WETLAND MITIGATION PLAN

SALT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
RALEIGH, NORTH CAROLINA

August 2000

Executive Summary

The North Carolina Department of Transportation (NCDOT) is preparing to improve U.S. Highway 1 (TIP #R-210), along an approximately 19.2 kilometer (km) (11.9 mile [mi]) corridor. The project exhibits potential to impact up to 17 hectares (ha) (43 acres [ac]) of wetlands. NCDOT evaluated on-site wetland mitigation options and determined that suitable on-site mitigation opportunities were not available. Subsequently, NCDOT initiated a regional search for suitable mitigation sites within the greater Sandhills region of Lee and Moore Counties. This search resulted in the identification of a 132-hectare (ha) (327-acre [ac]) site located near Lobelia in Moore County.

The Site is situated adjacent to the Little River and contains a variety of physiographic areas, including riverine floodplain, terrace ridge, upper and lower terrace, back-swamps, seepage slopes, and upland ridges. The Site includes a major drainage network, installed in the 1930s to promote conversion of the area to crop land and/or silvicultural operations. The ditch network is located primarily in central portions of the Site. Road construction, selective and clear-cut operations, and planting of loblolly pine (*Pinus taeda*) appear to have occurred within the drainage network. The Site alterations have induced significant degradation to adjacent wetland systems, including reductions in surface water storage, flood retention capacity, nutrient cycling functions, and wetland community structure. Approximately 75 ha (185 acres) of historic wetlands were drained by the drainage network.

Other than recent logging operations, the Site has been allowed to re-vegetate naturally. Currently, most of the Site is under forest cover. Passive ditch filling within the drainage network appears to be reducing impacts to the wetland system over time. However, significant areas remain under the influence of the drainage network. Vegetation composition and community dynamics have undergone transitions between characteristic upland species, and wetland species adapted to relatively long term saturation and inundation.

Wetland and stream mitigation activities have been designed to restore historic wetland features and functions that existed on the Site prior to the draining activities. Site alterations designed to restore characteristic wetland soil features and groundwater wetland hydrology include ditch backfilling and ford (stream crossing) construction. Subsequently, tree planting will occur throughout the Site to facilitate establishment of diagnostic natural communities, including bottomland hardwood forests, cypress-gum swamp, and wet pine flats. Ecotonal changes between community types will be encouraged to provide diversity and provide secondary benefits, such as enhanced feeding and nesting opportunities for mammals, birds, amphibians, and other wildlife.

After implementation, restoration activities are expected to restore approximately 20 ha (49 acres) of riverine hardwood and swamp forest wetlands. Additionally, mitigation activities will assist in the passive wetland development and restoration process of 67 ha (165 ac) of land degraded by the antecedent ditch network. The Site is being offered, in total, to offset wetland impacts associated with improvements to the US 1 corridor (R-210). Therefore, an ecosystem approach to mitigation has been implemented to maximize wetland functional benefits generated by the project.

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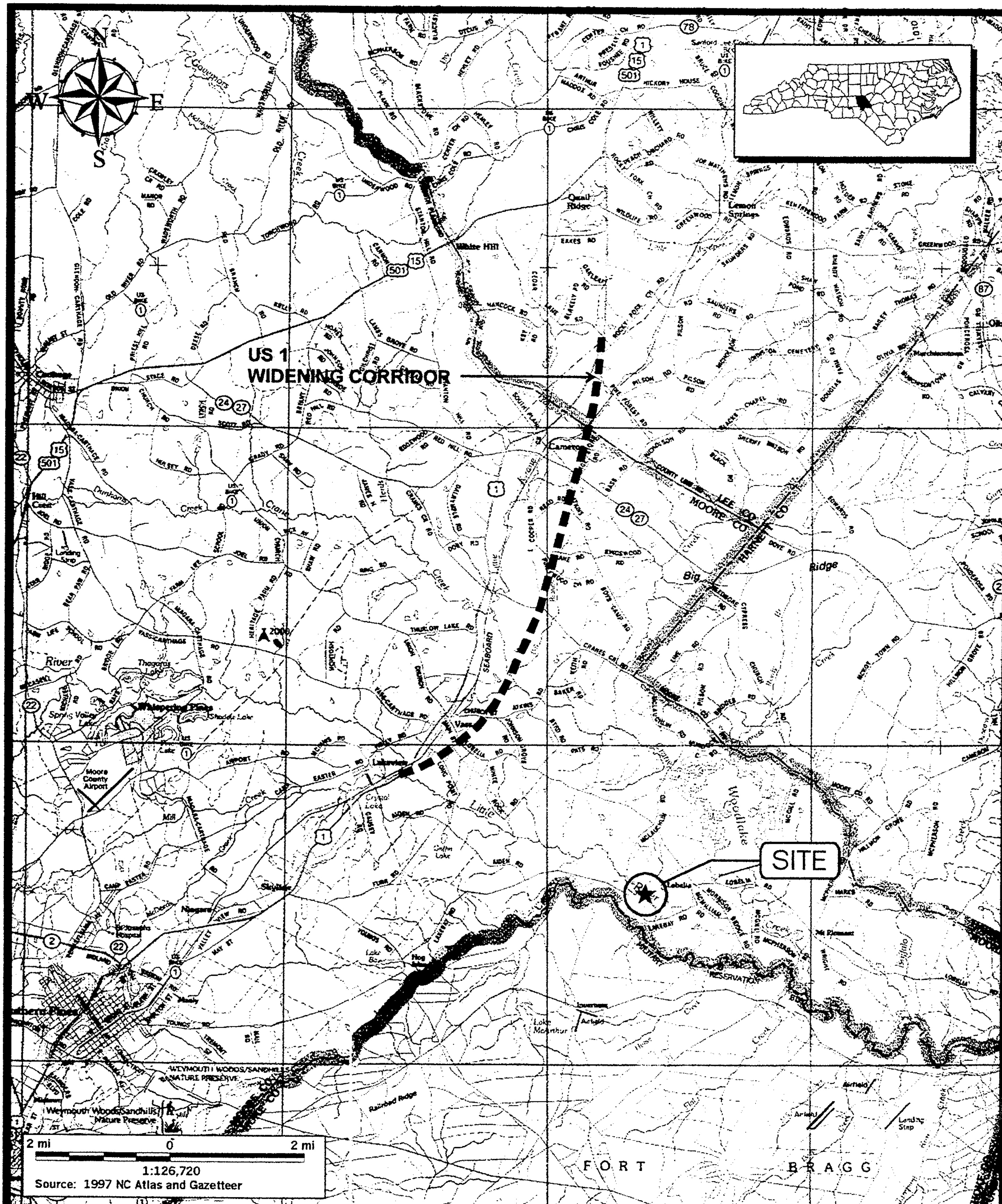
SALT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

1.0 INTRODUCTION

The North Carolina Department of Transportation (NCDOT) is preparing to improve U.S. Highway 1 (TIP #R-210), along an approximately 19.2 kilometer (km) (11.9 mile [mi]) corridor. The corridor extends from the existing four lane terminus southwest of Sanford in Lee County to the existing terminus north of Lakeview in Moore County. A portion of the project involves adding two lanes within the existing right-of-way in southern Lee County. The project also involves construction of a four lane highway on new right-of-way, beginning at SR1180. The project exhibits potential to impact up to 17 hectares (ha) (43 acres [ac]) of wetlands.

NCDOT evaluated on-site wetland mitigation options and determined that suitable on-site mitigation opportunities were not available. Subsequently, NCDOT initiated a regional search for suitable mitigation sites within the greater Sandhills region of Lee and Moore Counties. This search resulted in the identification of a 132-hectare (ha) (327-acre [ac]) site located along the Little River near Lobelia in Moore County (Figure 1). The Site is being offered, in total, to offset wetland impacts associated with improvements to the US 1 corridor (R-210). Therefore, an ecosystem approach to mitigation has been implemented to maximize wetland functional benefits generated by the project.

This document represents detailed mitigation procedures to facilitate the implementation of restoration and enhancement activities. The document includes: 1) a description of existing conditions; 2) detailed wetland restoration study and component analysis; 3) presentation of a mitigation plan for restoring/enhancing wetlands; and 4) presentation of a plan for monitoring and measuring success of restoration efforts.



NC DEPARTMENT OF TRANSPORTATION
PO BOX 25201
RALEIGH NC 27611

LOCATION MAP
SALT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn. by:	MAF
Ckd by:	JWG
Date:	Aug. 2000
Project:	98-024.06

FIGURE
1

2.0 METHODS

Infrared aerial photography was prepared by NCDOT in 1998 for mitigation planning purposes. Topographic mapping to one-foot contour intervals was generated from the photography. In 1999, additional land surveys were performed to plat property boundaries, provide ditch locations and cross-sections in obscured areas, and to determine groundwater well location and elevations.

Field reconnaissance was performed to validate published resource inventories, and to identify areas of particular environmental concern. Resources utilized in support of the field effort include U.S. Geological Survey (USGS) topographic mapping, U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) mapping (Lobelia 7.5 minute quadrangle), and Natural Resource Conservation Service (NRCS) soils information for Moore and Hoke Counties (USDA 1995). Mapping of natural resources was developed on the detailed topographic mapping.

North Carolina Natural Heritage Program (NCNHP) data bases were consulted for the presence of protected species and designated natural areas near the Site. A listing of Federal-protected species whose ranges extend into Moore County was obtained from the USFWS (dated May 14, 1999). State Historic Preservation Office (SHPO) records were evaluated for the presence of significant cultural resources in the Site vicinity.

Field investigations were initiated in April 1999 and include hydrological evaluations, detailed review of NRCS soil mapping, and evaluation of on-site resources. Existing plant communities, surface water flow, and soil disturbances were delineated, mapped, and described by structure and composition. A map depicting wetland boundaries delineated in 1998, was obtained and evaluated to assist with base mapping efforts (Carter 1998).

Sixteen continuous groundwater monitoring wells were installed to provide groundwater flow data and wetland hydroperiod information relative to drainage networks. Groundwater conditions were conceptually modeled using DRAINMOD, a computer model for simulating relatively shallow soils with high water tables. Drainage impacts to wetlands resulting from ditches were evaluated based on NRCS soil series and regional rainfall data. The conceptual model was utilized to predict the extent of wetland degradation due to ditching and the potential for wetland restoration through effective removal of the drainage network.

Flood frequency analyses were performed along the Little River to predict flood extent into the Site for 1, 2, 5, 10, 50, 100, and 500-year storm events. The analyses utilized the two-dimensional depth-averaged flow and sediment transport module Flo2DH of the Federal Highway Administration's (FHWA) Finite Element Surface-water Modeling System (FESWMS). The projected extent of flooding was used primarily to determine the influence of riverine flooding to the lower terraces and backwater portions of the Site.

Field survey and study information was platted and compiled within Geographic Information System (GIS) base mapping and analyzed to evaluate the Site under existing conditions. Based on field investigations and data analyses, a wetland restoration and enhancement plan has been developed for review and approval prior to on-site implementation.

3.0 EXISTING CONDITIONS

3.1 PHYSIOGRAPHY, TOPOGRAPHY, AND LAND USE

The Site is located in the Sandhills Physiographic Province of south-central North Carolina. The landscape is characterized by broad, gently rolling inter-stream divides intermixed with steeper slopes along well-defined drainage ways. The Site is situated in the Little River floodplain within the greater Cape Fear River Basin. The Cape Fear sub-basin boundary (Hydrologic Unit #03030004 [USGS 1974]) contains most of the northern portion of the Sandhills.

The Site comprises approximately 132-ha (327-ac) located 1 mi (1.6 km) west of Lobelia and approximately 1 mi (1.6 km) from the northern boundary of the Fort Bragg Military Reservation (Figure 1). It is a rectangular piece of property that lies lengthwise along a northwest to southeast axis. The Little River forms the boundary along the western edge of the property, and wooded upland slopes border the northern and eastern sides (Figure 2). Lakebay Road (SR 2023) runs along the southern end of the property.

Three land use and hydraulic conditions will be described throughout this document. The conditions will be referred to as 1) existing condition; 2) antecedent condition; and 3) historic condition. Historic condition describes the time period prior to entry of mechanized equipment. Antecedent condition includes the period beginning from the 1930s, after construction of the ditch network and the subsequent conversion of the site to crop land and/or silvicultural uses. Existing condition describes features present as the ditch network continues to exhibit decreasing influence on wetland function.

Under antecedent conditions, portions of the Site were ditched and drained in the early to mid 1930's by mechanized equipment (see Section 4.1.3). The drainage system was installed primarily to facilitate silvicultural and/or agricultural use of the property. Logging road construction appears evident during the period. Clearing of natural wetland vegetation and planting of loblolly pine (*Pinus taeda*) may have occurred within the drainage network. Conversion to crop land also appears to have occurred within approximately 8 ha (20 ac) during this period (Carter 1998).

The antecedent drainage network includes approximately 4,755 m (15,600 linear ft) of ditches primarily in central portions of the Site. The network was connected to the Little River at five primary outlets (Figure 2). Based on unconsolidated sediment cores, the ditches appear to have been constructed to depths ranging from 1.2 m (4 ft) to more than 1.8 m (6 ft) below the floodplain surface. The ditch network appears to have had significant impacts to adjacent wetland systems.

Under existing conditions, the ditches have not been maintained and have partially filled with unconsolidated sediment. The cross-section of the ditch not filled with sediments extends to depths averaging 0.3 m (1 ft) to 1.0 m (3 ft) below the surface. The passive process of ditch filling appears to be reducing impacts to the wetland system over time. Vegetation composition and community dynamics are undergoing a transition towards characteristic wetland species adapted to long term saturation and inundation (Carter 1998).

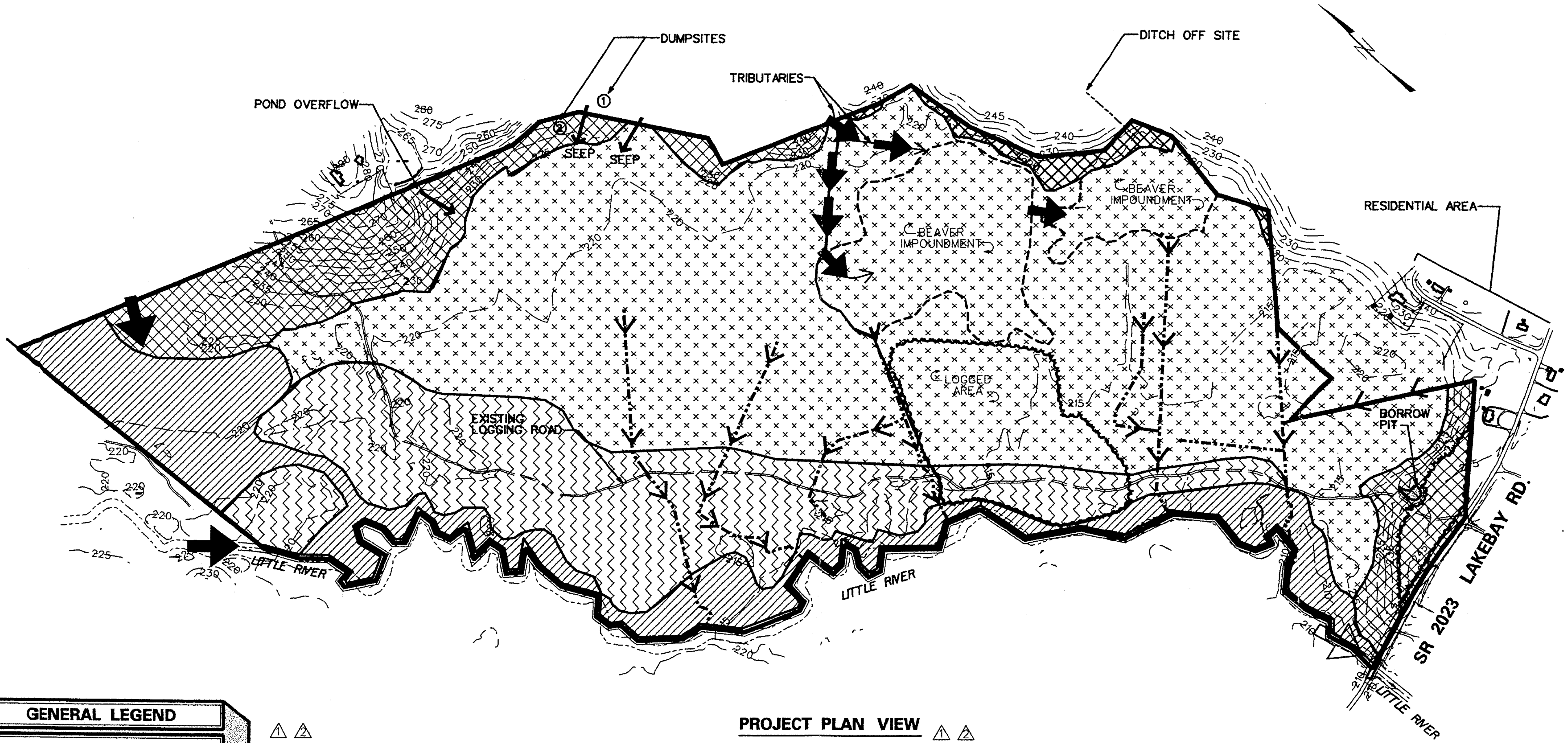
Currently, most of the tract is forested. Timber on the tract was likely cut periodically during the late 1800's and early 1900's. Aerial photographs taken between 1938 and 1998 show evidence of subsequent timber harvest during the ditch construction period. In addition, approximately 8 ha (20 ac) were clear-cut during the fall and summer of 1997 (Figure 2).

An old logging road that begins on SR 2023 and runs through the property was improved for this 1997 logging operation (Figure 2). A borrow pit was excavated in the hillside near SR 2023 and utilized as fill for the logging road. Additional road fill was placed through wetland areas by excavation from areas immediately adjacent to the road. Approximately seven culverts were placed under the road at ditch /stream crossings and depressional areas.

The Site has been subdivided into four primary physiographic landscape units for wetland classification and restoration planning: 1) groundwater slopes, 2), river terrace, 3) sandy terrace ridge; and 4) primary river floodplain (Figure 2). The primary variables utilized to segregate wetland landscape units include land slope, the expected direction of groundwater flow, relative elevation, and the expected influence from over bank flooding.

Groundwater slopes, found along the eastern and northeastern periphery of the Site, include relatively steep elevated escarpments supporting upland characteristics. The slopes are expected to exhibit primarily unidirectional, lateral flow of groundwater and surface water towards the Little River floodplain. The slope supports drainage from a 2.8 km^2 (1.1 mi^2) watershed, and includes dissection from one tributary entering the Site in central portions of the property. Numerous seeps, a ditch, and a pond exhibit near continuous, surficial expression of groundwater at the base of the groundwater slope.

The river terrace dominates central and interior portions of the Site. This landscape unit extends as a broad band lengthwise through the Site, with connectivity to the Little River occurring at several points through the sandy terrace ridge. Under base flow conditions within the river, this low-lying area is expected to exhibit primarily vertical to radial groundwater flow and discharge toward the Little River. Only during large flooding events from the Little River (*i.e.* exceeding the 100 year return interval) can inundation of the river terrace be expected.



PROJECT PLAN VIEW ⚠1 ⚠2

GENERAL LEGEND

- INFLOW
- OUTFLOW
- DIRECTION OF FLOW
- —220— MAJOR CONTOURS
- LOGGED AREA
- APPROX. MITIGATION SITE BOUNDARY
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING FENCE
- EXISTING DITCH

⚠1 ⚠2

LAND TYPES

- PRIMARY RIVER FLOODPLAIN
- SANDY TERRACE RIDGE
- RIVER TERRACE
- GROUNDWATER SLOPE

NO.	REVISIONS	DATE
1	REVISIONS PER NCDOT	SEPT 1999
2	REVISIONS PER NCDOT	FEB 2000

Client: NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project: PHYSIOGRAPHY, TOPOGRAPHY, AND LAND USE
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By: MAF | Date: AUG 2000
Ckd By: JWN | Scale: 1"= 600'

ESC Project No.: 98-024.06

Figure 2

Hydrodynamic influences are dominated by discharge from groundwater slopes from the north and east. This discharge provides intermittent surface water expression throughout the year, including numerous intermittent channels and ponded areas. Beaver impoundments are evident in this area (Figure 2). The river terrace additionally supports the floodplain of the tributary arising from the secondary watershed. Alterations to the landscape including ditching, logging activities, and beaver activity have obscured and redirected much of the tributary flow and concurrent floodplain area.

The sandy terrace ridge represents a relatively narrow, elevated band of sandy sediments situated between the terrace and the primary river floodplain. The primary logging road has been constructed along this convex ridge. The ditch network was constructed through low-lying portions of the sand ridge to accelerate drainage from the groundwater slope and terrace areas. This physiographic unit maintains natural communities that are unique to the Little River drainage, including the Little River terrace variant to mesic pine flatwoods (Schafale and Weakley 1990).

The primary river floodplain is concentrated as a low-lying band between the Little River and the sand ridge and logging road. The area supports numerous oxbows, and active channel sections. The surface is continuously being re-worked from frequent overbank floods with woody debris jams, wrack, and ephemeral pools scattered throughout the area. The ditch network supports outlets constructed through this physiographic area, exhibiting direct connectivity to the Little River.

3.2 CULTURAL RESOURCES

The term "cultural resources" refers to prehistoric or historic archaeological sites, structures, or artifact deposits over 50 years old. "Significant" cultural resources are those that are eligible or potentially eligible for inclusion in the *National Register of Historic Places*. Evaluations of site significance are made with reference to the eligibility criteria of the National Register (36 CFR 60) and in consultation with the North Carolina State Historic Preservation Officer (SHPO).

A file search was conducted at the Office of State Archaeology (OSA) in order to determine whether any cultural resources investigations have been conducted within the project vicinity and to determine whether any significant cultural resources have been documented within the study area. It appears that at least one survey for archaeological resources has been conducted within the Site; however, no archaeological finds were recorded. Multiple archaeological finds have been recorded south of the Site. These finds will not be impacted by work associated with mitigation activities and this project is not expected to adversely affect any known significant archaeological resources.

3.3 HAZARDOUS MATERIALS

Environmental Screening was conducted during multiple field visits in order to evaluate the presence of potentially harmful environmental hazards. Environmental concerns under review include past or present storage of hazardous or regulated materials and/or waste, illicit dumping of solids or hazardous waste, and degradation of surface waters which may have a negative impact on the environment. Visual screening for objects such as storage tanks, debris, hazardous material, and evidence of waste burial was conducted through field reconnaissance within study area.

Cursory field surveys revealed evidence of localized waste dumps within, and immediately adjacent to the Site (Figure 2). Isolated waste dumps include scattered household garbage and debris associated with timber harvest activities. In addition to general debris associated with timber harvest, two debris piles were identified on the western property boundary. The southerly dumping area (Site 1) contained plastic bags, chicken wire, a kitchen sink, boxes, crates, plastic planters, and other woody materials. At this dumping location an unidentified odor was noted; however, no odor source was documented. The northerly dumping area (Site 2) contained a storage drum, almost completely disintegrated by rust. No residual solids or liquids were identified in the drum, and no label was legible on the outer surface. No odors or slicks were noted adjacent to this dumping location and vegetation was not inhibited in the vicinity of the dump.

In addition to cursory field surveys, an Environmental Data Resources, Inc. (EDR) report was obtained. No mapped sites were identified by the EDR record search within the study area or within the American Society for Testing and Materials (ASTM E 1527-97) search radius. Databases reviewed included:

NPL	National Priority List
Delisted NPL	NPL Deletions
RCRIS-TSD	Resource Conservation and Recovery Information System
SHWS	State Hazardous Waste
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CERC-NFRAP	Comprehensive Environmental Response, Compensation, and Liability Information System
CORRACTS	Corrective Action Report
SWF/LF	Solid Waste Facilities
LUST	Incidents Management Databases
UST	Petroleum Underground Storage Tank Database
RAATS	RCRA Administrative Action Tracking System
RCRIS-SQG	Resource Conservation and Recovery Information System
RCRIS-LQG	Resource Conservation and Recovery Information System
HMIRS	Hazardous Materials Information Reporting System
PADS	PCB Activity Database System
ERNS	Emergency Response Notification System
FINDS	Facility Index System/Facility Identification Initiative Program Summary Report
TRIS	Toxic Chemical Release Inventory System
NPL Lien	NPL liens
NC HSDC	Hazardous Substance Disposal Site
IMD	Incident Management Database
TSCA	Toxic Substance Control Act

MLTS	Material Licensing Tracking System
ROD	ROD
CONSENT	Superfund (CERCLA) Consent Decrees
Coal Gas	Former Manufactured gas (Coal Gas) Sites

Unmapped (Orphan) sites were not considered as part of the foregoing analyses

Based on the database report is was determined that review of agency files was not necessary for this property.

3.4 SOILS

Soils have been mapped by NRCS (USDA 1995). Soils were verified in the Spring of 1999 by licensed soil scientists to refine soil map units and to locate inclusions and tax-adjunct areas. Areas most intensely surveyed include the floodplain and river terrace complex of hydric and non-hydric soils located along the center axis of the property. Systematic transects were established and sampled to ensure proper coverage.

Nine soil series were identified, including Bibb, Leon, Johns, Kennansville, Kalmia, Gilead, Ailey, Vaucluse, and Candor. Soil characteristics are listed in Table 1. Refined soil mapping is depicted in Figure 3. Typical profiles for four of the predominant soil series are depicted in Figures 4a and 4b.

3.4.1 Hydric Soils

Hydric soils are defined as "soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part" (USDA 1987). Soil mapping identifies two hydric soils within the study area, Bibb loam (*Typic Fluvaquents*) and Leon sand (*Aeric Haplaquods*). Bibb is the predominant soil type, representing 72% or approximately 95 ha (236 ac) of the 132-ha (327 ac) Site. Typical soil profile is shown in figure 4(a). Bibb soils are nearly level, poorly drained, and are located within the primary floodplain and river terrace physiographic areas. Bibb loam exhibits low permeability, high available water capacity, and a seasonal high water table at a depth of 0.2 to 0.3 m (0.5 to 1.0 ft) during the winter and early spring. The soil series is periodically exposed to overbank flooding and alluvial sediment deposition. Bibb soils typically support bottomland hardwood forest. Inclusions of the Johnston series (*Cumulic Humaquepts*) and bottomland swamp forest ecosystems occur within backwater areas due to prolonged inundation and organic matter accumulation.

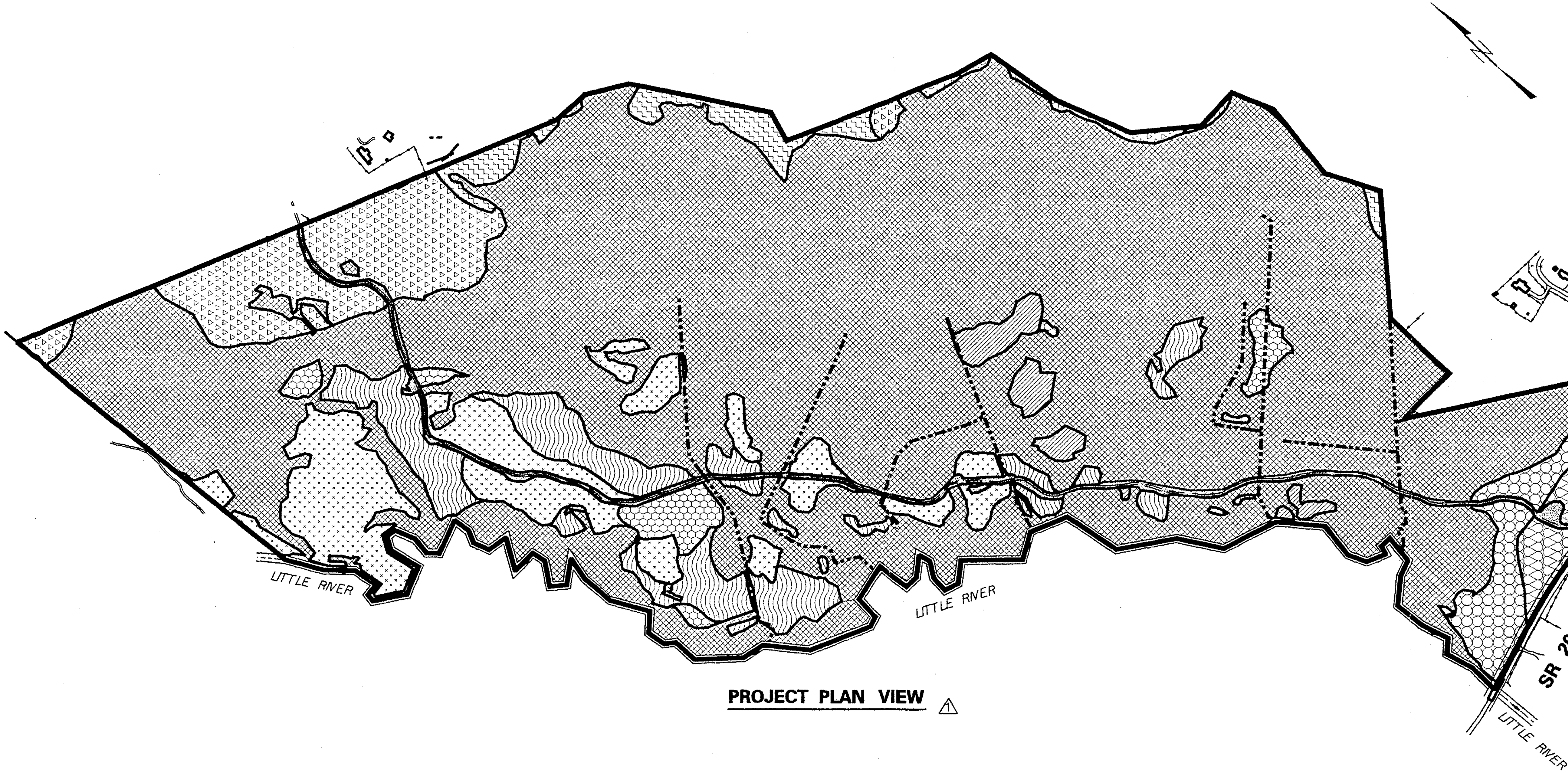
Leon sand is not recognized by NRCS in Moore County, but identified and mapped in limited areas on the Site. Leon sand is found in neighboring Hoke County and is listed as a hydric soil (USDA 1985, 1996). Leon sands, occupying approximately 2 ha (4 ac), are found in level to convex, poorly drained soils on intermittent sand flats and ridges. Leon soils have high to medium permeability, low available water capacity, and a seasonal high water table extending from surface saturation to 0.2 m (0.5 ft) during the winter months.

Table 1
Soil Characteristics

Soil Series	Taxonomic classification	Landscape positions	Seasonal high water table	Permeability depth	In/hr	% OM
Hydric Soils						
Bibb Bb	*Typic Fluvaquents*	river floodplain and river terrace	0.5 - 1.0 ft	0-12 in 12-70 in	0.6-2.0[1] 0.6-2.0	1-3
Leon LeA[2]	*Aeric Haplaquods*	low flats and upland depressions	0-1.0 ft	0-19 in 19-42 in	6.0-20 0.6-6.	0.5-4
Non-hydric Soils						
Gilead GhD	*Aquic Hapludults*	groundwater slopes	1.5 - 2.5, perched	0-12 in 8-17 in	2.0-6.0 0.6-2.0	0.5-1
Johns JoA	*Aquic Hapludults*	terrace ridge	1.5 - 3.0 ft	0-7 in 7-26 in	2.0-6.0 0.6-2.0	0.5-2
Kenansville KeB	*Arenic Hapludults*	river terrace and terrace ridge	4.0 - 6.0 ft	0-22 in	6.0-20	0.5-2
Kalmia KaA	*Typic Hapludults*	river terrace and terrace ridge	>6.0 ft	0-12 in 12-37 in	2.0-6.0 0.6-2.0	0.5-2
Ailey AeB/AeD	*Arenic Kanhapludults*	groundwater slopes	>6.0 ft	0-30 in	6.0-20	<1
Vaucluse VaE/VaD	*Typlc Kanhapludults*	groundwater slopes	>6.0 ft	0-13 in	6.0-20	<1
Candor CaB	*Arenic Paleudults*	groundwater slopes	>6.0 ft	0-26 in	6.0-20	0.5-1

[1] Based on the hydraulic conductivity tests, an average permeability value of (45 in/hr) was measured for Bibb soils.

[2] Leon is not listed in the Moore County soil survey. This information was obtained from neighboring Cumberland and Hoke County soil survey (NRCS 1985).



