlands.
- Reestablishing stream stability and the capacity to transport watershed flows and sediment loads by restoring stable dimension, pattern, and profile.

- Promoting floodwater attenuation through a) reconnecting bankfull stream flows to the abandoned floodplain terrace; b) restoring secondary, entrenched tributaries thereby reducing floodwater velocities within smaller catchment basins; c) restoring depressional floodplain wetlands and increasing storage capacity for floodwaters within the Site; and d) revegetating Site floodplains to increase frictional resistance on floodwaters crossing Site floodplains.
- Improving aquatic habitat by enhancing stream bed variability.
- Providing wildlife habitat including a forested riparian corridor within a region of the state highly dissected by agricultural land use.

As constructed, the Site provides 5858 linear feet of constructed stream, 3.3 acres of riverine wetland restoration, 3.1 acres of nonriverine wetland restoration, and 23.1 acres of forested upland buffer for a minimum of 4750 Stream Mitigation Units (SMUs), 3.3 Riverine Wetland Mitigation Units, and 3.1 Nonriverine Wetland Mitigation Units. The project offers 4750 SMUs; however, 5858 linear feet of channel was constructed. The reduction in footage results from 1) reaches of channel outside of the conservation easement, 2) reaches of channel expected to braid in the upper extent of the Site (sinuosity reduction from 1.3 to 1.1), and 3) linear footage of TerraCell drop structure. In total the Site is expected provide a minimum of 4750 SMUs after 5 years of Site monitoring.

TABLE OF CONTENTS

TABLES

APPENDICES

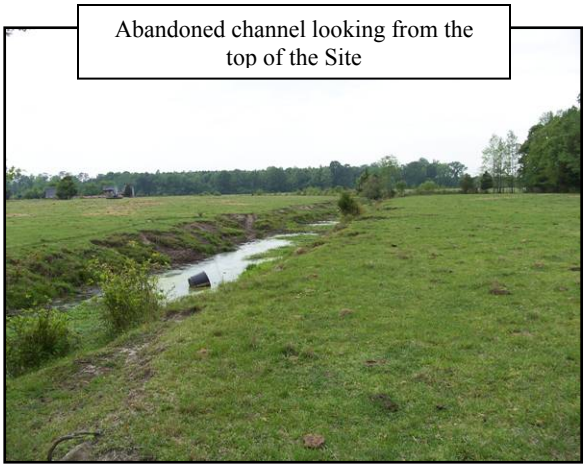
FIGURES

Lloyd Site Preconstruction Conditions

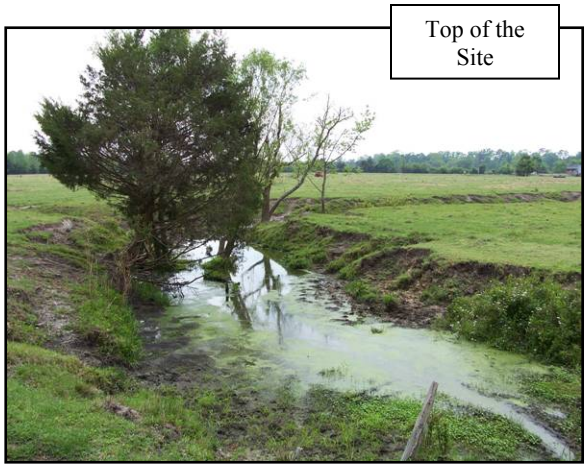
Bottom of the Site

Area proposed for nonriverine wetland restoration

Abandoned channel looking from the top of the Site

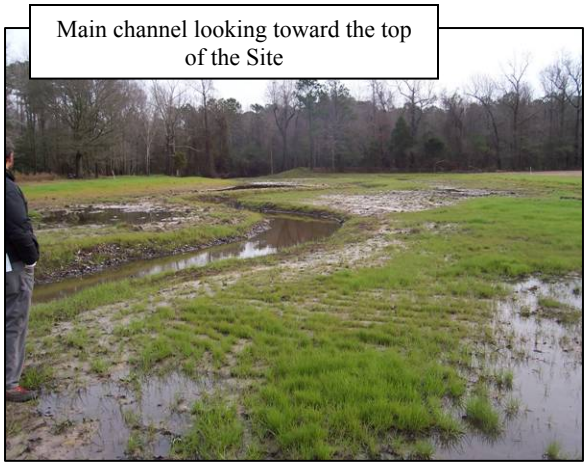


Top of the Site

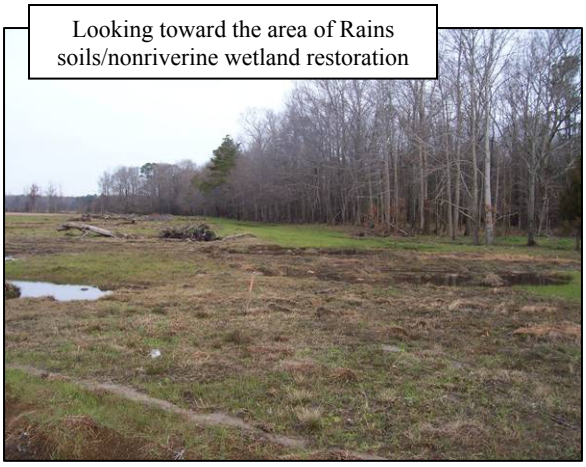


Lloyd Site During Construction

Main channel looking toward the top of the Site



Looking toward the area of Rains soils/nonriverine wetland restoration



LLOYD STREAM AND WETLAND RESTORATION SITE
AS-BUILT MITIGATION PLAN
ONSLOW COUNTY

1.0 INTRODUCTION

Restoration Systems, LLC. (Restoration Systems) has completed the restoration of stream, riverine wetlands, and nonriverine wetlands at the Lloyd Stream and Wetland Restoration Site (hereafter referred to as the "Site") to assist the North Carolina Ecosystem Enhancement Program (EEP) in fulfilling stream and wetland mitigation goals in the region. The Site is located approximately 1 mile southeast of Richlands and 5 miles northwest of Jacksonville, in Onslow County (Figure 1, Appendix A). The Site encompasses 24.3 acres, which contains 22.5 acres of hydric soil, two unnamed tributaries (UTs) to the New River, riparian buffer, and upland slopes. The project consists of 5858 linear feet of constructed stream, 3.3 acres of riverine wetland restoration, 3.1 acres of nonriverine wetland restoration, and 23.1 acres of reforestation, with benefits to water quality and wildlife.

The Site is located in United States Geological Survey (USGS) Hydrologic Unit (HU) 03030001010030 (North Carolina Division of Water Quality [NCDWQ] Subbasin 03-05-02) of the White Oak River Basin and will service the USGS 8-digit Cataloging Unit 03030001 (Figure 2, Appendix A) (USGS 1974). This subbasin of the White Oak River Basin is entirely contained within Onslow County and consists of the New River and its tributaries, several small Coastal Plain streams, and the Intracoastal Waterway (NCDWQ 2001).

A Detailed Stream and Wetland Restoration Plan was completed for the Site in June 2006. The plan outlined methods to restore pastureland used for livestock grazing. Site alterations including removal of riparian vegetation and straightening and rerouting of stream channels resulted in degraded water quality, unstable channel characteristics (stream entrenchment, erosion, and bank collapse), and decreased wetland function. Prior to implementation, the Site was underlain by approximately 22.0 acres of hydric soil that had been effectively drained and 0.5 acres of hydric soil with jurisdictional wetland hydrology. The Detailed Stream and Wetland Restoration Plan outlined restoration procedures including 1) belt-width preparation and grading, 2) floodplain bench excavation, 3) channel excavation, 4) installation of channel and ditch plugs, 5) backfilling of the abandoned channel and ditches, 6) ditch rerouting, 7) installation of in-stream structures and a Terracell drop structure at the Site outfall, 8) construction of a piped channel crossing, 9) floodplain soil scarification, and 10) plant community restoration.

The following objectives were proposed to provide mitigation credit requested under the EEP Request For Proposal (RFP) #16-D06003 dated March 23, 2005.

- Provide 4750 Stream Mitigation Units, as calculated in accordance with the requirements stipulated in RFP #16-D06003.
- Restore approximately 4750 linear feet of stream channel through construction of stable channel.
- Provide 3.3 Riverine Wetland Mitigation Units, as calculated in accordance with the requirements stipulated in RFP #16-D06003.
- Restore approximately 3.3 acres of riverine wetland through filling ditches, removal of spoil castings, eliminating agricultural practices, and/or planting with native forest vegetation.
- Provide 3.1 Nonriverine Wetland Mitigation Units, as calculated in accordance with the requirements stipulated in RFP #16-D06003.
- Restore approximately 3.1 acres of nonriverine wetland through filling ditches, removal of spoil castings, eliminating agricultural practices, and/or planting with native forest vegetation.

- Revegetate floodplains adjacent to restored streams and wetlands.
- Protect the Site in perpetuity with a conservation easement.

The primary goals of this stream and wetland restoration project focused on improving water quality, enhancing flood attenuation, and restoring aquatic and riparian habitat and were accomplished by:

- Removing nonpoint sources of pollution associated with agricultural production including a) removal of livestock from streams, stream banks, and floodplains; b) cessation of broadcasting fertilizer, pesticides, and other agricultural materials into and adjacent to Site streams and wetlands; and c) provide a vegetative buffer adjacent to streams and wetlands to treat surface runoff.
- Reducing sedimentation within onsite and downstream receiving waters through a) a reduction of bank erosion associated with hoof shear, vegetation maintenance, and agricultural plowing to Site streams and b) providing a forested vegetative buffer adjacent to Site streams and wetlands.
- Reestablishing stream stability and the capacity to transport watershed flows and sediment loads by restoring stable dimension, pattern, and profile.
- Promoting floodwater attenuation through a) reconnecting bankfull stream flows to the abandoned floodplain terrace; b) restoring secondary, entrenched tributaries thereby reducing floodwater velocities within smaller catchment basins; c) restoring depressional floodplain wetlands and increasing storage capacity for floodwaters within the Site; and d) revegetating Site floodplains to increase frictional resistance on floodwaters crossing Site floodplains.
- Improving aquatic habitat by enhancing stream bed variability.
- Providing wildlife habitat including a forested riparian corridor within a region of the state highly dissected by agricultural land use.

As constructed, the Site provides 5858 linear feet of constructed stream, 3.3 acres of riverine wetland restoration, 3.1 acres of nonriverine wetland restoration, and 23.1 acres of forested upland buffer for 4750 Stream Mitigation Units (SMUs), 3.3 Riverine Wetland Mitigation Units, and 3.1 Nonriverine Wetland Mitigation Units. The project offers 4750 SMUs; however, 5858 linear feet of channel was constructed. The reduction in SMUs results from 1) reaches of channel outside of the conservation easement, 2) reaches of channel expected to braid in the upper extent of the Site (sinuosity reduction from 1.3 to 1.1), and 3) linear footage of TerraCell drop structure.

2.0 SUMMARY

2.1 Preconstruction Conditions

Prior to construction, the entire Site was characterized by active pasture, fallow fields, and forest stands (Figure 3, Appendix A). Pasture was grazed by livestock including cattle and horses, and livestock had access to the entire Site. No exclusionary barriers were located adjacent to onsite streams or wetlands and livestock contributed to degradation of stream banks and compacted hydric soils.

Preconstruction Site Land Use

Streams

The Site encompasses two UTs to the New River (main and eastern tributaries) as well as the adjacent floodplain and hydric soils (Figure 3, Appendix A). The tributaries converge on the Site and drain an approximately 1.4-square mile watershed at the Site outfall. The main tributary, a second-order, bank-to-bank stream system, was impacted by ditching, vegetative clearing, hoof shear from cattle and horses, and erosive flows. A portion of the tributary was relocated from its original floodplain position to a linear ditch excavated along the edge of cleared pasture land.

The eastern tributary, a first-order, bank-to-bank stream system, had been impacted by ditching, vegetative clearing, hoof shear from cattle and horses, and incision and no longer received natural stream flows. A berm was placed near the eastern property/Site boundary to redirect stream flows into a linear ditch that drained south along the eastern property boundary into roadside ditches along the southern property boundary. The roadside ditch tied into the main tributary in the southwestern portion of the Site.

Riverine Hydric Soils

Riverine areas of hydric Muckalee soils had been disturbed by stream alterations including dredging, straightening, rerouting, and downcutting of streams; floodplain ditching; deforestation; and soil compaction due to livestock grazing. Site soils of the Muckalee series appeared to have historically supported jurisdictional riverine wetlands that were intermittently flooded by over-bank stream flows, upland runoff, groundwater migration into the Site, and, to a lesser extent, direct precipitation.

Nonriverine Hydric Soils

Nonriverine areas of hydric Rains soils had been disturbed by ditching, deforestation, and soil compaction due to livestock grazing. Site soils of the Rains series appeared to have historically supported jurisdictional nonriverine wetlands with groundwater hydrology driven primarily by precipitation.

Plant Communities

Two plant communities existed on the Site: 1) pasture/fallow fields and 2) forest (Figure 3, Appendix A).

Pastureland maintained little vegetative diversity, and was dominated by fescue (*Festuca* sp.) planted for grazing. Occasional opportunistic weeds were encountered and various shrubs and vines occured along ditch and stream banks such as greenbrier (*Smilax* sp.), Japanese honeysuckle (*Lonicera japonica*), Chinese privet (*Ligustrum sinense*), and rushes (*Juncus* spp.).

