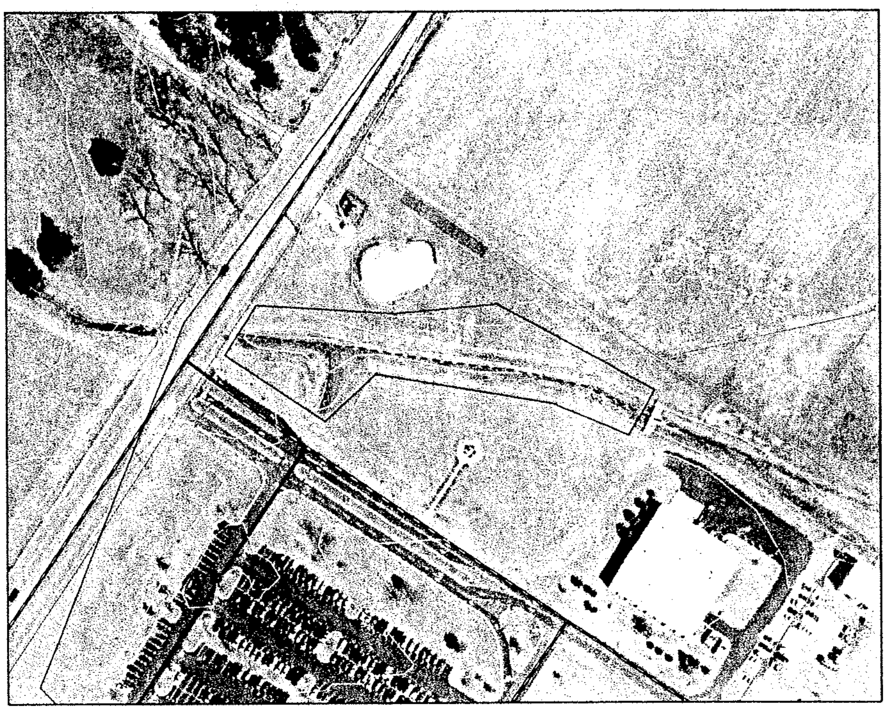
RP

Stormwater Best Management Practice Project at Wayne Community College
Wayne County, North Carolina



Prepared for:

Ecosystem Enhancement PROGRAM

NORTH CAROLINA
ECOSYSTEM ENHANCEMENT PROGRAM

2728 Capital Blvd, Suite 1H 103
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Conceptual Design Plan

January 4, 2007

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1 Project Site Location

The project site is located on the Wayne Community College Campus in the City of Goldsboro within Wayne County, North Carolina.

1.1 Directions to Project Site

The project is located at 3000 Wayne Memorial Drive in Goldsboro, North Carolina. From Raleigh, take I-40 East to the Highway 70 Bypass. Continue east to Goldsboro and stay on the bypass until you reach Wayne Memorial Drive exit. Following signs, take a left on Wayne Memorial Drive and proceed north approximately 2 miles. Wayne Community College is on the right just past Wayne Memorial Hospital. The project site is located at the northwest corner of the campus and on the left hand side off the second driveway entrance from Goldsboro on Wayne Memorial Drive.

1.2 USGS Hydrologic Unit Code

The 8-digit USGS HUC Code is 03020202 and the 14-digit HUC code is 03020202010010.

1.3 NC DWQ River Basin Designation

The project is located in the Middle Neuse River Basin. The Neuse River flows approximately 200 miles from its headwaters in Orange and Person counties to its mouth at the Pamlico Sound. The Neuse contains over 3,000 freshwater stream miles and flows through 19 counties. The drainage area of the Neuse River Basin is 6,235 square miles, which is 8.8 percent of the State of North Carolina. Agricultural land use comprises 23 percent of the basin and 56 percent of the basin is in forest. Approximately 8 percent of the drainage area is developed, and rapidly expanding in the headwaters of the basin. (NCDENR, 2002)

1.4 Project Vicinity Map

Figure 1 shows the project site location.

2 Watershed Characterization

2.1 Drainage Area

The drainage area is approximately 33 acres, with 6.8 acres of imperviousness (20.6 percent). Drainage to the site is primarily from the agricultural field to the north, and a portion of the WCC campus, consisting of several parking lots, a maintenance facility, and some rooftop drainage. Future plans obtained from the College propose additional development of the parcel located to the northeast of the existing campus. Digital and scaled plans were not available for the proposed expansion, so buildout was estimated from a paper copy provided by WCC. The future buildout plans indicate an estimated additional 4.3 acres of imperviousness, potentially increasing the percent imperviousness to 33.7 percent. Currently, runoff is conveyed through an existing swale to a 36-inch reinforced concrete pipe (RCP) located near Wayne Memorial Drive, where it is conveyed under the road and into a receiving channel. The current contributing drainage area delineated for the site is depicted in Figure 2.

2.2 Surface Water Classification

The NC DWQ classification of the receiving stream, Stoney Creek, is C NSW (Aquatic life propagation/ protection and secondary recreation, Nutrient Sensitive Water), with a use support rating of NS (Not Supporting). The existing swale that will be replaced by the proposed stormwater wetland has been called exempt from the Neuse Buffer Rules by NCDENR.

2.3 Physiography, Geology, and Soils

The project is located within the Middle Atlantic Coastal Plain. The elevation of Wayne County ranges from about 40 feet above sea level where the Neuse River enters Lenoir County, to about 190 feet in the southwestern part of the county elevation. The moderately dissected, smooth, gently undulating, plateau-like, uplands dominate the landscape in Wayne County. The uplands have a seaward sloping gradient of 0.1 to 0.3 m per km and a local relief of 1 to 2 m. The uplands are bounded by gentle to steep valley slopes near the rivers and streams (USDA-NRCS, 1974). The existing site for the proposed device has a low elevation of 115 at the bottom of the swale to a high elevation of 123 at the golf green.

The Coastal Plain is a wedge of mostly marine sedimentary rocks that gradually thickens to the east. The Coastal Plain is the largest geologic belt in the state, covering about 45 percent of the state's land area. The most common sediment types are sand and clay, although a significant amount of limestone occurs in the southern part of the Coastal Plain.

According to the NRCS Soil Survey for Wayne County, the existing soils within the drainage area are listed in Table 1 and shown on Figure 3.

