ECOSCIENCE
CORPORATION

WETLAND AND STREAM MITIGATION PLAN

ABC SITE
BEAUFORT COUNTY, NORTH CAROLINA

THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
RALEIGH, NORTH CAROLINA

June 1999

EXECUTIVE SUMMARY

The N.C. Department of Transportation (NCDOT) is developing wetland and stream mitigation sites within the upper Coastal Plain region of the Tar-Pamlico river basin. As part of this effort, NCDOT has completed detailed mitigation plans for the ABC Mitigation Site (Site), an approximately 75-hectare (187-acre) tract located along Acre Swamp, a tributary of Pungo Creek and the Pamlico River. The Site is situated approximately 18 kilometers (11 miles) northeast of Washington and approximately 77 kilometers (48 miles) west of the coast in Beaufort County, North Carolina.

The Site is situated along lower portions of a Coastal Plain interstream divide (precipitation flat), groundwater slope, and abandoned riverine floodplains located immediately adjacent to Acre Swamp. A majority of the Site has been cleared, ditched, drained, with wetlands effectively eliminated. The drainage system was installed to facilitate agricultural production and to convey drainage from the precipitation flat and groundwater slope into Acre Swamp. The Acre Swamp channel has been dredged and straightened throughout the watershed, inducing abandonment of floodplains, stream instability, and loss of riverine wetlands in the region. Additional impacts to former wetland surfaces include leveling, crowning, and compaction designed to further facilitate agricultural production.

Wetland and stream mitigation activities have been designed to restore wetland features and functions similar to those exhibited by reference wetlands in the region. Site alterations designed to restore characteristic wetland soil features and groundwater wetland hydrology include depression construction, impervious ditch plug construction, ditch backfilling, field crown removal, and harrowing/scarification of wetland soil surfaces. Subsequently, tree and shrub planting will occur throughout the Site to facilitate establishment of diagnostic natural communities, including levee/stream bank forest, nonriverine swamp forest, nonriverine wet hardwood forest, and dry mesic oak-hickory forest. 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, the Site is expected to support 37 hectares (92 acres) of restored nonriverine forested wetlands and 7 hectares (19 acres) of enhanced nonriverine wetland systems. Stream enhancement activities will also be undertaken along approximately 1252 meters (4107 ft) of Acre Swamp through shrub plantings and riparian forest buffer restoration. Upland buffers / ecotones, riparian buffers, and associated groundwater wetland recharge potential will also be restored within the remaining 31 hectares (76 acres) of uplands and stream-side management areas.

Based on Environmental Protection Agency (EPA) guidelines (Page and Wilcher 1990), approximately 25-ha (63-ac) nonriverine wetland replacement credits may become available for compensatory mitigation use. In addition, stream mitigation credit is proposed at a 2:1 ratio, generating approximately 626 m (2054 ft) of stream replacement credit. Actual mitigation credit generated by restoration activities should be determined based on the achievement of Success Criteria, completed provisions for site protection in perpetuity, and the type and condition of wetlands impacted by a particular project.

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WETLAND AND STREAM MITIGATION PLAN

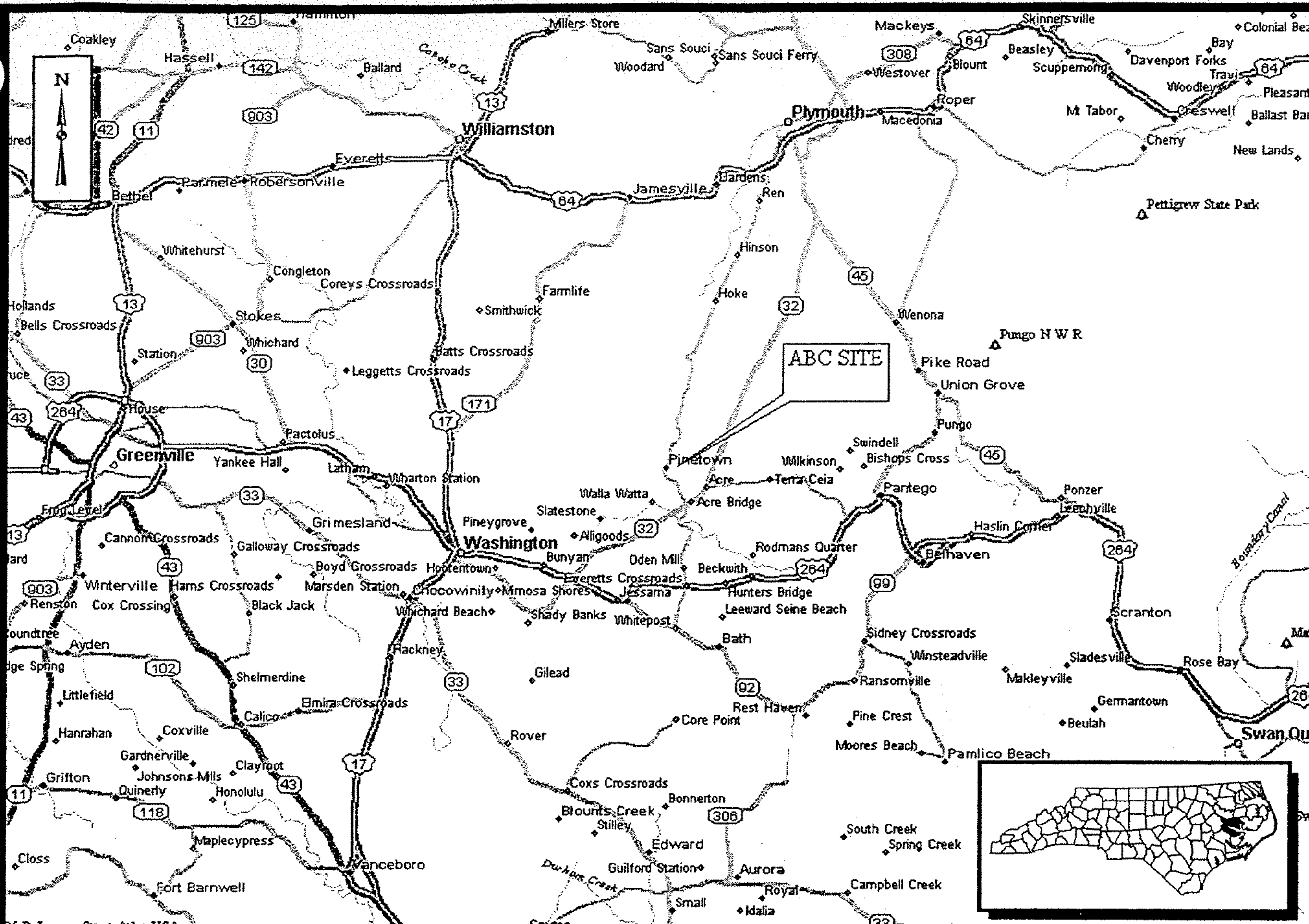
ABC SITE
BEAUFORT COUNTY, NORTH CAROLINA

1.0 INTRODUCTION

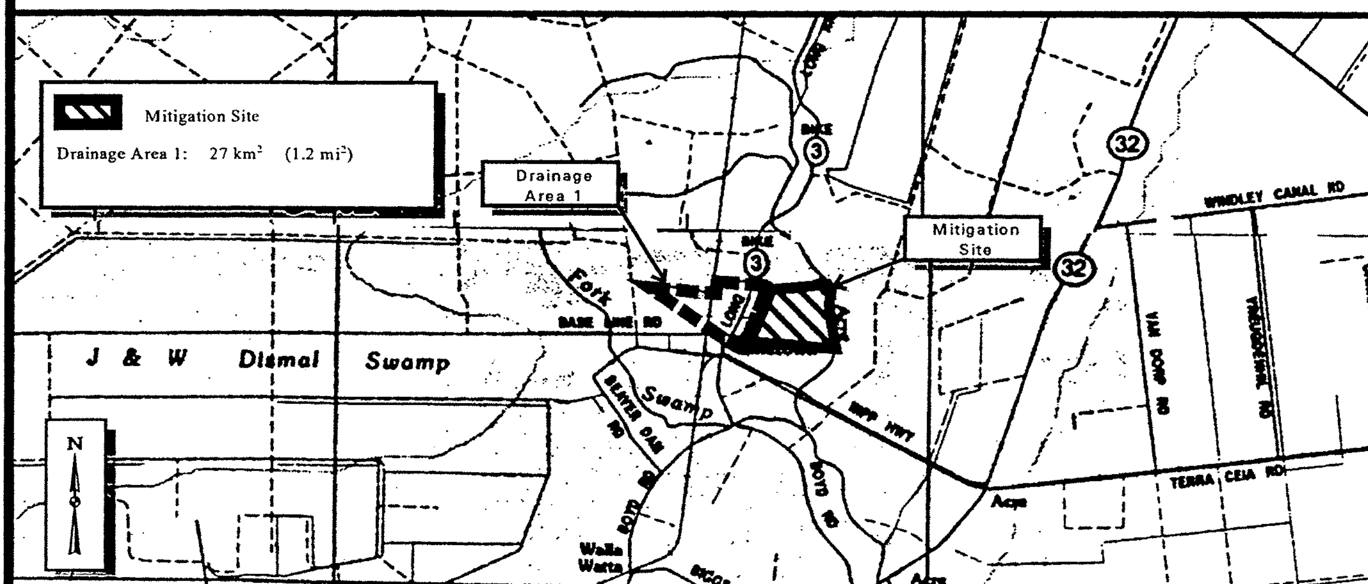
General Assembly House Bill 399, ratified in 1989, provides for the establishment of the North Carolina Highway Trust Fund. This fund was established to facilitate the development of free flowing, safe, inter-city travel for motorists, and to support statewide growth and development objectives. In 1994, the State of North Carolina created a new transportation plan called Transportation 2001 that emphasizes, among other things, the acceleration of highway projects associated with key regions of economic development. As part of this effort, the N.C. Department of Transportation (NCDOT) is planning and constructing roadway improvement projects in the eastern portion of the state. Priority completion corridors in this region include projects such as the NC 43, Rocky Mount Bypass in Edgecombe County (U-2218) and the US 17, Washington Bypass in Beaufort County (R-2510). Highway projects involve unavoidable wetland impacts; however, contiguous, on-site restoration-based compensatory mitigation is sometimes unavailable in the region.

NCDOT is attempting to establish wetland mitigation areas in regions of the state where projected roadway improvement projects will result in unavoidable impacts to wetlands. In 1997, the NCDOT performed a search for suitable wetland mitigation sites within the upper Coastal Plain region of the Tar-Pamlico River Basin. This search resulted in the identification of the ABC Mitigation Site (Site), an approximately 75-hectare [ha] (187-acre ([ac]) tract located adjacent to Acre Swamp in Beaufort County (Figure 1.1).

The Site is planned as a compensatory wetlands mitigation project for the central and upper Coastal Plain region of North Carolina. The purpose of this document is to: 1) describe existing conditions; 2) detail wetland restoration studies and component analyses; 3) present a mitigation plan for restoring wetlands; and 4) present a plan for monitoring and measuring success of restoration efforts. Wetland functional replacement potential is also described to assess site utility for compensatory mitigation in the region.



LOCATION MAP



VICINITY MAP

EcoScience Corporation

Site Location and Drainage Area

ABC Mitigation Site
Beaufort County, North Carolina

Figure: 1.1

Project: 98-024.03

Date: June 1999

2.0 METHODS

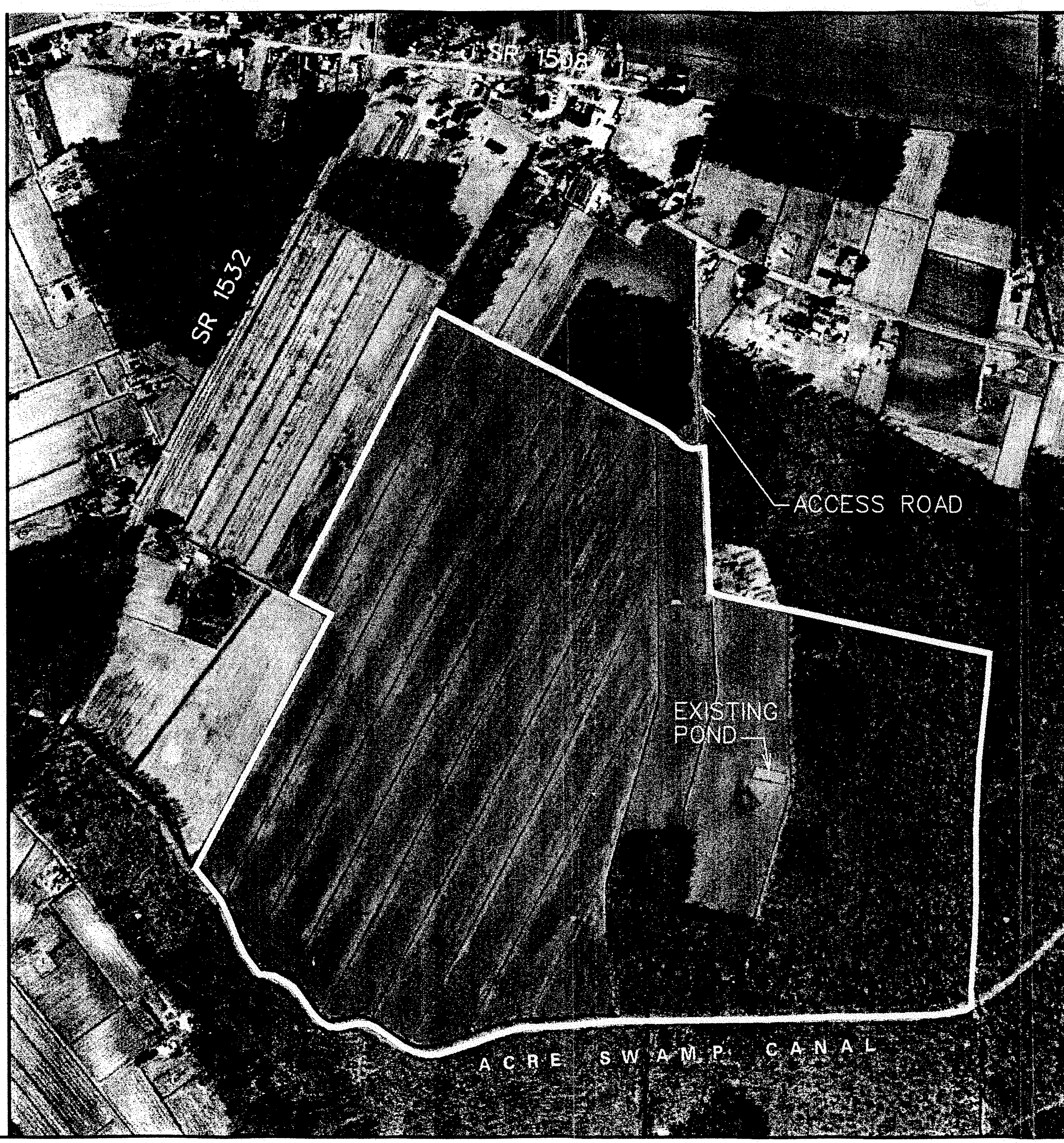
Natural resource information was obtained from available sources. U. S. Geological Survey (USGS) mapping, U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) mapping (Pinetown 7.5 minute quadrangle), and Natural Resource Conservation Service (NRCS) soil surveys (USDA 1995) were utilized to evaluate existing watershed, stream, land use, and soil information prior to on-site inspection. Historical aerial photographs (1958, 1973, 1994) were reviewed to identify land use patterns at the Site and in the watershed. Disturbances to wetlands, such as dredging of Acre Swamp and Site-conversion to crop land were tracked and utilized to orient restoration design.

Current (1998) aerial photography was prepared and utilized to determine primary hydrologic features and to map relevant environmental features (Figure 2.1). Detailed topographic mapping to 0.3 meter (m) (1 foot [ft]) contour intervals was generated from the aerial photography. Subsequently, groundwater piezometers, field crowns, reference wetland surfaces, channel cross-sections, and profiles were surveyed to quantify elevational gradients affecting hydrologic parameters and to predict wetland restoration potential.

North Carolina Natural Heritage Program (NCNHP) data bases were evaluated for the presence of protected species and designated natural areas which may serve as reference (relatively undisturbed) wetlands for restoration design. A listing of Federal-protected species whose ranges extend into Beaufort County was also obtained from the USFWS (May 1999). State Historic Preservation Office (SHPO) records were evaluated for the presence of significant cultural resources in the Site vicinity. Regional conservation areas within the nearby, Dismal Swamp refuge were also evaluated for reference use. Identified sites were sampled and evaluated to provide baseline information on target (post-restoration) wetland condition. Characteristic and target natural community patterns were classified according to Schafale and Weakley's, Classification of the Natural Communities of North Carolina (1990).

Detailed field investigations were performed in February and March 1999, and consisted of hydrological measurements, soil surveys, and mapping of on-site resources. Project scientists evaluated hydrology, vegetation, and soil parameters to delineate jurisdictional wetlands and open waters. The wetland boundaries were mapped using global positioning system (GPS) technology. Existing plant communities were also delineated, mapped, and described by structure and composition.

NRCS soil mapping was modified to identify hydric soil boundaries and to predict (target) biological diversity prior to human disturbances. NRCS soil map units were ground truthed by licensed soil scientists to verify existing units and to map (by GPS) inclusions and taxadjunct areas. A taxadjunct area contains soils which cannot be classified in a series recognized in the classification system. Such soils are named for a series they resemble and are designated as taxadjuncts to that series.



EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

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

Project:
1998 AERIAL PHOTOGRAPH
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: 04/26/99	Figure	
Ckd By: GL	Scale: 1"= 500'	2.1	
ESC Project No.: 98-024.03			

Hydrologic conditions were characterized by the following activities: 1) excavation of a series of soil borings and installation of piezometers into the borings; 2) collection of periodic water level measurements; 3) analysis of surface water profiles along drainageways; 4) development of groundwater contour maps; 5) modeling of groundwater withdrawal rates by DRAINMOD; and 6) flood frequency analyses (WSPRO) along the Acre Swamp canal.

A series of 14 automatic-recording wells were installed in November, 1998. Water level elevations were downloaded periodically from November 6 through April 4, 1999. Well data is presented in Appendix A. Groundwater contour maps were generated at periodic intervals to establish primary wetland physiographic areas and to assess drainage impacts during the early growing season. Groundwater conditions were modeled using DRAINMOD, a computer model for simulating drainage rates for relatively shallow soils with high water tables. The model was utilized to predict historic hydroperiods, 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 Acre Swamp canal to predict flood extent into the Site for the 1, 2, 5, 10, 50, and 100-year storm events. The analyses utilized existing Federal Emergency Management Agency (FEMA) studies along with a WSPRO model. The extent of flooding was used primarily to determine the potential for riverine wetland restoration in lower reaches of the Site.

Field survey 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 AND LAND USE

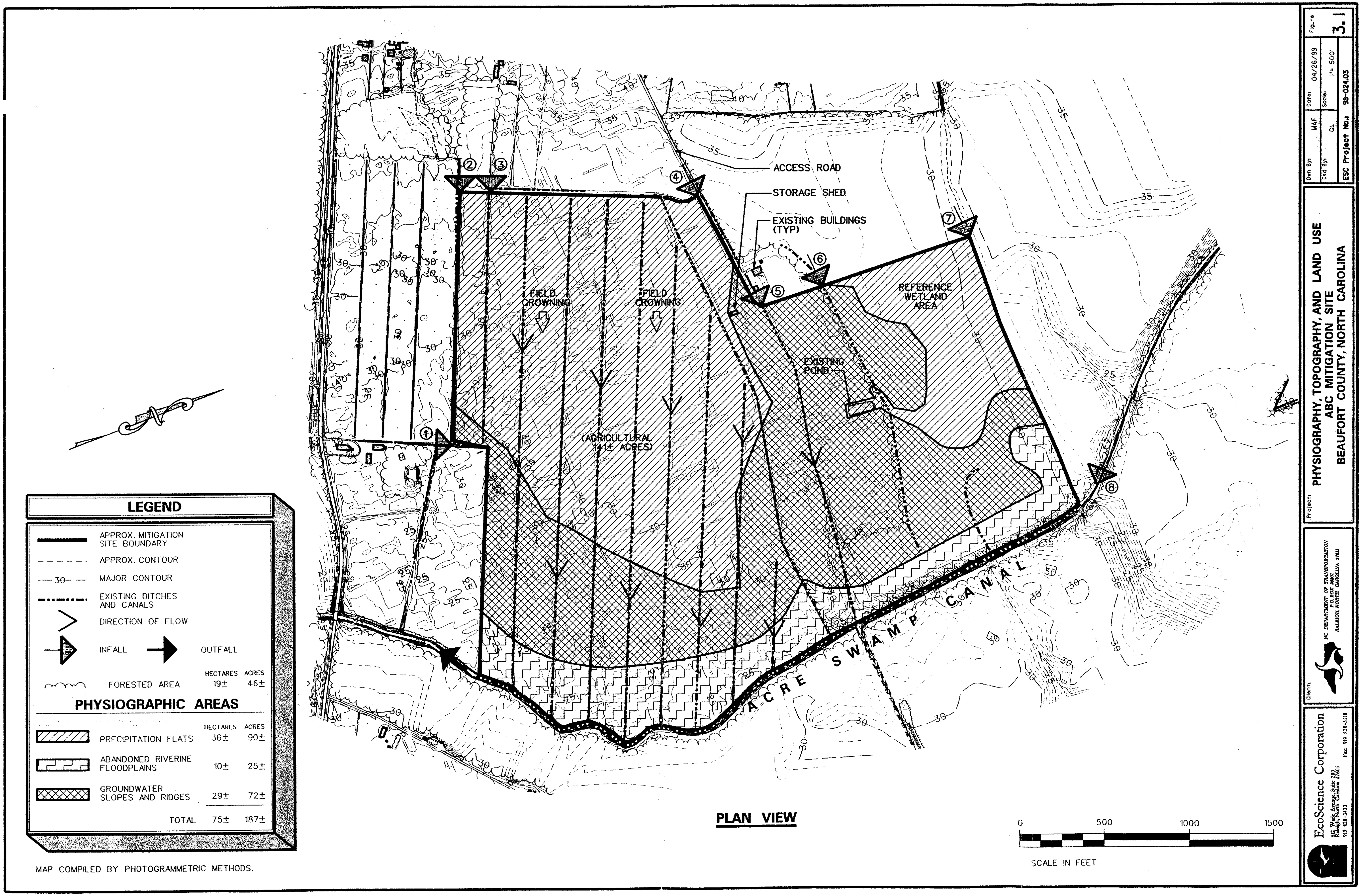
The Site is located in the Atlantic Coastal Plain Physiographic Province of North Carolina within the Outer Coastal Plain region of the Pamlico River Basin. This region of the Pamlico River Basin extends from the Suffolk Scarp near the town of Washington east to the Pamlico Sound (Hydrologic Unit #03020104 and #03020105 [USGS 1974]). The Site is located approximately 18 km (11 mi) northeast of Washington and approximately 77 km (48 mi) west of the coast.

The Site is situated along lower portions of a Coastal Plain interstream divide, intermediate slope, and former riverine floodplain located immediately adjacent to Acre Swamp, a tributary of Pungo Creek and the Pamlico River. Adjacent, broad interstream divides cover approximately 27 square kilometers (km^2) (1.2 square miles [mi^2]) of land with groundwater and surface water discharging from these interstream divides towards the Site (Figure 1.1). Elevations to the west, within upper reaches of the watershed, extend to approximately 15 m (50 ft) above mean sea level (MSL). Conversely, elevations within the Site range from approximately 10 m (33 ft) above MSL along the western periphery to approximately 6 m (20 ft) above MSL at the Site outfall (Figure 3.1).

The Site has been subdivided into three primary physiographic landscape units for wetland classification and restoration planning: 1) precipitation flats; 2) groundwater slopes/ridges; and 3) abandoned riverine floodplains (Figure 3.1). The primary variables utilized to segregate wetland landscape units comprise land slope, groundwater flow characteristics, soil features, and the primary hydrologic influence on historic wetland function.

Precipitation Flats

Precipitation flats, occupying approximately 36 ha (90 ac) of the 75 ha (187 ac) Site, are located along the western and northern Site periphery. Under historic conditions, these flats are expected to exhibit primarily vertical to semi-radial groundwater flow. Therefore, wetland hydrology is driven primarily by precipitation, the relative lack of land slope, and very low hydraulic conductivity in proximity to the soil surface. Perched water tables and the lack of drainage outlets within this physiographic area induce a mosaic of enclosed hummocks, depressions, and sloughs exhibiting a range of wetland hydroperiods. Groundwater models (Section 4.2) and reference studies (Section 4.4) suggest that these precipitation flats, in undisturbed conditions, support a broad range of hydroperiods from less than 5% to more than 20% of the growing season. These variations may occur over distances of less than 30 m (100 ft), dependent upon localized surface topography and drainage characteristics. This landscape mosaic supports numerous ecotonal fringes between designated natural communities including mesic pine flatwoods, mesic mixed hardwood forest, nonriverine wet hardwood forest, nonriverine swamp forest, and vernal pools (Schafale and Weakley 1990).


ACCESS ROAD
STORAGE SHED
EXISTING BUILDINGS (TYP)
REFERENCE WETLAND AREA
FIELD CROWNING
FIELD CROWNING
EXISTING POND
(AGRICULTURAL 141± ACRES)
ACRE SWAMP CANAL
LEGEND
APPROX. MITIGATION SITE BOUNDARY
APPROX. CONTOUR
MAJOR CONTOUR
EXISTING DITCHES AND CANALS
DIRECTION OF FLOW
INFALL
OUTFALL
HECTARES ACRES
FORESTED AREA 19± 46±
PHYSIOGRAPHIC AREAS
HECTARES ACRES
PRECIPITATION FLATS 36± 90±
ABANDONED RIVERINE FLOODPLAINS 10± 25±
GROUNDWATER SLOPES AND RIDGES 29± 72±
TOTAL 75± 187±
MAP COMPILED BY PHOTOGRAMMETRIC METHODS.
PLAN VIEW
0 500 1000 1500
SCALE IN FEET
Project: PHYSIOGRAPHY, TOPOGRAPHY, AND LAND USE
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA
Dwn By: MAF Date: 04/26/99
Ckd By: GL Scale: 1"= 500'
ESC Project No.: 98-024.03
Figure 3.1
Client: NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611
EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

Groundwater Slopes/Ridges

Groundwater slopes, comprising approximately 29 ha (72 ac), are represented as a broad band through central portions of the Site, adjacent to the former floodplains of Acre Swamp (Figure 3.1). The slope physiographic areas exhibit primarily semi-radial to radial groundwater flow and discharge towards Acre Swamp (Section 3.4). Increasing land slope, relatively coarse subsurface soils, and adjacent low-lying floodplains induce accelerated groundwater movement with intermittent wetland pockets located in areas where the groundwater table intersects the land surface along the base of the slope. Therefore, wetland hydrodynamics are driven primarily by groundwater migration and discharge characteristics from the adjacent interstream divide. At the Site, a large majority of the slope physiographic area supports non-hydric soils or marginally hydric soils that historically did not support wetlands. Typical communities include pine flatwoods, stream-head communities, and mesic hardwood forest.

Abandoned Riverine Floodplains

The riverine floodplain physiographic area, comprising approximately 10 ha (25 ac), abuts an approximately 1252-m (4107-ft) reach of Acre Swamp (Figure 3.1). The Acre Swamp channel supports a drainage area encompassing approximately 612 km^2 (27 mi^2). Under historic conditions, the area sustained near surface, lateral discharge of groundwater from adjacent slopes towards the stream channel and periodic overbank flooding from the stream channel onto the floodplain. The Acre Swamp channel has been dredged and straightened throughout the watershed to depths ranging from 2 m (6 ft) to 3 m (10 ft) below historic grade, inducing abandonment of floodplains within the Site. Hydrodynamic influences under existing conditions are dominated by accelerated lateral groundwater and surface water migration into the channel and floodplain forming (erosional) processes within the floor of the dredged Acre Swamp channel.

A majority of the Site has been cleared, ditched, drained, with wetlands effectively eliminated. The drainage system was installed to facilitate agricultural production and to convey drainage from the precipitation flat and groundwater slope into the Acre Swamp canal. The drainage network includes approximately 9000 m (30,000 ft) of ditches/canals distributed systematically throughout the Site.

On-Site Structures

Several structures are situated along the northwestern periphery of the Site (Figure 3.1). Structures consist of a house, septic system, and storage shed. Access to the Site is obtained by use of the driveway leading to these structures. No potentially hazardous materials or significant cultural resources were noted during field assessments. However, modifications to drainage networks for wetland restoration must be designed to avoid or minimize impacts to the adjacent structures and access roadway (Section 4.3).

3.2 SOILS

Surficial soils have been mapped by NRCS (USDA 1995). In addition, hydric soils boundaries were delineated and mapped by GPS. In March 1999, soil map units were field verified by licensed soil scientists to modify NRCS soil map units and to locate inclusions and taxadjunct areas. General transects were established by soil scientists and sampled to ensure proper coverage. Refined soil mapping is depicted in Figure 3.2. Typical soil profiles are depicted in Figure 3.3.

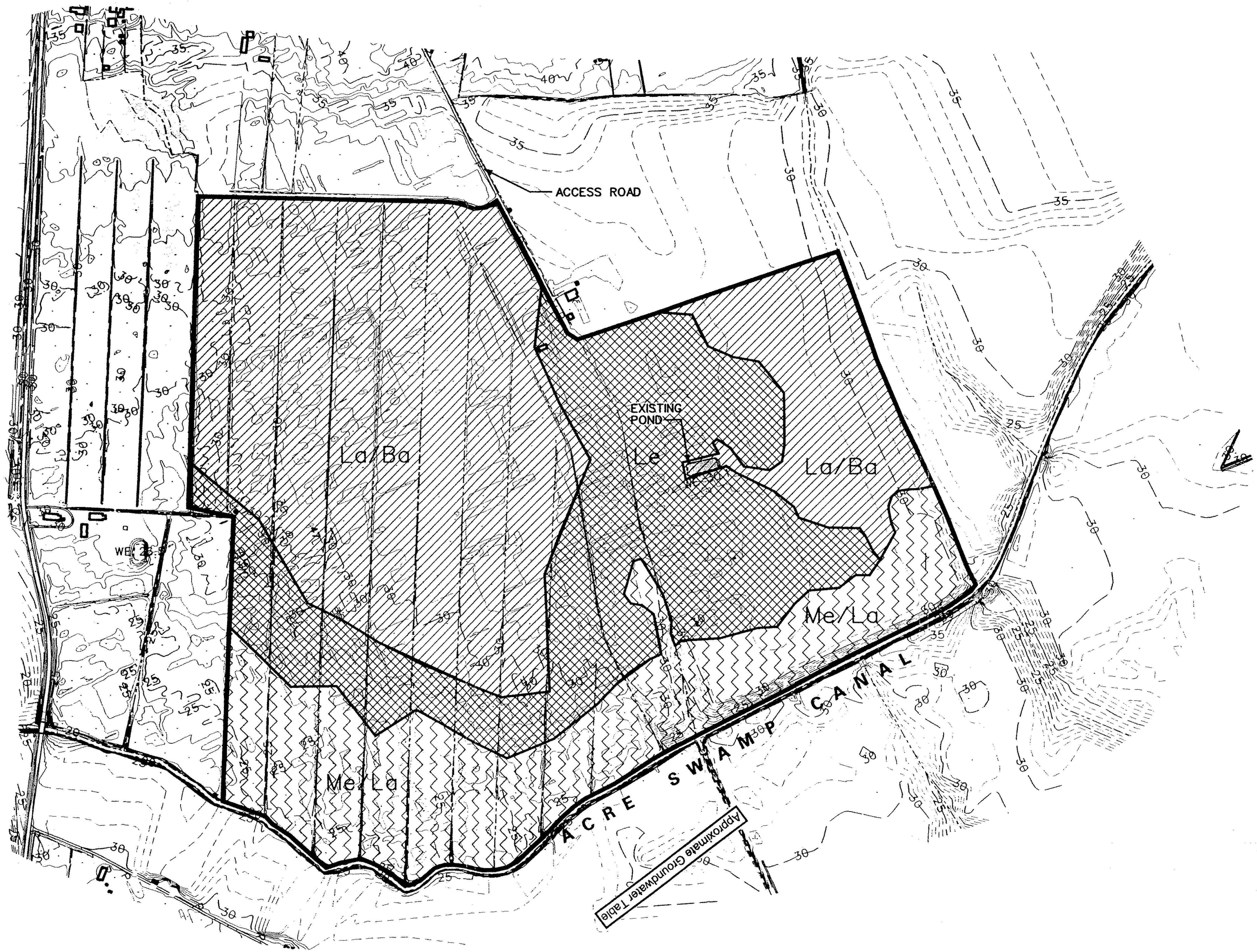
Four soil series were identified, including Lenoir (*Aeric Paleaquults*), Leaf (*Typic Albaquults*), Bayboro (*Umbric Paleaquults*), and Muckalee (*Typic Fluvaquents*) (Figure 3.2). Bayboro inclusions occur throughout the Leaf soil map unit depicted in Figure 3.2. However, conversion to crop land and field crowning have buried landscape depressions that are characteristic of these inclusions. These Bayboro inclusions appear to range from less than 0.004 ha (0.01 ac) to 0.02 ha (0.05 ac) in size. Similarly, Leaf inclusions and a sandy clay taxadjunct to the Muckalee series appear to occur along outer portions of the Muckalee soil map unit. However, these inclusions and taxadjuncts have been obscured by field crowning.

These series typically have upper horizon soil textures ranging from silt loam to clay with drainage classes ranging from very poorly drained to moderately well drained. The seasonal high water table ranges from at or above the soil surface to a depth of 1.5 m (5 ft) below ground. Actual surface horizon textures varied, with specific sites being affected by fluvial activity, agricultural practices, and erosion within the surface (A) horizon. Surface soil textures documented in the field for each map unit were utilized to refine drainage models implemented for wetland (groundwater) restoration planning (Section 4.1 and 4.2).

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 soil layer" (USDA 1987). Hydric soils comprise 72 percent (approximately 54 ha [135 ac]) of the 75-ha (187-ac) Site. Hydric series present include the Muckalee, Leaf, and Bayboro map units. Organic matter within these series potentially range from a minimum of 0.1 percent in the Muckalee series to 10 percent in the Bayboro series. However, reductions in organic matter are expected as a result of long term drainage, crowning, harvest, erosion, and oxidation. Construction of large canals and feeder ditches have drained most of the Site to the extent that hydric conditions in the upper soil horizons are currently limited.

Frequently flooded Muckalee loam is characteristic of floodplains associated with Acre Swamp. Areas underlain by Muckalee loam have moderate permeability and available water capacity. The Leaf and Bayboro series represent flats, toe slopes, and depressions in interior areas of the Site. These soils exhibit very low permeabilities and high shrink/swell potential with clay (B) horizons. Perching of water for various periods after rainfall events is typical for these soil types.

Non-hydric series present include the Lenoir map unit. This series comprises approximately 21 ha (52 ac). These soils are primarily non-hydric but may contain minor hydric inclusions of Leaf or Bayboro. The non-hydric series occupies a relatively narrow escarpment adjacent to the Acre Swamp floodplain and a broad, convex ridge extending through the northern section of the Site. These soils typically lack wetland hydrology but are included in the mitigation landscape to provide the potential for restoration of upland buffers and upland/wetland ecotones.