Forested areas occured within a small portion of the Site. The community was characterized by a canopy layer consisting of sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), cherrybark oak (*Quercus pagoda*), American holly (*Ilex opaca*), white oak (*Quercus alba*), water oak (*Quercus nigra*), loblolly pine (*Pinus taeda*), and eastern red cedar (*Juniperus virginiana*). The understory was sparse and consisted of species listed above as well as sweetbay (*Magnolia virginiana*), giant cane (*Arundinaria gigantea*), Japanese honeysuckle, greenbrier, Chinese privet, and fetterbush (*Lyonia lucida*).

Drainage Area

The Site hydrophysiographic region is considered characteristic of the Coastal Plain Physiographic Province. The region is characterized by Carolina bays, swamps, and low-gradient streams with silty or sandy substrate (Griffith 2002). This hydrophysiographic region is characterized by moderate rainfall with precipitation averaging approximately 56 inches per year (USDA 1992). The Site occurs within USGS 14-digit HU 03030001010030 (NCDWQ Subbasin 03-05-02) of the White Oak River Basin (Figure 2, Appendix A) (USGS 1974).

The Site drainage area encompasses approximately 1.4 square miles at the downstream Site outfall. The drainage area is characterized by agricultural land, forest, and low-density residential development. The

two Site UTs to the New River ultimately drain to a section of the New River which has been assigned Stream Index Number 19-(1) and a Best Usage Classification of C NSW (NCDWQ 2005).

2.2 Project History

On December 2, 2005, the EEP entered into a contract with Restoration Systems to restore the Site. A Detailed Stream and Wetland Restoration Plan was completed for the project in June 2006. Upon completion of the detailed plan, construction schematics were developed and construction was initiated on November 20, 2006. Backwater Environmental completed earthwork and grading at the Site on February 16, 2007. Carolina Silvics completed planted the Site February 19-20, 2007.

Information on project managers, owners, and contractors follows:

Owner Information
Restoration Systems, LLC
George Howard and John Preyer
1101 Haynes Street, Suite 107
Raleigh, North Carolina 27604
(919) 755-9490

Planting Contractor Information
Carolina Silvics
Dwight McKinney
908 Indian Trail Road
Edenton, North Carolina 27932
(919) 523-4375

Designer Information
Axiom Environmental, Inc.
W. Grant Lewis
2126 Rowland Pond Drive
Willow Spring, North Carolina 27592
(919) 215-1693

Earthwork Contractor Information
Backwater Environmental
Wes Newell
PO Box 1654
Pittsboro, North Carolina 27312
(919) 523-4375

3.0 RESTORATION ACTIVITIES

Primary activities at the Site included 1) stream restoration, 2) wetland restoration, 3) soil scarification, and 4) plant community restoration (Sheets P1-P5, Appendix A). Restoration plans constructed 5858 linear feet of stream and restored 3.3 acres of riverine wetlands, 3.1 acres of nonriverine wetlands, and reforested 23.1 acres of the Site. Project SMU calculations accounted for 1) reaches of channel outside of the conservation easement, 2) reaches of channel expected to braid in the upper extent of the Site (sinuosity reduction from 1.3 to 1.1), and 3) linear footage of TerraCell drop structure. In total the Site is expected provide a minimum of 4750 SMUs after 5 years of Site monitoring.

3.1 Stream Restoration

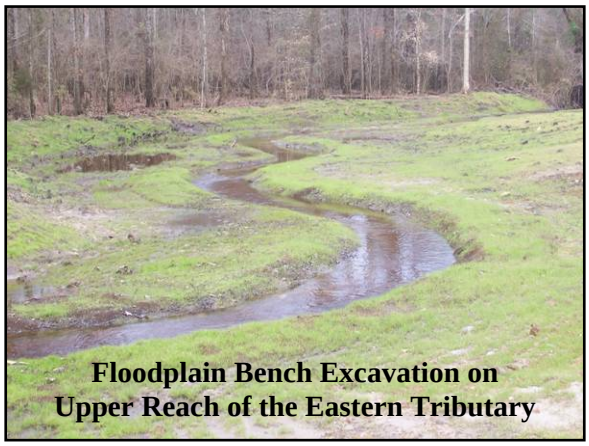
The entire Site is located within a floodplain that was suitable for design channel excavation on new location. The stream was constructed on new location and the old, dredged and straightened channel was abandoned and backfilled. Primary activities designed to restore the channel on new location included 1) belt-width preparation and grading, 2) floodplain bench excavation, 3) channel excavation, 4) installation of channel plugs, 5) backfilling of the abandoned channel, 6) ditch rerouting, 7) installation of in-stream structures and a Terracell drop structure at the Site outfall, and 8) construction of a piped channel crossing.

3.1.1 Belt-width Preparation and Grading

The belt-width was prepared and graded; material excavated during grading was stockpiled immediately adjacent to channel segments to be abandoned and backfilled. These segments were backfilled after stream diversion is completed. After preparation of the corridor, the design channel and updated profile survey was developed and the location of each meander wavelength plotted and staked along the profile.

3.1.2 Floodplain Bench Excavation

A bankfull, floodplain bench was created to 1) remove eroding material and collapsing banks, 2) promote overbank flooding during bankfull flood events, 3) reduce the erosive potential of flood waters, and 4) increase the width of the active floodplain. Bankfull benches were created by excavating the adjacent floodplain to bankfull elevations or filling eroded/abandoned channel areas with suitable material. After excavation, or filling of the bench, a relatively level floodplain surface was stabilized with suitable erosion control measures. Planting of the bench with native floodplain vegetation is expected to reduce erosion of bench sediments, reduce flow velocities in flood waters, filter pollutants, and provide wildlife habitat.



Floodplain Bench Excavation on Upper Reach of the Eastern Tributary

3.1.3 Channel Excavation

The channel was constructed within the range of values depicted in Sheet D-1 (Appendix A), which provides geometry and elevation data for the constructed channel.

The stream banks and local belt-width area of constructed channels were planted with shrub and herbaceous vegetation. Deposition of shrub and woody debris into and/or overhanging the constructed channel was encouraged.

Particular attention was directed toward providing vegetative cover and root growth along the outer bends of each stream meander. Live willow stake revetments, available root mats, and/or biodegradable, erosion-control matting were embedded into the break-in-slope to promote more rapid development of an overhanging bank.

3.1.4 Channel Plugs

Impermeable plugs were installed along abandoned channel segments. The plugs consist of low-permeability materials designed to be of sufficient strength to withstand the erosive energy of surface flow events across the Site. Dense clays imported from off-site and existing material, compacted within the channel, were used for plug construction. The plugs were of sufficient width and depth to form an imbedded overlap in the existing banks and channel bed.

3.1.5 Channel Backfilling

After impermeable plugs were installed, the abandoned channel was backfilled by pushing stockpiled materials into the channel. The channel was filled to the extent that onsite material allowed and compacted to maximize microtopographic variability, including ruts, ephemeral pools, and hummocks in the vicinity of the backfilled channel.

Borrow material was generated through excavation of groundwater storage depressions throughout the Site landscape. The primary purpose of these depressions was to provide suitable, low permeability material for ditch plugs and backfilling, to increase water storage potential within the wetland restoration area, and to increase potential for biological diversity within the complex.

The depressions were constructed by excavating and stockpiling top soils overlying the B horizon (clay layer). Subsequently, clay from the B horizon was excavated as individual pockets approximately 2 to 3 feet in width and 2 to 3 feet in depth, such that the landscape was "pockmarked" with small, groundwater storage depressions (Sheet P-3, Appendix A). Clays excavated from the depressions were utilized as backfill material on adjacent ditch sections. Top soils and sediment removed from ditch cleaning efforts were utilized to backfill the depression to within 0.3 foot of the surface.

3.1.6 Ditch Rerouting

Prior to Site construction, the eastern tributary was routed around Site pastures to the roadside drainage network. Restoration activities diverted this stream flow through its historic floodplain. However, the roadside drainage network must remain in place upon completion of restoration activities, and must function to drain the existing hydrologic design of the roadway. Therefore, the ditch was rerouted around the Site and the ditch network was tied back into Site drainage features near the Site outfall. The rerouted ditch was excavated to adequately drain the roadway.

3.1.7 In-Stream Structures

In-stream structures were used within the Site for bank stabilization, grade control, and habitat improvement. This included the installation of two log vanes and a TerraCell drop structure at the bottom of the Site (Sheet P-5, Appendix A).

Log Vanes

Log vanes were used to direct high velocity flows during bankfull events towards the center of the channel. Log vanes were constructed utilizing large tree trunks harvested from the Site. The tree stem harvested for a log cross-vane arm were long enough to be imbedded into the stream channel and extend several feet into the floodplain. Logs create an arm that slopes from the center of the channel upward at approximately 5 to 7 degrees, tying in at the bankfull floodplain elevation. Logs extend from each stream bank at an angle of 20 to 30 degrees. A trench was dug into the stream channel that was deep enough for the head of the log to be at or below the channel invert. The trench was then extended into the floodplain and the log was set into the trench such that the log arm was below the floodplain elevation. Once the vane was in place, filter fabric was toed into a trench on the upstream side of the vane and draped over the structure to force water over the vane. The upstream side of the structure was then backfilled with suitable material.

TerraCell Outfall Structure

A TerraCell drop structure was installed at the Site outfall to lower Site hydrology to its preconstruction elevation to avoid hydrologic trespass. The drop structure was installed approximately 200 feet from the downstream Site outfall. The structure was constructed to resist erosive forces associated with hydraulic drops proposed at the Site. TerraCell is a light weight, flexible mat made of high density polyethylene strips. The strips are bonded together to form a honeycomb configuration. The honeycomb mat was fixed in place and filled with gravel or sand. Material in the TerraCell structure was be planted with grasses and shrubs for additional erosion protection. The TerraCell structure forms a nickpoint that approximates geologic controls in stream beds.

3.1.8 Piped Channel Crossing

Landowner constraints necessitated the installation of one piped channel crossing to allow access to portions of the property isolated by stream restoration activities. The crossing is located on the section of stream which bisects the conservation easement; the location of the proposed channel crossing is depicted on Sheet P-1 (Appendix A). The crossing was constructed of two pipes 36 inches in diameter and

hydraulically stable rip-rap or suitable rock and is large enough to handle the weight of anticipated vehicular traffic. Approach grades to the crossing were at an approximate 10:1 slope.

3.1.9 Forded Channel Crossing

Landowner constraints necessitated the installation of one forded channel crossing to allow access to portions of the property isolated by stream restoration activities. The location of the forded channel crossing is depicted on Sheet P-1 (Appendix A). The crossing was constructed of hydraulically stable rip-rap or suitable rock and is large enough to handle the weight of anticipated vehicular traffic. Approach grades to the crossing were at an approximate 10:1 slope.

3.1.10 Cattle Exclusion Fencing

Cattle exclusion fencing, 4-foot woven wire, was installed around the perimeter of the easement to exclude livestock from the reconstructed streams and wetlands. The location of the fencing is depicted on Sheet P-1 (Appendix A).

3.2 Wetland Restoration

Wetland restoration activities focused on 1) the reestablishment of historic water table elevations, 2) excavation and grading of elevated spoil and sediment embankments, 3) reestablishment of hydrophytic vegetation, and 4) reconstruction of stream corridors.

3.2.1 Reestablishment of Historic Groundwater Elevations

Preconstruction channel depths averaged 5 feet, while the depth for the constructed restoration channels average approximately 1 foot. Hydric soils adjacent to the incised channels were drained due to lowering of the groundwater tables and a lateral drainage effect from preconstruction stream reaches. Reestablishment of channel inverts is expected to rehydrate hydric Muckalee soils adjacent to Site streams, resulting in the restoration of jurisdictional hydrology to riverine wetlands within the Site.

In addition, drainage ditches present prior to Site construction were effectively removing wetland hydrology within the interstream flat. Filling of these ditches is expected to rehydrate hydric Rains soils within the Site, resulting in the restoration of jurisdictional hydrology to nonriverine wetlands.

3.2.2 Excavation and Grading of Elevated Spoil and Sediment Embankments

Spoil/sediment deposition adjacent to the preconstruction channel and area ditches were removed. Spoil materials were used to fill of onsite ditches, which represented a critical element of onsite wetland restoration.

3.2.3 Hydrophytic Vegetation

Onsite wetland areas endured significant disturbance from land use activities prior to construction such as land clearing, livestock grazing, and other anthropogenic maintenance. Wetland areas were revegetated with native vegetation typical of wetland communities in the region. Emphasis focused on developing a diverse plant assemblage. Plant Community Restoration is discussed in more detail in Section 4.0.

3.2.4 Reconstruction of Stream Corridors

The stream restoration plan involved the reconstruction of the entire onsite length of two UTs to the New River. Prior to construction, the eastern tributary was routed around the Site pasture into the roadside drainage network. Restoration activities revolved around diverting this stream flow through its historic floodplain. Existing channels were backfilled to restore the water table to historic conditions. However, some portions of the abandoned channels remain open for the creation of wetland "oxbow lake-like"

features. These features were plugged on each side of the open channel and will function as open water systems. They are expected to provide habitat for a variety of wildlife as well as create open water/freshwater marsh within the Site.