PROJECT PLAN VIEW ⚠

NRCS SOIL MAP UNITS ⚠

	HYDRIC SOILS	HECTARES	ACRES
Le	LEON	2±	4±
Bb	BIBB	95±	236±
	NON-HYDRIC SOILS		
KaA	KALMIA	2±	5±
JoA	JOHNS	7±	18±
KeB	KENANSVILLE	9±	23±

	NON-HYDRIC SOILS (cont.)	HECTARES	ACRES
AeB/AeD	AILEY	8±	19±
VaE/VaD	VAUCLUSE	2±	6±
CaB	CANDOR	2±	4±
GhD/Ghb	GILEAD	3±	7±
Ud	UDORTHENTS	2±	5±
	SITE TOTAL	132±	327±

GENERAL LEGEND

- APPROX. MITIGATION SITE BOUNDARY
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING FENCE
- EXISTING DITCH

NO.	REVISIONS	DATE
⚠	REVISIONS PER NCDOT	SEPT 1999

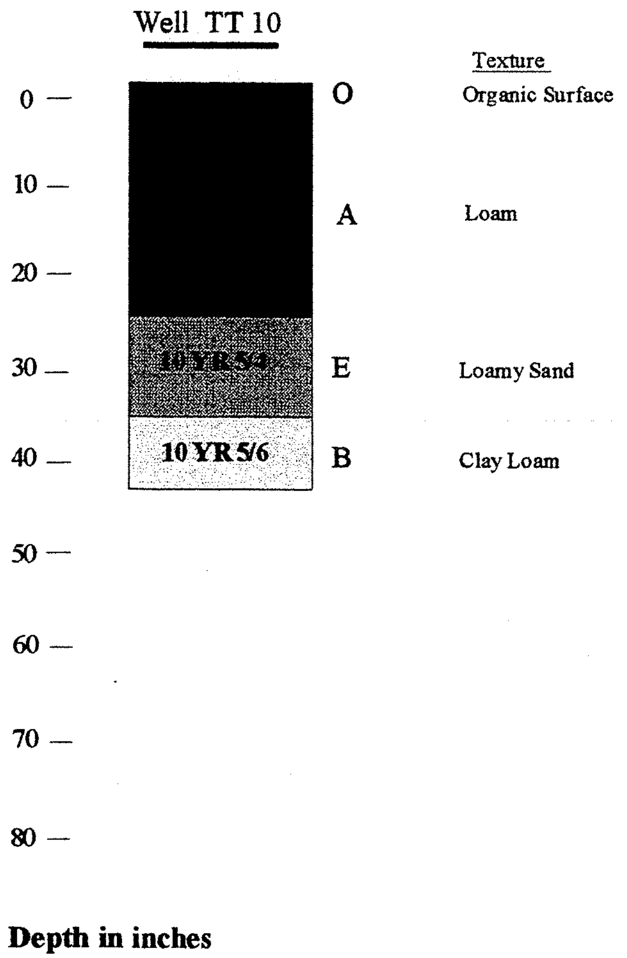
Client: NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project: **SOIL MAP UNITS**
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

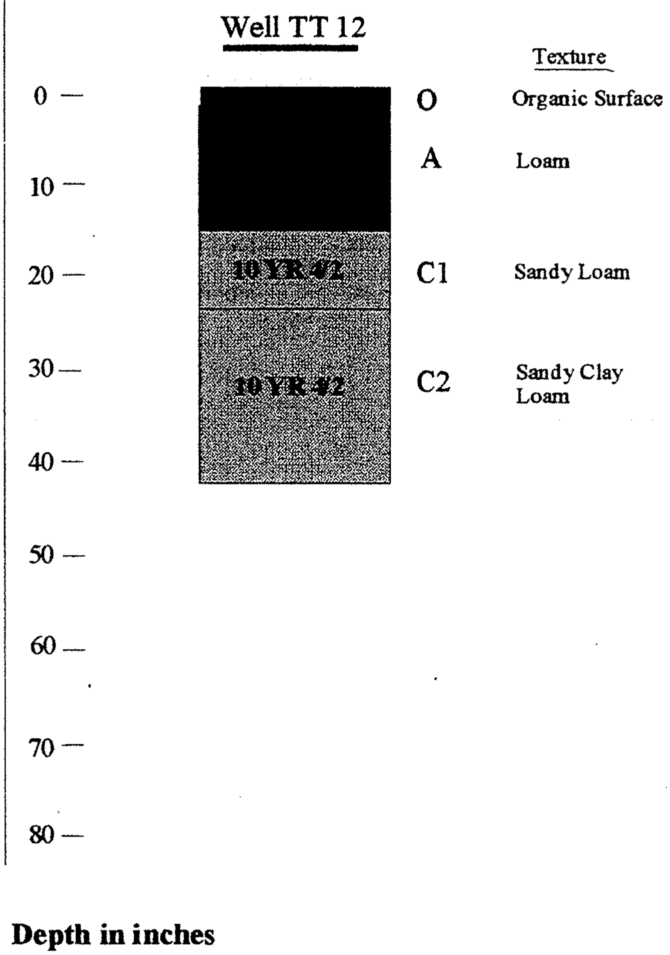
Dwn By: MAF	Date: AUG 2000	Figure
Ckd By: JWN	Scale: 1"= 600'	3
ESC Project No.: 98-024.06		

Soil Profiles

Kalmia sandy loam, wet substratum, 0 to 2 percent slopes



Bibb loam, 0 to 2 percent slopes, frequently flooded



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Soil Profiles
SALT Mitigation Site
Moore County, North Carolina

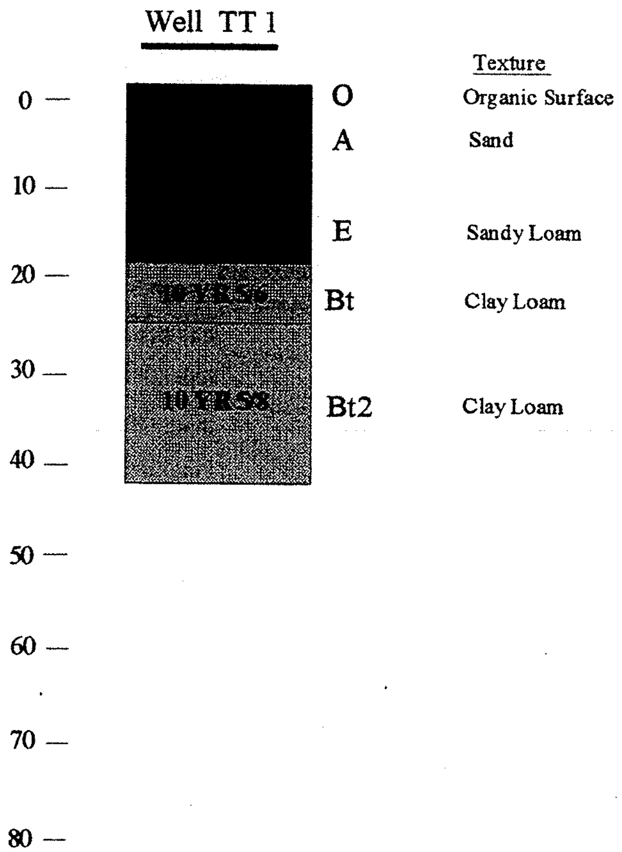
Figure: 4a

Project 98-024.06

Date: AUG 2000

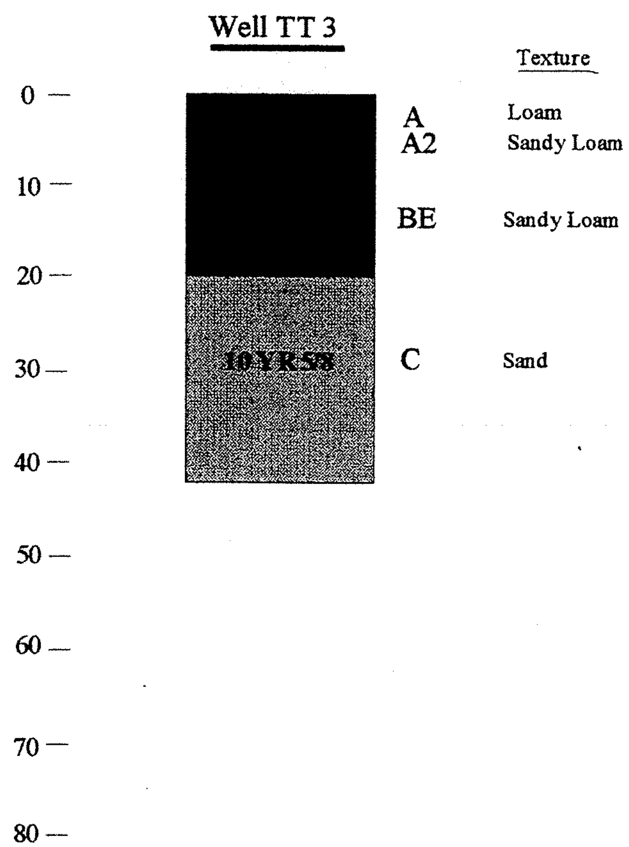
Soil Profiles

Kenansville loamy sand, 0 to 4 percent slopes



Depth in inches

Johns fine sandy loam, 0 to 2 percent slopes



Depth in inches

NC DEPARTMENT OF TRANSPORTATION
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Soil Profiles
SALT Mitigation Site
Moore County, North Carolina

Figure: 4b

Project 98-024.06

Date: AUG 2000

3.4.2 Nonhydric Soils

Nonhydric soils within the river terrace ridge include Johns (*Aquic Hapludults*), Kenansville (*Arenic Hapludults*), and Kalmia (*Typic Hapludults*). These series together comprise approximately 18 ha (46 ac) of the Site. The landscape is nearly level, supporting excessively drained to somewhat poorly drained soils along alluvial sand and silt deposits from the river. The soils exhibit moderate to moderately rapid permeability and a seasonal high water table from 0.5 to 1.8 m (1.5 to 6 ft) below the land surface.

Upland soils on groundwater slopes include Ailey, Vaucluse, Candor, and Gilead. These series together comprise approximately 15 ha (36 ac) of the Site. These soils are moderately well to excessively drained. These soils are generally droughty due to high permeability, steep slope, and low water holding capacity.

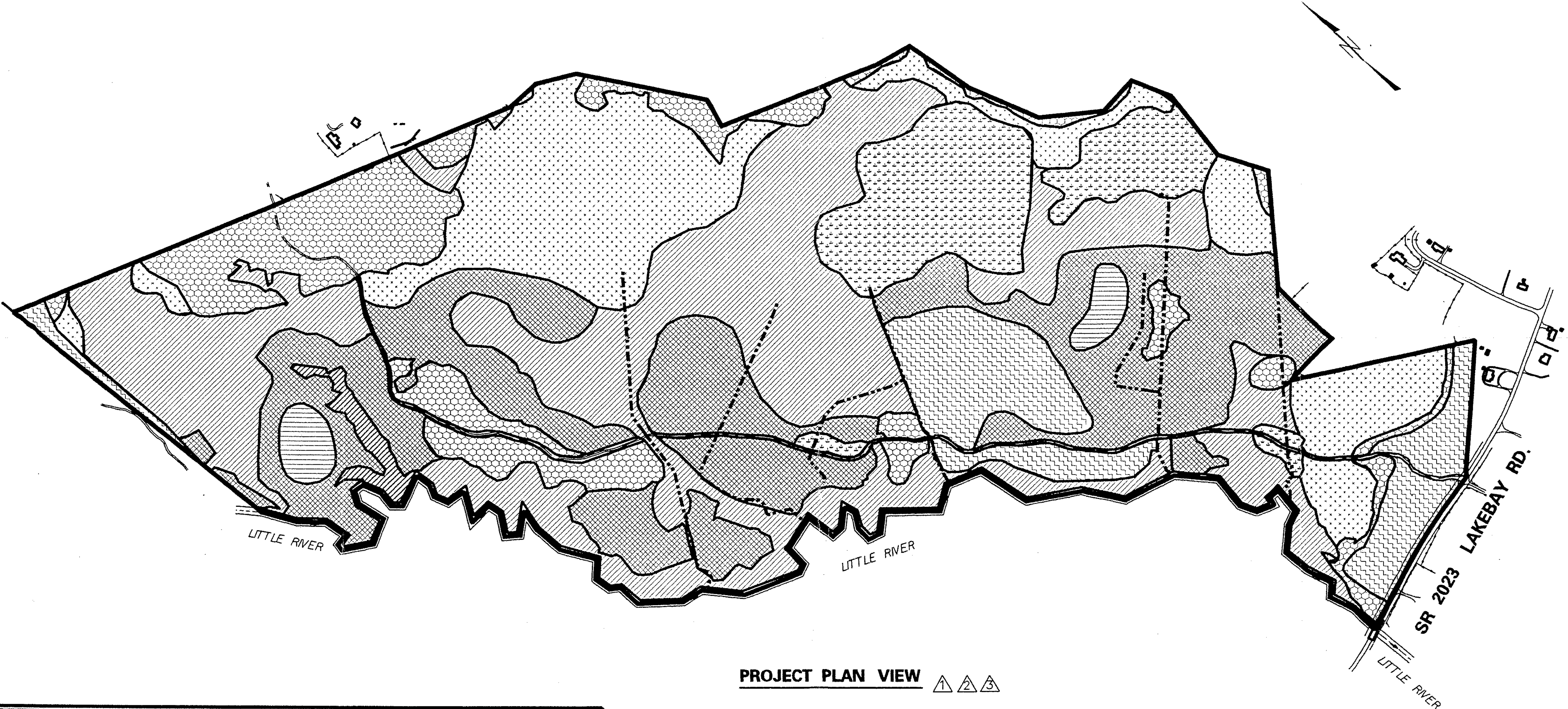
3.5 PLANT COMMUNITIES

Distribution and composition of plant communities reflect landscape-level variations in topography, soils, hydrology, and past land use practices. The major plant communities identified in the study area include: palustrine hardwood forest, pine/scrub oak forest, wet pine flats, streamhead Atlantic white cedar forest, and beaver impoundments (Figure 5). A more complete listing and community description can be found in Appendix A (Carter 1998).

Palustrine hardwood forest encompasses several forest communities including coastal plain levee, coastal plain small stream swamp, and cypress-gum swamp. These communities occur mainly along the Little River and in sloughs and drainage ways throughout the property. The dominant canopy species include swamp tupelo (*Nyssa biflora*), and red maple (*Acer rubrum*), but bald cypress (*Taxodium distichum*), pond cypress (*Taxodium ascendens*), loblolly pine (*Pinus taeda*), water oak (*Quercus nigra*), and sweet gum (*Liquidambar styraciflua*) also occur. The sub-canopy is characterized by young canopy species as well as ironwood (*Carpinus caroliniana*) (near the river), large specimens of titi (*Cyrilla racemiflora*), American holly (*Ilex opaca*), and sweet bay (*Magnolia virginiana*). The shrub layer is sparse to moderate and dominated by species such as dog-hobble (*Leucothoe axillaris*), giant cane (*Arundinaria gigantea*), and greenbrier (*Smilax* spp.). The forest floor is generally sparse but may contain cinnamon fern (*Osmunda cinnamomea*) and netted chain-fern (*Woodwardia areolata*). Much of the forest floor remains saturated for extended periods, consequently, sphagnum mats occur frequently in microtopographic depressions.

Upland pine/scrub oak forest occurs on the hillsides along the northern, eastern and southern portion of the Site and on the sandy ridge in the interior of the property. The overstory within the upland pine/scrub oak is dominated by loblolly pine, sand (pale) hickory (*Carya pallida*), mockernut hickory (*Carya tomentosa*), and various scrub oaks including: blackjack oak (*Quercus marilandica*), scrubby (sand) post oak (*Quercus margaretta*), turkey oak (*Quercus laevis*), bluejack oak (*Quercus incana*), and few remnant longleaf pine (*Pinus palustris*). The subcanopy include the above species, sourwood (*Oxydendrum arboreum*), sassafras (*Sassafras albidum*), persimmon (*Diospyros virginiana*), and flowering dogwood (*Cornus florida*). The ground layer is sparse to medium with bracken fern (*Pteridium aquilinum*), wire grass (*Aristida stricta*), dwarf blueberry (*Vaccinium tenellum*), and dwarf huckleberry (*Gaylussacia dumosa*) dominating in patches.

Wet pine flats occur on seasonally wet, flat terrace areas in the center of the Site. Part of this community was recently clear-cut. Loblolly pine dominates these areas but sweetgum and red maple are locally prevalent. The subcanopy is dominated by invading hardwoods listed above, sweet bay, water oak, and swamp red bay (*Persea palustris*). A dense, low shrub layer includes ink-berry (*Ilex glabra*), sweet gallberry (*Ilex coriacea*), sweet pepper bush (*Clethra alnifolia*), fetterbush (*Lyonia lucida*), giant cane, poison ivy (*Toxicodendron radicans*), and dangleberry (*Gaylussacia frondosa*).



PROJECT PLAN VIEW △1 △2 △3

EXISTING PLANT COMMUNITIES

△1 △2 △3

	HECTARES	ACRES
PALUSTRINE HARDWOOD FOREST	39±	97±
PINE / SCRUB OAK FOREST	15±	38±
WET PINE FLATWOODS	31±	78±
STREAMHEAD ATLANTIC WHITE CEDAR FOREST	21±	51±
MESIC PINE FLATWOODS	2±	5±

	HECTARES	ACRES
BEAVER IMPOUNDMENTS/MARSH	11±	27±
CUTOVER AREA	10±	25±
ACREAGE LOST TO LITTLE RIVER	2±	4±
ACREAGE LOST TO ROAD	1±	2±
SITE TOTAL	132±	327±

GENERAL LEGEND

- APPROX. MITIGATION SITE BOUNDARY
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING FENCE
- EXISTING DITCH

NO.	REVISIONS	DATE
△1	REVISIONS PER NCDOT	09-30-99
△2	REVISIONS PER NCDOT	01-10-00
△3	REVISIONS PER NCDOT	07-25-00

Client: *NC DEPARTMENT OF TRANSPORTATION*
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project: **PLANT COMMUNITIES**
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By:	MAF	Date:	AUG 2000
Ckd By:	JWN	Scale:	1"= 600'

ESC Project No.: 98-024.06

Figure 5

An endemic subset of the wet pine flats community is mesic pine flats. This community is separated from wet pine flatwoods at the Terrestrial-Palustrine boundary. The mesic pine flats are found on the large sandy terrace in the northern center and other smaller areas of the property. Historically, these areas supported an open, fire maintained longleaf pine community. These communities are currently dominated by loblolly pine but include invading hardwoods such as sweetgum, water oak, and various scrub oaks. The understory includes hardwoods listed above along with sparkleberry (*Vaccinium arboreum*) and highbush blueberry (*Vaccinium corymbosum*). The shrub layer is sparse but may contain the same species listed above. The herb layer is generally dominated by wire grass and bracken fern, species characteristic of mesic pine flats.

Streamhead Atlantic white cedar forest occurs in the eastern and northeastern perimeter of the property, along seepage slopes. These sites are seasonally or permanently flooded or saturated. These forests are dominated by Atlantic white cedar (*Chamaecyparis thyoides*) but include water tupelo, pond pine (*Pinus serotina*), red maple, and tulip poplar (*Liriodendron tulipifera*). A dense to fairly dense shrub layer occurs, with species such as sweet bay, inkberry, fetterbush, red bay, laurel-leaf greenbrier (*Smilax laurifolia*), and common greenbrier (*Smilax rotundifolia*). The herb layer is sparse, with cinnamon fern the most common species. Much of the forest floor remains saturated for extended periods of time and has sphagnum mats blanketing microtopographic depressions.

Beaver activity is common throughout the Site. Two shallow beaver impoundments are found on the eastern side of the property. The vegetation in the ponds includes many floating or submerged aquatics including water lily (*Nymphaea odorata*), duckweed (*Lemna* spp.), green arrow-arum (*Peltandra virginica*), smartweed (*Polygonum* spp.), and water-milfoil (*Myriophyllum* spp.). These impoundments also contain remnants of drowned trees and a few live young trees, predominantly red maple.

3.6 HYDROLOGY

3.6.1 Watersheds (Surface Water Hydrology)

The Site has been subdivided into two sub-watersheds for surface water studies and planning purposes: 1) the primary watershed associated with the Little River drainage basin; and 2) the secondary watershed associated with drainage from elevated ridges immediately north and east of the Site.

Primary Watershed

The primary watershed associated with the Little River drains central Moore County and encompasses approximately 448 km^2 (173 mi^2). The basin includes the town of Whispering Pines, portions of Southern Pines and Pinehurst, and the US1 and US 15-501 highway corridors. Land use primarily includes silviculture, agriculture, dairy/poultry production, residential, commercial, and recreational development associated with population centers.

Elevations within the Little River basin rise to approximately 180 m (590 ft) above National Geodetic Vertical Datum (NGVD). Elevations along the Little River, at the Site outfall, is approximately 63 m (210 ft) above NGVD.

Secondary Watershed

The secondary watershed includes drainage from groundwater slopes immediately north and east of the Site. The watershed encompasses approximately 2.8 km^2 (1.1 mi^2) of land with groundwater and surface water discharging directly into and through the Site. The discharge enters the northeastern property boundary through a series of groundwater seeps, an unnamed tributary, and several minor drainage ways, ditches, and an off-site pond (Figure 2). The watershed supports primarily woodland, crop land, poultry production, and residential use (Carter 1998).

3.6.2 Groundwater

Sixteen groundwater wells and one precipitation gauge were installed in the winter and spring of 1999 to track groundwater within interior areas adjacent to the ditch network. A conceptual model was used as part of detailed mitigation planning to evaluate groundwater for existing, antecedent, and historic conditions. The groundwater model is described in Section 4.0.

Topographically, the Site is generally expressed as a relatively flat valley floor bounded by the Little River to the west and a relatively steep escarpment to the east. Within the terrace physiographic area, groundwater flow is most likely dominated by vertical and to a lesser extent radial movement during normal climatic conditions. Lateral and radial groundwater migration may occur episodically during wet periods, mimicking surface water flow patterns. Based on field surveys, this preferential migration occurs primarily in the down valley direction (north to south), parallel to the Little River channel.

The relict ditch network is diverting a portion of this vertical to down-valley flow prematurely to the west, through the sandy terrace ridge and directly towards the Little River. This drainage network connects to the Little River at five outfalls points (Figure 2). Approximately 3,550 m (11,650 ft) of relict ditches have been identified, ranging from approximately 0.3 m (1 ft) to 1 m (3 ft) deep. However, approximately 2347 m (7,700 linear ft) of ditches are considered in functioning condition based on groundwater models (considered at least 0.3 m [1 ft] or greater in depth) (Section 4.0).

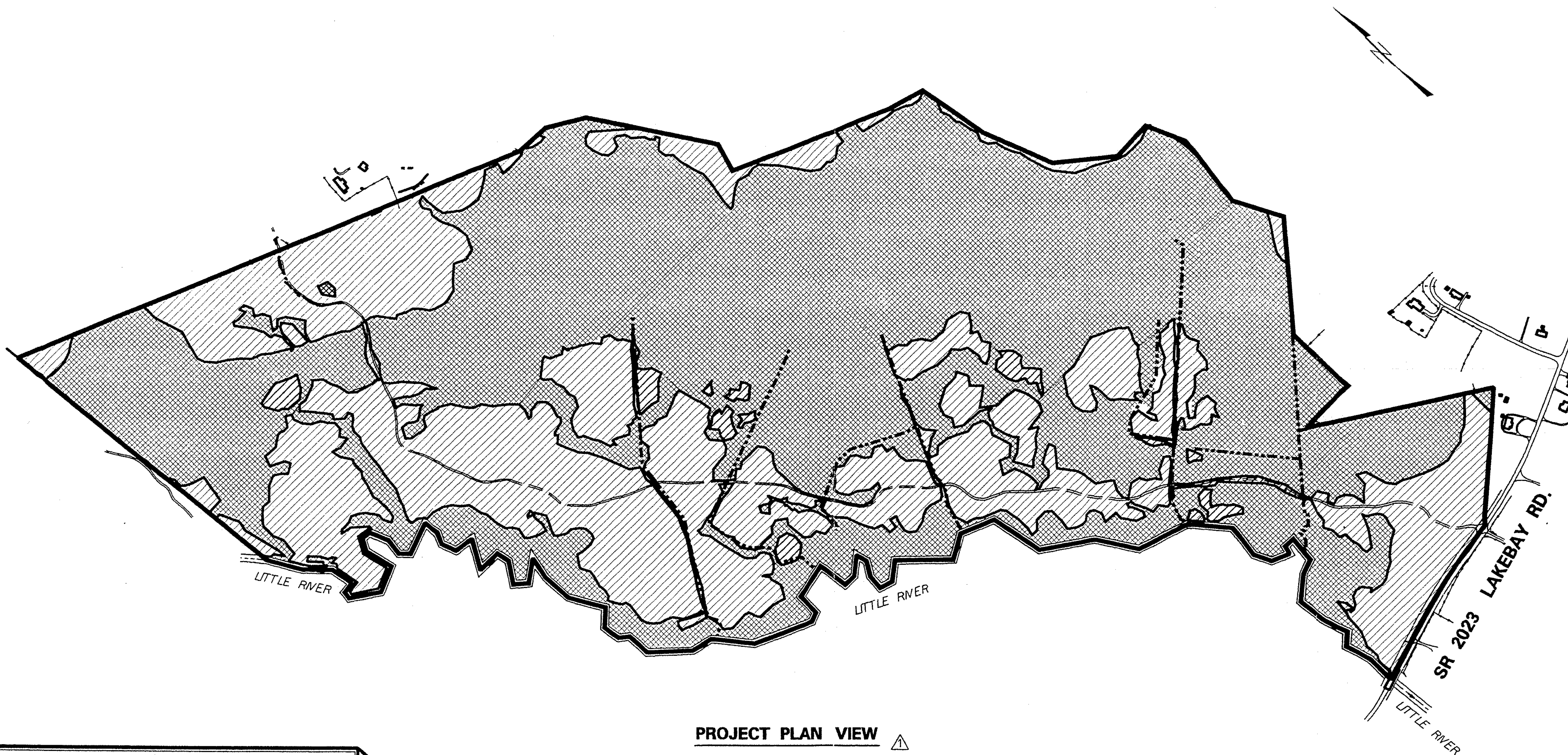
3.6.3 Off-Site Drainage

As depicted in Figure 2, six primary surface flow inlets have been identified extending from the secondary watershed into the Site. Inlets include upland drainage ways, a stream, several ditches, and seeps located along the northern and eastern project boundaries. Additional inlets include multiple river overflow points through the sand ridge and the river channel along the western boundary. Due to the size of the Site and expected slope gradients below in-fall, all but one of these influent surface flows appear to maintain base level elevations that are conducive to on-site storage, regardless of modifications to hydrology such as removal of interior ditches. However, the ditch along the southern property boundary, immediately east and north of Well #11 (Figure 2) is associated with the drainage of adjacent properties. Provisions will be required for this ditch to remain open during wetland restoration activities.

3.7 JURISDICTIONAL WETLANDS

A map depicting delineated jurisdictional boundaries was obtained and utilized to assist in base mapping efforts (Carter 1998). Jurisdictional area was evaluated using the three parameters set forth in the U.S. Army Corps of Engineers (USACE) Wetlands Delineation Manual (DOA 1987). Approximately 80 ha (199 ac) of jurisdictional wetland have been identified under existing conditions. Figure 6 depicts the boundary location of existing jurisdictional wetland systems. The jurisdictional boundary was surveyed by NCDOT personnel.

Approximately 20 ha (49 ac) of hydric soil areas are projected not to support jurisdictional wetlands in central reaches of the site. These areas are considered effectively drained by the ditch network. During antecedent conditions, the ditch network efficiently moved abundant water originating from the stream and seepage slopes at the base of the steep hillside to the north and east, across the area into the Little River. This situation caused a region wide draw-down, which led to vegetation turn-over in upper wetland reaches. Over the past 60+ years, plant species have responded to the hydrologic fluctuations by "sliding up and down" the moisture gradient. Certain areas have, either, not fully recovered from the draw down effects as the ditches have filled in; or these areas remain under the influence of the remaining ditch network. Vegetation turnover is still on-going in certain areas and will continue after the completion of restoration activities.



PROJECT PLAN VIEW ⚠1

GENERAL LEGEND

		HECTARES	ACRES
(heavy line)	APPROX. MITIGATION SITE BOUNDARY		
(double line)	EXISTING ROAD		
(building symbol)	EXISTING BUILDING		
—x—x—	EXISTING FENCE		
— - — -	EXISTING DITCH		
(outline)	NON-JURISDICTIONAL AREAS	52±	128±
(hatched)	JURISDICTIONAL WETLANDS	80±	199±
	TOTAL	132±	327±

⚠1

NOTE:
JURISDICTIONAL WETLAND DELINEATION PERFORMED 1998 BY DR. J. H. CARTER AND ASSOCIATES. INC., SOUTHERN PINES, NORTH CAROLINA.

NO.	REVISIONS	DATE
⚠1	REVISIONS PER NCDOT	SEPT 1999

Client:
NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project:
EXISTING JURISDICTIONAL WETLANDS
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: AUG 2000
Ckd By: JWN	Scale: 1"= 600'

ESC Project No.: 98-024.06

Figure 6

4.0 WETLAND RESTORATION STUDIES

4.1 CONCEPTUAL GROUNDWATER MODELING

Groundwater modeling was used to characterize the water table elevations under historic and current drainage conditions. Subsequently, the model was modified to evaluate restoration alternatives and to predict groundwater gradients under post-restoration conditions. The DRAINMOD groundwater model was selected for simulating shallow subsurface conditions and groundwater behavior at the Site. This model was developed by R.W. Skaggs, Ph.D., P.E., of North Carolina State University (NCSU) to simulate the performance of water table management systems.

4.1.1 Model Description

DRAINMOD was originally developed to simulate the performance of agricultural drainage and water table control systems on sites with shallow water table conditions. DRAINMOD predicts water balances in the soil-water regime at the midpoint between two drains of equal elevation. The model is capable of calculating hourly values for water table depth, surface runoff, subsurface drainage, infiltration, and actual evapotranspiration over long periods referenced to climatological data. The reliability of DRAINMOD has been tested for a wide range of soil, crop, and climatological conditions. Results of tests in North Carolina (Skaggs, 1982), Ohio (Skaggs *et al.* 1981), Louisiana (Gayle *et al.* 1985; Fouss *et al.* 1987), Florida (Rogers 1985), Michigan (Belcher and Merva 1987), and Belgium (Susanto *et al.* 1987) indicate that the model can be used to reliably predict water table elevations and drain flow rates. DRAINMOD has also been used to evaluate wetland hydrology by Skaggs *et al.* (1993). Methods for evaluating water balance equations and equation variables are discussed in detail in Skaggs (1980).

DRAINMOD was modified for application to wetland studies by adding a counter that accumulates the number of events wherein the water table rises above a specified depth and remains above that threshold depth for a given duration during the growing season. Important inputs into the DRAINMOD model include length of the growing season, rainfall data, surface storage parameters, evapotranspiration rates, ditch depth and spacing, and soil hydraulic conductivity values (see section 4.1.2). The United States Department of Agriculture (USDA) soil texture classification and number of days in the growing season were obtained from the NRCS soil survey for Moore County (USDA 1995). Inputs for soil parameters such as the water table depth/volume drained/upflux relationship, Green-ampt parameters, and the water content/matric suction relationship were obtained utilizing the MUUF computer program developed by USDA.

Wetland hydrology is defined in the model as groundwater within 12 inches (30 cm) of the surface for 29 consecutive days during the growing season (12.5 percent of the growing season). For the development of this mitigation plan, additional modeling for a wetland hydrology criteria of 11 consecutive days (5 percent of the growing season) was conducted to allow further analysis of wetland restoration potential. The growing season is defined as the period between 23 March and 7 November (228 days, USDA 1995). Wetland hydrology is achieved in the model if target hydroperiods are met for one half of the years modeled (i.e. 19 out of 38 years). DRAINMOD simulations were conducted for the time periods from 1956 to 1993, using the climatological record at Pinehurst, N.C.

4.1.2 Hydraulic Conductivity

Hydraulic conductivity data were collected to verify permeability rates of the Bibb soils found on site (Appendix A). Hydraulic conductivity was calculated using the "Auger Hole Method", as outlined by the USDA (VanBeers 1970). Hydraulic conductivity is an expression of how readily water will pass through a soil in response to a given gradient. This value is most directly related to texture (pore space) and structure of a given soil. Relatively homogenous soils with small pores or small particle size, such as clay of high shrink/swell potential, will typically exhibit low hydraulic conductivity values. Conversely, course textured soils with large pores or large particle size, such as sands or fluvial material, will exhibit high hydraulic conductivity values. Hydraulic conductivity is also influenced markedly by the moisture content of the soil. At high moisture levels, especially near levels of saturation, a large portion of the soil water is in the macropores and saturated flow is relatively rapid. As the moisture content decrease, the soil water is held mostly in the micropores and hydraulic conductivity is greatly reduced.

Hydraulic conductivity tests (slug tests) were conducted by removing a volume of water from the boring and recording the depth to water at selected intervals as the water returned to equilibrium. Slug test results indicate that project area soil hydraulic conductivities are above the published ranges for the Bibb Series (USDA 1995). Conductivities averaged 114 centimeters/hour (cm/hr) [45 in/hr] in floodplain soils, indicating rapid (greater than 5.1cm/hr [2 in/hr]) infiltration and potentially rapid lateral transfer of groundwater in draw-down situations (such as stream channelization). Rapid permeability classifications are associated with sandy-textured soils with single-grained structures. It appears that flow of water through the floodplain soil is extremely rapid and ditching effects on saturated soil layers may be more extensive than published numbers for the Bibb series indicate. A beaver impoundment upstream from the test area may be a contributing factor to the high conductivity values. An increase in groundwater flow is potentially occurring, in response to increased groundwater pressure (gradient of head) caused by the elevated pond. Based on the hydraulic conductivity tests which suggest very rapid infiltration rates, a conservative value of 50.8cm/hr (20 in/hr) was deemed warranted for use in the groundwater model. This value represents the maximum conductivity utilized by NRCS for soil series characterizations (USDA 1995).

4.1.3 Model Applications and Results

DRAINMOD simulations were used to model the zone of wetland loss due to ditching under existing conditions, antecedent conditions (immediately after ditch construction, circa 1930), and conditions upon completion of wetland restoration activities. The model was applied to Bibb soils which is the dominate hydric soil. Model application and results are summarized below.

Antecedent Condition

Antecedent conditions were evaluated for the ditch network after construction activities were completed in the 1930s. Antecedent conditions may provide an indication of the rate of jurisdictional wetland recovery over the approximately 60-year period. Acquisition and protection of the Site in perpetuity will allow this ecosystem recovery process to proceed undisturbed, including prevention of the potential for ditch cleaning, reversal of this recovery process, and loss of jurisdictional wetlands in the system.

Antecedent ditch depths were estimated by collecting systematic sediment boring within the ditches. The depth of unconsolidated sediment overlying residual soil surfaces was added to the depth of surveyed cross-sections of the open portion of the ditch. The minimum ditch depth estimated by the sampling process measured 1.2 m (4 ft) in depth; the maximum depth extended to over 2.4 m (8 ft) in depth. For this assessment, the 1.2 m (4 ft) depth was utilized for all ditches on the Site to provide a conservative estimate of wetland loss under antecedent conditions.

DRAINMOD simulations for antecedent conditions indicate that 1.2-m (4-ft) deep ditches effectively drain wetlands (i.e. saturation less than 12.5% of the growing season) at a distance of 137 m (450 ft) from the ditch edge (Table 2). Figure 7 shows the area of jurisdictional wetland loss for antecedent conditions, based on relict ditch corridors identified in the field. In summary, approximately 75 ha (185 ac) are modeled as not supporting jurisdictional wetland hydrology (i.e. saturation greater than 12.5% of the growing season) during the period of a fully functioning ditch network.

Existing Condition

The model was applied to determine which areas may not achieve wetland hydrology criteria (a minimum of 12.5% of the growing season) under existing conditions (Table 2). Ditch depths were obtained by surveying cross-sections of the ditch at systematic intervals throughout the Site. The measured cross-sections include open portions of the ditches that have not been filled in with sediments.

TABLE 2
DRAINMOD Results
Zone of Wetland Loss and Wetland Degradation for Bibb Soils
SALT Mitigation Site

Forested and Timbered Stages (relatively high surface storage)		
Depth meters (feet)	**Wetland Hydroperiod for Bibb Soils (% of the growing season)**	
	5%	**12.5%**
	Zone of Influence (meters (feet))[1]	
0.3 (1)	1 (3)[2]	1 (3)[2]
0.6 (2)	72 (235)	95 (310)
0.9 (3)	95 (310)	119 (390)
1.2 (4)	111 (365)[3]	137 (450)[3]
1.5 (5)	125 (410)	152 (500)
1.8 (6)	133 (435)	163 (535)
2.1 (7)	142 (465)	171 (560)
2.4 (8)	148 (485)	174 (570)

1: Zone of influence equal to ½ of the modeled ditch spacing
2: The model predicts that a 0.3 m (1 ft) deep ditch exhibits negligible impact on drainage.
3: Zone of influence for antecedent conditions at a 1.2 m (4 ft) average ditch depth.

PROJECT PLAN VIEW ⚠

GENERAL LEGEND

(heavy line)	APPROX. MITIGATION SITE BOUNDARY
(double line)	EXISTING ROAD
◇	EXISTING BUILDING
—x——x—	EXISTING FENCE
- - - - -	EXISTING DITCH

WETLAND HYDROLOGY

		HECTARES	ACRES
(pattern)	HYDRIC SOILS NON-DRAINED	24±	60±
(pattern)	NON-HYDRIC SOILS UPLAND	33±	82±
(pattern)	BIBB SOILS < 5% HYDROPERIOD	71±	175±
(pattern)	< 12.5% HYDROPERIOD	4±	10±
	TOTAL	132±	327±

NO.	REVISIONS	DATE
⚠	REVISIONS PER NCDOT	SEPT 1999

Client: NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project: DRAINMOD: ANTECEDENT CONDITIONS
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By: MAF | Date: AUG 2000
Ckd By: JWN | Scale: 1"= 600'

ESC Project No.: 98-024.06

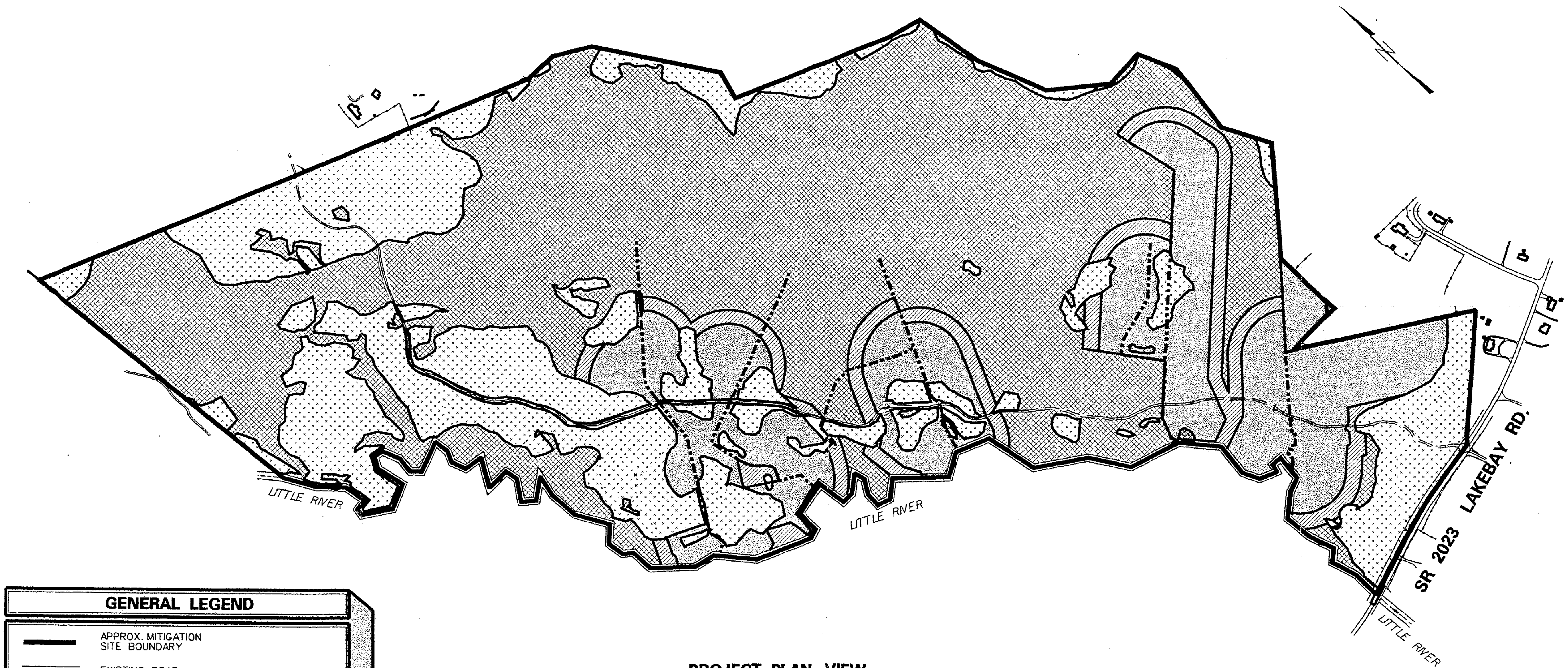
Figure 7

In Bibb soils, DRAINMOD simulations for existing conditions indicate that ditches ranging from 0.6 m to 2.4 m (2 ft to 8 ft) deep effectively drain wetlands (< 12.5% of the growing season) to distances ranging from 95 m to 174 m (310 ft to 570 ft) from the ditch (Table 2). In Bibb soils, a 0.3 m (1 ft) deep ditch exhibits negligible impact on groundwater withdrawal and resultant wetland hydroperiods. Figure 8 shows the modeled area not supporting jurisdictional wetland hydrology. Based on DRAINMOD, approximately 28 ha (69 ac) of historic wetlands are drained by the existing ditch network.