LEGEND

APPROX. MITIGATION SITE BOUNDARY

APPROX. CONTOUR

—30— MAJOR CONTOUR

SOILS

		HECTARES	ACRES
HYDRIC			
La/Ba	LEAF SILT LOAM (Bayboro Inclusions)	37±	92±
Me/La	MUCKALEE LOAM (Leaf Inclusions)	17±	43±
NON-HYDRIC			
Le	LENOIR LOAM	21±	52±
	TOTAL	75±	187±

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

PLAN VIEW

0 500 1000 1500

SCALE IN FEET

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

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

Project:
SOIL MAP UNITS
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: 04/26/99	Figure
Ckd By: GL	Scale: 1"= 500'	3.2
ESC Project No.: 98-024.03		

3.2.1 Surface and Subsurface Soil Compaction/Leveling and Crowning

Soil surfaces have been leveled, graded, crowned and compacted as a result of agricultural practices. In crop land supporting clayey subsurface horizons (ex: Leaf and Bayboro series), the upper approximately 30 cm (12 in) of soil surface (A horizon) represents relatively high permeability, loamy soils that have been annually plowed. Immediately below the plow layer, a compacted clay layer or "pan" (upper portion of the B horizon) exhibits very low permeabilities. Precipitation infiltrates to the top of this clay pan and may migrate laterally through the permeable surface horizon. As a result, perched water in active crop land tends to flow laterally away from crowns and towards ditches placed in downslope areas. This preferential migration laterally through the surface soil horizon may assist in providing adequate drainage for farming shallow rooted crops in hydric soil areas.

During construction of ditches, earthen spoil material was utilized to establish crowns in the inter-field area between drainage ditches (Figure 3.1). Subsequent annual tilling was also designed to progressively elevate the inter-field area between ditches. The crowns extend, on average, to approximately 0.15 m (0.5 ft) above the surrounding soil surface and serve to further promote drainage within the rooting zone.

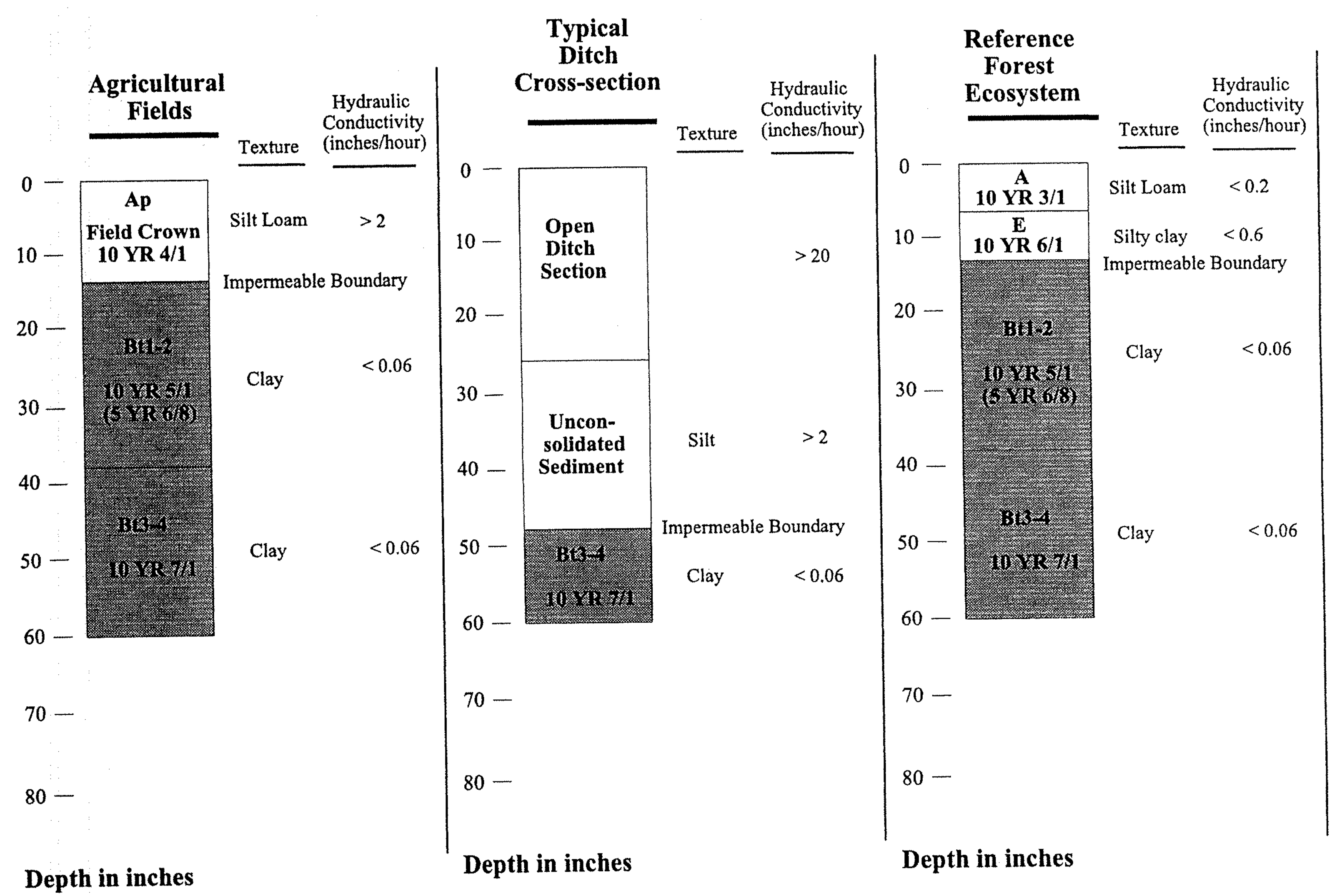
Surface (A horizon) and subsurface (B Horizon) microtopography represents an important component of nonriverine wetlands as water storage functions and micro-habitat complexity are provided by hummocks and swales across the wetland landscape. If ditches are back-filled but the clay pan is not modified, perched water may continue preferential migration laterally through the surface soil layer, promoting flood conditions in downslope areas and dryer conditions in upper landscape positions.

3.3 PLANT COMMUNITIES

Distribution and composition of plant communities reflect landscape-level variations in topography, soils, hydrology, and past or present land use practices. Communities identified on the study area include; wet hardwood forest, upland hardwood forest, pine/mixed hardwood forest, and agricultural fields (Figure 3.4).

Wet hardwood forests are situated in the northern portion of the study area in precipitation flats, depressions, floodplains adjacent to Acre Swamp, and intermediate groundwater slope areas not cleared for agriculture. This area may serve as reference (relatively undisturbed) wetlands utilized to orient restoration design and to monitor restoration areas. Characteristic canopy species include laurel oak (*Quercus laurifolia*), sweetgum (*Liquidambar styraciflua*), black gum (*Nyssa sylvatica*), tulip tree (*Liriodendron tulipifera*), and swamp chestnut oak (*Quercus michauxii*). A dense subcanopy and shrub layer is characterized by young canopy species as well as cherrybark oak (*Quercus pagoda*), Chinese privet (*Ligustrum sinense*), titi (*Cyrilla racemiflora*), sweetbay (*Magnolia virginiana*), bitter gallberry (*Ilex glabra*), fetter-bush (*Lyonia lucida*), fetter-bush (*Leucothoe racemosa*), sweet pepperbush (*Clethra alnifolia*), and giant cane (*Arundinaria gigantea*). The subcanopy and shrub layer is generally densely overgrown with vines such as muscadine grape (*Vitis rotundifolia*), common green brier

Leaf-Bayboro Association



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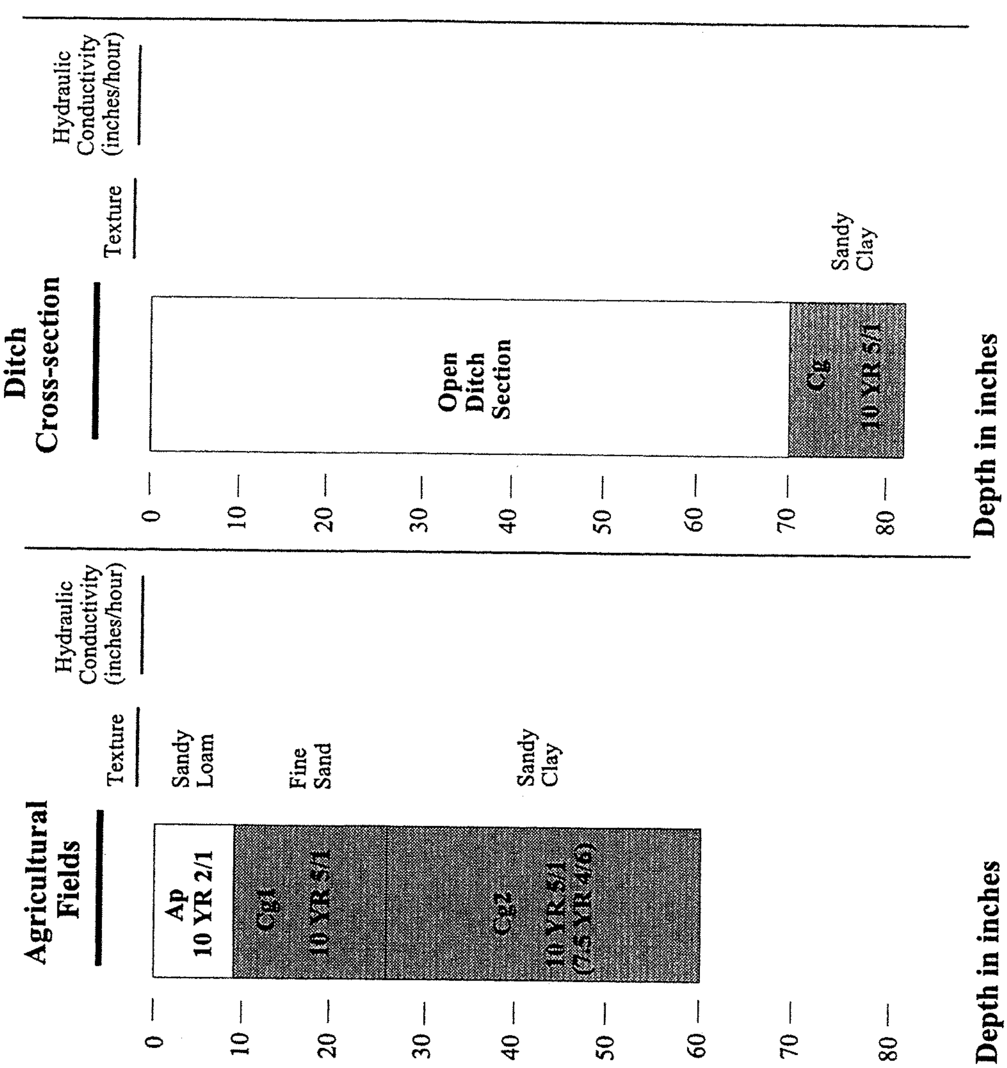
Typical Soil Profile
ABC Mitigation Site
Beaufort County, North Carolina

Figure: 3.3
Project 98-021.03
Date: April 1999

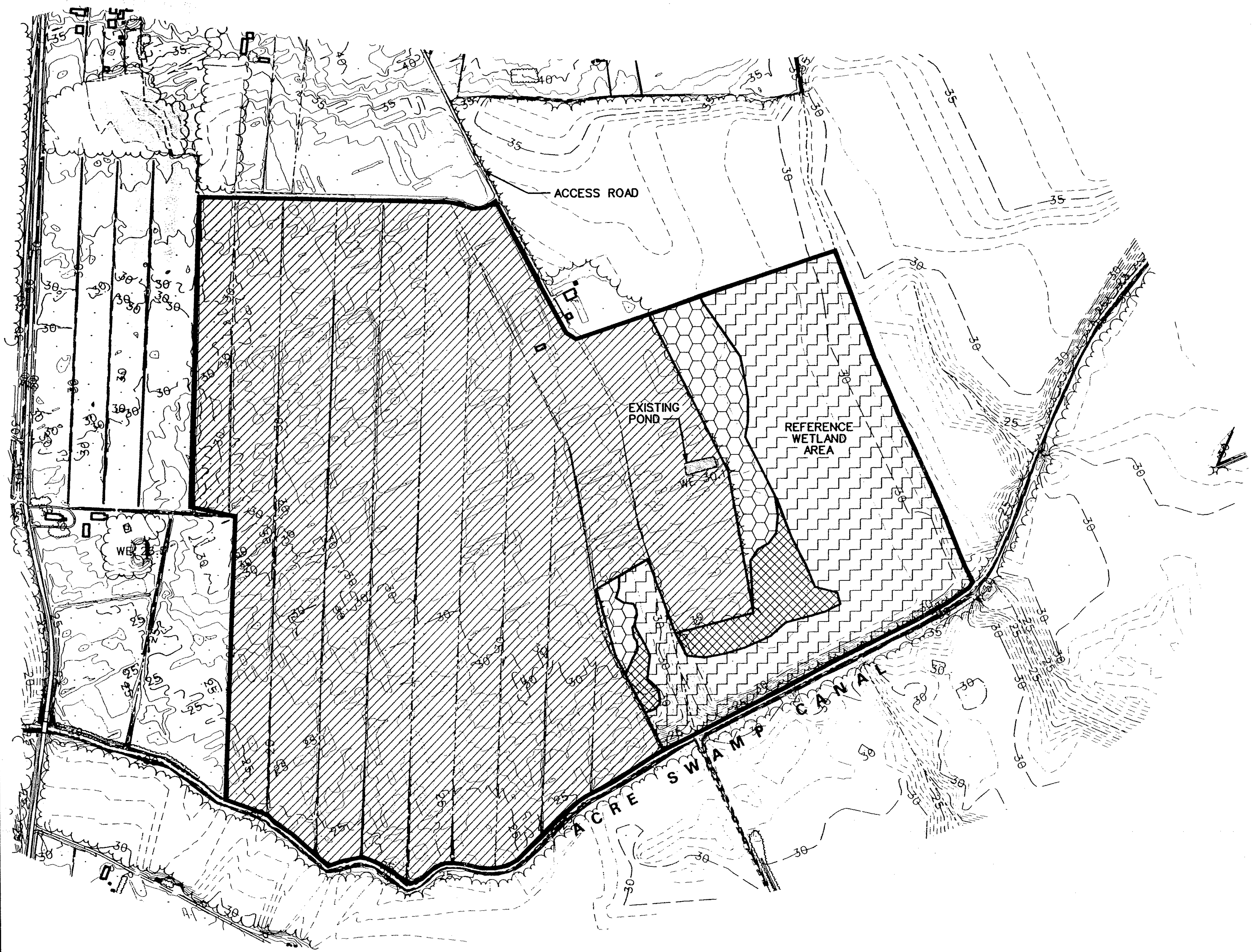
Muckalee Leaf Association



EcoScience Corporation

Typical Soil Profile
ABC Mitigation Site
Beaufort County, North Carolina

Figure: 3.3a	
Project 98-021.03	
Date: April 1999	



PLAN VIEW

0 500 1000 1500
SCALE IN FEET

LEGEND

APPROX. MITIGATION SITE BOUNDARY

WOODS

APPROX. CONTOUR

—30— MAJOR CONTOUR

COMMUNITIES

	HECTARES	ACRES
AGRICULTURAL FIELDS	57±	141±
PINE/MIXED HARDWOOD FOREST	3±	7±
WET HARDWOOD FOREST	13±	34±
MESIC HARDWOOD FOREST	2±	5±
TOTAL	75±	187±

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

Project: **PLANT COMMUNITIES**
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: 04/26/99	Figure
Ckd By: GL	Scale: 1"= 500'	3.4
ESC Project No.: 98-024.03		

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

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

(*Smilax rotundifolia*), laurel-leaf greenbrier (*Smilax laurifolia*), and crossvine (*Bignonia capreolata*). The forest floor is covered by herbaceous groundcover characterized by Nepal microstegium (*Eulalia vimineum*), false nettle (*Boehmeria cylindrica*), and ferns such as cinnamon fern (*Osmunda cinnamomea*), netted chain-fern (*Woodwardia areolata*), and royal fern (*Osmunda regalis*). Much of the forest floor remains saturated for extended periods of time and have Sphagnum mats blanketing microtopographic depressions.

Upland hardwood forests are situated in the northern portion of the Site and are located on non-hydric soils adjacent to agricultural fields. Upland hardwood forests support mixed mesophytic hardwoods such as white oak (*Quercus alba*), black gum, tulip tree, red maple, and sweetgum. The subcanopy is characterized by American holly (*Ilex opaca*), horse sugar (*Symplocus tinctoria*), pokeweed (*Phytolacca americana*), Chinese privet, sweet pepperbush, American beautyberry (*Callicarpa americana*), and common catbrier.

Pine/hardwood forests are located in the northern portion of the Site adjacent to agricultural fields. This community is bounded by both wetland and upland hardwood forest, and agriculture. Pine/hardwood forests are confined to upland locations; however, wetland vegetation does grade into the community. The community, although dominated by loblolly pine (*Pinus taeda*), is characterized by species associated with upland and wetland hardwood forest such as sweetgum, red maple, water oak, cherrybark oak, wax myrtle (*Myrica cerifera*), horse sugar, highbush blueberry (*Vaccinium corymbosum*), sweetbay, American holly, and fetter-bush.

Agricultural fields occur in the southern portion of the Site and support a current crop of soybeans. Invasive weeds dominate unproductive areas including species such as rough cockle-bur (*Xanthium strumarium*), sicklepod (*Cassia obtusifolia*), ragweed (*Ambrosia artemisiifolia*), pigweed (*Chenopodium album*), Pennsylvania smartweed (*Polygonum pennsylvanicum*), goldenrod (*Solidago sp.*), and various grasses such as Johnson grass (*Sorghum halepense*), vasey-grass (*Paspalum urvillei*), and ground cherry (*Physalis virginiana*).

3.4 HYDROLOGY

The hydrophysiographic region consists of relatively flat, Inner Coastal Plain environments characterized by moderate rainfall (USDA 1995). The Site is situated along the periphery of a Coastal Plain interstream divide and includes groundwater slopes and former riverine floodplains located immediately adjacent to Acre Swamp. Therefore, historic wetlands were most likely complex, influenced by groundwater and surface water flow from the adjacent interstream divide, overbank flooding from Acre Swamp, as well as precipitation inputs maintained within the Site.

Topographically, the Site is generally expressed as a broad flat with an escarpment generally grading towards Acre Swamp. Adjacent, broad interstream divides cover approximately 27 km^2 (1.1 mi^2) of land with groundwater discharging from these interstream divides towards the Site. Near surface groundwater is intercepted by a network of drainage ditches designed to facilitate alternative land uses such as agriculture and residential development in the watershed.

Under historic conditions, interior wetlands most likely served as an above headwater storage and groundwater discharge area for Acre Swamp. Conversely, lateral surface (stream) flow and overbank flooding is expected to have dominated wetland hydrodynamics in the riverine floodplain. The floodplain appears to have surrounded a number of intermittent stream channels which coalesced into primary channels near the confluence with Acre Swamp. The Acre Swamp channel appears to have represented a third order stream prior to channelization (Strahler 1964). The canal supports a drainage area of approximately 612 km^2 (27 mi^2) at the Site boundary. In addition, remnant first order stream channels are expected to have occurred within crop lands under historic conditions. However, these surface flow pathways have been obscured under existing land uses.

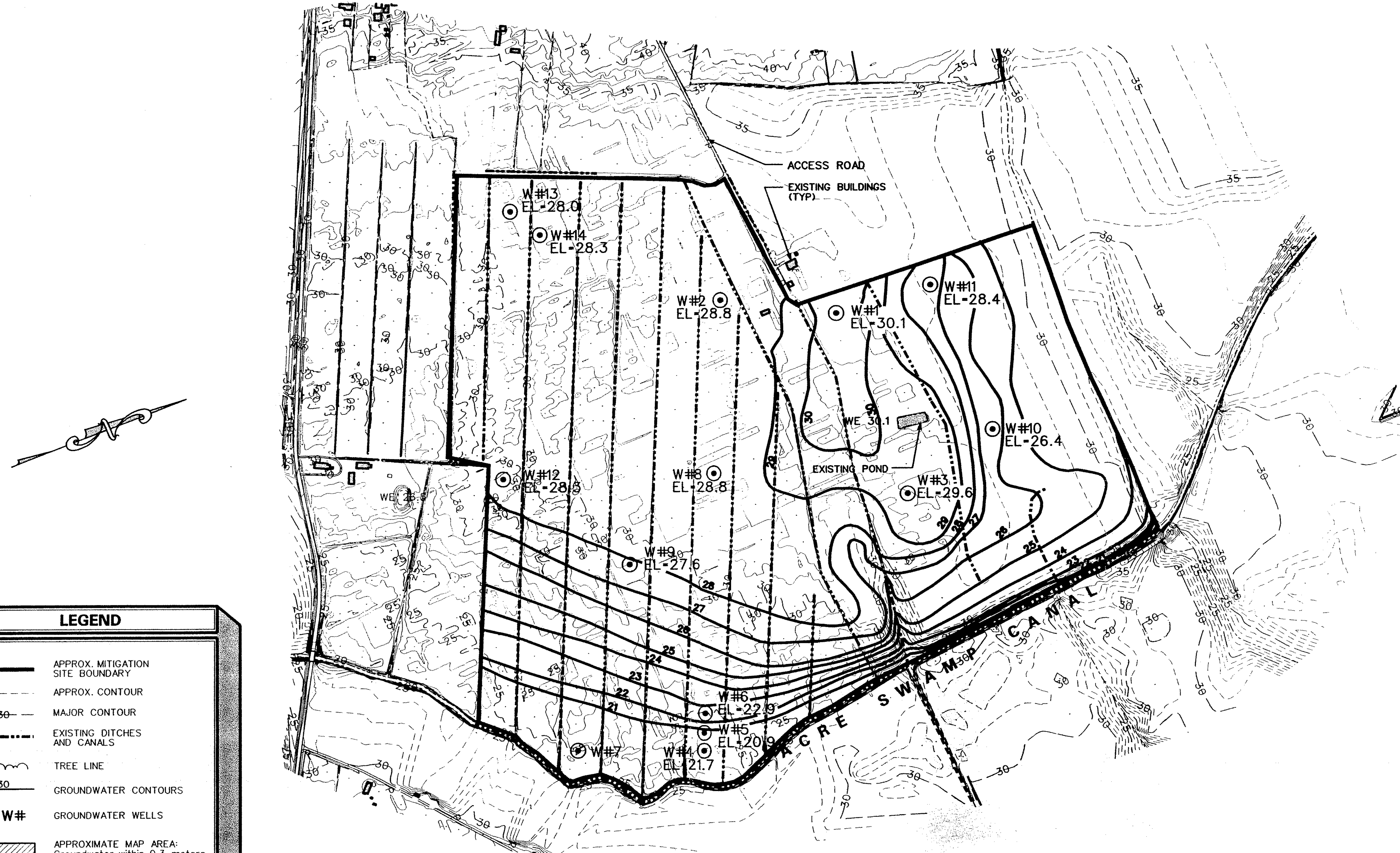
Currently, groundwater migration has been accelerated in crop lands by leveling of the soil surface, increased permeability within the plow layer, and potential removal of subsurface impediments to flow (rooting functions and B horizon surface complexity). The induced groundwater migration is intercepted by a network of inter-field ditches which effectively drains farmed portions of the Site. Approximately 9000 m (30,000 ft) of ditches have been constructed and range from approximately 1.2 m (4 ft) deep in inter-field ditches to 3 m (10 ft) deep at the Site out-fall. This drainage network connects discharge to Acre Swamp, a dredged canal, which extends towards Pungo Swamp, approximately 2.6 mi (4.3 km) below the Site.

3.4.1 Groundwater flow

Groundwater flow maps were prepared periodically for the period November 1998 through April 4, 1999. Groundwater elevation data at periodic intervals is presented in Table 3.1. Groundwater flow maps for November 6,1998 and January 26, 1999 are presented in Figures 3.5 and 3.6. During the sample period, groundwater was encountered from above ground surface in the forested areas to a depth of 1.06 m (3.48 ft) within the farmed fields. The highest groundwater elevations were measured in northwestern forested areas representing a Bayboro depression (Well # 11). Inundation of this depression occurred in early January 1999 and has persisted into early April 1999. This area will serve as a reference wetland to evaluate established hydroperiods within restored wetland areas. As expected, water table elevations decrease along accelerated drainage gradients within the groundwater slope and riverine floodplain area adjacent to the Acre Swamp canal.

3.4.1 Off-Site Drainage

As depicted in Figure 3.1, eight surface flow infalls have been identified extending from adjacent properties into the Site. Infalls consist primarily of ditches along the southern, western, and northern project boundaries, and Acre Swamp along the eastern boundary. Infalls # 1, 2, 3, 7, and 8 discharge into ditches along the site periphery. Conversely, Infalls # 4, 5, and 6 discharge into ditches bisecting north-central sections of the property. These infalls are associated with a house and driveway located in the area. Provisions for drainage of infalls # 4, 5, and 6 must be made within the Site interior (Section 4.3.2).



LEGEND

(heavy solid line)	APPROX. MITIGATION SITE BOUNDARY
(dashed line)	APPROX. CONTOUR
—30—	MAJOR CONTOUR
(dash-dot line)	EXISTING DITCHES AND CANALS
(scalloped line)	TREE LINE
30	GROUNDWATER CONTOURS
⊙W#	GROUNDWATER WELLS
(hatched box)	APPROXIMATE MAP AREA: Groundwater within 0.3 meters (1 foot) of the soil surface

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

PLAN VIEW

0 500 1000 1500

SCALE IN FEET

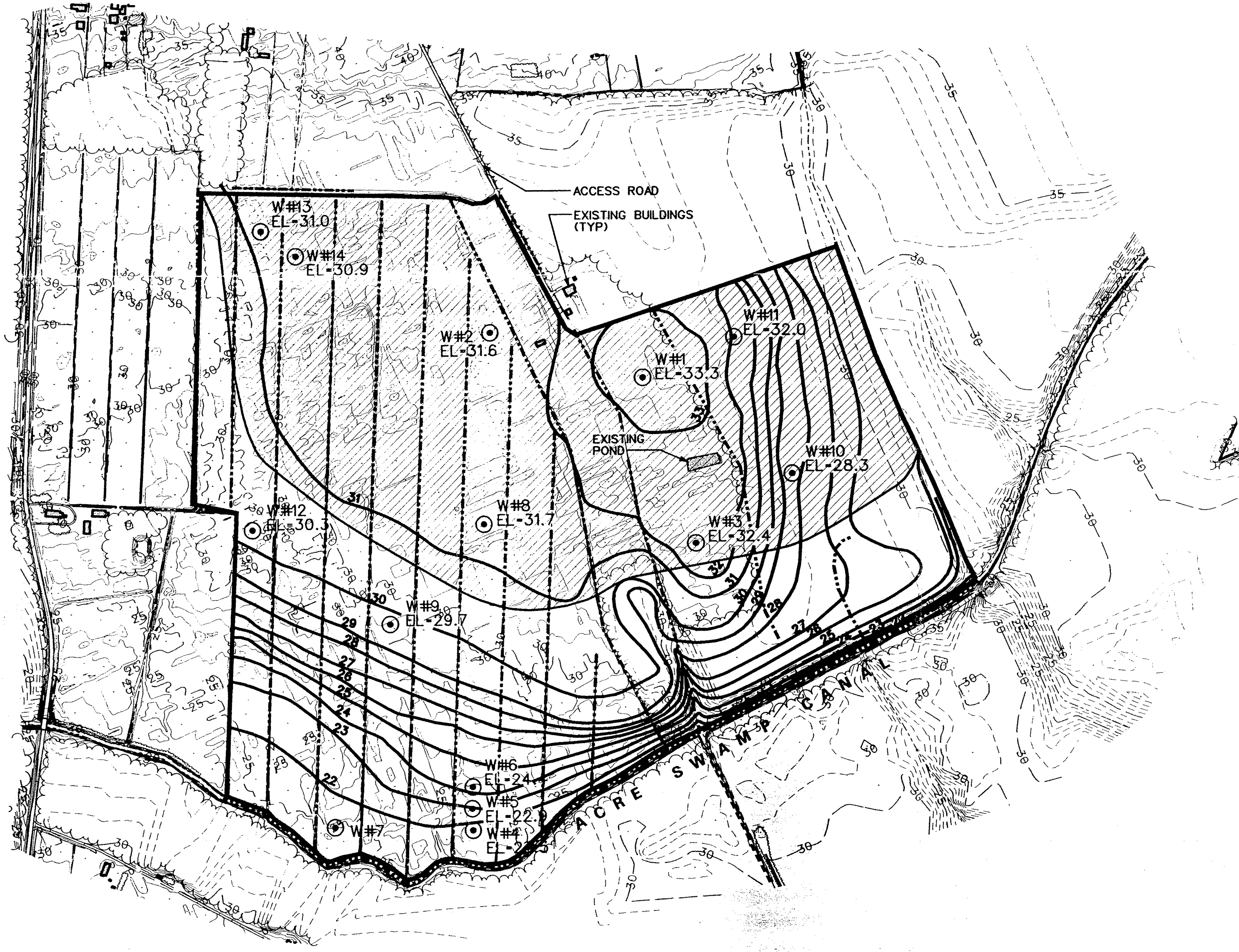
EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

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

Project: GROUNDWATER CONTOURS (1/06/98)
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Dwn By: MAF Date: 04/26/99
Ckd By: GL Scale: 1"= 500'
ESC Project No.: 98-024.03

Figure 3.5



LEGEND

(thick line)	APPROX. MITIGATION SITE BOUNDARY
(dashed line)	APPROX. CONTOUR
—30—	MAJOR CONTOUR
(dash-dot line)	EXISTING DITCHES AND CANALS
(scalloped line)	TREE LINE
30	GROUNDWATER CONTOURS
⊙W#	GROUNDWATER WELLS
(hatched box)	APPROXIMATE MAP AREA: Groundwater within 0.3 meters (1 foot) of the soil surface

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

PLAN VIEW

0 500 1000 1500

SCALE IN FEET

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

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

Project: GROUNDWATER CONTOURS (01/26/99)
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: 04/26/99	Figure	
Ckd By: GL	Scale: 1"= 500'	3.6	
ESC Project No.: 98-024.03			

TABLE 3.1

Representative Groundwater Elevations
ABC Mitigation Site

Date		11/6/98		12/20/98		1/26/99		4/4/99	
Well Number	Well Elevation (feet above MSL)	Depth below ground surface (feet)	Ground-water Elevation (feet above MSL)	Depth below ground surface (feet)	Ground-water Elevation (feet above MSL)	Depth below ground surface (feet)	Ground-water Elevation (feet above MSL)	Depth below ground surface (feet)	Ground-water Elevation (feet above MSL)
Restoration Planning Wells									
W-1	33.56	3.48	30.1	1.68	31.9	**0.24**	33.3	1.75	31.8
W-2	32.09	3.30	28.8	1.11	31.0	**0.49**	31.6	1.94	30.2
W-3	33.10	3.48	29.6	1.87	31.2	**0.73**	32.4	3.03	30.1
W-4	25.18	3.47	21.7	2.62	22.6	1.68	23.5	3.31	21.9
W-5	24.36	3.45	20.9	1.84	22.5	1.48	22.9	2.39	22.0
W-6	26.39	3.45	22.9	2.49	23.9	2.04	24.4	2.95	23.4
W-8	32.24	3.45	28.8	1.03	31.2	**0.55**	31.7	1.91	30.3
W-9	31.09	3.48	27.6	1.03	30.1	1.42	29.7	2.18	28.9
W-12	31.78	3.47	28.3	2.04	29.7	1.45	30.3	2.53	29.3
W-13	31.46	3.48	28.0	**0.87**	30.6	**0.51**	31.0	1.73	29.7
W-14	31.13	2.83	28.3	**0.35**	30.8	**0.23**	30.9	1.14	30.0
Reference Wells									
W-10	29.92	3.48	26.4	1.53	28.4	Well Damaged		Well Damaged	
W-11	31.83	3.41	28.4	2.05	29.8	**-0.18**	32.0	**-0.60**	32.4

3.5 WILDLIFE

Although the original forest tracts have been utilized for large-scale agricultural purposes, the adjacent forests provide food, water, and cover for various species of wetland dependent wildlife. Forested floodplains along upper and lower reaches of Acre Swamp support wildlife species adapted to riparian forest habitat. In addition, ephemeral drainageways and ponding within contiguous wetland flats and slopes provide interaction among riparian and non-riparian wildlife guilds in the region. Wetland/upland ecotones provide additional habitat diversity near the Site. These ecotones are among the most diverse and productive environments for wildlife (Brinson *et al.* 1981).

In spite of area-wide changes to forested habitat (agriculture, timber harvesting, textiles, and sand mining practices) within the region, it is still known to support large mammals such as black bear (*Ursus americanus*), bobcat (*Felis rufus*), and white-tailed deer (*Odocoileus virginianus*). In addition, the swamp and surrounding lands support many smaller mammals in a complex food chain of predator and prey elements.

Characteristic bird species that can be expected to utilize wetlands in the region include great blue heron (*Ardea herodias*), green heron, mallard (*Anas platyrhynchos*), wood duck (*Aix sponsa*), and barred owl (*Strix varia*). In addition, a high number of passerine birds, both permanent and summer resident species, nest in hardwood swamp forest. Among these are several neotropical migrants such as Swainson's warbler (*Limnothlypis swainsonii*) and prothonotary warbler (*Protonotaria citrea*), and other forest interior species such as the wood thrush (*Hylocichla mustelina*) and Acadian flycatcher (*Empidonax virescens*), that require large tracts of contiguous forest for survival (Keller *et al.* 1993).

Extensive areas of standing water, seasonal wetlands, and stream channels in the area provide favorable conditions for many species of reptiles and amphibians. Characteristic species include red-bellied water snake (*Nerodia erythrogaster*), cottonmouth (*Agkistrodon piscivorus*), yellow-bellied turtle (*Trachemys scripta*), spotted turtle (*Clemmys guttata*), southern leopard frog (*Rana utricularia*) and marbled salamander (*Ambystoma opacum*). These and numerous other reptiles and amphibians are integral components of the wetland food chain.

Extensive agricultural land on the Site, considered prevalent in the region, provides limited habitat opportunities for these wetland dependant species.

3.6 JURISDICTIONAL WETLANDS

Jurisdictional wetlands and waters were evaluated and mapped in the field by GPS. Jurisdictional areas are defined using the criteria set forth in the COE Wetlands Delineation Manual (DOA 1987). The field determination was supplemented by the groundwater drainage model near ditches and canals in the forested area (Section 4.1). Approximately 9 ha (23 ac) of jurisdictional wetlands were identified within forested sections of the Site. Figure 3.7 depicts the location of existing jurisdictional wetland systems.

NRCS records indicate that farmed portions of the Site are designated as prior-converted (PC) crop land. A PC crop land is a wetland which was both manipulated and cropped prior to 23 December 1985 to the extent that it no longer exhibits important wetland functions (Section 512.15 of the National Food Security Act Manual, August 1988). PC crop lands are not subject to regulation under the jurisdiction of Section 404 of the Clean Water Act. Approximately 41 ha (102 ac) of PC crop land occur within hydric soil areas of the Site (Figure 3.6).