4.0 PLANT COMMUNITY RESTORATION

On February 19-20, 2007, the Site was planted with native, wetland-adapted tree species (Sheet P-4, Appendix A). Onsite observations, reference forest, and pertinent community descriptions from *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990) were used to develop the primary plant community association promoted during restoration efforts. Approximately 23.1 acres of the Site was planted with species characteristic of the Coastal Plain Small Stream Swamp and Nonriverine Wet Hardwoods communities.

Before plant community restoration was implemented, the entire Site was scarified. Scarification was performed as linear bands directed perpendicular to the land slope. Subsequently, community restoration was initiated on scarified surfaces.

Fourteen tree species were planted at the Site; they are as follows (with planted quantity).

Table 1. Planted Tree Species

Vegetation Association (Planting Area)	**Coastal Plain Small Stream Swamp/Nonriverine Wet Hardwoods Forest**	
Area (acres)	**23.1**	
SPECIES	**Total Number Planted**	**Percentage of Total**
Pawpaw (*Asimina triloba*)	2000	7.15
River birch (*Betula nigra*)	2000	7.15
Mockernut hickory (*Carya alba*)	2000	7.15
Water hickory (*Carya aquatica*)	2000	7.15
Sugarberry (*Celtis laevigata*)	2000	7.15
Buttonbush (*Cephalanthus occidentalis*)	2000	7.15
Green ash (*Fraxinus pennsylvanica*)	2000	7.15
Black walnut (*Juglans nigra*)	2000	7.15
Black gum (*Nyssa sylvatica*)	2000	7.15
Sycamore (*Platanus occidentalis*)	2000	7.15
Cherrybark oak (*Quercus pagodaefolia*)	2000	7.15
Water oak (*Quercus nigra*)	2000	7.15
Willow oak (*Quercus phellos*)	2000	7.15
American elm (*Ulmus americana*)	2000	7.15
TOTAL	**28,000**	**100**

Bare-root seedlings of canopy and understory tree species were planted within the Site at a density of 1212 stems per acre (6.0-foot centers). Planting was performed during February 2007 to allow plants to stabilize during the dormant period and set root during the spring season. Bare-root seedlings were hand planted to minimize wetland soil disturbance. A total of 28,000 diagnostic tree and shrub seedlings were planted in support of Site wetland restoration.

5.0 MONITORING PLAN

The Lloyd Stream and Wetland Restoration Site monitoring plan will entail analysis of the stream channel, hydrology, and vegetation. Monitoring of restoration efforts will be performed for a minimum of 5 years or until success criteria are fulfilled. The detailed monitoring plan is depicted in Sheet P-5 (Appendix A).

5.1 Stream

The Site stream reach is proposed to be monitored for geometric activity. After completion of Site construction twelve stream cross-sections were established; two riffle cross-sections and two maximum pool cross-sections were established on each of the three stream reaches: 1) the eastern tributary, 2) the main tributary upstream of the confluence with the eastern tributary, and 3) the main tributary downstream of the confluence with the eastern tributary.

Annual fall monitoring will include development of channel cross-sections on riffles and pools, pebble counts, and a profile of the channel. A total of 3,000 feet of the project will be monitored. The data will be presented in graphic and tabular format. Data to be presented will include 1) cross-sectional area, 2) bankfull width, 3) average depth, 4) maximum depth, 5) width-to-depth ratio, 6) meander wavelength, 7) belt-width, 8) water surface slope, and 9) sinuosity. The stream will subsequently be classified according to stream geometry and substrate (Rosgen 1996). Significant changes in channel morphology will be tracked and reported by comparing data in each successive monitoring year. A photographic record that will include preconstruction and post-construction pictures has been initiated (Appendix B).

5.2 Hydrology

After hydrological modifications were completed at the Site, continuously recording, surficial monitoring gauges were installed in accordance with specifications in *Installing Monitoring Wells/Piezometers in Wetlands* (NCWRP 1993). Monitoring gauges were set to a depth of approximately 24 inches below the soil surface. Screened portions of each gauge were surrounded by filter fabric, buried in screened well sand, and sealed with a bentonite cap to prevent siltation and surface flow infiltration during floods.

Four monitoring gauges were installed in wetland restoration areas to provide representative coverage of the Site (Sheet P-5, Appendix A). One additional gauge was placed in a reference wetland area in similar landscape positions for comparison with onsite conditions (Sheet P-5, Appendix A). Hydrological sampling will be performed in restoration and reference areas during the growing season (April 8 through November 5) at daily intervals necessary to satisfy the hydrology success criteria within each physiographic landscape area (USDA 1992).

5.3 Vegetation

Following Site planting, five 10-meter by 10-meter vegetation monitoring plots were established within the Site (Sheet P-5, Appendix A). During the first year, vegetation will receive a cursory, visual evaluation on a periodic basis to ascertain the degree of overtopping of planted elements by nuisance species. Subsequently, quantitative sampling of vegetation will be performed each year using the EEP/CVS

methods for vegetation sampling (Lee et al. 2006) between June 1 and September 30 until the vegetation success criteria are achieved.

A photographic record of plant growth will be included in each annual monitoring report.

6.0 SUCCESS CRITERIA

6.1 Stream Success Criteria

Success criteria for stream restoration will include 1) successful classification of the reach as a functioning stream system (Rosgen 1996) and 2) channel variables indicative of a stable stream system.

The channel configuration will be measured on an annual basis in order to track changes in channel geometry, profile, or substrate. These data will be utilized to determine the success in restoring stream channel stability. Specifically, the width-to-depth ratio should characterize an E-type and/or a borderline E-type/C-type channel (≤ 18), bank-height ratios indicative of a stable or moderately unstable channel, and minimal changes in cross-sectional area, channel width, and/or bank erosion along the monitoring reach. In addition, channel abandonment and/or shoot cutoffs must not occur and sinuosity values must remain at approximately 1.3 (thalweg distance/straight-line distance). The field indicator of bankfull will be described in each monitoring year and indicated on a representative channel cross-section figure. If the stream channel is down-cutting or the channel width is enlarging due to bank erosion, additional bank or slope stabilization methods will be employed.

Some areas within the design channel may be expected to form low-slope, braided, stream/swamp complexes similar to Muckalee swamps in the area. These stream/swamp complexes would not be considered unstable; however, footage of stream channel restoration in these reaches will be recalculated from distance along the thalweg (1.3 sinuosity) to distance along the valley (1.0 sinuosity).

Although stream substrate is not expected to coarsen over time, pebble counts will be conducted and the data will be used, along with other measured parameters (cross-sections, etc.), to assess stream stability.

Visual assessment of in-stream structures will be conducted to determine if failure has occurred. Failure of a structure may be indicated by collapse of the structure, undermining of the structure, abandonment of the channel around the structure, and/or stream flow beneath the structure.

6.2 Hydrologic Success Criteria

Target hydrological characteristics include saturation or inundation for at least 10 percent within Rains soils (nonriverine wetlands) and 8 percent within Muckalee soils (riverine wetlands) of the growing season, during average climatic conditions. This value is based on DRAINMOD simulations for 42 years of rainfall data in an old field stage. These areas are expected to support hydrophytic vegetation. If wetland parameters are marginal as indicated by vegetation and/or hydrology monitoring, a jurisdictional determination will be performed in these areas.

In atypical dry years, the hydroperiod must exceed 75 percent of the hydroperiod exhibited by the reference gauges. Reference gauge data will be used to compare wetland hydroperiods between the restoration areas and relatively undisturbed reference wetlands. This data will supplement regulatory evaluation of success criteria and also provide information that shall allow interpretation of mitigation success in years not supporting “normal” rainfall conditions.

6.2 Vegetation Success Criteria

Success criteria have been established to verify that the vegetation component supports community elements necessary for forest development. Success criteria are dependent upon the density and growth of characteristic forest species. Additional success criteria are dependent upon density and growth of "Characteristic Tree Species." Characteristic Tree Species include planted species, species identified through inventory of a reference (relatively undisturbed) forest community used to orient the planting plan, and appropriate Schafale and Weakley (1990) community descriptions (Coastal Plain Small Stream Swamp and Nonriverine Wet Hardwoods Forest). All canopy tree species planted and identified in the reference forest will be utilized to define "Characteristic Tree Species" as termed in the success criteria.

Table 2. Characteristic Tree Species

PLANTED SPECIES	REFERENCE SPECIES
Pawpaw (*Asimina triloba*)	Red maple (*Acer rubrum*)
River birch (*Betula nigra*)	Ironwood (*Carpinus carolinia*)
Mockernut hickory (*Carya alba*)	Pignut hickory (*Carya glabra*)
Water hickory (*Carya aquatica*)	Dogwood (*Cornus* sp.)
Sugarberry (*Celtis laevigata*)	Ash (*Fraxinus* sp.)
Buttonbush (*Cephalanthus occidentalis*)	American holly (*Ilex opaca*)
Green ash (*Fraxinus pennsylvanica*)	Sweetgum (*Liquidambar styraciflua*)
Black walnut (*Juglans nigra*)	Yellow poplar (*Liriodendron tulipifera*)
Black gum (*Nyssa sylvatica*)	White oak (*Quercus alba*)
Sycamore (*Platanus occidentalis*)	Water oak (*Quercus nigra*)
Cherrybark oak (*Quercus pagodaefolia*)	Laurel oak (*Quercus laurifolia*)
Water oak (*Quercus nigra*)	Swamp chestnut oak (*Quercus michauxii*)
Willow oak (*Quercus phellos*)	Cherrybark oak (*Quercus pagoda*)
American elm (*Ulmus americana*)	

An average density of 320 stems per acre of Characteristic Tree Species must be surviving at the end of the third monitor year. Subsequently, 290 Characteristic Tree Species per acre must be surviving at the end of year 4 and 260 Characteristic Tree Species per acre at the end of year 5.

If vegetation success criteria are not achieved, based on average density calculations from combined plots over the entire restoration area, supplemental planting may be performed with tree species approved by regulatory agencies. Supplemental planting will be performed as needed until achievement of vegetation success criteria.

7.0 MONITORING REPORT SUBMITTAL

An Annual Stream and Wetland Monitoring Report will be prepared at the end of each monitoring year (growing season). The monitoring report will depict the sample plot and quadrant locations and include photographs which illustrate Site conditions. Data compilation and analyses will be presented including graphic and tabular format, where practicable.

8.0 CONTINGENCY

In the event that success criteria are not fulfilled, a mechanism for contingency will be implemented.

Stream

In the event that stream success criteria are not fulfilled, a mechanism for contingency will be implemented. Stream contingency may include, but may not be limited to 1) structure repair and/or installation; 2) repair of dimension, pattern, and/or profile variables; and 3) bank stabilization. The method of contingency is expected to be dependent upon stream variables that are not in compliance with success criteria. Primary concerns, which may jeopardize stream success include 1) structure failure, 2) headcut migration through the Site, and/or 3) bank erosion.

Structure Failure

In the event that onsite structures are compromised, the affected structure will be repaired, maintained, or replaced. Once the structure is repaired or replaced, it must function to stabilize adjacent stream banks and/or maintain grade control within the channel. Structures which remain intact, but exhibit flow around, beneath, or through the header/footer pilings will be repaired by excavating a trench on the upstream side of the structure and reinstalling filter fabric in front of the pilings. Structures which have been compromised, resulting in shifting or collapse of header/footer pilings, will be removed and replaced with a structure suitable for onsite flows.

Headcut Migration Through the Site

In the event that a headcut occurs within the Site (identified visually or through onsite measurements [i.e. bank-height ratios exceeding 1.4]), provisions for impeding headcut migration and repairing damage caused by the headcut will be implemented. Headcut migration may be impeded through the installation of in-stream grade control structures (rip-rap sill and/or log cross-vane weir) and/or restoring stream geometry variables until channel stability is achieved. Channel repairs to stream geometry may include channel backfill with coarse material and stabilizing the material with erosion control matting, vegetative transplants, and/or willow stakes.

Bank Erosion

In the event that severe bank erosion occurs at the Site resulting in elevated width-to-depth ratios, contingency measures to reduce bank erosion and width-to-depth ratio will be implemented. Bank erosion contingency measures may include the installation of cross-vane weirs and/or other bank stabilization measures. If the resultant bank erosion induces shoot cutoffs or channel abandonment, a channel may be excavated which will reduce shear stress to stable values.

Hydrology

Hydrological contingency will require consultation with hydrologists and regulatory agencies if wetland hydrology enhancement is not achieved. Floodplain surface modifications, including construction of ephemeral pools, represent a likely mechanism to increase the floodplain area in support of jurisdictional wetlands. Recommendations for contingency to establish wetland hydrology will be implemented and monitored until Hydrology Success Criteria are achieved.

Vegetation

If vegetation success criteria are not achieved based on average density calculations from combined plots over the entire restoration area, supplemental planting may be performed with tree species approved by

regulatory agencies. Supplemental planting will be performed as needed until achievement of vegetation success criteria.

9.0 REFERENCES

Griffith, G.E. 2002. Ecoregions of North and South Carolina. Reston Virginia. U.S. Geological Society (map scale 1:1,500,000).

Lee, M.T., R.K. Peet, S.D. Roberts, and T.R. Wentworth. 2006. CVS-EEP Protocol for Recording Vegetation. Version 4.0. North Carolina Department of Environment and Natural Resources, Ecosystem Enhancement Program. Raleigh, North Carolina.