Table 1. Project Site Soils

DSL_NAME	DESCRIPTION	HYDRIC	ACRES	% of Drainage Area
NoA	Norfolk loamy sand-0 to 2 percent slopes		6.9	20.8%
NoB	Norfolk loamy sand-2 to 6 percent slopes		0.7	2.1%
Ly	Lynchburg sandy loam	B	14.8	44.7%
Ra	Rains sandy loam	A	8.0	24.2%
WaB	Wagram loamy sand-0 to 6 percent slopes	B	2.7	8.2%
		Total	**33.1**	**100.0%**

Lynchburg sandy loam and Norfolk loamy sand are the primary soils at the proposed project site as shown in Figure 3. The existing swale currently has wetland vegetation and hydric soils, so it is expected that a stormwater wetland can be supported with these soil types.

2.4 HISTORICAL LAND USE AND DEVELOPMENT TRENDS

The historical land use of the site is agricultural, primarily row crops. The first WCC building was completed in November 1960, eventually expanding to seven buildings with a total of 287,000 square feet of classrooms, laboratories, and offices. The college has plans for expansion, as described in Section 2.1, although the exact timeframe is unknown.

3 Restoration Goals and Objectives

Due to the NSW status of the Neuse River and Stoney Creek, the purpose of providing a stormwater device at the WCC site is to reduce nitrogen loading to Stoney Creek, and ultimately the Neuse River. Control and treatment of the 1-inch storm has proven extremely beneficial in pollutant removal as the majority of stormwater pollutants are conveyed in the first inch of rainfall, or the first flush. This project will provide a means to reduce pollutant loadings, particularly nitrogen, to the downstream receiving waterbodies. Additional control of the 1-year, 24-hour storm will help prevent downstream bed and bank erosion, as this storm event is generally considered the channel-forming flow.

3.1 Existing Conditions

The existing site is primarily an old agricultural ditch with existing wetland vegetation, i.e., cattails and sedges. A wooden bridge exists on the east end of the site, and a practice golf green is located to the west at the downstream end. The channel enters the project site from the east and conveys runoff from adjacent parking lots, rooftops, and driveways from the campus, as well as a large agricultural area to the north. A 36-inch RCP discharges runoff from parking lots and drives to the south of the site at the downstream end of the channel near the outlet at Wayne Memorial Drive. Another 36-inch RCP conveys the flow under Wayne Memorial Drive and into a receiving channel. Appendix A provides photographs of the site and Figure 4 shows the existing site in plan view.

4 Conceptual Plan

4.1 BMP Description

An extended detention stormwater wetland is proposed for this site to help reduce nitrogen loading to the Neuse River. The Neuse River Basin is a Nutrient Sensitive Water with nitrogen concerns from historical agricultural activities within the watershed. The North Carolina Department of the Environment and Natural Resources (NCDENR) has mandated a 30 percent reduction of nitrogen loading within the basin to reduce algal blooms, which have recently killed millions of fish. Stoney Creek, the receiving waterbody and a tributary of the Neuse River, is also classified as Nutrient Sensitive. Stormwater wetlands are provided an 85 percent TSS and 40 percent nitrogen removal efficiency by NCDENR.

Stormwater wetlands provide an efficient method for removing a wide variety of pollutants, such as suspended solids, nutrients (nitrogen and phosphorous), heavy metals, toxic organic pollutants, and petroleum compounds. These wetlands temporarily store runoff in shallow pools that support emergent and riparian vegetation. The storage, complex microtopography, and vegetative community combine to form an ideal matrix for pollutant removal. Treatment wetlands can also effectively mitigate peak runoff rates and stabilize flow to adjacent wetlands and streams. Wetlands are effective sedimentation devices and provide conditions that facilitate the chemical and biological processes that cleanse water. Pollutants are taken up and transformed by plants and microbes, immobilized in sediment, and released in reduced concentrations in the wetlands outflow (NCDENR, 2006).

4.2 Constructed Stormwater Wetland

The wetland was sized using NCDENR's Stormwater Best Management Practice Manual, latest draft version (2006). Table 2 provides the assumptions used in sizing the facility for treating the water quality storm, or the runoff from the first inch of rainfall.

Table 2. Stormwater Wetland Design Assumptions – Existing Conditions

Knowns:		
Drainage Area =	33.1	acres
Impervious Area =	6.8	acres
% impervious =	20.6%	
Water Quality Runoff Volume:		
Rv =	0.05 + 0.009*I (percent imperviousness)	
Rv =	0.235	in/in
Volume (V) =	1" x Rv x 1'/12" x DA (acres) * 43,560 ft^2/ac	
V =	28,288.6	ft^3
	0.65	ac-ft
Surface Area Calculation:		
Required Surface Area =	(1.06[a]/100)*DA (acres)	
SA =	0.35	acres
	15,319.5	ft^2

[a] 1.06 is the Surface Area / Drainage Area ratio recommended in the BMP Manual for a drainage area with a 22.5 percent imperviousness.

HEC-HMS was used to estimate peak flows and storm event volumes. The Hydrologic Modeling System (HEC-HMS) is designed to simulate the precipitation-runoff processes of dendritic watershed systems. It is designed to be applicable in a wide range of geographic areas for solving the widest possible range of problems. This includes large river basin water supply and flood hydrology, and small urban or natural watershed runoff. Hydrographs produced by the program are used directly or in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation.

The program is a generalized modeling system capable of representing many different watersheds. A model of the watershed is constructed by separating the hydrologic cycle into manageable pieces and constructing boundaries around the watershed of interest. Any mass or energy flux in the cycle can then be represented with a mathematical model. In most cases, several model choices are available for representing each flux. Each mathematical model included in the program is suitable in different environments and under different conditions.

Table 3 provides the calculations and input data entered into the model. Table 4 presents the results of the analysis, including the NRCS Type II 24-hour rainfall amounts used in the model scenarios. The model was run using the SCS Curve Number (CN) Method to account for losses and transformations.