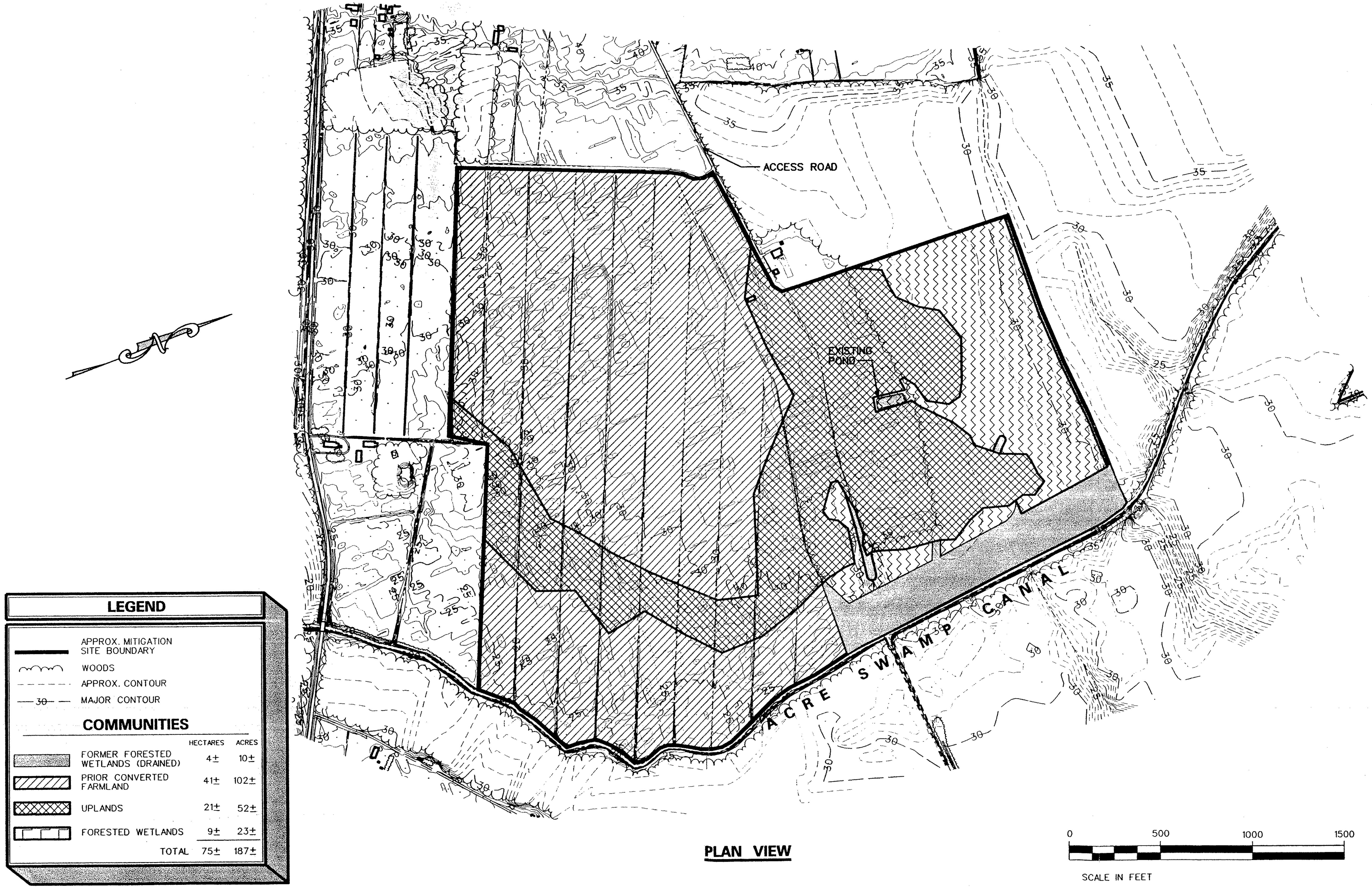
3.7 WATER QUALITY

Acre Swamp and tributaries in the Site vicinity maintain a state best usage classification of **C Sw NSW** (Stream Index No. 29-34-35-1-1) (DWQ 1998). Class **C** uses include aquatic life propagation and survival, fishing, wildlife, and secondary recreation. Secondary recreation refers to activities involving human body contact with water on an infrequent or incidental basis. These systems have also been assigned a "Nutrient Sensitive Waters" (NSW) supplemental classification, which requires limitations on future nutrient inputs that could be detrimental to water quality. In addition, the "Swamp Waters" (Sw) designation signifies systems which support low velocities and other natural characteristics, which are different from adjacent waters (DWQ 1998).

The Site consists of eroded crop land located adjacent to a network of drainage ditches and canals, including direct connectivity with a major drainageway (Acre Swamp). Fertilizers, pesticides, and nutrients associated with farming practices are expected to influence water quality in flows leaving the Site. Vegetated buffers adjacent to drainage ditches, which may serve as nutrient and chemical filtration strips, do not exist within the farm-fields. As such, runoff is expected to enter the unprotected drainage network and directly into nutrient sensitive waters of the Pamlico River.

The North Carolina Wetland Restoration Program (WRP) has developed a basinwide wetland and riparian restoration plan for the Tar-Pamlico River Basin, including watersheds that encompass the Site. The restoration plan identifies priority watersheds based on the need for restoration. Subsequently, sites within priority watersheds are evaluated to determine potential for restoration that contributes to goals established for the river basin. Primary restoration goals in the Tar-Pamlico River Basin include: 1) improvement of water quality; 2) increase in flood retention capacity; 3) improvement in wildlife habitat; and 4) increase in recreational opportunities.

The Site resides within the State, 14 digit sub-basin 03020104110010, within Hydrologic Unit (HU) # 4. This watershed to Acre Swamp is designated as a high priority sub-basin and a targeted HU for restoration use.



MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

EXISTING JURISDICTIONAL WETLANDS
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Project:

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

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

Dwn By: MAF	Date: 04/26/99	Figure
Ckd By: GL	Scale: 1"= 500'	3.7
ESC Project No.: 98-024.03		

4.0 WETLAND RESTORATION STUDIES

4.1 GROUNDWATER MODELING

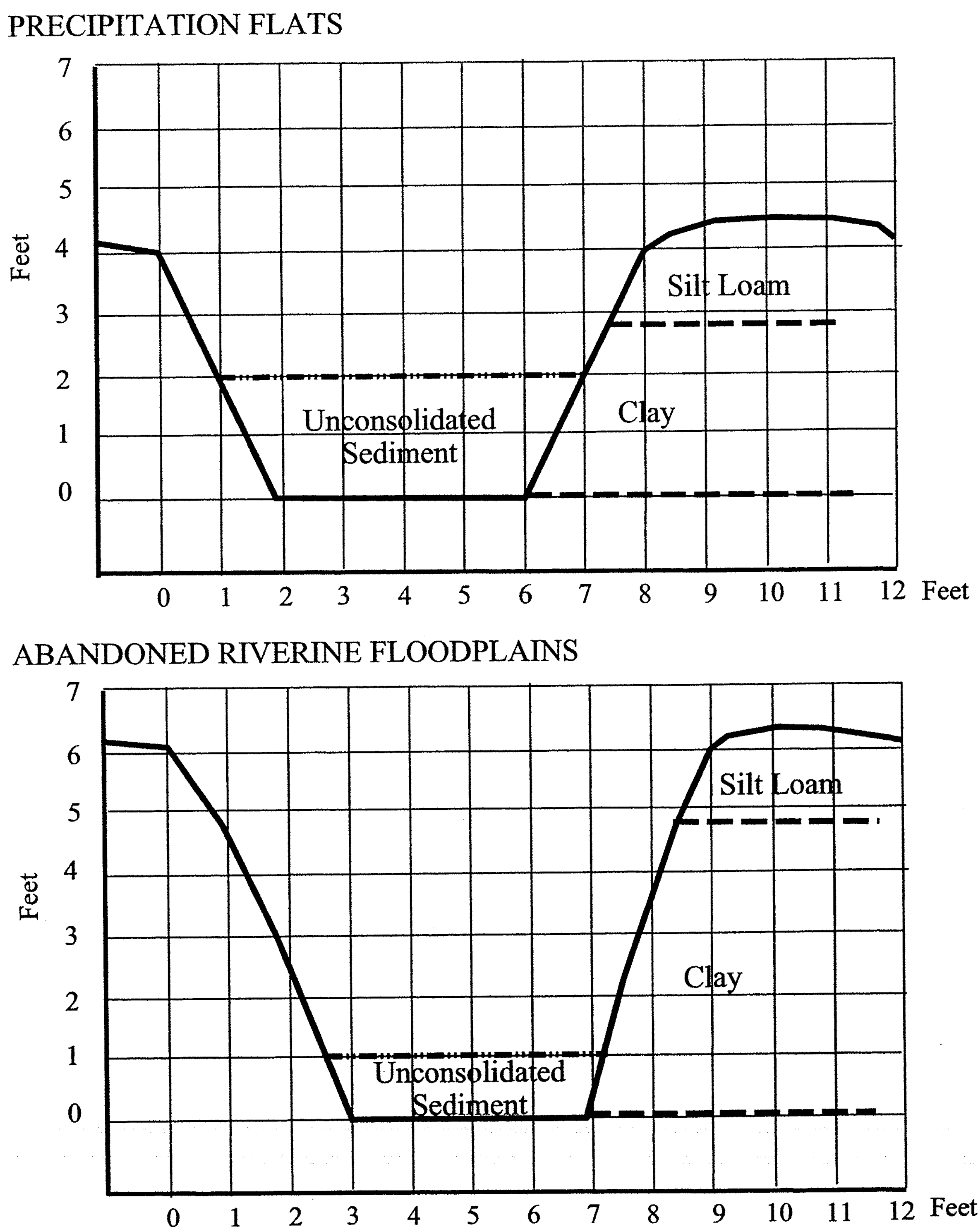
Groundwater modeling was performed to characterize water table elevations under historic (reference), existing, and post-restoration conditions. The groundwater modeling software selected for simulating shallow subsurface conditions and groundwater behavior at the Site is DRAINMOD. This model was developed 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 networks 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 incorporating 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. Required model inputs include: 1) precipitation data; 2) soil and surface storage parameters; 3) drain depth and spacing data; 4) hydraulic conductivity values; 5) evapotranspiration rates; 6) the threshold water table depth (25 cm [12 in]); 7) the required duration of high water tables (ex: 13 days); and 8) beginning and ending dates of the growing season. Typical ditch cross-sections are depicted in Figure 4.1. The United States Department of Agriculture (USDA) soil texture classification, conductivity ranges, and number of days in the growing season were obtained from the NRCS soil survey for Beaufort 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. DRAINMOD simulations were conducted for the time periods from 1956 to 1993, using the climatological record for Greenville, N.C.

Wetland hydrology is defined in the model as groundwater within 30 cm (12 inches) of the surface for 32 consecutive days during the growing season (12.5 percent of the growing season). Additional modeling for a wetland hydrology criteria of 13 consecutive days (5



EcoScience Corporation

TYPICAL DITCH CROSS-SECTIONS:
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Figure: 4.1

Project: 98-024.03

Date: April 1999

percent of the growing season) was conducted to allow further analysis of wetland restoration potential. The growing season is defined as the period between 13 March and 25 November (256 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).

4.1.2 Model Applications and Results

DRAINMOD simulations were used to model: 1) the historic, reference wetland conditions (relatively undisturbed); 2) the hydroperiod exhibited by abandoned farmland immediately after ditches are effectively removed; and 3) the zone of wetland loss and degradation due to ditching under existing conditions. The models for reference and abandoned farmland are theoretical applications of DRAINMOD that will require field testing to substantiate predictions. The model was applied to Leaf and Muckalee soils which dominate the Site. Model applications and results are summarized below.

4.1.2.1 Reference Wetland Model

For development of reference wetland standards, modeling was performed to predict historic wetland hydroperiods (as percent of the growing season) in various undrained conditions. The reference model was developed by effectively eliminating the influence of ditching and forecasting the average hydroperiod over the number of years modeled. Two iterations were performed to evaluate changes in wetland hydroperiod between: 1) old field (post farmland) stages of wetland development; and 2) forested stages of wetland development.

Old field stages of wetland development were simulated by modifying soil drainage characteristics such as rooting functions in proximity to the B (clay) horizon, A horizon (plow layer) hydraulic conductivity, and water storage capacity within the plow layer. The old field model provides a hypothetical approximation of the potential hydroperiod exhibited immediately after drainage networks are removed.

Forested stages were modeled to predict wetland hydroperiods that may occur within reference (relatively undisturbed) wetlands in the region. The reference forest model may provide a projection of wetland hydroperiods and associated functions that may be achieved over the long term (10+ years) as a result of wetland restoration activities and steady state forest conditions. The steady state model application assumes increases in rooting functions, organic matter content, and water storage capacity relative to post-farmland periods.

Leaf Soils

The reference model predicts that, in Leaf soils, old field stages of wetland development exhibit an average wetland hydroperiod encompassing 8% of the growing season over the years modeled (Table 4.1). This average hydroperiod translates to free water within 0.3 m (1 ft) of the soil surface for a 21 day period extending from 21 March to 10 April. During the 38-year modeling period, reference wetland hydroperiods exhibited a range extending from

TABLE 4.1

DRAINMOD Results
Reference Wetland Hydroperiods For Leaf Soil
ABC Mitigation Site

Percent of Growing Season	**Number of Years Wetland Hydrology Achieved** (38-year model period)	
	Old Field Stage (immediately after backfilling and plugging ditches, relatively low surface water storage)	**Forested Stages** (10+ years after restoration, relatively high surface water storage)
4% (10 days)	34/38	37/38
6% (15 days)	28/38	37/38
8% (21 days)	**21/38**	35/38
10% (26 days)	12/38	33/38
12% (31 days)	7/38	32/38
14% (36 days)	5/38	31/38
16% (41 days)	1/38	28/38
18% (46 days)	1/38	26/38
20% (51 days)	0/38	**22/38**
22% (57 days)	0/38	17/38
24% (62 days)	0/38	12/38

less than 4% (4 out of 38 years) to more than 18% (1 out of 38 years) of the growing season, dependent upon rainfall patterns (Table 4.1).

As surface topography, rooting, roughness, and storage variables increase during successional phases, the model predicts that hydroperiods will increase to steady state forest conditions averaging a 20% wetland hydroperiod over the 38 years modeled (Table 4.1). The average hydroperiod translates to free water within 0.3 m (1 ft) of the soil surface for a 51 day period extending from 21 March to 10 May. Again, the hydroperiod ranges from less than 12% (6 years) to more than 24% (12 years) during the 38 year period dependent upon rainfall patterns. Therefore, the reference model suggests that groundwater fluctuations must be tracked within a reference wetland site to accurately assess a target hydroperiod for any given year.

As described above, the average wetland hydroperiod in Leaf soil is forecast to exhibit a gradual increase from 8% of the growing season immediately after drainage structures are removed to as much as 20% under steady state forest conditions. A gradual increase in hydroperiods may suggest that water storage capacity (rooting functions, organic materials/debris accumulation, microtopography, etc.) exhibits a significant effect on maintenance of wetland hydrology in precipitation driven wetlands. In old field stages of succession, accelerated runoff may occur within the former plow layer. For purposes of this preliminary model, runoff is assumed to occur at accelerated rates which reduce the influence of evapotranspiration on wetland hydrodynamics. If so, accelerated runoff will reduce amounts of available water within the soil surface layer along elevated flats and slopes in western portions of the Site. Consequently, periodic flooding or accelerated discharge into streams would be expected to occur at the lower end of the landscape gradient, along Acre Swamp. This accelerated drainage would be expected to decrease as successional vegetation colonizes the Site.

Because wetland hydroperiods during old field stages of wetland development are projected to extend for less than 12.5% of the growing season, wetland monitoring plans that extend for a five year period after restoration should utilize a minimum 5% wetland hydrology criteria to substantiate restoration success. Alternatively, hydroperiods within the restored wetland area may be tracked relative to the reference wetland, with success criteria stipulating that restored hydroperiods must exceed 40% of the hydroperiod exhibited by reference. The 40% threshold is established by dividing model predictions for old field stages of wetland development (8% projected hydroperiod) by model predictions for reference, steady state wetlands (20% projected hydroperiod).

Methods may be employed to increase complexity in the soil surface (A horizon plow layer) and the surface of the B (subsurface clay) horizon during restoration activities. These modifications, including woody debris deposition, soil scarification, and extensive deep harrowing (ripping), may increase water storage capacity across the surface of relatively impermeable layers (B horizon surface). If water storage is not adequately established during early stages of wetland development, marginal or non-wetland conditions may occur in elevated (upslope) areas of the Site. Invariably, rooting influences on water storage capacity will require an extended period of forest development to establish (assumed at greater than 10 years).

Muckalee Soil

The reference wetland model predicts that, in Muckalee soils, old field stages of wetland development exhibit an average wetland hydroperiod encompassing 12% of the growing season over the years modeled (Table 4.2). This average hydroperiod translates to free water within 0.3 m (1 ft) of the soil surface for a 31 day period extending from 21 March to 20 April.

During forest development, the model predicts that hydroperiods will increase to steady state forest conditions averaging a 24% wetland hydroperiod over the 38 years modeled. The average hydroperiod translates to free water within 0.3 m (1 ft) of the soil surface for a 62 day period extending from 21 March to 20 May. Therefore, the average wetland hydroperiod is forecast to increase from 12% of the growing season immediately after drainage structures are removed and crop land is abandoned to as much as 24% under steady state forest conditions.

4.1.2.2 Wetland Degradation Model

The reference wetland model was utilized to forecast the maximum zone of ditch influence on reference wetland hydroperiods. The maximum zone of influence may be used to predict the area of wetland hydrological enhancement that may result due to effective ditch removal. In addition, the model provides an estimate of the area that may continue to be degraded in perpetuity by remaining ditches and canals used to drain adjacent properties. Ditch depths and spacing were varied in the model until wetland hydroperiods were reduced relative to the reference hydroperiods depicted in Table 4.1 and 4.2 (20% to 24% of the growing season).

In Leaf soils, the model predicts that a 1.2-m (4-ft) deep ditch exhibits a zone of influence on the reference wetland hydroperiod for 195 m (640 ft) in old field stages of wetland development (Table 4.3). As the site succeeds towards steady state forest conditions, the zone of potential wetland degradation due to a 1.2-m (4-ft) deep ditch is reduced due to projected, lower infiltration and runoff rates. The potential zone of degradation in forested conditions is forecast to extend 49 m (160 ft) into the wetland interior (Table 4.3). In effect, forest development exhibits a dampening effect on ditch influence over time, most likely resulting from increased rooting functions, surface/subsurface microtopography, increased organic matter content, and increased water storage across more complex wetland surfaces. Figure 4.2 provides a depiction of modeled wetland hydroperiods based on ditch depths and spacings under existing conditions.

PLAN VIEW

0 500 1000 1500

SCALE IN FEET

LEGEND

		Hectares	Acres
	APPROX. MITIGATION SITE BOUNDARY		
	WOODS		
	APPROX. CONTOUR		
—30—	MAJOR CONTOUR		
	UPLAND	21±	52±

WETLAND HYDROLOGY

		Hectares	Acres
	< 5%	22±	56±
	5%-12.5%	25±	61±
	12.5%-20%	1±	2±
	20% (REFERENCE)	6±	16±
	TOTAL	75±	187±

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

Dwn By: MAF | Date: 04/26/99 | Ckd By: GL | Scale: 1"= 500' | ESC Project No.: 98-024.03 | Figure 4.2

Project: PRE-RESTORATION DRAINMOD RESULTS
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

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

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

TABLE 4.2

DRAINMOD Results
Reference Wetland Hydroperiods For Muckalee Soil
ABC Mitigation Site

Percent of Growing Season	**Number of Years Wetland Hydrology Achieved** (38-year model period)	
	Old Field Stage (immediately after backfilling and plugging ditches, relatively low surface water storage)	**Forested Stages** (10+ years after restoration, relatively high surface water storage)
10% (26 days)	27/38	34/38
12% (31 days)	**21/38**	33/38
14% (36 days)	15/38	32/38
16% (41 days)	9/38	30/38
18% (46 days)	4/38	26/38
20% (51 days)	1/38	26/38
22% (57 days)	1/38	25/38
24% (62 days)	1/38	**21/38**
26% (67 days)	0/38	14/38

TABLE 4.3

DRAINMOD Results
Zone of Wetland Loss and Wetland Degradation for Leaf Soil
ABC Mitigation Site

Old Field Stage (immediately after backfilling and plugging ditches) (relatively low surface storage)			
Depth (feet)	**Wetland Hydroperiod (% of the growing season)**		
	0-5%	**5-8%**	**>8%**
	Zone of Influence (feet)*		
1	25	nc	na
2	35	465	na
3	45	555	na
4	50	640	na
5	55	nc	na

Forested Stages (10+ years after restoration) (relatively high surface storage)			
Depth (feet)	**Wetland Hydroperiod (% of the growing season)**		
	0-5%	**5-12.5%**	**12.5-20%**
	Zone of Influence (feet)*		
1	10	30	nc
2	20	40	120
3	20	50	150
4	25	55	160
5	30	60	nc

* Zone of influence equal to ½ of the modeled ditch spacing
nc: not calculated
na: not acheivable

<u>TABLE 4.4</u>

DRAINMOD Results
Zone of Wetland Loss and Degradation for Muckalee Soil
ABC Mitigation Site

Old Field Stage (immediately after backfilling and plugging ditches) (relatively low surface storage)			
Depth (feet)	**Wetland Hydroperiod (% of the growing season)**		
	0-5%	**5-12%**	**>12%**
	Zone of Influence (feet)*		
10	250	1465	na

Forested Stages (10+ years after restoration) (relatively high surface storage)			
Depth (feet)	**Wetland Hydroperiod (% of the growing season)**		
	0-5%	**5-12.5%**	**12.5-24%**
	Zone of Influence (feet)*		
10	235	330	~1000

* Zone of influence equal to ½ of the modeled ditch spacing
na: not acheivable

4.1.2.3 Wetland Loss Model

The wetland loss model was applied to determine which areas may not achieve wetland hydrology criteria (5% and 12.5% of the growing season) under existing and post-restoration conditions (Table 4.3 and Table 4.4). After conceptual restoration plans were developed, DRAINMOD was subsequently applied to determine the influences from remaining drainage networks on the Site or in the Site vicinity. Remaining drained sites are subsequently excluded from areas which provide wetland restoration potential.

In Leaf soils, DRAINMOD simulations for existing conditions indicate that portions of the prior converted (PC) crop land area are forecast to meet wetland hydrology criteria (5 % of the growing season) at distances of 8 m (25 ft) to 17 m (55 ft) from the existing drainage ditches (Table 4.3 and Figure 4.2). Muckalee soils are considered effectively drained throughout the Site due to the 3 m (10-ft depth) of the Acre Swamp channel and simulated drainage rates (Table 4.4 and Figure 4.2). Away from Acre Swamp, the remainder of agricultural fields are projected to support average hydroperiods ranging from 5% to 8% of the growing season under existing conditions.

In forested areas, removal of jurisdictional wetland hydrology (12.5%) by ditching in Leaf soils is localized (10 m [30 ft] to 20 m [60 ft] from the ditch) while degradation of historic wetland hydroperiods (12.5% to 20%) is more widespread (40 m [120 ft] to 53 m [160 ft] from the ditch) (Table 4.3). The 3-m (10-ft) deep Acre Swamp canal is simulated as draining the entire Muckalee soil map unit in forested areas as well (Table 4.4 and Figure 4.2). Therefore, riparian areas adjacent to the dredged stream are projected as never achieving wetland jurisdictional status unless the stream is modified throughout the watershed, including adjacent properties.

4.1.2.4 Post-Restoration DRAINMOD Results

Site alterations to restore wetland hydrology are expected to entail effective removal of drainage systems and re-introduction of surface and subsurface microtopography (Section 5.1). However, canals and ditches extending through hydric soils along the site periphery will remain open to prevent impacts to adjacent properties. Post-restoration groundwater modeling was applied to forecast wetland hydrology within the Site interior and near these perimeter canals. Primary drainage features consist of the Acre Swamp Canal, a drain along the northern property boundary, and ditches along the southern and western property boundaries.

Post-restoration DRAINMOD simulations were conducted for remaining open ditch segments under old field stages of wetland development (Figure 4.3) and forested stages of wetland development (Figure 4.4). These simulations include increases in projected surface storage ratings due to increased microtopography resulting from scarification, deep harrowing, and restoration of forest vegetation in wetland and upland buffer areas.

LEGEND

		HECTARES	ACRES
	APPROX. MITIGATION SITE BOUNDARY		
	WOODS		
	APPROX. CONTOUR		
—30—	MAJOR CONTOUR		
	UPLAND	21±	52±

WETLAND HYDROLOGY

	HECTARES	ACRES
< 5%	10±	25±
5%-12.5%	37±	92±
12.5%-20%	1±	2±
20% (REFERENCE)	6±	16±
TOTAL	75±	187±

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

NOTE:
RESULTS REPRESENT RELATIVELY LOW SURFACE STORAGE PROJECTED TO DOMINATE DURING EARLY OLD FIELD SUCCESSION.

PLAN VIEW

0 500 1000 1500
SCALE IN FEET

Project: POST-RESTORATION DRAINMOD RESULTS (OLD FIELD STAGE) ABC MITIGATION SITE BEAUFORT COUNTY, NORTH CAROLINA

Client: NC DEPARTMENT OF TRANSPORTATION

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

Dwn By: MAF Date: 04/26/99
Ckd By: GL Scale: 1"= 500'
ESC Project No.: 98-024.03
Figure 4.3

LEGEND

		HECTARES	ACRES
	APPROX. MITIGATION SITE BOUNDARY		
	WOODS		
	APPROX. CONTOUR		
—30—	MAJOR CONTOUR		
	UPLAND	21±	52±

WETLAND HYDROLOGY

		HECTARES	ACRES
	< 5%	10±	24±
	5%-12.5%	3±	8±
	12.5%-20%	1±	3±
	20% (REFERENCE)	40±	100±
	TOTAL	75±	187±

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

NOTE:
RESULTS REPRESENT RELATIVELY HIGH SURFACE STORAGE PROJECTED TO DOMINATE UNDER FORESTED CONDITIONS.

PLAN VIEW

0 500 1000 1500

SCALE IN FEET

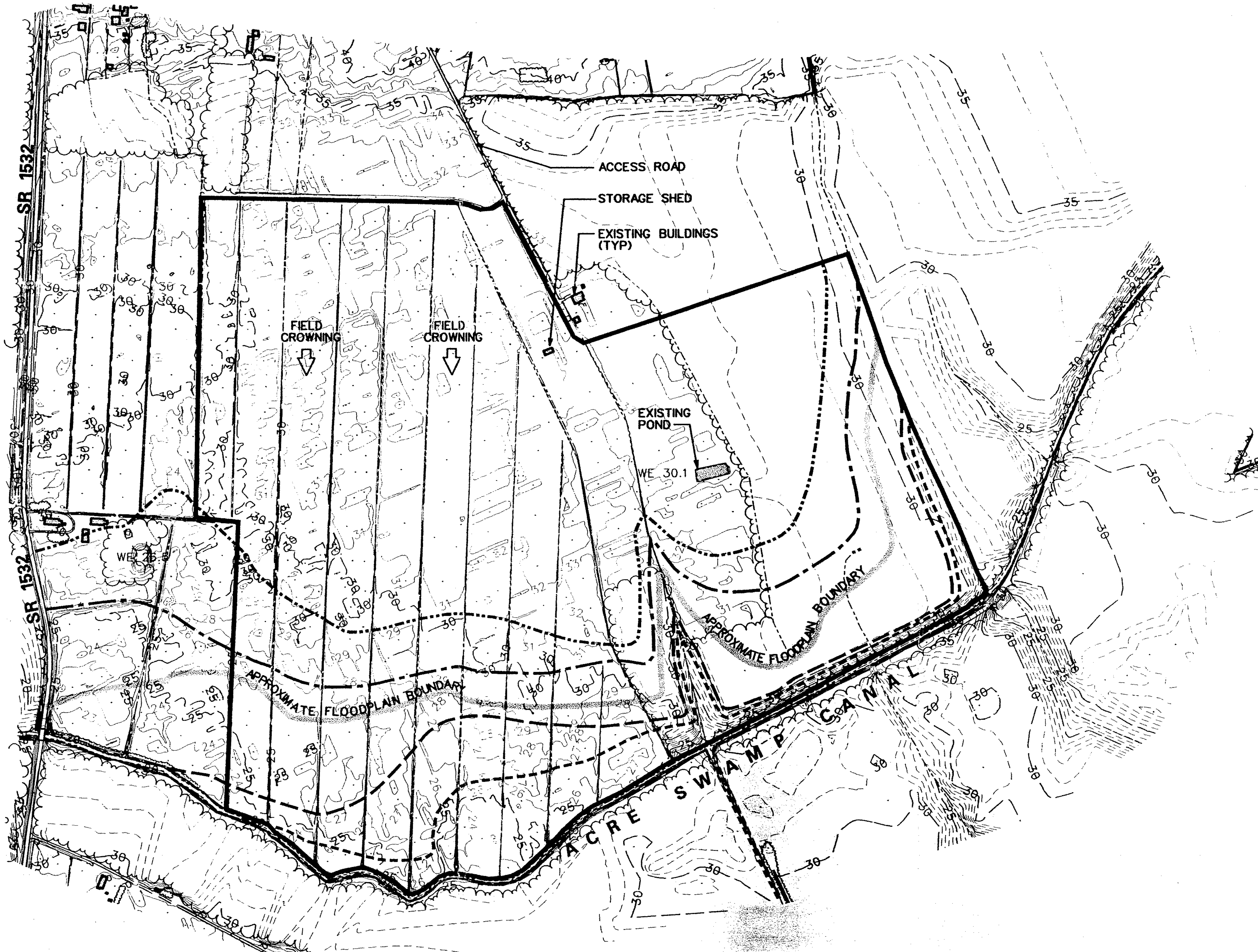
Project: POST-RESTORATION DRAINMOD RESULTS (FORESTED STAGES) ABC MITIGATION SITE BEAUFORT COUNTY, NORTH CAROLINA

Dwn By: MAF | Date: 04/26/99
Ckd By: GL | Scale: 1"= 500'
ESC Project No.: 98-024.03

Figure 4.4

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

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518



PLAN VIEW

0 500 1000 1500

SCALE IN FEET

LEGEND

▬▬	APPROX. MITIGATION SITE BOUNDARY		
– – –	APPROX. CONTOUR		
—30—	MAJOR CONTOUR		
-·-·-·-	EXISTING DITCHES AND CANALS		
		HECTARES	ACRES
⌒⌒⌒	FORESTED AREA	19±	46±

FLOOD FREQUENCY

CONFINED WITHIN CHANNEL BANKS	1 YEAR
CONFINED WITHIN CHANNEL BANKS	2 YEAR
- - - - -	5 YEAR
— — —	10 YEAR
▬▬▬ (shaded)	25 YEAR
—·—	50 YEAR
-···-···-	100 YEAR

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

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

Project: FLOOD FREQUENCY ANALYSIS
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: 04/26/99	Figure	
Ckd By: GL	Scale: 1"= 500'	4.5	
ESC Project No.: 98-024.03			

Table 4.5

Flood Frequency Analyses
Water Surface Elevations for Different Flood Frequencies

Section	Description	Return Interval						
		1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
		Elevation Above Mean Sea Level [meters (ft)]						
APPR	50 ft upstream of SR 1532	5.4 (17.8)	5.7 (18.8)	6.3 (20.8)	6.7 (22.0)	7.1 (23.4)	8.0 (26.1)	8.9 (29.1)
SEC1	450 ft upstream of SR 1532	5.8 (19.0)	6.2 (20.2)	6.7 (22.1)	7.1 (23.3)	7.7 (25.2)	8.1 (26.5)	8.9 (29.2)
SECA	950 ft upstream of SR 1532	6.2 (20.3)	6.6 (21.5)	7.1 (23.4)	7.6 (24.8)	8.0 (26.4)	8.3 (27.2)	9.0 (29.4)
SEC3	1450 ft upstream of SR 1532	6.5 (21.4)	6.9 (22.7)	7.6 (24.9)	8.0 (26.3)	8.5 (28.0)	8.7 (28.4)	9.1 (29.7)
SEC4	1950 ft upstream of SR 1532	6.9 (22.5)	7.3 (23.8)	8.0 (26.1)	8.4 (27.6)	8.8 (28.9)	9.0 (29.4)	9.2 (30.2)
SEC5	2450 ft upstream of SR 1532	7.2 (23.5)	7.6 (24.9)	8.3 (27.3)	8.8 (28.8)	9.2 (29.9)	9.3 (30.4)	9.4 (31.0)
SECB	3150 ft upstream of SR 1532	7.5 (24.7)	8.0 (26.1)	8.7 (28.3)	9.2 (29.8)	9.4 (30.8)	9.5 (31.3)	9.7 (31.8)
SEC6	3650 ft upstream of SR 1532	7.8 (25.5)	8.2 (26.8)	8.7 (28.6)	9.1 (29.9)	9.4 (30.9)	9.6 (31.4)	9.7 (31.9)
SEC7	4150 ft upstream of SR 1532	8.0 (26.3)	8.4 (27.6)	8.8 (29.0)	9.2 (30.2)	9.5 (31.2)	9.7 (31.7)	9.8 (32.1)
SEC8	4650 ft upstream of SR 1532	8.3 (27.2)	8.7 (28.5)	9.1 (29.8)	9.3 (30.6)	9.6 (31.6)	9.8 (32.0)	9.9 (32.6)
SEC9	5150 ft upstream of SR 1532	8.6 (28.2)	9.0 (29.4)	9.4 (30.7)	9.6 (31.4)	9.8 (32.2)	10.0 (32.7)	10.1 (33.3)

Figure 4.3 (old field stage) suggests that approximately 37 ha (92 ac), composed primarily of former farmland, will support wetland hydrology from between 5% and 12.5% of the growing season. After forest development ensues (Figure 4.4), the Site will approach reference wetland conditions (20% of the growing season) within approximately 40 ha (100 ac). An additional, approximately 4 ha (11 ac) located in the outlying vicinity of remaining perimeter ditches will support average wetland hydroperiods between 5% and 20% of the growing season. Assuming that regulatory agencies allow wetland mitigation credit to be applied for conditions projected to occur after completion of the 5-year monitoring plan, this 44 ha (111 ac) area includes the extent of wetlands projected to be supported by the Site in perpetuity. The remaining, approximately 31 ha (76 ac) is projected to support upland buffers along remaining ditches and within nonhydric soil (upland) areas.

4.2 SURFACE WATER ANALYSES

Surface water analyses include: 1) modeling the frequency and extent of overbank flooding from Acre Swamp; and 2) analysis of ditch profiles extending from off-site drainage ditches into the Site interior. The analyses are designed to predict the extent of riverine influence on wetland hydrology due to overbank flooding along with appropriate procedures to minimize hydraulic impacts to adjacent properties.

4.2.1 Overbank Flood Model

The objective of developing the overbank flood model was to determine and compare the extent of flooding along Acre Swamp under existing and historic conditions. The results of the analyses were utilized to determine the potential for restoration of historic stream channel dimensions and adjacent riverine wetland systems.

The hydraulic analysis was performed using the Water Surface Profile Computational Model (WSPRO, Appendix B). The accuracy of model results were evaluated using Federal Emergency Management Agency (FEMA) studies within the Acre Swamp watershed immediately below the Site. The computer model was developed by establishing surveyed cross sections of the existing dredged channel and cross sections of the Acre Swamp valley from topographic mapping. Observations of existing hydraulic characteristics were incorporated into the model and computed water surface elevations were calibrated by utilizing engineering judgement. The historic and existing floodplain boundaries were further predicted by existing soil and landform characteristics along with comparison to FEMA studies within the lower watershed.