Post-Restoration Condition

Groundwater modeling was applied to forecast the extent of land supporting wetland hydrology after restoration activities are completed. Site alterations to restore wetland hydrology are expected to entail effective removal of the drainage network (see Section 5.1). For the model, the drainage ditch along the southern Site periphery is projected to remain open after wetland restoration activities are completed to accommodate drainage from adjacent properties. With this ditch remaining open, approximately 8 ha (20 ac) of wetlands will remain effectively drained under post-restoration conditions.

Figure 9 suggests that approximately 91 ha (225 ac) will support wetland hydrology for greater than 12.5% of the growing season after restoration is completed. This estimate represents a 20 ha (49 ac) increase in wetlands relative to model predictions for existing conditions. The estimate also suggests a 67 ha (165 ac) increase in wetlands relative to antecedent conditions (1930's), and prevention of future ditch cleaning activities.



PROJECT PLAN VIEW ⚠

GENERAL LEGEND

▬	APPROX. MITIGATION SITE BOUNDARY
═	EXISTING ROAD
◇	EXISTING BUILDING
—x—x—	EXISTING FENCE
—·—·—	EXISTING DITCH

WETLAND HYDROLOGY

		HECTARES	ACRES
(crosshatch)	HYDRIC SOILS NON-DRAINED	71±	176±
(x pattern)	NON-HYDRIC SOILS UPLAND	33±	82±
(stipple)	BIBB SOILS < 5% HYDROPERIOD	22±	53±
(hatch)	< 12.5% HYDROPERIOD	6±	16±
	TOTAL	132±	327±

NO.	REVISIONS	DATE
⚠	REVISIONS PER NCDOT	SEPT 1999

Client: *NC DEPARTMENT OF TRANSPORTATION*
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project: **DRAINMOD: EXISTING CONDITIONS**
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By: MAF | Date: AUG 2000
Ckd By: JWN | Scale: 1"= 600'
ESC Project No.: 98-024.06

Figure 8

PROJECT PLAN VIEW ⚠

GENERAL LEGEND

(heavy line)	APPROX. MITIGATION SITE BOUNDARY
(double line)	EXISTING ROAD
(building symbol)	EXISTING BUILDING
—x—x—	EXISTING FENCE
-------	EXISTING DITCH

WETLAND HYDROLOGY

	HECTARES	ACRES
BIBB SOILS < 5% HYDROPERIOD	7±	17±
< 12.5% HYDROPERIOD	1±	3±
> 12.5% HYDROPERIOD	91±	225±
UPLAND	33±	82±
TOTAL	132±	327±

NO.	REVISIONS	DATE
⚠	REVISIONS PER NCDOT	SEPT 1999

Client: NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project: DRAINMOD:
PROJECTED POST-RESTORATION CONDITIONS
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: AUG 2000			Figure
Ckd By: JWN	Scale: 1"= 600'			9
ESC Project No.: 98-024.06				

4.2 SURFACE WATER ANALYSES

The objective of developing the overbank flood model was to determine the historic and existing influence of the drainage network on overbank flood hydrodynamics from the primary watershed, or impediments to overbank flow due to logging road construction.

Extent of floodplain inundation was calculated using the two-dimensional depth-averaged flow and sediment transport module Flo2DH of the Federal Highway Administration's (FHWA) and a Finite Element Surface-water Modeling System (FESWMS). A detailed discussion on the model and flood frequency analysis can be found in Appendix B.

The hydraulic analysis indicates negligible human induced modifications to overbank flooding and its residual hydraulic effects on the SALT Site. Figure 10 depicts the projected surface water elevations for the 2, 5, 10, and 100-year storm events. The higher frequency storms (those less than 2-year return interval) may approach but rarely exceed the logging road elevation. The active floodplain generally includes areas directly adjacent to the river channel, extending across approximately 48 acres of the Site. The model indicates that flood water under historic and current conditions do not regularly inundate areas above and beyond the logging road, nor the areas influenced by the ditch network.

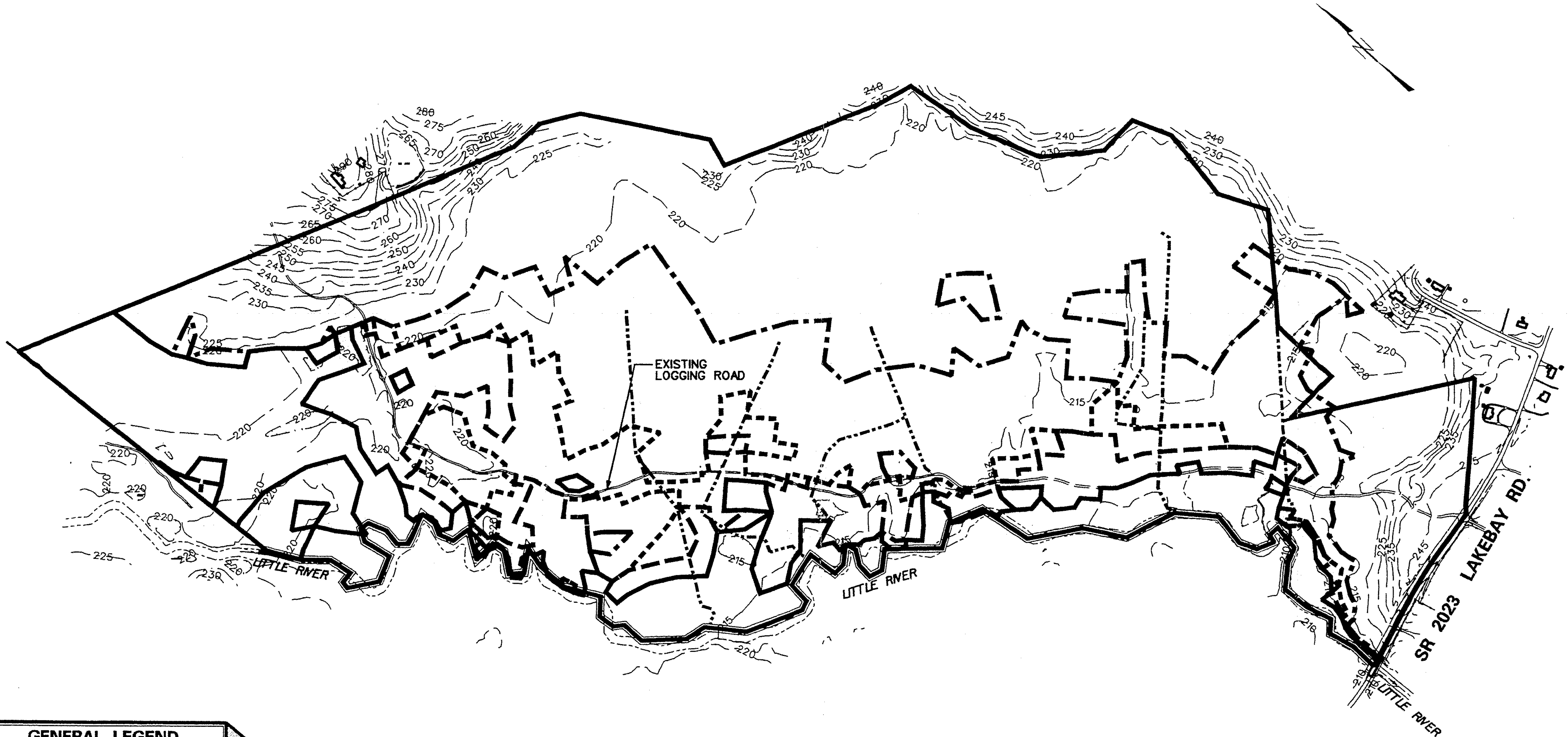
Therefore, overbank flooding does not represent a net contributor to wetland hydrology in northern and eastern portions of the Site, rather, these areas are influenced primarily by the secondary watershed in the form of groundwater seeps and the associated tributary inputs.

4.3 REFERENCE WETLAND STUDIES

A reference wetland system has been utilized as the primary method for development of this wetland restoration plan. Reference wetlands, as depicted in Figure 11, are located predominantly, in the north and northeastern sections of the Site. Additional off-site reference areas were evaluated to the north and south of the Site, along similar landscape positions supporting Bibb soils. The on-site reference wetlands will be utilized to supplement the monitoring plan as a comparison between relatively undisturbed wetlands and the adjacent, restored wetland areas. Reference wetland studies included groundwater data analysis and vegetation sampling.

4.3.1 Groundwater Data Analyses

Two piezometer (monitoring well) installation efforts were conducted for groundwater analysis throughout the site. Seven (7) continuous recording piezometers were installed in reference and potential restoration areas in December of 1998. An additional nine (9) piezometers were installed in March 1999 to supplement data for groundwater analysis. Most of the on-site reference areas are located away from the network of ditches. These wells encompass the various wetland communities within the dominant river terrace physiographic area. Well locations are shown on Figure 11. The groundwater data were collected periodically from December 9, 1998 through June 18, 1999. Hydrographs for each well can be found in



GENERAL LEGEND

- APPROX. MITIGATION SITE BOUNDARY
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING FENCE
- EXISTING DITCH
- Q2 FLOODPLAIN
- Q5 FLOODPLAIN
- Q10 FLOODPLAIN
- Q100 FLOODPLAIN

PROJECT PLAN VIEW

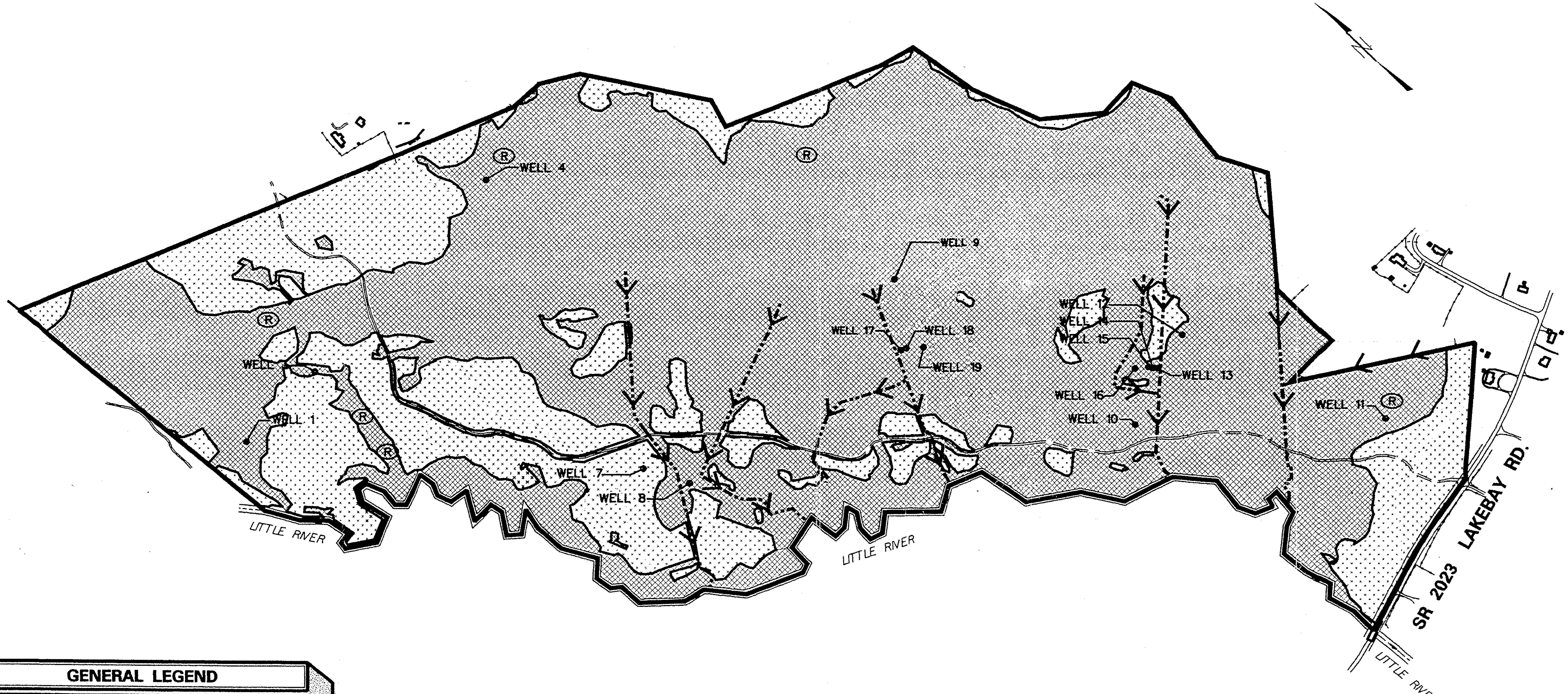
Client: NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project: FLOOD FREQUENCY ANALYSIS
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: AUG 2000
Ckd By: JWN	Scale: 1"= 600'

ESC Project No.: 98-024.06

Figure 10



PROJECT PLAN VIEW

GENERAL LEGEND

- APPROX. MITIGATION SITE BOUNDARY
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING FENCE
- EXISTING DITCH
- DIRECTION OF FLOW
- PIEZOMETER LOCATION
- Ⓡ REFERENCE WETLAND AREAS

WETLAND HYDROLOGY

	HECTARES	ACRES
HYDRIC SOILS	99±	245±
NON-HYDRIC SOILS	33±	82±
TOTAL	132±	327±

WELL ELEVATIONS

Well	Top Elev.	Ground Elev.
WELL 1	220.95 FT.	219.00 FT.
WELL 3	220.20 FT.	218.24 FT.
WELL 4	222.52 FT.	220.54 FT.
WELL 7	219.14 FT.	217.32 FT.
WELL 8	217.04 FT.	214.70 FT.
WELL 9	219.64 FT.	217.56 FT.
WELL 10	213.96 FT.	211.92 FT.
WELL 11	216.82 FT.	214.52 FT.
WELL 12	216.37 FT.	214.37 FT.
WELL 13	216.23 FT.	214.13 FT.
WELL 14	216.13 FT.	214.12 FT.
WELL 15	215.48 FT.	213.58 FT.
WELL 16	214.98 FT.	212.87 FT.
WELL 17	217.82 FT.	215.76 FT.
WELL 18	218.25 FT.	215.87 FT.
WELL 19	217.84 FT.	215.79 FT.

Client: *NC DEPARTMENT OF TRANSPORTATION*
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project: **ONSITE REFERENCE AND PIEZOMETER LOCATIONS**
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By:	MAF	Date:	AUG 2000	Figure
Ckd By:	JWN	Scale:	1"= 600'	11

ESC Project No.: 98-024.06

Appendix C. Table 3 depicts water table measurements at periodic intervals during the sample period. Groundwater depths varied considerably across the Site during the monitoring period. Groundwater levels in low lying upland soils, in and around the river floodplain, were several feet deep through December 1998 and January of 1999 (Wells 1 and 3). In February groundwater tables elevated to the surface, where groundwater draw-down was observed after each rainfall event through the sampling period. By contrast groundwater slopes and depressional wetland areas remained saturated (< 12 inches of the surface) for most of the monitoring period (Wells 4,9,10,12,16, 17, 18 and 19). In areas remaining under the influence of ditching, saturation within the top 12 inches was reduced (Wells 8,11,15). Well data generally correspond with DRAINMOD results under current conditions. The remaining wells (7,13,14) were placed in uplands away from flooding events, where groundwater remained at or below 12 inches through the monitoring period.

4.3.2 Vegetation Sampling

In order to establish a forested wetland system for mitigation purposes, a reference community needs to be established. According to Mitigation Site Classification (MiST) guidelines (EPA 1990), the area of proposed restoration should attempt to emulate a Reference Forest Ecosystem (RFE) in terms of soils, hydrology, and vegetation. In this case the target RFEs were composed of relatively undisturbed woodlands within the Site which support soil, landform, and hydrological characteristics that restoration will attempt to emulate. All of the RFE sites were impacted by selective cutting or high grading, therefore the species composition of these plots should be used as a guide only. Reference forest data used in restoration were modified to emulate steady state, climax community structure as described in the Classification of the Natural Communities of North Carolina (Schafale and Weakley 1990).

Reference plots within three distinct landscape positions within the river floodplain physographic area (backswamp/sloughs, elevated floodplain flats, and seepage slopes) were identified in mature forested areas that best characterize the communities proposed for restoration. Sites were chosen that typify steady-state forest composition. A circular plot sampling scheme was used to sample the forest structure at each site. Canopy trees were recorded by species and diameter. Importance values were calculated from relative basal area and relative density (Brower *et al.* 1990). The composition of shrub/sapling and herb strata were recorded and identified to species. The vegetative communities targeted include cypress-gum swamp (active slough variant), coastal plain bottomland hardwoods (blackwater subtype), and streamhead Atlantic white cedar forest (Schafale and Weakley 1990). Soils targeted for each community include Kenansville, Leon, Bibb, and Johnston (USDA 1985 and 1995).

1. Cypress-Gum Swamp: This plant community is found in and along backswamps, sloughs, and depressional areas. Three plots from on-site were sampled. The canopy is dominated by swamp tupelo (Importance value [IV] 47%), sweetgum(12%), water oak

<u>TABLE 3</u>

Representative Groundwater Elevations
SALT Mitigation Site

Representative Groundwater Depths		Shallow		Medium		Deep	
Date		5/14/99		4/6/99		6/15/99	
Well Number	Well Elevation (feet above MSL)	Depth below ground surface (inches)	Ground- water Elevation (feet above MSL)	Depth below ground surface (inches)	Ground- water Elevation (feet above MSL)	Depth below ground surface (inches)	Ground- water Elevation (feet above MSL)
W-1	219.00	4.40	218.6	12.90	217.9	40.70	215.6
W-3	218.24	1.10	218.1	9.60	217.4	36.90	215.2
W-4	220.54	3.10	220.3	6.50	220.0	28.90	218.1
W-7	217.32	26.10	215.1	33.40	214.5	41.10	213.9
W-8	214.70	3.00	214.5	10.60	213.8	38.30	211.5
W-9	217.56	0.40	217.5	5.30	217.1	17.50	216.1
W-10	211.92	0.00	211.9	4.30	211.6	35.80	208.9
W-11	214.52	11.90	213.5	19.60	212.9	37.40	211.4
W-12	214.37	0.00	214.4	5.90	213.9	28.80	212.0
W-13	214.13	18.50	212.6	20.40	212.4	29.10	211.7
W-14	214.12	10.90	213.2	17.90	212.6	24.80	212.1
W-15	213.58	2.70	213.4	8.90	212.8	15.60	212.3
W-16	212.87	0.00	212.9	4.60	212.5	17.00	211.5
W-17	215.76	0.00	215.8	4.00	215.4	32.00	213.1
W-18	215.87	5.10	215.4	5.20	215.4	36.70	212.8
W-19	215.79	2.20	215.6	4.90	215.4	30.30	213.3

(11%), red maple (8%), pond cypress (8%), and American holly) (6%) (Table 4). Other species include ti-ti (*Cyrilla racemiflora*), green ash (*Fraxinus pennsylvanica*), and loblolly pine. The sapling/shrub layer is open and dominated by ti-ti, fetterbush (*Lyonia lucida*), highbush blueberry, sweetbay, buttonbush (*Cephalanthus occidentalis*), and species listed in the canopy. The herbaceous layer is generally sparse and includes netted chain fern, poison ivy), yellow jessamine (*Gelsemium sempervirens*), and greenbriar.

2. Coastal Plain Bottomland Hardwood: This plant community is found on elevated floodplain flats. Two on-site plots were sampled. The overstory dominants are swamp tupelo (38%), red maple (24%), sweetgum (17%), tulip poplar (*Liriodendron tulipifera*) (9%), and bald cypress (4%) (Table 5). Other species found in the overstory are willow oak (*Quercus phellos)*, laurel oak (*Quercus laurifolia*), American holly, loblolly pine, and water oak. The common sapling/shrub species include red maple, tulip poplar, tag alder (*Alnus serrulata*), sweet bay, water oak, and highbush blueberry. Herbaceous species include netted chain fern, Virginia chain fern (*Woodwardia virginiana*), yellow root (*Xanthorhiza simplicissima*), Japanese honeysuckle (*Lonicera japonica*), Chinese privet (*Ligustrum sinensis*), blackberry (*Rubus* sp.), and cross-vine (*Bignonia capreolata*).

3. Streamhead Atlantic White Cedar Forest: Two plots from on-site and two plots from a regional data base were sampled. This forest type is found on seepage slopes and adjacent flat bottoms. The overstory is dominated by Atlantic white cedar (41%), red maple (16%), swamp tupelo (16%), tulip poplar (7%), and loblolly pine (7%) (Table 6). Other species found in the overstory include sweet bay, sweetgum, black willow (*Salix nigra*), and American holly. The sapling/shrub layer is generally dense with species such as gallberry, inkberry, Southern wild raisin (*Viburnum nudum*), swamp red bay (*Persea palustris*), fetterbush, and American holly. The herbaceous layer is well developed with netted chain fern, Virginia chain fern, greenbriar (*Smilax rotundifolia*), and laurel-leaf greenbriar as common species.

Degradation of bottomland forests is common throughout the region. All sites exhibited evidence of intensive silvicultural practices such as selective cutting, high-grading, and ditch construction which has resulted in a less diverse, intra-specific tree assemblage. Disruption of the natural fire regime has also played an important role in current forest stand development. Fire exclusion reduces the occurrence of fire dependent species such as pond pine and longleaf pine and, conversely, allows fire intolerant species including red maple, sweetgum, several oak species, and thick under story to invade. In order to facilitate a reduction in dominance by disturbance adapted species, initial removal of unwanted species will be conducted through mechanical or herbicidal means prior to planting. Areas requiring initial vegetation

TABLE 4

Reference Forest Ecosystem
Cypress-Gum Swamp (Active Slough Variant) Plots Summary (Canopy Species)

Species	Density		Basal Area		Relative Density	Relative Basal Area	Importance Value
	trees/ha	trees/acre	sq.m/ha	sq. ft/acre			
Swamp Tupelo	466	193	17.2	74.7	46.4	47.7	47.0
Sweetgum	129	53	3.7	16.0	12.8	10.2	11.5
Water Oak	96	40	4.1	17.8	9.6	11.4	10.5
Red Maple	56	23	3.8	16.5	5.6	10.5	8.1
Pond Cypress	64	27	3.4	14.7	6.4	9.4	7.9
American Holly	80	33	1.2	5.2	8.0	3.3	5.6
Ti-ti	56	23	0.9	3.8	5.6	2.4	4.0
Green Ash	48	20	0.5	2.1	4.8	1.3	3.1
Loblolly Pine	8	3	1.35	5.9	0.8	3.8	2.3
Total	1004	417	43.7	190.1	100	100	100

[1] Importance value = (Relative Density + Relative Basal Area)/2*100

TABLE 5

Reference Forest Ecosystem
Coastal Plain Bottomland Hardwood Summary (Canopy Species)

Species	Density		Basal Area		Relative Density	Relative Basal Area	Importance Value
	trees/ha	trees/acre	sq.m/ha	sq. ft/acre			
Swamp Tupelo	444	180	18.2	73.0	34.4	41.3	37.8
Red Maple	411	167	6.9	29.0	31.9	15.6	23.8
Sweetgum	237	96	7.1	36.9	18.4	16.1	17.2
Tulip Poplar	79	32	4.8	22.4	6.1	10.8	8.5
Bald Cypress	25	10	2.3	3.6	1.9	5.2	3.6
Willow Oak	10	4	1.9	7.4	0.8	4.2	2.5
Laurel Oak	30	12	0.9	5.8	2.3	2.0	2.2
American Holly	40	16	0.5	3.0	3.1	1.1	2.1
Loblolly Pine	5	2	1.5	0.6	0.4	3.3	1.8
Water Oak	10	4	0.2	0.2	0.8	0.3	0.6
Total	1100	444	44.1	182	100	100	100

[1] Importance value = (Relative Density + Relative Basal Area)/2*100

TABLE 6

Reference Forest Ecosystem
Streamhead Atlantic White Cedar Forest Plots Summary (Canopy Species)

Species	Density		Basal Area		Relative Density	Relative Basal Area	Importance Value
	trees/ha	trees/acre	sq.m/ha	sq. ft/acre			
Atlantic White Cedar	502	203	17.9	71.0	42.4	40.3	41.4
Red Maple	217	88	5.9	23.4	18.3	13.3	15.8
Swamp Tupelo	146	59	8.4	33.2	12.3	18.8	15.6
Tulip Poplar	194	78	6.5	26.0	16.4	14.7	15.5
Loblolly Pine	33	13	4.5	18.0	2.7	10.2	6.5
Sweetbay	60	24	0.6	2.4	5.1	1.4	3.2
Sweetgum	10	4	0.4	1.4	0.8	0.8	0.8
Black Willow	13	5	0.1	0.4	1.1	0.2	0.6
American Holly	10	4	0.1	0.4	0.8	0.2	0.5
Total	1183	479	176.1	44.3	100	100	100

[1] Importance value = (Relative Density + Relative Basal Area)/2*100

removal are identified under full planting (see Figure 14) for bottomland hardwood, wet pine flats, and cypress-gum. Future maintenance of unwanted species will be accomplished through future long term hydrological changes and a fire management program as established by the Sandhills Area Land Trust, upon dispensation of property. RFE sampling has established a baseline data set that will be integrated into a planting plan for the Site.

5.0 MITIGATION PLAN

5.1 WETLAND HYDROLOGY RESTORATION

Site alterations designed to restore characteristic wetland soil features and groundwater wetland hydrology will be accomplished primarily through ditch plugs, ditch backfilling, and ford (shallow road crossing) construction (Figure 12). During construction of the antecedent ditch network, the canals were extended through the elevated terrace and into the Little River. These canals provide surface water outlets from behind the terrace that did not likely exist prior to disturbance. Surface water flows would pond behind the terrace or migrate down valley, with connectivity to the Little River limited primarily to hyporheic (down-valley) or groundwater seepage inputs. Based on these inferences, partial backfill and ditch plugs are the primary means for hydrologic restoration. These operations are recommended at various strategic locations within the terrace / levee to redirect relatively shallow surface water flows towards historic conditions (from perpendicular to parallel) relative to the river.

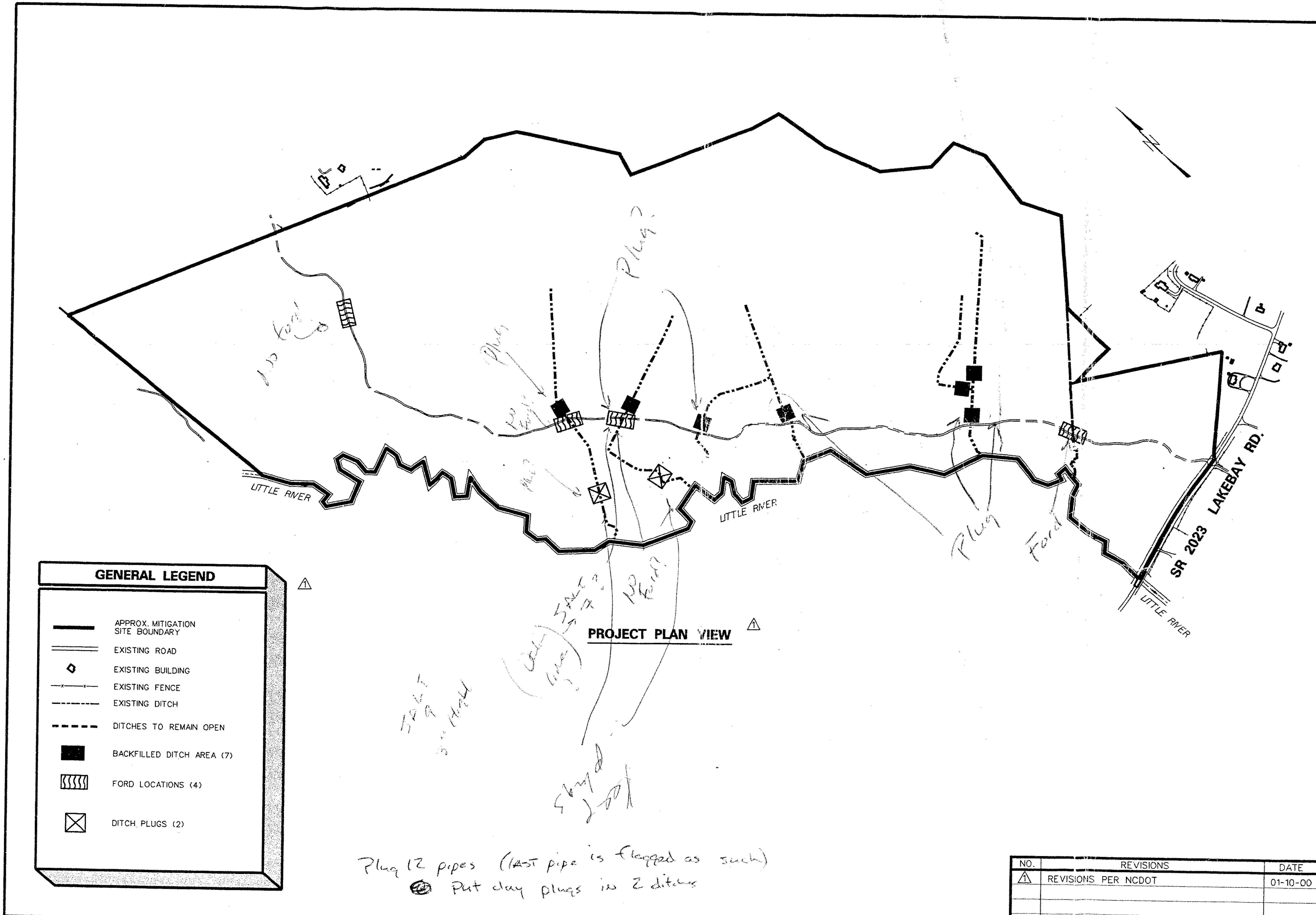
Complete ditch backfilling in conjunction with a low permeable earthen plug is generally recommended in wetland restoration areas where precipitation inputs and resultant surface storage represent significant contributors to wetland hydrology. Surface storage refers to residual (perched) water within the rooting zone that is not necessarily associated with the groundwater table. When groundwater table expression in the open ditch sections is lower than the stored surface or near-surface water, runoff is potentially increased. This accelerated draw-down in the near-surface region may reduce a wetland hydroperiod by less than one week in many instances. This period of draw-down may be critical to satisfying jurisdictional wetland hydrology in precipitation driven, mineral soil flats.

However, at the SALT tract, the high rate of lateral conductivity and relatively steep groundwater slopes suggest that precipitation is not a significant contributor. Across-valley (riparian) and down-valley (hyporheic) ground and surface water flow are the primary concerns for sustaining wetland hydrology. Therefore, extensive earthwork to refill the current ditch network is not warranted.

Additionally, a mature and appropriate vegetative communities have become established adjacent to the ditch network. Large impacts to these plant communities would be required for fill operations and would run counter to the effective, transitional process already in-place. Two locations within the high energy, primary river floodplain will require traditional ditch plugs with impermeable clay substrate. Construction access to the ditch plug sites will require the removal of existing vegetation. The amount of disturbance to existing vegetation will be minimized to the extent feasible.

5.1.1 Ditch Cleaning Prior to Backfill

Ditch sections identified for plugging and backfilling in Figure 12 will be cleaned, as needed, to remove unconsolidated sediments within the bottom of the ditch. Accumulated sediment



NO.	REVISIONS	DATE
⚠	REVISIONS PER NCDOT	01-10-00

Project: HYDROLOGY AND SOIL RESTORATION PLAN
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Client: NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Dwn By: MAF	Date: AUG 2000		Figure
Ckd By: JWN	Scale: 1"= 600'		12
ESC Project No.: 98-024.06			

within the ditches represents relatively high permeability material that may act as a conduit for continued drainage after restoration. The unconsolidated sediments will be lifted from the channel to expose the underlying, relatively impermeable clay substrate along the ditch invert. The sediment will be temporarily placed on adjacent surfaces during ditch backfilling operation. Subsequently, the unconsolidated sediment will be redistributed as top soil and over the back-filled material and graded to the approximate elevation of the adjacent wetland surface.

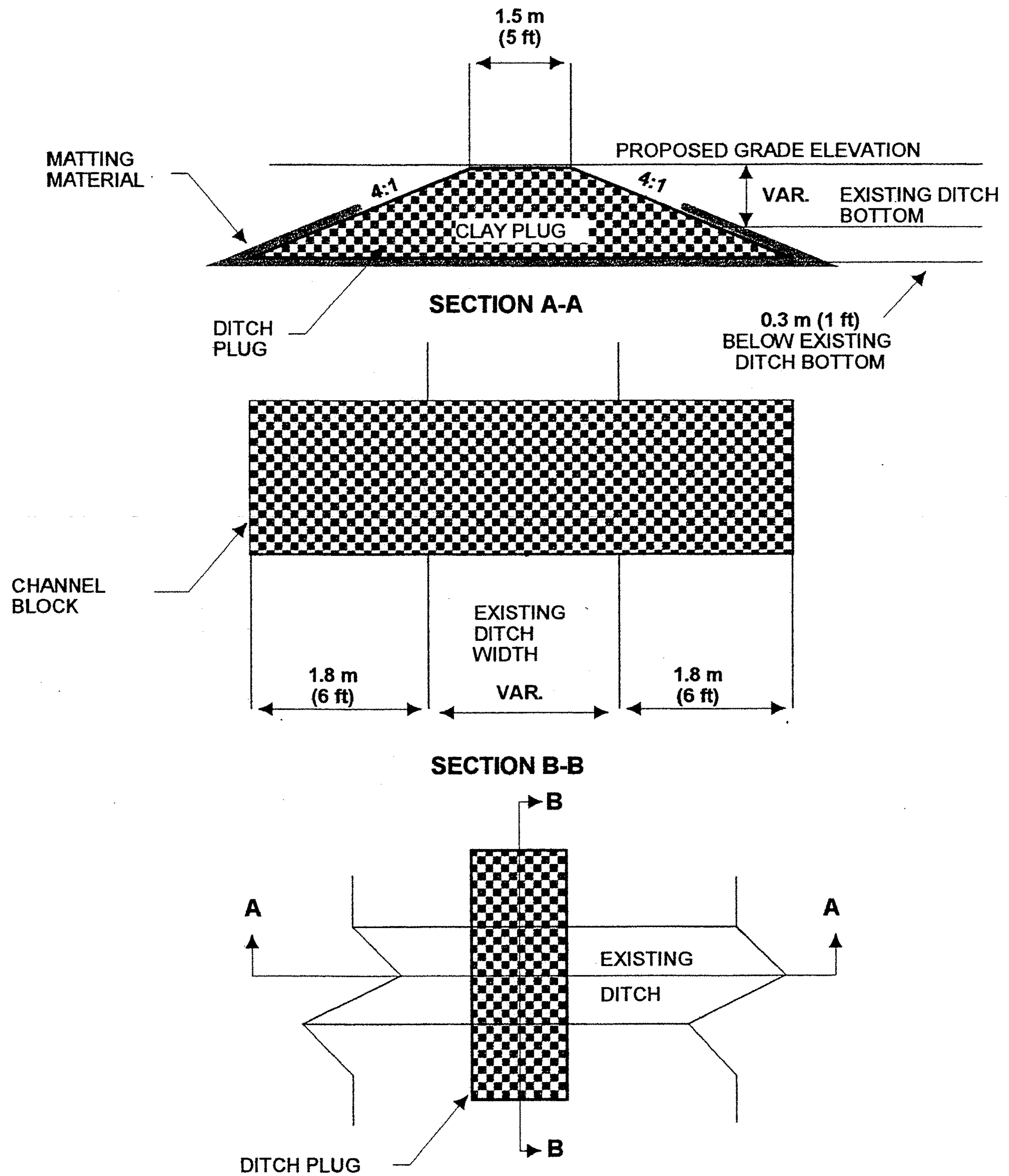
5.1.2 Ditch Backfilling

Ditch backfill operations will be performed to sections of ditch, approximately 100 feet in length, generally along portions of the ditch adjacent to the logging road. Approximately 7 ditch sections are targeted for backfill operations, as identified in Figure 12. Back-fill material will consist of available on-site earthen material. Approximately 213 m (700 ft) of ditches will be filled and compacted to within a foot of the surrounding elevations. If available, a top layer of unconsolidated material (*i.e.* topsoil; see 5.1.1) will be redistributed over the back-filled material, at a nominal 12 inch depth. The final grade shall be graded to the approximate adjacent floodplain elevation. Compaction and smearing of the topsoil layer should be avoided. The existing roadbed is constructed of compacted clay material and will adequately substitute for the customary ditch plug. The existing culverts shall be removed and filled and compacted with surrounding clay fill material or similar material from on-site.