North Carolina Division of Water Quality (NCDWQ). 2001. White Oak River Basinwide Water Quality Plan. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina.

North Carolina Division of Water Quality (NCDWQ). 2005. North Carolina Waterbody Reports (online). Available: http://h2o.enr.state.nc.us/bims/reports/reportsWB.html [June 24, 2005]. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina.

North Carolina Wetlands Restoration Program (NCWRP). 1993. Installing Monitoring Wells/Piezometers in Wetlands (WRP Technical Note HY-IA-3.1). North Carolina Department of Environment, Health, and Natural Resources, Raleigh, North Carolina

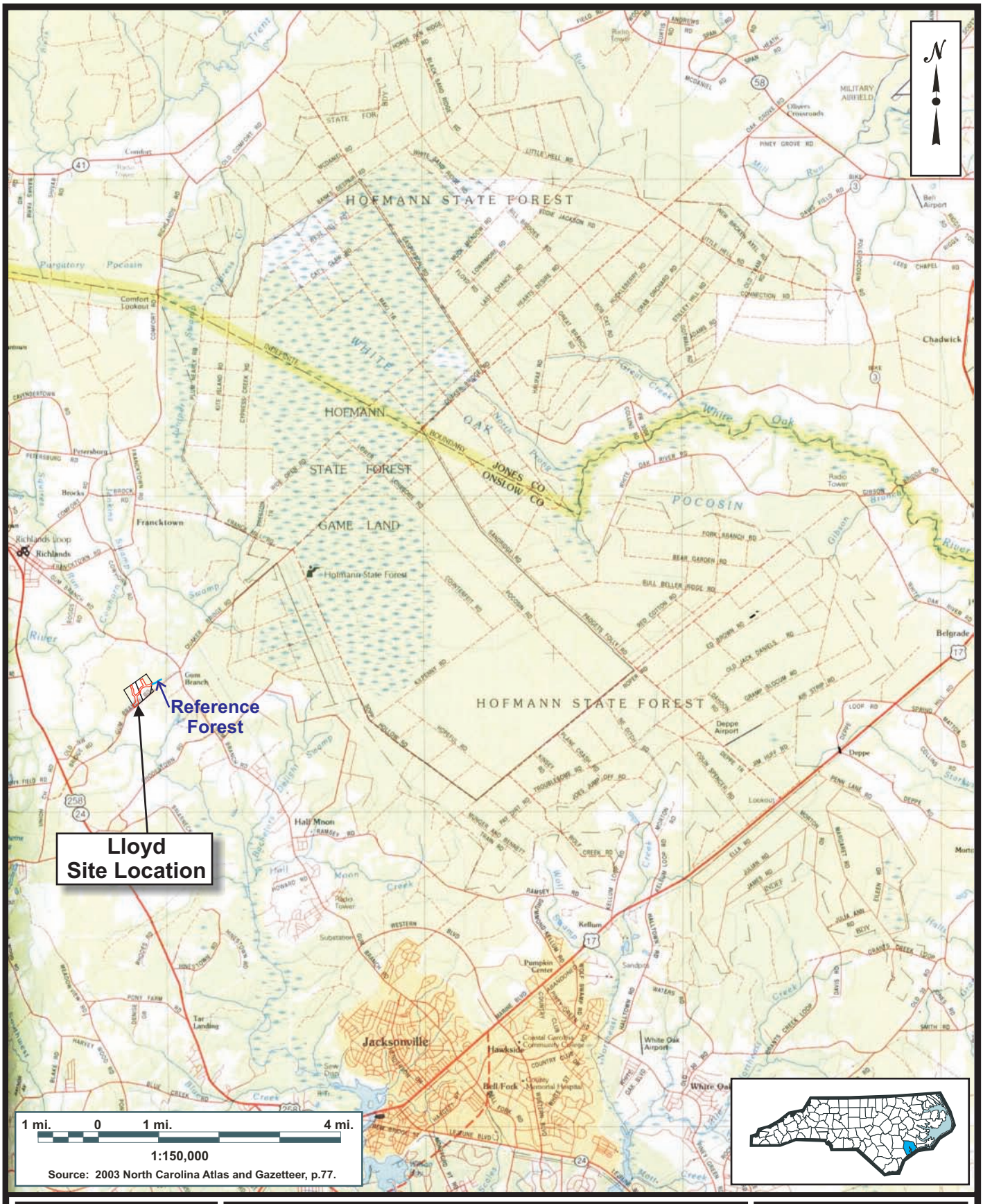
Rosgen D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado.

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

United States Department of Agriculture (USDA). 1992. Soil Survey of Onslow County, North Carolina. United State Department of Agriculture, Soil Conservation Service.

United States Geological Survey (USGS). 1974. Hydrologic Unit Map - 1974. State of North Carolina.

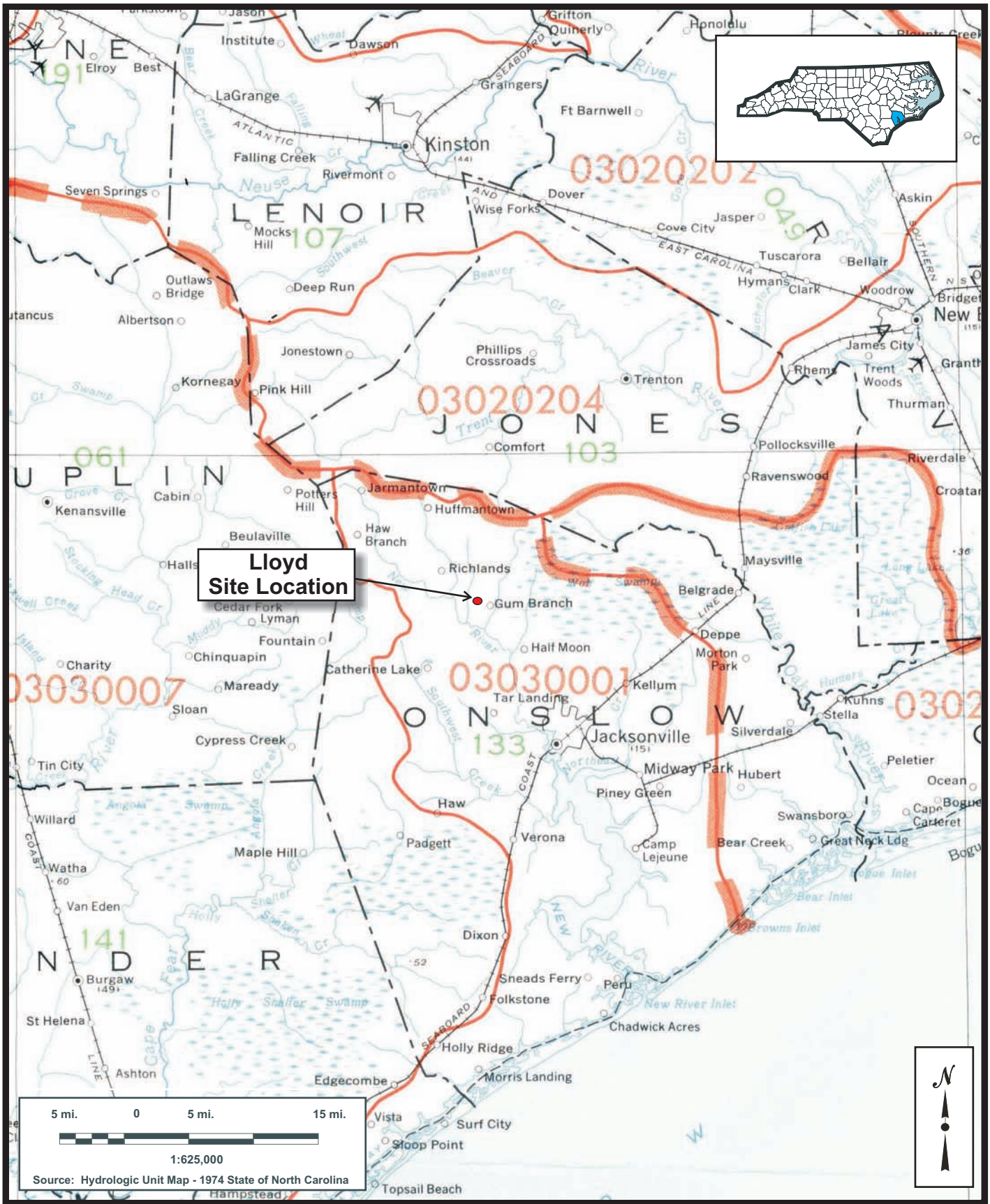
Appendix A.
Figures



Axiom Environmental, Inc.
2126 Rowland Pond Drive
Willow Spring, NC 27592
(919) 215-1693
(919) 341-3839 fax

SITE LOCATION
LLOYD RESTORATION SITE
Onslow County, North Carolina

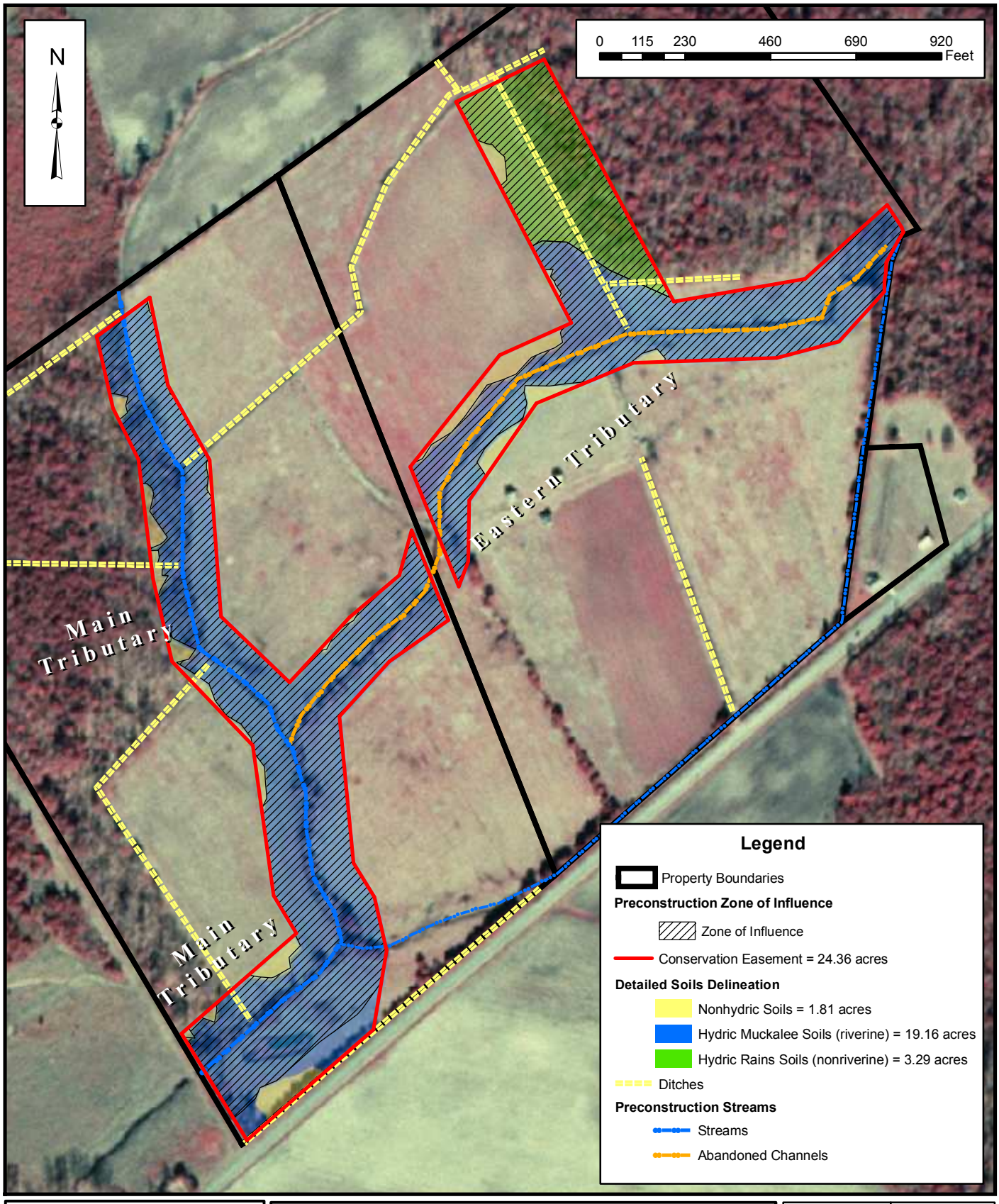
Dwn. by:	CLF
Date:	April 2007
Project:	05-021
FIGURE	1



Axiom Environmental, Inc.
2126 Rowland Pond Drive
Willow Spring, NC 27592
(919) 215-1693
(919) 341-3839 fax