Table 3. HMS Input Data – Existing Conditions

Land Use	Area	(Hydro Group = B)	
	(acres)	CN	CN * Area
Impervious	6.82	98	668.36
Cultivated	15.64	81	1266.84
Grass	10.64	61	649.04
Total	**33.1**		**2584.24**
Adjusted CN = (CN * Area)/(Area) =	78.07	Use	78

S =	2.82	S = 1000/CN - 10
Ia =	0.56	Ia = 0.2*S

Lag Time Calculations:

$T_L = .6 * T_c$ T_L = Lag time T_c = time of concentration

$T_c = t_{sheet} + t_{conc} + t_{channel}$

t_{sheet} =	$(0.007*(N*L)^{.8}) / (P_2^{.5} * S^{.4})$	
t_{sheet} =	**0.84 hrs**	
where:		
N =	0.17	N = overland roughness coefficient
L =	300 feet	L = flow length
P_2 =	3.44 inches	P_2 = 2-year, 24-hour precipitation
S =	0.0035	S = average slope
t_{conc} =	L / V	

t_{conc} =	**0.35 hours**	
L =	1218.7 feet	L = Flow length
V =	$16.1345 * S^{1/2}$	
	0.95 fps	
S =	0.0035	S = average slope
$t_{channel}$ =	L / V	
$t_{channel}$ =	**0.10 hours**	
L =	638.1 feet	
V =	$(1.49 * r^{2/3} * s^{.5}) / n$	
	1.68 fps	
r =	$(b*d + Z*d^2) / (b + 2*d* (z^2 + 1)^{1/2})$	
	1.85	
where:		
b =	10 feet	b = bottom width
d =	3 feet	d = depth
Z =	5	Z = side slopes
S =	0.0036 foot/foot	S = slope
n =	0.08	n = roughness coefficient
$T_c = t_{sheet} + t_{conc} + t_{channel}$		
T_c =	1.3 hours	
T_c =	**78.1 minutes**	
T_L =	$.6 * T_c$	
T_L =	**46.9 minutes**	

Table 4. HMS Results – Existing Conditions

Event	Rainfall (in)	Peak Flow (cfs)	Volume (ac-ft)	Volume (ft^3)
1-inch	1	0.33	0.15	6534.0
1-year	2.58	12.03	2.27	98881.2
2-year	3.44	21.95	3.93	171190.8
5-year	4.72	38.47	6.71	292287.6
10-year	5.73	52.28	9.07	395089.2
100-year	9.92	112.10	19.56	852033.6

Future conditions were analyzed in a similar fashion. Table 5 provides the assumptions used in the future conditions analysis, and Table 6 depicts the input data used. Table 7 shows the results of the HMS future conditions scenario.

Table 5. Stormwater Wetland Design Assumptions – Future Conditions

Knowns:

Drainage Area =	33.1	acres
Impervious Area =	11.1	acres
% impervious =	33.7%	

Water Quality Runoff Volume:

Rv =	0.05 + 0.009*I (percent imperviousness)	
Rv =	0.353	in/in
Volume (V) =	1" x Rv x 1'/12" x DA (acres) * 43,560 ft^2/ac	
V =	42,426.5	ft^3
	0.97	ac-ft

Surface Area Calculation:

Required Surface Area =	(1.44ᵃ/100)*DA (acres)	
SA =	0.48	acres
	20,798.5	ft^2

Table 6. HMS Input Data – Future Conditions

Land Use	**Area (ac)**	**(Hydro Group = B)**	
		CN	**CN * Area**
Impervious	11.15	98	1092.7
Cultivated	15.64	81	1266.84
Grass	6.31	61	384.91
Total	**33.1**		**2744.45**
Adjusted CN = (CN * Area)/(Area) =	82.91	Use	83
S =	2.04	S = 1000/CN - 10	
Ia =	0.41	Ia = 0.2*S	

Table 7. HMS Results – Future Conditions

Event	Rainfall (in)	Peak Flow (cfs)	Volume (ac-ft)	Volume (ft^3)
1-inch	1	1.13	0.35	15246.0
1-year	2.58	14.37	3.01	131115.6
2-year	3.44	23.8	4.88	212572.8
5-year	4.72	38.9	7.90	344124.0
10-year	5.73	51.14	10.40	453024.0
100-year	9.92	102.67	21.23	924778.8

Due to the two existing inlets into the proposed device, the upstream channel and the 36-inch RCP, two forebays are proposed to treat the incoming flow prior to discharging into the main body of the wetland. The forebays will remove gross pollutants and sediment, as well as still the incoming flow velocities. The existing channel is expected to provide some pollutant and sediment removal benefits prior to entering the wetland.

The available space is constrained by Wayne Memorial Drive and a golf green to the west/northwest, the maintenance facility and a wooden bridge to the east, property lines to the north, and landscaping, drives, and monuments to the south. The College has requested a 30-foot buffer between the northern property line and the proposed BMP. A 36-inch RCP located at the downstream end of the site conveys the flow under Wayne Memorial Drive. An outlet structure will be placed over the existing 36-inch outlet pipe to control the water surface elevation and gradually release the accumulated stormwater over a period of 2-5 days. An adjustable weir structure will be used for the outlet to allow for manipulation of the permanent pool elevation, which is proposed at elevation 115. The proposed grading plan calls for varying depths across the wetland, with two deep pools, one toward the upstream end and a deeper pool at the outlet to help prevent clogging of the outlet structure. The wetland is shaped to maximize the flow path. The overtopping elevation of the wetland is proposed as 118 feet. Other design components are expected to include a drain to empty the wetland for maintenance purposes and various species of native vegetation to maximize sediment removal and pollutant uptake. Figure 5 depicts the proposed grading plan.

Table 8 provides the stage-storage relationship for the proposed stormwater wetland and Figure 6 shows it graphically. Using this relationship and an estimated water quality volume of 0.65 acre-feet, the water surface elevation corresponding to the water quality volume is 115.7 feet. Given the results from the HMS analysis and using the values in the stage-storage curve, the proposed wetland will be able to store the runoff volumes associated with the water quality and 1-year design storms. Peak flow control for the 1-year, 24-hour storm should help reduce downstream erosion. Using this plan, the wetland should be large enough to treat the runoff from the future condition, as well as provide storage for the future 1-year storm event.

Figure 7 illustrates the proposed planting zones. The area designated as "no planting" indicates where either the deep water pools or upper forebay will exist, and planting will not be necessary in these areas. The planting plan will be developed according to the Hydrologic Zones outlined in NCDENR (2006). Planting Zone A includes elevations below the recommended permanent pool elevation of 115 feet, excluding the deep water pools at 113 feet; plants recommended for Hydrologic Zone 2 (shallow water bench) will be identified for this planting zone. Planting Zone B ranges in elevation from 115 to 116 feet; plants recommended for Hydrologic Zones 3 and 4 (shoreline fringe and riparian fringe) will be identified for this planting zone. Planting Zone C ranges in elevation from 116 to 118 feet; plants recommended for

Hydrologic Zones 5 and 6 (floodplain terrace and upland slopes) will be identified for this planting zone. Detailed planting instructions will be written for these planting zones with special instructions for areas on or near the inlet, outlet, embankment, maintenance access area, and emergency spillway. Plant selection will consider native plant diversity, maintenance needs, and mosquito control, among other factors.