Backfilling ditches is expected to reduce or eliminate the drainage capacity of the logging road culverts. Fords will be utilized in lieu of backfilling if the ditch has been placed within a historic stream channel that supports perennial flow (see 5.1.4). Additional fords will be constructed where the roadway has obstructed historic drainage patterns. Because of the backfilling and ford construction, the logging road can be expected to sustain increased flooding and reduced accessibility during winter months and high rainfall periods.

5.1.3 Ditch Plugs

Impermeable plugs will be installed in two drainage ditches on west side of the logging road as identified in Figure 12. The plugs will consist of low permeable earthen material designed to withstand the erosive energy associated with river floods. Each plug will consist of a core of impervious material and be sufficiently wide and deep to form an imbedded overlap in the existing banks and ditch bed. The face of the ditch plug will be covered with rip-rap. A typical cross section of a ditch plug is shown in Figure 13. Construction access to the ditch plug sites will require the removal of existing vegetation. The amount of disturbance to existing wetland and vegetation will be minimized to the extent feasible.



PLAN VIEW OF EXISTING DITCH WITH CHANNEL BLOCK

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PO BOX 25201
RALEIGH NC 27611

TYPICAL CROSS-SECTION:
IMPERVIOUS DITCH PLUG
SALT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Figure: 13

Project: 98-024.06

Date: August 00

5.1.4 Ford Construction

Construction of fords are anticipated at various points along the logging road. Fords are shallow places in the stream where crossings can be made in a vehicle. Fords will be utilized at ditch crossings if the channel historically supported perennial flow or in places where the roadway has obstructed historic drainage patterns. Four (4) locations are targeted for ford construction. A conceptual ford design is shown in Figure 14. Fords shall be constructed of hydraulically stable rip-rap or shot rock (or equal) and should be large enough to handle the weight of the anticipated vehicular traffic. Approach grades to the ford should be approximately 30 feet in length and be constructed with hard, weather-resistant crushed rock free of fines to ensure these areas do not become a source of sedimentation. The bed elevation of the ford should be equal to the bed elevation of the natural stream channel above and below the ford to reduce hydraulic jumps and the risk of head-cutting. Ongoing inspection and maintenance of stream crossing structures may be required to ensure they are functioning properly.

5.2 WETLAND COMMUNITY RESTORATION

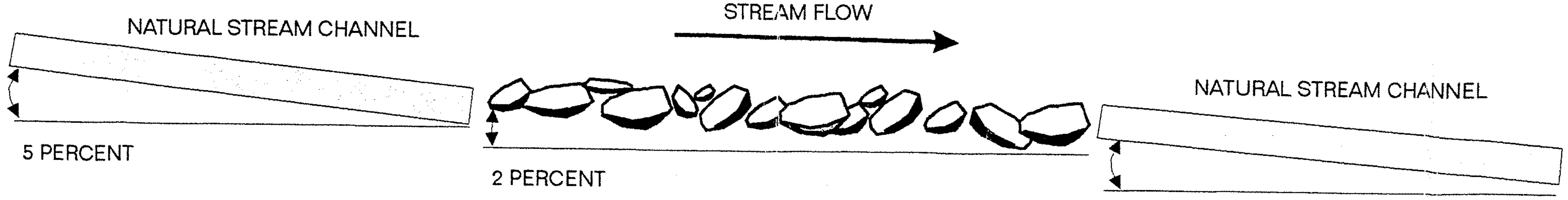
A large portion of the Site has experienced prolonged hydrologic modifications due to the extensive drainage network put in place more than 65 years ago. As a result, native wetland vegetation communities have, in part, been replaced with a suite of species more similar to those found on upland sites. Further changes to the native plant communities have occurred as a result of the removal of dominant overstory species (bald cypress, pond pine, swamp tupelo, Atlantic white cedar) and fire exclusion. The lack of ditch cleaning activities in the 60+ years following drainage network construction has allowed the Site to initiate development of the historic wetland ecosystems. This transitional process towards stable wetland hydrodynamics and community structure is continuing to occur passively at the present time.

Restoration of wetland forested communities will provide habitat for area wildlife and will allow development and expansion of characteristic wetland dependent species across the landscape. Ecotonal changes between community types developed through a landscape approach to wetland community restoration contribute to area diversity and provide secondary benefits, such as enhanced feeding and nesting opportunities for mammals, birds, amphibians, and other wildlife. Of particular importance are fire maintained ecotonal zones between upland and wetland communities which support primary habitat for many rare plant and animal species.

Primary plant communities to be reestablished on-site were developed from NRCS soil map units, topographical landscape position, conceptual ground and surface water models, and steady state structure described in Classification of the Natural Communities of North Carolina (Schafale and Weakley 1990). The plant communities to be restored or enhanced include: 1) Sandhill bottomland hardwoods; 2) cypress-gum swamp, 3) wet pine flatwoods; 4) mesic pine flatwoods (Little River terrace variant); 5) longleaf pine forest, and 6) streamhead Atlantic white cedar forest. Figure 15(a-c) provides a conceptual depiction of potential forest communities

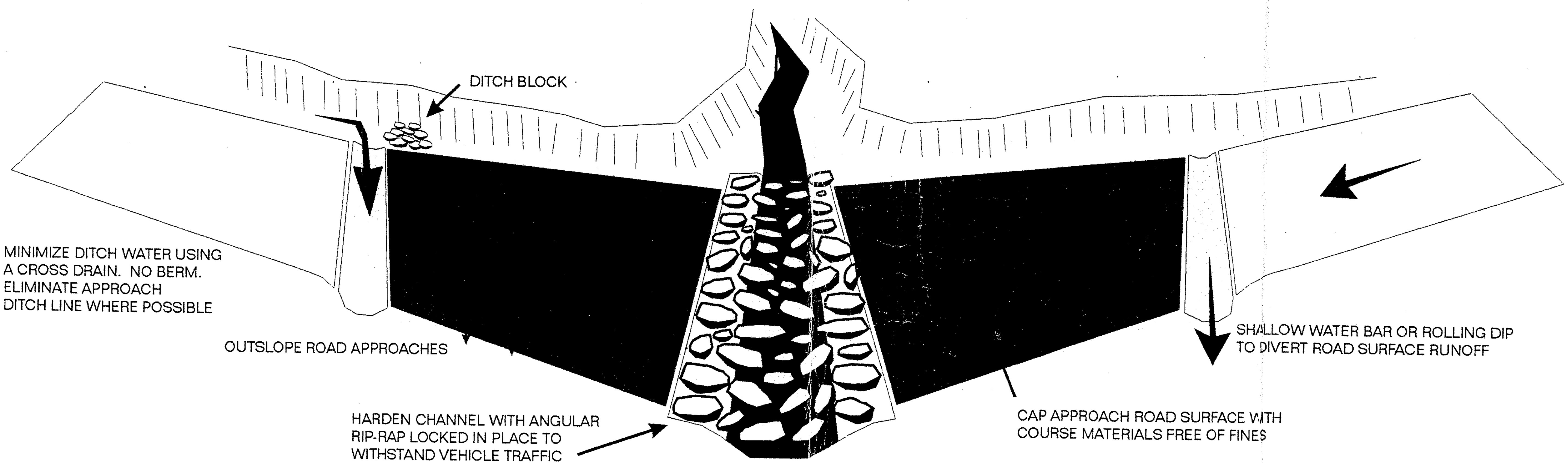
Adapted from Stream Crossing Guidebook for Fish Streams. A Working Draft 1997/1998 Forest Practice Code Guide Books. B.C Canada

CROSS-SECTIONAL VIEW



MAINTAIN A FORD GRADIENT NO LESS THAN 1-2 PERCENT OF THE NATURAL STREAM GRADIENT

PLAN VIEW



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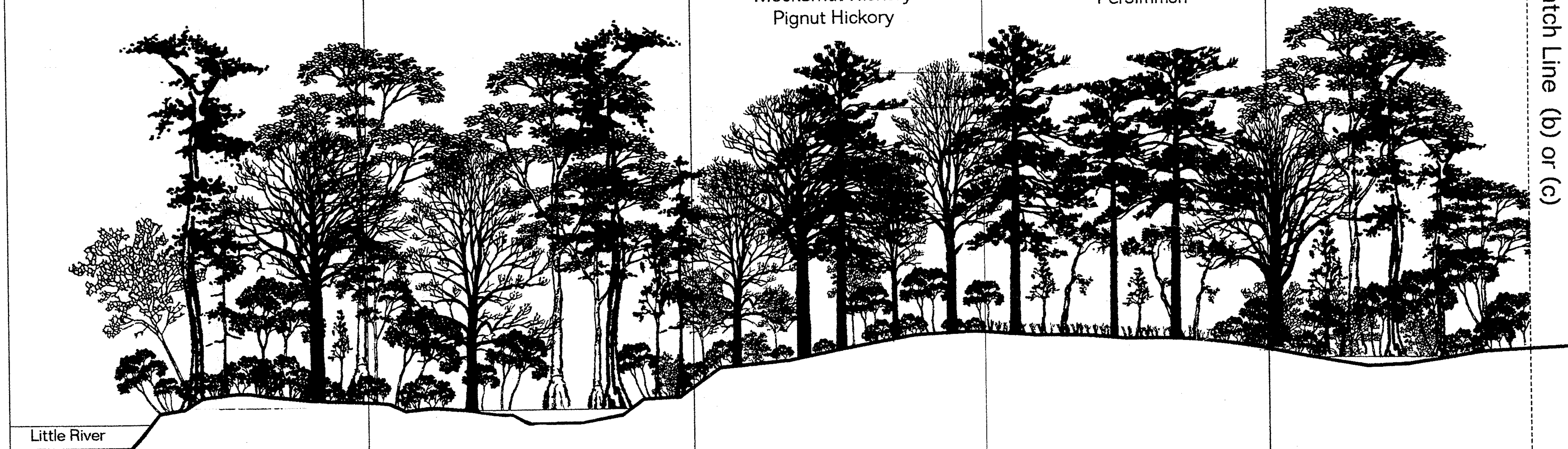
CONCEPTUAL FORD DESIGN
SALT MITIGATION SITE
Moore County, North Carolina

Figure:	14
Project:	98-024.06
Date:	August 2000

COMMUNITY ASSEMBLAGE (Shafale and Weakley 1990)	COASTAL PLAIN LEVEE FOREST	CYPRESS-GUM SWAMP (Backwater Variant)	DRY-OAK HICKORY FOREST (Coastal Plain Sand Variant)	PINE/SCRUB OAK SANDHILL (Blackjack-Mixed Oak Variant)	CYPRESS-GUM FOREST (Relic Slough Variant))
DIAGNOSTIC VEGETATION	Bald Cypress Swamp Tupelo Laurel Oak River Birch Willow Oak Ironwood	Swamp Tupelo Pond Cypress Bald Cypress Green Ash Water Oak Ti-ti	White Oak Spanish Oak Post Oak Blackjack Oak Black Oak Loblolly pine Longleaf Pine Mockernut Hickory Pignut Hickory	Longleaf Pine Turkey Oak Blackjack Oak Sand Post Oak Bluejack Oak Wire Grass Sassafras Persimmon	Swamp Tupelo Pond Cypress Ti-ti Fetterbush Sphagnum Greenbriar
			Reduced Fire Frequency	Fire Dependent	
LAND FORM	Natural Levee/ Blackwater Stream	Floodplain Bottom	Terrace Ridge		Swales/Depressions
SOILS	Bibb	Bibb	Kenansville/Johns/Kalmia		Bibb
	Poorly Drained	Poorly Drained	Moderately Well to Well Drained		Poorly Drained



Match Line (b) or (c)

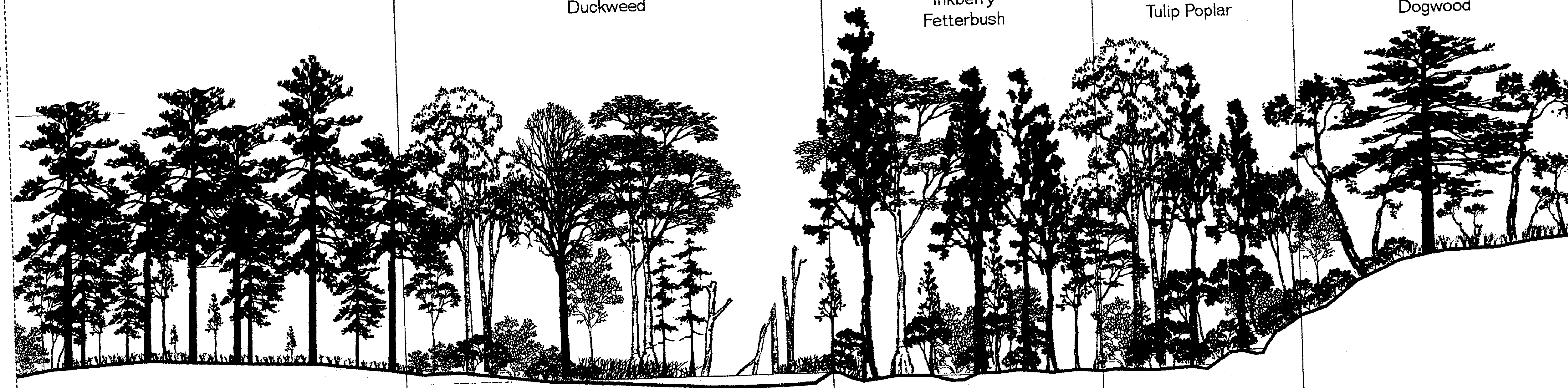
NC DEPARTMENT OF TRANSPORTATION
PO BOX 25201
RALEIGH NC 27611

Target Landscape Ecosystems
SALT MITIGATION SITE
Moore County, North Carolina

Figure:	15a
Project:	98-024.06
Date:	AUG 2000

Match Line

MESIC PINE FLATWOOD	COASTAL PLAIN SEMIPERMANENT IMPOUNDMENT	STREAMHEAD ATLANTIC WHITE CEDAR FOREST	STREAMHEAD POCOSIN	PINE/SCRUB OAK SANDHILL (Blackjack-Mixed Oak Variant)
Loblolly Pine Longleaf Pine Wire Grass Inkberry	Swamp Tupelo Pond Cypress Bald Cypress Smartweeds Water Lily Cowlily Duckweed	Atlantic White Cedar Tulip Poplar Swamp Tupelo Pond Pine Sweetbay Red Bay Inkberry Fetterbush	Ti-ti Fetterbush Inkberry Gallberry Swamp Doghobble Blue Huckleberry Pond Pine Tulip Poplar	Longleaf Pine Turkey Oak Blackjack Oak Sand Post Oak Bluejack Oak Sassafras Persimmon Dogwood



Upper Terrace Flats	Lower Terrace	Seepage Slopes/Adjacent Flat Bottoms	Headwaters/ Seepage Slopes	Upland Slopes/Ridges
Kenansville	Bibb	Bibb/Johnston	Bibb/Johnston	Ailey/Vaucluse
Well Drained	Poorly Drained	Poorly to Very Poorly Drained	Poorly to Very Poorly Drained	Well Drained

NC DEPARTMENT OF TRANSPORTATION
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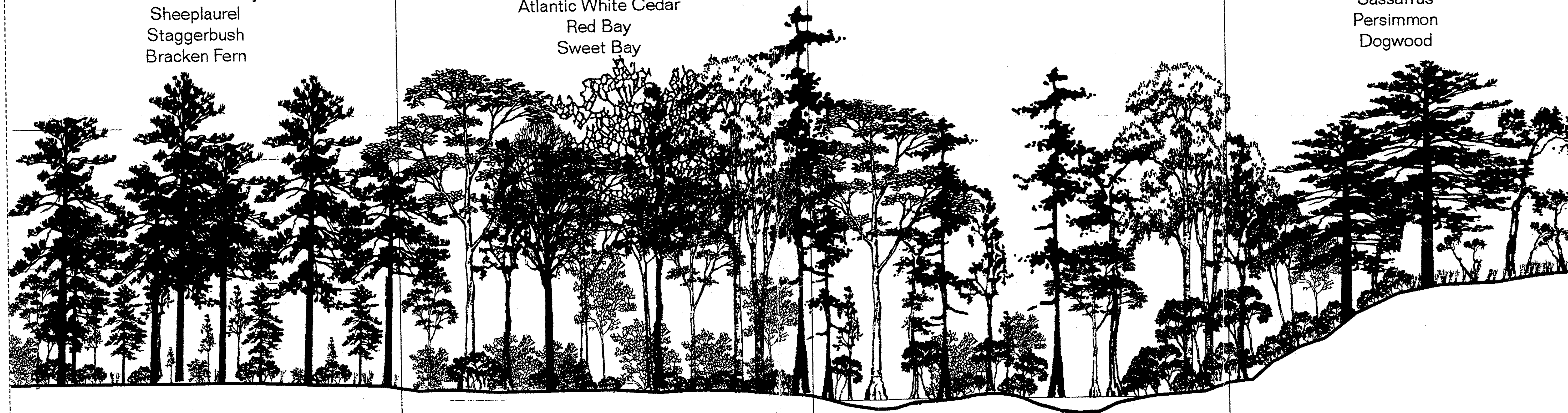
Target Landscape Ecosystems
SALT MITIGATION SITE
Moore County, North Carolina

Figure: 15b
Project: 98-024.06
Date: AUG 2000

Match Line

WET PINE FLATWOODS (includes: Wet Spodosol Variant)	COASTAL PLAIN BOTTOMLAND HARDWOODS	CYPRESS-GUM SWAMP (Active Slough Variant)	PINE/SCRUB OAK SANDHILL (Blackjack-Mixed Oak Variant)
Loblolly Pine Longleaf Pine Pond Pine Inkberry Blue Huckleberry Sheeplaurel Staggerbush Bracken Fern	Swamp Tupelo Laurel Oak Overcup Oak Willow Oak Loblolly Pine Atlantic White Cedar Red Bay Sweet Bay	Swamp Tupelo Pond Cypress Bald Cypress Ti-ti Sweet Pepper Bush	Longleaf Pine Turkey Oak Blackjack Oak Sand Post Oak Bluejack Oak Sassafras Persimmon Dogwood



Upper Terrace Flats	Lower Terrace Flats	Backswamp/Sloughs	Upland Slopes/Ridges
Bibb/Leon	Bibb	Bibb/Johnston	Ailey/Vaucluse
Somewhat Poorly to Poorly Drained	Poorly Drained	Very Poorly to Poorly Drained	Well Drained

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PO BOX 25201
RALEIGH NC 27611

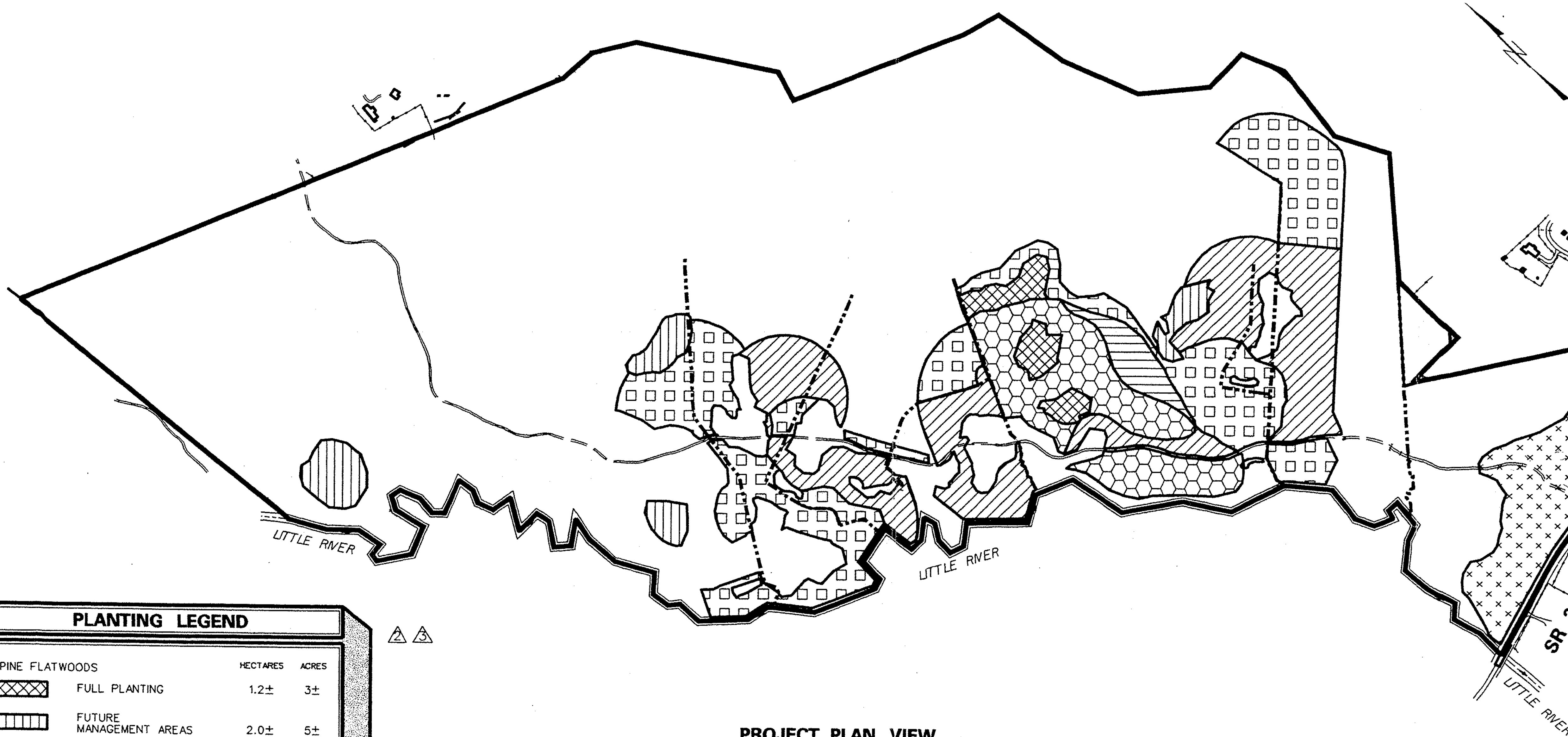
Target Landscape Ecosystems
SALT MITIGATION SITE
Moore County, North Carolina

Figure:	15c
Project:	98-024.06
Date:	AUG 2000

and their relative landscape position. Figure 16 identifies the location of each target community on the Site. Emphasis has been focused on developing a diverse plant assemblage. This is particularly vital due to the limited distribution of mast-producing hardwood tree species presently existing in the region, as evidenced during the RFE search. Planting a variety of mast-producing species will provide a food source for wildlife and will facilitate habitat diversity. The restoration of upland forest communities within the wetland complex is also proposed. Upland forest restoration plans will enhance wetland functions and restore a wetland/upland forest ecotone that is considered uncommon in the region.

Some of the planned vegetation associations are typically fire-maintained. This is particularly true for longleaf pine forest, wet pine flatwoods, and the rare mesic pine flatwoods (Little River variant) that depend on fire for both reproduction and competition control. A fire management plan, including prescribed fire, may represent an appropriate long term strategy designed to retain the endemic Sandhills vegetation patterns across the Site.

As part of the dispensation agreement between SALT and NCDOT, NCDOT will be responsible for planting the upland area adjacent to Lakebay Road (SR 2023). This effort will include an initial herbicide treatment or burn to clear competing vegetation. Future maintenance of unwanted species in this area, as well as, fire dependent communities within interior portions of the site will be accomplished through future long term hydrological changes and a fire management program as established by the Sandhills Area Land Trust, upon dispensation of property.



PROJECT PLAN VIEW ⚠1 ⚠2 ⚠3

PLANTING LEGEND ⚠2 ⚠3

		HECTARES	ACRES
PINE FLATWOODS			
	FULL PLANTING	1.2±	3±
	FUTURE MANAGEMENT AREAS	2.0±	5±
LONGLEAF PINE FOREST			
	FULL PLANTING	4.1±	10±
SANDHILLS BOTTOMLAND HARDWOOD			
	FULL PLANTING	4.9±	12±
	SUPPLEMENTAL PLANTING	8.9±	22±
CYPRESS-GUM SWAMP			
	FULL PLANTING	0.8±	2±
	SUPPLEMENTAL PLANTING	11.3±	28±
	TOTAL	33.2±	82±

GENERAL LEGEND

- APPROX. MITIGATION SITE BOUNDARY
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING FENCE

NO.	REVISIONS	DATE
⚠1	REVISIONS PER NCDOT	09-30-99
⚠2	REVISIONS PER NCDOT	01-10-00
⚠3	REVISIONS PER NCDOT	07-25-00

Client:
NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project:
PLANTING PLAN
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By: MAF | Date: AUG 2000
Ckd By: JWN | Scale: 1"= 600'

ESC Project No.: 98-024.06

Figure 16

5.3 PLANTING PLAN

The planting plan consists of acquisition and planting of wetland tree species. Target planting densities and total stems needed by species were designed according to COE bottomland hardwood forest mitigation guidelines (DOA 1993).

Species selected for planting will be dependent upon availability of local seedling sources. Advance notification to nurseries (1 year) will facilitate availability of various non-commercial elements. Appropriate species names and the primary soil types by plant community are listed below.

<u>Sandhill Bottomland Hardwoods</u>

Primary Soil Map Unit: Bibb (*Typic Fluvaquents*)

1. Bald cypress (*Taxodium distichum*)
2. Swamp tupelo (*Nyssa biflora*)
3. Atlantic white cedar (*Chamaecyparis thyoides*)
4. Laurel oak (*Quercus laurifolia*)
5. Willow oak (*Quercus phellos*)
6. Water oak (*Quercus nigra*)

<u>Cypress-Gum Swamp</u>

Primary Soil Map Unit: Bibb (*Typic Fluvaquents*)

1. Bald cypress (*Taxodium distichum*)
2. Pond cypress (*Taxodium ascendens*) — ?
3. Swamp tupelo (*Nyssa biflora*)
4. Swamp red bay (*Persea palustris*) — ?
5. Sweet bay (*Magnolia virginiana*) — ?

<u>Pine Flatwoods</u>

Primary Soil Map Units: Leon (*Aeric Haplaquod*)), Kenansville (*Arenic Hapludults*), and Bibb (*Typic Fluvaquents*)

1. Longleaf pine (*Pinus palustris*)
2. Pond pine (*Pinus serotina*)

<u>Longleaf Pine Forest</u>

Primary Soil Map Units: Candor (*Arenic Paleudults*), Gilead (*Aquic Hapludults*), and Johns (*Aquic Hapludults*)

1. Longleaf pine (*Pinus palustris*)

Two levels of planting will be used according to restoration goals: full planting and supplemental planting (Figure 16). Full planting will occur in on prepared surfaces in previously timbered areas. These areas will be cleared of all existing competing vegetation by various appropriate methods including: clearing, drum chopping, herbicidal treatment, or prescribed burning. Bare root and/or containerized tree seedlings will be inter-planted randomly on approximately 2.4 m (8-ft) centers (1680 trees/ha [680 trees/ac]) within the specified planting unit. Table 7(a) depicts the total number of stems and species distribution within each full planting association.

A management plan for the upland longleaf pine planting area will be implemented following the recommendations and specifications prepared by the North Carolina Division of Forest Resources (NCDFR). The planting area can be prepared for planting by a mid to late summer application of herbicides, in strict accordance with their labels. A prescribed fire should follow approximately one month after herbicide treatment. The burn should be conducted between June and October by a licenced contractor. The prescribed fire should kill remaining vegetation, reduce ground litter, and obtrusive debris. Planting should commence the winter immediately following site preparation.

Supplemental planting will occur in areas supporting a poor species mix or sparse forest cover. Bare root and/or containerized tree seedlings will targeted toward tree or canopy gaps within specified map areas at a density of 175 tree per hectare (70 trees/acre). This will be performed by having the planter identify the various locations for planting by walking to pockets of sunlight within the forest canopy during planting. Table 7(b) depicts the total number of stems and species distributions within each supplemental planting vegetation association.

Planting will be performed between December 1 and March 15 to allow plants to stabilize during the dormant period and set root during the spring season. Opportunistic species, which typically dominate disturbed forests, have been excluded from initial community restoration efforts. Characteristic species such as sweet gum, red maple, loblolly pine, American sycamore, and black willow may become established. However, to the degree that species diversity is not jeopardized, these species should be considered important components of steady-state forest communities.

TABLE 7a

Stocking Levels
SALT Wetland Mitigation Site
(Full Planting[1])

Vegetation Association (Planting Area)	Longleaf Pine Savanna (Full)	Wet Pine Flats (Full)	Bottomland Hardwoods (Full)	Cypress-Gum Swamp (Full)	TOTAL
Trees/ha (ac)	1680 (680)	1680 (680)	1680 (680)	1680 (680)	1680 (680)
Area (ha [ac])	4.1 (10)	1.2 (3)	4.9 (12)	0.8 (2)	11 (27)
SPECIES[2]	# planted (% total)[1]	# planted (% total)	# planted (% total)	# planted (% total)	# planted (%total)
Longleaf Pine	6890 (100)	1010 (50)			7,900
Pond Pine		1010 (50)			1,010
Water Oak			410 (5)		410
Willow OaK			825 (10)		825
Laurel Oak			825 (10)		825
Atlantic White Cedar			1650 (20)		1,650
Swamp Tupelo			2060 (25)	400 (30)	2,460
Bald Cypress			2060 (25)	400 (30)	2,460
Sweet Bay			410 (5)	135 (10)	545
Pond Cypress				270 (20)	270
Carolina Ash				135 (10)	135
TOTAL	6890	2020	8240	1340	**18,490**

1: Full planting densities comprise of 1680 trees per hectare (680 trees/acre) within each specified planting area.

2: Some non-commercial elements may not be locally available at the time of planting. The stem count for unavailable species should be distributed among other target elements based on the percent (%) distribution. One year of advance notice to forest nurseries will promote availability of some non-commercial elements. However, reproductive failure in the nursery may occur. Scientific names for each species, required for nursery inventory, are listed in the mitigation plan.

TABLE 7b

Stocking Levels
SALT Wetland Mitigation Site
(Supplemental Planting[1])

Vegetation Association (Planting Area)	Bottomland Hardwoods (Supplemental)	Cypress-Gum Swamp (Supplemental)	TOTAL
Trees/ha (ac)	175 (70)	175 (70)	175 (70)
Area (ha [ac])	8.9 (22)	11.3 (28)	20.2 (50)
SPECIES[2]	# planted (% total)	# planted (% total)	# planted (%total)
Atlantic White Cedar	160 (10)		160
Willow Oak	160 (10)		160
Laurel Oak	160 (10)	200 (10)	360
Swamp Tupelo	310 (20)	595 (30)	905
Bald Cypress	780 (50)	1000 (50)	1780
Carolina Ash		200 (10)	200
TOTAL	1560	1995	**3,555**

1. Supplemental planting densities comprise of 175 trees per hectare (70 trees/acre) within each specified planting area.
2: Some non-commercial elements may not be locally available at the time of planting. The stem count for unavailable species should be distributed among other target elements based on the percent (%) distribution. One year of advance notice to forest nurseries will promote availability of some non-commercial elements. However, reproductive failure in the nursery may occur. Scientific names for each species, required for nursery inventory, are listed in the mitigation plan.

6.0 MONITORING PLAN

The Monitoring Plan consists of a comparison between reference and restoration areas along with evaluation of jurisdictional wetland criteria. Wetland monitoring will entail analysis of two primary parameters: vegetation and hydrology. Monitoring of restoration and enhancement efforts will be performed for 5 years or until success criteria are fulfilled.

6.1 HYDROLOGY MONITORING

After hydrological modifications are performed, a series of monitoring wells will be installed in accordance with specifications in U.S. Army Corps of Engineers', Installing Monitoring Wells/Piezometers in Wetlands (WRP Technical Note HY-IA-3.1, August 1993). Monitoring wells will be set to a depth of 50 cm (20 in) below the soil surface. All screened portions of the well will be buried in a sand screen, filter fabric, and/or a bentonite cap to prevent siltation.

Eight (8) continuous monitoring wells will be installed in restoration areas to provide representative coverage within each planting area, as depicted in Figure 17. In addition, four (4) continuous monitoring wells will be placed within the reference wetlands located in throughout central sections of the Site (Figure 17). Well locations will be placed at representative elevations within the monitoring area. The elevation of each well will be surveyed. The reference well 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 will allow interpretation of mitigation success in years not supporting, "normal rainfall conditions". Hydrological sampling will be performed on a daily basis throughout the year. Well data will be downloaded from the data logger on an average 6 week interval.

6.2 HYDROLOGY SUCCESS CRITERIA

Target hydrological characteristics include a minimum regulatory criteria or comparisons to reference wells in drought years.

Regulatory Criteria

Target hydrological characteristics during years with average rainfall include saturation or inundation (free water) within one foot of the soil surface for at least 12.5% of the growing season. This hydroperiod translates to saturation for a minimum, 29-day consecutive period during the growing season, extending from March 23 through November 7 (USDA1995). Upper landscape reaches and hummocks within wetland areas may exhibit surface saturation/inundation for between 5 percent and 12.5 percent of the growing season based on well data. These 5 to 12.5 percent areas are expected to support hydrophytic vegetation within hydric soils. If wetland parameters are marginal as indicated by vegetation and hydrology monitoring, consultation with COE personnel will be undertaken to determine jurisdictional extent in these areas.

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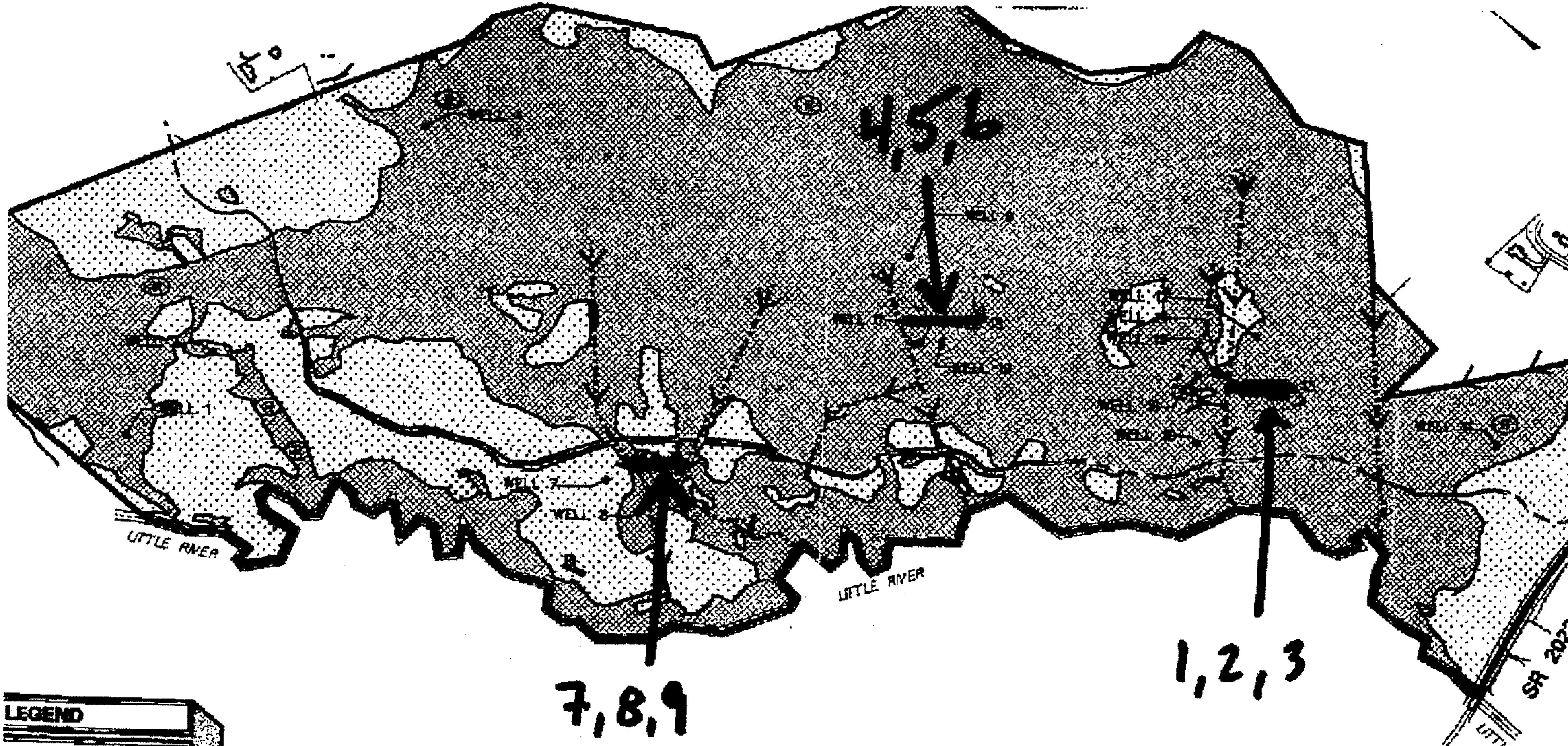
CATENA GROUP GAUGE LOCATIONS – 12/15/04



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HYDROLOGY

	HECTARES	ACRES
	99±	245±
LS	33±	82±
TOTAL	132±	327±

PROJECT PLAN VIEW

WELL ELEVATIONS

WELL 1
TOP ELEV. = 220.95 FT.
GROUND ELEV. = 215.00 FT.