The hydraulic analysis indicates that, under existing conditions, there is negligible overbank flooding of Acre Swamp in its current dredged channel. Table 4.5 and Figure 4.5 depict the projected surface water elevations for the 1, 2, 5, 10, 50, and 100-year storm events. The higher frequency storms (less than 2-year return interval) and corresponding bankfull flows do not approach the land surface (former floodplain) elevations under current conditions. Therefore, overbank flooding does not represent a net contributor to wetland hydrology in floodplain portions of the Site.

The surface water profile for the 25-year storm is expected to range from 7.7 m (25.2 ft) to 9.8 m (32.2 ft) above MSL under existing conditions, extending across approximately 17 ha (43 ac) of land within the Site (Figure 4.5). Conversely, relict floodplain and soil features suggest that the 1-year to 2-year storm approached a similar flood elevation under historic conditions. Due to the major modification in overbank flood characteristics by dredging, modifications to the channel such as weir placement for riverine wetland restoration would not be contained within the boundaries of the Site. Additional flooding would be expected along Acre Swamp immediately adjacent to, and upstream of the Site, potentially inducing wide spread hydrologic trespass. Riverine wetland restoration would be expected to require excavation of a new floodplain at a lower elevation immediately adjacent to the existing canal.

4.2.2 Off-Site Drainage

Groundwater wetland restoration efforts will entail effective backfilling and plugging of ditches within the Site. However, drainage originating from adjacent properties flows through portions of, or along the boundary of the Site. Therefore, provisions must be made to accommodate off-site drainage while minimizing potential for impacts to adjacent properties.

Eight surface water flow infalls (ditches) reside along the boundary of the Site. These ditches have been labeled as Infall # 1 through # 8 in Figure 3.1. Infalls # 1, 2, 3, 7, and 8 discharge into ditches along the site periphery. Therefore, these perimeter ditches will be left open during wetland restoration efforts.

Infalls # 4, 5, and 6 discharge into ditches bisecting north-central sections of the property. These infalls are associated with a house and driveway located in the area. The driveway and adjacent ditch also serve as the primary access to the Site. Therefore, provisions for drainage of infalls # 4, 5, and 6 must be made within the Site interior. Infalls # 4, and 5 flow through a ditch bisecting the upper ridge portion of the groundwater slope (upland) area (Figure 3.1). The impact of this ditch on projected wetland functions is expected to be negligible as groundwater flows from the slope physiographic area are not significantly altered by the channel. Therefore, this central ditch will be left open under post-restoration conditions.

Infall # 6 flows through a ditch located along lower portions of the groundwater slope along the existing forest line. Significant discharge of groundwater has been noted flowing into the ditch, suggesting that near-surface groundwater flow has been intercepted along the lower slope prior to entry into the adjacent forested wetlands. Conversion of migrating groundwater to confined surface water flow is expected to have degraded wetland hydroperiods and associated functions in the forested area. Therefore, this ditch should be effectively eliminated to provide wetland enhancement benefits in the forested area.

Ditch profile measurements indicate that the ditch invert at Infall # 6 resides at approximately 9.1 m (30 ft) above MSL. Conversely, the central ditch invert that drains infalls #4, and 5 drops below 9.0 m (29 ft) approximately 244 m (800 ft) below the confluence of infalls with the Site boundary. Therefore, Infall #6 may be diverted to the south and connected to the central ditch. Detailed procedures for accommodating the off-site drainage is included in Section 6.0 (Mitigation Plan).

4.3 REFERENCE WETLAND STUDIES

A reference wetland system has been utilized as the primary method for development of this wetland restoration plan. The primary reference wetland, as depicted in Figure 3, is located in the northwestern section of the Site. Additional reference areas were evaluated to the north and south of the Site, along similar landscape positions supporting Leaf and Bayboro soils in the area. The primary reference wetland will be utilized to supplement the monitoring plan as a comparison between relatively undisturbed wetlands and adjacent, restored wetland areas. Reference wetland studies included: 1) groundwater data analyses; 2) soil surface characterization; and 3) vegetation sampling.

4.3.1 Groundwater Data Analyses

During well installation efforts, two continuous recording wells were installed in reference and 12 wells were installed in potential restoration areas. The data was collected periodically from November 6, 1998 through April 4, 1999 and compared between the two systems. In addition, 27 systematic soil borings were taken in the reference wetland during the groundwater sample period to evaluate changes in water table elevations across portions of the reference landscape. Comprehensive well data is contained in Appendix A; Table 3.1 depicts water table measurements at periodic intervals during the sample period.

In November, groundwater remained relatively consistent within reference and restoration areas at an average depth of 1 m (3.4 ft) below the soil surface. In December, groundwater tables elevated, on average, to within 0.6 m (2 ft) of the soil surface throughout the area. In January, a majority of the wells in both reference and the restoration area elevated to within 1 ft of the soil surface. In the restoration area, groundwater draw-down occurred rapidly after each rainfall event, approaching the surface for, on average, a three- to seven-day cycle after significant rainfall events. However, reference wells remained saturated or inundated from 26 December 1998 through 4 April 1999.

Soil borings adjacent to the reference wells in early April 1999 indicated that saturation to within 0.3 m (1 ft) of the surface persisted throughout the reference area including significant variation based on surface microtopography. The variation in water table depths was most pronounced between hummocks and depressions in the reference area. Therefore, soil surface cross-sections and profiles were prepared to evaluate the relationship between depth to groundwater and microtopography between reference monitoring wells and soil borings (Section 4.3.2).

4.3.2 Soil Surface Characterization

Wetland surface microtopography was evaluated in reference wetlands by measuring changes in relief across local reaches of the landscape. In Leaf soils, depressional storage associated with microtopography appears to play an important role in wetland hydrology and function. Microtopography was measured through the use of a laser level tied to well elevations in the reference area.

Surface topography varies across a 131 m (430 ft) cross-section from 0.3 m (1 ft) above the groundwater table to 0.2 m (0.8 ft) below the groundwater table. Within the interior reference wetland area, depressional areas are generally spaced at distances ranging from 9 m (30 ft) to 30 m (100 ft) between hummocks and flats. The depressions ranged from 6 m (20 ft) to 21 m (70 ft) in width and averaged approximately 0.2 m (0.7 ft) in maximum depth. The area of depressional storage per depression averaged 3.7 m^2 (40 ft^2). The depressional areas also support an increased accumulation of organic matter, with sphagnum mosses and characteristic swamp forest species dominating the inundated areas.

4.3.3 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 was 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 (riverine floodplains, groundwater slopes, and precipitation flats) were identified in mature forested areas that characterize the communities proposed for mitigation. Circular plot sampling was utilized in data collection. Sites were chosen that best characterize expected steady-state forest composition. Species were recorded along with individual tree diameters, canopy class, and dominance. From collected field data, importance values (Brower *et al.* 1990) of dominant trees were calculated. The composition of shrub/sapling and herb strata were recorded and identified to species. The vegetative communities targeted include riverine swamp forest (Blackwater Subtype), mesic hardwood forest, and nonriverine wet hardwood forest (Schafale and Weakley 1990). Soils targeted for each community include Leaf, Muckalee and Lenoir (USDA 1990).

1. Riverine Swamp Forest: Three plots from on-site and three plots from a regional data base were sampled. The overstory is dominated by sweetgum (*Liquidambar styraciflua*) (Importance value [IV] 25%), red maple (*Acer rubrum*), (23%), willow oak (*Quercus phellos*) (12%), laurel oak (*Quercus laurifolia*) (9.9%), swamp tupelo (*Nyssa biflora*) (6%), water oak (*Quercus nigra*) (5%), swamp chestnut oak (*Quercus michauxii*) (5%), American holly (*Ilex opaca*) (5%) (Table 4.6). Other species include bald cypress (*Taxodium distichum*) (13%), American elm (*Ulmus americana*), red bay (*Persea palustris*), green ash (*Fraxinus pennsylvanica*), Tulip poplar (*Liriodendron tulipifera*), and sweet bay (*Magnolia virginiana*), white oak (*Quercus alba*). The sapling/shrub layer is open and dominated by red maple, sweet pepper bush (*Clethra alnifolia*), green ash, American holly, swamp chestnut oak, and sweet bay. The herbaceous layer is generally sparse and dominated by Japanese honeysuckle (*Lonicera sempervirens*), leucothoe (*Leucothoe axillaris*), giant cane (*Arundinaria gigantea*), Virginia chain-fern (*Woodwardia virginica*), and greenbriers (*Smilax* spp.).

2. Mesic Hardwood Forest: Two on-site plots were sampled. These plots represent the wetter end of this community type. The overstory dominants are laurel oak (IV 17%), sweet gum (16%), water oak (15%), sweet bay (10%), swamp chestnut oak (9%), red maple (8%), loblolly pine (*Pinus taeda*) (7%), American beech (*Fagus grandifolia*) (5%), and tulip poplar (5%) (Table 4.7). Other species found in the overstory are shagbark hickory (*Carya ovata)*, cherrybark oak (*Quercus pagoda*), and white oak. The common sapling/shrub species include red maple, sweet pepper bush, Titi (*Cyrilla racemosa*), horse sugar (*Symplocus tinctoria*), blueberry (*Vaccinium* spp.), ink-berry (*Ilex glabra*), and sweet bay. Herbaceous species include giant cane, Fetter-bush (*Lyonia lucida*), crane-fly orchid (*Tipularia discolor*), and Carolina jasimine (*Gelsemium sempervirens*).

3. Nonriverine Wet Hardwood Forest: Two plots from on-site and four plots from a regional data base were sampled. The overstory is dominated by willow oak (importance value [IV] 19%), sweet gum (19%), swamp chestnut oak (11%), red maple (10%), American holly (9%), water oak (8%), tulip poplar (7%), laurel oak, and swamp tupelo (5%) (Table 4.8). Other species found in the overstory include American beech (*Fagus grandifolia*), red bay, sweet bay, swamp tupelo, cherrybark oak, loblolly pine, and bald cypress. The sapling/shrub layer is characterized by American holly, Chinese privet (*Ligustrum sinense*), sweet pepper bush, and red bay. A sparse herbaceous layer include Japanese honeysuckle, giant cane, and sedges (*Carex* spp.).

All sites exhibited evidence of past silvicultural practices such as selective cutting, high-grading, and ditch construction which has resulted in a less diverse, intra-specific tree assemblage. Degradation of nonriverine wet hardwood forests is common throughout the region. Therefore, community restoration procedures will be modified to facilitate a reduction in dominance by disturbance adapted species such as red maple and sweet gum. RFE sampling has established a baseline data set that will be integrated into a planting plan for the mitigation

TABLE 4.6

Reference Forest Ecosystem
Riverine Swamp Forest Plots Summary (Canopy Species)

Species	Density		Basal Area		Relative Density	Relative Basal Area	Importance Value
	tress/ha	trees/acre	sq.m/ha	sq. ft/acre			
Sweetgum	388	143	12.7	55.4	26.4	22.6	24.5
Red Maple	352	130	12.2	53.3	23.9	21.7	22.8
Willow Oak	154	57	7.1	31.0	10.4	12.6	11.5
Laurel oak	36	13	9.8	42.5	2.5	17.3	9.9
Swamp Tupelo	81	30	3.2	14.0	5.5	5.7	5.6
Water Oak	108	40	1.9	8.5	7.4	3.5	5.4
Swamp Chestnut Oak	81	30	2.9	12.5	5.5	5.1	5.3
American Holly	108	40	1.7	7.5	7.4	3.1	5.2
Bald Cypress	27	10	2.7	11.8	1.8	4.8	3.3
American Elm	18	7	1.3	5.5	1.2	2.2	1.7
Red Bay	45	17	0.1	0.6	3.1	0.2	1.6
Green Ash	27	10	0.3	1.5	1.8	0.6	1.2
Tulip Poplar	18	7	0.2	0.7	1.2	0.3	0.8
Sweet Bay	18	7	0.2	0.7	1.2	0.3	0.8
White Oak	9	3	0.1	0.1	0.6	0.1	0.3
Total	1084	400	43.7	190.1	100	100	100

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

TABLE 4.7

Reference Forest Ecosystem
Mesic Upland Slope Forest Plots Summary (Canopy Species)

Species	Density		Basal Area		Relative Density	Relative Basal Area	Importance Value
	tress/ha	trees/acre	sq.m/ha	sq. ft/acre			
Laurel Oak	129	50	8.6	33.7	11.8	22.7	17.2
Sweetgum	173	70	5.7	22.3	16.5	15.0	15.7
Water Oak	136	55	6.7	26.1	12.9	17.6	15.3
Sweet Bay	148	60	2.1	8.2	14.1	5.5	9.8
Swamp Chestnut Oak	99	40	3.6	14.0	9.4	9.4	9.4
Red Maple	136	55	1.5	5.8	12.9	3.9	8.4
Loblolly Pine	37	15	4.0	15.8	3.5	10.6	7.1
American Beech	74	30	1.3	5.2	7.1	3.5	5.3
Tulip Poplar	49	20	1.9	7.3	4.7	4.9	4.8
Shagbark Hickory	25	10	1.3	5.0	2.4	3.3	2.8
Cherrybark Oak	25	10	0.8	3.3	2.4	2.2	2.3
White Oak	25	10	0.4	1.7	2.4	1.2	1.8
Total	1051	425	37.8	148.6	100	100	100

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

TABLE 4.8

Reference Forest Ecosystem
Nonriverine Wet Hardwood Forest Plots Summary (Canopy Species)

Species	Density		Basal Area		Relative Density	Relative Basal Area	Importance Value
	tress/ha	trees/acre	sq.m/ha	sq. ft/acre			
Willow oak	111	45	5.3	23.2	14.3	24.1	19.2
Sweetgum	198	80	2.7	11.6	25.4	12.1	18.7
Swamp Chestnut Oak	62	25	3.2	13.7	7.9	14.2	11.1
Red Maple	117	48	1.1	4.7	15.1	4.9	10.0
American Holly	93	38	1.5	6.6	11.9	6.8	9.4
Water Oak	74	30	1.5	6.4	9.5	6.6	8.1
Tulip Poplar	25	10	2.3	10.2	3.2	10.5	6.9
Laurel Oak	25	10	2.1	9.0	3.2	9.3	6.3
American Beech	19	8	1.4	6.2	2.4	6.4	4.4
Red Bay	31	13	0.1	0.4	4.0	0.4	2.2
Sweet Bay	12	5	0.4	1.7	1.6	1.7	1.7
Swamp Tupelo	6	3	0.3	1.5	0.8	1.6	1.2
Bald Cypress	6	3	0.3	1.3	0.8	1.4	1.1
Total	778	315	22.2	96.5	100	100	100

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

5.0 MITIGATION PLAN

5.1 WETLAND HYDROLOGY AND SOIL RESTORATION

Site alterations designed to restore characteristic wetland soil features and groundwater wetland hydrology include: 1) access road improvements; 2) off-site drainage redirection; 3) ditch cleaning prior to backfill; 4) depression construction; 5) impervious ditch plug construction; 6) ditch backfilling; and 7) crown removal (Figure 5.1).

5.1.1 Access Road Improvements

The primary access road to the Site represents a driveway to the adjacent private residence along the northwestern property boundary (Figure 5.1). This road may require minor improvements to support construction traffic during the implementation period. In addition, the access road may be utilized during the wetland monitoring period and by land managers of the wetland area in perpetuity. Access road improvements may be performed concurrently with the off-site drainage redirection.

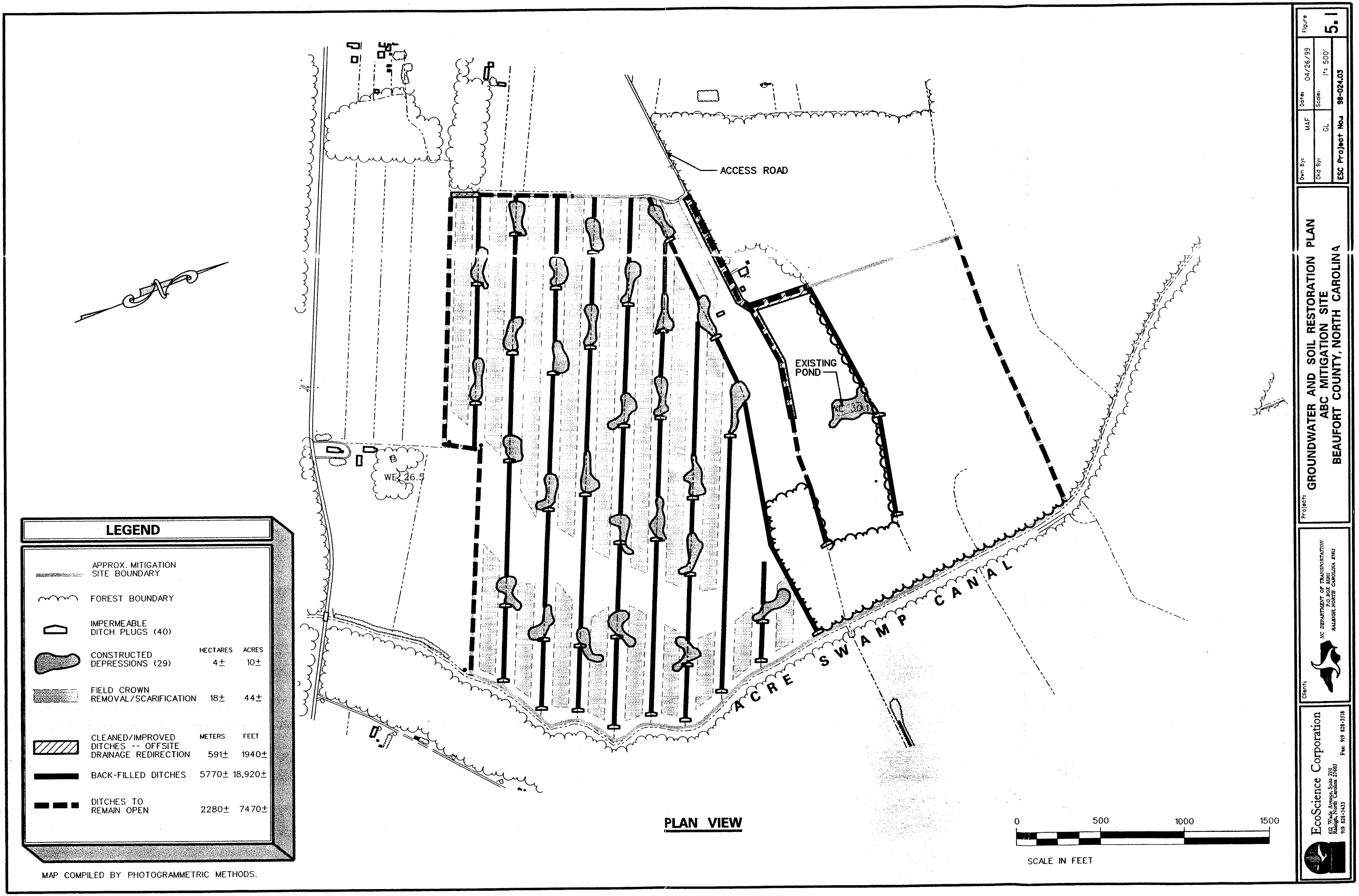
5.1.2 Off-Site Drainage Redirection

Off-site drainage will be accommodated at two locations along the periphery of the Site (Figure 5.1). Along the southwest corner, approximately 76 linear m (250 linear ft) of ditch channel will be constructed to connect peripheral ditches flowing to the north and east. The ditch will connect existing channels averaging approximately 2.4 m (6 ft) wide by 0.9 m (3 ft) deep.

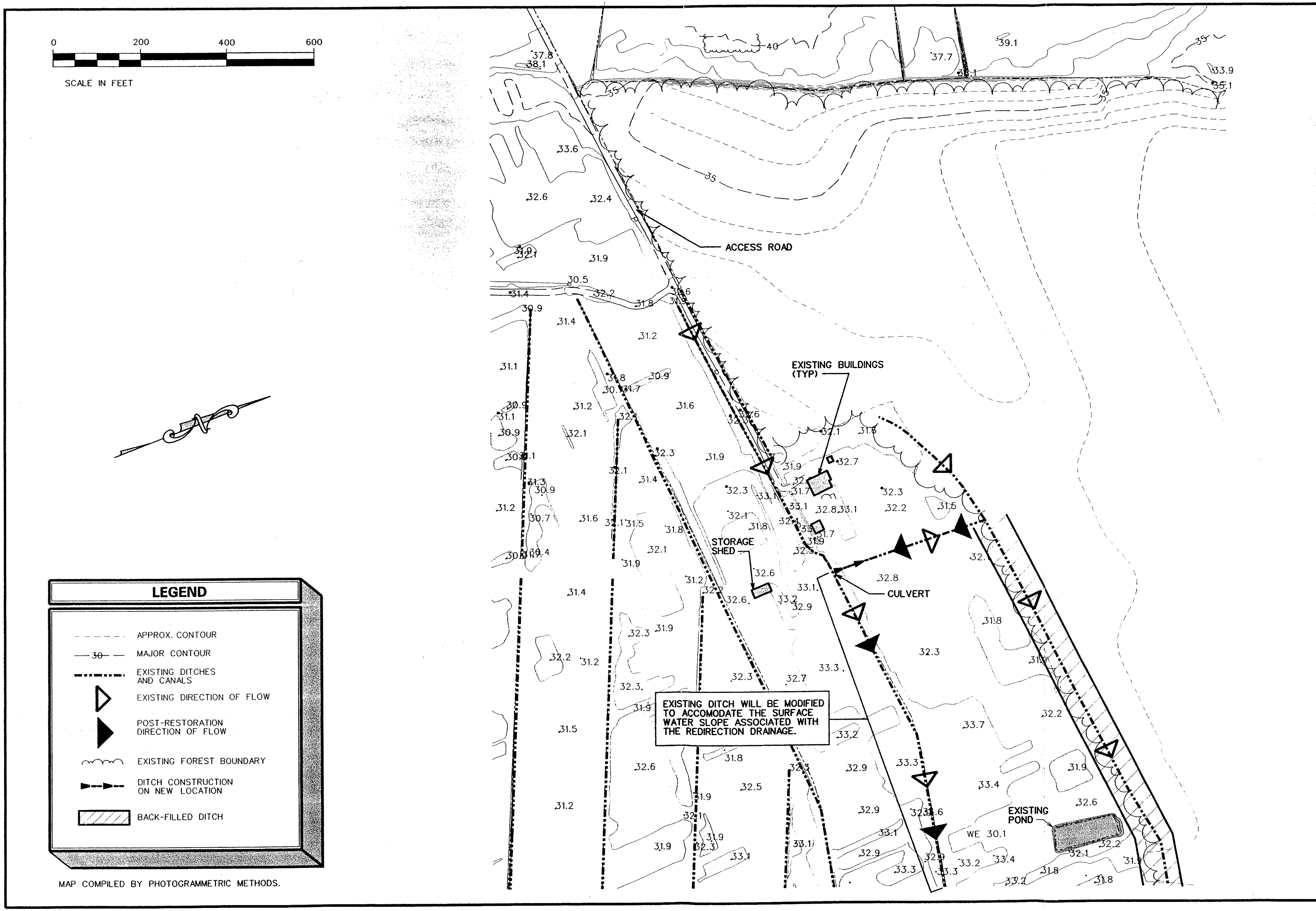
Along the northwestern property boundary, drainage will be redirected along an approximately 91 m (300 ft) length of ditch located adjacent to the private residence (Figure 5.1). Figure 5.2 depicts a plan view of the drainage redirection, including ditch construction on new location, and re-sloping of the existing channel to provide for adequate drainage. This drainage redirection and ditch modifications will also facilitate improvements to the access road described above.

5.1.3 Ditch Cleaning Prior to Backfill

Ditches identified for backfilling in Figure 5.1 will be cleaned, as needed, to remove unconsolidated sediments within the lower portion of the cross-section. As depicted in Figure 3.3 (Typical Soil Profile), and Figure 4.1 (Typical Ditch Cross-Sections), accumulated sediment 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 depression construction and ditch backfilling. Subsequently, the unconsolidated sediment will be incorporated into top soils graded during field crown removal.



ACCESS ROAD
EXISTING POND
WE 30.1
WE 26.5
ACRE SWAMP CANAL
LEGEND
APPROX. MITIGATION SITE BOUNDARY
FOREST BOUNDARY
IMPERMEABLE DITCH PLUGS (40)
HECTARES ACRES
CONSTRUCTED DEPRESSIONS (29) 4± 10±
FIELD CROWN REMOVAL/SCARIFICATION 18± 44±
METERS FEET
CLEANED/IMPROVED DITCHES -- OFFSITE DRAINAGE REDIRECTION 591± 1940±
BACK-FILLED DITCHES 5770± 18,920±
DITCHES TO REMAIN OPEN 2280± 7470±
MAP COMPILED BY PHOTOGRAMMETRIC METHODS.
PLAN VIEW
0 500 1000 1500
SCALE IN FEET
EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518
Client:
NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611
Project:
GROUNDWATER AND SOIL RESTORATION PLAN
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA
Dwn By: MAF
Date: 04/26/99
Ckd By: GL
Scale: 1"= 500'
ESC Project No.: 98-024.03
Figure
5.1



Project:
OFF-SITE DRAINAGE REDIRECTION
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

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

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

Dwn By: MAF	Date: 04/26/99	Figure	
Ckd By: GL	Scale: 1"= 200'	5.2	
ESC Project No.: 98-024.03			

5.1.4 Depression Construction

Depressions will be constructed along ditch sections to mimic the Bayboro (nonriverine swamp forest) depressions identified in reference wetlands. The primary purpose of these depressions is to provide suitable, low permeability material for ditch plugs and backfilling, to increase water storage potential within the wetland restoration area, and to increase potential for biological diversity within the complex.

Based on volume calculations for backfill material, approximately 29 depressions will be constructed in the landscape (Figure 5.1). The depressions average 30 m (100 ft) in width and 60 m (200 ft) in length, centered along the existing ditches (Figure 5.3). The area covered by each nonriverine swamp forest depression ranges from 0.12 ha (0.3 ac) to 0.20 ha (0.5 ac) in size. The depression will be constructed by excavating and stockpiling top soils overlying the B Horizon (clay layer) surface. Subsequently, clays will be excavated to a depth of approximately 1.2 m (4 ft) below the soil surface and utilized as backfill material on adjacent ditch sections. Subsequently, the top soils and adjacent field crowns will be utilized to backfill the depression to within 0.1 m (0.3 ft) to 0.3 m (1 ft) of the surface. The pool will be contoured to provide for approximate 8:1 slopes upon completion.

Figure 5.1 provides a conceptual depiction of pool locations. The location, depth, and configuration of each pool will be modified during construction to maximize landscape diversity, provide varying pool depths throughout the Site, and to balance cut and fill needs for ditch backfilling and plug construction.

5.1.5 Ditch Plugs

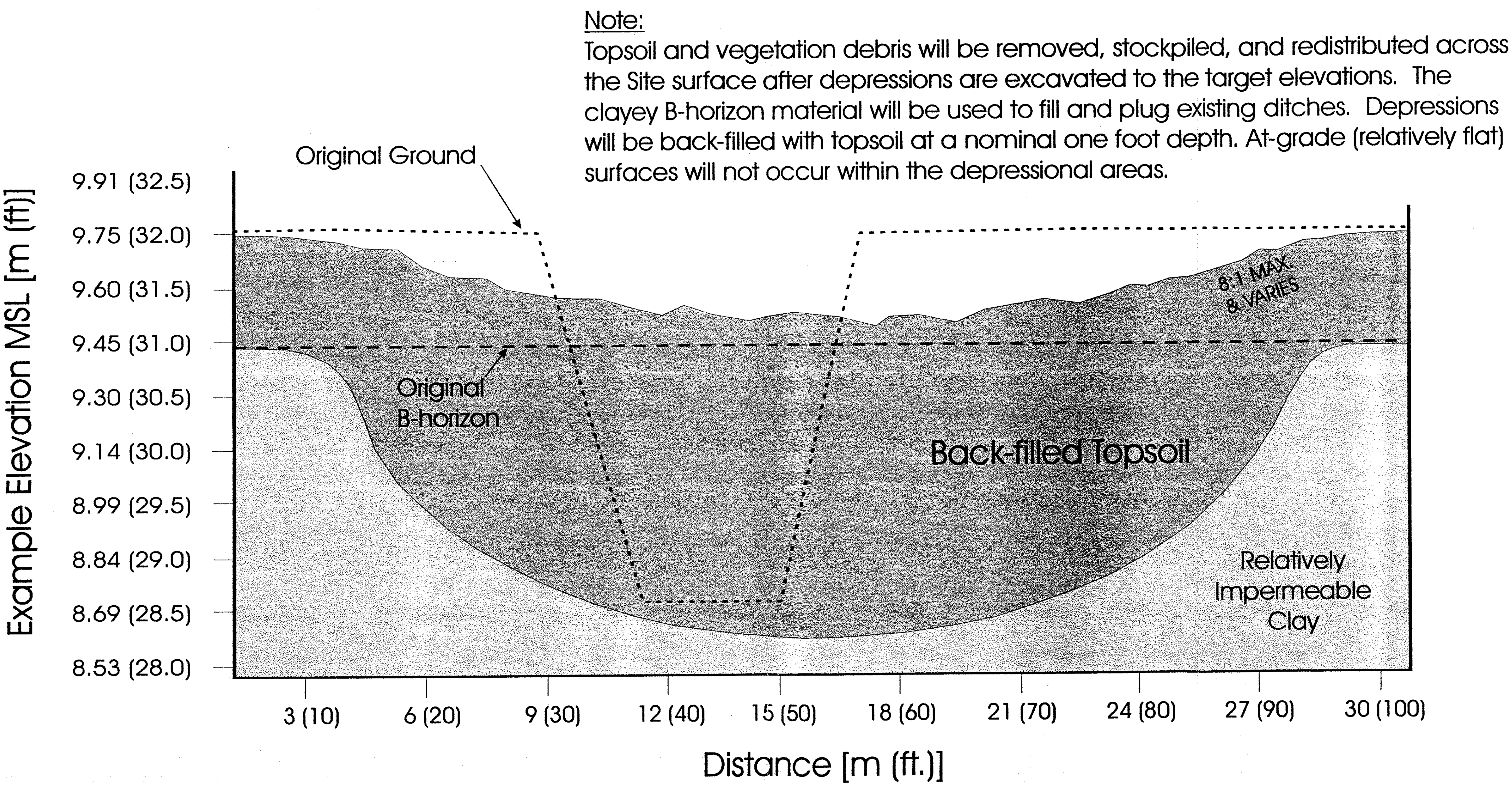
Impermeable plugs will be installed along drainage ditches and canals at locations identified in Figure 5.1. Approximately 40 plugs will be placed immediately below the constructed depressions or prior to ditch outfall into Acre Swamp. The plugs will consist of low permeability materials excavated from the adjacent depressions. The plugs will consist of a core of impervious material and be sufficiently wide and deep to form an imbedded overlap in the existing ditch banks and ditch bed (Figure 5.4).

5.1.6 Ditch Backfilling

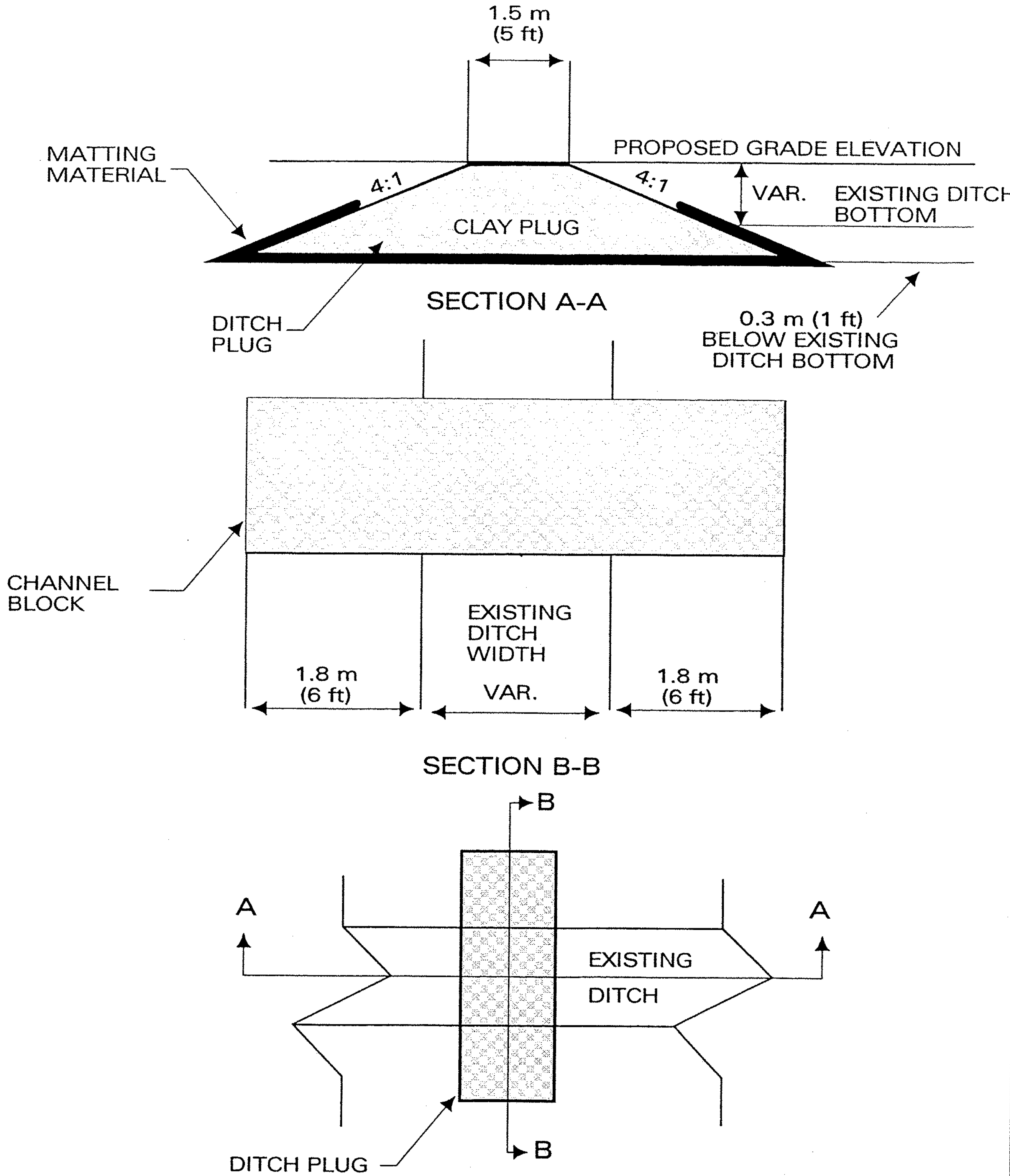
Ditches located between the constructed depressions and impermeable ditch plugs will be back-filled with clay-based material excavated from the depressions (Figure 5.1). Approximately 5770 m (18,920 ft) of ditches will be filled, graded, and compacted to the approximate elevation of the adjacent wetland surface.