USGS HYDROLOGIC UNIT MAP
LLOYD RESTORATION SITE
Onslow County, North Carolina

Dwn. by: CLF	FIGURE
Date: April 2007	2
Project: 05-021	



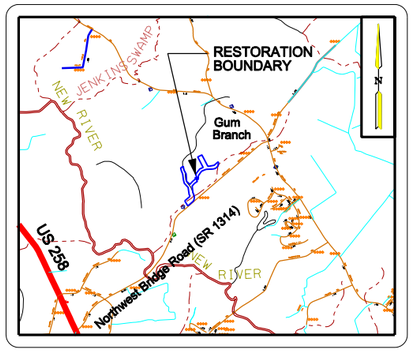
Axiom Environmental, Inc.
2126 Rowland Pond Drive
Willow Spring, NC 27592
(919) 215-1693
(919) 341-3839 fax

PRECONSTRUCTION CONDITIONS
LLOYD RESTORATION SITE
Onslow County, North Carolina

Dwn. by: CLF
Date: April 2007
Project: 05-021

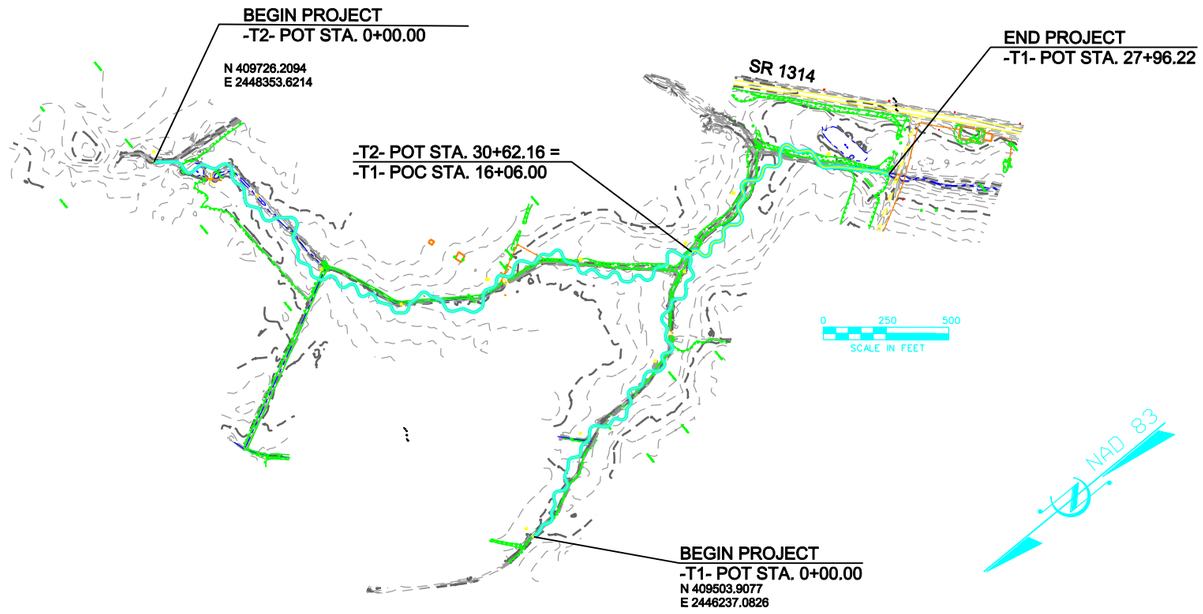
FIGURE
3

SITE LOCATION



AS-BUILT DRAWINGS

Lloyd Property Stream and Wetland Restoration
Onslow County, North Carolina



INDEX OF SHEETS

PROJECT DESCRIPTION

The Lloyd Property Stream and Wetland Restoration project is located along an unnamed tributary to the New River, approximately 5 miles north of Jacksonville in northeastern Onslow County. The project includes 5,858 feet of stream restoration and 24.3 acres of degraded floodplain pastures within an active dairy farm. In addition, the project includes the restoration of 3.3 acres of riparian wetlands and 3.1 acres of nonriparian wetlands by reconnecting the stream to the historic floodplain. Over the last several decades, the stream channels were diverted into canals and the floodplain was cleared and converted to pasture. Long term cattle activity has further eroded the floodplain and stream banks. The primary components of of the restoration involved: 1) establishment of a conservation easement encompassing the floodplain; 2) erection of cattle exclusion fencing; 3) elevating a restored system of streams and wetlands back onto the historic (abandoned) floodplain surfaces; 4) backfilling the old entrenched ditch and canal system; 5) reforestation of the 24.3-acre floodplain area; and 5) installation of a monitoring program to track stream and wetland development on the site. Primary construction and planting activities were performed over a 5-month period, from November 2006 through March 2007.

Restoration Systems
1101 Haynes Street, Suite 107
Raleigh, N.C. 27604
(919) 755-9490

NOTES/REVISIONS

Project:

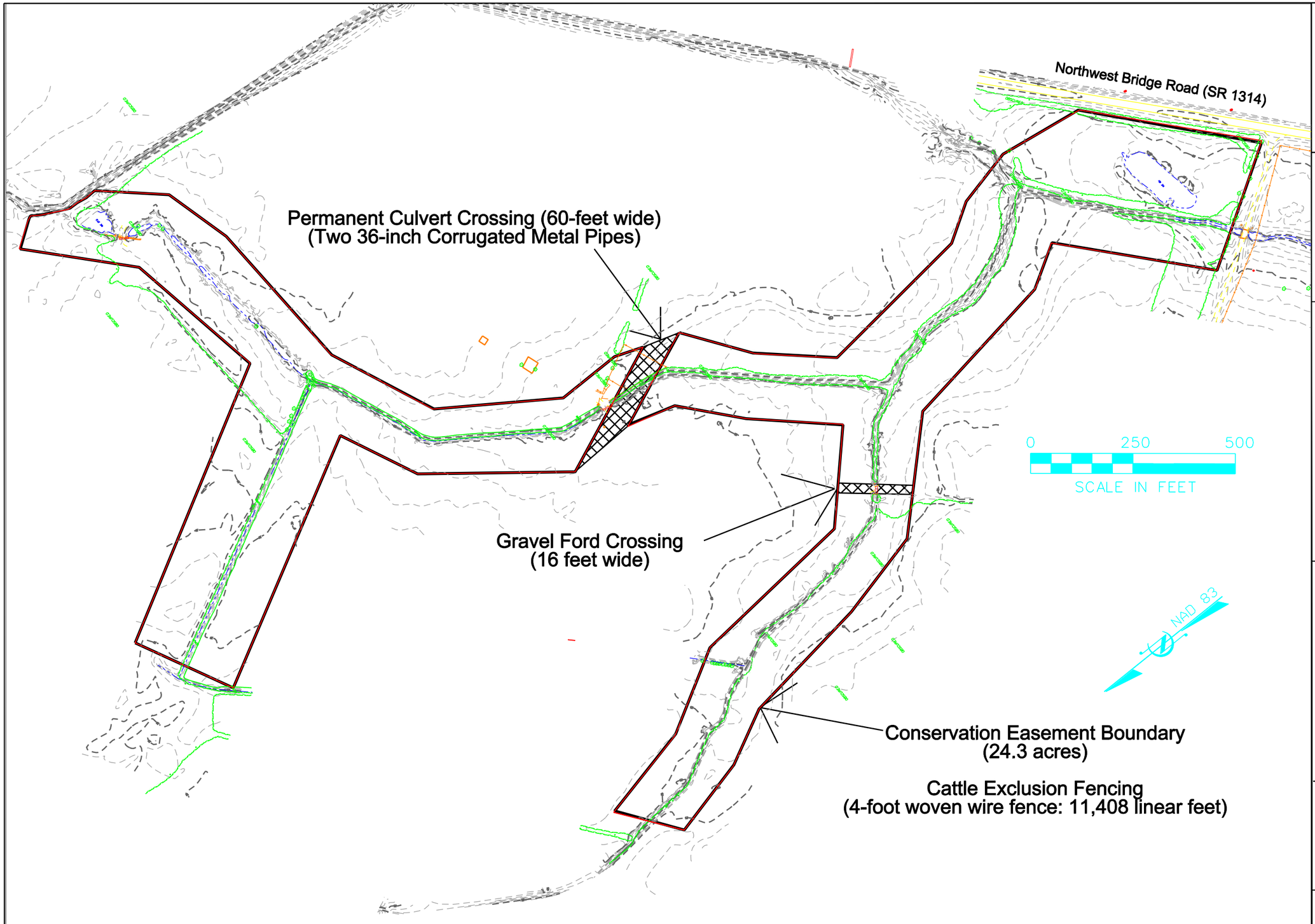
LLOYD PROPERTY
STREAM AND WETLAND
RESTORATION

ONSLOW COUNTY
NORTH CAROLINA

Title:

Title
Index of Sheets

Scale:	SHEET NO.
NTS	T-1
Date: April 2007	
Project No.: 06-3885	



RESTORATION SYSTEMS, LLC

Restoration Systems
1101 Haynes Street, Suite 107
Raleigh, N.C. 27604
(919) 755-9490

NOTES/REVISIONS

Project:

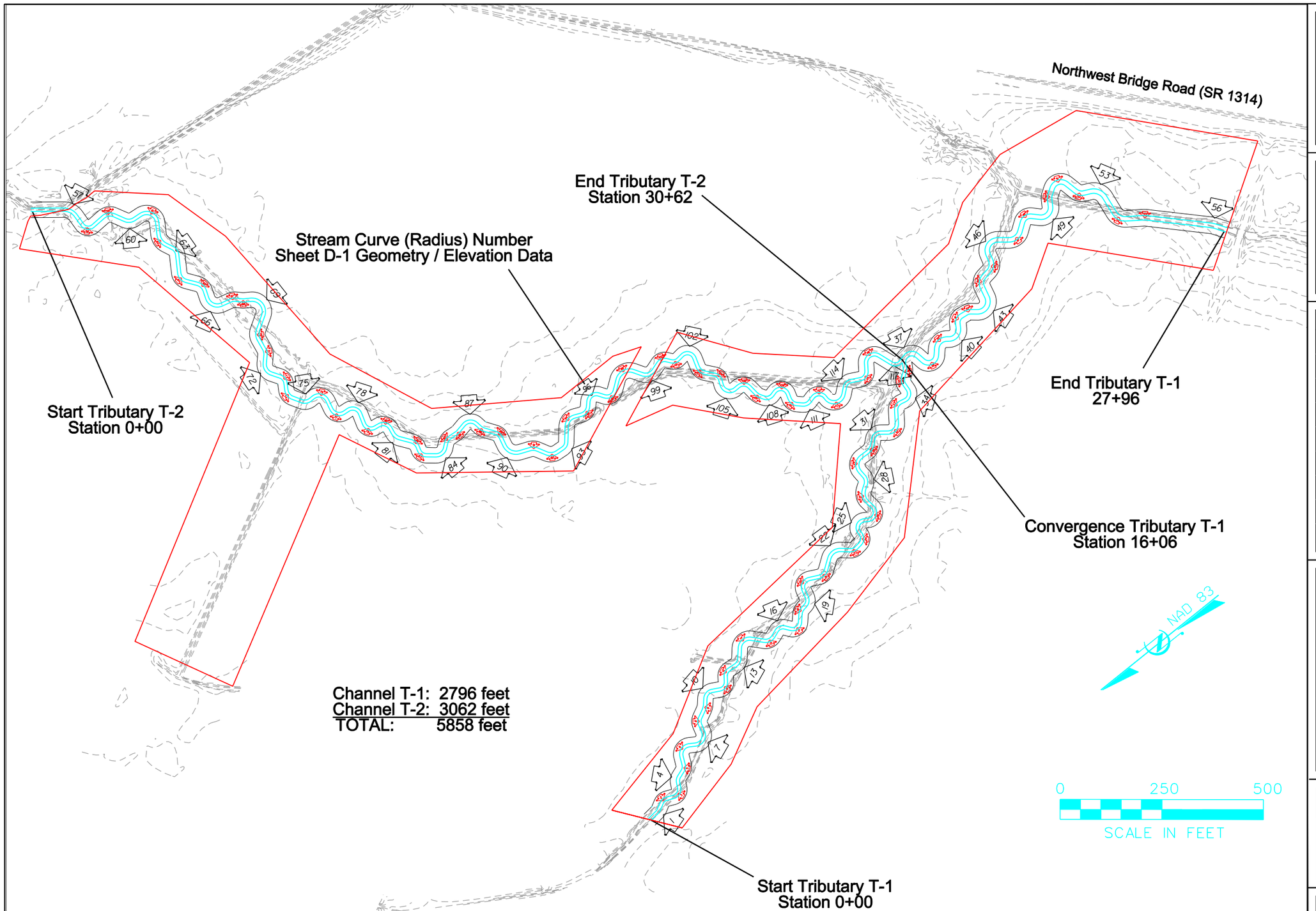
LLOYD PROPERTY
STREAM AND WETLAND
RESTORATION

ONSLOW COUNTY
NORTH CAROLINA

Title:

Conservation
Area

Scale:	SHEET NO.
As Shown	P-1
Date: April 2007	
Project No.: 06-3885	



RESTORATION SYSTEMS, LLC

Restoration Systems
1101 Haynes Street, Suite 107
Raleigh, N.C. 27604
(919) 755-9490

NOTES/REVISIONS

Project:

