

REVISED WETLAND & STREAM MITIGATION PLAN REPORT
for the
CLAYHILL FARMS PROPERTY
JONES COUNTY, NORTH CAROLINA

REVISED

WETLAND & STREAM MITIGATION PLAN REPORT
for the
CLAYHILL FARMS PROPERTY
JONES COUNTY, NORTH CAROLINA

Prepared for:

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REVISED WETLAND & STREAM MITIGATION PLAN REPORT
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1.0 DOCUMENT DESCRIPTION & INTENT

The following document represents revisions to the *Final Wetland and Stream Mitigation Plan Report for the Clayhill Farms Property, Jones County, North Carolina* prepared for the North Carolina Department of Transportation Project Development and Environmental Analysis Branch in July 1999 by Langley & McDonald, Inc. (L&M), now LandMark Design Group, Inc., of Virginia Beach, Virginia. This revised plan incorporates comments from meeting minutes dated March 1, 2002, March 4, 2002, April 30, 2002; results of the May 24, 2002 MBRT meeting; and the *Forest Management Plan* (prepared by Carolina Silvics, Inc. in July 2003).

2.0 EXECUTIVE SUMMARY

The North Carolina Department of Transportation (NCDOT) acquired the 355.6 acre Clayhill Farms property in the summer of 1998 based upon the findings of the *Wetland Mitigation Site Feasibility Study* conducted by L&M in the fall of 1997 (L&M 1998). The following report describes the Clayhill Farms Wetland and Stream Mitigation Site (hereafter referred to as the "Site") in detail and proposes methods for restoring, enhancing, and preserving wetland communities to compensate for wetland impacts associated with future road construction projects. The Site also provides the NCDOT with the opportunity to restore 8,262 linear feet of stream which was channelized to maximize agricultural production in the mid 1970s.

The following major studies were conducted in preparation of this report including:

- Soils delineation and location by Global Positioning System (GPS) survey on certain farm fields,
- Wetland delineation and location by traditional survey of forested area mapped as Class B hydric soils,
- Groundwater table characterization and modeling using DRAINMOD,
- Shallow groundwater monitoring,
- Surface water hydrology and hydraulics of farm field (feeder) ditches,
- Fluvial geomorphological analysis of reference streams and the on-site, channelized reach of Billy's Branch,
- Surface water hydrology and hydraulics of Billy's Branch,
- Importance value calculations for off-site reference plant communities,
- General inventory of on-site vegetation and wildlife, and
- Section 7 consultation for the red-cockaded woodpecker (*Picoides borealis*).

This report also addresses vegetation and stream monitoring protocol, mitigation ratios, and dispensation of the property.

The Site currently contains approximately 155.9 acres of forested wetlands, 199.7 acres of non-wetlands (141.8 acres of Prior Converted cropland and 57.9 acres of forested land), 6,170 linear feet of incised, straightened stream, and 1,280 linear feet natural perennial stream. Following implementation of the mitigation plan, the property will provide the following:

- 97.7 acres of wetland restoration, 1.8 acres of wetland enhancement, and 154.1 acres of wetland preservation;
- 5,132 linear feet of perennial stream restoration, 3,200 linear feet of intermittent stream restoration, 1,280 linear feet of stream preservation; and
- 44.1 acres of upland restoration and 57.9 acres of upland preservation.