5.1.7 Crown Removal

Field crowns located between ditches will be graded towards the ditches to establish localized, enclosed hummocks and depressions across the landscape (Figure 5.1). Currently, ditch corridors represent long, linear corridors that reside up to 0.15 m (0.5 ft) below the elevation of inter-field crowns. Figure 5.5 provides a conceptual depiction of existing surface topography and approximate target elevations after the crowns are effectively removed. The crowns will be graded towards the depressions and backfilled ditches under supervision of



EcoScience Corporation 612 Wade Ave, Suite 200 Raleigh, North Carolina 27605 919 828-3433	**Typical Cross-section: Constructed Depression** **ABC MITIGATION SITE** **Beaufort County, North Carolina**	Figure: 5.3 Project: 98-024.03 Date: March 1999

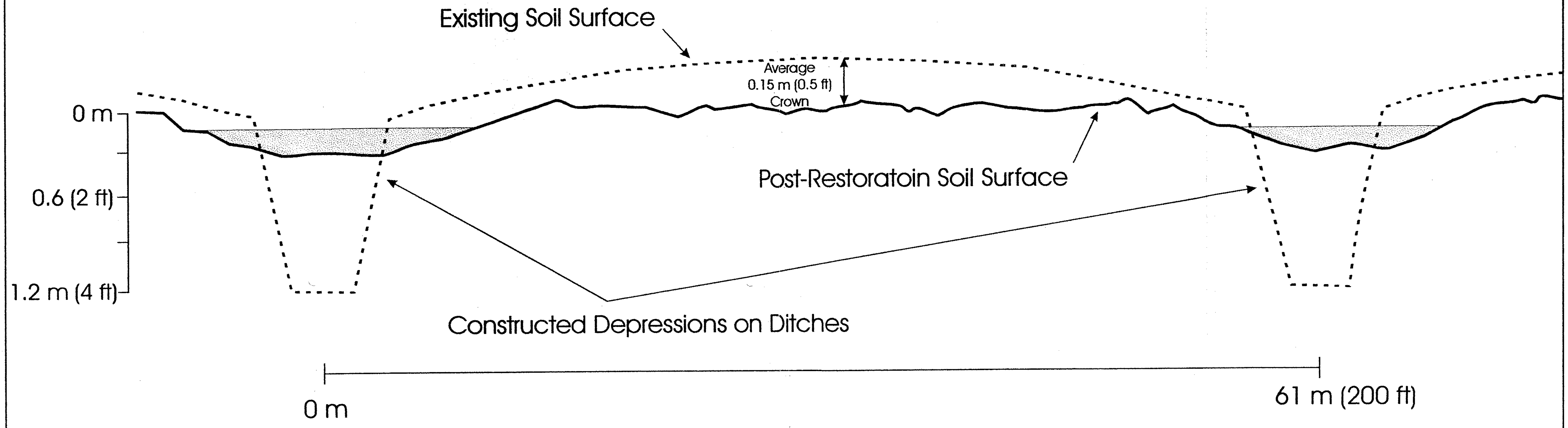


PLAN VIEW OF EXISTING
DITCH WITH CHANNEL BLOCK

EcoScience Corporation

TYPICAL CROSS-SECTION:
IMPERVIOUS DITCH PLUG
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Figure:	5.4
Project:	98-024.03
Date:	April 1999



Note:
Excavated clay (B-horizon) from constructed depressions will be used to fill and plug ditches. Existing crown between ditches will be excavated and redistributed over the site (including constructed depressions) to the target range of surface elevations. Localized surface micro-topography (eg. hummocks, troughs, and swales) will be achieved through circular and irregular plowing of finished grade.

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Typical Cross-section: Post-Restoration Soil Surface
ABC MITIGATION SITE
Beaufort County, North Carolina

Figure:	5.5
Project:	98-024.03
Date:	March 1999

a qualified wetland scientist. The material will be used to establish enclosed, circular to irregularly shaped microtopographic enclosures through circular to irregular plowing and soil harrowing / scarification to finished grade.

Reference wetlands exhibit complex surface microtopography. Small concavities, swales, exposed root systems, and hummocks associated with vegetative growth and hydrological patterns are scattered throughout the system. Large woody debris and partially decomposed litter provide additional complexity across the wetland soil surface. Although vegetative components of surface storage capacity will not develop in restored wetlands for several decades, efforts to advance the development of characteristic surface roughness will be implemented on the Site. As stated above, disking and harrowing will be implemented as part of the crown removal effort to promote the formation of non-linear, hummocks and concavities that act to increase surface storage and provide micro-habitat for invertebrates, reptiles, and amphibians. After scarification, the soil surface should exhibit complex microtopography ranging to approximately 0.3 m (1 ft) in vertical asymmetry across local reaches of the landscape. Restored microtopographic relief is considered critical to hydrology restoration efforts. Therefore, a harrow plow or deep disking plow will be implemented to ensure adequate surface roughing and surface water storage potential. Subsequently, vegetative restoration will be initiated on scarified wetland surfaces.

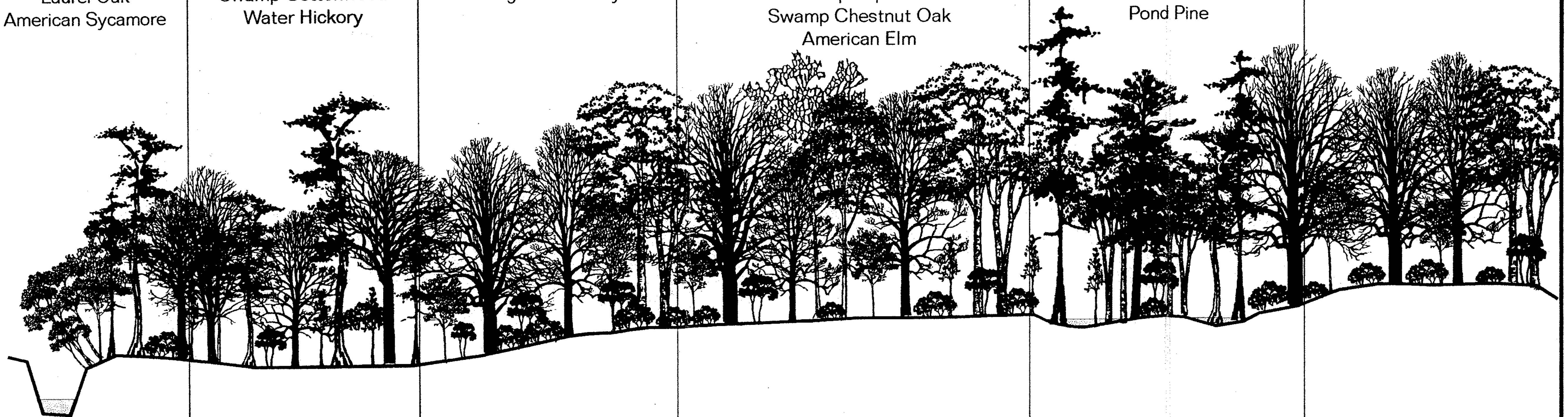
5.2 WETLAND COMMUNITY RESTORATION

Restoration of wetland forested communities provides habitat for area wildlife and allows for development and expansion of characteristic wetland dependent species across the landscape. Ecotonal changes between community types contribute to diversity and provide secondary benefits, such as enhanced feeding and nesting opportunities for mammals, birds, amphibians, and other wildlife.

RFE data, on-site observations, utilization of Schafale and Weakley classification of natural communities, and a review of the available literature were used to develop the primary plant community associations that will be established during community restoration activities. These community associations include: 1) levee/stream bank forest; 2) nonriverine swamp forest; 3) riverine swamp forest; 4) nonriverine wet hardwood forest; 5) mesic upland slope forest; and 6) dry mesic oak/hickory forest. Figure 5.6 provides a conceptual depiction of potential forest communities to be restored. Figure 5.7 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 in a region dominated by monotypic pine plantations.

COMMUNITY ASSEMBLAGE (Schafale and Weakley 1990)	COASTAL PLAIN LEVEE FOREST	RIVERINE SWAMP FOREST (Blackwater Subtype)	MESIC HARDWOOD FOREST (Coastal Plain Subtype)	NONRIVERINE WET HARDWOOD	NONRIVERINE SWAMP FOREST	DRY MESIC OAK/ HICKORY FOREST
DIAGNOSTIC CANOPY VEGETATION	Bald Cypress Overcup Oak Swamp Tupelo Red Ash River Birch Willow Oak Laurel Oak American Sycamore	Bald Cypress Swamp Tupelo Green Ash Overcup Oak Laurel Oak Carolina Ash Swamp Cottonwood Water Hickory	Water Oak Cherrybark Oak Tulip Poplar American Beech Red Oak White Oak Shagbark Hickory	American Holly Swamp Tupelo Cherrybark Oak Overcup Oak Water Oak Laurel Oak Tulip Poplar Swamp Chestnut Oak American Elm	Laurel Oak Willow Oak Swamp Tupelo Cherrybark Oak Bald Cypress Tulip Poplar American Elm Pond Pine	Red Oak White Oak Mockernut Hickory Sweet Pignut Hickory Pignut Hickory



LAND FORM	Natural Levee/ Blackwater Stream	Floodplain (Terrace)	Mesic Upland Slope	Precipitation Flat	Precipitation Depression	Low Ridge / Upland Flat
SOILS	Muckalee	Muckalee	Lenoir	Leaf	Leaf	Lenoir
	Poorly Drained	Poorly Drained	Somewhat Poorly Drained	Poorly Drained	Poorly Drained	Somewhat Poorly Drained

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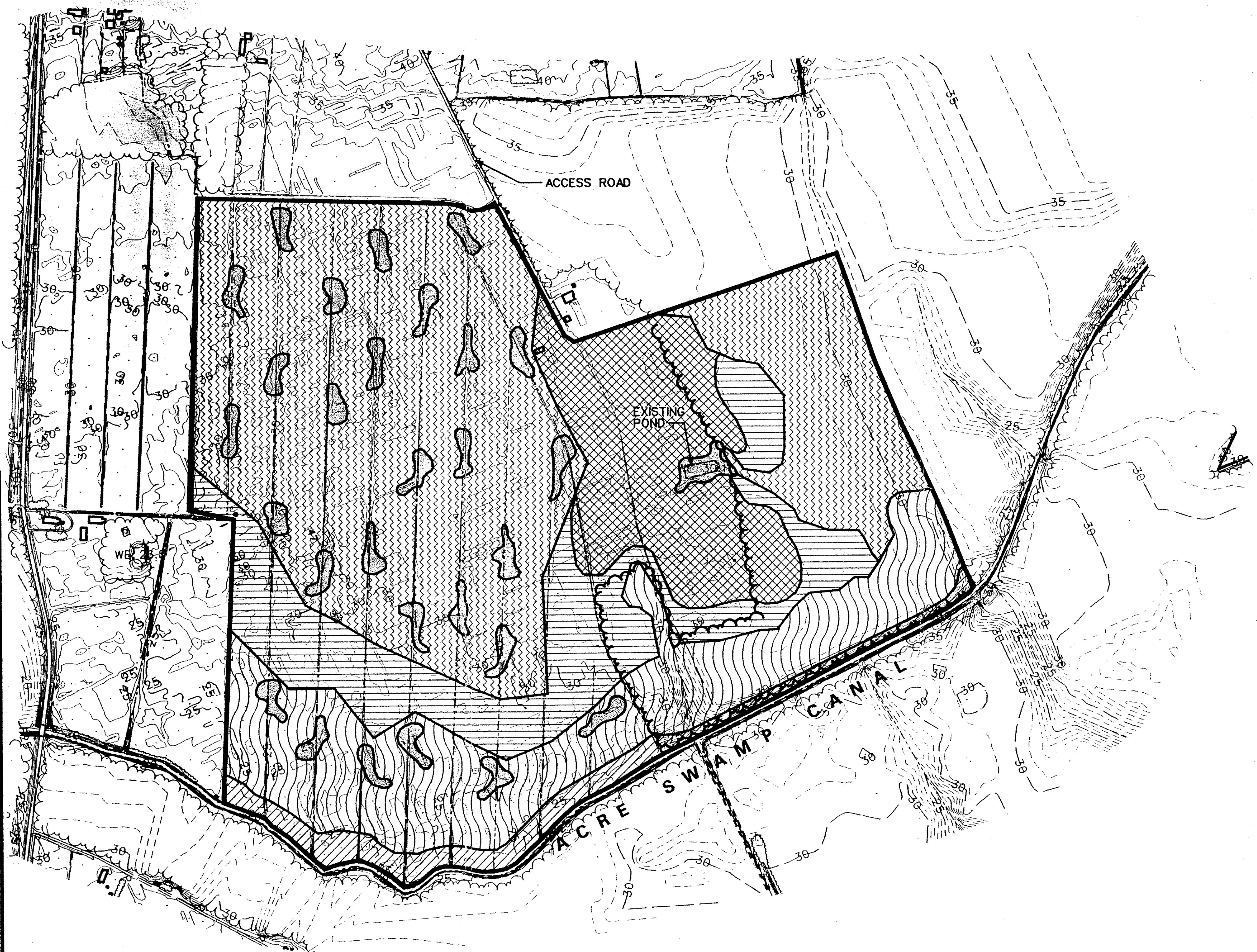
Target Landscape Ecosystems
ABC MITIGATION SITE
Beaufort County, North Carolina

Figure:	5.6
Project:	98-024.03
Date:	APRIL 1999



LEGEND

APPROX. MITIGATION SITE BOUNDARY
APPROX. CONTOUR
MAJOR CONTOUR
FOREST BOUNDARY

PLANTINGS

	HECTARES	ACRES
LEVEE/STREAMBANK FOREST		
SUPPLEMENTAL	.4±	1±
FULL	2±	6±
RIVERINE SWAMP FOREST		
SUPPLEMENTAL	6±	14±
FULL	8±	20±
MESIC HARDWOOD FOREST		
SUPPLEMENTAL	3±	8±
FULL	8±	20±
NON-RIVERINE WET HARDWOOD		
SUPPLEMENTAL	7±	18±
FULL	27±	67±
DRY MESIC OAK/HICKORY FOREST		
SUPPLEMENTAL	2±	5±
FULL	7±	18±
NON-RIVERINE SWAMP FOREST		
SUPPLEMENTAL	N/A	N/A
FULL	4±	10±
TOTAL	75±	187±

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

PLAN VIEW

0 500 1000 1500

SCALE IN FEET

Dwn By: MAF	Date: 04/26/99
Ckd By: GL	Scale: 1"= 500'
ESC Project No.: 98-024.03	Figure: 5.7

Project: **PLANTING PLAN ABC MITIGATION SITE BEAUFORT COUNTY, NORTH CAROLINA**

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

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

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.

5.2.1 Planting Plan

The planting plan consists of: 1) acquisition of available wetland species; 2) implementation of proposed surface topography improvements; and 3) planting of selected species. The COE bottomland hardwood forest mitigation guidelines (DOA 1993) were utilized in developing this plan.

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 community are listed below.

Levee/Riparian Stream Bank Forest

Primary Soil Map Unit: Muckalee (Typic Fluvaquents)

1. American Elm (*Ulmus americana*)
2. Pumpkin Ash (*Fraxinus profunda*)
3. River Birch (*Betula nigra*)
4. Willow Oak (*Quercus phellos*)
5. Laurel Oak (*Quercus laurifolia*)
6. Bald Cypress (*Taxodium distichum*)
7. Swamp Tupelo (*Nyssa biflora*)
8. Overcup Oak (*Quercus lyrata*)
9. Buttonbush[1] (*Cephalanthus occidentalis*)
10. Tag Alder[1] (*Alnus serrulata*)
11. Black Willow[1] (*Salix nigra*)

1: Buttonbush seedlings, tag alder seedlings, and black willow stakes will be placed along the stream banks of Acre Swamp only.

Riverine Swamp Forest

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

1. Bald Cypress (*Taxodium distichum*)
2. Swamp Tupelo (*Nyssa biflora*)
3. Overcup Oak (*Quercus lyrata*)
4. Carolina Ash (*Fraxinus caroliniana*)
5. Swamp Cottonwood (*Populus heterophylla*)
6. Water Hickory (*Carya aquatica*)
7. Green Ash (*Fraxinus pennsylvanica*)
8. Laurel Oak (*Quercus laurifolia*)
9. Willow Oak (*Quercus phellos*)
10. Swamp Chestnut Oak (*Quercus michauxii*)

Mesic Upland Slope Forest

Primary Soil Map Unit: Lenoir (*Aeric Paleaquults*)

1. Green Ash (*Fraxinus pennsylvanica*)
2. Swamp Chestnut Oak (*Quercus michauxii*)
3. Cherrybark oak (*Quercus pagoda*)
4. Tulip Poplar (*Liriodendron tulipifera*)
5. American Beech (*Fagus grandifolia*)
6. White Oak (*Quercus alba*)
7. Red oak (*Quercus rubra*)
8. Shagbark Hickory (*Carya ovata*)
9. Pignut Hickory (*Carya glabra*)
10. Southern Sugar Maple (*Acer saccharum*)

Nonriverine Wet Hardwood Forest

Primary Soil Map Unit: Leaf (*Typic Albaquults*)

1. American Elm (*Ulmus americana*)
2. Willow Oak (*Quercus phellos*)
3. Laurel Oak (*Quercus laurifolia*)
4. Swamp Tupelo (*Nyssa biflora*)
5. Green Ash (*Fraxinus pennsylvanica*)
6. Swamp Chestnut Oak (*Quercus michauxii*)
7. Water Oak (*Quercus nigra*)
8. Cherrybark Oak (*Quercus pagoda*)
9. Tulip Poplar (*Liriodendron tulipifera*)

Nonriverine Swamp Forest

Primary Soil Map Units: Leaf (*Typic Albaquults*)

1. American Elm (*Ulmus americana*)
2. Laurel Oak (*Quercus laurifolia*)
3. Bald Cypress (*Taxodium distichum*)
4. Swamp Tupelo (*Nyssa biflora*)
5. Overcup Oak (*Quercus lyrata*)
6. Green Ash (*Fraxinus pennsylvanica*)
7. Swamp Chestnut Oak (*Quercus michauxii*)
8. Water Oak (*Quercus nigra*)
9. Cherrybark Oak (*Quercus pagoda*)
10. Pond Cypress (*Taxodium ascendens*)

Dry Mesic Oak/Hickory Forest

Primary Soil Map Units: Lenoir (*Aeric Paleaquults*)

1. White Oak (*Quercus alba*)
2. Spanish Oak (*Quercus falcata*)

3. Pignut Hickory (*Carya glabra*)
4. Mockernut Hickory (*Carya tomentosa*)
5. Swamp Chestnut Oak (*Quercus michauxii*)
6. Cherrybark Oak (*Quercus pagoda*)
7. American Beech (*Fagus grandifolia*)
8. Red Oak (*Quercus rubra* var. *rubra*)
9. Black gum (*Nyssa sylvatica*)

Two levels of planting will be used, Full and Supplemental. Full Planting will occur in the cultivated areas, currently void of any trees. Bare-root seedlings of tree species will be planted randomly within specified map areas at a density of 1680 stems per ha (680 stems per ac) on 2.4-m (8-ft) centers. Shrub plantings of buttonbush, tag alder, and black willow will be placed on 1.2 m (4-ft) centers, as bank stabilization elements, in four contiguous rows along the stream banks of Acre Swamp. Table 5.1 depicts the total number of stems and species distributions within each Full Planting vegetation association.

Supplemental Planting will occur in existing forested areas to ameliorate current plant community deficiencies. Bare-root seedlings of tree species will be planted in tree gaps within specified map areas at a density of 270 stems per ha (110 stems per ac). Table 5.2 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. Opportunistic species such as sweet gum, red maple, loblolly bay, loblolly pine, American sycamore, black willow, long leaf pine, and pond pine 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 5.1

Stocking Levels (Full Planting Areas)
ABC Wetland Mitigation Site

Vegetation Association (Planting Area)	Levee/ Stream Bank Forest	Riverine Swamp Forest	Mesic Upland Slope Forest	Nonriverine Wet Hardwood Forest	Nonriverine Swamp Forest	Dry Mesic Oak/Hickory Forest	TOTAL
Area (ha [ac])	2.3 (5.7)	8.1 (20.0)	8.0 (19.8)	27.1 (67.0)	4.0 (9.8)	7.4 (18.4)	56.9 (140.7)
SPECIES	# planted[1] (% total)[2]	# planted (% total)	# planted (% total)	# planted (% total)	# planted (% total)	# planted (% total)	# planted (%total)
Pumkin Ash	890 (10)						890
American Elm	890 (10)			4,550 (10)	680 (10)		6,120
River Birch	1,780 (20)						1,780
Willow Oak	890 (10)	680 (5)		2,280 (5)			3,850
Laurel Oak	890 (10)	680 (5)		6,830 (15)	1,010 (15)		9,410
Bald Cypress	890 (10)	2,040 (15)			1,010 (15)		3,940
Swamp Tupelo	890 (10)	2,040 (15)		4,550 (10)	1,340 (20)		8,820
Overcup Oak	1,780 (20)	2,040 (15)		2,280 (5)	340 (5)		6,440
Button Bush[4]	1300 (--)[4]						1,300
Tag Alder[4]	1300 (--)[4]						1,300
Black Willow[4]	1300 (--)[4]						1,300
Carolina Ash		1,360 (10)					1,360
Swamp Cottonwood		1,360 (10)					1,360
Water Hickory		1,360 (10)					1,360
Green Ash		1,360 (10)	670 (5)	4,550 (10)	340 (5)		6,920
Swamp Chestnut Oak		680 (5)	2,020 (15)	6,830 (15)	680 (10)		10,210
Water Oak				2,280 (5)			2,280
Pond Cypress					1,010 (15)		1,010
Cherrybark Oak			2,020 (15)	6,830 (15)	340 (5)	740 (10)	9,930
Tulip Poplar			1,340 (10)	4,550 (10)			5,890
American Beech			2,690 (20)			740 (10)	3,430
White oak			670 (5)			1,480 (20)	2,150
Red Oak			670 (5)			1,110 (15)	1,780
Southern Sugar			670 (5)				670
Shagbark Hickory			1,340 (10)				1,340
Pignut Hickory			1,340 (10)			1,110 (15)	2,450
Spanish Oak						740 (10)	740
Mockernut Hickory						1,110 (15)	1,110
Blackgum						370 (5)	370
TOTAL	12,800	13,600	13,430	45,530	6,750	7,400	**99,510**

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.
3: Scientific names for each species, required for nursery inventory, are listed in the mitigation plan.
4. Shrub elements, including button bush, tag alder, and black willow will be planted along the banks of Acre Swamp only.

TABLE 5.2

Stocking Levels (Supplemental Planting Areas)
ABC Wetland Mitigation Site

Vegetation Association (Planting Area)	Levee/ Stream Bank Forest	Riverine Swamp Forest	Mesic Upland Slope Forest	Nonriverine Wet Hardwood Forest	Nonriverine Swamp Forest	Dry Mesic Oak/Hickory Forest	TOTAL
Area (ha [ac])	0.6 (1.4)	5.6 (13.8))	3.0 (8.0)	7.0 (18.0)	na[4]	1.9 (4.7)	18.1 (45.9)
SPECIES[3]	# planted[1] (% total)[2]	# planted (% total)	# planted (% total)	# planted (% total)	# planted (% total)	# planted (% total)	# planted (%total)
Pumkin Ash	30 (15)						30
American Elm	20 (10)			730 (10)			750
River Birch	20 (10)						20
Willow Oak	20 (10)	80 (5)			20 (10)		120
Laurel Oak	20 (10)	80 (5)		1,100 (15)	20 (10)		1,220
Bald Cypress	20 (10)	230 (15)			60 (25)		310
Swamp Tupelo	30 (15)	230 (15)		1,100 (15)	50 (20)		1,410
Overcup Oak	40 (20)	230 (15)		370 (5)			640
Carolina Ash		150 (10)					150
Swamp Cottonwood		150 (10)					150
Water Hickory		150 (10)					150
Green Ash		150 (10)	100 (10)	730 (10)			980
Swamp Chestnut Oak		80 (5)	290 (15)	730 (10)	30 (15)		1,130
Water Oak				730 (10)			730
Pond Cypress					50 (20)		50
Cherrybark Oak			290 (15)	1,100 (15)		50 (10)	1,440
Tulip Poplar			190 (10)	730 (10)			920
American Beech			380 (20)			50 (10)	430
White oak			100 (5)			100 (20)	200
Red Oak			100 (5)			80 (15)	180
Southern Sugar			100 (5)				100
Shagbark Hickory			190 (10)				190
Pignut Hickory			190 (10)			80 (15)	270
Spanish Oak						50 (10)	50
Mockernut Hickory						80 (15)	80
Blackgum						30 (5)	30
TOTAL	200	1,530	1,930	7320	230	520	**11,730**

1: Supplemental planting densities comprise of 270 trees per hectare (110 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.
3: Scientific names for each species, required for nursery inventory, are listed in the mitigation plan.
4: The supplemental planting for this unit is not expressly separated from nonriverine wet hardwood. However, depressions within this unit would benefit from planting nonriverine swamp forest species (approximately 0.8 ha).

6.0 MONITORING PLAN

The Monitoring Plan will consist of a comparison between hydrology model predictions and regulatory wetland criteria, supplemented by data from on-site reference wetlands. Wetland monitoring will entail analysis of two primary parameters: vegetation and hydrology. Monitoring of restoration and enhancement efforts will be performed until success criteria are fulfilled.

6.1 HYDROLOGY MONITORING

After hydrological modifications are performed, continuous monitored, surficial monitoring wells will be designed and placed in accordance with specifications in U.S. 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 approximately 16 inches below the soil surface. The 16-inch well depth will provide a more accurate depiction of perching across low permeability, subsurface soil layers (B horizon surface).

Ten monitoring wells will be installed to provide representative coverage within each of the wetland physiographic landscape areas (Figure 6.1). Five monitoring wells will also be placed within the reference wetland site in similar landscape positions. Hydrological sampling will be performed on-site and within reference on a daily basis throughout the year.

6.2 HYDROLOGY SUCCESS CRITERIA

Target hydrological characteristics include a minimum regulatory wetland hydrology criteria based upon reference groundwater modeling. Evaluation of success criteria will also be supplemented by sampling and data comparison between restoration areas and the reference wetland site.

The reference groundwater model forecasts that the wetland hydroperiod in restoration areas will average 8% of the growing season in early successional phases (Section 4.1 and Table 4.1). Average wetland hydroperiods encompassing 8% of the growing season are predicted as occurring in 55% of the years modeled (21 out of 38 years).

The average wetland hydroperiod is forecast to exhibit a gradual increase from 8% of the growing season immediately after farm land is abandoned and drainage structures are removed to as much as 20% under steady state forest conditions. A gradual increase in hydroperiods may suggest that water storage capacity (rooting functions, organic materials/debris accumulation, microtopography, etc.) exhibits a significant effect on maintenance of wetland hydrology in precipitation driven wetlands. In old field stages of succession, accelerated runoff may occur within the former plow layer, relict field crowns, and any relict linear depressions or conduits associated with backfilled ditches. For purposes of this model, runoff is assumed to occur at accelerated rates which reduces the influence of evapotranspiration on wetland hydrodynamics. Consequently, accelerated drainage would be expected to decrease, and wetland hydroperiods increase, as successional vegetation colonizes the Site.

LEGEND

APPROX. MITIGATION SITE BOUNDARY

WOODS

APPROX. CONTOUR

MAJOR CONTOUR

REFERENCE WETLANDS

BAYBORO (NON-RIVERINE SWAMP FOREST) DEPRESSIONS (APPROXIMATE LOCATION)

LEAF (NON-RIVERINE WET HARDWOOD FOREST) HAMMOCKS AND FLATS (APPROXIMATE LOCATION)

● RW1 24 INCH MONITORING WELL

MITIGATION AREAS

NON- RIVERINE SWAMP FOREST DEPRESSIONS

NON-RIVERINE WET HARDWOOD FOREST HUMMOCKS AND FLATS

UPLANDS

● MW1 24 INCH MONITORING WELL

MAP COMPILED BY PHOTOGRAMMETRIC METHODS.

PLAN VIEW

0 500 1000 1500

SCALE IN FEET

EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

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

Project:
MONITORING PLAN
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Dwn By: MAF	Date: 04/23/99	Figure	
Ckd By: GL	Scale: 1"= 500'	6.1	
ESC Project No.: 98-024.03			

Based on the groundwater model, hydrology success criteria for the five-year monitoring period will include a minimum regulatory criterion, comprising saturation (free water) within one foot of the soil surface for 5% of the growing season. Based on the model, this success criteria should be achieved in 82% of the monitoring years.

Reference Wetland Sites

Five monitoring wells will be placed in the reference wetland located in the northwestern periphery of the Site. Wetland hydroperiods within reference will be compared to the restoration area to further evaluate mitigation success and to verify model predictions. Based on the model, the restoration areas should maintain saturation within one foot of the soil surface for at least 40% of the hydroperiod exhibited by the reference wetland (8%/20%) in any given year.

6.3 VEGETATION

Restoration monitoring procedures for vegetation are designed in accordance with EPA guidelines presented in Mitigation Site Type (MiST) documentation (EPA 1990) and COE Compensatory Hardwood Mitigation Guidelines (DOA 1993). The following presents a general discussion of the monitoring program.

After planting has been completed in winter or early spring, an initial evaluation will be performed to verify planting methods and to determine initial species composition and density. Supplemental planting and additional site modifications will be implemented after the first year on a case by case basis based on success criteria consultation with USACE.

During the first year, vegetation will receive cursory, visual evaluation on a periodic basis to ascertain the degree of overtopping of planted elements by weeds. Subsequently, quantitative sampling of vegetation will be performed between August 1 and October 31 after each growing season until the vegetation success criteria is achieved.

Permanent 0.04 ha (0.1 ac) plots will be established randomly in immediate proximity to monitoring wells (Figure 6.1). Fifteen (15) plots will be established throughout the Site and correlated with hydrological monitoring locations to provide point-related data on hydrological and vegetation parameters. The plot distribution will provide a 0.8% sample of the Site. Monitoring will determine survivorship of planted trees.

6.4 VEGETATION SUCCESS CRITERIA

Success criteria have been established to verify that the wetland vegetation component supports a species composition sufficient for a jurisdictional determination. Additional success criteria are dependent upon the density and growth of characteristic forest species. Specifically, a minimum mean density of 790 characteristic trees/ha (320 characteristic tree species/ac) must be 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. Loblolly pine (softwood species) cannot comprise more than 10 percent of the 320 stem/acre requirement. In addition, at least five character tree species must be present, and no species can comprise more than 20 percent of the 320 stem/acre total. Supplemental plantings will be performed as needed to achieve the vegetation success criteria.

No quantitative sampling requirements are proposed for herb and shrub assemblages as part of the vegetation success criteria. Development of a swamp forest canopy over several decades and restoration of wetland hydrology will dictate the success in migration and establishment of desired wetland understory and groundcover populations.

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.

7.0 DISPENSATION OF PROPERTY

NCDOT will maintain ownership of the property until all mitigation activities are completed and the site is determined to be successful. Although no plan for dispensation of the Site has been developed, NCDOT will deed the property to a resource agency (public or private) acceptable to the appropriate regulatory agencies. Covenants and/or restrictions on the deed will be included that will ensure adequate management and protection of the site in perpetuity.

8.0 MITIGATION CREDIT ASSESSMENT

Mitigation credit will be based on functions generated by restoration and comparison of restored functions to impacted resources. Although impacted wetland and stream resources are currently unknown, an evaluation of mitigation activities is provided to orient debiting procedures as impacts are quantified. This assessment subjectively evaluates mitigation wetland and stream functions under existing conditions and compares these functions to the post restoration conditions.

Wetland functional evaluations entail subjective assessments of hydrogeomorphic (HGM) wetland functions outlined in various research (Brinson 1994). This assessment categorizes functions into three primary areas: a) hydrodynamics; b) biogeochemical processes; and c) biotic resources.

Reference wetlands within the Site and in the region were utilized as an indicator of wetland functions and wetland functional capacity. Target functions have been identified based on the types of potential wetlands present, primarily nonriverine precipitation driven, mineral soil flats.

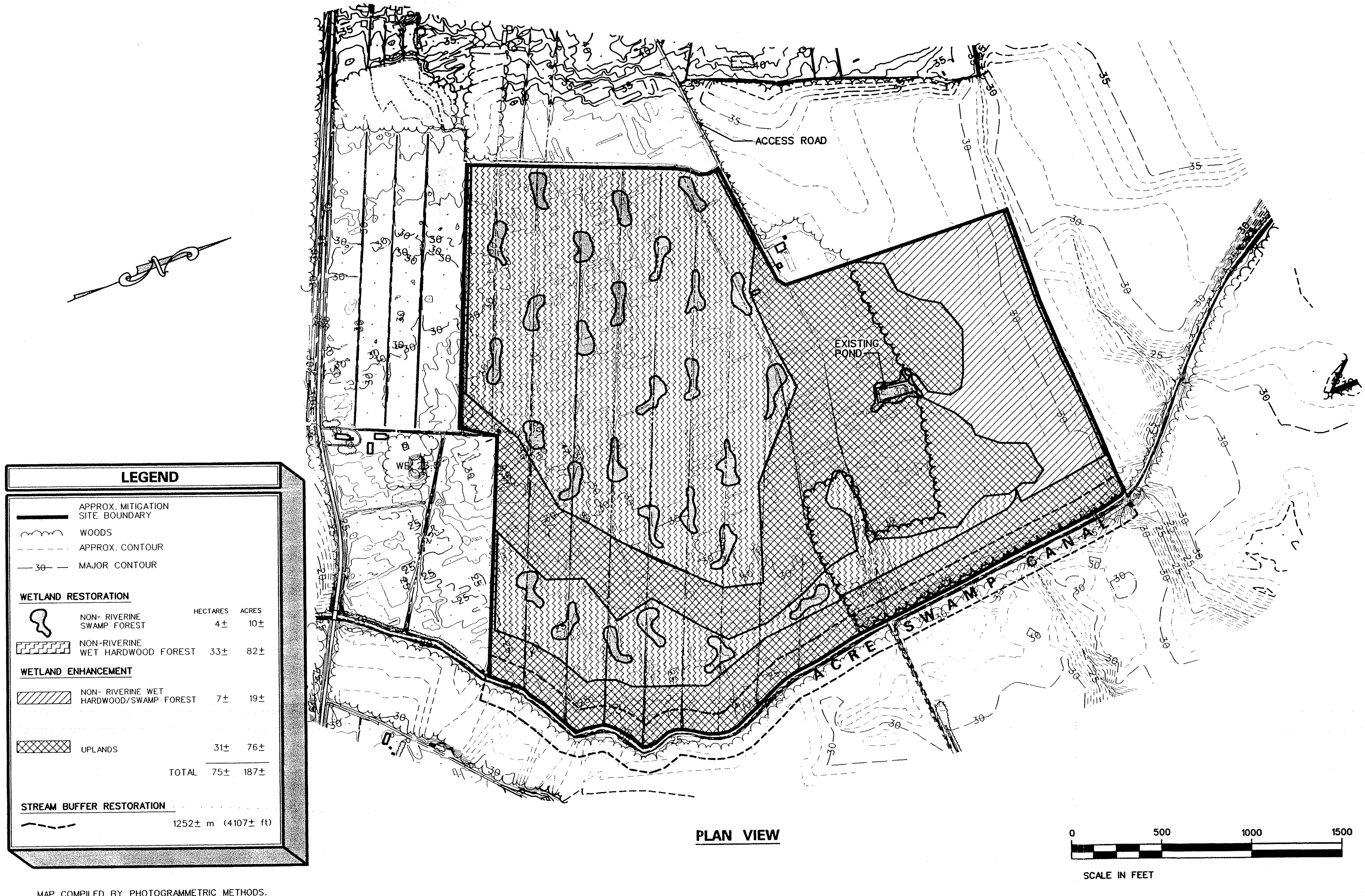
8.1 WETLAND AND STREAM FUNCTIONS UNDER EXISTING CONDITIONS

The 75-ha (187-ac) Site consists of approximately 37 ha (92 ac) of PC crop land on potentially restorable wetlands (Figure 8.1). An additional 7 ha (19 ac) comprises existing forested wetlands. The remainder of the Site (31 ha [76 ac]) is located in upland ecotones and buffers adjacent to wetland restoration areas. In addition, 1252 m (4107 ft) of dredged, third order stream channel that does not support riparian vegetation.