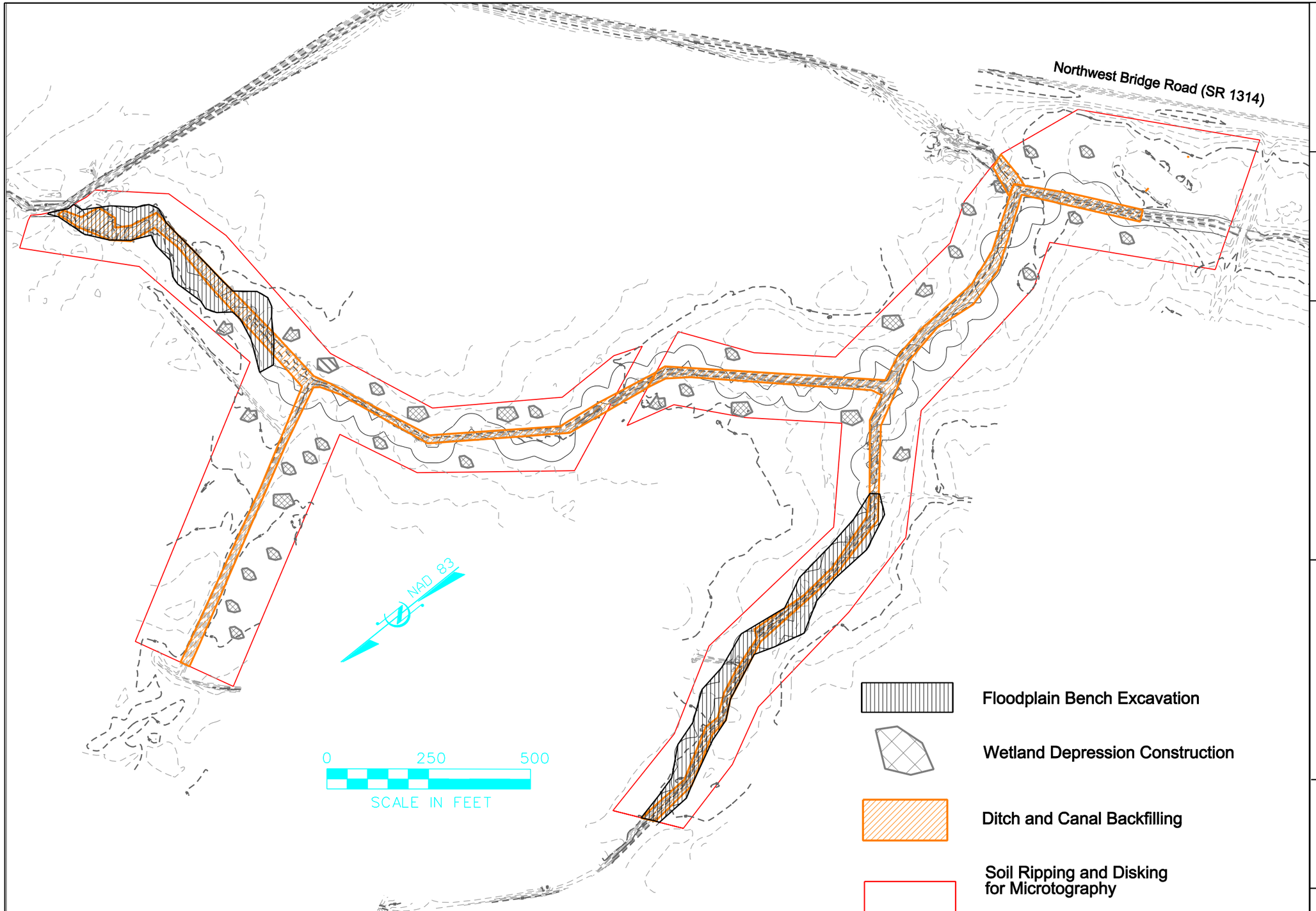
LLOYD PROPERTY
STREAM AND WETLAND
RESTORATION

ONSLOW COUNTY
NORTH CAROLINA

Title:

Stream
Construction

Scale:	SHEET NO.
As Shown	P-2
Date: April 2007	
Project No.: 06-3885	



RESTORATION SYSTEMS, LLC

Restoration Systems
1101 Haynes Street, Suite 107
Raleigh, N.C. 27604
(919) 755-9490

NOTES/REVISIONS

Project:

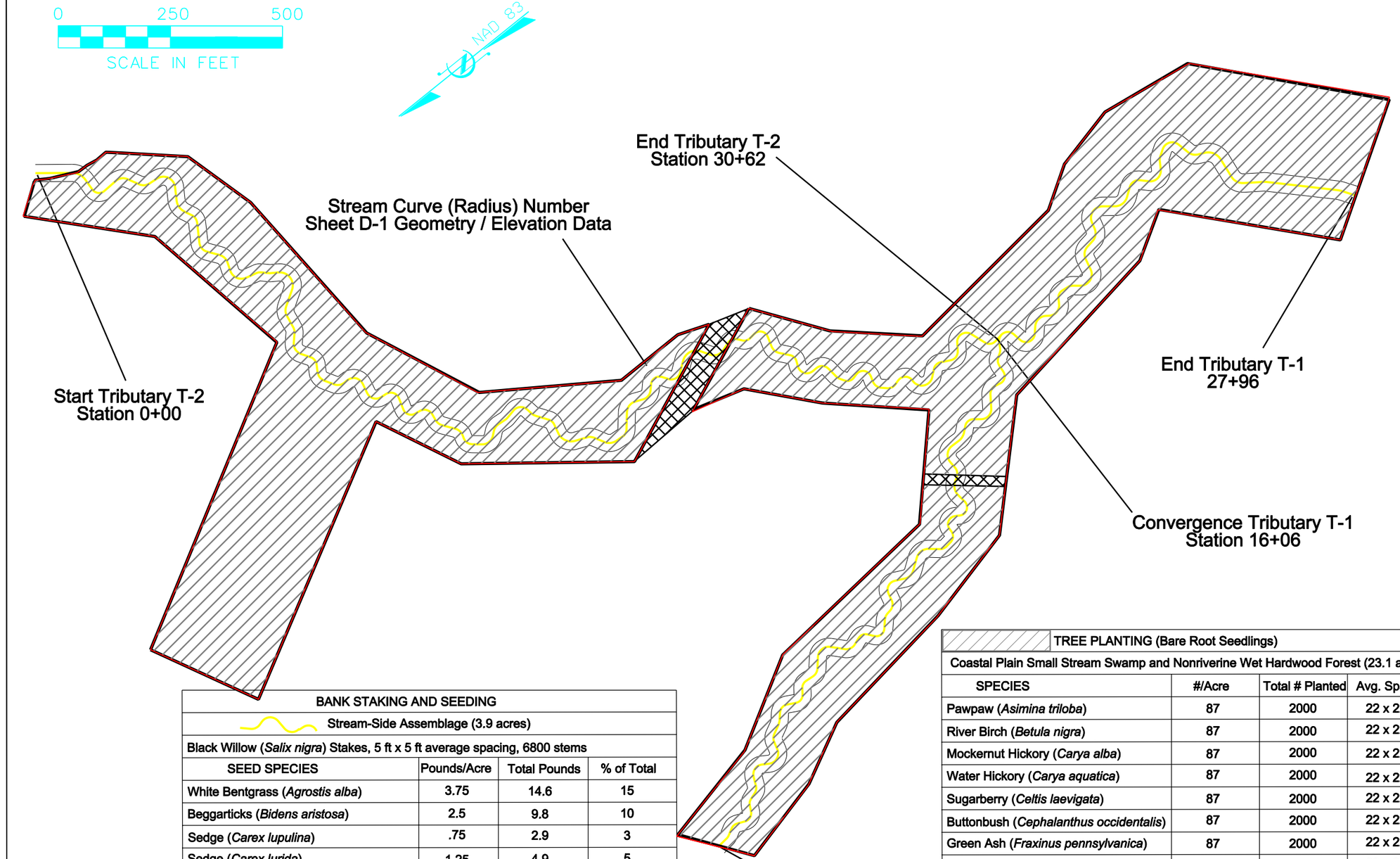
LLOYD PROPERTY
STREAM AND WETLAND
RESTORATION

ONSLOW COUNTY
NORTH CAROLINA

Title:

Wetland
Construction

Scale:	SHEET NO.
As Shown	P-3
Date: April 2007	
Project No.: 06-3885	



BANK STAKING AND SEEDING			
Stream-Side Assemblage (3.9 acres)			
Black Willow (*Salix nigra*) Stakes, 5 ft x 5 ft average spacing, 6800 stems			
SEED SPECIES	Pounds/Acre	Total Pounds	% of Total
White Bentgrass (*Agrostis alba*)	3.75	14.6	15
Beggarticks (*Bidens aristosa*)	2.5	9.8	10
Sedge (*Carex lupulina*)	.75	2.9	3
Sedge (*Carex lurida*)	1.25	4.9	5
Coreopsis (*Coreopsis lanceolata*)	2.5	9.8	10
Virginia Wild Rye (*Elymus virginicus*)	6.25	24.4	25
Lamp Rush (*Juncus effusus*)	1.75	6.8	7
Panic Grass (*Panicum virgatum*)	3.75	14.6	15
Smartweed (*Polygonum pennsylvanicum*)	2.5	9.8	10
TOTAL	25	97.5	100
Temporary Rye Grain	25	23.1 acres, 600 pounds	
Temporary Rye Grass	50	23.1 acres, 1200 pounds	

TREE PLANTING (Bare Root Seedlings)			
Coastal Plain Small Stream Swamp and Nonriverine Wet Hardwood Forest (23.1 acres)			
SPECIES	#/Acre	Total # Planted	Avg. Spacing
Pawpaw (*Asimina triloba*)	87	2000	22 x 22 ft
River Birch (*Betula nigra*)	87	2000	22 x 22 ft
Mockernut Hickory (*Carya alba*)	87	2000	22 x 22 ft
Water Hickory (*Carya aquatica*)	87	2000	22 x 22 ft
Sugarberry (*Celtis laevigata*)	87	2000	22 x 22 ft
Buttonbush (*Cephalanthus occidentalis*)	87	2000	22 x 22 ft
Green Ash (*Fraxinus pennsylvanica*)	87	2000	22 x 22 ft
Black Walnut (*Juglans nigra*)	87	2000	22 x 22 ft
Black Gum (*Nyssa sylvatica*)	87	2000	22 x 22 ft
Amer. Sycamore (*Platanus occidentalis*)	87	2000	22 x 22 ft
Cherrybark Oak (*Quercus pagodaefolia*)	87	2000	22 x 22 ft
Water Oak (*Quercus nigra*)	87	2000	22 x 22 ft
Willow Oak (*Quercus phellos*)	87	2000	22 x 22 ft
American Elm (*Ulmus americana*)	87	2000	22 x 22 ft
TOTAL	1212	2000	22 x 22 ft

RESTORATION SYSTEMS, LLC

Restoration Systems
1101 Haynes Street, Suite 107
Raleigh, N.C. 27604
(919) 755-9490

NOTES/REVISIONS

Project:

LLOYD PROPERTY
STREAM AND WETLAND
RESTORATION

ONSLOW COUNTY
NORTH CAROLINA

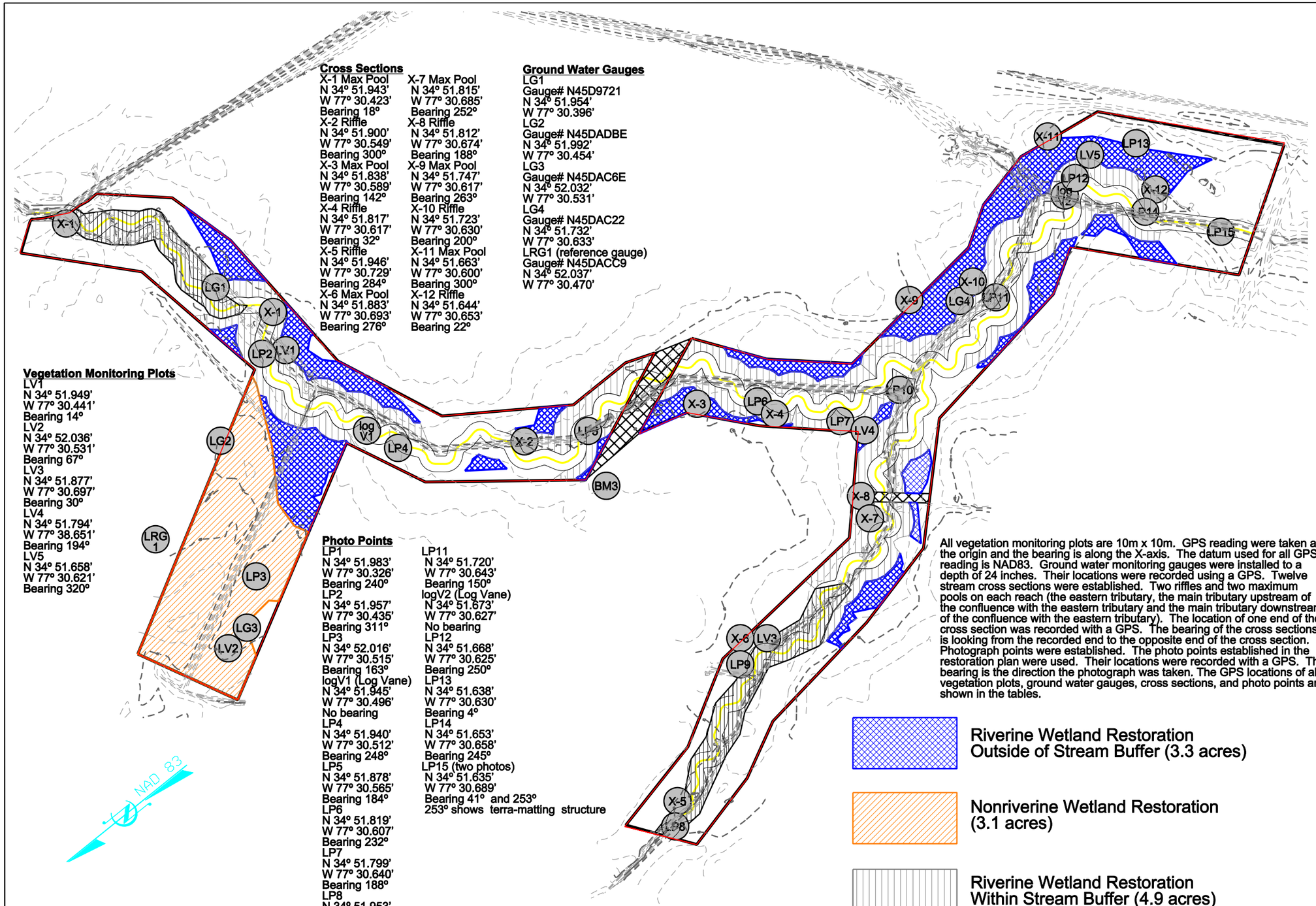
Title:

Vegetation
Planting

Scale: As Shown
Date: April 2007
Project No.: 06-3885

SHEET NO.