WELL 3
TOP ELEV. = 220.20 FT.
GROUND ELEV. = 218.24 FT.

WELL 4
TOP ELEV. = 222.52 FT.
GROUND ELEV. = 220.54 FT.

WELL 7
TOP ELEV. = 219.[illegible] FT.
GROUND ELEV. = 217.32 FT.

WELL 8
TOP ELEV. = 217.04 FT.
GROUND ELEV. = 214.70 FT.

WELL 9
TOP ELEV. = 219.64 FT.
GROUND ELEV. = 217.56 FT

WELL 10
TOP ELEV. = 213.96 FT.
GROUND ELEV. = 211.92 FT.

WELL 11
TOP ELEV. = 2[illegible].82 FT.
GROUND ELEV. = 214.52 FT.

WELL 12
TOP ELEV. = 216.37 FT.
GROUND ELEV. = 214.37 FT.

WELL 13
TOP ELEV. = 216.23 FT.
GROUND ELEV. = 214.13 FT.

WELL 14
TOP ELEV. = 216.13 FT.
GROUND ELEV. = 214.12 FT.

WELL 15
TOP ELEV. = 215.48 FT.
GROUND ELEV. = 213.58 FT.

WELL 16
TOP ELEV. = 214.98 FT
GROUND ELEV. = 212.87 FT.

WELL 17
TOP ELEV. = 217.82 FT
GROUND ELEV. = 215.76 FT

WELL 18
TOP ELEV. = 218.25 FT.
GROUND ELEV. = 215.87 FT.

WELL 19
TOP ELEV. = 217.84 FT.
GROUND ELEV. = 215.79 FT.

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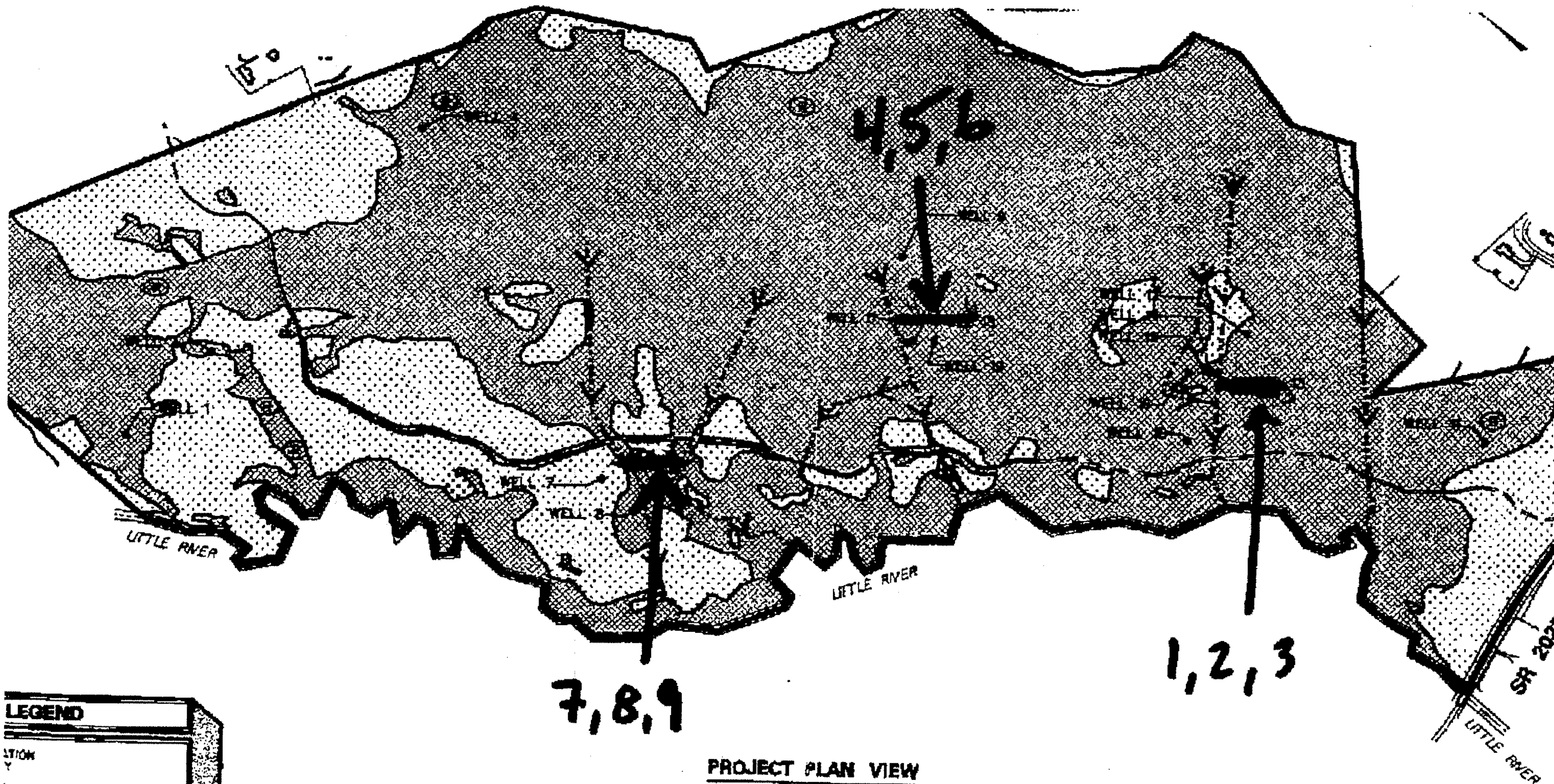
CATENA GROUP GAUGE LOCATIONS — 12/15/04



PROJECT PLAN VIEW

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HYDROLOGY

	HECTARES	ACRES
	99±	245±
LS	33±	82±
TOTAL	132±	327±

WELL ELEVATIONS

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TOP ELEV. = 220 20 FT.
GROUND ELEV. = 218.24 FT.

WELL 4
TOP ELEV. = 222.52 FT.
GROUND ELEV. = 220.54 FT.

WELL 7
TOP ELEV. = 219.[illegible]4 FT.
GROUND ELEV. = 217.32 FT.

WELL 8
TOP ELEV. = 217.04 FT.
GROUND ELEV. = 714.70 FT.

WELL 9
TOP ELEV. = 219.64 FT.
GROUND ELEV. = 217.56 FT

WELL 10
TOP ELEV. = 213.98 FT.
GROUND ELEV. = 211.92 FT.

WELL 11
TOP ELEV. = 2[illegible].82 FT.
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GROUND ELEV. = 213.58 FT.

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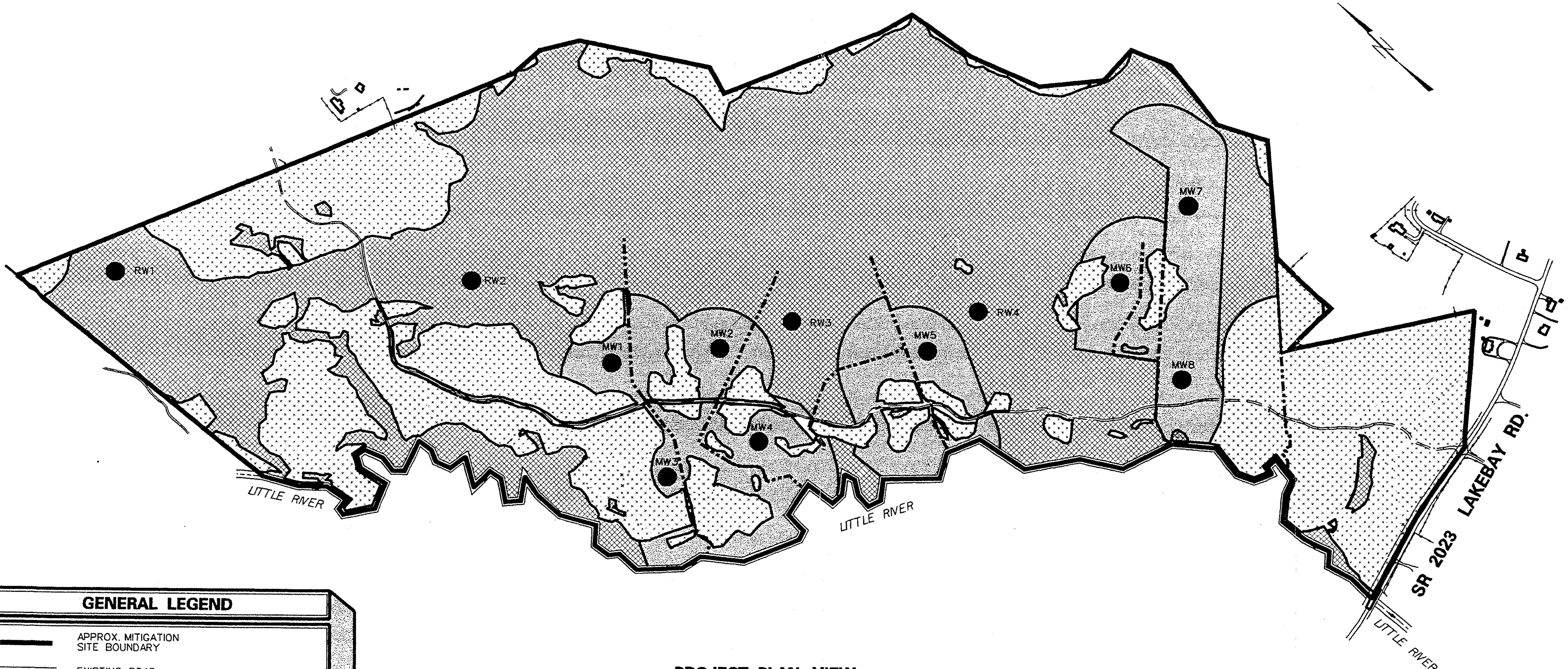
TOP ELEV. = 214.98 FT
GROUND ELEV. = 212.87 FT.

WELL 17
TOP ELEV. = 217.82 FT
GROUND ELEV. = 215.76 FT

WELL 18
TOP ELEV. = 718.25 FT.
GROUND ELEV = 215.87 FT.

WELL 19
TOP ELEV. = 217.84 FT.
GROUND ELEV. = 215.79 FT.



PROJECT PLAN VIEW

GENERAL LEGEND

- APPROX. MITIGATION SITE BOUNDARY
- EXISTING ROAD
- EXISTING BUILDING
- EXISTING FENCE
- EXISTING DITCH

24" MONITORING WELLS

- RW1 REFERENCE WETLAND (4)
- MW1 RESTORATION AREAS (8)

	HECTARES	ACRES
WETLAND ENHANCEMENT / PROTECTION	71±	176±
UPLAND REFORESTATION / PROTECTION	41±	102±
WETLAND RESTORATION	20±	49±
TOTAL	132±	327±

Client: *NC DEPARTMENT OF TRANSPORTATION*
P.O.BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project: **MITIGATION AND MONITORING PLAN**
SALT TRACT MITIGATION SITE
MOORE COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: AUG 2000	Ckd By: JWN	Scale: 1"= 600'	Figure 17

ESC Project No.: 98-024.06

Reference Criteria

Alternatively, hydrology success criteria may be established through comparison of well data between the wetland restoration area and the reference wetland (i.e. depth to groundwater). Specifically, a surveyed cross section will be established at each reference well depicting variation in elevation across the land surface. The cross section at each well location will extend 100 feet, with measurements taken at 10 foot increments. The average hydroperiod along the cross sections will be calculated assuming a level groundwater table. Subsequently, the reference hydroperiod will be compared to restoration areas in each successive year. The hydroperiod must exceed 75 percent of the hydroperiod exhibited by the reference wells, located within the same physiographic landscape area.

6.3 VEGETATION

Restoration monitoring procedures for vegetation are designed in accordance with EPA guidelines enumerated in Mitigation Site Type (MiST) documentation (EPA 1990) and COE Compensatory Hardwood Mitigation Guidelines (DOA 1993). Quantitative vegetation sampling will take place in early autumn of the first year following planting. Only full planted wetland restoration areas will be vegetatively monitored. Permanent 50 X 50 ft plots will be established randomly within each restored ecosystem type, in the proximity to monitoring wells (Figure 17). Fifteen (15) plots will be established and correlated with hydrological monitoring locations to provide point-related data on hydrological and vegetation parameters.

Supplemental and upland planting areas will not be vegetatively monitored. Supplemental areas are not feasibley monitored using standardized monitoring protocol. Affiliated agencies will be notified when supplemental planting will occur and will be encouraged to meet with the contractor on-site at such time.

6.4 VEGETATION SUCCESS CRITERIA

Success criteria include the verification, per the vegetation data form, that each plot supports a species composition sufficient for a jurisdictional determination. Additional success criteria are dependent upon the density and growth of characteristic forest species. Characteristic species will include planted elements and may include naturally recruited species indentified in reference wetlands. The vegetation success criteria will vary between pine and hardwood forests to account for lower overstory species diversity among the various Sandhills forest types. This criteria is based on future management plans to be administered by SALT.

6.4.1 Hardwood Success Critera

Vegetation success criteria for Sandhills bottomland forest and cypress gum swamp will require a minimum mean density of 790 characteristic trees/ha (320 characteristic tree species/ac) surviving for 3 years after initial planting. Subsequently, 715 characteristic trees/ha (290 characteristic tree species/ac) must be surviving in year 4, and 640 characteristic trees/ha (260 characteristic tree species/ac) in year 5. In addition, at least five (5) character tree species must be present, and no species can comprise more than 20 percent of the 320 stem/acre total.

6.4.2 Pine Forest Success Criteria

Vegetation success criteria for pine flatwood forest will require a minimum mean density of 790 characteristic trees/ha (320 characteristic tree species/ac) surviving for 3 years after initial planting. Subsequently, 715 characteristic trees/ha (290 characteristic tree species/ac) must be surviving in year 4, and 640 characteristic trees/ha (260 characteristic tree species/ac) in year 5. The two character tree species, longleaf and pond pine, must be present, with neither species comprising more than 75 percent of the 320 stem/acre total.

6.5 REPORT SUBMITTAL

An "as built" plan drawing of the area, including initial species compositions by community type, and sample plot and well locations, will be provided after completion of planting. A discussion of the planting design, including what species were planted, the species densities and numbers planted will also be included. The report will be provided within 90 days of completion of all work.

Subsequently, reports will be submitted yearly to appropriate permitting agencies following each assessment. Reports will document the sample plot locations, along with photographs which illustrate site conditions.

Surficial well data will be presented. The duration of wetland hydrology during the growing season will also be calculated within each community restoration map unit. The survival and density of planted tree stock and natural recruitment will be reported and evaluated relative to the success criteria.

6.6 CONTINGENCY

In the event that vegetation or hydrology success criteria are not fulfilled, a mechanism for contingency will be implemented. For vegetation contingency, replanting and extended monitoring periods will be implemented if community restoration does not fulfill minimum species density and distribution requirements.

Hydrological contingency will require consultation with hydrologists and regulatory agencies if wetland hydrology restoration is not achieved during the monitoring period. Recommendations for contingency to establish wetland hydrology will be implemented and monitored until the Hydrology Success Criteria are achieved.

6.7 DISPENSATION OF PROPERTY

The property is owned by the Sandhill Area Land Trust Inc. (SALT) with funds provided by NCDOT. NCDOT will maintain responsibility for all on-site mitigation activities for five years or until mitigation activities are deemed successful. Covenants and/or restrictions on the deed will be included that will ensure adequate management and protection of the site in perpetuity.

7.0 WETLAND MITIGATION POTENTIAL

The Site is being offered, in total, to offset wetland impacts associated with improvements to U.S. Highway 1 (TIP #R-210), along an approximately 19.2 km (11.9 mi) corridor in Sanford and Lee Counties. The highway improvement project exhibits potential to impact up to 17 ha (43 ac) of isolated wetlands.

An ecosystem approach to mitigation has been implemented to replace proposed wetland impacts. The Site encompasses approximately 132 ha (327ac) of floodplain and backwater sloughs along the Little River in Moore County (Figure 1). Compensatory mitigation activities will be consolidated within this contiguous wetland area to maximize wetland functional benefits realized through long term management and protection in perpetuity. The tract will be maintained by the Sandhills Area Land Trust Inc. (SALT), further enhancing long term functional benefits derived from the mitigation project. Clear-cutting, logging, ditch cleaning, or other alternative land uses will be prevented. In addition, the Site supports rare floodplain communities, endemic to the Little River basin, that will benefit from long term protection and management.

Under historic (undisturbed) conditions, the Site functioned as a backwater storage area for the Little River basin, accommodating discharge from an approximately 448-km^2 (173-mi^2) watershed. The secondary watershed, encompassing approximately 2.8 km^2 (1.1 mi^2), discharges groundwater and surface water directly into the Site. Historically, the secondary watershed induced near-permanent soil saturation, intermittent channels, and organic soil development to large portions of the river terrace. Long term water storage and flood retention capacity were most likely significant functional attributes of the wetland prior to the 1930s. Based on conceptual groundwater models, the Site supported approximately 97 ha (240 ac) of riverine bottomland and swamp forest wetlands under historic conditions.

Under antecedent conditions, a drainage network was installed within the Site in the 1930s to promote conversion to crop land and/or silvicultural operations. The network included approximately 4,760 m (15,600 linear ft) of ditches primarily in central portions of the Site. Road construction, clearing of natural wetland vegetation, and planting of loblolly pine (*Pinus taeda*) appear to have occurred within the drainage network. The Site alterations have induced significant degradation to adjacent wetland systems, including reductions in surface water storage, flood retention capacity, nutrient cycling functions, and wetland community structure. Conceptual drainage models suggest that the drainage network accelerated groundwater withdrawal rates throughout central portions of the floodplain, including direct loss of approximately 75 ha (185 ac) of wetlands.

Under existing conditions, the ditch network has not been maintained and has partially filled with unconsolidated sediment. Based on groundwater analyses, approximately 2,340 m (7,670 ft) of the ditches remain in functioning condition. The passive process of ditch filling within the drainage network appears to be reducing impacts to the wetland system over time. Vegetation composition and community dynamics are undergoing a transition towards characteristic wetland species adapted to long term saturation and inundation (Carter 1998). However, clear-cutting has occurred in the last several years, inducing disturbance adapted wetland assemblages to dominate portions of the Site. In addition, the logging road has been improved over the last several years to facilitate logging activities. A borrow pit was excavated and utilized as fill for the logging road. Approximately seven culverts were placed under the road at ditch/stream crossings and depressional areas. The antecedent ditch network was cleaned out in proximity to the installed culverts to facilitate drainage through the corridor with associated impacts to wetlands.

Conceptual groundwater models under existing conditions utilized open portions of the ditches for preliminary groundwater drainage rate calculations. Flow of water through the floodplain soil is extremely rapid and ditching effects on saturated soil layers may be more extensive than published numbers for the Bibb series indicate. Based on the hydraulic conductivity tests which suggest very rapid infiltration rates, a conservative value of 50.8 cm/hr (20 in/hr) was deemed warranted for use in the model. Conceptual groundwater models indicate that open portions of the relict ditch network effectively drain approximately 28 ha (69 ac) of wetlands relative to historic condition.

Based upon surface and groundwater studies, hydrological restoration activities include limited ditch backfilling, and ford construction in proximity to the logging road. Backfilling will also occur in ditch sections in proximity to the Little River. A limited access road shall remain through the Site. Community restoration in clear-cut and transitional areas, including full and supplemental planting of seedlings, is expected to introduce tree species that are characteristic of reference (relatively undisturbed) bottomland hardwood, swamp forest, or pine flat communities in the area. Community restoration and enhancement strategies are designed to promote the development of steady-state, riverine forests which support an array of native plant and wildlife communities.

Removal of waste dumps may be performed in various portions of the Site, dependent upon consultation with NCDOT personnel. Vehicular access points that are conducive to waste dumping will also be blocked by woody debris, road cuts, gates, or other structures to prevent contamination of wetland systems within the Site by potentially hazardous materials. Water quality improvements associated with the prevention of extensive dumping in floodplains represents an important component of wetland restoration efforts throughout the region.

The primary functional benefits associated with mitigation activities include restoring historical hydrologic conditions on the property, reforestation of upland groundwater recharge areas, and the protection of the restored wetlands from future disturbance and contamination. The lack of ditch cleaning activities in the 60+ years following drainage network construction has allowed the Site to initiate development of functioning wetland ecosystems. This transitional process towards stable wetland hydrodynamics and community structure is continuing to occur passively at the present time. Acquisition and establishment of a perpetual conservation easement will allow the wetland development and restoration process to proceed unimpeded. The easement will prevent cleaning out of the ditch network, continuous logging operations, ongoing road construction/improvements, and periodic dredge and fill activities in the wetlands. Long term management and gated or reduced access should also reduce waste dumping activities that are occurring at the present time.

Factors generating wetland functional replacement for compensatory mitigation use include: 1) effective removal of the drainage network; 2) the location and size of the Site on the contiguous floodplain of a major river; 3) protection of the Site from continuous waste dumping, road construction/improvements, ditch cleaning, and clear-cutting activities; 4) the ongoing process of wetland restoration over time. Restoration activities are expected to restore approximately 20 ha (49 acres) of riverine hardwood and swamp forest wetlands (Figure 15). Additionally, mitigation activities will assist in the passive wetland development and restoration process within a minimum of 75 ha (185 ac) of land degraded by the antecedent ditch network. Therefore, the 132 ha (327 ac) floodplain and wetland terrace, in total, appears to provide adequate compensatory mitigation for isolated wetland impacts associated with improvements to U.S. Highway 1 (TIP #R-210).

8.0 REFERENCES

Adamus P.R., L.T. Stockwell, E.J. Clairain Jr., M.E. Morrow, L.P. Rozas, R.D. Smith. 1991. Wetland Evaluation Technique (WET), Volume 1: Literature Review and Evaluation Rationale. Wetlands Research Program Technical Report WRP-DE-2. U.S. Army Corps of Engineers Waterways Experiment Station. Vicksburg, MS.

Adamus P.R., L.T. Stockwell. 1983. A Method for Wetland Functional Assessment, Volume I. Critical Review and Evaluation Concepts. Federal Highway Administration Report no. FHWA-IP-82-23. U.S. Department of Transportation, Washington, D.C.

Belcher, H.W. and G.E. Merva. 1987. Results of DRAINMOD verification study for Zeigenfuss soil and Michigan climate. ASAE Paper No. 87-2554. ASAE, St. Joseph, MI 49085.

Bouwer, H. and R.C. Rice. 1985. A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research, 3, pp 423-428.

Bouwer, H. 1989. The Bouwer and Rice slug test-an update. Ground Water 27 (3) 304-309.

Brinson, M.M., F.R. Hauer, L.C. Lee, R.P. Novitzki, W.L. Nutter, and D.F. Whingham. 1994. Guidebook for Application of Hydrogeomorphic Assessments to Riverine Wetlands. The National Wetlands Science Training Cooperative. Seattle, WA.

Brinson M., B. Swift, R. Plantico, J. Barclay. 1981. Riparian Ecosystems: Their ecology and status. U.S. Fish and Wildlife Service FWS/OBS 81/17.

British Columbia Ministry of Forests. A working draft 1997/1998. Forest practice Code Guide Books. Stream Crossing Guidebook for Fish Streams. Prepared by V.A. Paulin, V.A. Paulin and Associates Ltd. and H.W. Argent, Consulting Civil Engineer. http://www.for.gov.bc.ca/tasb/legsregs/fpx/fpcguide.

Brown, Philip M., et al, 1985, Geologic Map of North Carolina, North Carolina Department of Natural Resources and Community Development, 1-.500,000 scale.

Brower, J.E., J.H. Zar, C.N. von Ende. 1990. Field and Laboratory Methods for General Ecology. William C. Brown Publishers, Debuque, IA.

Cowardin, L.M., V. Carter, F. C. Golet, and Edward T. Laroe. 1979. Classification of Wetland and Deepwater Habitats of the United States. Fish and Wildlife Service, U.S. Department of Interior.

Carter, J. H. 1998. Biological and Wetland Assessment for proposed Wetland Mitigation Site (Taylor Tract), Lobelia, Moore County, North Carolina. NCDOT.

Department of the Army (DOA). 1987. Corps of Engineers Wetland Delineation Manual. Tech. Rpt. Y-87-1, Waterways Experiment Station, COE, Vicksburg, Mississippi.

Department of the Army (DOA). 1993 (unpublished). Corps of Engineers Wilmington District. Compensatory Hardwood Mitigation Guidelines (12/8/93).

Division of Environmental Management (DEM). 1996. Cape Fear River Basinwide Water Quality Management Plan. N.C. Department of Environment, Health, and Natural Resources, Water Quality Section, Raleigh, NC.

Environmental Protection Agency (EPA). 1990. Mitigation Site Classification (MiST) A Methodology to Classify Pre-Project Mitigation Sites and Develop Performance Standards for Construction and Restoration of Forested Wetlands. USEPA Workshop, August 13-15, 1989. USEPA Region IV and Hardwood Research Cooperative, North Carolina State University, Raleigh, NC.

Fouss, J.L., R.L. Bengtson and C.E. Carter. 1987. Simulating subsurface drainage in the lower Mississippi Valley with DRAINMOD. Transactions of the ASAE 30 (6).(1679 - 1688).

Gayle, G., R.W. Skaggs and C.E. Carter. 1985. Evaluation of a water management model for a Louisiana sugar cane field. J. of Am. Soc. of Sugar Cane Technologists, 4: 18 - 28. Graham County Historical Society, 1992. Graham County Heritage. Robbinsville, NC.

Hamel, P.B. 1992. The Land Manager's Guide to the Birds of the South. The Nature Conservancy, Southeastern Region, Chapel Hill, NC. 437 pp.

Hvorslev, M.J, 1951. Time lag and soil permeability in groundwater observations. U.S. Army Corps of Engineers Waterways Experimental Station Bulletin 36, Vicksburg, MS.

Martof, B.S., W.M. Palmer, J.R. Bailey, and J.R. Harrison III. 1980. Amphibians and Reptiles of the Carolinas and Virginia. University of North Carolina Press, Chapel Hill, NC. 264 pp.

Menhinick, E.F. 1991. The Freshwater Fishes of North Carolina. The Delmar Company, Charlotte, NC for North Carolina Wildlife Resources Commission, Raleigh, NC. 227 pp.

Page, R.W. and L.S. Wilcher. 1990. Memorandum of Agreement Between the EPA and the DOE Concerning the Determination of Mitigation Under the Clean Water Act, Section 404(b)(1) Guidelines. Washington, DC.

Palmer, W.M. and A.L. Braswell. 1995. Reptiles of North Carolina. The University of North Carolina Press, Chapel Hill, NC for the N.C. State Museum of Natural Sciences. 412 pp.

Potter, E.F., J.F. Parnell, and R.P. Teulings. 1980. Birds of the Carolinas. The University of North Carolina Press, Chapel Hill, NC. 408 pp.

Rogers, J.S. 1985. Water management model evaluation for shallow sandy soils.Transactions of the ASAE 28 (3): 785-790.

Schafale, M. P., A.S. Weakley. 1990. Classification of the Natural Communities of North Carolina: Third Approximation, NC Natural Heritage Program, Division of Parks and Recreation, NC DEM, Raleigh NC.

Skaggs, R.W. 1982. Field Evaluation of a Water Management Simulation Model. Transactions of the ASAE 25 (3), pp 666-674.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. University of North Carolina Press, Chapel Hill, NC. 1183 pp.

Rohde, F.C., R.G. Arndt, D.G. Lindquist, and J.F. Parnell. 1994. Freshwater Fishes of the Carolinas, Virginia, Maryland, & Delaware. The University of North Carolina Press, Chapel Hill, NC. 222 pp.

U.S. Department of Agriculture (USDA). 1996. Technical Guide, Section II-A-2, USDA Natural Resource Conservation Service.

U.S. Department of Agriculture (USDA). 1995. Soil Survey of Moore County, North Carolina, USDA Natural Resource Conservation Service.

U.S. Department of Agriculture (USDA). 1987. Hydric Soils of the United States. In cooperation with the National Technical Committee for Hydric Soils, USDA Natural Resource Conservation Service.

U.S. Department of Agriculture (USDA). 1985. Soil Survey of Cumberland and Hoke Counties, North Carolina, USDA Natural Resource Conservation Service.

Webster, W.D., J.F. Parnell, and W.C. Biggs, Jr. 1985. Mammals of the Carolinas, Virginia, and Maryland. The University of North Carolina Press, Chapel Hill, NC. 255 pp.

VanBeers, W. F. J. 1970. The Auger-Hole Method. A Field Measurement of the Hydraulic Conductivity of Soil Below the Water Table. International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands, 1958. In: C.W. Doty, R. Evans, H. Gibson, R. Hinson, W. Williams. May 1986. Agriculture Water Table Management "A Guide for Eastern North Carolina", North Carolina State University and United States Department of Agriculture.

APPENDICES

APPENDIX A

Biological and Wetlands Assessment for the Proposed Wetland Mitigation Site (Taylor Tract)

(Carter 1998)

BIOLOGICAL AND WETLANDS ASSESSMENT
FOR
PROPOSED WETLAND MITIGATION SITE (TAYLOR TRACT)
LOBELIA, MOORE COUNTY, NORTH CAROLINA

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To:
Sandhills Area Land Trust
And
North Carolina Department of Transportation

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BIOLOGICAL AND WETLANDS ASSESSMENT
FOR
PROPOSED WETLAND MITIGATION SITE (TAYLOR TRACT)
LOBELIA, MOORE COUNTY, NORTH CAROLINA

INTRODUCTION

The North Carolina Department of Transportation (NCDOT) is preparing to improve U.S. Highway 1 (R-210) from the existing 4 lane terminus southwest of Sanford in Lee County to the existing 4 lane terminus just south of Vass in Moore County. A portion of the project involves adding 2 lanes beside the existing 2 lane right-of-way in southern Lee County. However, much of the project will be constructed on new right-of-way. Because of unavoidable impacts to jurisdictional waters, including wetlands, NCDOT conducted a search for potential wetland mitigation sites in the project area. The Taylor Tract, a 320 acre (legal description varies from 320.0 to 333.7 acres) parcel located along Little River near Lobelia in Moore County, was chosen for further evaluation. A protected species reconnaissance and wetland delineation were conducted between mid-December 1997 and early May 1998. This assessment presents the results of these evaluations.

PROJECT AREA

The project is located in the Greater Sandhills of south-central North Carolina (Figure 1), an area characterized by golf courses and residential developments, sandy soils and pine forested, gently rolling hills.

Uplands in the Sandhills are predominantly forested with longleaf pine *(Pinus palustris)*. Understories vary from open to dense and are typically comprised of scrub oaks (*Quercus* spp.), of which turkey oak *(Quercus laevis)* is most common. Carolina wiregrass (*Aristida stricta*) is the dominant native ground cover. Stands of loblolly pine *(Pinus taeda)*, often mixed with longleaf pine, occur on many old field sites. Xeric

Sandhill Scrub, Pine-Scrub Oak Sandhill and Mesic Pine Flatwoods are the dominant upland community types.

Hillside drains, seeps and small stream swamps support stands of pond pine *(Pinus serotina)*, often mixed with tulip poplar (*Liriodendron tulipifera*), swamp black gum (*Nyssa biflora*) and red maple (*Acer rubrum*), and dense thickets of shrubs and vines. Atlantic white cedar (*Chamaecyparis thyoides*) is sometimes mixed with the above species or occurs in monotypic stands of varying size. Mesic and swamp hardwood species, including tulip poplar, swamp black gum, sweetgum (*Liquidambar styraciflua*) and red maple are dominant overstory species in the larger swamp forests and in disturbed wetlands. Streamhead Pocosin, Sandhill Seep and Coastal Plain Small Stream Swamp–Blackwater Subtype are the primary wetland community types.

Elevations in the project area range from 220 to 620 feet above mean sea level. Upland soils are well drained and consist predominantly of Candor sand, Ailey loamy sand, Gilead loamy sand and Vaucluse loamy sand. The most widespread wetland soil is Bibb loam. Kalmia sandy loam and Kenansville loamy sand occur on terraces along James Creek and Little River.

Little River and its tributaries drain central Moore County. This small blackwater river supports a variety of floodplain and river terrace vegetative communities. Its floodplain is approximately 4000 feet wide south of Vass, but the stream becomes increasingly entrenched and the floodplain nearly disappears as it cuts through the Cape Fear Formation near the Hoke County line.

PROJECT SITE

The Taylor Tract is a 320 (or 333.7) acre parcel located 1 mile west of Lobelia in east central Moore County (Figure 1). It is a rectangular property that lengthwise lies on a northwest to southeast axis. Little River forms the western property boundary and woodland borders the northern and eastern sides. State Road (SR) 2023 runs along the southern boundary. There are no improvements on the property. The area immediately surrounding the property supports woodland, agricultural and rural residential uses.

The tract is flat except for a bluff and hillside around the northern and eastern boundaries. Elevations range from 220 to 250 feet above mean sea level. The

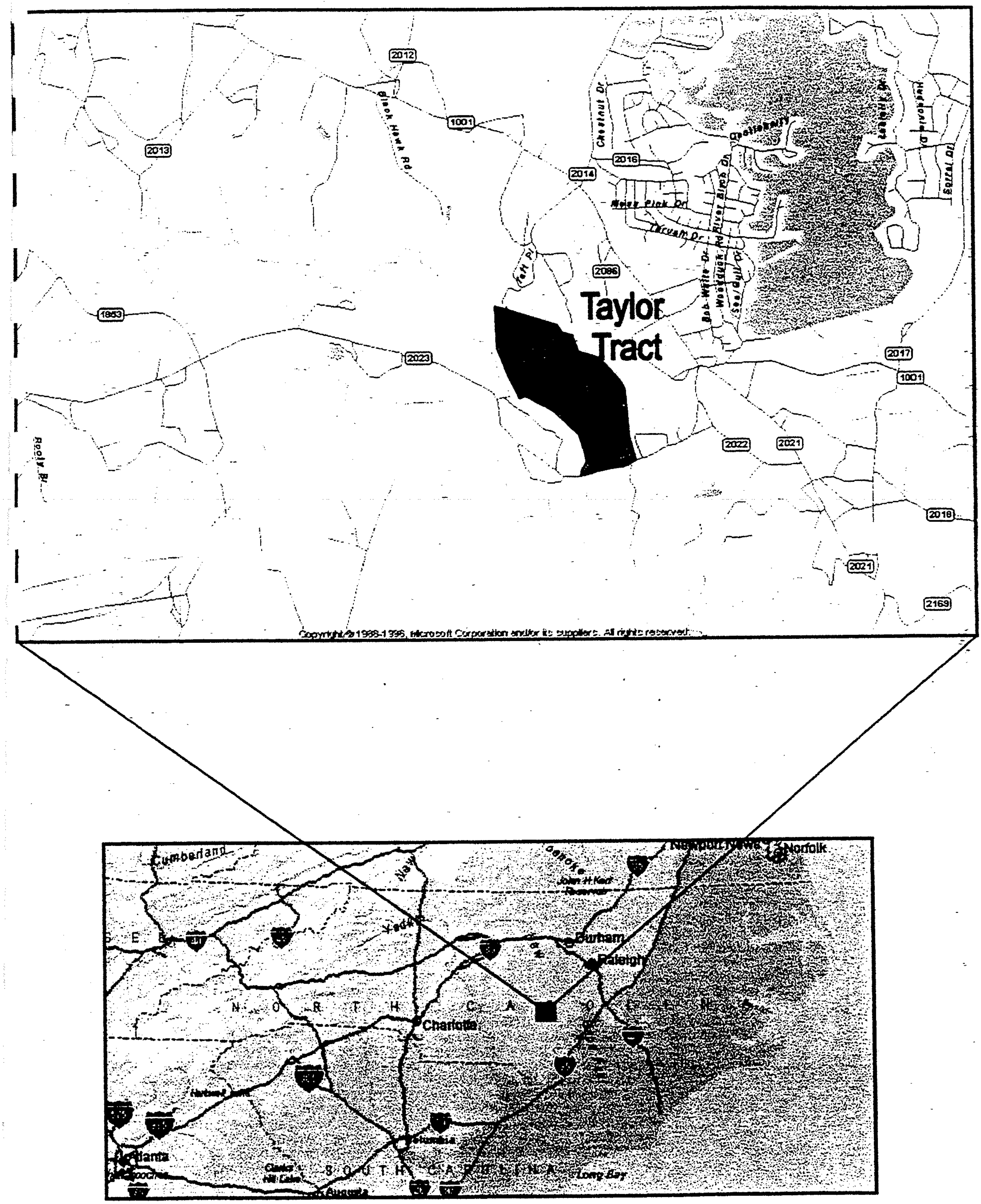


Figure 1. Location map of the project area and Taylor Tract in eastern Moore County, North Carolina.

predominant soil type is Bibb loam, with Kalmia sandy loam on the large terrace that runs northwest to southeast through the center of the property (Figure 2). Ailey loamy sand and Vauclüse loamy sand occur on the hillsides on the northern and eastern boundaries. There are small amounts of Johns fine sandy loam, Kenansville loamy sand, Gilead loamy sand and Candor sand on the site (Figure 2).