Under agricultural land uses, the entire area exhibits negligible wetland functions. Hydrodynamic functions have been effectively eliminated from the site due to construction of drainage networks, soil leveling/compaction, and removal of forest vegetation. Features which depict performance of hydrodynamic wetland functions, such as surface microtopography, ephemeral ponding, forest vegetation, and characteristic wetland soil properties have been eliminated by alternative land uses.

Reduction or elimination of wetland hydrology and removal of forest vegetation has also negated biogeochemical cycling and biological functions within the complex. PC crop lands typically do not support natural communities adapted to wetlands or the wetland dependent wildlife characteristic in the region.

The Acre Swamp stream channel has been entrenched and straightened into the valley floor by dredging. Throughout a majority of the Site, crop land extends to the bank of the channel with mowing activity utilized to remove all bank vegetation. The banks are actively collapsing into the stream, introducing heavy bed loads that are expected to significantly degrade water quality and in-stream aquatic habitat.



EcoScience Corporation
612 Wade Avenue, Suite 200
Raleigh, North Carolina 27605
919 828-3433 Fax: 919 828-3518

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

Project: WETLAND MITIGATION DESIGN UNITS
ABC MITIGATION SITE
BEAUFORT COUNTY, NORTH CAROLINA

Dwn By	MAF	Date	04/23/99	Figure
Ckd By	GL	Scale	1"= 500'	8.1
ESC Project No.:	98-024.03			

8.2 PROJECTED WETLAND AND STREAM FUNCTIONS UNDER POST-RESTORATION CONDITION

The wetland restoration has been designed to restore wetland features and functions similar to those exhibited by the reference wetlands. After implementation, the Site is expected to support a minimum of 37 ha (92 ac) of restored nonriverine wet hardwood and swamp forest wetlands (Figure 8.1). Wetland enhancement will occur within an additional 7 ha (19 ac) in the existing forest area. Upland buffers / ecotones, riparian buffer establishment, and associated groundwater wetland recharge potential will also be restored within the remaining 31 ha (76 ac) of upland and stream-side management area.

Projected performance of wetland functions is inferred from conditions expected 20+ years after mitigation activities are completed. This assessment assumes that restoration plans are implemented and that the wetland and riparian areas are protected from man-induced disturbances in perpetuity. These assumptions are valid if the Site is deeded or donated to a conservation organization that will manage the Site after wetland restoration success is achieved.

Site alterations are expected to restore and enhance near-surface and above-surface hydrodynamics. Ephemeral pools, surface microtopography, and swamp forest depressions characteristic of reference wetlands are expected to re-establish. Moderation of groundwater flow and discharge towards downstream areas would be redirected towards historic wetland conditions. The transformation of crop land adjacent to Acre Swamp into forested wetlands will also maximize water quality benefits and biochemical functions such as retention of particulates, removal of elements and compounds, and nutrient cycling. Retention features in the restored wetlands result primarily from spatial elimination of agricultural land immediately adjacent to approximately 9000 m (30,000 ft) of unprotected ditches and 1252 m (4107 ft) of the Acre Swamp canal.

Upland/wetland ecotones will also be restored within the wetland complex. Integration of wetland and upland interfaces are an important part of this mitigation plan. Wetland buffers will be restored along groundwater slopes, offering an ecological gradient from uplands to wetlands and providing for ecotonal fringes. Without upland restoration/enhancement and wetland buffer establishment, intrinsic functions in adjacent, restored wetlands may be diminished or lost in the future. In addition, a number of biological and physical wetland parameters are also enhanced by the presence of wetland/upland ecotones on the mitigation site (Brinson *et al.* 1981).

Biotic functions potentially restored in the complex include maintenance of habitat for certain terrestrial and semi-aquatic wildlife guilds. Species populations promoted include those dependent upon interspersion and connectivity with bottomland areas along with the need for forest interior habitat. Habitat value and community maintenance functions will also be improved by creation and interconnection of six plant community types along the restored environmental gradient (Figure 5.6).

8.3 MITIGATION CREDIT

Approximately 75 ha (187 ac) of land are being offered by the Site for future transportation projects in the region. The acreage for various wetland restoration types are summarized in the following table. Based on Environmental Protection Agency (EPA) guidelines (Page and Wilcher 1990), approximately 25-ha (63-ac) wetland replacement credits may become available for compensatory mitigation use.

Mitigation Design Unit	Area (ha [ac])	EPA Potential Mitigation Ratio (Mitigation area:Impact Area) (Page and Wilcher 1990)	Potential Replacement Credit (ha [ac])
Nonriverine Hardwood Forest Restoration	37 (92)	1.6	23 (58)
Nonriverine Hardwood Forest Enhancement	7 (19)	4:1	2 (5)
Upland Buffer / Ecotone Restoration	31 (76)	-----[1]	-----[1]
TOTAL	75 (187)	2.97:1	25 (63)
Stream Mitigation	1252 m (4107 ft)	2:1	626 m (2054 ft)

1: Restoration of upland buffers and ecotones may generate reduced credit ratios for wetland restoration in the complex. Past applications of HGM indicate that uplands may provide as much as a 20% lift in adjacent wetland functions on a per acre basis (31 ha [76 ac]). Therefore, mitigation ratios in restored wetland areas may be reduced to 1.6:1 by employing a landscape ecosystem approach to restoration.

Riverine portions of the Site adjacent to the Acre Swamp canal are projected to lack wetland hydrology due to the depth and drainage characteristics of the canal. However, riparian forest buffers would be restored along an approximately 1252 m (4107 ft) of the stream as a result of mitigation activities (Figure 8.1). Therefore, stream mitigation credit is proposed at a 2:1 ratio, generating approximately 626 m (2054 ft) of stream replacement credit for compensatory mitigation use.

Actual mitigation credit generated by restoration activities should be determined based on the achievement of Success Criteria, completed provisions for site protection in perpetuity, and the type and condition of wetlands impacted by a particular project. Restoration and enhancement strategies are designed to create steady-state nonriverine hardwood forests which support an array of native plant and wildlife communities. Restored steady-state wetland ecosystems would be expected to generate higher mitigation credit when compared to the degraded condition of potentially impacted wetlands typical of the project region. Therefore, above-estimated credit for this mitigation plan should be considered a base-line for determining appropriate credit on a project-by-project basis.

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10.0 APPENDICES

Appendix A: Well Data

Appendix B: Flood Frequency Analyses

Appendix A

Well Data

Continous Monitoring Well Data Available Upon Request

Appendix B

Flood Frequency Analyses

HYDRAULIC ANALYSIS OF ACRE SWAMP FOR THE ABC WETLAND MITIGATION SITE

BEAUFORT COUNTY, NC

ACRE SWAMP, BEAUFORT COUNTY, NC
WETLAND RESTORATION, ABC MITIGATION SITE
WATER SURFACE ELEVATIONS FOR DIFFERENT FLOOD FREQUENCIES

The following describes the assumptions and methodology used in estimating the water surface elevations for Acre Swamp which is on the eastern side of ABC mitigation site. ABC Mitigation site is north east of Pinetown in Beaufort County. ABC Mitigation Site has SR 1532 to the south and SR 1508 to the west.

Acre Swamp north of SR 1532 in Beaufort County is the study area for the Water Surface Profile Computational model (WSPRO). Acre Swamp north of SR 1532 is not in a FEMA detailed study area completed for Beaufort County. Since the study area is not a detailed study area, a WSPRO model was used instead of HEC-2 to estimate water surface elevations for different flood frequencies.

Other Studies in the Area: Bridge survey report for Bridge No. 157 (which is on SR 1532 over Acre Swamp) and FEMA study for Acre Swamp south of SR 1532 were the two sources of information for the study area. The study area is not a detailed FEMA study area. However, FEMA elevations south of SR 1532 can be used to verify reasonable accuracy of WSPRO model. Bridge report for Bridge No. 157 completed in March 1956 was used to get information about the bridge..

Controlling Factors: Acre Swamp both north and south of SR 1532 has wide flood plain (more than 500 feet). Bridge No. 157 crosses over Acre Swamp on SR 1532. Bridge No. 157 is a 51 feet long bridge with three 17 feet long spans. Acre Swamp severely constricts the stream near the bridge. Because of this severe constriction through the bridge, bridge hydraulics will be the controlling factor for estimating water surface elevations upstream of the bridge. WSPRO modeling of Acre Swamp started near the bridge and extended 5,150 feet upstream to the end of ABC Mitigation Site.

Drainage Area: United States Geological Survey (USGS) topographic maps were used to estimate the drainage area of Acre Swamp near the Bridge No. 157. Estimated drainage area of Acre Swamp near the bridge is 26.6 square miles and was confirmed by the 1956 Bridge Report.

Flood Discharges: Flood discharges for different flood frequencies were estimated using regression equations for Coastal Plains published in U.S. Geological Survey Water-Resources Investigations Report 87-4096. However, there were no regression equations to estimate 1-year flood. Log-log graph was used to estimate 1-year flood discharge. Flood discharges for different flood frequencies and Log-log graph can be seen in Appendix A.

Cross-Sections Along Acre Swamp: Two stream cross sections of the Acre Swamp near ABC Mitigation Site were provided by Eco-Science. These cross sections were supplemented by the cross sections stripped from the topographic maps of the area.

WSPRO Model: As mentioned before, WSPRO model started near the bridge on SR 1532 over Acre Swamp and extended five thousand one hundred fifty feet upstream to the limits of ABC Mitigation Site. Water surface elevations for different flood frequencies were found at eleven sections along Acre Swamp. Description and summary of water surface elevations at these eleven sections can be found in Appendix B. Complete WSPRO input and output can be found in Appendix C. 100 year flood elevation for Acre Swamp just after merging with Fork Swamp, as published by FEMA was 28.8 feet above Mean Sea Level. The 100 year flood elevations upstream should be either equal or more than this elevation. As shown in the summary, the 100 year flood elevation near the bridge was 29.125 feet. This verifies the reasonable accuracy of this WSPRO model. Flood boundaries for different flood frequencies can be found on the topographic maps included in Appendix D.

APPENDIX A

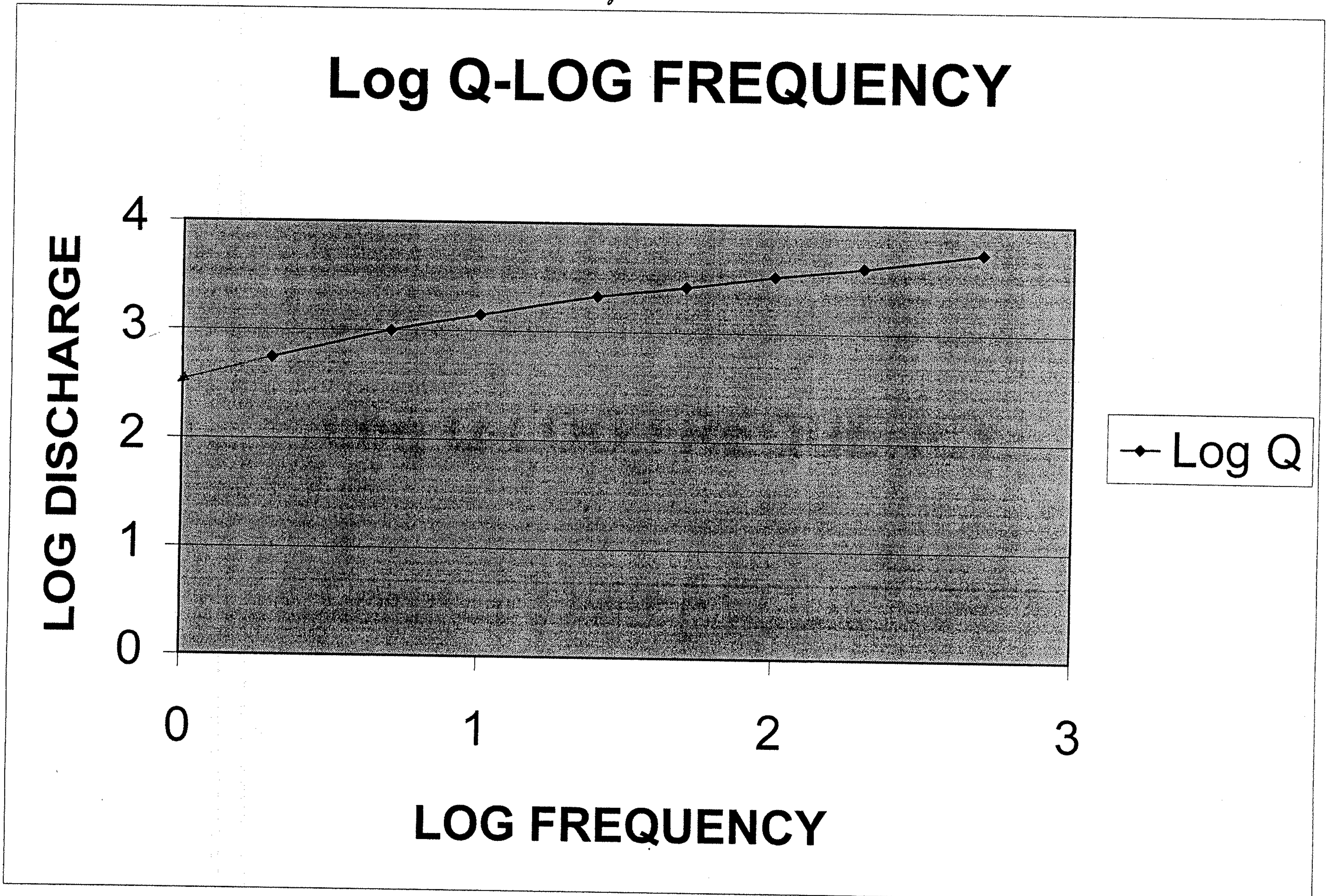
ACRE SWAMP, BEAUFORT COUNTY, NC
DISCHARGES FOR DIFFERENT FLOOD FREQUENCIES AT BRIDGE NO. 157 ON SR 1532 OVER ACRE SWAMP

Drainage Area(A) = 26.6 square miles

Use USGS Regression Equations for Coastal Plain areas

$Q_2 = 69.4\ A^{0.632} = 551.93$, say 550.00 cfs (cubic feet per second)
$Q_5 = 149\ A^{0.582} = 1005.69$, say 1000.00 cfs
$Q_{10} = 225\ A^{0.559} = 1408.29$, say 1400.00 cfs
$Q_{25} = 362\ A^{0.532} = 2073.70$, say 2100.00 cfs
$Q_{50} = 490\ A^{0.514} = 2645.97$, say 2600.00 cfs
$Q_{100} = 653\ A^{0.497} = 3334.87$, say 3300.00 cfs

1 year flood discharge = 350 cfs



APPENDIX B

ACRE SWAMP, BEAUFORT COUNTY, NC
WETLAND RESTORATION, ABC SITE
WATER SURFACE ELEVATIONS FOR DIFFERENT FLOOD FREQUENCIES

SECTION	DESCRIPTION	1 YR Q	2 YR Q	5 YR Q	10 YR Q	25 YR Q	50 YR Q	100 YR Q
APPR	50' upstram of bridge on SR 1532	17.783	18.796	20.801	21.969	23.421	26.062	29.125
SEC1	450' upstream of bridge on SR 1532	19.046	20.179	22.095	23.325	25.205	26.472	29.203
SECA	950' upstream of bridge on SR 1532	20.262	21.470	23.430	24.800	26.387	27.230	29.389
SEC3	1450' upstream of bridge on SR 1532	21.405	22.726	24.921	26.326	27.953	28.391	29.699
SEC4	1950' upstream of bridge on SR 1532	22.459	23.841	26.145	27.630	28.919	29.386	30.236
SEC5	2450' upstream of bridge on SR 1532	23.481	24.901	27.255	28.762	29.909	30.386	31.005
SECB	3150' upstream of bridge on SR 1532	24.709	26.126	28.343	29.800	30.830	31.278	31.808
SEC6	3650' upstream of bridge on SR 1532	25.449	26.779	28.555	29.916	30.929	31.380	31.916
SEC7	4150' upstream of bridge on SR 1532	26.305	27.584	28.997	30.156	31.152	31.605	32.136
SEC8	4650' upstream of bridge on SR 1532	27.229	28.470	29.766	30.617	31.585	32.045	32.564
SEC9	5150' upstream of bridge on SR 1532	28.196	29.426	30.694	31.355	32.230	32.715	33.252

APPENDIX C

```
I 0
T1 ACRE SWAMP, BEAUFORT COUNTY, NC
T2 WETLAND RESTORATION,ABC SITE
T3 EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE
*
*  1Q   2Q  5Q   10Q  25Q  50Q  100Q
Q  350 550 1000 1400 2100 2600 3300
SK .002 .002  .002  .002  .002  .002  .002
*
*
XS EXIT 1000 * * *
GR -500 30 -30 25 -27 24 -25 23 -23 22 -21 21 -19 20 -17 19
GR -15 18 -13 17 -11 16 -9 15 -6 13.711 -4 12.01 -2 12.271
GR 0 12.311 2 12.411 4 12.811 6 14.511 13 15 34 16 57 17
GR 77 18 95 19 110 20 1000 30
N 0.05 0.04 0.05
SA -9 13
*
XS FULV 1050 * * *
GT +0.1
*
BR BRDG 1050 27.25 0 * * *
GR -25 27.25 -22 26 -20 25 -13 20 -8 16 -6 13.811 -4 12.11
GR -2 12.371 0 12.411 2 12.511 4 12.911 6 14.611 10 16
GR 15.5 20 22 25 24 26 25 27.25 -25 27.25
CD 2 25 2 28.5
PD 0 15 1.5 1 17 3.0 2
N  0.05 0.04 0.05
A -8 10

XR ROAD 1062 25 1
GR -520 31 -25 29.4 0 29 25 29 500 31
*
XS APPR 1120 * * *
GR -460 31 -400 29 -260 28 -110 27 -78 26 -54 25 -42 24 -30 23
GR -19 22 -17 21 -15 20 -14 19 -12 18 -10 17 -8 16 -6 13.911
GR -4 12.21 -2 12.471 0 12.511 2 12.611 4 13.011 6 16 10 17 13 18
GR 17 19 20 20 23 21 26 22 65 23 800 31
N  0.05 0.04 0.05
SA -8 10
*
XS SEC1 1500 0.0 * * 0.002
*
XS SECA 2000 0.0 * *
GR -500 31 -440 30 -18 25 -16 24.231 -14 23.041 -12 22.131 -10 21.131
GR -8 19.201 -7.4 18.131 -6 15.731 -4 14.031 -2 14.291 0 14.331
GR 2 14.431 4 14.831 6 16.531 8 17.931 10 19.671 12 22.171 14 23.361
GR 16 23.431 18 23.521 20 23.531 22 23.681 24 23.791 26 23.881
GR 28 23.991 30 24.101 32 24.101 34 24.081 36 24.141 36.5 24.231 38 25
GR 440 30 500 31
*
XS SEC3 2500 0.0 * * 0.002
*
XS SEC4 3000 0.0 * * 0.002
*
XS SEC5 3500 0.0 * * 0.002
*
S SECB 4200 0.0 * *
GR -400 32 -360 30 -240 29 -130 29.5 -28 29 -18 25.761 -16 25.361
GR -14 25.011 -12 24.761 -10 24.211 -8 23.511 -6 22.361 -4 21.161
```

```
GR -3 20.111 -2 18.811 -1 18.711 0 18.661 2 18.511 4 18.461 6 17.611
GR 8 17.961 9 19.511 10 21.111 12 22.761 14 23.461 16 23.761 18 24.061
GR 20 24.361 22 24.511 24 24.611 26 24.611 28 24.761 32 24.861
GR 36 24.961 40 25.161 44 25.261 48 25.461 52 25.561 57.8 25.761
GR 180 26 440 30 500 32
*
XS SEC6 4700 0.0 * * 0.002
*
XS SEC7 5200 0.0 * * 0.002
*
XS SEC8 5700 0.0 * * 0.002
*
XS SEC9 6200 0.0 * * 0.002
*
EX 0 0 0 0 0 0 0
ER
```

```
     ************************  W S P R O  **************************
        Federal Highway Administration  -  U. S. Geological Survey
            Model for Water-Surface Profile Computations.
          Run Date & Time:  4/23/99  8:53 am     Version V050196
           Input File: BEAUBR.WSP     Output File: BEAUBR.LST
     *-------------------------------------------------------------*
 *F
  ***                     Input Data In Free Format                     ***

 SI  0
 T1  ACRE SWAMP, BEAUFORT COUNTY, NC
 T2  WETLAND RESTORATION,ABC SITE
 T3  EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE
 Q   350 550 1000 1400 2100 2600 3300

  ***   Processing Flow Data; Placing Information into Sequence  1    ***

 SK  .002 .002  .002  .002  .002  .002  .002
     ************************  W S P R O  **************************
        Federal Highway Administration  -  U. S. Geological Survey
            Model for Water-Surface Profile Computations.
           Input Units: English  /  Output Units: English
    *-------------------------------------------------------------*
                   ACRE SWAMP, BEAUFORT COUNTY, NC
                    WETLAND RESTORATION,ABC SITE
    EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

         *-----------------------------------------------------*
         *      Starting To Process Header Record EXIT         *
         *-----------------------------------------------------*

 XS EXIT 1000 * * *
 GR  -500 30 -30 25 -27 24 -25 23 -23 22 -21 21 -19 20 -17 19
 GR  -15 18 -13 17 -11 16 -9 15 -6 13.711 -4 12.01 -2 12.271
 GR  0 12.311 2 12.411 4 12.811 6 14.511 13 15 34 16 57 17
 GR  77 18 95 19 110 20 1000 30
 N  0.05 0.04 0.05
 SA  -9 13

  ***   Completed Reading Data Associated With Header Record EXIT    ***
  ***  Storing X-Section Data In Temporary File As Record Number  1  ***

  ***              Data Summary For Header Record EXIT               ***
  SRD Location:     1000.   Cross-Section Skew:    .0   Error Code   0
  Valley Slope:   .00000    Averaging Conveyance By Geometric Mean.
  Energy Loss Coefficients ->  Expansion:   .50   Contraction:   .00

                     X,Y-coordinates (26 pairs)
       X          Y            X          Y            X          Y
  ---------- ----------  ---------- ----------  ---------- ----------
    -500.000     30.000     -30.000     25.000     -27.000     24.000
     -25.000     23.000     -23.000     22.000     -21.000     21.000
     -19.000     20.000     -17.000     19.000     -15.000     18.000
     -13.000     17.000     -11.000     16.000      -9.000     15.000
      -6.000     13.711      -4.000     12.010      -2.000     12.271
        .000     12.311       2.000     12.411       4.000     12.811
       6.000     14.511      13.000     15.000      34.000     16.000
      57.000     17.000      77.000     18.000      95.000     19.000
     110.000     20.000    1000.000     30.000
  ---------- ----------  ---------- ----------  ---------- ----------
```

```
                    Minimum and Maximum X,Y-coordinates
   Minimum X-Station:     -500.000  ( associated Y-Elevation:    30.000 )
   Maximum X-Station:     1000.000  ( associated Y-Elevation:    30.000 )
   Minimum Y-Elevation:     12.010  ( associated X-Station:      -4.000 )
   Maximum Y-Elevation:     30.000  ( associated X-Station:    -500.000 )

                       Roughness Data (  3 SubAreas )
                               Roughness    Horizontal
                     SubArea  Coefficient   Breakpoint
                     -------  -----------   ----------
                        1         .050          ---
                                  ---          -9.000
                        2         .040          ---
                                  ---          13.000
                        3         .050          ---
                     -------  -----------   ----------

           *-----------------------------------------------------*
           *       Finished Processing Header Record EXIT        *
           *-----------------------------------------------------*
      *************************  W S P R O  ***************************
        Federal Highway Administration  -  U. S. Geological Survey
               Model for Water-Surface Profile Computations.
              Input Units: English  /  Output Units: English
     *-----------------------------------------------------------------*
                        ACRE SWAMP, BEAUFORT COUNTY, NC
                         WETLAND RESTORATION,ABC SITE
     EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

           *-----------------------------------------------------*
           *      Starting To Process Header Record FULV         *
           *-----------------------------------------------------*

 XS FULV 1050 * * *
 GT  +0.1

  ***   Completed Reading Data Associated With Header Record FULV    ***
  ***   No Roughness Data Input, Propagating From Previous Section   ***
  ***  Storing X-Section Data In Temporary File As Record Number  2  ***

  ***              Data Summary For Header Record FULV               ***
  SRD Location:      1050.   Cross-Section Skew:    .0   Error Code   0
  Valley Slope:    .00000   Averaging Conveyance By Geometric Mean.
  Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                        X,Y-coordinates (26 pairs)
        X           Y            X           Y            X           Y
   ----------  ----------   ----------  ----------   ----------  ----------
     -500.000      30.000      -30.000      25.000      -27.000      24.000
      -25.000      23.000      -23.000      22.000      -21.000      21.000
      -19.000      20.000      -17.000      19.000      -15.000      18.000
      -13.000      17.000      -11.000      16.000       -9.000      15.000
       -6.000      13.711       -4.000      12.010       -2.000      12.271
         .000      12.311        2.000      12.411        4.000      12.811
        6.000      14.511       13.000      15.000       34.000      16.000
       57.000      17.000       77.000      18.000       95.000      19.000
      110.000      20.000     1000.000      30.000
   ----------  ----------   ----------  ----------   ----------  ----------

                    Minimum and Maximum X,Y-coordinates
   Minimum X-Station:     -500.000  ( associated Y-Elevation:    30.000 )
```

```
Maximum X-Station:     1000.000  ( associated Y-Elevation:    30.000 )
Minimum Y-Elevation:     12.010  ( associated X-Station:      -4.000 )
Maximum Y-Elevation:     30.000  ( associated X-Station:    -500.000 )

                 Roughness Data (  3 SubAreas )
                          Roughness   Horizontal
                 SubArea  Coefficient Breakpoint
                 -------  ----------- ----------
                    1         .050       ---
                              ---       -9.000
                    2         .040       ---
                              ---       13.000
                    3         .050       ---
                 -------  ----------- ----------

          *-----------------------------------------------*
          *     Finished Processing Header Record FULV     *
          *-----------------------------------------------*
    ***********************  W S P R O  ************************
      Federal Highway Administration  -  U. S. Geological Survey
             Model for Water-Surface Profile Computations.
            Input Units: English  /  Output Units: English
   *------------------------------------------------------------*
                    ACRE SWAMP, BEAUFORT COUNTY, NC
                     WETLAND RESTORATION,ABC SITE
   EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

          *-----------------------------------------------*
          *     Starting To Process Header Record BRDG     *
          *-----------------------------------------------*

BR BRDG 1050 27.25 0 * * *
GR  -25 27.25 -22 26 -20 25 -13 20 -8 16 -6 13.811 -4 12.11
GR  -2 12.371 0 12.411 2 12.511 4 12.911 6 14.611 10 16
GR  15.5 20 22 25 24 26 25 27.25 -25 27.25
CD  2 25 2 28.5
PD  0 15 1.5 1 17 3.0 2
N   0.05 0.04 0.05
SA  -8 10

 ***  Completed Reading Data Associated With Header Record BRDG    ***
 ***  Storing Bridge Data In Temporary File As Record Number  3    ***

 ***              Data Summary For Bridge Record BRDG              ***
 SRD Location:     1050.  Cross-Section Skew:    .0  Error Code   0
 Valley Slope:  *******   Averaging Conveyance By Geometric Mean.
 Energy Loss Coefficients ->  Expansion:   .50  Contraction:   .00

                  X,Y-coordinates (18 pairs)
```

X	Y	X	Y	X	Y
-25.000	27.250	-22.000	26.000	-20.000	25.000
-13.000	20.000	-8.000	16.000	-6.000	13.811
-4.000	12.110	-2.000	12.371	.000	12.411
2.000	12.511	4.000	12.911	6.000	14.611
10.000	16.000	15.500	20.000	22.000	25.000
24.000	26.000	25.000	27.250	-25.000	27.250

```
               Minimum and Maximum X,Y-coordinates
 Minimum X-Station:     -25.000  ( associated Y-Elevation:   27.250 )
```

```
Maximum X-Station:       25.000  ( associated Y-Elevation:   27.250 )
Minimum Y-Elevation:     12.110  ( associated X-Station:     -4.000 )
Maximum Y-Elevation:     27.250  ( associated X-Station:    -25.000 )

                  Roughness Data (  3 SubAreas )
                          Roughness   Horizontal
                SubArea  Coefficient  Breakpoint
                -------  -----------  ----------
                   1         .050         ---
                             ---        -8.000
                   2         .040         ---
                             ---        10.000
                   3         .050         ---
                -------  -----------  ----------

                Discharge coefficient parameters
           BRType    BRWdth    EMBSS    EMBElv     UserCD
            2         25.000   2.00     28.500 **********

                    Pressure flow elevations
                       AVBCEL       PFElev
                    *********       27.250

                        Abutment Parameters
      ABSLPL  ABSLPR   XTOELT    YTOELT    XTOERT    YTOERT
     ******* ******* ********* ********* ********* *********


               Pier/Pile Data (  2 Group(s) )
             Code Indicates Bridge Uses Piers
             Group  Elevation  Gross Width  Number
            ------  ---------  -----------  ------
               1     15.000      1.500        1
               2     17.000      3.000        2
            ------  ---------  -----------  ------

          *--------------------------------------------------*
          *      Finished Processing Header Record BRDG      *
          *--------------------------------------------------*
       ************************* W S P R O ***************************
         Federal Highway Administration  -  U. S. Geological Survey
                Model for Water-Surface Profile Computations.
               Input Units: English  /  Output Units: English
      *------------------------------------------------------------------*
                        ACRE SWAMP, BEAUFORT COUNTY, NC
                          WETLAND RESTORATION,ABC SITE
      EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

          *--------------------------------------------------*
          *      Starting To Process Header Record ROAD      *
          *--------------------------------------------------*

XR ROAD 1062 25 1
GR  -520 31 -25 29.4 0 29 25 29 500 31

 ***   Completed Reading Data Associated With Header Record ROAD     ***
  ***   Storing Roadway Data In Temporary File As Record Number  4     ***

 ***                Data Summary For Roadway Record ROAD                ***
 SRD Location:      1062.   Cross-Section Skew:     .0   Error Code    0
 Roadway Width:    25.000   User-Specified Weir Coefficient:  ******
```

```
Input Code Indicates Roadway Surface Consists of a Paved Material.

                         X,Y-coordinates ( 5 pairs)
     X          Y          X          Y          X          Y
 ---------- ---------- ---------- ---------- ---------- ----------
   -520.000     31.000    -25.000     29.400       .000     29.000
     25.000     29.000    500.000     31.000
 ---------- ---------- ---------- ---------- ---------- ----------

                   Minimum and Maximum X,Y-coordinates
  Minimum X-Station:     -520.000  ( associated Y-Elevation:    31.000 )
  Maximum X-Station:      500.000  ( associated Y-Elevation:    31.000 )
  Minimum Y-Elevation:     29.000  ( associated X-Station:      25.000 )
  Maximum Y-Elevation:     31.000  ( associated X-Station:    -520.000 )

Bridge datum projection:  XREFLT = *******

          *-----------------------------------------------------*
          *      Finished Processing Header Record ROAD         *
          *-----------------------------------------------------*
    ************************ W S P R O *************************
       Federal Highway Administration  -  U. S. Geological Survey
              Model for Water-Surface Profile Computations.
             Input Units: English  /  Output Units: English
    *---------------------------------------------------------------*
                   ACRE SWAMP, BEAUFORT COUNTY, NC
                   WETLAND RESTORATION,ABC SITE
    EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

          *-----------------------------------------------------*
          *      Starting To Process Header Record APPR         *
          *-----------------------------------------------------*

 XS APPR 1120 * * *
 GR  -460 31 -400 29 -260 28 -110 27 -78 26 -54 25 -42 24 -30 23
 GR  -19 22 -17 21 -15 20 -14 19 -12 18 -10 17 -8 16 -6 13.911
 GR  -4 12.21 -2 12.471 0 12.511 2 12.611 4 13.011 6 16 10 17 13 18
 GR  17 19 20 20 23 21 26 22 65 23 800 31
 N   0.05 0.04 0.05
 SA  -8 10

  ***   Completed Reading Data Associated With Header Record APPR    ***
  ***  Storing X-Section Data In Temporary File As Record Number  5  ***

  ***             Data Summary For Header Record APPR                ***
  SRD Location:     1120.   Cross-Section Skew:    .0   Error Code   0
  Valley Slope:   .00000    Averaging Conveyance By Geometric Mean.
  Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                         X,Y-coordinates (30 pairs)
     X          Y          X          Y          X          Y
 ---------- ---------- ---------- ---------- ---------- ----------
   -460.000     31.000   -400.000     29.000   -260.000     28.000
   -110.000     27.000    -78.000     26.000    -54.000     25.000
    -42.000     24.000    -30.000     23.000    -19.000     22.000
    -17.000     21.000    -15.000     20.000    -14.000     19.000
    -12.000     18.000    -10.000     17.000     -8.000     16.000
     -6.000     13.911     -4.000     12.210     -2.000     12.471
       .000     12.511      2.000     12.611      4.000     13.011
      6.000     16.000     10.000     17.000     13.000     18.000
     17.000     19.000     20.000     20.000     23.000     21.000
```

```
   26.000      22.000      65.000      23.000      800.000      31.000
 ----------  ----------  ----------  ----------  ----------  ----------

                    Minimum and Maximum X,Y-coordinates
    Minimum X-Station:    -460.000  ( associated Y-Elevation:    31.000 )
    Maximum X-Station:     800.000  ( associated Y-Elevation:    31.000 )
    Minimum Y-Elevation:    12.210  ( associated X-Station:      -4.000 )
    Maximum Y-Elevation:    31.000  ( associated X-Station:    -460.000 )

                       Roughness Data (  3 SubAreas )
                             Roughness   Horizontal
                     SubArea  Coefficient  Breakpoint
                     -------  -----------  ----------
                        1        .050         ---
                                 ---        -8.000
                        2        .040         ---
                                 ---        10.000
                        3        .050         ---
                     -------  -----------  ----------

 Bridge datum projection(s):  XREFLT  XREFRT  FDSTLT  FDSTRT
                              ******* ******* ******* *******

          *-----------------------------------------------------*
          *      Finished Processing Header Record APPR         *
          *-----------------------------------------------------*
      ************************* W S P R O **************************
         Federal Highway Administration  -  U. S. Geological Survey
                Model for Water-Surface Profile Computations.
               Input Units: English  /  Output Units: English
    *------------------------------------------------------------------*
                       ACRE SWAMP, BEAUFORT COUNTY, NC
                         WETLAND RESTORATION,ABC SITE
    EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

          *-----------------------------------------------------*
          *      Starting To Process Header Record SEC1         *
          *-----------------------------------------------------*

  XS SEC1 1500 0.0 * * 0.002

   ***   Completed Reading Data Associated With Header Record SEC1     ***
   ***   No Roughness Data Input, Propagating From Previous Section    ***
   ***  Storing X-Section Data In Temporary File As Record Number  6   ***

   ***               Data Summary For Header Record SEC1               ***
   SRD Location:      1500.    Cross-Section Skew:     .0    Error Code   0
   Valley Slope:    .00200     Averaging Conveyance By Geometric Mean.
   Energy Loss Coefficients ->   Expansion:    .50   Contraction:    .00

                        X,Y-coordinates (30 pairs)
       X           Y           X           Y           X           Y
  ----------  ----------  ----------  ----------  ----------  ----------
    -460.000      31.760    -400.000      29.760    -260.000      28.760
    -110.000      27.760     -78.000      26.760     -54.000      25.760
     -42.000      24.760     -30.000      23.760     -19.000      22.760
     -17.000      21.760     -15.000      20.760     -14.000      19.760
     -12.000      18.760     -10.000      17.760      -8.000      16.760
      -6.000      14.671      -4.000      12.970      -2.000      13.231
        .000      13.271       2.000      13.371       4.000      13.771
       6.000      16.760      10.000      17.760      13.000      18.760
```