Table 8. Proposed Stage-Storage Relationship for WCC Wetland

Elevation (ft)	Surface Area (ac)	Volume (ft^3)	Volume (ac-ft)
118	1.35	172832.7	3.92
117	1.19	117691.2	2.65
116	0.97	65892.59	1.47
115	0.79	27483.63	0.59
114	0.44	14014.24	0.32
113	0.30	0	0

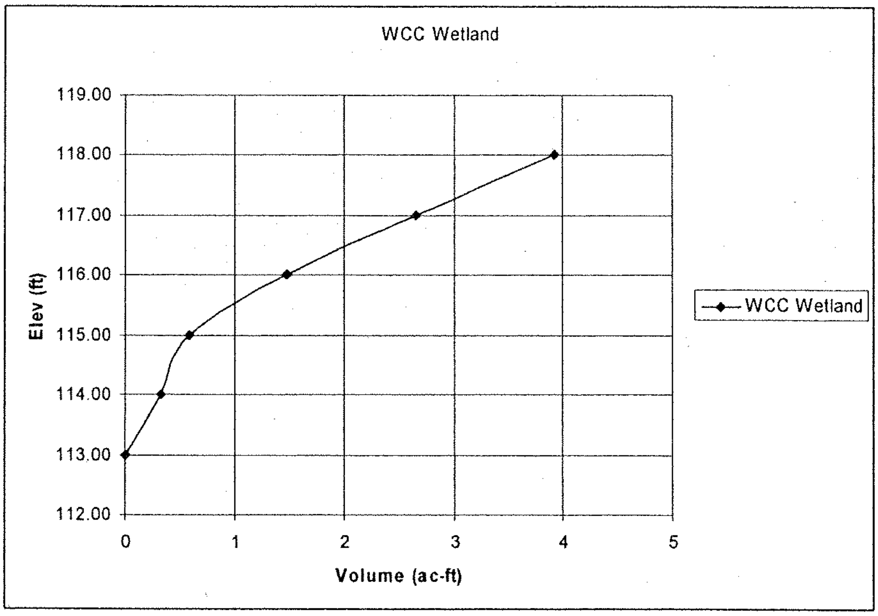


Figure 6. Proposed WCC Stormwater Wetland Stage-Storage Curve

5 References

NCDENR, 2002. Neuse River Basinwide Water Quality Plan. North Carolina Department of Environment and Natural Resources. Division of Water Quality. Raleigh, NC.

NCDENR. 2006. Updated Draft Manual of Stormwater Best Management Practices. Prepared by the North Carolina Department of Environment and Natural Resources (DENR), Division of Water Quality. Raleigh, North Carolina.

USDA-NRCS. 1974. Soil Survey of Wayne County, North Carolina. U.S. Department of Agriculture - Natural Resource Conservation Service.

6 Figures

The following figures were prepared using ArcView. The shapefiles used to generate the graphics are listed below.

Drainage area.shp – Delineated drainage area for existing conditions.

Project_site.shp – Area available for device.

Dot_cntrs – 2-foot contours downloaded from NCDOT website, generated from LIDAR in March 2005.

Channel.shp – stream hydrology downloaded from Wayne County GIS website.

Parcels.shp – Property lines downloaded from Wayne County GIS website.

Soils.shp – NRCS soil polygons, obtained from NRCS website.

Survey_cntrs.shp – 1-foot contours generated from site survey.

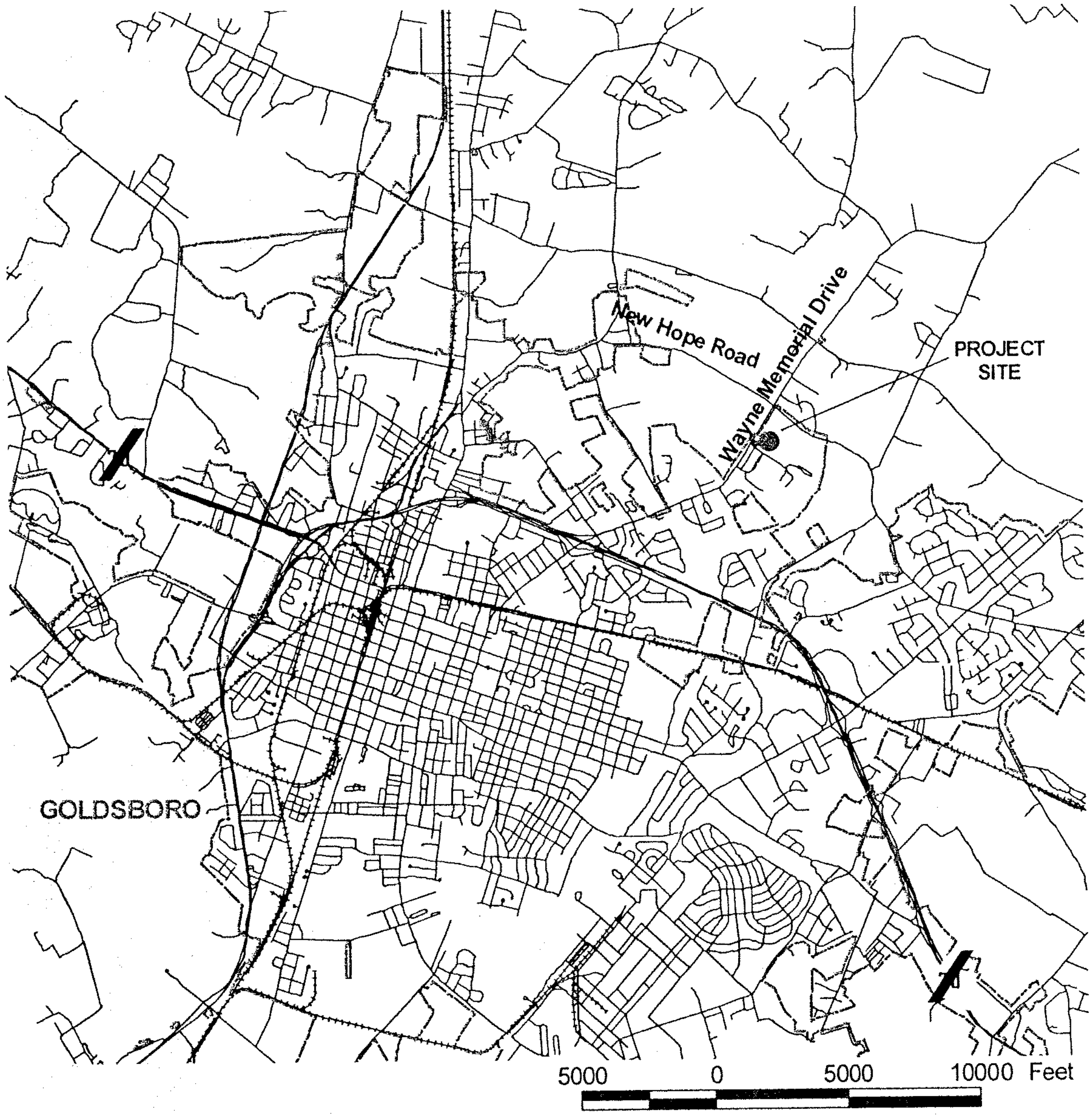
P_design_11-06.shp – Proposed 1-foot contours exported from AutoCAD.