Little River follows a winding course along the western property boundary, averaging approximately 30 feet wide and ranging in depth from 1 to 3+ feet. The banks are generally 2-3 feet high. There are numerous overflow channels, sloughs and oxbows. Most of the property is subject to flooding.

At least 15 distinct vegetative community types occurred on the site historically and are still recognizable. They are listed below (see The Nature Conservancy (TNC) 1993) for detailed community descriptions).

Coastal Plain Levee Forest (Blackwater Subtype)
Coastal Plain Heath Bluff
Coastal Plain Semipermanent Impoundment
Coastal Plain Small Stream Swamp (Blackwater Subtype)
Cypress-Gum Swamp (Blackwater Subtype)
Dry Oak-Hickory Forest (Coastal Plain sand variant)
Mesic Pine Flatwoods (Little River terrace variant)
Peatland Atlantic White Cedar Forest
Pine/Scrub Oak Sandhill (Blackjack-mixed oak variant and Mesic transition variant)
Sandhill Seep
Streamhead Atlantic White Cedar Forest
Streamhead Pocosin
Vernal Pool
Wet Pine Flatwoods
Xeric Sandhill Scrub

Most vegetative communities were dependent on periodic fire to maintain their integrity and all non-aquatic communities burned at least occasionally. The natural fire regime has been disrupted for several decades and there was no evidence of recent fire.

A network of drainage ditches (Figure 2) was excavated during the early to mid 1930s, apparently to facilitate drainage for agricultural use. However, the only evidence of farming was on the 1938 aerial photography (approximately 20 acres). The ditches have not been maintained. Small sand and gravel exploration pits are scattered about the site.

Currently, most of the tract is forested. Timber on the tract was undoubtedly cut during the widespread logging that occurred in the Sandhills during the late 1800s and early 1900s. Aerial photographs taken between 1938 and 1998 show evidence of subsequent timber harvesting. Approximately 20 acres were clear-cut during the summer and fall of 1997 (Figure 2). An old trail that begins on SR 2023 and runs through the property was improved for this latter logging operation. A borrow pit was excavated in the hillside near SR 2023 and the old trail bed was filled and stabilized. Pipes were placed beneath the roadbed where it crossed the old ditches.

PROJECT DESCRIPTION

The Taylor Tract is a proposed wetland mitigation site for NCDOT and will be used to offset wetland impacts associated with the construction of a 4 lane segment of U.S. Highway 1 in southern Lee County and northeastern Moore County (R-210). If the property meets certain qualifying criteria, it will be purchased by the Sandhills Area Land Trust and protected by a Forever Wild Conservation Easement. NCDOT will restore the natural wetland hydrology by filling the drainage ditches and removing the fill used for road construction. Native vegetation will be planted and managed for the recovery of natural wetland and upland communities.

METHODS

A reconnaissance for species listed as threatened or endangered, or proposed for such listing, by the U.S. Fish and Wildlife Service (USFWS) or the State of North Carolina (Table 1) was conducted on the tract between 8 and 11 December 1997. Additional reconnaissances were conducted through 4 May 1998. Representative transects were traversed on foot by biologists familiar with the species of concern. No detailed floristic, faunal or aquatic surveys were conducted.

Table 1. Protected species which occur, or may occur, in the project area in Moore and Hoke Counties, North Carolina.

Scientific Name	Common Name	Status Federal	Status State
ANIMALS:			
Ambystoma tigrinum	tiger salamander		T
Haliaeetus leucocephalus	American bald eagle		E
Neonympha mitchellii francisci	Saint Francis' satyr	E	SR
Picoides borealis	red-cockaded woodpecker	E	E
PLANTS:			
Agalinis aphylla	scale-leaf gerardia		C
Amorpha georgiana var. *georgiana*	Georgia indigo-bush		E
Amphicarpum muehlenbergianum	Florida goober grass		C
Astragalus michauxii	Sandhills milkvetch		C
Carex canescens ssp. *disjuncta*	silvery sedge		C
Carex exilis	coastal sedge		T
Carex tenax	wire sedge		C
Desmodium ochroleucum	creamy tick-trefoil		C
Dionaea muscipula	Venus' flytrap		C/SC
Eleocharis robbinsii	Robbins's spikerush		C
Eupatorium resinosum	resinous boneset		T/SC
Gaillardia aestivalis	Sandhills gaillardia		C
Galactia mollis	soft milk-pea		C
Kalmia cuneata	white wicky		E
Lechea torreyi	Torrey's pinweed		C
Lillium "iridollae"	Sandhills bog lily		C
Lindera subcoriacea	bog spicebush		E
Litsea aestivalis	pondspice		C
Lobelia boykinii	Boykin's lobelia		C
Lotus helleri	Carolina birdfoot-trefoil		C
Lysimachia asperulàefolia	rough-leaf loosestrife	E	E
Muhlenbergia torreyana	pinebarrens smokegrass		E
Myriophyllum laxum	loose watermilfoil		T
Parnassia caroliniana	Carolina grass-of-parnassus		E
Phaseolus sinuatus	Sandhills bean		C
Platanthera nivea	snowy orchid		T
Potamogeton confervoides	conferva pondweed		C
Pteroglossaspis ecristata	spiked medusa		E
Pyxidanthera barbulata var. *brevifolia*	Sandhill pixie-moss		E
Rhexia aristosa	awned meadow-beauty		T
Rhus michauxii	Michaux's sumac	E	E
Rhynchospora crinipes	Alabama beaksedge		E
Rhynchospora macra	southern white beaksedge		E
Rhynchospora oligantha	feather-bristle beaksedge		C

--Continued

Table 1. (Continued) Protected species which occur, or may occur, in the project area in Moore and Hoke Counties, North Carolina.

Scientific Name	Common Name	Status Federal	Status State
Rudbeckia heliopsidis	sun-facing coneflower		E
Ruellia ciliosa	Sandhills wild-petunia		C
Schwalbea americana	chaffseed	E	E
Scutellaria leonardii	shale-barren skullcap		C
Solidago verna	spring-flowering goldenrod		E
Stylisma pickeringii var. *pickeringii*	Pickering's dawnflower		E
Tofieldia glabra	Carolina asphodel		C
Tridens caroliniana	Carolina triodia		C
Tridens strictus	spike triodia		C
Utricularia geminiscapa	two-flowered bladderwort		C
Utricularia olivacea	dwarf bladderwort		T
Warea cuneifolia	Carolina pineland-cress		C
Xyris chapmanii	Chapman's yellow-eyed grass		C
Xyris scabrifolia	roughleaf yellow-eyed grass		C

Status: E = Endangered, T = Threatened C = Candidate, SC = Special Concern

Jurisdictional waters, including wetlands, were delineated between 16 December 1997 and 4 May 1998 using the Army Corps of Engineers *1987 Wetlands Delineation Manual*. Numbered strips of flagging tape were placed at wetland/upland boundaries. Flag locations were determined by the presence/absence of a hydric soil, wetland hydrology and hydrophytic vegetation. Data were obtained at representative wetland/upland plots for each major wetland/upland boundary and placed on the appropriate data sheets. Each major wetland type was ranked using the *Guidance for ranking the values of wetlands in North Carolina (Fourth Version)* (NCDEHNR 1995).

In addition to marking the jurisdictional wetland boundary, the approximate boundary of hydrologically modified (drained) former wetlands was marked and documented (as described above). This boundary was primarily delineated using vegetation because soils on such sites were hydric and torrential winter rains obscured normal soil hydrology. The prevalence or dominance of sweetgum and/or southern red oak (*Quercus falcata*) in the overstory and American holly (*Ilex opaca*) and/or horse sugar (*Symplocos tinctoria*) in the understory of a vegetative community growing on a hydric soil was considered to be evidence of a hydrologically modified (drained) wetland. Sites with similar soils were considered to be jurisdictional if red maple and/or other hydrophytic species (FAC or wetter) were significant constituents of the vegetative community and southern red oak and horse sugar were essentially absent. The prevalence of sweetgum and American holly was normally reduced on such sites relative to their abundance on drained sites. Upland sites with vegetation similar to that on drained sites were distinguished by non-hydric soils and a lack of wetland hydrology.

Narrow upland terraces immediately along Little River generally were not delineated because of their small size and because they were an integral part of the riverine system. Therefore these terraces were included within the jurisdictional wetland boundary. Small pockets (usually <0.1 acre) of unlike habitat types (e.g., wetland, drained, upland) were not delineated and were included within the dominant habitat type present.

NCDOT personnel using the Global Positioning System mapped the flags. The acreage of uplands, former wetlands and jurisdictional wetlands were determined from the point data by the Locations and Surveys Unit of NCDOT.

Vegetative community types were evaluated during the protected species survey and wetlands delineation. Dominant species were noted, however, community types were not specifically mapped.

RESULTS AND DISCUSSION

Protected Species

Numerous species of concern are known from Moore and Hoke Counties (Table 1) and several occur only or primarily within the Little River and James Creek drainages. The protected species reconnaissances associated with this project were commissioned and primarily conducted during the non-growing season. In addition, significant portions of the property were flooded for weeks or months during the survey period. Therefore, conclusive determinations about the absence or presence of some species cannot be made.

The protected species surveys did not detect any species listed as threatened or endangered, or proposed for such listing, by the USFWS or the State of North Carolina. Special Concern, Significantly Rare and Watch List species listed by the State of North Carolina were not formally considered. However, NCDOT personnel found a single population of nestronia (*Nestronia umbellula*) (State Significantly Rare) along the northern property boundary.

Following are brief discussions for federally species that may occur in the project area.

American chaffseed - *Schwalbea americana*

This herb is an erect, tomentose, unbranched perennial, 3 to 6 decimeters (dm) in height, and blooms from May into June (Radford et al. 1987). It occurs in Mesic Pine Flatwoods, frequently burned Pine Savannas, and along the upper ecotones of Streamhead Pocosins.

American chaffseed has been found on the Fort Bragg Military Reservation only in frequently burned pinewoods. No suitable habitat for this species was found on the project site and no individuals were detected.

Proposed longleaf pine restoration and management activities (prescribed burning) on uplands would favor this species.

Biological Conclusion - No effect

Michaux's sumac - *Rhus michauxii*

This plant is a small shrub reaching 1.5 to 4 dm in height. It flowers in June and has a red drupe that ripens from August to September (Radford et al.1987). Michaux's sumac occurs in sandy or rocky, open woods and woodland edges (TNC 1993). It is usually dependent upon some form of disturbance to maintain the open quality of its habitat and is occasionally found on roadsides and around field margins.

It is found within the Inner Coastal Plain and the Lower Piedmont of North Carolina and is known from adjacent Hoke County. There is potential habitat for this species on the upland along SR 2023 and on the higher terraces along Little River. However, it is unlikely that this species occurs on the project site due to prolonged shading and fire exclusion, and in some areas, severe soil disturbance. This species would have been undetectable during most of the survey period.

Proposed longleaf pine restoration and management activities (prescribed burning) on uplands would favor this species.

Biological Conclusion – No effect

Rough-leaf loosestrife - *Lysimachia asperulaefolia*

This plant is an erect, rarely branched perennial reaching 3 to 6 dm in height. It blooms from May into June and fruits from August to October (Radford et al. 1987). It is typically found in ecotones between longleaf pine uplands and Streamhead Pocosins, but also can occur in the middle of low shrub pocosins and along the margins of ponds.

Potential habitat occurred on hummocks in the 2 large beaver (*Castor canadensis*) ponds onsite and in non-riverine wetlands throughout the property, particularly those containing Atlantic white cedar. The prolonged lack of fire in the forested wetlands onsite precluded its detection, if present. This species would have been undetectable during most of the survey period.

Proposed hydrological and vegetative restoration activities in wetlands, including prescribed burning, would favor this species.

Biological Conclusion - No effect

Small whorled pogonia - *Isotria medeoloides*

This perennial orchid is 9.5 to 25 centimeters tall and flowers from May to June. The flowers are purple and green. It is found on wooded slopes and along stream margins, mostly in the Mountains of North Carolina (Radford et al.1987).

Potential habitat for this species was restricted to the steep pocosin ecotone along the northern property boundary. This habitat was marginal and no individuals of this species were found. However, this species would have been undetectable during the survey period.

Proposed restoration and management activities would be unlikely to effect this species because of the proximity of potential habitat to the property boundary, where management activities would likely be restricted.

Biological Conclusion – No effect

St. Francis' satyr - *Neonympha mitchellii francisci*

The St. Francis' satyr is one of the rarest butterflies in eastern North America. This endangered species is small and fragile, ranging from 34 to 44 millimeters in length. The wings are translucent, with the underside marked with closely spaced black, yellow rimmed eyespots. Known habitat for this butterfly is limited to a few locations on the Fort Bragg Military Reservation, where 7 colonies occur within a 70 to 100 square mile area. This species is thought to be associated with wet sedge meadows that have been created by recent burns or beaver activities. It has 2 flight periods, the second week of May through the third week of June, and the last week of July through the third week of August.

This species has been recorded on the Fort Bragg Military Reservation in adjacent Hoke County. No habitat likely to support this species occurs on the project site. However, this species would have been undetectable during the survey period.

Proposed hydrological and vegetative restoration activities, including prescribed burning, could create habitat suitable for this species.

Biological Conclusion - No effect

American alligator - *Alligator mississippiensis*

The USFWS lists the American alligator as "threatened due to similarity of appearance" to other endangered crocodilians. Species listed with this classification are not subject to Section 7 consultation under the Endangered Species Act. Alligators are found in rivers, lakes, swamps, bayous, and coastal marshes, especially areas that support significant populations of wading birds, large turtles and large fish.

There is a recent record of an 8-foot specimen in the Little River along the northern boundary of the Fort Bragg Military Reservation (Myers 1996), approximately 2 miles southeast of the project site. There has been 1 other recent unsubstantiated record in the project area. Potential habitat occurs along Little River on the project site, but no individuals or "sign" were seen.

Proposed hydrological and vegetative restoration activities would have no effect on this species.

Biological Conclusion - No effect

Red-cockaded woodpecker - *Picoides borealis*

The red-cockaded woodpecker (RCW) is a small, black and white bird endemic to mature, fire-maintained pine forests in the southeastern United States, where it was historically common. Fire exclusion, conversion of forestlands to agricultural and other uses, and logging have destroyed most of this species' habitat.

Extensive research has been done on this species in the North Carolina Sandhills from 1973 to date (North Carolina State University RCW Research Project). RCW groups located on Fort Bragg, Camp Mackall, the Sandhill Game Land and on adjacent private lands, collectively comprise the second largest RCW population in existence, the long term viability of which is essential to the recovery of this species. The importance of the Sandhills' RCW population has resulted in its designation as a recovery population by the USFWS (1985). RCWs in the Sandhills are divided into 2 populations, and 1 population contains 2 subpopulations. The largest population contains RCW groups on Fort Bragg (exclusive of Camp Mackall), groups around Southern Pines and Pinehurst, and those on Overhills, McCain and the Calloway Tract. The smaller population consists of RCW groups on Camp Mackall, the Sandhills Game Land and adjacent and intermingled private lands. Both Sandhills' RCW populations are well below the size (500 active clusters) that is needed for "recovery". Numerous RCW clusters occur on the Fort Bragg Military Reservation in adjacent Hoke County. The nearest clusters on Fort Bragg (FB 174 and 331) are located slightly less than 1 mile south and south-southeast of the project site, respectively. These clusters were inactive in 1998 (Fort Bragg Endangered Species Branch, pers. comm.).

No RCW cavity trees were found on, or within one-half mile of, the project site. There is a small amount of potential RCW foraging habitat on the property, but most forest stands are dominated by species other than pines. There is very little potential foraging habitat on adjacent properties (mostly fields or hardwood-dominated forests).

Proposed restoration and management activities, including restoration of native pine communities and prescribed burning, would favor this species in the future.

Biological Conclusion- No effect

Bald Eagle- *Haliaeetus leucocephalus*

This species is a very large brown raptor. Adults have a white head and tail and are unmistakable. Immatures lack the white head and pure white tail, but have varying amounts of white in the underwings and tail. Bald eagles nest in large trees, usually near large bodies of water. They forage primarily along the shorelines of rivers and lakes and in coastal estuaries.

Eagles have been seen in the general project area with increasing regularity over the last decade, and are not unusual at any season. A pair has been observed regularly at Woodlake, slightly more than 1 mile northeast of the project site, and may be nesting in the area. No eagles were seen on the project site and no potential foraging or nesting habitat occurs there.

Proposed restoration and management activities in uplands and wetlands would have no effect on this species.

Biological Conclusion- No effect

There are several State listed species of concern that could occur on the project site. Few, if any, of these species would have been detectable during the protected species surveys. Georgia indigo-bush (*Amorpha georgiana* var. *georgiana*), spring-flowering goldenrod (*Solidago verna*), Pickering's dawnflower (*Stylisma pickeringii* var. *pickeringii*), Sandhills bean (*Phaseolus sinuatus*) and sun-facing coneflower (*Rudbeckia heliopsidis*) have been recorded on nearby sandy river terraces or in nearby mesic woods. Bog spicebush (*Lindera subcoriacea*) undoubtedly occurs in the white cedar stands onsite and several aquatic plants of concern may occur in the beaver ponds. Other species of concern are known from Little River itself or its associated banks and seepage slopes (TNC 1993).

The proposed restoration and management activities would enhance habitats for most species of concern. Little River, and its adjacent sloughs and terraces, will not be directly impacted by restoration and management activities. Stands of Atlantic white cedar and the aquatic habitats in the 2 large beaver ponds will not be impacted by management activities. Prior to any soil disturbing activities, additional protected species surveys will be conducted at the appropriate season in the affected habitat(s).

Vegetative Communities

At least 15 distinct vegetative community types occurred on the project site historically and can still be identified. These are discussed below (see TNC 1993 for detailed community descriptions). Acreages of the community types given below are rough estimates. See Appendix I for photographs of some of the communities. No detailed floral survey was conducted, but such an inventory should be completed prior to the initiation of restoration activities.

The entire project site has been subject to prolonged fire exclusion and past timber harvesting. Approximately 20 acres were clear-cut within the last year and a road was constructed through wetlands for access (Figure 2). Ditches were constructed in the early to mid 1930s (Figure 2) in order to drain the wetlands onsite and approximately 20 acres were cleared for farming. All wetlands onsite, other than those immediately adjacent to Little River, were subjected to some degree of adverse hydrologic modification (drainage) due to the extensive ditching and some wetlands were effectively drained. Following ditching and logging, large areas were revegetated with species with drier site affinities than those originally present. The lack of ditch maintenance and the construction activities of beavers have converted some formerly drained areas back to wetlands. However, natural hydrology and vegetative communities cannot be reestablished without active management, such as the plugging of ditches, plantings and prescribed burning.

Coastal Plain Levee Forest (Blackwater Subtype)

This palustrine community type occurs on narrow, sandy terraces immediately adjacent to Little River. Sweetgum, red maple and river birch (*Betula nigra*) dominate the overstory, along with occasional loblolly pine, pond cypress and swamp black gum. American holly, red maple and ironwood (*Carpinus caroliniana*) dominate the understory. Switch cane (*Arundinaria tecta*) and greenbriers (*Smilax* spp.) compose most of the ground cover. The soil is Bibb loam.

Approximately 5 acres (estimated) of this community type occur onsite. It is relatively undisturbed and no specific management other than an occasional low intensity prescribed burn is recommended.

Coastal Plain Heath Bluff

This terrestrial community type occurs in a very restricted zone on a steep, southeast facing, bluff on the northern property boundary. The overstory is dominated by off-site Atlantic white cedar. The understory is dominated by a variety of ericaceous shrubs, especially mountain laurel (*Kalmia latifolia*) and sheep-kill (*Kalmia carolina*). The soil is Vaucluse loamy sand.

Approximately 0.5 acre (estimated) of this community type occurs onsite. It is relatively undisturbed, though white cedar is probably not the native overstory type. Prescribed burning is the only management recommended.

Coastal Plain Semipermanent Impoundment

This palustrine community type is found in 2 large beaver ponds that occur near the northeastern boundary of the property. The community is characterized by expanses of water with a very open overstory of swamp black gum. Denser stands of swamp black gum, sometimes mixed with red maple, occur around the pond margin. Clumps of wetland shrubs and herbs occur on hummocks around some gum trees. There is an abundance of aquatic and emergent species, with water lily (*Nymphaea odorata*) being most prevalent. There is a high likelihood of occurrence for plant species of concern. The underlying soil is Bibb loam.

Approximately 15 acres (estimated) of this community type occur onsite. These ponds should be left intact because they provide high quality aquatic and wetland habitats. No specific management is recommended. Other beaver impoundments occur in woodlands along some ditches, but have not yet caused a dramatic shift in vegetation.

Coastal Plain Small Stream Swamp (Blackwater Subtype)

This intermittently flooded, palustrine community type occurs in low-lying areas along Little River and in some portions of drainages elsewhere on the property. Swamp black gum and red maple dominate the overstory, but pond cypress, loblolly pine, sweetgum and Atlantic white cedar also occur. The understory contains swamp black gum, red maple and ironwood (near the river). Dog-hobble (*Leucothoe axillaris*) and switch cane often dominate the ground cover. The soil is Bibb loam.

Approximately 40 acres (estimated) of this community type occur onsite. No specific management, other than occasional low intensity prescribed burning, is recommended where this community type occurs along Little River. The plugging of ditches will enhance the recovery of the Small Stream Swamp community in drainages away from the river.

Cypress-Gum Swamp (Blackwater Subtype)

This seasonally flooded, palustrine community type occurs in sloughs near Little River and in sloughs along drainages elsewhere on the property. Swamp black gum alone or in combination with pond cypress dominate the overstory. The understory is usually open, but large titi (*Cyrilla racemiflora*) are common. The ground cover is often dominated by Virginia chain-fern (*Woodwardia virginica*). Some drained sites have been captured by sweet gum and loblolly pine, but the sweet gum is now stressed and dying, and is being replaced by swamp black gum. The soil is Bibb loam.

Approximately 20 acres (estimated) of this community type occur onsite. The plugging of drainage ditches (where necessary) will restore natural hydrology to this habitat type. Removal of the sweetgum overstory would speed the recovery process. No other management is recommended other than occasional low intensity prescribed burns.

Dry Oak-Hickory Forest (Coastal Plain sand variant)

This terrestrial community type probably was of very restricted occurrence on the property historically and may not have occurred at all. It occurs today on the hillside along the northeastern and eastern property boundary. Hardwoods such as southern red oak, post oak (*Quercus stellata*), black oak (*Quercus velutina*) and hickories (*Carya* spp.) dominate the overstory. Flowering dogwood (*Cornus florida*) is common in the understory. The ground cover is normally sparse. This community type represents a long fire suppressed Pine-Scrub Oak Sandhill community where most or all pines have been removed. The prolonged fire exclusion has severely degraded floristic diversity. It occurs on Vaucluse loamy sand.

Approximately 7 acres (estimated) of this community type occurs on the property. It could be converted back to a longleaf pine community by treating the hardwoods with herbicide, planting longleaf pine and the repeated application of growing season prescribed fire. However, the location of this community type along the property boundary would make such management difficult. As a result, no specific management other than occasional growing season prescribed burning is recommended.

Mesic Pine Flatwoods (Little River terrace variant)

This mesic, terrestrial vegetative community type is found on the large sandy terrace in the center of the property (away from Little River). The Little River terrace variant is unique to Little River and has high potential for plant species of concern. Flooding is rare to absent. Historically, the overstory was dominated by longleaf pine, but no longleaf remains. Some sites have a loblolly pine overstory, others are dominated by hardwoods such sweetgum, water oak (*Quercus nigra*) and sand post oak (*Quercus margaretta*). The hardwoods listed above, highbush blueberry (*Vaccinium fuscatum*) and sparkleberry (*Vaccinium arboreum*) dominate the understory. Ground cover may be essentially absent or be dominated by dwarf blueberry (*Vaccinium tenellum*), bracken fern (*Pteridium aquilinum*) or remnant Carolina wiregrass. This community type can exhibit high floristic diversity following repeated or intense fires, however, the diversity onsite is severely degraded due to prolonged fire exclusion. The soils are Kalmia sandy loam and Kenansville loamy sand.

Approximately 35 acres (estimated) of this community type occur onsite. These sites should be converted back to longleaf pine dominance. The larger hardwoods should be cut and the stumps treated with a systemic herbicide. The smaller hardwoods should be killed with a soil-applied herbicide such as hexazinone. After the hardwoods are adequately controlled, the site should be treated with a growing season prescribed burn and planted with longleaf pine, then prescribed burned every 2-4 years during the growing season. The plugging of drainage ditches may convert some of this community type to Wet Pine Flatwoods.

Peatland Atlantic White Cedar Forest

This rare palustrine community type occurs in the northern and eastern portions of the property in the flats below a steep hillside. The hydrology originates from groundwater seepage from the base of the adjacent bluff. Flooding is rare. The overstory consists of pure stands of large (12-24+ inches diameter at breast height) Atlantic white cedar or mixed stands of cedar, loblolly pine, swamp black gum and red maple. There are some stands of the latter species where cedar has been almost eradicated. Many canopy gaps are filled with cedar saplings. The understory may be relatively open in the denser cedar stands or dense with cedar regeneration, sweet gallberry (*Ilex coriacea*) and fetterbush (*Lyonia lucida*). The ground cover is often dense with netted chain-fern (*Woodwardia areolata*) and *Sphagnum* moss, but there are patches of unvegetated muck and pools of water. The soil is mapped as Bibb loam, but is a saturated, organic muck.

Approximately 30 acres (estimated) of this community type occur onsite. Drainage ditches exist within this community type and have undoubtedly had an adverse hydrological effect on some areas. Plugging the ditches will restore the natural hydrology. The larger red maples should be killed by the application of a systemic herbicide. Stands with hardwood dominance should be cleared and planted with white cedar. The ecotones around this community type should be periodically prescribed burned during the growing season. It is unlikely that fire will penetrate the denser cedar stands.

Pine/Scrub Oak Sandhill (Blackjack-mixed oak variant and Mesic transition variant)

This terrestrial community type occurs on portions of the hillsides along the northern, southern and eastern property boundaries (Blackjack-mixed oak variant) and on portions of the larger terraces in the interior of the property (Mesic transition variant). Flooding is absent on the hillsides and rare on the terraces. It was formerly dominated by longleaf pine, but almost no longleaf remains. The area on the southern property boundary along SR 2023 was clear-cut approximately 2 years ago and was subject to severe soil disturbance. The overstory within the Blackjack-mixed oak variant on the northern and eastern hillsides is dominated by blackjack oak (*Quercus marilandica*), sand post oak, hickories, other oaks and loblolly pine. The understory contains the above species, flowering dogwood and sourwood (*Oxydendrum arboreum*). The ground cover is generally sparse with bracken fern, dwarf blueberry, and remnant Carolina wiregrass and herbs. Prolonged fire exclusion has severely degraded the floristic diversity. The soils are Ailey, Gilead and Vaucluse loamy sands.

The Mesic transition variant on the terraces is similar with the exception that sweetgum is present in the overstory and understory. Dangleberry (*Gaylussacia* *frondosa*) may be common in the ground cover. This variant grades into Mesic Pine Flatwoods. The soil is Kenansville loamy sand.

Approximately 15 acres (estimated) of this community type occur onsite. Hardwoods on these sites should be controlled through a soil-applied herbicide such as hexazinone, then prescribed burned during the growing season and planted with longleaf pine. The sites should be prescribed burned during the growing season every 2-4 years thereafter.

Sandhill Seep

This palustrine community type is restricted to a portion of the steep bluff on the northeastern boundary of the property. Soils are seasonally saturated by groundwater. It is dominated by an Atlantic white cedar overstory and a shrub (sweet gallberry, fetterbush) understory. There is no ground cover. Prolonged fire exclusion has severely degraded the floristic diversity of this community. The soil is Vaucluse loamy sand. This community type grades into Coastal Plain Heath Bluff, Pine/Scrub Oak Sandhill, Streamhead Atlantic White Cedar Forest and Streamhead Pocosin.

Approximately 0.25 acre (estimated) of this community type occurs onsite. It needs to be treated with growing season prescribed fire, but its location on the property boundary may prevent such management.

Streamhead Atlantic White Cedar Forest

This palustrine community type occurs at the head of drainages where there is some topographic relief. Such sites occur along the northeastern and eastern boundaries of the property. These sites are seasonally to permanently saturated by groundwater and are not subject to flooding. Atlantic white cedar is the dominant overstory species, but may be mixed with pond pine, swamp black gum, red maple and tulip poplar. The understory is dense and consists of red maple, sweet bay, titi, sweet gallberry, fetterbush, other shrubs, and laurel-leaf greenbrier (*Smilax laurifolia*). The ground cover is often sparse due to shading and consists of ferns and *Sphagnum* mosses. Floristic diversity is usually low due to infrequent fire and dense shading. This community type is essentially a Streamhead Pocosin that is locally dominated by white cedar. The soil is Bibb loam.

Approximately 3 acres (estimated) of this community type onsite. Natural hydrology is intact or nearly so. This community should be treated with infrequent growing season prescribed fire. No other management is necessary.

Streamhead Pocosin

This community is found at the head of drainages with some topographic relief, along sluggish drains and on some poorly drained flats. These types of sites are scattered throughout the property away from the river. The primary source of hydrology is from groundwater, however, the flat areas are subject to occasional flooding. Part of this community type was clear-cut within the last year. The overstory is normally dominated by pond pine, often mixed with swamp black gum, tulip poplar, red maple, loblolly pine and/or Atlantic white cedar. Due to the past removal of pines and prolonged fire exclusion, hardwoods dominate many Streamhead Pocosins onsite. Loblolly pine, sweetgum and red maple have captured some sites. The understory is dense with species such as red maple, sweet bay, red bay, titi, sweet gallberry, fetterbush and laurel-leaf greenbrier. The ground cover is often sparse due to dense shading. Cinnamon fern (*Osmunda cinnamomea*) is the most common ground cover species. This community type can exhibit high floristic diversity following intense or repeated fires, however, the diversity onsite is severely degraded due to prolonged fire exclusion. The soil is Bibb loam.

Approximately 96 acres (estimated) of this community type occur onsite. Streamhead Pocosins on drain heads are relatively intact hydrologically. No specific management is recommended for these sites except for periodic growing season prescribed fire. Streamhead Pocosins on poorly drained flats will require active restoration. The plugging of drainage ditches will restore the natural hydrology. Loblolly pine, sweetgum and red maple will require removal. These sites should be prescribed burned with growing season fire and planted with pond pine. Some sites may require roller chopping to control hardwood sprouts and shrubs prior to planting. Fire will need to be excluded until the planted pond pines are well established, although light intensity burning is desirable.

Vernal Pool

The only natural example of this palustrine community type is found at the north end of the large terrace in the north-central part of the property. Borrow pits and gravel exploration pits that may function like Vernal Pools are also found onsite. Most are quite small, being little more than a hole in the ground. Rainwater ponds in these sites and may remain several inches to 1 foot or more deep all winter. There is little to no hydrologic input from groundwater or surface water. Vernal Pools may provide important breeding habitat for amphibians, but may dry up during the growing season.

The natural Vernal Pool onsite is approximately 0.25 acre in size and is forested with loblolly pine, sweetgum, red maple and swamp black gum. There is little understory or ground cover. The soil is mapped as Kenansville loamy sand. The human-excavated pits are non-forested. No specific management is recommended other than periodic prescribed burning during the dry (growing) season.

Wet Pine Flatwoods

This palustrine community type occurs on poorly drained flats around the high terrace in the center of the property. The primary source of hydrology is groundwater, though flooding may occur occasionally. Part of this community type was clear-cut within the last year. Historically, pond pine and longleaf pine dominated the overstory. Understory composition differed dramatically with fire frequency. Where fire was infrequent, the understory was a dense tangle of shrubs dominated by species such as inkberry *(Ilex glabra)*, sweet gallberry, sweet pepperbush (*Clethra alnifolia*), fetterbush, dangleberry and switch cane. Herbaceous species, including several grasses, were prevalent where fire was frequent or intense.

Currently, loblolly pine or hardwoods such as sweetgum and red maple dominate this community type, except in the clear-cut area. The understory is dominated by the shrub species listed above. There is little to no ground cover due to shading and shrub competition. This community type can exhibit high floristic diversity following high intensity or repeated fires, however, diversity onsite is severely degraded due to prolonged fire exclusion. Soils are mapped as Bibb loam and Kalmia sandy loam.

Approximately 50 acres of this community type occur onsite. This community will require active restoration including the plugging of drainage ditches, suppression of hardwoods (particularly sweet gum and red maple) and shrubs (possibly with herbicides and/or roller chopping), removal of loblolly pines, planting of pond and longleaf pines, and frequent prescribed burning during the growing season. Care must be taken not to kill the planted pines with fire.

Xeric Sandhill Scrub

This terrestrial community type occurs on deep, xeric sands on ridges and may also occur on some river terraces. The river terraces may be briefly subjected to flooding during extraordinary flood events. The natural overstory is longleaf pine, with an understory of turkey oak, possibly mixed with sand post oak and/or bluejack oak (*Quercus incana*). The native ground cover is dominated of Carolina wiregrass and dwarf huckleberry (*Gaylussacia dumosa*). A small area of Xeric Sandhill Scrub occurs on Candor sand along SR 2023 on the southern property boundary. This site was clear-cut within the last 2 years and suffered severe soil disturbance. There is little native ground cover. There may be minor occurrences of this community type on the highest terraces in the center of the property, but no longleaf pine remains. This community can exhibit moderate floristic diversity when burned repeatedly, however, prolonged fire exclusion has severely degraded diversity. There is fair potential for the occurrence of plant species of concern.

Approximately 3 acres of this community type occurs onsite. Hardwood sprouts should be controlled with a soil-applied herbicide such as hexazinone. The site should be burned a year after the herbicide application and planted with longleaf pine. Carolina wiregrass should also be reestablished through plantings. Once the pines are established, the site should be prescribed burned every 2-4 years during the growing season.

Animal Communities

No specific surveys were conducted for animal species. However, the high diversity of vegetative community types strongly suggests that animal diversity is also high, particularly for amphibians, reptiles and birds. Neotropical migrant songbirds are common and 14 species of wood warblers are believed to breed onsite. These latter species include the uncommon Kentucky warbler (*Oporornis formosus*) and the rare Swainson's warbler (*Limnothylpis swainsonii*). Both resident and migratory waterfowl frequently utilize the semipermanent impoundments. Several species of raptors were seen during the surveys including resident red-shouldered hawks (*Buteo lineatus*) and the summer resident broad-winged hawks (*Buteo platypterus*).

A detailed faunal inventory, including aquatic species, should be conducted prior to the initiation of restoration activities.

Wetlands

An extensive network of drainage ditches was constructed on the property during the early to mid 1930s (Figure 2). The main ditches cross the property on an east to west axis and averaged 4 feet wide and 4 feet deep. They originate at the base of the hillside on the northern and eastern sides of the tract and empty into Little River. One large ditch extends eastward off the property and probably drains nearby agricultural land. The ditches were presumably built to drain the property for agricultural development and some fields are distinguishable on a 1938 aerial photograph.

The ditches served to move the abundant groundwater originating at the base of the steep hillside to the north and east, across the property to Little River. The ditches also drained the adjacent wet flats and low terraces. During moderate to severe flooding events, an overflow channel on Little River shunts large volumes of water into a slough on the north end of the property (Figure 2). The floodwater flows southeast between the high terrace in the center of the tract and the hillside to the north and east, then turns to the west and reenters the river near the south end of the property (figure 2). Following such flood events, water is trapped in several sloughs and the adjacent flats and low terraces are saturated for extended periods (mainly during winter and spring, but after any significant flooding event). The ditches have effectively short-circuited this system Figure 2). Floodwaters now exit the overflow or "back swamp" at 6 locations prior reaching the natural discharge site, which is also ditched. This serves to remove water from the site more rapidly than normal, reduce the area flooded and reduce the soil hydroperiod. During severe flooding events during January and February 1998, water 2-3 feet deep was observed exiting the back swamp via the ditches. Reverse flooding (e.g., from the river through the ditches was observed only immediately adjacent to the river. During the late summer of 1997, only the ditch in the natural drain at the south end of the property was carrying water.

The delineation of jurisdictional and hydrologically modified (drained) former wetlands was severely hampered by the record rains during the El Nino winter of 1997-98 that resulted in extensive and prolonged flooding of much of the property. Even some of the highest river terraces were overwashed. Soils were saturated on virtually the entire tract, including unquestionably upland sites, for most of the survey period between mid-December 1997 and early May 1998. The abnormally wet winter and spring and short survey period precluded the use of monitoring wells to document hydrology.

The jurisdictional delineation resulted in the following approximate acreages: jurisdictional waters, including wetlands = 216 acres, hydrologically modified (drained) former wetlands = 43 acres, filled wetlands (road fill) = 1.0 acre and uplands = 60 acres (data derived from area calculations by NCDOT Locations and Surveys Unit). Representative wetland/drained/upland data sheets are included in Appendix II.