17.000	19.760	20.000	20.760	23.000	21.760
26.000	22.760	65.000	23.760	800.000	31.760

Minimum and Maximum X,Y-coordinates

```
Minimum X-Station:    -460.000  ( associated Y-Elevation:   31.760 )
Maximum X-Station:     800.000  ( associated Y-Elevation:   31.760 )
Minimum Y-Elevation:    12.970  ( associated X-Station:     -4.000 )
Maximum Y-Elevation:    31.760  ( associated X-Station:   -460.000 )
```

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	-8.000
2	.040	---
	---	10.000
3	.050	---

```
*-------------------------------------------------------*
*      Finished Processing Header Record SEC1           *
*-------------------------------------------------------*
```

```
************************* W S P R O **************************
Federal Highway Administration  -  U. S. Geological Survey
        Model for Water-Surface Profile Computations.
       Input Units: English  /  Output Units: English
*---------------------------------------------------------------*
```

ACRE SWAMP, BEAUFORT COUNTY, NC
WETLAND RESTORATION,ABC SITE
EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

```
*-------------------------------------------------------*
*      Starting To Process Header Record SECA           *
*-------------------------------------------------------*
```

```
XS SECA 2000 0.0 * *
GR  -500 31 -440 30 -18 25 -16 24.231 -14 23.041 -12 22.131 -10 21.131
GR  -8 19.201 -7.4 18.131 -6 15.731 -4 14.031 -2 14.291 0 14.331
GR  2 14.431 4 14.831 6 16.531 8 17.931 10 19.671 12 22.171 14 23.361
GR  16 23.431 18 23.521 20 23.531 22 23.681 24 23.791 26 23.881
GR  28 23.991 30 24.101 32 24.101 34 24.081 36 24.141 36.5 24.231 38 25
GR  440 30 500 31
```

```
***   Completed Reading Data Associated With Header Record SECA    ***
***   No Roughness Data Input, Propagating From Previous Section   ***
***  Storing X-Section Data In Temporary File As Record Number  7  ***
```

```
***                Data Summary For Header Record SECA                ***
SRD Location:      2000.   Cross-Section Skew:    .0   Error Code   0
Valley Slope:    .00200    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->  Expansion:   .50   Contraction:   .00
```

X,Y-coordinates (35 pairs)

X	Y	X	Y	X	Y
-500.000	31.000	-440.000	30.000	-18.000	25.000
-16.000	24.231	-14.000	23.041	-12.000	22.131
-10.000	21.131	-8.000	19.201	-7.400	18.131
-6.000	15.731	-4.000	14.031	-2.000	14.291

.000	14.331	2.000	14.431	4.000	14.831
6.000	16.531	8.000	17.931	10.000	19.671
12.000	22.171	14.000	23.361	16.000	23.431
18.000	23.521	20.000	23.531	22.000	23.681
24.000	23.791	26.000	23.881	28.000	23.991
30.000	24.101	32.000	24.101	34.000	24.081
36.000	24.141	36.500	24.231	38.000	25.000
440.000	30.000	500.000	31.000		

Minimum and Maximum X,Y-coordinates

Minimum X-Station:	-500.000	(associated Y-Elevation: 31.000)
Maximum X-Station:	500.000	(associated Y-Elevation: 31.000)
Minimum Y-Elevation:	14.031	(associated X-Station: -4.000)
Maximum Y-Elevation:	31.000	(associated X-Station: -500.000)

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	-8.000
2	.040	---
	---	10.000
3	.050	---

```
*-------------------------------------------------*
*      Finished Processing Header Record SECA     *
*-------------------------------------------------*
************************* W S P R O *************************
Federal Highway Administration - U. S. Geological Survey
Model for Water-Surface Profile Computations.
Input Units: English / Output Units: English
*-------------------------------------------------------------*
ACRE SWAMP, BEAUFORT COUNTY, NC
WETLAND RESTORATION,ABC SITE
EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

*-------------------------------------------------*
*      Starting To Process Header Record SEC3     *
*-------------------------------------------------*

XS SEC3 2500 0.0 * * 0.002

***  Completed Reading Data Associated With Header Record SEC3  ***
***  No Roughness Data Input, Propagating From Previous Section  ***
***  Storing X-Section Data In Temporary File As Record Number 8  ***

***            Data Summary For Header Record SEC3              ***
SRD Location:    2500.   Cross-Section Skew:    .0   Error Code  0
Valley Slope:   .00200   Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->  Expansion:   .50  Contraction:   .00
```

X,Y-coordinates (35 pairs)

X	Y	X	Y	X	Y
-500.000	32.000	-440.000	31.000	-18.000	26.000
-16.000	25.231	-14.000	24.041	-12.000	23.131
-10.000	22.131	-8.000	20.201	-7.400	19.131
-6.000	16.731	-4.000	15.031	-2.000	15.291

.000	15.331	2.000	15.431	4.000	15.831
6.000	17.531	8.000	18.931	10.000	20.671
12.000	23.171	14.000	24.361	16.000	24.431
18.000	24.521	20.000	24.531	22.000	24.681
24.000	24.791	26.000	24.881	28.000	24.991
30.000	25.101	32.000	25.101	34.000	25.081
36.000	25.141	36.500	25.231	38.000	26.000
440.000	31.000	500.000	32.000		

Minimum and Maximum X,Y-coordinates

```
Minimum X-Station:     -500.000  ( associated Y-Elevation:    32.000 )
Maximum X-Station:      500.000  ( associated Y-Elevation:    32.000 )
Minimum Y-Elevation:     15.031  ( associated X-Station:      -4.000 )
Maximum Y-Elevation:     32.000  ( associated X-Station:    -500.000 )
```

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	-8.000
2	.040	---
	---	10.000
3	.050	---

```
*-----------------------------------------------*
*     Finished Processing Header Record SEC3    *
*-----------------------------------------------*
************************ W S P R O ************************
Federal Highway Administration  -  U. S. Geological Survey
      Model for Water-Surface Profile Computations.
    Input Units: English  /  Output Units: English
*----------------------------------------------------------*
              ACRE SWAMP, BEAUFORT COUNTY, NC
               WETLAND RESTORATION,ABC SITE
EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

*-----------------------------------------------*
*     Starting To Process Header Record SEC4    *
*-----------------------------------------------*

XS SEC4 3000 0.0 * * 0.002

 ***  Completed Reading Data Associated With Header Record SEC4     ***
 ***  No Roughness Data Input, Propagating From Previous Section    ***
 *** Storing X-Section Data In Temporary File As Record Number  9   ***

 ***            Data Summary For Header Record SEC4                 ***
SRD Location:      3000.   Cross-Section Skew:     .0   Error Code   0
Valley Slope:    .00200    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->   Expansion:    .50   Contraction:    .00
```

X,Y-coordinates (35 pairs)

X	Y	X	Y	X	Y
-500.000	33.000	-440.000	32.000	-18.000	27.000
-16.000	26.231	-14.000	25.041	-12.000	24.131
-10.000	23.131	-8.000	21.201	-7.400	20.131
-6.000	17.731	-4.000	16.031	-2.000	16.291

.000	16.331	2.000	16.431	4.000	16.831
6.000	18.531	8.000	19.931	10.000	21.671
12.000	24.171	14.000	25.361	16.000	25.431
18.000	25.521	20.000	25.531	22.000	25.681
24.000	25.791	26.000	25.881	28.000	25.991
30.000	26.101	32.000	26.101	34.000	26.081
36.000	26.141	36.500	26.231	38.000	27.000
440.000	32.000	500.000	33.000		

Minimum and Maximum X,Y-coordinates

Minimum X-Station: -500.000 (associated Y-Elevation: 33.000)
Maximum X-Station: 500.000 (associated Y-Elevation: 33.000)
Minimum Y-Elevation: 16.031 (associated X-Station: -4.000)
Maximum Y-Elevation: 33.000 (associated X-Station: -500.000)

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	-8.000
2	.040	---
	---	10.000
3	.050	---

```
*-------------------------------------------------*
*    Finished Processing Header Record SEC4       *
*-------------------------------------------------*
************************  W S P R O  *************************
Federal Highway Administration  -  U. S. Geological Survey
       Model for Water-Surface Profile Computations.
      Input Units: English  /  Output Units: English
*-------------------------------------------------------------*
```

ACRE SWAMP, BEAUFORT COUNTY, NC
WETLAND RESTORATION,ABC SITE
EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

```
*-------------------------------------------------*
*    Starting To Process Header Record SEC5       *
*-------------------------------------------------*
```

XS SEC5 3500 0.0 * * 0.002

```
***  Completed Reading Data Associated With Header Record SEC5     ***
***  No Roughness Data Input, Propagating From Previous Section    ***
***  Storing X-Section Data In Temporary File As Record Number 10  ***

***              Data Summary For Header Record SEC5               ***
SRD Location:     3500.   Cross-Section Skew:    .0   Error Code   0
Valley Slope:   .00200    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->  Expansion:   .50   Contraction:   .00
```

X,Y-coordinates (35 pairs)

X	Y	X	Y	X	Y
-500.000	34.000	-440.000	33.000	-18.000	28.000
-16.000	27.231	-14.000	26.041	-12.000	25.131
-10.000	24.131	-8.000	22.201	-7.400	21.131
-6.000	18.731	-4.000	17.031	-2.000	17.291

```
      .000      17.331       2.000      17.431       4.000      17.831
     6.000      19.531       8.000      20.931      10.000      22.671
    12.000      25.171      14.000      26.361      16.000      26.431
    18.000      26.521      20.000      26.531      22.000      26.681
    24.000      26.791      26.000      26.881      28.000      26.991
    30.000      27.101      32.000      27.101      34.000      27.081
    36.000      27.141      36.500      27.231      38.000      28.000
   440.000      33.000     500.000      34.000
----------  ----------  ----------  ----------  ----------  ----------

               Minimum and Maximum X,Y-coordinates
  Minimum X-Station:     -500.000  ( associated Y-Elevation:    34.000 )
  Maximum X-Station:      500.000  ( associated Y-Elevation:    34.000 )
  Minimum Y-Elevation:     17.031  ( associated X-Station:      -4.000 )
  Maximum Y-Elevation:     34.000  ( associated X-Station:    -500.000 )

                  Roughness Data (  3 SubAreas )
                        Roughness    Horizontal
                SubArea  Coefficient  Breakpoint
                -------  -----------  ----------
                   1         .050        ---
                             ---       -8.000
                   2         .040        ---
                             ---       10.000
                   3         .050        ---
                -------  -----------  ----------

          *-----------------------------------------------------*
          *      Finished Processing Header Record SEC5         *
          *-----------------------------------------------------*
     *************************  W S P R O  **************************
        Federal Highway Administration  -  U. S. Geological Survey
               Model for Water-Surface Profile Computations.
              Input Units: English  /  Output Units: English
    *-----------------------------------------------------------------*
                     ACRE SWAMP, BEAUFORT COUNTY, NC
                      WETLAND RESTORATION,ABC SITE
    EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

          *-----------------------------------------------------*
          *      Starting To Process Header Record SECB         *
          *-----------------------------------------------------*

XS SECB 4200 0.0 * *
GR  -400 32 -360 30 -240 29 -130 29.5 -28 29 -18 25.761 -16 25.361
GR  -14 25.011 -12 24.761 -10 24.211 -8 23.511 -6 22.361 -4 21.161
GR  -3 20.111 -2 18.811 -1 18.711 0 18.661 2 18.511 4 18.461 6 17.611
GR  8 17.961 9 19.511 10 21.111 12 22.761 14 23.461 16 23.761 18 24.061
GR  20 24.361 22 24.511 24 24.611 26 24.611 28 24.761 32 24.861
GR  36 24.961 40 25.161 44 25.261 48 25.461 52 25.561 57.8 25.761
GR  180 26 440 30 500 32

 ***   Completed Reading Data Associated With Header Record SECB      ***
 ***   No Roughness Data Input, Propagating From Previous Section     ***
 ***  Storing X-Section Data In Temporary File As Record Number 11    ***

 ***             Data Summary For Header Record SECB                  ***
 SRD Location:     4200.   Cross-Section Skew:    .0   Error Code   0
 Valley Slope:   .00200    Averaging Conveyance By Geometric Mean.
 Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00
```

X,Y-coordinates (42 pairs)

X	Y	X	Y	X	Y
-400.000	32.000	-360.000	30.000	-240.000	29.000
-130.000	29.500	-28.000	29.000	-18.000	25.761
-16.000	25.361	-14.000	25.011	-12.000	24.761
-10.000	24.211	-8.000	23.511	-6.000	22.361
-4.000	21.161	-3.000	20.111	-2.000	18.811
-1.000	18.711	.000	18.661	2.000	18.511
4.000	18.461	6.000	17.611	8.000	17.961
9.000	19.511	10.000	21.111	12.000	22.761
14.000	23.461	16.000	23.761	18.000	24.061
20.000	24.361	22.000	24.511	24.000	24.611
26.000	24.611	28.000	24.761	32.000	24.861
36.000	24.961	40.000	25.161	44.000	25.261
48.000	25.461	52.000	25.561	57.800	25.761
180.000	26.000	440.000	30.000	500.000	32.000

Minimum and Maximum X,Y-coordinates

```
Minimum X-Station:     -400.000  ( associated Y-Elevation:    32.000 )
Maximum X-Station:      500.000  ( associated Y-Elevation:    32.000 )
Minimum Y-Elevation:     17.611  ( associated X-Station:       6.000 )
Maximum Y-Elevation:     32.000  ( associated X-Station:    -400.000 )
```

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	-8.000
2	.040	---
	---	10.000
3	.050	---

```
*---------------------------------------------------*
*      Finished Processing Header Record SECB       *
*---------------------------------------------------*
```

```
************************  W S P R O  *************************
 Federal Highway Administration  -  U. S. Geological Survey
          Model for Water-Surface Profile Computations.
         Input Units: English  /  Output Units: English
*--------------------------------------------------------------*
```

ACRE SWAMP, BEAUFORT COUNTY, NC
WETLAND RESTORATION,ABC SITE
EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

```
*---------------------------------------------------*
*     Starting To Process Header Record SEC6        *
*---------------------------------------------------*
```

XS SEC6 4700 0.0 * * 0.002

```
***   Completed Reading Data Associated With Header Record SEC6    ***
***   No Roughness Data Input, Propagating From Previous Section   ***
***  Storing X-Section Data In Temporary File As Record Number 12  ***

***                Data Summary For Header Record SEC6             ***
SRD Location:      4700.    Cross-Section Skew:     .0   Error Code   0
Valley Slope:    .00200    Averaging Conveyance By Geometric Mean.
```

Energy Loss Coefficients -> Expansion: .50 Contraction: .00

X,Y-coordinates (42 pairs)

X	Y	X	Y	X	Y
-400.000	33.000	-360.000	31.000	-240.000	30.000
-130.000	30.500	-28.000	30.000	-18.000	26.761
-16.000	26.361	-14.000	26.011	-12.000	25.761
-10.000	25.211	-8.000	24.511	-6.000	23.361
-4.000	22.161	-3.000	21.111	-2.000	19.811
-1.000	19.711	.000	19.661	2.000	19.511
4.000	19.461	6.000	18.611	8.000	18.961
9.000	20.511	10.000	22.111	12.000	23.761
14.000	24.461	16.000	24.761	18.000	25.061
20.000	25.361	22.000	25.511	24.000	25.611
26.000	25.611	28.000	25.761	32.000	25.861
36.000	25.961	40.000	26.161	44.000	26.261
48.000	26.461	52.000	26.561	57.800	26.761
180.000	27.000	440.000	31.000	500.000	33.000

Minimum and Maximum X,Y-coordinates

Minimum X-Station: -400.000 (associated Y-Elevation: 33.000)
Maximum X-Station: 500.000 (associated Y-Elevation: 33.000)
Minimum Y-Elevation: 18.611 (associated X-Station: 6.000)
Maximum Y-Elevation: 33.000 (associated X-Station: -400.000)

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	-8.000
2	.040	---
	---	10.000
3	.050	---

--
* Finished Processing Header Record SEC6 *
--

************************ W S P R O ************************
Federal Highway Administration - U. S. Geological Survey
Model for Water-Surface Profile Computations.
Input Units: English / Output Units: English
--

ACRE SWAMP, BEAUFORT COUNTY, NC
WETLAND RESTORATION,ABC SITE
EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

--
* Starting To Process Header Record SEC7 *
--

XS SEC7 5200 0.0 * * 0.002

*** Completed Reading Data Associated With Header Record SEC7 ***
*** No Roughness Data Input, Propagating From Previous Section ***
*** Storing X-Section Data In Temporary File As Record Number 13 ***

*** Data Summary For Header Record SEC7 ***

```
SRD Location:      5200.   Cross-Section Skew:    .0   Error Code   0
Valley Slope:   .00200    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00
```

X,Y-coordinates (42 pairs)

X	Y	X	Y	X	Y
-400.000	34.000	-360.000	32.000	-240.000	31.000
-130.000	31.500	-28.000	31.000	-18.000	27.761
-16.000	27.361	-14.000	27.011	-12.000	26.761
-10.000	26.211	-8.000	25.511	-6.000	24.361
-4.000	23.161	-3.000	22.111	-2.000	20.811
-1.000	20.711	.000	20.661	2.000	20.511
4.000	20.461	6.000	19.611	8.000	19.961
9.000	21.511	10.000	23.111	12.000	24.761
14.000	25.461	16.000	25.761	18.000	26.061
20.000	26.361	22.000	26.511	24.000	26.611
26.000	26.611	28.000	26.761	32.000	26.861
36.000	26.961	40.000	27.161	44.000	27.261
48.000	27.461	52.000	27.561	57.800	27.761
180.000	28.000	440.000	32.000	500.000	34.000

```
           Minimum and Maximum X,Y-coordinates
Minimum X-Station:    -400.000  ( associated Y-Elevation:    34.000 )
Maximum X-Station:     500.000  ( associated Y-Elevation:    34.000 )
Minimum Y-Elevation:    19.611  ( associated X-Station:       6.000 )
Maximum Y-Elevation:    34.000  ( associated X-Station:    -400.000 )
```

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	-8.000
2	.040	---
	---	10.000
3	.050	---

```
*---------------------------------------------------*
*      Finished Processing Header Record SEC7       *
*---------------------------------------------------*
```

```
************************  W S P R O  **************************
  Federal Highway Administration  -  U. S. Geological Survey
         Model for Water-Surface Profile Computations.
        Input Units: English  /  Output Units: English
*-------------------------------------------------------------*
```

ACRE SWAMP, BEAUFORT COUNTY, NC
WETLAND RESTORATION,ABC SITE
EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

```
*---------------------------------------------------*
*      Starting To Process Header Record SEC8       *
*---------------------------------------------------*
```

XS SEC8 5700 0.0 * * 0.002

```
***   Completed Reading Data Associated With Header Record SEC8    ***
***   No Roughness Data Input, Propagating From Previous Section   ***
***  Storing X-Section Data In Temporary File As Record Number 14  ***
```

```
***                Data Summary For Header Record SEC8                  ***
SRD Location:       5700.   Cross-Section Skew:     .0   Error Code    0
Valley Slope:    .00200    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->    Expansion:    .50    Contraction:    .00
```

X,Y-coordinates (42 pairs)

X	Y	X	Y	X	Y
-400.000	35.000	-360.000	33.000	-240.000	32.000
-130.000	32.500	-28.000	32.000	-18.000	28.761
-16.000	28.361	-14.000	28.011	-12.000	27.761
-10.000	27.211	-8.000	26.511	-6.000	25.361
-4.000	24.161	-3.000	23.111	-2.000	21.811
-1.000	21.711	.000	21.661	2.000	21.511
4.000	21.461	6.000	20.611	8.000	20.961
9.000	22.511	10.000	24.111	12.000	25.761
14.000	26.461	16.000	26.761	18.000	27.061
20.000	27.361	22.000	27.511	24.000	27.611
26.000	27.611	28.000	27.761	32.000	27.861
36.000	27.961	40.000	28.161	44.000	28.261
48.000	28.461	52.000	28.561	57.800	28.761
180.000	29.000	440.000	33.000	500.000	35.000

```
              Minimum and Maximum X,Y-coordinates
Minimum X-Station:     -400.000  ( associated Y-Elevation:    35.000 )
Maximum X-Station:      500.000  ( associated Y-Elevation:    35.000 )
Minimum Y-Elevation:     20.611  ( associated X-Station:       6.000 )
Maximum Y-Elevation:     35.000  ( associated X-Station:    -400.000 )
```

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	-8.000
2	.040	---
	---	10.000
3	.050	---

```
*-----------------------------------------------------*
*       Finished Processing Header Record SEC8        *
*-----------------------------------------------------*
 ************************  W S P R O  **************************
   Federal Highway Administration  -  U. S. Geological Survey
          Model for Water-Surface Profile Computations.
         Input Units: English  /  Output Units: English
*-------------------------------------------------------------*
                ACRE SWAMP, BEAUFORT COUNTY, NC
                WETLAND RESTORATION,ABC SITE
EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

*-----------------------------------------------------*
*       Starting To Process Header Record SEC9        *
*-----------------------------------------------------*

XS SEC9 6200 0.0 * * 0.002

***   Completed Reading Data Associated With Header Record SEC9    ***
```

```
***   No Roughness Data Input, Propagating From Previous Section   ***
***  Storing X-Section Data In Temporary File As Record Number 15   ***

***             Data Summary For Header Record SEC9                 ***
SRD Location:     6200.   Cross-Section Skew:    .0   Error Code   0
Valley Slope:   .00200    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00
```

X,Y-coordinates (42 pairs)

X	Y	X	Y	X	Y
-400.000	36.000	-360.000	34.000	-240.000	33.000
-130.000	33.500	-28.000	33.000	-18.000	29.761
-16.000	29.361	-14.000	29.011	-12.000	28.761
-10.000	28.211	-8.000	27.511	-6.000	26.361
-4.000	25.161	-3.000	24.111	-2.000	22.811
-1.000	22.711	.000	22.661	2.000	22.511
4.000	22.461	6.000	21.611	8.000	21.961
9.000	23.511	10.000	25.111	12.000	26.761
14.000	27.461	16.000	27.761	18.000	28.061
20.000	28.361	22.000	28.511	24.000	28.611
26.000	28.611	28.000	28.761	32.000	28.861
36.000	28.961	40.000	29.161	44.000	29.261
48.000	29.461	52.000	29.561	57.800	29.761
180.000	30.000	440.000	34.000	500.000	36.000

```
              Minimum and Maximum X,Y-coordinates
Minimum X-Station:    -400.000  ( associated Y-Elevation:    36.000 )
Maximum X-Station:     500.000  ( associated Y-Elevation:    36.000 )
Minimum Y-Elevation:    21.611  ( associated X-Station:       6.000 )
Maximum Y-Elevation:    36.000  ( associated X-Station:    -400.000 )
```

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	-8.000
2	.040	---
	---	10.000
3	.050	---

```
        *-----------------------------------------------------*
        *      Finished Processing Header Record SEC9          *
        *-----------------------------------------------------*
□    ************************ W S P R O **************************
       Federal Highway Administration  -  U. S. Geological Survey
              Model for Water-Surface Profile Computations.
             Input Units: English  /  Output Units: English
   *-------------------------------------------------------------*
                    ACRE SWAMP, BEAUFORT COUNTY, NC
                     WETLAND RESTORATION,ABC SITE
   EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE
 EX  0 0 0 0 0 0 0

        *=====================================================*
        *      Summary of Boundary Condition Information       *
        *=====================================================*
```

#	Reach Discharge	Water Surface Elevation	Friction Slope	Flow Regime
1	350.00	********	.0020	Sub-Critical
2	550.00	********	.0020	Sub-Critical
3	1000.00	********	.0020	Sub-Critical
4	1400.00	********	.0020	Sub-Critical
5	2100.00	********	.0020	Sub-Critical
6	2600.00	********	.0020	Sub-Critical
7	3300.00	********	.0020	Sub-Critical

```
*=====================================================*
*         Beginning  7 Profile Calculation(s)         *
*=====================================================*
```

```
************************  W S P R O  *************************
    Federal Highway Administration  -  U. S. Geological Survey
           Model for Water-Surface Profile Computations.
          Input Units: English  /  Output Units: English
*-------------------------------------------------------------*
```

ACRE SWAMP, BEAUFORT COUNTY, NC
WETLAND RESTORATION,ABC SITE
EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: EXIT Header Type: XS SRD: 1000.000	17.065 17.240 15.641	.174 ****** ******	350.000 2.747 .442	127.410 7821.57 ******	********* ********* 1.485	-13.131 58.305 ******
Section: FULV Header Type: FV SRD: 1050.000	17.183 17.337 15.641	.155 .093 .000	350.000 2.574 .410	135.956 8425.94 .0019	50.000 50.000 1.499	-13.366 60.655 .005

<<< The Preceding Data Reflect The "Unconstricted" Profile >>>

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "APPR ".
KRATIO: .51

Section: APPR Header Type: AS SRD: 1120.000	17.217 17.763 15.922	.546 .237 .196	350.000 5.832 .619	60.012 4287.59 .0034	70.000 70.000 1.033	-10.434 10.652 -.007

<<< The Preceding Data Reflect The "Unconstricted" Profile >>>

<<< The Following Data Reflect The "Constricted" Profile >>>
<<< Beginning Bridge/Culvert Hydraulic Computations >>>

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: BRDG Header Type: BR SRD: 1050.000	17.026 17.526 15.766	.500 .174 .118	350.000 5.489 .570	63.761 4887.43 ******	50.000 50.000 1.067	-9.282 11.410 .019

Specific Bridge Information C P/A PFELEV BLEN XLAB XRAB

Bridge Type 2	Flow Type 1	------	-----	---------	--------	--------	--------
Pier/Pile Code	0	.9681	.071	27.250	********	********	********

*** Roadway Section Located at SRD 1062.000 ***

Section: ROAD Header Type: XR

<<< Embankment Is Not Overtopped >>>

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: APPR	17.783	.385	350.000	72.732	45.000	-11.565
Header Type: AS	18.167	.218	4.812	5658.66	45.000	12.348
SRD: 1120.000	15.922	.421	.503	.0034	1.069	.013

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.000	.000	5622.9	-10.223	10.420	17.608

<<< End of Bridge Hydraulics Computations >>>

Section: SEC1	19.046	.289	350.000	85.438	380.000	-12.571
Header Type: XS	19.335	1.167	4.097	7049.71	380.000	14.143
SRD: 1500.000	16.682	.000	.425	.0031	1.108	.001
Section: SECA	20.262	.285	350.000	82.373	500.000	-9.099
Header Type: XS	20.546	1.208	4.249	7193.47	500.000	10.473
SRD: 2000.000	17.706	.000	.368	.0024	1.013	.003
Section: SEC3	21.405	.267	350.000	85.199	500.000	-9.248
Header Type: XS	21.672	1.123	4.108	7580.68	500.000	10.587
SRD: 2500.000	18.706	.000	.352	.0022	1.017	.003
Section: SEC4	22.459	.261	350.000	86.273	500.000	-9.304
Header Type: XS	22.720	1.045	4.057	7728.94	500.000	10.630
SRD: 3000.000	19.706	.000	.347	.0021	1.018	.002
Section: SEC5	23.481	.258	350.000	86.714	500.000	-9.327
Header Type: XS	23.739	1.017	4.036	7789.90	500.000	10.648
SRD: 3500.000	20.706	.000	.345	.0020	1.019	.002
Section: SECB	24.709	.193	350.000	109.772	700.000	-11.811
Header Type: XS	24.902	1.154	3.188	9540.40	700.000	27.308
SRD: 4200.000	21.449	.000	.371	.0016	1.221	.009
Section: SEC6	25.449	.218	350.000	100.554	500.000	-10.864
Header Type: XS	25.667	.738	3.481	8696.57	500.000	21.167
SRD: 4700.000	22.449	.013	.373	.0015	1.159	.014
Section: SEC7	26.305	.235	350.000	96.111	500.000	-10.341
Header Type: XS	26.539	.855	3.642	8241.36	500.000	19.624
SRD: 5200.000	23.449	.008	.382	.0017	1.137	.010
Section: SEC8	27.229	.244	350.000	93.883	500.000	-10.067
Header Type: XS	27.473	.928	3.728	8005.28	500.000	19.122
SRD: 5700.000	24.449	.005	.389	.0019	1.128	.001

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 Section: SEC9          28.196    .248    350.000      92.930   500.000    -9.958
 Header Type: XS        28.445    .968      3.766     7903.76   500.000    18.903
 SRD:     6200.000      25.449    .002       .392       .0019     1.125      .001

        ************************  W S P R O  **************************
          Federal Highway Administration  -  U. S. Geological Survey
                 Model for Water-Surface Profile Computations.
                 Input Units: English  /  Output Units: English
        *-----------------------------------------------------------------*

                         ACRE SWAMP, BEAUFORT COUNTY, NC
                          WETLAND RESTORATION,ABC SITE
        EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

                         WSEL     VHD       Q          AREA      SRDL      LEW
                         EGEL     HF        V          K         FLEN      REW
                         CRWS     HO       FR #        SF        ALPHA     ERR
                       --------- ------ ---------- ---------- --------- ---------
 Section: EXIT          17.827    .206    550.000     188.179 *********   -14.653
 Header Type: XS        18.033  ******      2.923    12292.16 *********    73.533
 SRD:     1000.000      16.373  ******       .439      ******     1.552    ******

 Section: FULV          17.946    .185    550.000     198.901    50.000   -14.893
 Header Type: FV        18.132    .094      2.765    13119.98    50.000    75.929
 SRD:     1050.000      16.373    .000       .411       .0019     1.557      .005

        <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "APPR ".
       KRATIO:    .44

 Section: APPR          17.846    .916    550.000      74.255    70.000   -11.692
 Header Type: AS        18.762    .277      7.407     5824.56    70.000    12.537
 SRD:     1120.000      17.075    .365       .773       .0040     1.073     -.012

        <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

         <<< The Following Data Reflect The "Constricted" Profile >>>
           <<< Beginning Bridge/Culvert Hydraulic Computations >>>


                         WSEL     VHD       Q          AREA      SRDL      LEW
                         EGEL     HF        V          K         FLEN      REW
                         CRWS     HO       FR #        SF        ALPHA     ERR
                       --------- ------ ---------- ---------- --------- ---------
 Section: BRDG          17.677    .842    550.000      77.787    50.000   -10.096
 Header Type: BR        18.519    .205      7.071     6565.04    50.000    12.305
 SRD:     1050.000      16.692    .282       .696      ******     1.083      .001

 Specific Bridge Information    C     P/A    PFELEV     BLEN      XLAB      XRAB
 Bridge Type 2   Flow Type 1 ------ ----- -------- -------- -------- --------
 Pier/Pile Code  0             .9607  .084   27.250 ******** ******** ********
 ----------------------------- ------ ----- -------- -------- -------- --------

          *** Roadway Section Located at SRD  1062.000 ***

                Section:  ROAD       Header Type: XR
                <<< Embankment Is Not Overtopped >>>

                         WSEL     VHD       Q          AREA      SRDL      LEW
                         EGEL     HF        V          K         FLEN      REW
                         CRWS     HO       FR #        SF        ALPHA     ERR
```

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                        --------- ------ ---------- ---------- --------- ---------
Section: APPR            18.796   .543    550.000     99.858    45.000   -13.593
Header Type: AS          19.340   .265      5.508    8642.73    45.630    16.185
SRD:      1120.000       17.075   .553       .569      .0040     1.151    -.011

              Approach Section APPR  Flow Contraction Information
             M( G )   M( K )     KQ      XLKQ     XRKQ     OTEL
            -------- -------- --------- -------- -------- --------
               .046     .005    8631.4  -11.050   11.350   18.615
            -------- -------- --------- -------- -------- --------

            <<< End of Bridge Hydraulics Computations >>>

Section: SEC1            20.179   .395    550.000    119.378   380.000   -14.419
Header Type: XS          20.574  1.224      4.607   10868.14   380.000    18.256
SRD:      1500.000       17.835   .000       .465      .0032     1.196      .010

Section: SECA            21.470   .429    550.000    107.415   500.000   -10.678
Header Type: XS          21.899  1.296      5.120   10741.21   500.000    11.439
SRD:      2000.000       18.672   .017       .420      .0026     1.052      .012

Section: SEC3            22.726   .390    550.000    113.179   500.000   -11.191
Header Type: XS          23.116  1.216      4.860   11580.73   500.000    11.644
SRD:      2500.000       19.672   .000       .397      .0024     1.062      .002

Section: SEC4            23.841   .374    550.000    115.818   500.000   -11.420
Header Type: XS          24.215  1.091      4.749   11966.99   500.000    11.736
SRD:      3000.000       20.672   .000       .387      .0022     1.067      .008

Section: SEC5            24.901   .366    550.000    117.222   500.000   -11.541
Header Type: XS          25.268  1.038      4.692   12172.95   500.000    11.784
SRD:      3500.000       21.672   .000       .382      .0021     1.070      .014

Section: SECB            26.126   .209    550.000    228.963   700.000   -19.128
Header Type: XS          26.335  1.086      2.402   16023.89   700.000   188.212
SRD:      4200.000       22.470   .000       .615      .0016     2.329     -.018

Section: SEC6            26.779   .261    550.000    171.913   500.000   -18.054
Header Type: XS          27.039   .669      3.199   14107.99   500.000    66.762
SRD:      4700.000       23.470   .026       .507      .0013     1.637      .009

Section: SEC7            27.584   .288    550.000    157.595   500.000   -17.113
Header Type: XS          27.872   .811      3.490   13216.14   500.000    52.656
SRD:      5200.000       24.470   .014       .505      .0016     1.521      .008

Section: SEC8            28.470   .309    550.000    149.940   500.000   -16.546
Header Type: XS          28.779   .903      3.668   12670.24   500.000    48.365
SRD:      5700.000       25.470   .010       .517      .0018     1.475     -.006

Section: SEC9            29.426   .318    550.000    147.100   500.000   -16.324
Header Type: XS          29.743   .958      3.739   12455.40   500.000    47.297
SRD:      6200.000       26.470   .004       .524      .0019     1.460      .002

      ************************  W S P R O  **************************
        Federal Highway Administration  -  U. S. Geological Survey
                Model for Water-Surface Profile Computations.
               Input Units: English  /  Output Units: English
    *------------------------------------------------------------------*
                        ACRE SWAMP, BEAUFORT COUNTY, NC
                          WETLAND RESTORATION,ABC SITE
    EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE
```