P-4



Cross Sections

X-1 Max Pool
N 34° 51.943'
W 77° 30.423'
Bearing 18°

X-2 Riffle
N 34° 51.900'
W 77° 30.549'
Bearing 300°

X-3 Max Pool
N 34° 51.838'
W 77° 30.589'
Bearing 142°

X-4 Riffle
N 34° 51.817'
W 77° 30.617'
Bearing 32°

X-5 Riffle
N 34° 51.946'
W 77° 30.729'
Bearing 284°

X-6 Max Pool
N 34° 51.883'
W 77° 30.693'
Bearing 276°

X-7 Max Pool
N 34° 51.815'
W 77° 30.685'
Bearing 252°

X-8 Riffle
N 34° 51.812'
W 77° 30.674'
Bearing 188°

X-9 Max Pool
N 34° 51.747'
W 77° 30.617'
Bearing 263°

X-10 Riffle
N 34° 51.723'
W 77° 30.630'
Bearing 200°

X-11 Max Pool
N 34° 51.663'
W 77° 30.600'
Bearing 300°

X-12 Riffle
N 34° 51.644'
W 77° 30.653'
Bearing 22°

Ground Water Gauges

LG1
Gauge# N45D9721
N 34° 51.954'
W 77° 30.396'

LG2
Gauge# N45DADBE
N 34° 51.992'
W 77° 30.454'

LG3
Gauge# N45DAC6E
N 34° 52.032'
W 77° 30.531'

LG4
Gauge# N45DAC22
N 34° 51.732'
W 77° 30.633'

LRG1 (reference gauge)
Gauge# N45DACC9
N 34° 52.037'
W 77° 30.470'

Vegetation Monitoring Plots

LV1
N 34° 51.949'
W 77° 30.441'
Bearing 14°

LV2
N 34° 52.036'
W 77° 30.531'
Bearing 67°

LV3
N 34° 51.877'
W 77° 30.697'
Bearing 30°

LV4
N 34° 51.794'
W 77° 38.651'
Bearing 194°

LV5
N 34° 51.658'
W 77° 30.621'
Bearing 320°

Photo Points

LP1
N 34° 51.983'
W 77° 30.326'
Bearing 240°

LP2
N 34° 51.957'
W 77° 30.435'
Bearing 311°

LP3
N 34° 52.016'
W 77° 30.515'
Bearing 163°

logV1 (Log Vane)
N 34° 51.945'
W 77° 30.496'
No bearing

LP4
N 34° 51.940'
W 77° 30.512'
Bearing 248°

LP5
N 34° 51.878'
W 77° 30.565'
Bearing 184°

LP6
N 34° 51.819'
W 77° 30.607'
Bearing 232°

LP7
N 34° 51.799'
W 77° 30.640'
Bearing 188°

LP8
N 34° 51.953'
W 77° 30.737'
Bearing 158°

LP9
N 34° 51.889'
W 77° 30.697'
Bearing 210°

LP10
N 34° 51.773'
W 77° 30.647'
Bearing 194°

LP11
N 34° 51.720'
W 77° 30.643'
Bearing 150°

logV2 (Log Vane)
N 34° 51.673'
W 77° 30.627'
No bearing

LP12
N 34° 51.668'
W 77° 30.625'
Bearing 250°

LP13
N 34° 51.638'
W 77° 30.630'
Bearing 4°

LP14
N 34° 51.653'
W 77° 30.658'
Bearing 245°

LP15 (two photos)
N 34° 51.635'
W 77° 30.689'
Bearing 41° and 253°
253° shows terra-matting structure

All vegetation monitoring plots are 10m x 10m. GPS reading were taken at the origin and the bearing is along the X-axis. The datum used for all GPS reading is NAD83. Ground water monitoring gauges were installed to a depth of 24 inches. Their locations were recorded using a GPS. Twelve stream cross sections were established. Two riffles and two maximum pools on each reach (the eastern tributary, the main tributary upstream of the confluence with the eastern tributary and the main tributary downstream of the confluence with the eastern tributary). The location of one end of the cross section was recorded with a GPS. The bearing of the cross sections is looking from the recorded end to the opposite end of the cross section. Photograph points were established. The photo points established in the restoration plan were used. Their locations were recorded with a GPS. The bearing is the direction the photograph was taken. The GPS locations of all vegetation plots, ground water gauges, cross sections, and photo points are shown in the tables.

Riverine Wetland Restoration
Outside of Stream Buffer (3.3 acres)

Nonriverine Wetland Restoration
(3.1 acres)

Riverine Wetland Restoration
Within Stream Buffer (4.9 acres)

Riverine Wetland Creation
Within Stream Buffer (floodplain bench)
(1.9 acres)

RESTORATION SYSTEMS, LLC

Restoration Systems
1101 Haynes Street, Suite 107
Raleigh, N.C. 27604
(919) 755-9490

NOTES/REVISIONS

Project:

LLOYD PROPERTY
STREAM AND WETLAND
RESTORATION

ONSLOW COUNTY
NORTH CAROLINA

Title:

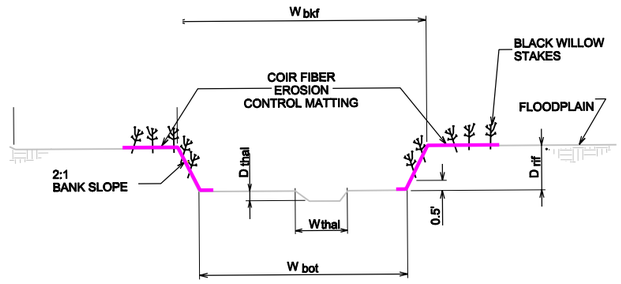
Monitoring
Installation

Scale:	SHEET NO.
As Shown	P-5
Date: April 2007	
Project No.: 06-3885	

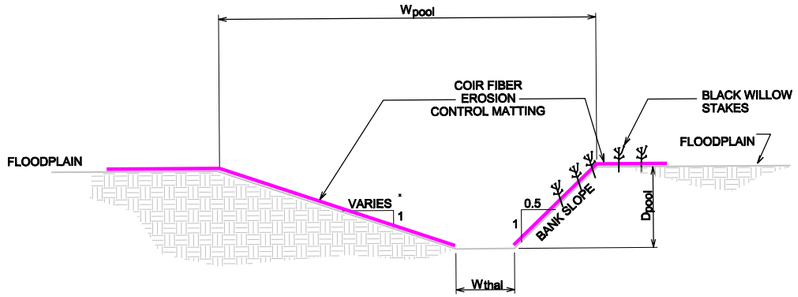
Tributary T-1					
Sta. #	Rad #	Rc	Loc.	Bed Elev.	Bankfull Elev.
0			tr1	20.70	21.9
25			br1	20.67	21.9
35	R1	24.5	tr2	20.66	21.9
51			br2	20.64	21.8
68	R2	18	tr3	20.61	21.8
86			br3	20.59	21.8
114	R3	19	tr4	20.54	21.7
128			br4	20.52	21.7
142	R4	19	tr5	20.49	21.7
160			br5	20.48	21.7
175	R5	19	tr6	20.45	21.6
196			br6	20.43	21.6
233	R6	22	tr7	20.35	21.6
249			br7	20.34	21.5
292	R7	23	tr8	20.26	21.5
310			br8	20.24	21.4
327	R8	21	tr9	20.20	21.4
348			br9	20.18	21.4
363	R9	40.5	tr10	20.15	21.4
377			br10	20.14	21.3
404	R10	20	tr11	20.09	21.3
423			br11	20.07	21.3
449	R11	18	tr12	20.02	21.2
463			br12	20.01	21.2
482	R12	18.5	tr13	19.97	21.2
501			br13	20.00	21.2
521	R13	22	tr14	20.00	21.2
547			br14	20.00	21.2
587	R14	24	tr15	20.00	21.2
620			br15	19.99	21.2
645	R15	21.5	tr16	19.99	21.2
662			br16	19.99	21.2
684	R16	18	tr17	19.99	21.2
700			br17	19.98	21.2
732	R17	18	tr18	19.98	21.2
751			br18	19.98	21.2
768	R18	25	tr19	19.98	21.2
776			br19	19.98	21.2
799	R19	20	tr20	19.98	21.2
817			br20	19.98	21.2
853	R20	20	tr21	19.98	21.2
876			br21	19.97	21.2
902	R21	24	tr22	19.97	21.2
932			br22	19.96	21.2
968	R22	27.5	tr23	19.96	21.2
992			br23	19.96	21.2
1010	R23	21	tr24	19.96	21.2
1022			br24	19.96	21.2
1048	R24	18.5	tr25	19.96	21.2
1055			br25	19.96	21.2
1093	R25	18	tr26	19.96	21.2
1103			br26	19.95	21.2
1145	R26	18.5	tr27	19.95	21.2
1163			br27	19.95	21.2
1196	R27	29	tr28	19.95	21.2
1208			br28	19.95	21.1
1230	R28	21	tr29	19.95	21.1
1245			br29	19.95	21.1
1287	R29	25	tr30	19.95	21.1
1305			br30	19.94	21.1
1328	R30	31	tr31	19.94	21.1
1342			br31	19.94	21.1
1367	R31	18	tr32	19.94	21.1
1385			br32	19.93	21.1
1421	R32	22	tr33	19.93	21.1
1452			br33	19.93	21.1
1476	R33	20.5	tr34	19.93	21.1
1488			br34	19.93	21.1
1519	R34	18	tr35	19.93	21.1
1534			br35	19.92	21.1
1553	R35	21	tr36	19.92	21.1
1564			br36	19.92	21.1
1574	R36	23	tr37	19.90	21.1
1589			br37	19.89	21.3
1636	R37	19.5	tr38	19.80	21.4
1656			br38	19.74	21.3
1699	R38	19.5	tr39	19.65	21.3
1716			br39	19.60	21.2
1753	R39	24.5	tr40	19.53	21.1
1759			br40	19.50	21.1
1798	R40	23.5	tr41	19.43	21.0
1810			br41	19.35	21.0
1831	R41	18.5	tr42	19.31	20.9
1846			br42	19.22	20.8
1857	R42	19	tr43	19.20	20.8
1873			br43	19.10	20.7
1925	R43	25.5	tr44	19.00	20.6
1951			br44	18.85	20.4
1980	R44	24	tr45	18.79	20.4
1997			br45	18.69	20.3
2026	R45	25.5	tr46	18.63	20.2
2041			br46	18.54	20.1
2092	R46	25.5	tr47	18.44	20.0
2120			br47	18.28	19.9
2156	R47	28	tr48	18.21	19.8
2179			br48	18.09	19.7
2208	R48	20	tr49	18.03	19.6
2229			br49	17.93	19.5
2271	R49	23.5	tr50	17.85	19.4
2291			br50	17.75	19.3
2299	R50	20	tr51	17.73	19.3
2318			br51	17.62	19.2
2360	R51	22	tr52	17.54	19.1
2388			br52	17.37	19.0
2410	R52	24	tr53	17.33	18.9
2427			br53	17.23	18.8
2467	R53	32.5	tr54	17.15	18.8
2512			br54	16.86	18.5
2545	R54	30.5	tr55	16.80	18.4
2589			br55	16.51	18.1
2595	R55	31.5	tr56	16.50	NA
2754			br56	12.81	NA
2764	R56	53	tr57	12.79	NA
2796			br57	12.63	NA