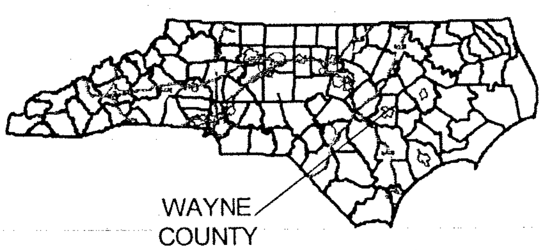
No Planting.shp – Area where no planting will occur due to deep water or upper forebay.

Planting Zone A.shp – Planting zone for shallow water bench/ low marsh.

Planting Zone B.shp – Planting zone for shoreline fringe/ high marsh and riparian fringe.

Planting Zone C.shp – Planting zone for floodplain terrace and upland slopes.





TETRA TECH, INC.

Ecosystem Enhancement PROGRAM

WCC Stormwater Wetland
Wayne County, NC
November 30, 2006

Figure 1. Project Site Vicinity Map

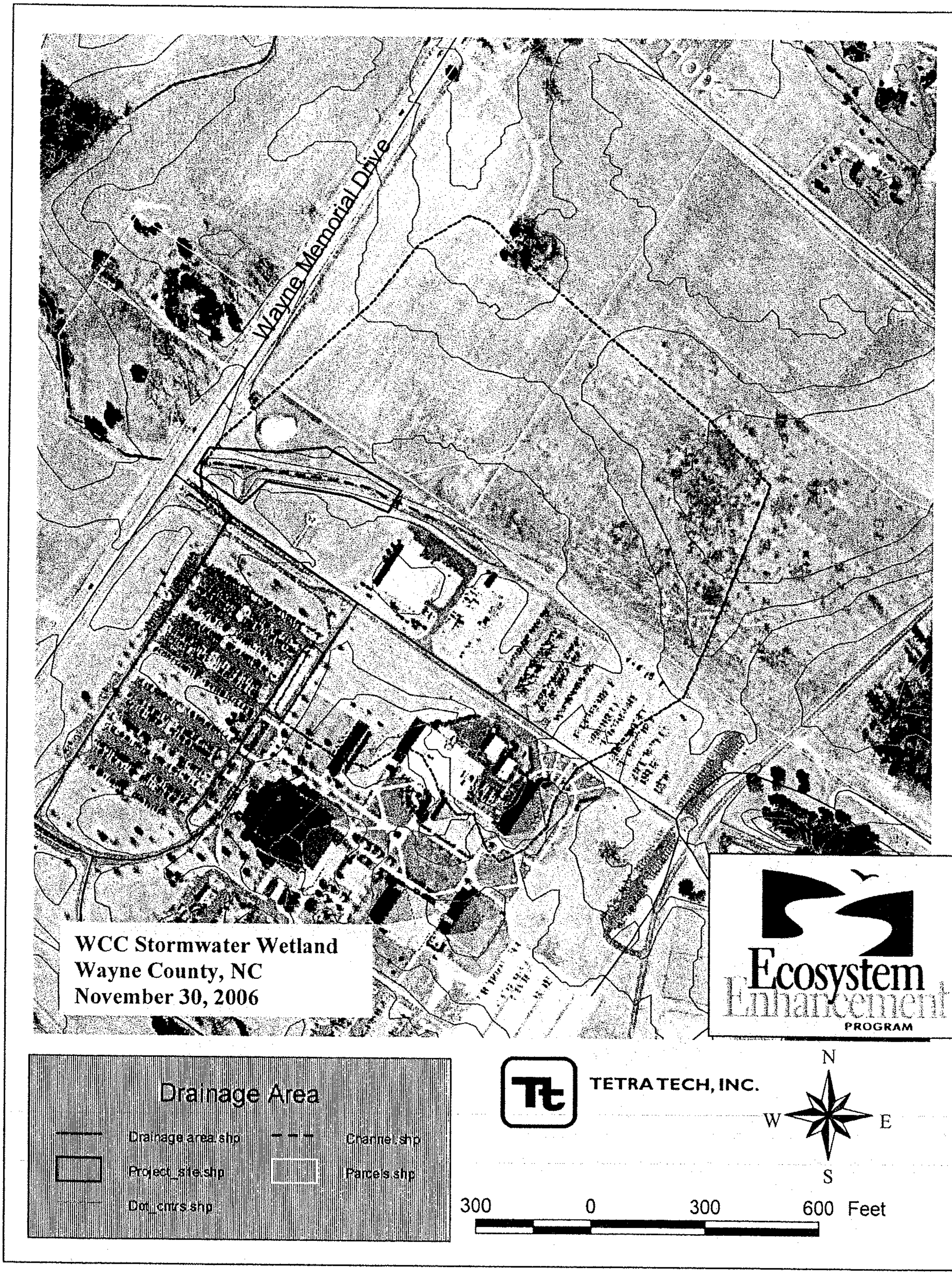


Figure 2. Project Site Drainage Area

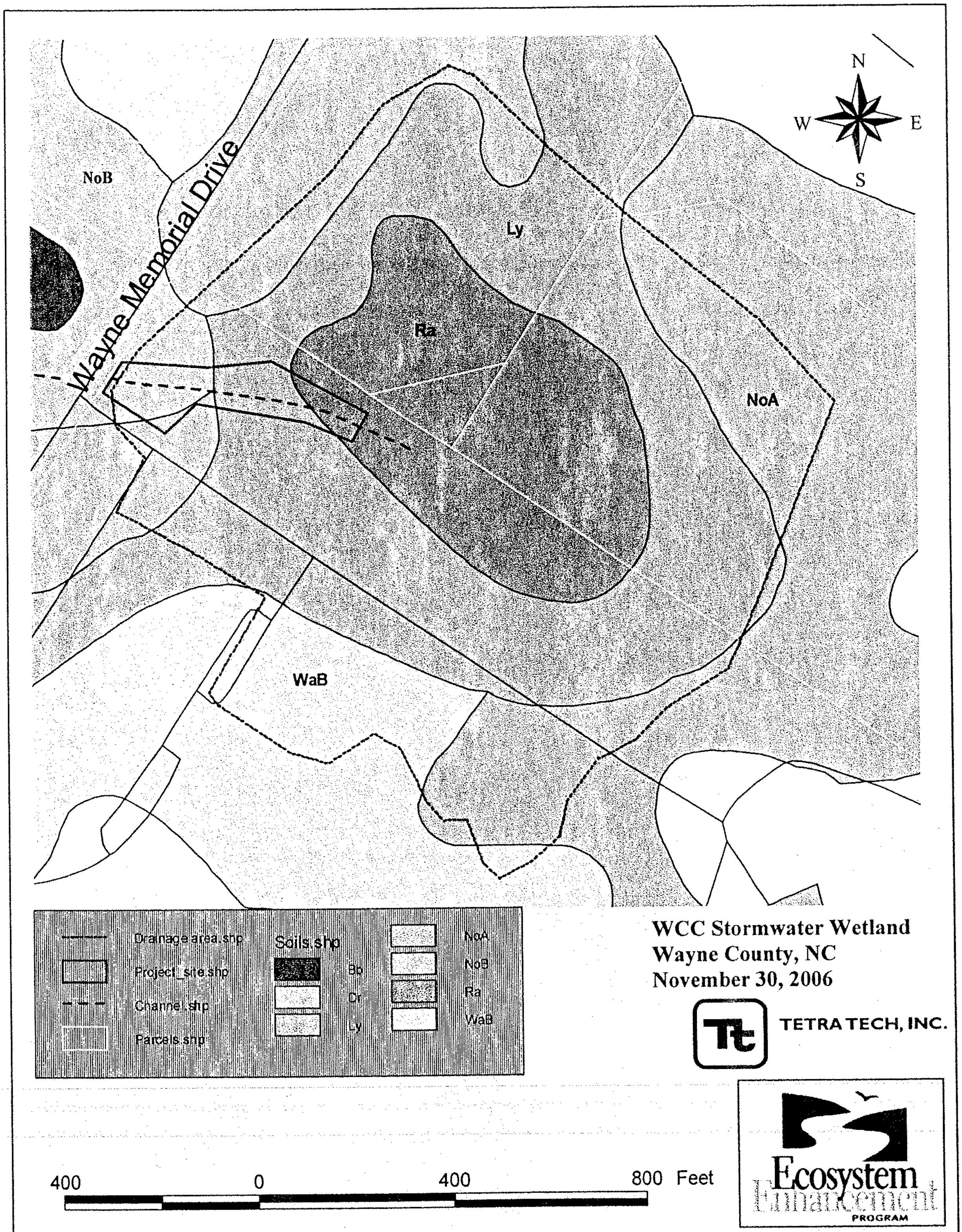


Figure 3. Project Site NRCS Soil Survey

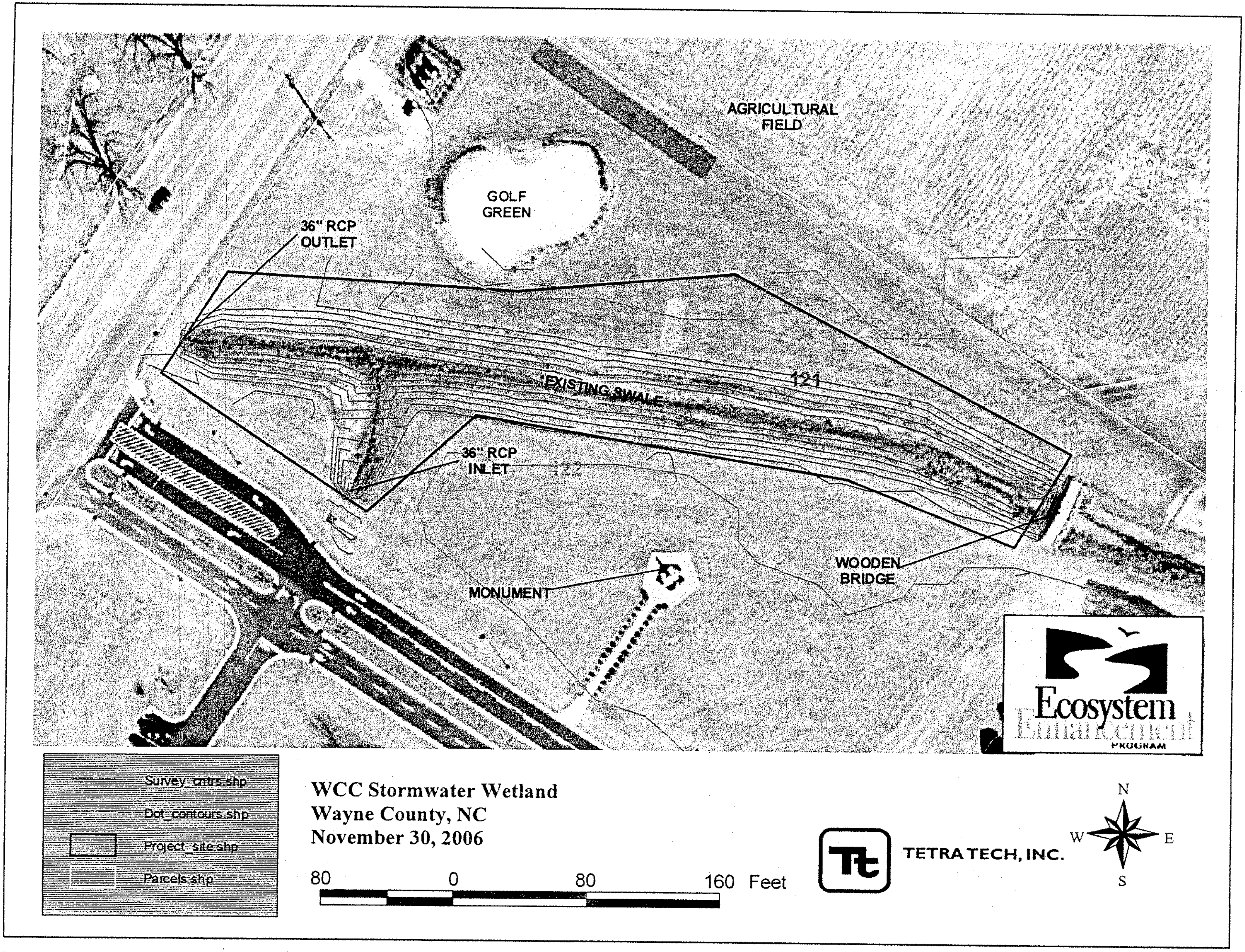


Figure 4. Existing Conditions