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                        WSEL      VHD        Q          AREA       SRDL       LEW
                        EGEL      HF         V           K         FLEN       REW
                        CRWS      HO       FR #          SF        ALPHA      ERR
                     ---------- ------ ---------- ---------- ---------- ----------
 Section: EXIT          19.029   .254   1000.000    308.997  *********   -17.057
 Header Type: XS        19.282 ******      3.236   22345.36  *********    95.428
 SRD:    1000.000       17.385 ******       .430     ******      1.557    ******

 Section: FULV          19.151   .231   1000.000    322.897     50.000   -17.302
 Header Type: FV        19.382   .095      3.097   23610.43     50.000    97.265
 SRD:    1050.000       17.385   .000       .405      .0019      1.552      .005

         <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

===125 FR# EXCEEDS FNTEST AT SECID "APPR ":  TRIALS CONTINUED.
       FNTEST, FR#, WSEL, CRWS:    .80     1.07        18.69       18.69

===110 WSEL NOT FOUND AT SECID "APPR ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:     18.69       31.00       .50

===115 WSEL NOT FOUND AT SECID "APPR ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:     18.69       31.00       18.69

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "APPR ".
       KRATIO:    .35

 Section: APPR          18.688  1.901   1000.000     96.664     70.000   -13.376
 Header Type: AS        20.589   .358     10.345    8288.09     70.000    15.751
 SRD:    1120.000       18.688   .835      1.070      .0051      1.142      .014

         <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

          <<< The Following Data Reflect The "Constricted" Profile >>>
            <<< Beginning Bridge/Culvert Hydraulic Computations >>>

                        WSEL      VHD        Q          AREA       SRDL       LEW
                        EGEL      HF         V           K         FLEN       REW
                        CRWS      HO       FR #          SF        ALPHA      ERR
                     ---------- ------ ---------- ---------- ---------- ----------
 Section: BRDG          18.611  1.736   1000.000     99.852     50.000   -11.263
 Header Type: BR        20.347   .263     10.015    9385.45     50.000    13.590
 SRD:    1050.000       18.475   .802       .929     ******      1.113      .001

 Specific Bridge Information   C      P/A    PFELEV     BLEN      XLAB      XRAB
 Bridge Type 2   Flow Type 1 ------ ----- -------- -------- -------- --------
 Pier/Pile Code  0            .9479  .093   27.250 ******** ******** ********
 --------------------------- ------ ----- -------- -------- -------- --------

              *** Roadway Section Located at SRD  1062.000 ***

                     Section:  ROAD       Header Type: XR
                     <<< Embankment Is Not Overtopped >>>

                        WSEL      VHD        Q          AREA       SRDL       LEW
                        EGEL      HF         V           K         FLEN       REW
                        CRWS      HO       FR #          SF        ALPHA      ERR
                     ---------- ------ ---------- ---------- ---------- ----------
 Section: APPR          20.801   .697   1000.000    168.673     45.000   -16.601
 Header Type: AS        21.498   .315      5.929   16864.81     45.388    22.402
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 SRD:    1120.000      18.688   .832          .568       .0051      1.276      -.012

              Approach Section APPR  Flow Contraction Information
             M( G )   M( K )     KQ       XLKQ      XRKQ      OTEL
            -------- -------- --------- -------- -------- --------
               .098     .032   16374.4  -12.233    12.617   20.643
            -------- -------- --------- -------- -------- --------

               <<< End of Bridge Hydraulics Computations >>>

 Section: SEC1           22.095   .560  1000.000    190.219   380.000   -17.669
 Header Type: XS         22.654  1.149     5.257   19603.22   380.000    24.004
 SRD:    1500.000        19.448   .000      .495      .0030     1.302      .007

 Section: SECA           23.430   .728  1000.000    157.038   500.000   -14.654
 Header Type: XS         24.158  1.417     6.368   18004.03   500.000    15.973
 SRD:    2000.000        20.335   .084      .533      .0028     1.155      .003

 Section: SEC3           24.921   .622  1000.000    175.136   500.000   -15.478
 Header Type: XS         25.543  1.376     5.710   20185.79   500.000    26.719
 SRD:    2500.000        21.335   .000      .547      .0028     1.227      .009

 Section: SEC4           26.145   .579  1000.000    185.359   500.000   -15.856
 Header Type: XS         26.724  1.166     5.395   21252.06   500.000    36.023
 SRD:    3000.000        22.335   .000      .569      .0023     1.278      .015

 Section: SEC5           27.255   .554  1000.000    191.093   500.000   -16.062
 Header Type: XS         27.809  1.077     5.233   21845.59   500.000    36.546
 SRD:    3500.000        23.335   .000      .552      .0022     1.301      .008

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SECB ".
        KRATIO:   2.54

 Section: SECB           28.343   .046  1000.000    855.795   700.000   -25.971
 Header Type: XS         28.389   .577     1.169   55546.13   700.000   332.286
 SRD:    4200.000        24.286   .000      .197      .0008     2.181      .003

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SEC6 ".
        KRATIO:    .67

 Section: SEC6           28.555   .109  1000.000    594.771   500.000   -23.540
 Header Type: XS         28.664   .243     1.681   37046.97   500.000   281.097
 SRD:    4700.000        25.286   .031      .334      .0005     2.482      .001

 Section: SEC7           28.997   .218  1000.000    435.394   500.000   -21.817
 Header Type: XS         29.215   .500     2.297   26999.70   500.000   244.829
 SRD:    5200.000        26.286   .054      .516      .0010     2.653     -.004

 Section: SEC8           29.766   .295  1000.000    375.406   500.000   -21.101
 Header Type: XS         30.061   .787     2.664   23529.54   500.000   229.760
 SRD:    5700.000        27.286   .039      .628      .0016     2.674      .020

 Section: SEC9           30.694   .325  1000.000    357.583   500.000   -20.880
 Header Type: XS         31.019   .943     2.797   22537.16   500.000   225.097
 SRD:    6200.000        28.286   .015      .668      .0019     2.670      .000

       ************************  W S P R O  **************************
         Federal Highway Administration  -  U. S. Geological Survey
                Model for Water-Surface Profile Computations.
               Input Units: English  /  Output Units: English
      *--------------------------------------------------------------*
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```
             ACRE SWAMP, BEAUFORT COUNTY, NC
               WETLAND RESTORATION,ABC SITE
   EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

                      WSEL      VHD        Q           AREA       SRDL       LEW
                      EGEL      HF         V           K          FLEN       REW
                      CRWS      HO       FR #          SF         ALPHA      ERR
                   ---------- ------ ----------- ----------- ---------- ----------
 Section: EXIT        19.824   .285   1400.000     403.818 *********   -18.647
 Header Type: XS      20.108 ******      3.467    31304.33 *********   107.356
 SRD:   1000.000      18.009 ******       .421      ******     1.523    ******

 Section: FULV        19.942   .264   1400.000     418.781    50.000   -18.883
 Header Type: FV      20.205   .095      3.343    32783.96    50.000   109.123
 SRD:   1050.000      18.009   .000       .402       .0019     1.518      .002

      <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

===110 WSEL NOT FOUND AT SECID "APPR ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:     19.80       31.00      .50

===115 WSEL NOT FOUND AT SECID "APPR ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:    19.80      31.00      19.80

===130 CRITICAL WATER-SURFACE ELEVATION A _ S _ S _ U _ M _ E _ D  !!!!!
       ENERGY EQUATION N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPR ".
       WSBEG, WSEND, CRWS:     19.80      31.00       19.80

 Section: APPR        19.803  2.124   1400.000     132.239    70.000   -14.803
 Header Type: AS      21.928 ******     10.587    12394.68    70.000    19.410
 SRD:   1120.000      19.803 ******      1.048       .0001     1.219    ******

      <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

       <<< The Following Data Reflect The "Constricted" Profile >>>
         <<< Beginning Bridge/Culvert Hydraulic Computations >>>

===210 QUESTIONABLE CRITICAL-FLOW SOLUTION AT SECID "BRDG ".
       Q, CRWS:      1400.00       19.73


                      WSEL      VHD        Q           AREA       SRDL       LEW
                      EGEL      HF         V           K          FLEN       REW
                      CRWS      HO       FR #          SF         ALPHA      ERR
                   ---------- ------ ----------- ----------- ---------- ----------
 Section: BRDG        19.730  2.037   1400.000     129.315    50.000   -12.662
 Header Type: BR      21.767 ******     10.826    13427.94    50.000    15.129
 SRD:   1050.000      19.730 ******       .935      ******     1.118    ******

 Specific Bridge Information   C     P/A   PFELEV    BLEN     XLAB     XRAB
 Bridge Type 2   Flow Type 1 ------ ----- -------- -------- -------- --------
 Pier/Pile Code  0            .9459  .098   27.250 ******** ******** ********
 ---------------------------- ------ ----- -------- -------- -------- --------

             *** Roadway Section Located at SRD  1062.000 ***

                 Section:  ROAD      Header Type: XR
                 <<< Embankment Is Not Overtopped >>>

                      WSEL      VHD        Q           AREA       SRDL       LEW
                      EGEL      HF         V           K          FLEN       REW
```

```
                              CRWS      HO       FR #         SF        ALPHA      ERR
                           --------- ------ ----------  ----------  ---------  ---------
Section: APPR               21.969    .855   1400.000     217.668     45.000    -18.938
Header Type: AS             22.824    .316      6.432    23190.08     45.219     25.908
SRD:    1120.000            19.803    .743       .593       .0001      1.329       .006

                 Approach Section APPR  Flow Contraction Information
                M( G )    M( K )      KQ       XLKQ      XRKQ      OTEL
               --------  --------  ---------  --------  --------  --------
                   .171      .032   22415.4   -13.490    14.301    21.805
               --------  --------  ---------  --------  --------  --------

                   <<< End of Bridge Hydraulics Computations >>>

Section: SEC1               23.325    .759   1400.000     252.474    380.000    -25.218
Header Type: XS             24.084   1.245      5.545    25790.12    380.000     48.045
SRD:    1500.000            20.563    .000       .663       .0033      1.587       .014

Section: SECA               24.800    .872   1400.000     220.427    500.000    -17.479
Header Type: XS             25.671   1.518      6.351    25036.93    500.000     37.609
SRD:    2000.000            21.563    .056       .660       .0030      1.389       .013

===125 FR# EXCEEDS FNTEST AT SECID "SEC3 ":  TRIALS CONTINUED.
       FNTEST, FR#, WSEL, CRWS:    .80      .82      26.33      22.56

===110 WSEL NOT FOUND AT SECID "SEC3 ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:    22.56      32.00      .50

===115 WSEL NOT FOUND AT SECID "SEC3 ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:    22.56      32.00      22.56

Section: SEC3               26.326    .780   1400.000     258.601    500.000    -45.536
Header Type: XS             27.106   1.426      5.414    27446.29    500.000     64.231
SRD:    2500.000            22.563    .000       .813       .0029      1.711       .009

===125 FR# EXCEEDS FNTEST AT SECID "SEC4 ":  TRIALS CONTINUED.
       FNTEST, FR#, WSEL, CRWS:    .80      .85      27.63      23.56

===110 WSEL NOT FOUND AT SECID "SEC4 ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:    23.56      33.00      .50

===115 WSEL NOT FOUND AT SECID "SEC4 ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:    23.56      33.00      23.56

Section: SEC4               27.630    .682   1400.000     299.544    500.000    -71.172
Header Type: XS             28.312   1.206      4.674    29612.00    500.000     88.652
SRD:    3000.000            23.563    .000       .853       .0024      2.008       .000

===125 FR# EXCEEDS FNTEST AT SECID "SEC5 ":  TRIALS CONTINUED.
       FNTEST, FR#, WSEL, CRWS:    .80      .84      28.76      24.56

===110 WSEL NOT FOUND AT SECID "SEC5 ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:    24.56      34.00      .50

===115 WSEL NOT FOUND AT SECID "SEC5 ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:    24.56      34.00      24.56

Section: SEC5               28.762    .633   1400.000     322.069    500.000    -82.309
Header Type: XS             29.395   1.076      4.347    30771.01    500.000     99.261
SRD:    3500.000            24.563    .000       .844       .0022      2.153       .007
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===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SECB ".
       KRATIO:   3.41

 Section: SECB         29.800   .025   1400.000   1603.945   700.000  -335.973
 Header Type: XS       29.825   .424       .873  105036.20   700.000   426.985
 SRD:     4200.000     26.585   .000       .154      .0006     2.094      .005

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SEC6 ".
       KRATIO:    .69

 Section: SEC6         29.916   .053   1400.000   1072.257   500.000   -27.740
 Header Type: XS       29.969   .129      1.306   72419.08   500.000   369.532
 SRD:     4700.000     27.585   .014       .198      .0003     1.992      .001

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SEC7 ".
       KRATIO:    .70

 Section: SEC7         30.156   .110   1400.000    789.946   500.000   -25.393
 Header Type: XS       30.266   .267      1.772   50672.30   500.000   320.123
 SRD:     5200.000     28.585   .029       .310      .0005     2.250      .001

 Section: SEC8         30.617   .199   1400.000    613.784   500.000   -23.731
 Header Type: XS       30.816   .505      2.281   38315.41   500.000   285.126
 SRD:     5700.000     29.585   .044       .447      .0010     2.458      .001

 Section: SEC9         31.355   .272   1400.000    534.966   500.000   -22.920
 Header Type: XS       31.627   .772      2.617   33149.11   500.000   268.043
 SRD:     6200.000     30.585   .037       .544      .0015     2.555      .002

       ************************  W S P R O  **************************
        Federal Highway Administration  -  U. S. Geological Survey
               Model for Water-Surface Profile Computations.
              Input Units: English  /  Output Units: English
     *---------------------------------------------------------------*
                     ACRE SWAMP, BEAUFORT COUNTY, NC
                       WETLAND RESTORATION,ABC SITE
   EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

                       WSEL    VHD        Q         AREA      SRDL       LEW
                       EGEL    HF         V          K        FLEN       REW
                       CRWS    HO       FR #         SF       ALPHA      ERR
                     -------- ------  ---------- ---------- --------- ---------
 Section: EXIT         21.181   .329   2100.000    642.033 *********  -21.361
 Header Type: XS       21.510 ******      3.271   46915.73 *********  215.081
 SRD:     1000.000     18.828 ******       .492     ******     1.979   ******

 Section: FULV         21.314   .302   2100.000    674.302    50.000  -21.628
 Header Type: FV       21.616   .096      3.114   49164.68    50.000  226.925
 SRD:     1050.000     18.828   .000       .472      .0019     2.004     .010

      <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

===110 WSEL NOT FOUND AT SECID "APPR ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:     21.31       31.00      .50

===115 WSEL NOT FOUND AT SECID "APPR ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:     21.31       31.00      21.31

===130 CRITICAL WATER-SURFACE ELEVATION A _ S _ S _ U _ M _ E _ D  !!!!!
       ENERGY EQUATION N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPR ".
       WSBEG, WSEND, CRWS:    21.31       31.00       21.31
```

```
Section: APPR           21.313  2.490   2100.000    189.321     70.000    -17.626
Header Type: AS         23.803 ******     11.092   19487.68     70.000     23.939
SRD:    1120.000        21.313 ******      1.045      .0002      1.301     ******

       <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

        <<< The Following Data Reflect The "Constricted" Profile >>>
          <<< Beginning Bridge/Culvert Hydraulic Computations >>>

===210 QUESTIONABLE CRITICAL-FLOW SOLUTION AT SECID "BRDG ".
       Q, CRWS:      2100.00      21.55

                        WSEL     VHD        Q         AREA       SRDL       LEW
                        EGEL     HF         V          K         FLEN       REW
                        CRWS     HO       FR #         SF        ALPHA      ERR
                      --------- ------ ---------- ---------- --------- ---------
Section: BRDG           21.553  2.208   2100.000    184.419     50.000    -15.174
Header Type: BR         23.760 ******     11.387   21625.07     50.000     17.518
SRD:    1050.000        21.553 ******       .884     ******      1.095     ******

Specific Bridge Information   C      P/A    PFELEV     BLEN      XLAB      XRAB
Bridge Type 2   Flow Type 1 ------ ----- -------- -------- -------- --------
Pier/Pile Code  0            .9557  .098   27.250 ******** ******** ********
--------------------------- ------ ----- -------- -------- -------- --------

         *** Roadway Section Located at SRD  1062.000 ***

                 Section:  ROAD      Header Type: XR
                 <<< Embankment Is Not Overtopped >>>

                        WSEL     VHD        Q         AREA       SRDL       LEW
                        EGEL     HF         V          K         FLEN       REW
                        CRWS     HO       FR #         SF        ALPHA      ERR
                      --------- ------ ---------- ---------- --------- ---------
Section: APPR           23.421  1.222   2100.000    338.300     45.000    -35.056
Header Type: AS         24.643   .324      6.208   31699.79     45.204    103.712
SRD:    1120.000        21.313   .570      1.001      .0002      2.039       .018

             Approach Section APPR  Flow Contraction Information
            M( G )   M( K )     KQ       XLKQ      XRKQ      OTEL
           -------- -------- --------- -------- -------- --------
               .229     .000   31896.1  -15.825   16.867   23.222
           -------- -------- --------- -------- -------- --------

              <<< End of Bridge Hydraulics Computations >>>

Section: SEC1           25.205   .633   2100.000    534.694    380.000    -47.336
Header Type: XS         25.838  1.203      3.927   43938.01    380.000    197.730
SRD:    1500.000        22.073   .000       .761      .0032      2.638      -.009

===125 FR# EXCEEDS FNTEST AT SECID "SECA ":  TRIALS CONTINUED.
       FNTEST, FR#, WSEL, CRWS:      .80     1.04       26.39       23.35

===110 WSEL NOT FOUND AT SECID "SECA ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:     23.35      31.00      .50

===115 WSEL NOT FOUND AT SECID "SECA ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:     23.35      31.00       23.35
```

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Section: SECA          26.387   .898   2100.000    467.682   500.000  -135.042
Header Type: XS        27.285  1.314      4.490   38189.95   500.000   149.495
SRD:    2000.000       23.353   .133      1.045      .0026     2.865      .001

Section: SEC3          27.953   .528   2100.000    655.375   500.000  -182.868
Header Type: XS        28.482  1.198      3.204   48181.66   500.000   195.054
SRD:    2500.000       24.353   .000       .780      .0024     3.309     -.001

===125 FR# EXCEEDS FNTEST AT SECID "SEC4 ":  TRIALS CONTINUED.
        FNTEST, FR#, WSEL, CRWS:    .80      .80      28.91      25.35

===110 WSEL NOT FOUND AT SECID "SEC4 ":  REDUCED DELTAY.
        WSLIM1, WSLIM2, DELTAY:    25.35      33.00      .50

===115 WSEL NOT FOUND AT SECID "SEC4 ":  USED WSMIN = CRWS.
        WSLIM1, WSLIM2, CRWS:    25.35      33.00      25.35

Section: SEC4          28.919   .547   2100.000    642.347   500.000  -179.936
Header Type: XS        29.466   .964      3.269   47467.13   500.000   192.262
SRD:    3000.000       25.353   .009       .796      .0019     3.291      .010

===125 FR# EXCEEDS FNTEST AT SECID "SEC5 ":  TRIALS CONTINUED.
        FNTEST, FR#, WSEL, CRWS:    .80      .80      29.90      26.35

===110 WSEL NOT FOUND AT SECID "SEC5 ":  REDUCED DELTAY.
        WSLIM1, WSLIM2, DELTAY:    26.35      34.00      .50

===115 WSEL NOT FOUND AT SECID "SEC5 ":  USED WSMIN = CRWS.
        WSLIM1, WSLIM2, CRWS:    26.35      34.00      26.35

Section: SEC5          29.909   .553   2100.000    638.631   500.000  -179.092
Header Type: XS        30.461   .983      3.288   47263.90   500.000   191.457
SRD:    3500.000       26.353   .003       .800      .0020     3.286      .010

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SECB ".
        KRATIO:   3.65

Section: SECB          30.830   .020   2100.000   2441.428   700.000  -376.595
Header Type: XS        30.850   .378       .860  172627.80   700.000   464.892
SRD:    4200.000       27.152   .000       .118      .0005     1.756      .010

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SEC6 ".
        KRATIO:    .65

Section: SEC6          30.929   .049   2100.000   1704.231   500.000  -351.502
Header Type: XS        30.978   .114      1.232  111717.00   500.000   435.397
SRD:    4700.000       28.152   .014       .213      .0002     2.075      .000

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SEC7 ".
        KRATIO:    .70

Section: SEC7          31.152   .103   2100.000   1174.450   500.000  -258.298
Header Type: XS        31.256   .253      1.788   78095.17   500.000   384.911
SRD:    5200.000       29.152   .027       .295      .0005     2.076     -.002

Section: SEC8          31.585   .161   2100.000    944.353   500.000   -26.717
Header Type: XS        31.746   .453      2.224   62297.75   500.000   347.993
SRD:    5700.000       30.152   .029       .358      .0009     2.097      .008

Section: SEC9          32.230   .229   2100.000    815.633   500.000   -25.621
Header Type: XS        32.459   .673      2.575   52558.16   500.000   324.920
```

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SRD:    6200.000      31.152   .034        .444        .0013      2.223       .006

        ************************  W S P R O  **************************
          Federal Highway Administration  -  U. S. Geological Survey
                 Model for Water-Surface Profile Computations.
                Input Units: English  /  Output Units: English
       *-------------------------------------------------------------------*

                        ACRE SWAMP, BEAUFORT COUNTY, NC
                          WETLAND RESTORATION,ABC SITE
        EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

                         WSEL      VHD        Q          AREA       SRDL       LEW
                         EGEL      HF         V          K          FLEN       REW
                         CRWS      HO        FR #        SF         ALPHA      ERR
                       --------- ------ ---------- ---------- --------- ---------
 Section: EXIT           21.775   .339   2600.000    798.596 *********   -22.550
 Header Type: XS         22.114 ******      3.256   58085.06 *********   267.967
 SRD:    1000.000        19.306 ******       .496     ******     2.055    ******

 Section: FULV           21.911   .308   2600.000    838.883    50.000   -22.821
 Header Type: FV         22.219   .095      3.099   61054.09    50.000   280.052
 SRD:    1050.000        19.306   .000       .471      .0019     2.061      .010

        <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

===110 WSEL NOT FOUND AT SECID "APPR ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:    21.98       31.00       .50

===115 WSEL NOT FOUND AT SECID "APPR ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:    21.98       31.00       21.98

===130 CRITICAL WATER-SURFACE ELEVATION A _ S _ S _ U _ M _ E _ D  !!!!!
       ENERGY EQUATION N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPR ".
       WSBEG, WSEND, CRWS:    21.98       31.00       21.98

 Section: APPR           21.982  2.935   2600.000    218.258    70.000   -18.965
 Header Type: AS         24.917 ******     11.912   23268.42    70.000    25.947
 SRD:    1120.000        21.982 ******      1.099      .0002     1.330    ******

        <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

         <<< The Following Data Reflect The "Constricted" Profile >>>
           <<< Beginning Bridge/Culvert Hydraulic Computations >>>

===210 QUESTIONABLE CRITICAL-FLOW SOLUTION AT SECID "BRDG ".
       Q, CRWS:      2600.00       22.64


                         WSEL      VHD        Q          AREA       SRDL       LEW
                         EGEL      HF         V          K          FLEN       REW
                         CRWS      HO        FR #        SF         ALPHA      ERR
                       --------- ------ ---------- ---------- --------- ---------
 Section: BRDG           22.638  3.078   2600.000    221.507    50.000   -16.694
 Header Type: BR         25.716 ******     11.738   27509.84    50.000    18.930
 SRD:    1050.000        22.638 ******       .995     ******     1.437    ******

 Specific Bridge Information   C      P/A   PFELEV    BLEN      XLAB      XRAB
 Bridge Type 2  Flow Type 1 ------  ----- -------- -------- -------- --------
 Pier/Pile Code  0           .8343   .097   27.250 ******** ******** ********
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              *** Roadway Section Located at SRD  1062.000 ***

                  Section:  ROAD       Header Type: XR
                  <<< Embankment Is Not Overtopped >>>

                    WSEL     VHD       Q          AREA       SRDL      LEW
                    EGEL     HF        V          K          FLEN      REW
                    CRWS     HO        FR #       SF         ALPHA     ERR
                  --------- ------ ---------- ---------- --------- ---------
 Section: APPR      26.062   .262   2600.000   1073.737    45.000   -79.988
 Header Type: AS    26.325   .155      2.421   79740.16    45.232   346.334
 SRD:    1120.000   21.982   .456       .456      .0002     2.878      .011

             Approach Section APPR  Flow Contraction Information
            M( G )   M( K )    KQ        XLKQ     XRKQ      OTEL
            -------- -------- --------- -------- -------- --------
               .251     .335   52771.7  -17.252   18.371   26.014
            -------- -------- --------- -------- -------- --------

              <<< End of Bridge Hydraulics Computations >>>

 Section: SEC1      26.472   .352   2600.000    931.673   380.000   -71.085
 Header Type: XS    26.824   .461      2.791   69880.69   380.000   314.152
 SRD:    1500.000   22.742   .045       .539      .0012     2.905     -.007

===125 FR# EXCEEDS FNTEST AT SECID "SECA ":  TRIALS CONTINUED.
       FNTEST, FR#, WSEL, CRWS:    .80      .82       27.23       26.67

===110 WSEL NOT FOUND AT SECID "SECA ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:    26.67       31.00      .50

===115 WSEL NOT FOUND AT SECID "SECA ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:    26.67       31.00      26.67

 Section: SECA      27.230   .611   2600.000    766.253   500.000  -206.221
 Header Type: XS    27.841   .889      3.393   54391.87   500.000   217.301
 SRD:    2000.000   26.674   .129       .821      .0018     3.410     -.002

 Section: SEC3      28.391   .516   2600.000    836.492   500.000  -219.794
 Header Type: XS    28.907  1.063      3.108   58443.30   500.000   230.230
 SRD:    2500.000   27.674   .000       .745      .0021     3.435      .003

 Section: SEC4      29.386   .519   2600.000    834.272   500.000  -219.377
 Header Type: XS    29.905   .992      3.116   58313.85   500.000   229.833
 SRD:    3000.000   28.674   .001       .747      .0020     3.434      .005

 Section: SEC5      30.386   .519   2600.000    834.205   500.000  -219.365
 Header Type: XS    30.905   .994      3.117   58309.95   500.000   229.821
 SRD:    3500.000   29.674   .000       .747      .0020     3.434      .006

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SECB ".
       KRATIO:   3.59

 Section: SECB      31.278   .021   2600.000   2823.394   700.000  -385.554
 Header Type: XS    31.299   .388       .921  209102.30   700.000   478.331
 SRD:    4200.000   27.448   .000       .114      .0006     1.625      .006

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SEC6 ".
       KRATIO:    .67

 Section: SEC6      31.380   .047   2600.000   2068.258   500.000  -367.606
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 Header Type: XS        31.427   .115       1.257  139958.30    500.000    451.408
 SRD:    4700.000       28.448   .013        .193      .0002      1.916       .000

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SEC7 ".
       KRATIO:    .68

 Section: SEC7          31.605   .104    2600.000   1458.619    500.000   -312.562
 Header Type: XS        31.709   .253       1.783   95635.61    500.000    414.304
 SRD:    5200.000       29.448   .029        .322      .0005      2.112       .001

 Section: SEC8          32.045   .169    2600.000   1124.677    500.000   -245.402
 Header Type: XS        32.214   .470       2.312   75261.20    500.000    377.926
 SRD:    5700.000       30.448   .032        .360      .0009      2.037       .003

 Section: SEC9          32.715   .219    2600.000    993.778    500.000    -27.120
 Header Type: XS        32.934   .679       2.616   66158.79    500.000    356.466
 SRD:    6200.000       31.448   .025        .411      .0014      2.055       .016

□      ************************  W S P R O  **************************
         Federal Highway Administration  -  U. S. Geological Survey
               Model for Water-Surface Profile Computations.
              Input Units: English  /  Output Units: English
      *------------------------------------------------------------------*
                       ACRE SWAMP, BEAUFORT COUNTY, NC
                        WETLAND RESTORATION,ABC SITE
      EXISTING CONDITIONS FROM BRIDGE ON SR 1532 TILL THE END OF ABC SITE

                        WSEL      VHD        Q          AREA       SRDL        LEW
                        EGEL      HF         V           K         FLEN        REW
                        CRWS      HO       FR #          SF        ALPHA       ERR
                      --------- ------ ----------  ---------- ---------  ---------
 Section: EXIT          22.423   .345    3300.000   1006.081  *********   -23.847
 Header Type: XS        22.768 ******       3.280   73737.98  *********   325.670
 SRD:    1000.000       19.860 ******        .489     ******      2.060    ******

 Section: FULV          22.559   .313    3300.000   1054.271     50.000   -24.118
 Header Type: FV        22.872   .095       3.130   77495.90     50.000   337.729
 SRD:    1050.000       19.860   .000        .463      .0019      2.054      .008

          <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

===110 WSEL NOT FOUND AT SECID "APPR ":  REDUCED DELTAY.
       WSLIM1, WSLIM2, DELTAY:     24.72       31.00      .50

===115 WSEL NOT FOUND AT SECID "APPR ":  USED WSMIN = CRWS.
       WSLIM1, WSLIM2, CRWS:    24.72       31.00       24.72

===130 CRITICAL WATER-SURFACE ELEVATION A _ S _ S _ U _ M _ E _ D  !!!!!
       ENERGY EQUATION N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPR ".
       WSBEG, WSEND, CRWS:     24.72       31.00       24.72

 Section: APPR          24.717  1.267    3300.000    605.151     70.000    -50.598
 Header Type: AS        25.983 ******       5.453   48449.69     70.000    222.706
 SRD:    1120.000       24.717 ******       1.069      .0003      2.739    ******

          <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

           <<< The Following Data Reflect The "Constricted" Profile >>>
             <<< Beginning Bridge/Culvert Hydraulic Computations >>>

===220 FLOW CLASS 1 ( 4 ) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
```

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      WS3, WSIU, WS1, PFELV:     23.99       28.18       28.28       27.25

===245 ATTEMPTING FLOW CLASS 2 ( 5 ) SOLUTION.

                          WSEL      VHD        Q          AREA       SRDL       LEW
                          EGEL       HF        V           K         FLEN       REW
                          CRWS       HO      FR #          SF        ALPHA      ERR
                       ---------- ------ ---------- ---------- --------- ---------
 Section: BRDG            27.250  1.678   3344.236    381.917    50.000   -25.000
 Header Type: BR          28.928 ******      8.756   40650.20 *********    25.000
 SRD:     1050.000        24.062 ******       .937     ******     1.407    ******

 Specific Bridge Information    C      P/A    PFELEV    BLEN      XLAB      XRAB
 Bridge Type 2   Flow Type 5 ------  -----  --------  --------  --------  --------
 Pier/Pile Code  0             .4585  .084    27.250  ********  ********  ********
 --------------------------- ------  -----  --------  --------  --------  --------

                          WSEL      VHD        Q          AREA       FLEN       LEW
                          EGEL       HF        V           ERR        SRD       REW
                       ---------- ------ ---------- ---------- --------- ---------
 Section: ROAD            29.125   .038      7.496      5.469    45.000    -7.813
 Header Type: XR          29.154   .009      1.371       .016  1062.000    54.688

       Hydraulic Characteristics of Left and Right Roadway Sections

                                        Left Weir             Right Weir
       Weir Flow               (Q)          .73                   6.77
       Weir Length          (WLEN)        8.364                 54.136
       Weir LEW              (LEW)       -7.813                   .552
       Weir REW              (REW)         .552                 54.688
       Maximum Depth        (DMAX)         .125                   .125
       Average Depth        (DAVG)         .067                   .091
       Maximum Velocity     (VMAX)        1.366                  1.564
       Average Velocity     (VAVG)        1.310                  1.378
       Average Head         (HAVG)         .096                   .120
       Weir Coefficient     (CAVG)        2.943                  3.011

                          WSEL      VHD        Q          AREA       SRDL       LEW
                          EGEL       HF        V           K         FLEN       REW
                          CRWS       HO      FR #          SF        ALPHA      ERR
                       ---------- ------ ---------- ---------- --------- ---------
 Section: APPR            29.125   .038   3300.000   3219.783    45.000  -403.750
 Header Type: AS          29.163   .061      1.025  239312.30    50.069   627.734
 SRD:     1120.000        24.717   .353       .155      .0003     2.309      .016

            Approach Section APPR  Flow Contraction Information
           M( G )    M( K )     KQ       XLKQ      XRKQ      OTEL
          --------  --------  ---------  --------  --------  --------
          ********  ********  *********  ********  ********  ********
          --------  --------  ---------  --------  --------  --------

                 <<< End of Bridge Hydraulics Computations >>>

 Section: SEC1            29.203   .065   3300.000   2561.667   380.000  -322.012
 Header Type: XS          29.268   .093      1.288  186401.90   380.000   565.070
 SRD:     1500.000        25.477   .014       .212      .0002     2.524     -.001

 Section: SECA            29.389   .107   3300.000   2064.817   500.000  -388.451
 Header Type: XS          29.496   .206      1.598  141487.70   500.000   390.894
 SRD:     2000.000        27.264   .021       .284      .0004     2.695      .001
```

Section: SEC3	29.699	.210	3300.000	1566.052	500.000	-330.183
Header Type: XS	29.909	.366	2.107	105279.70	500.000	335.388
SRD: 2500.000	28.264	.052	.422	.0007	3.042	-.004
Section: SEC4	30.236	.339	3300.000	1275.788	500.000	-291.139
Header Type: XS	30.575	.604	2.587	85681.80	500.000	298.194
SRD: 3000.000	29.264	.064	.559	.0012	3.257	-.002
Section: SEC5	31.005	.433	3300.000	1144.048	500.000	-271.643
Header Type: XS	31.438	.823	2.884	77188.38	500.000	279.622
SRD: 3500.000	30.264	.047	.646	.0016	3.344	-.007

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SECB ".
KRATIO: 3.33

Section: SECB	31.808	.024	3300.000	3288.876	700.000	-396.168
Header Type: XS	31.832	.384	1.003	257214.60	700.000	494.251
SRD: 4200.000	27.808	.000	.113	.0005	1.504	.010

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SEC6 ".
KRATIO: .70

Section: SEC6	31.916	.046	3300.000	2513.820	500.000	-378.311
Header Type: XS	31.962	.118	1.313	179316.40	500.000	467.467
SRD: 4700.000	28.808	.011	.176	.0002	1.728	.001

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "SEC7 ".
KRATIO: .69

Section: SEC7	32.136	.097	3300.000	1869.846	500.000	-362.724
Header Type: XS	32.234	.245	1.765	123927.30	500.000	444.086
SRD: 5200.000	29.808	.026	.290	.0005	2.010	.001
Section: SEC8	32.564	.175	3300.000	1429.267	500.000	-307.691
Header Type: XS	32.739	.469	2.309	93780.66	500.000	411.666
SRD: 5700.000	30.808	.039	.420	.0009	2.114	-.002
Section: SEC9	33.252	.235	3300.000	1226.932	500.000	-270.266
Header Type: XS	33.487	.713	2.690	81415.64	500.000	391.394
SRD: 6200.000	31.808	.030	.461	.0014	2.086	.005

ER

****************** Normal end of WSPRO execution. *****************
*************** Elapsed Time: 0 Minutes 6 Seconds **************