Tributary T-2					
Sta. #	Rad. #	Rc	Loc.	Bed Elev.	Bankfull Elev.
0			tr1	27.20	28.1
81			br1	27.16	28.1
116	57	36	tr2	27.16	28.1
143			br2	27.15	28.3
173	58	18	tr3	27.15	28.3
207			br3	27.13	28.3
231	59	21	tr4	27.13	28.3
263			br4	27.11	28.3
287	60	23.5	tr5	27.11	28.3
307			br5	27.10	28.3
360	61	26	tr6	27.10	28.3
389			br6	27.09	28.3
421	62	32	tr7	27.09	28.3
440			br7	27.08	28.3
461	63	21	tr8	27.08	28.3
505			br8	27.06	28.3
533	64	23.5	tr9	27.06	28.3
561			br9	27.04	28.2
587	65	26	tr10	27.04	28.2
606			br10	27.03	28.2
650	66	26	tr11	27.03	28.2
675			br11	27.02	28.2
685	67	20	tr12	27.02	28.2
703			br12	27.01	28.2
707	68	20	tr13	27.01	28.2
724			br13	27.00	28.2
782	69	29	tr14	27.00	28.2
821			br14	26.99	28.2
841	70	27	tr15	26.99	28.2
871			br15	26.97	28.2
886	71	25	tr16	26.97	28.2
907			br16	26.96	28.2
939	72	24	tr17	26.96	28.2
961			br17	26.95	28.2
983	73	20	tr18	26.95	28.2
1000			br18	26.93	28.1
1026	74	23.5	tr19	26.88	28.1
1019			br19	26.81	28.0
1073	75	22.5	tr20	26.78	28.0
1081			br20	26.73	27.9
1122	76	22.5	tr21	26.67	27.9
1115			br21	26.52	27.7
1182	77	21.5	tr22	26.46	27.7
1194			br22	26.38	27.6
1229	78	19.5	tr23	26.32	27.5
1256			br23	26.14	27.3
1288	79	18.5	tr24	26.09	27.3
1299			br24	26.02	27.2
1331	80	20	tr25	25.96	27.2
1345			br25	25.87	27.1
1366	81	26.5	tr26	25.83	27.0
1395			br26	25.63	26.8
1418	82	24.5	tr27	25.59	26.8
1425			br27	25.55	26.7
1449	83	20.5	tr28	25.51	26.7
1472			br28	25.35	26.5
1504	84	23.5	tr29	25.30	26.5
1514			br29	25.22	26.4
1534	85	25	tr30	25.19	26.4
1552			br30	25.08	26.3
1558	86	22.5	tr31	25.07	26.3
1579			br31	24.93	26.1
1613	87	21	t r32	24.87	26.1
1626			br32	24.80	26.0
1637	88	25	tr33	24, 78	26.0
1667			br33	24.60	25.8
1684	89	20	tr34	24.57	25.8
1706			br34	24.44	25.6
1750	90	31	tr35	24.37	25.6
1777			br35	24.29	25.5
1794	91	25	tr36	24.26	25.5
1818			br36	24.18	25.4
1846	92	28	tr37	24.14	25.3
1864			br37	24.10	25.3
1881	93	18.5	tr38	24.07	25.3
1920			br38	24.00	25.2
1952	94	25.5	tr39	23.94	25.1
1970			br39	23.91	25.1
1998	95	23	tr40	23.86	25.1
2010			br40	23.81	25.0
2045	96	19	tr41	23.75	25.0
2060			br41	23.66	24.9
2092	97	20	tr42	23.61	24.8
2120			br42	23.42	24.6
2170	98	30	tr43	23.33	24.5
2192			br43	23.18	24.4
2224	99	24	tr44	23.12	24.3
2245			br44	22.98	24.2
2267	100	18	tr45	22.94	24.1
2279			br45	22.85	24.1
2298	101	18.5	tr46	22.82	24.0
2312			br46	22.73	23.9
2348	102	18	tr47	22.67	23.9
2371			br47	22.51	23.7
2395	103	24.5	tr48	22.47	23.7
2419			br48	22.30	23.5
2439	104	18	tr49	22.26	23.5
2452			br49	22.18	23.4
2493	105	20.5	tr50	22.11	23.3
2503			br50	22.04	23.2
2533	106	20	tr51	21.99	23.2
2555			br51	21.83	23.0
2569	107	31	tr52	21.81	23.0
2578			br52	21.75	22.9
2602	108	18.5	tr53	21.71	22.9
2610			br53	21.65	22.9
2650	109	18.5	tr54	21.59	22.8
2663			br54	21.49	22.7
2687	110	21.5	tr55	21.45	22.7
2700			b r55	21.36	22.6
2720	111	20	tr56	21.33	22.5
2733			br56	21.24	22.4
2768	112	19	tr57	21.18	22.4
2771			br57	21.16	22.4

Tributary T-2					
Sta. #	Rad. #	Rc	Loc.	Bed Elev.	Bankfull Elev.
2826	113	24	tr58	21.07	22.3
2845			br58	20.94	22.1
2866	114	18	tr59	20.90	22.1
2890			br59	20.71	21.9
2917	115	19	tr60	20.67	21.9
2937			br60	20.51	21.7
2982	116	20.5	tr61	20.44	21.6
3018			br61	20.15	21.3
3043	117	18	tr62	20.11	21.3
3062			br62	19.95	21.1



RIFFLE CROSS-SECTION



POOL CROSS-SECTION

CROSS-SECTION DIMENSIONS							
REACH	Wbkf (ft.)	Wbot (ft.)	Driff (ft.)	Dthal (ft.)	Dpool (ft.)	Wpool (ft.)	Wthal (ft.)
Eastern Trib.	7.9	3.1	1.2	0.2	2.0	11.1	1.2
Main Trib. upstream	7.9	3.1	1.2	0.2	2.0	11.1	1.2
Main Trib. downstream	11.0	4.6	1.6	0.2	3.0	15.4	1.6

RESTORATION SYSTEMS, LLC

Restoration Systems
1101 Haynes Street, Suite 107
Raleigh, N.C. 27604
(919) 755-9490

NOTES/REVISIONS

Project:

LLOYD PROPERTY
STREAM AND WETLAND
RESTORATION

ONSLOW COUNTY
NORTH CAROLINA

Title:

Geometry / Elevation Data

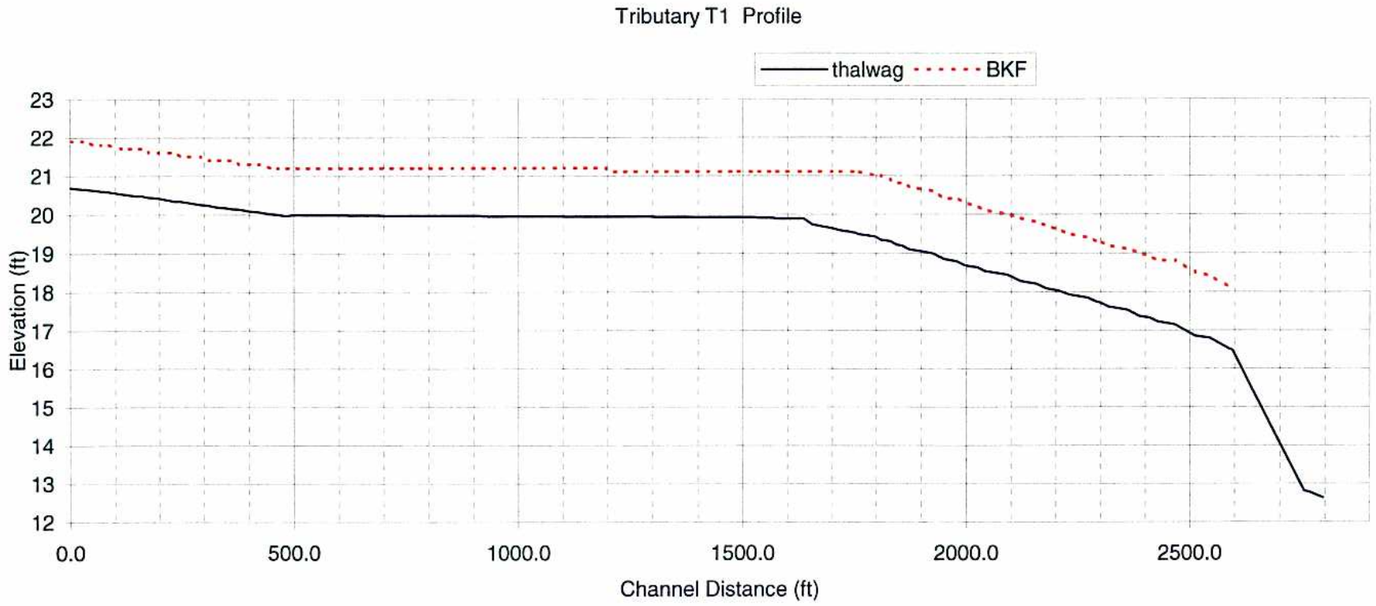
Scale: NTS

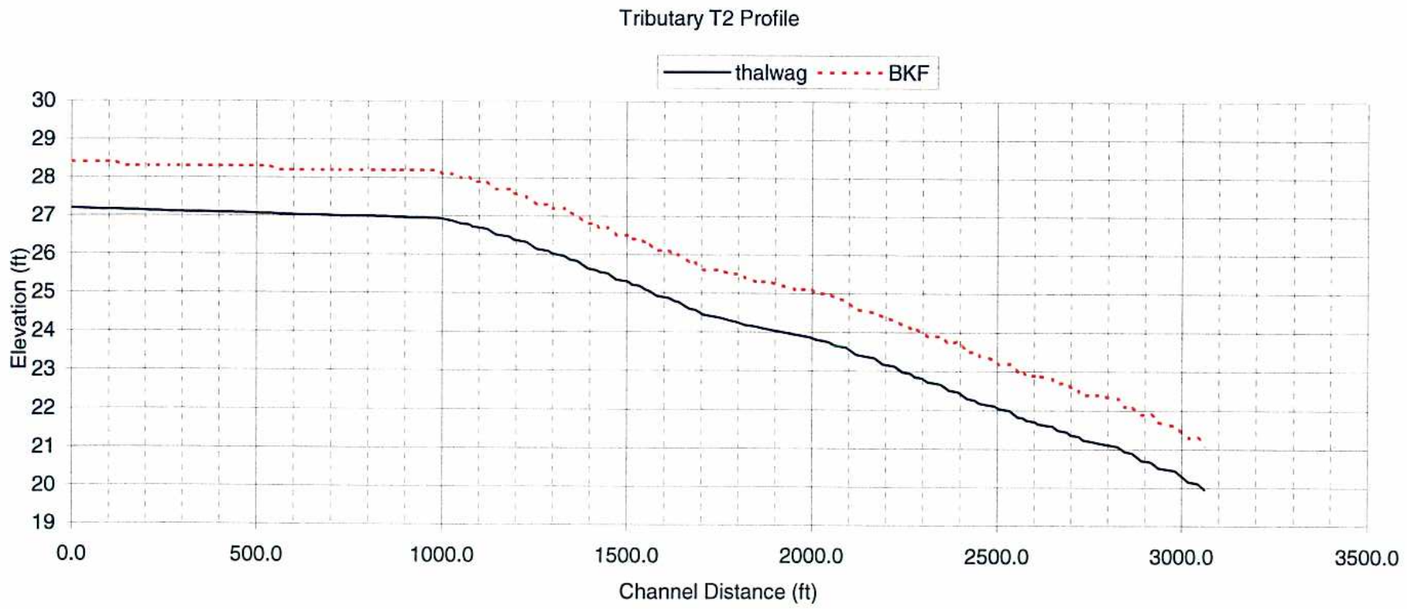
Date: April 2007

Project No.: 06-3885

SHEET NO.

D-1





Restoration Systems
1101 Haynes Street, Suite 107
Raleigh, N.C. 27604
(919) 755-9490

NOTES/REVISIONS

Project:

LLOYD PROPERTY
STREAM AND WETLAND
RESTORATION

ONSLOW COUNTY
NORTH CAROLINA

Title:

Stream Profiles

Scale:	SHEET NO.
NTS	D-2
Date: July 2007	
Project No.: 06-3885	

Appendix B.
Preconstruction and
Construction Photographs

Appendix B: Preconstruction Photographs

Looking upstream on abandoned channel at Site infall.

Looking downstream on abandoned channel from Site infall.

Looking downstream on abandoned channel.

Looking upstream on abandoned channel.

Looking across the abandoned channel toward the main tributary adjacent to the tree line.

Appendix B: Preconstruction Photographs (continued)

Looking across the abandoned channel toward the area of Rains soils proposed for nonriverine wetland restoration.

Looking upstream at the main channel adjacent to the tree line.

Looking towards the abandoned channel near the location of the culverted crossing that will bisect the easement.

Looking downstream at the confluence of the main channel and the abandoned channel.

Looking upstream towards the confluence of the main channel and the existing eastern channel/roadside ditch.

Appendix B: Construction Photographs

Overview of the Site looking from east to west.

Looking from the top of the Site, downstream at the Main Channel (previously abandoned).

Looking from the bottom of the Site, upstream.

Looking upstream at the Main Channel (previously abandoned).

Overview of the Site looking from the northwest toward the southeast.

Appendix B: Construction Photographs (continued)

Looking across the filled abandoned channel toward the area of Rains soils/nonriverine wetland restoration.

Wrack adjacent to the Main Channel from an overbank event that occurred during construction.

Looking at the Main Channel from the top of the Site. Adjacent Muckalee soils/riverine wetland restoration areas are beginning to rehydrate.

Looking upstream at upper reach of the Eastern Tributary where a floodplain bench was excavated to encourage overbank flooding.