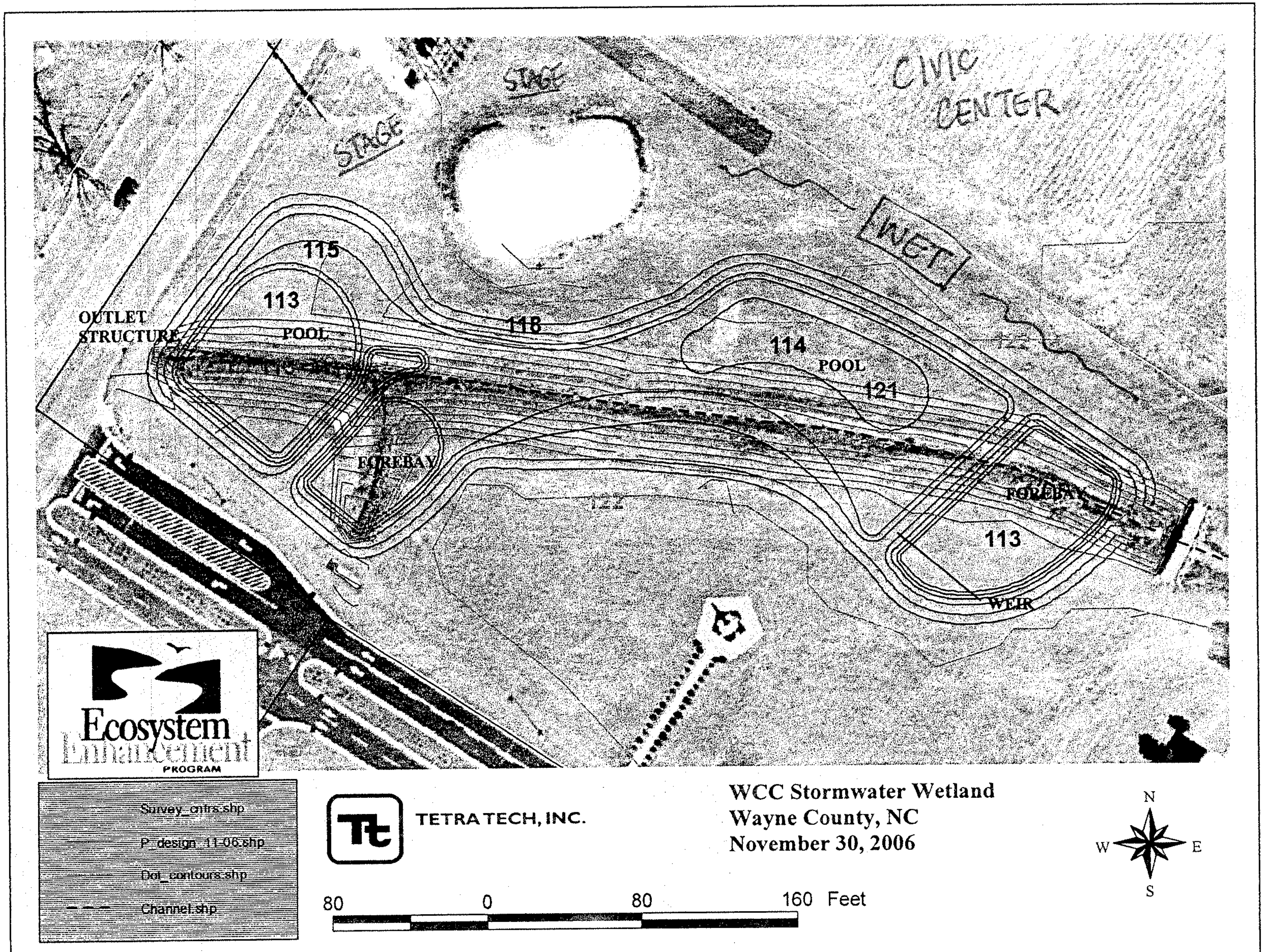


Figure 5. Proposed WCC Stormwater Wetland Design

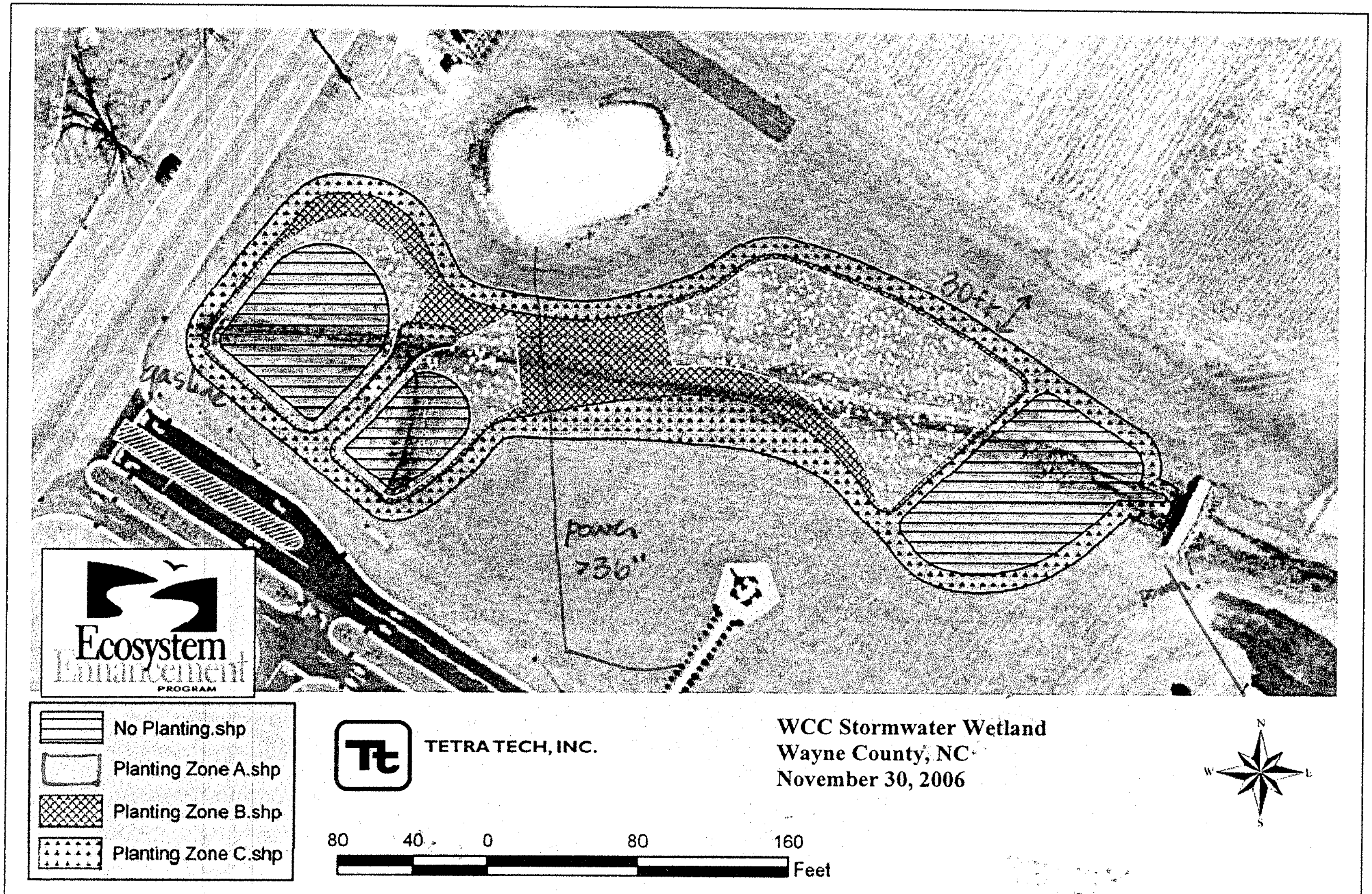


Figure 7. Proposed WCC Planting Zones

Appendix A. Site Photographs

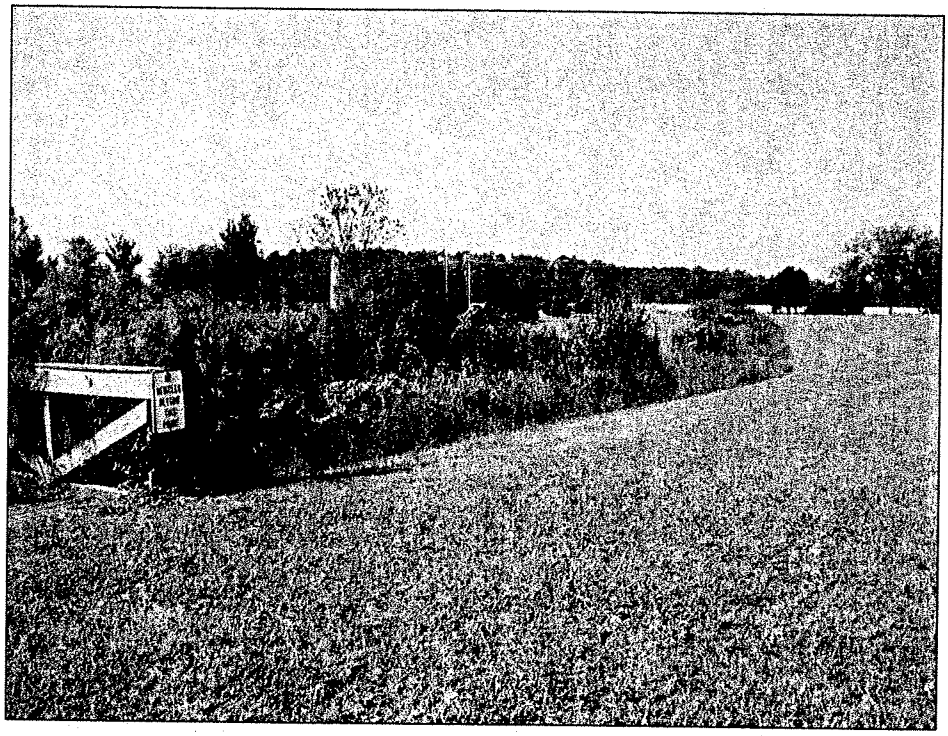


Figure A-1. Project Site looking from existing wooden bridge towards Wayne Memorial Drive

Figure A-2. Downstream 36-inch RCP with headwall under Wayne Memorial Drive