Jurisdictional waters, including wetlands, included Little River and adjacent low terraces, major ditches, sloughs, beaver ponds (semipermanent), wet flats, pocosins and swamps. Most jurisdictional wetlands occurred immediately adjacent to Little River or between the hillside on the northern and eastern property boundaries and the terrace in the middle of the property. The riverine communities and Atlantic white cedar communities onsite are of outstanding ecological quality. See the *Vegetation* section for detailed descriptions of the vegetative community types. Representative *Wetlands Rating Worksheets* are included in Appendix III.

Virtually all wetlands on the property have been ditched for more than 65 years. Whereas, many wetland areas still meet all 3 jurisdictional parameters (hydrophytic vegetation, wetland hydrology, hydric soils), the extensive and prolonged ditching undoubtedly have adversely affected the natural hydrology of the site (see discussion below). Exceptions are the wetlands immediately adjacent to the river and those in the groundwater recharge area at the base of the steep hillside on the northern and eastern property boundaries. Native wetland vegetative communities have been further degraded by removal of the dominant overstory species (pond pine, pond cypress, swamp black gum Atlantic white cedar) and prolonged fire exclusion.

Nearly all wetlands onsite could be enhanced by plugging the drainage ditches, suppressing invasive species (sweetgum, red maple, and/or loblolly pine, depending on site), planting native canopy species (pond pine, pond cypress, swamp black gum or Atlantic white cedar, depending on site) and restoring a more natural fire regime via prescribed burning. Between 110 and 170 acres of existing degraded jurisdictional wetlands could be enhanced with the management techniques listed above.

Drained former wetlands consisted of flats and low terraces where drainage was evidenced by either the absence of wetland hydrology or a shift in vegetative composition to a species assemblage characteristic of drier sites. All drained sites had hydric soils or soils that showed strong hydric characteristics. Although most soils were mineral, many had a high organic content in the surface layer or A horizon. Due to the abnormally high rainfall noted above, most drained sites met the wetland hydrology parameter during the survey period. Therefore, vegetative composition was the primary means of separating drained wetlands from jurisdictional wetlands. Most of the "drained" areas are located on flats adjacent to ditches. The presence of a non-hydric soil was the primary means of separating uplands from drained wetlands.

Logging, fire exclusion and drainage have adversely impacted the historically dominant tree species in drained wetlands onsite. For instance, pond pine was undoubtedly a dominant tree in the Streamhead Pocosin and Wet Pine Flatwoods communities (see *Vegetation* section for detailed description). Most of it was cut in the past and the lack of fire inhibited regeneration. Drainage facilitated regeneration of drier-site species such as sweetgum and southern red oak (on mineral soils), horse sugar and American holly, and in some cases, loblolly pine. The former 4 species are most commonly found on uplands in the Sandhills. Likewise, stands formerly dominated by swamp black gum regenerated to the above species assemblage following logging and drainage. The reversal of this process was noted onsite where drainage ditches have become clogged. In these areas, mature sweetgum shows signs of stress including strict crowns, dead tops and tree death. Beneath the sweetgum canopy, swamp black gum and red maple saplings are now established. Both of these species are much more hydrophytic than sweetgum in the Sandhills area. Plugging the drainage ditches, controlling invasive species, planting native canopy species and restoring a more natural fire regime through prescribed burning could restore approximately 43 acres of former wetlands.

Filled wetlands consisted of small linear areas that were filled to create access to the property for timber harvesting. Most of this fill occurred within the last year. Removal of the fill would restore wetland functions to the affected areas. However, temporary maintenance of the road will be necessary in order to facilitate wetland restoration. The filling of the ditches in areas currently considered jurisdictional wetlands will offset the removal of the road fill.

Uplands are found along the northern and eastern property boundaries, along SR 2023 on the southern property boundary and on the large terrace in the center of the property. Wetland restoration elsewhere on the property may expand the wetland ecotones around the upland terraces. Prescribed burning will greatly enhance native vegetation. Longleaf pine, the native overstory species, will be planted on most uplands after competing woody species have been controlled. The dominant native upland ground cover, Carolina wiregrass, will be reestablished. Approximately 50 acres can be restored to native longleaf pine communities.

CONCLUSIONS

A biological reconnaissance and jurisdictional wetlands delineation were conducted on the 320 acre Taylor Tract, located near Lobelia in Moore County, N.C., between mid-December 1997 and early May 1998. No species listed as threatened or endangered, or proposed for such listing, by the USFWS or the State of North Carolina were found. Potential habitats for some plant species of concern do occur onsite.

The property has approximately 216 acres of jurisdictional waters, including wetlands, 43 acres of hydrologically modified former wetlands, 1 acre of filled former wetlands and 60 acres of uplands. The site contains outstanding examples of riverine and Atlantic white cedar vegetative communities. However, most wetlands onsite have been degraded or eliminated by drainage, and further degraded by past logging that removed dominant canopy species and prolonged fire exclusion. Upland vegetative communities have been severely degraded by past logging and prolonged fire exclusion.

Approximately 43 acres of former wetlands could be restored through the plugging of ditches, control of invasive species, planting of native canopy species and restoration of a more natural fire regime. These same techniques could enhance between 110 and 170 acres of existing degraded jurisdictional wetland. Approximately 50 acres of upland could be restored to longleaf pine dominated communities by controlling hardwood species, planting longleaf pine and restoring a more natural fire regime.

This property is highly worthy of protection and restoration. The Atlantic white cedar stands alone should make protection a priority. Restoration recommendations are included in the text.

LITERATURE CITED

Myers, Terry. 1996. *A project to construct a portion of Highway 13 at Fort Bragg, North Carolina. DPWE, Fort Bragg.* 13 pp. and enclosures.

North Carolina Department of Environment, Health and Natural Resources. 1995. *Guidance for ranking the values of wetlands in North Carolina (Fourth Version).* Report No. 95-01; Water Quality Section.

Radford, A.E., H.E. Ahles and C.R. Bell. 1987. *Manual of the vascular flora of the Carolinas.* The University of North Carolina Press, Chapel Hill, NC. 1183 pp.

The Nature Conservancy. 1993. *Rare and endangered plant survey and natural area inventory for Fort Bragg and Camp Mackall Military Reservations, North Carolina.* North Carolina Chapter TNC, Carrboro, NC.

U.S. Army Corps of Engineers. 1987. *Corps of Engineers Wetlands Delineation Manual.* Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

U.S. Fish and Wildlife Service. 1985. *Red-cockaded woodpecker recovery plan.* U.S. Fish and Wildl. Serv. Atlanta, GA. 88 pp.

APPENDIX I

Photographs of vegetative communities on the Taylor Tract, near Lobelia, Moore County, N.C., 1998.

APPENDIX B

SALT Tract
Flood Frequency Analysis

Little River Hydrology

Hydrologic studies of annual flooding from the Little River were carried out to evaluate the extent and duration of floodplain inundation within the Taylor Tract. Peak flood flows and average daily flows for specified exceedance times during the growing season were calculated and used in subsequent hydraulic analyses

Peak Flood Flow Rates

Peak flood flow rates on the Little River were calculated using regional flood frequency relations developed for North Carolina by Jones and Smith (1999). Relations for the sandhills region of North Carolina are given by equations of the form

$$Q_T = a_T A^{b_T} \tag{1}$$

where Q_T = peak flow rate in ft^3/sec, A = drainage area in mi^2, a_T and b_T are coefficients that depend and the annual return period $T = 1/P_a$, and P_a = annual exceedance probability of the flood. Coefficients a_T and b_T are given in Table 1 for several annual exceedance probabilities. Peak flow rates given by (1) are graphed as a function of drainage area in Figure 1. A simple relation between Little River peak flow Q in ft^3/sec and return period T in years at the Taylor Tract is given by

$$Q = 895\ T^{0.68} \tag{2}$$

where the catchment drainage area was found to be A = 109 mi^2 at the County Road 2023 bridge near Lobelia.

TABLE 1. Sandhills Region Flood Peak Discharge Equation Coefficients for Various Annual Exceedance Probabilities.

Annual exceedance probability P_a	Return period T (years)	Coefficients	
		a_T	b_T
0.5	2	33.7	0.711
0.2	5	56.1	0.700
0.1	10	73.9	0.696
0.04	25	100	0.692
0.02	50	122	0.690
0.01	100	147	0.688
0.005	200	175	0.686
0.002	500	216	0.683

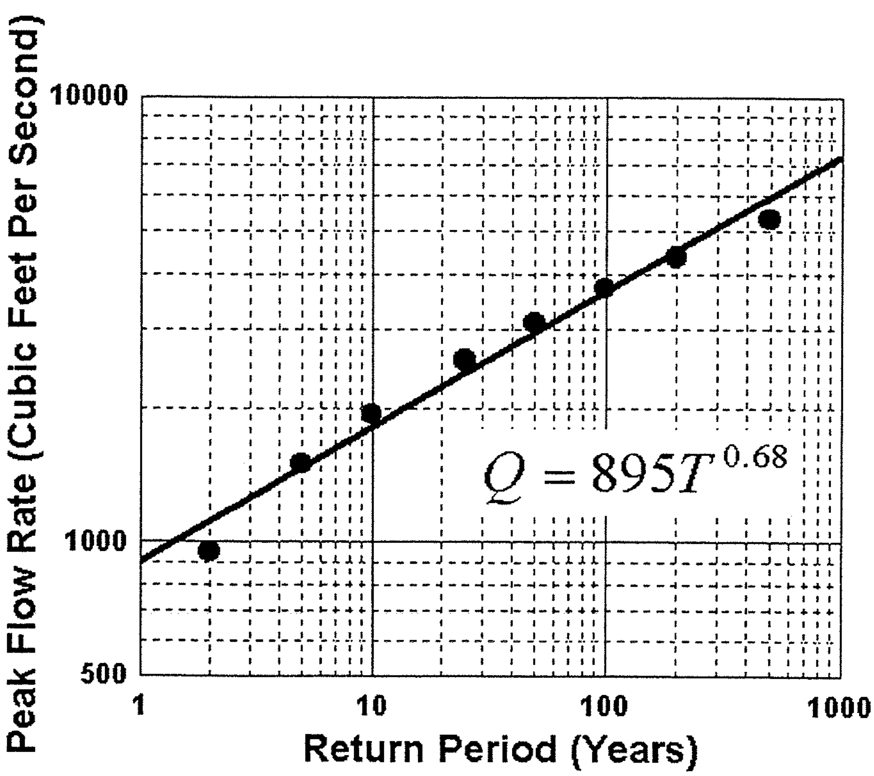


Figure 1. Peak flood flow rate in ft^3/sec as a function of return period in years.

Duration of Floodplain Inundation

Duration of floodplain inundation was based on average daily flow rates. Because wetlands are defined primarily by growing season conditions, average daily flow for the growing season only was used to evaluate duration of floodplain inundation at the Taylor Tract. Beginning and ending dates of the growing season were taken from the National Resource Conservation Service (NRCS) WETS Station located in Raleigh, North Carolina at the North Carolina State University. WETS data define the normal range for monthly precipitation and normal range for growing season required to assess the climatic characteristics for a geographic area over a representative time period. Average growing season was found to extend from March 17 to November 18, a period of 246 days.

Average daily flow rate in the Little River was estimated based on analysis of recorded flows from seven nearby gaging stations. Gaging station data are summarized in Table 2. A relation between drainage area and average daily flow rate during the growing season for the region was found to be

$$\bar{Q} = 1.680 A^{0.941} \qquad (3)$$

where $\bar{Q}$ = growing season average daily flow rate in ft^3/sec, and A = drainage area in mi^2. The average daily flow relation has a coefficient of determination of 0.996 and is shown in Figure 2. Based on the analysis if data from nearby gaging stations, growing season average daily flow of the Little River at the Taylor Tract is 139 ft^3/sec.

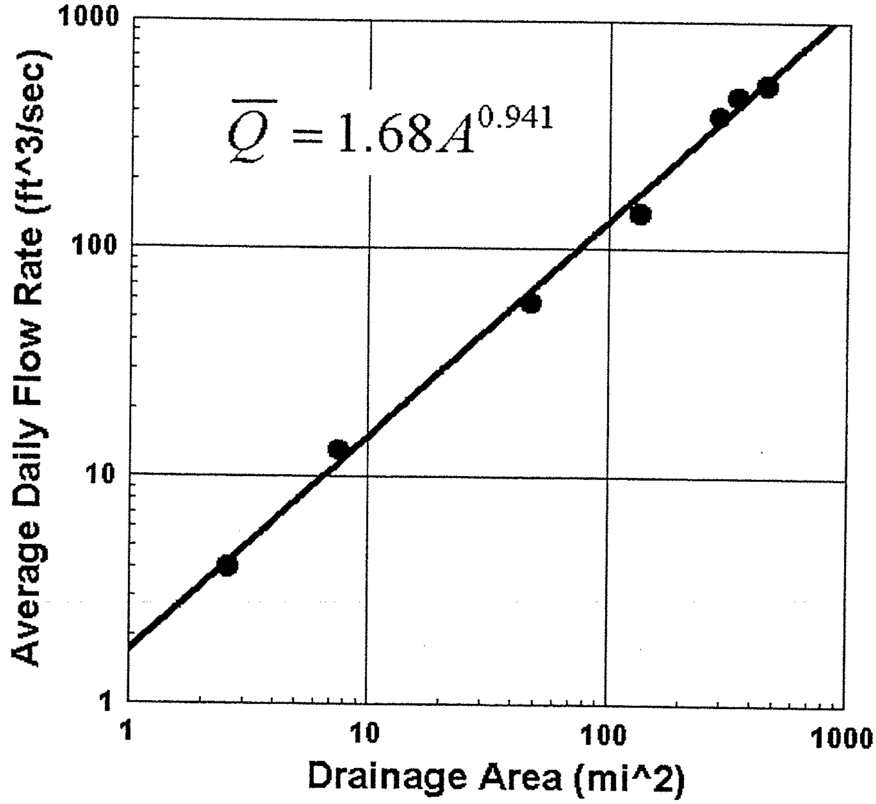


Figure 2. Relation between average daily flow rate and drainage area for streams in the sandhills region of North Carolina.

A relation between relative average daily flow rate (that is, average daily flow rate divided by the mean average daily flow rate) for the Little River at the Taylor Tract was assumed to be the same as at the Little River gage at Manchester, North Carolina. This relation is given in Figure 3.

TABLE 2. Summary of Gaging Stations Used to Estimate Average Daily Flow Rate

Station number	Station name	Drainage area (mi^2)	Years of record	Average Daily Flow Rate (ft^3/sec)	
				All year	Growing season[a]
02101000	Bear Creek at Robbins, NC	137	1939-1971	136	144
02102908	Flat Creek near Inverness, NC	7.63	1968-1998	13.1	14.3
02103000	Little River at Manchester, NC	348	1938-1950	432	465
02103500	Little River at Linden, NC	456	1928-1971	563	522
02104387	Buckhead Creek near Owens, NC	2.62	1976-1980	4.1	4.0
02104500	Rockfish Creek near Hope Mills, NC	292	1939-1954	361	384
02106681	Black River Near Dunn N C	48.3	1976-1977	88.5	58.0

[a]Based on an average 246 day growing season (March 17 to November 18)

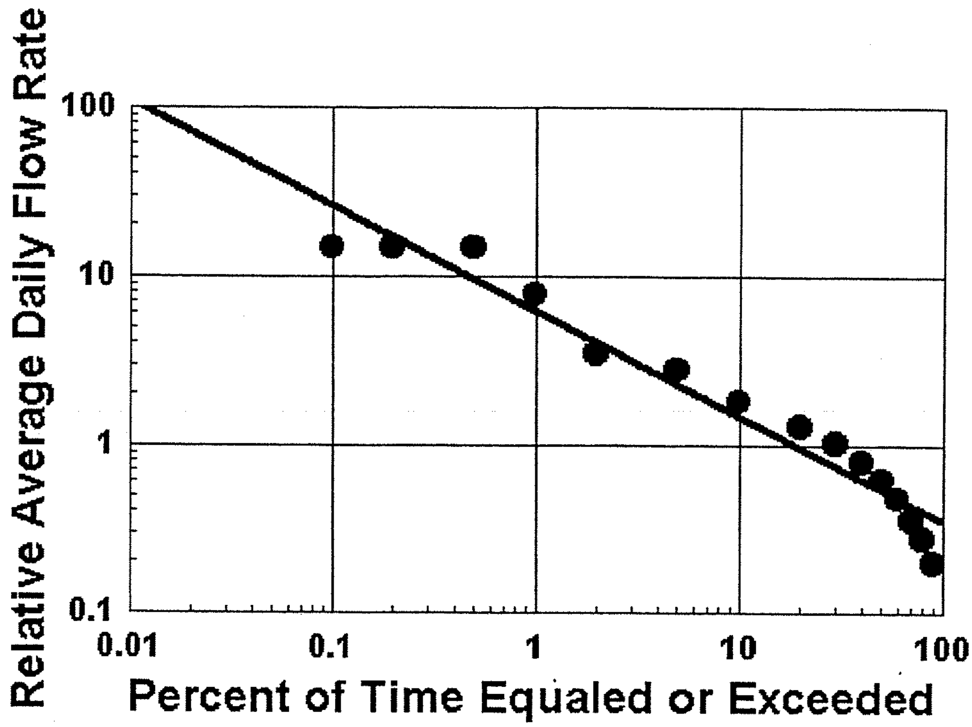


Figure 3. Relation between relative average daily flow rate (that is, the ratio of average daily flow to the mean daily flow rate) and the percent of time equaled or exceeded during the growing season at the Little River gage at Manchester, North Carolina.

Taylor Tract Hydraulic Analysis

Extent of floodplain inundation was calculated using the two-dimensional depth-averaged flow and sediment transport module Flo2DH of the Federal Highway Administration (FHWA) Finite Element Surface-water Modeling System (FESWMS). The finite element network developed to study Little River flooding of the Taylor Tract is shown in Figure 4. Each element is characterized by a set of coefficients that described the flow resistance properties of the element. Ten sets of coefficients referred to as an element type were used to model the channel and floodplain of the Little River as shown in Figure 5.

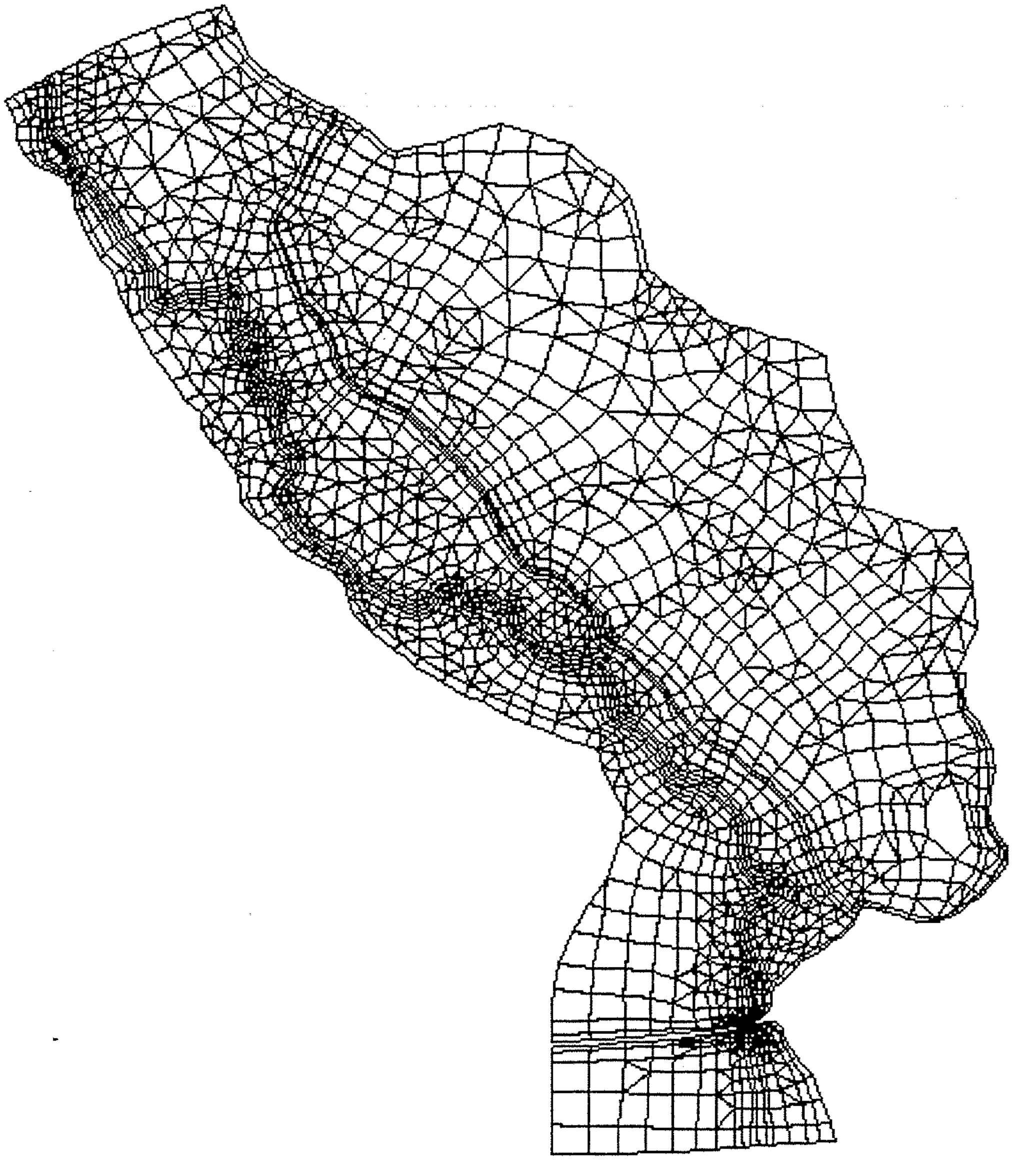


Figure 4. Finite element network used to evaluate Little River flooding of the Taylor Tract. The network consists of 2893 elements and 9182 node points.

Water surface elevations used as boundary conditions at the downsteam limit of the finite element network were obtained from a rating curve developed using the slope area method. A stream slope of 0.002 ft/ft was measured from U.S. Geological Survey 1:24000 scale topographic maps and used to calculate flow rate as a function of water-surface elevation. The rating curve relation is shown in Figure 6.

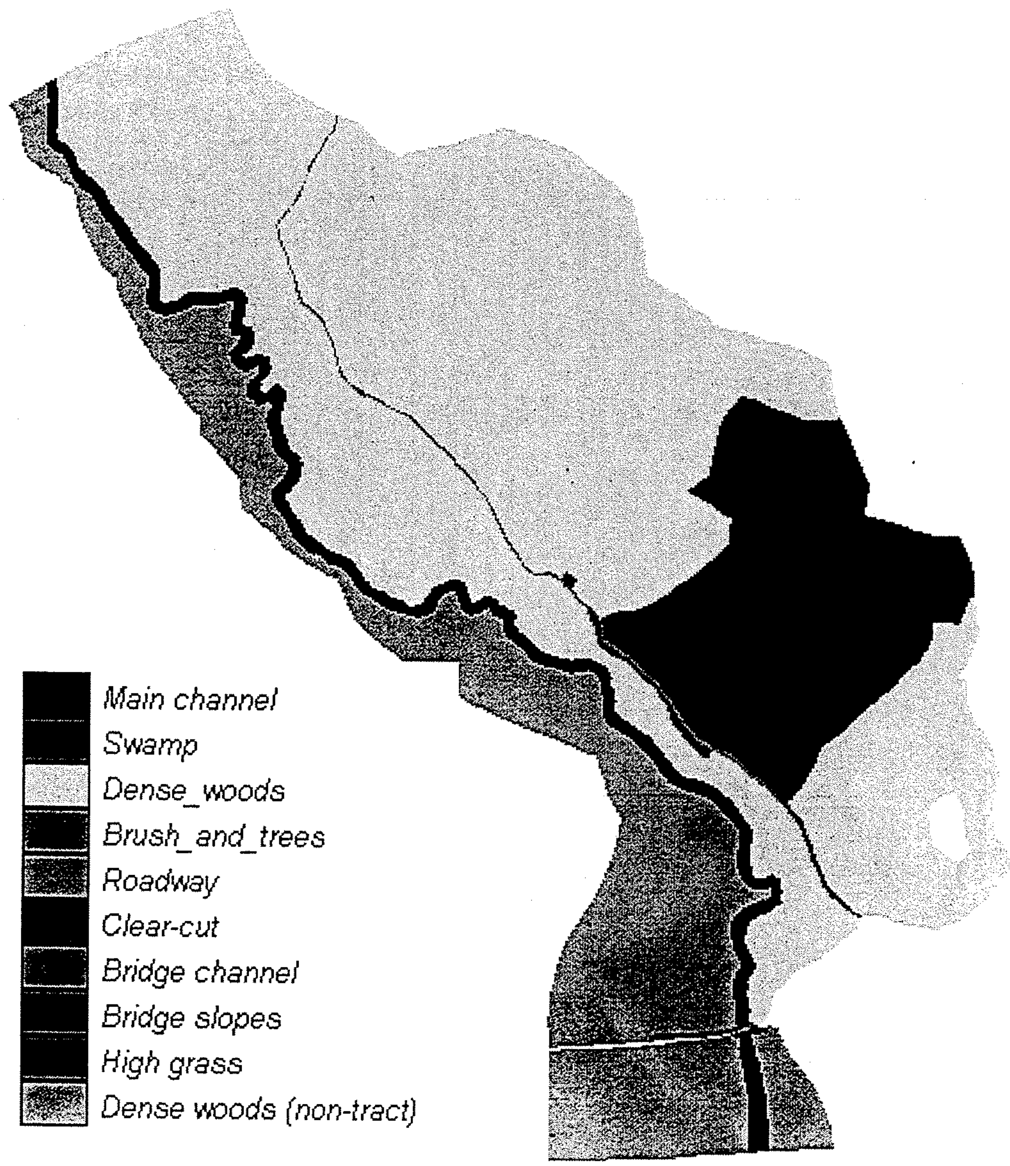


Figure 5. Ten element types were used to characterize the channel and floodplain of the Little River. Each element type consists of a set of coefficients that described flow resistance and other properties of elements.

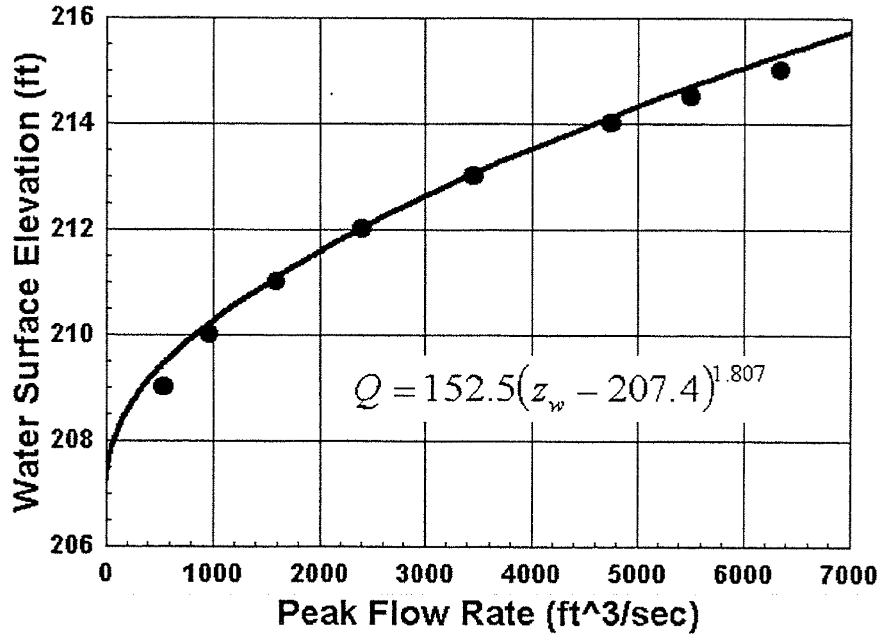


Figure 6. Rating curve used to establish water-surface elevations at the downstream boundary of the two-dimensional finite element model.

Simulation of flooding for a range of flows having various inundation durations was carried out to develop the relation between the area of inundated non-channel floodplain and duration of inundation during the growing season as shown in Figure 7. Calculated inundated areas for various durations are summarized in Table 3. A daily flow rate of 1350 ft^3/sec is equaled or exceeded 0.5% of growing season days (that is, 1.23 days during an average growing season). The non-channel tract area inundated by this flood is 285 acres. Therefore, 285 acres of non-channel tract land will be inundated 1.23 days during an average growing season.

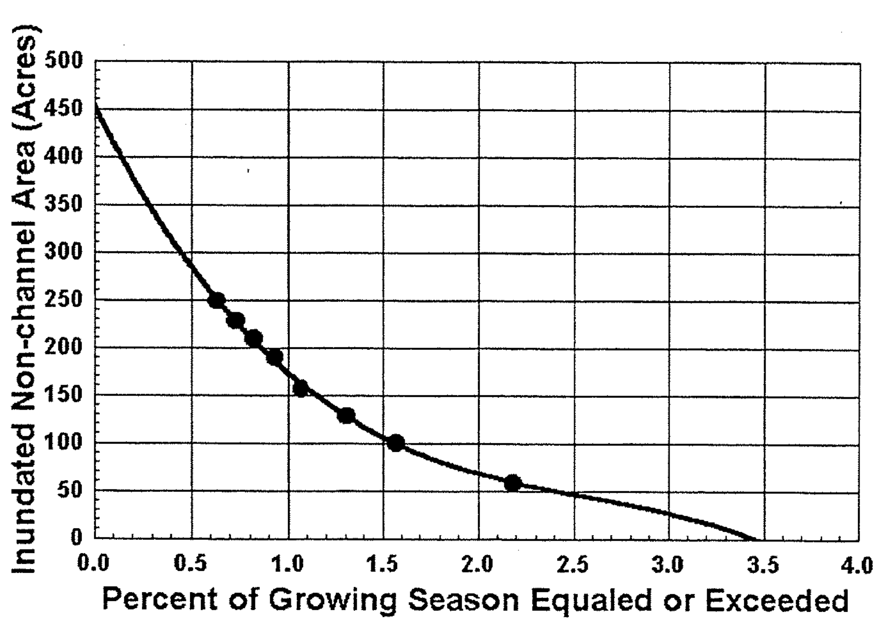


Figure 7. Amount of non-channel area inundated a specified percentage of the growing season.

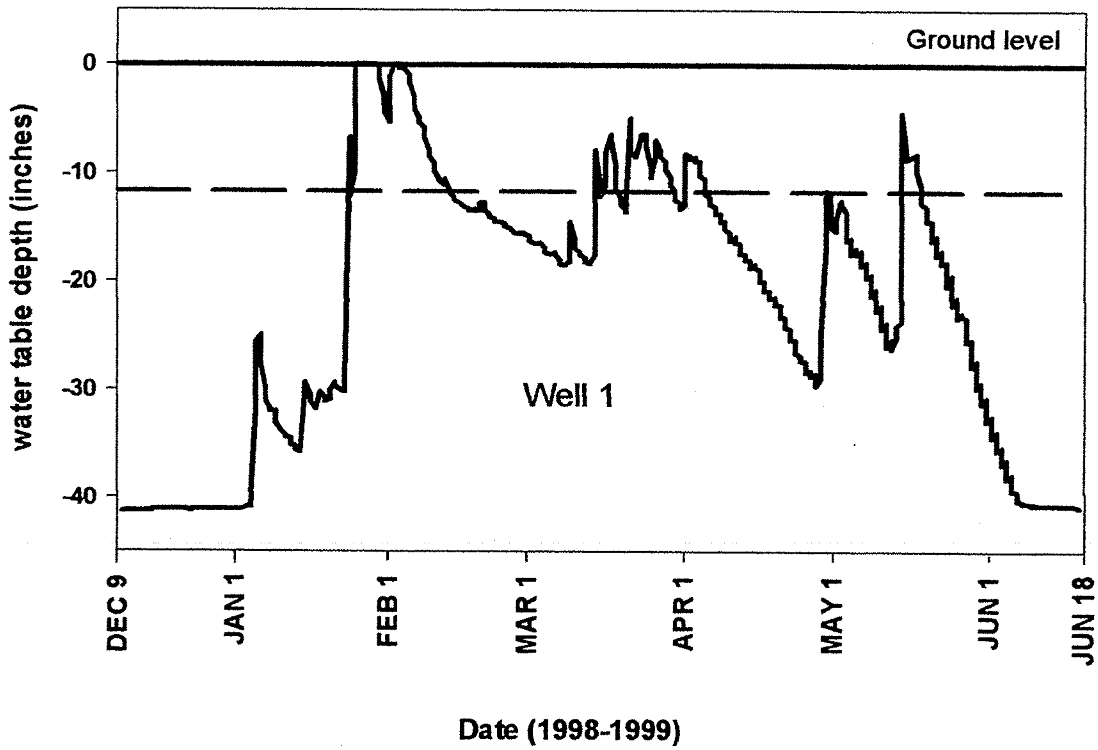
TABLE 3. Duration of Flooding of Non-channel Taylor Tract Area During Growing Season

Growing Season Time Equaled or Exceeded		Daily flow rate (ft^3/sec)	Flooded non-channel tract area (ac)
Percent	Days[a]		
0.5	1.23	1350	285
1.0	2.46	876	173
1.5	3.69	680	105
2.0	4.92	568	67
2.5	6.15	494	45
3.0	7.38	441	26

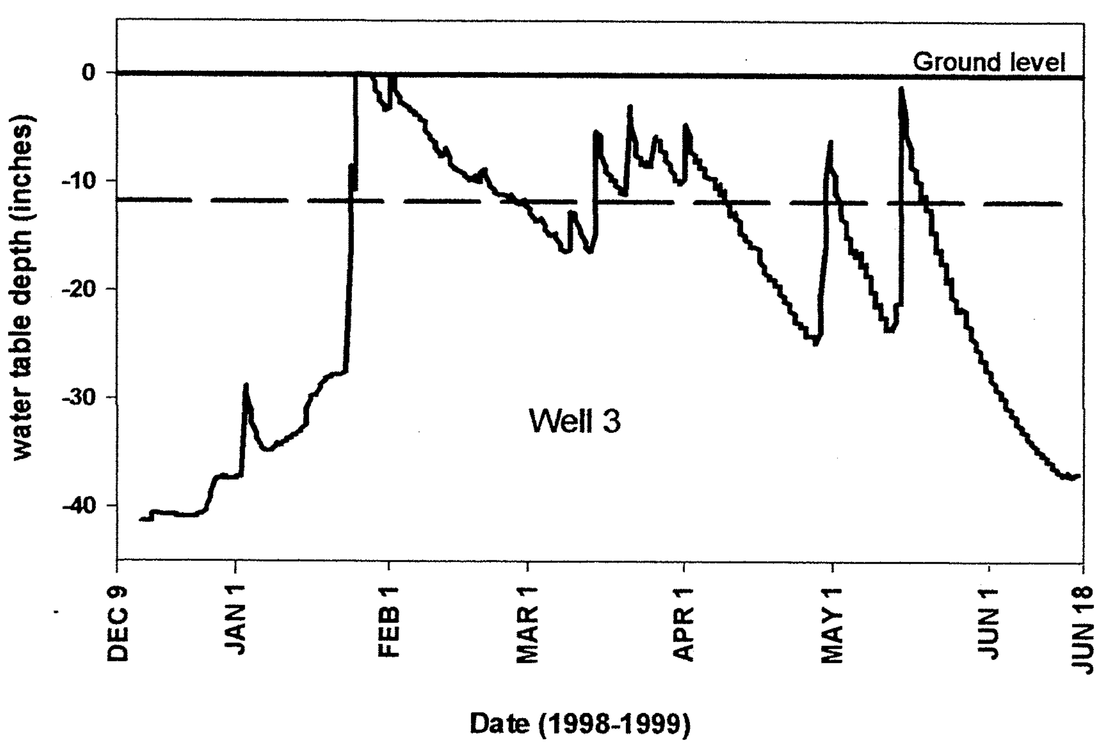
[a]Based on an average 246 day growing season (March 17 to November 18)