Figure A-3. Project site looking from South to North. Existing wooden bridge is upstream project limit.

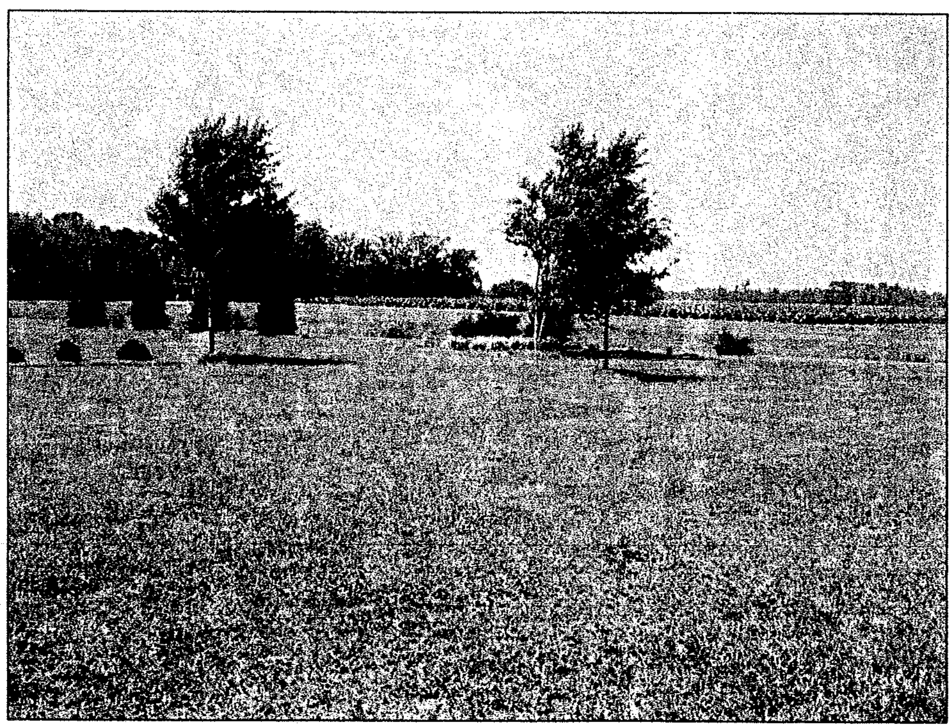


Figure A-4. Existing landscaping on Wayne Community College Campus on south side of project site.

Figure A-5. Existing ditch, standing on wooden bridge and looking towards Wayne Memorial Drive.