APPENDIX C

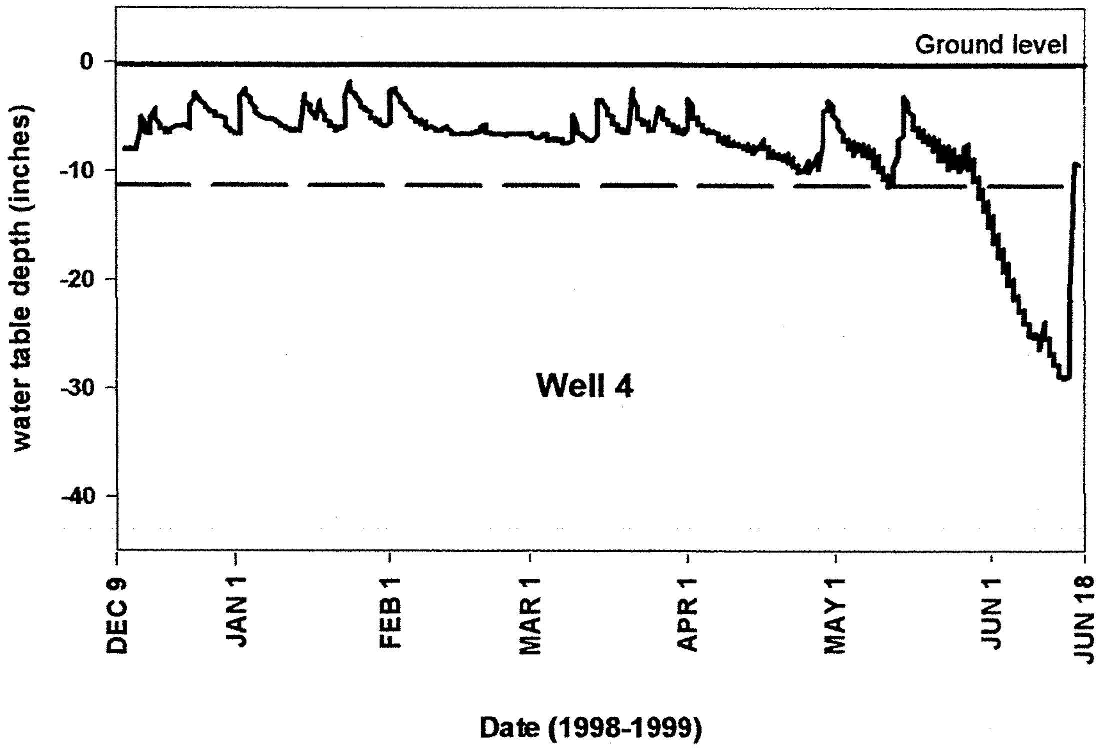
Hydrographs for the Groundwater Monitoring Wells



Ground level
0
-10
-20
-30
-40
water table depth (inches)
Well 1
DEC 9
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)



Ground level
0
-10
-20
-30
-40
water table depth (inches)
Well 3
DEC 9
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)


Ground level
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-10
-20
-30
-40
water table depth (inches)
Well 4
DEC 9
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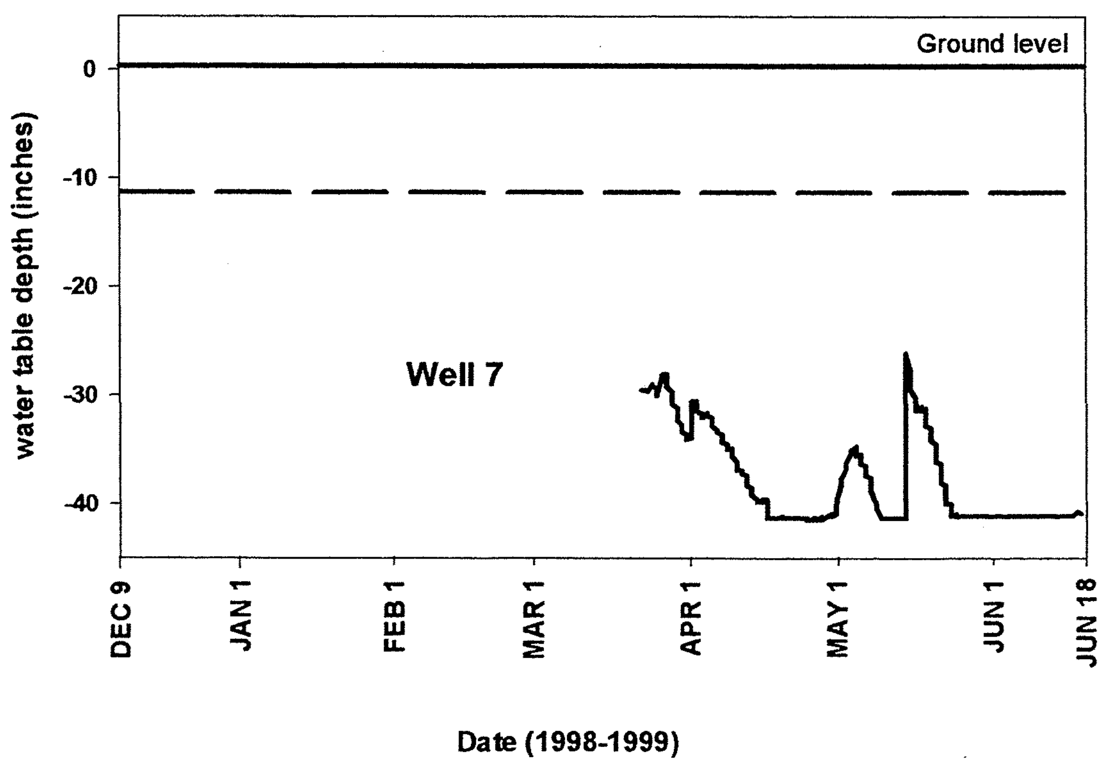
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)


Ground level
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-10
-20
-30
-40
water table depth (inches)
Well 7
DEC 9
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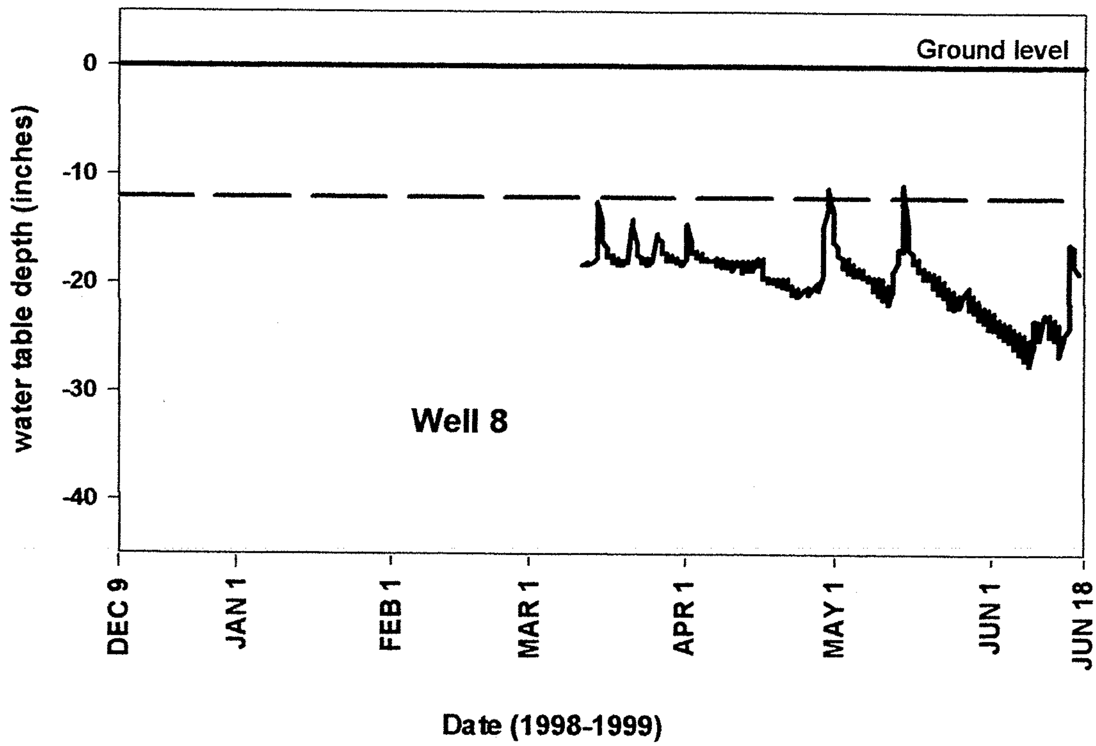
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)



Ground level
0
-10
-20
-30
-40
water table depth (inches)
Well 8
DEC 9
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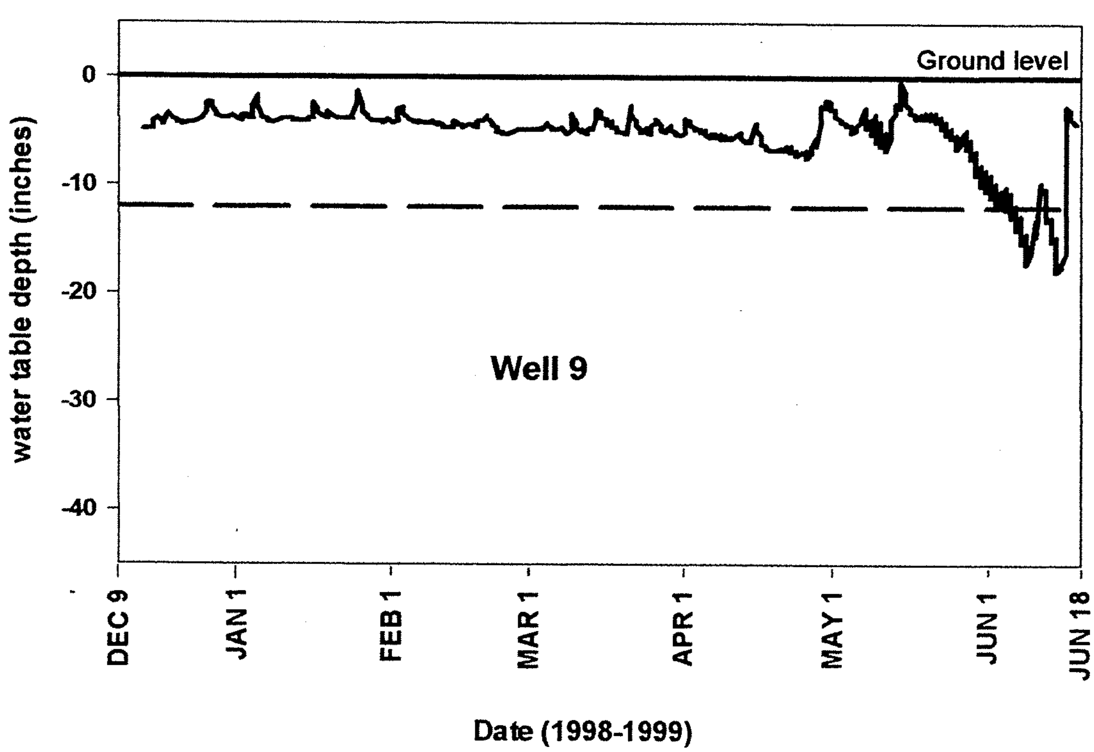
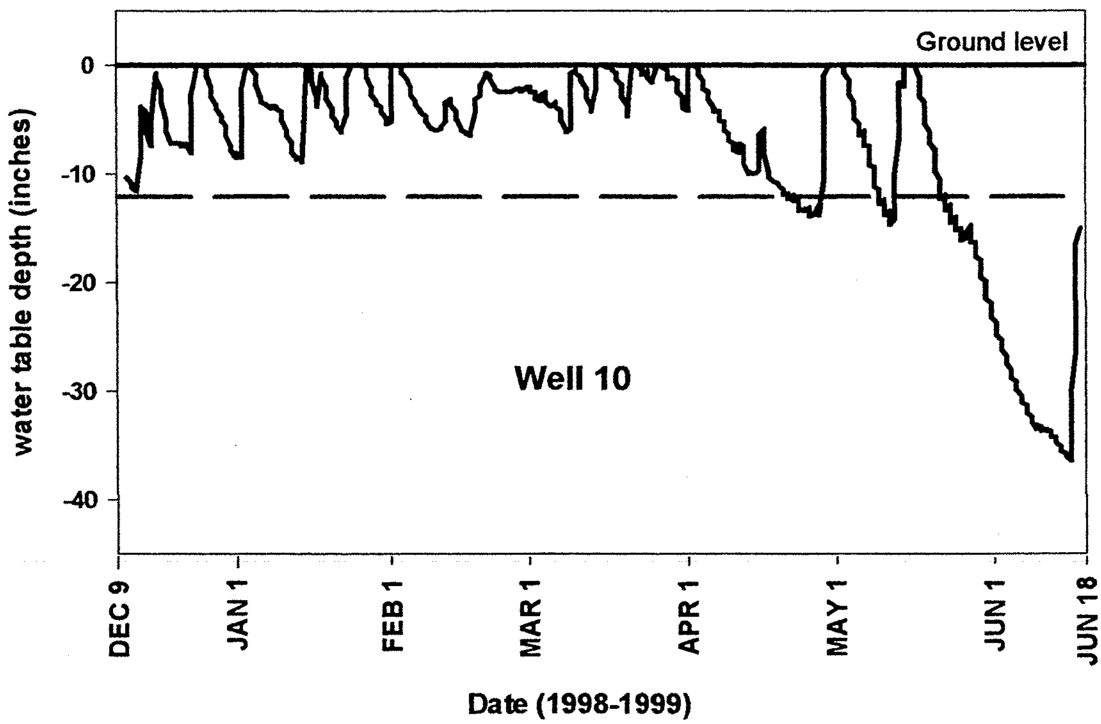
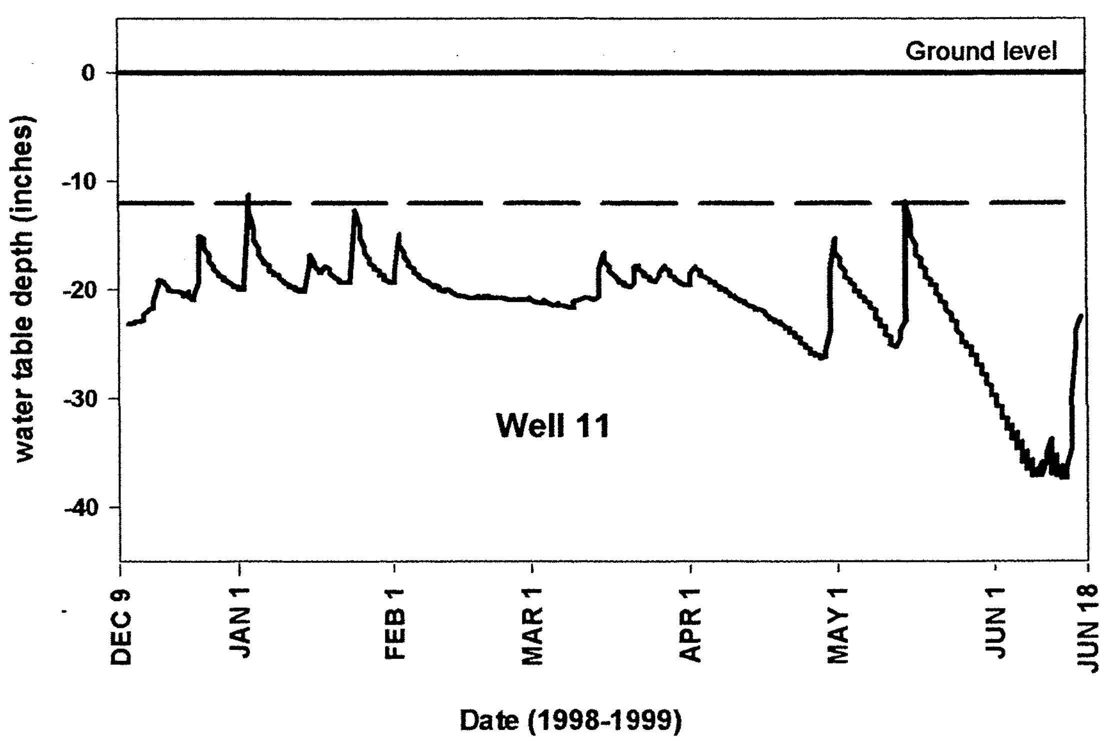
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)



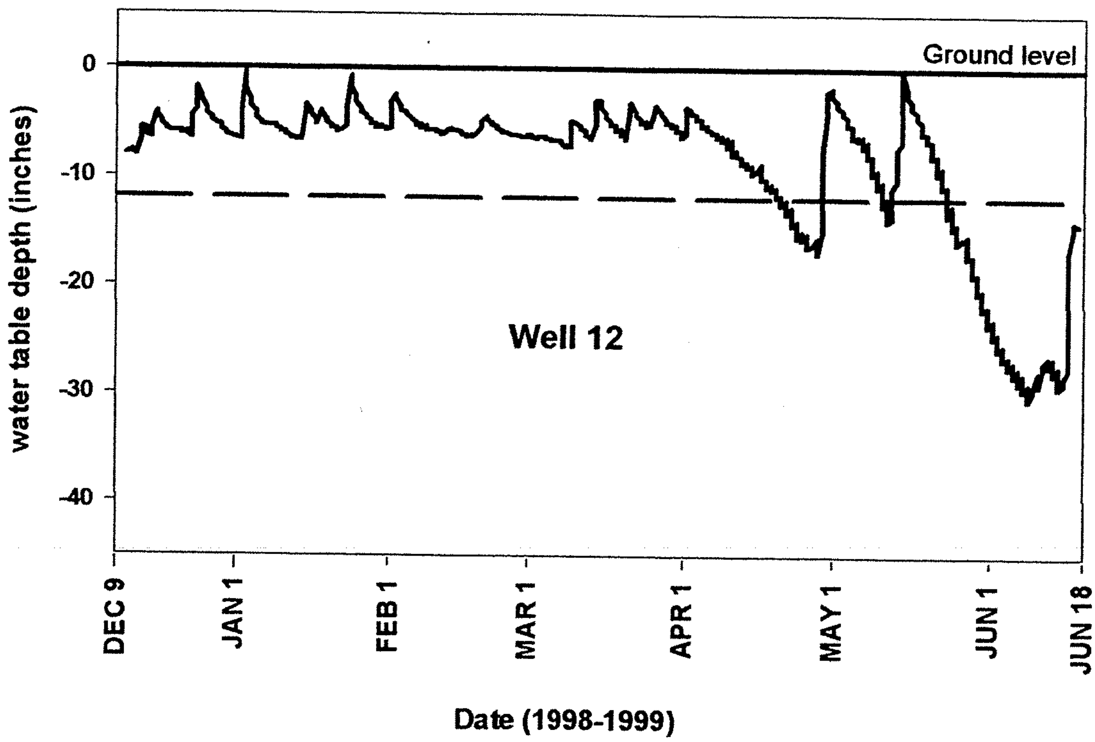
Ground level
0
-10
-20
-30
-40
water table depth (inches)
Well 9
DEC 9
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)



Ground level
0
-10
-20
-30
-40
water table depth (inches)
Well 10
DEC 9
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)



Ground level
0
-10
-20
-30
-40
water table depth (inches)
Well 11
DEC 9
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)


Ground level
Well 12
water table depth (inches)
0
-10
-20
-30
-40
DEC 9
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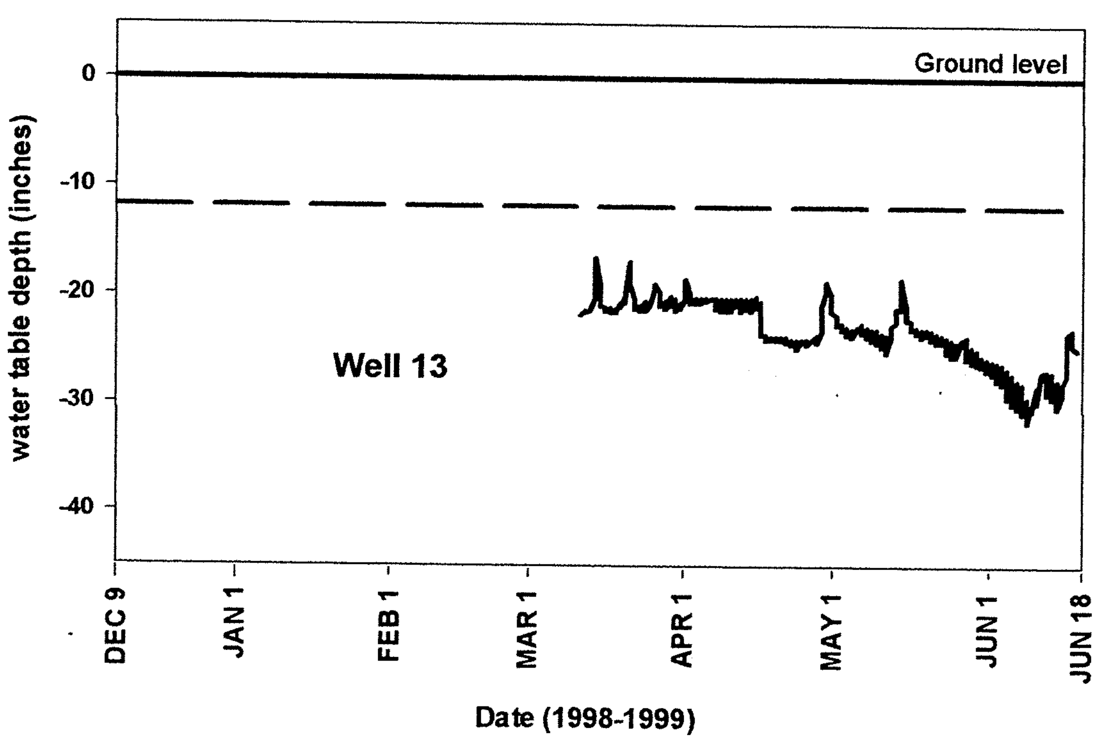
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)


Ground level
Well 13
water table depth (inches)
0
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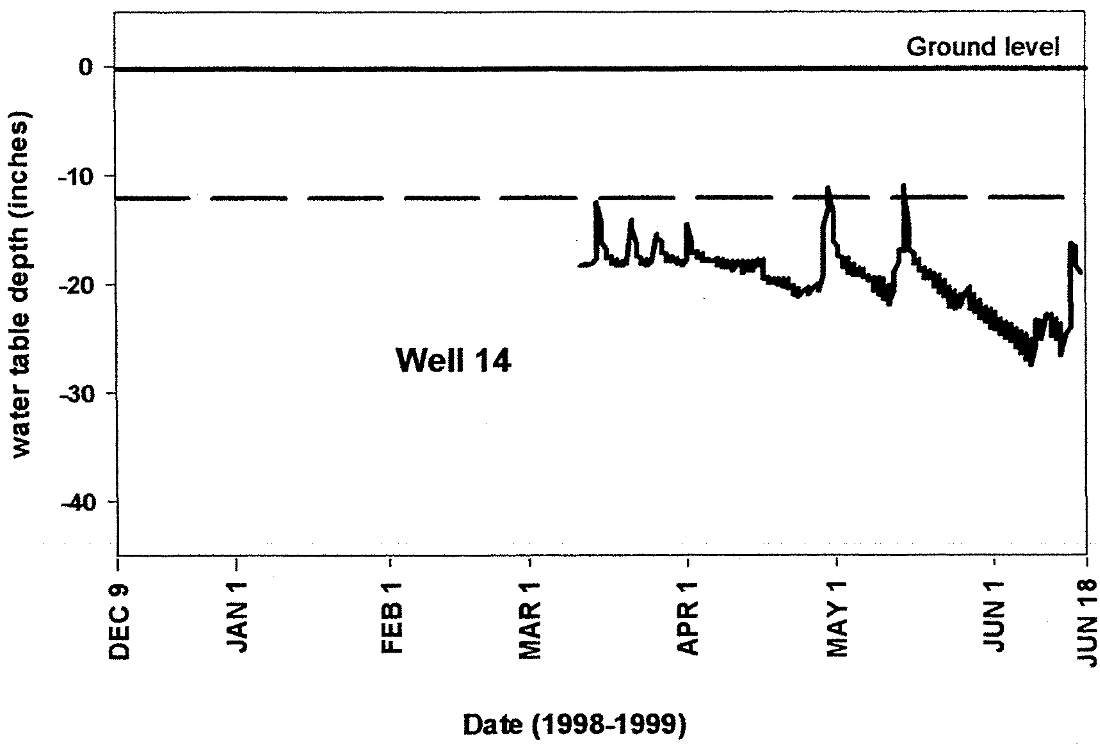
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)


Ground level
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-10
-20
-30
-40
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Well 14
DEC 9
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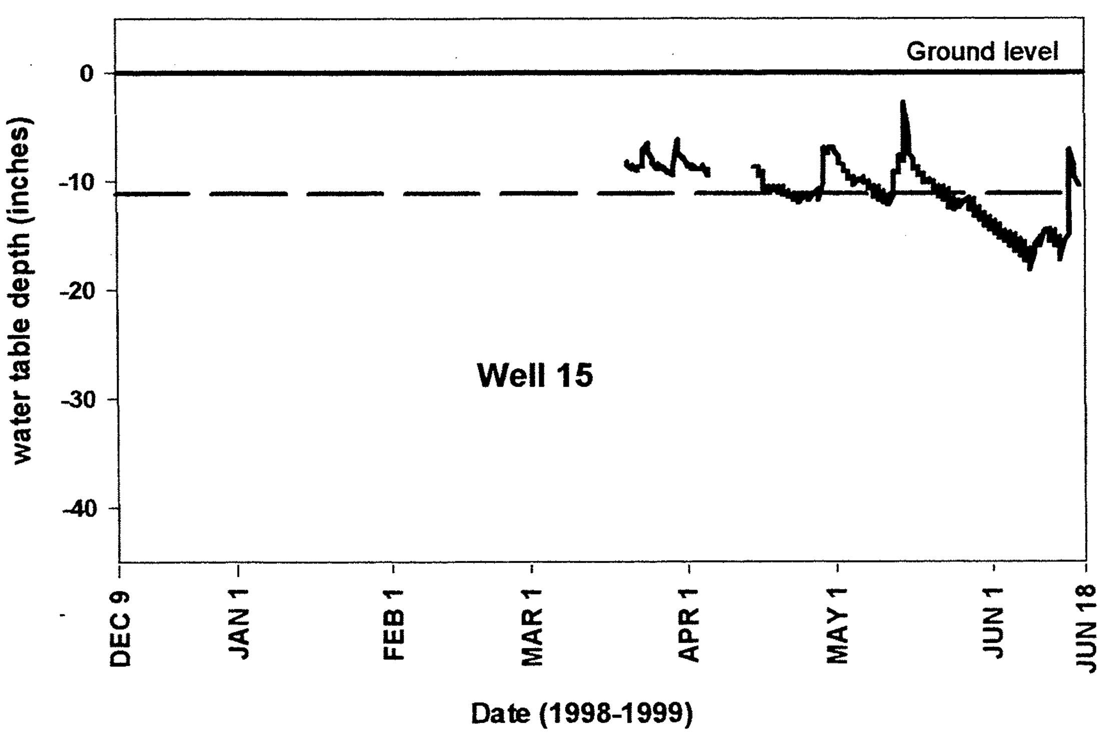
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)


Ground level
0
-10
-20
-30
-40
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Well 15
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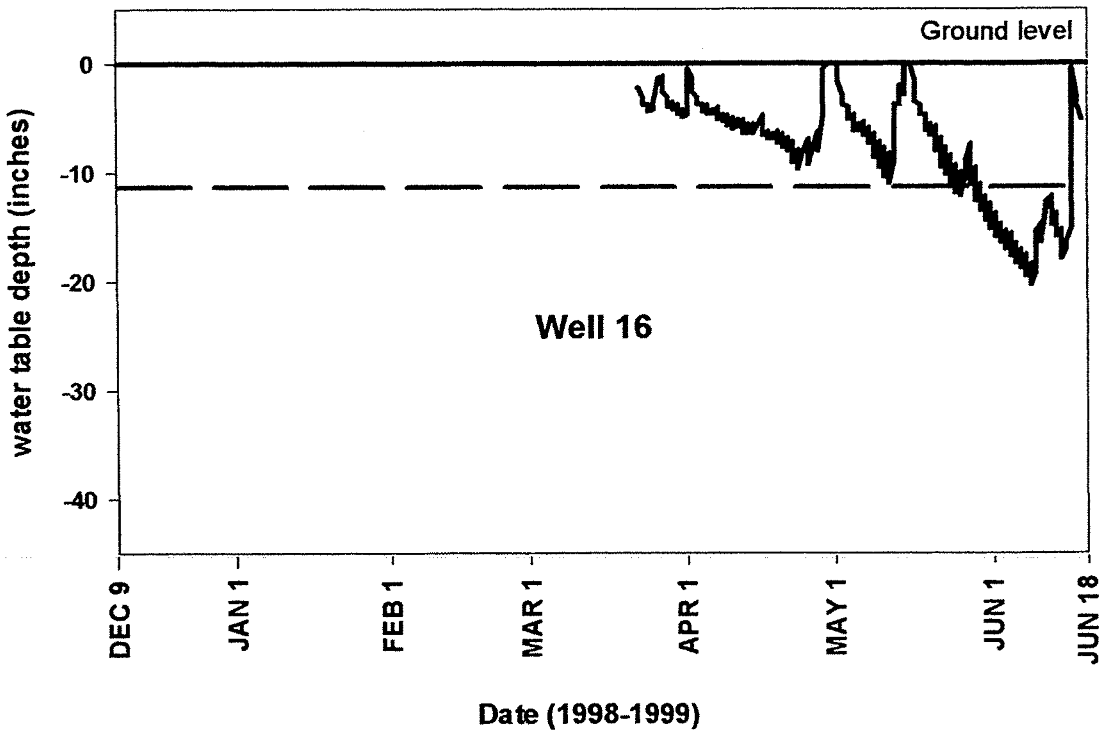
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)


Ground level
0
-10
-20
-30
-40
water table depth (inches)
Well 16
DEC 9
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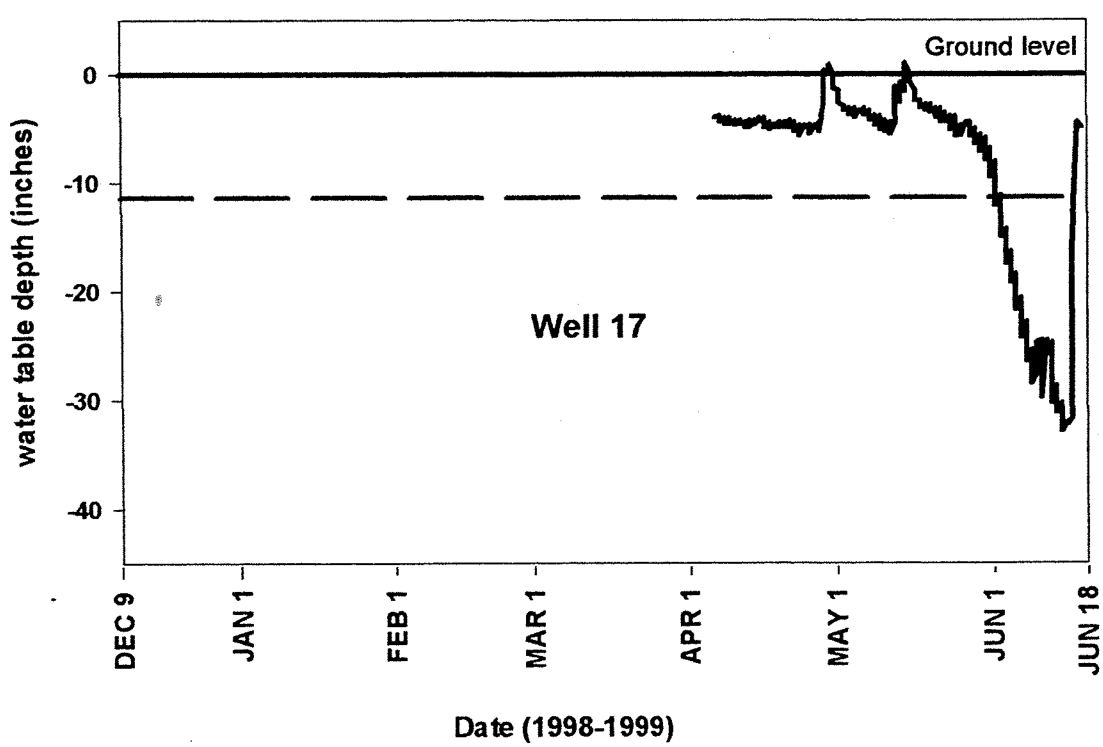
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)


Ground level
0
-10
-20
-30
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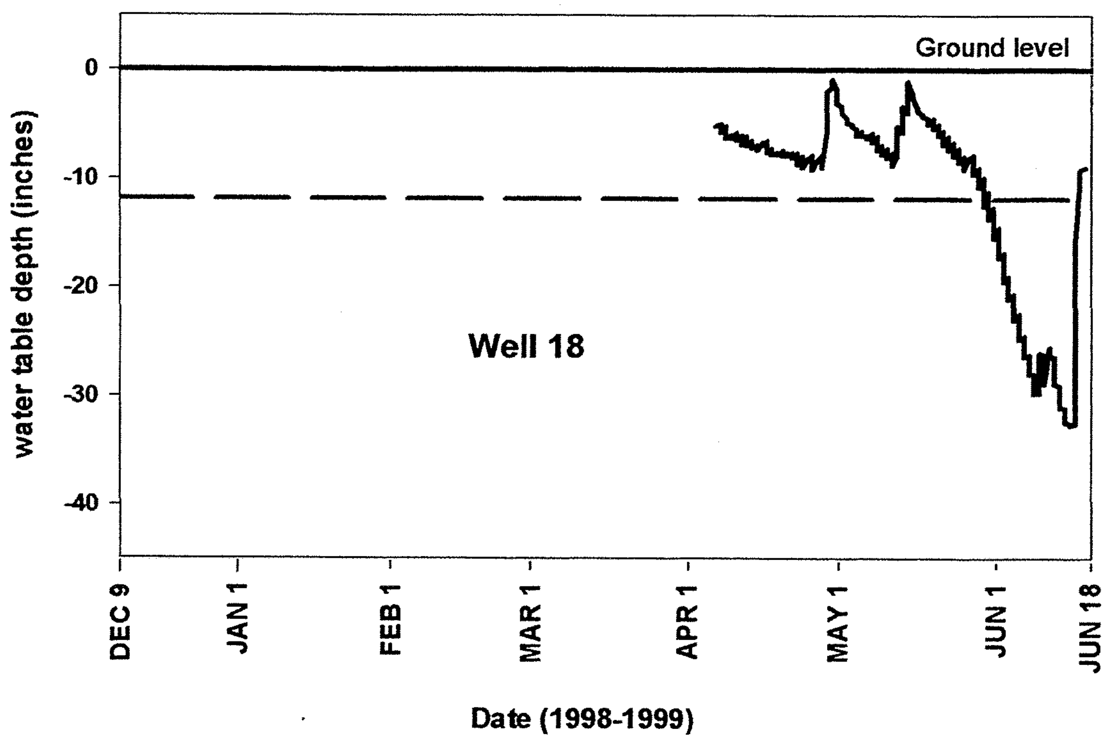
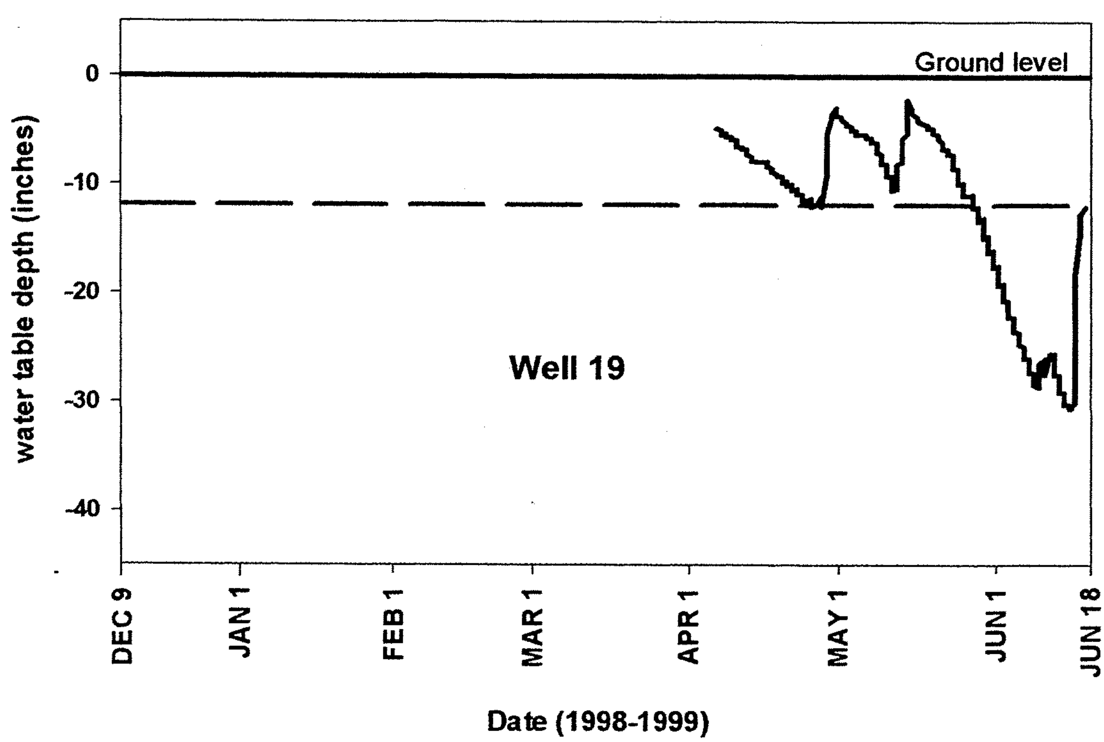
water table depth (inches)
Well 17
DEC 9
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)



Ground level
0
-10
-20
-30
-40
water table depth (inches)
Well 18
DEC 9
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)



Ground level
0
-10
-20
-30
-40
water table depth (inches)
Well 19
DEC 9
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUN 18
Date (1998-1999)