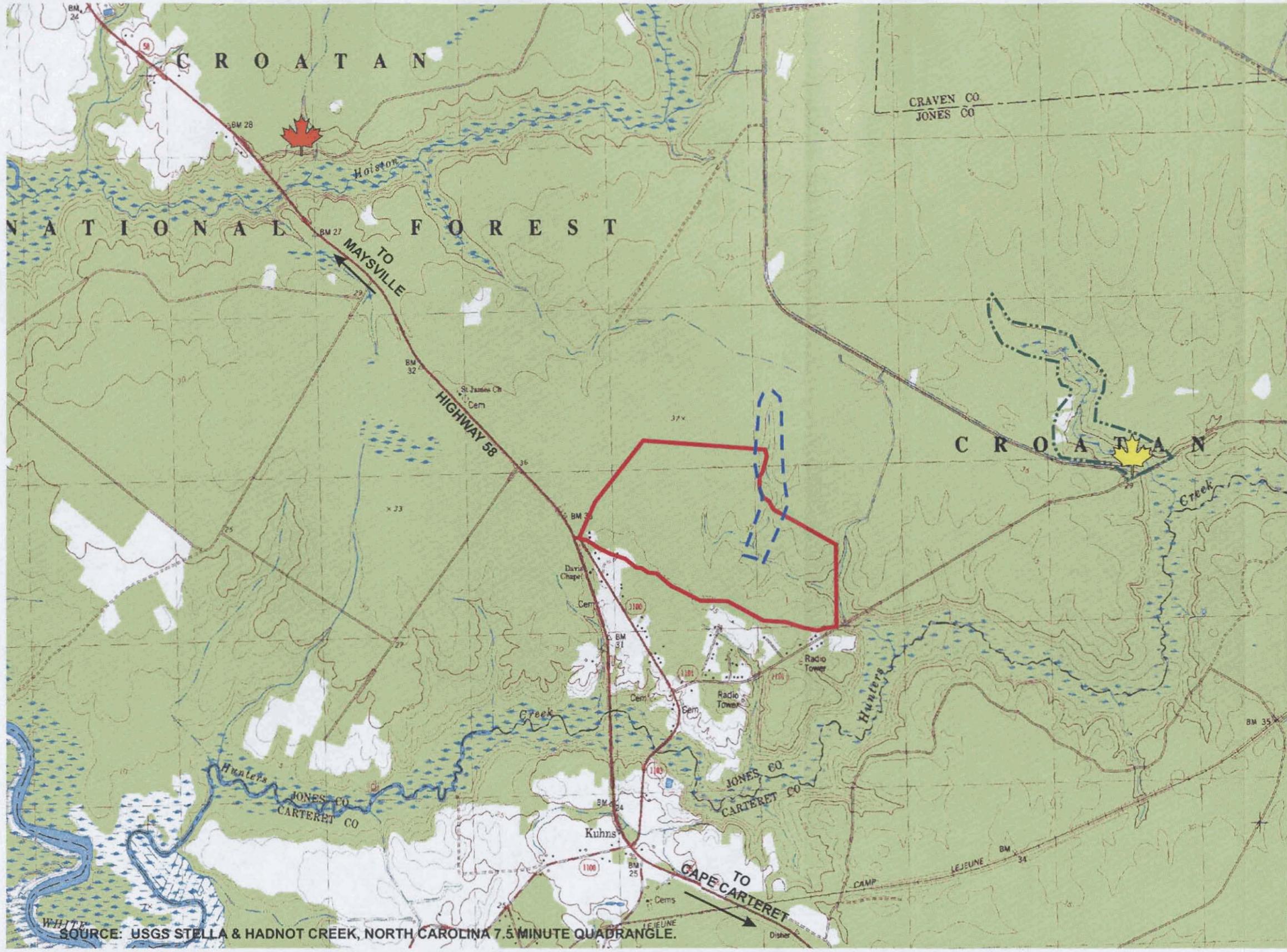
Stream restoration at the Site will be accomplished utilizing Priority 1 methodologies, which calls for re-establishing the stream at an elevation which is compatible with the abandoned floodplain. The stream mitigation plan will allow approximately 65 acres of floodplain to be re-established on-site by decreasing the width and depth of Billy's Branch and increasing the sinuosity (decreasing the slope) of the stream. Hydraulic analysis indicates that there should be no adverse affect of this stream restoration on downstream properties.

3.0 INTRODUCTION

The NCDOT first became aware of Clayhill Farms in early 1997 when the property was identified during the L&M "*Highway 24 Wetland Mitigation Site Search*" (NCDOT Consulting Project Number 96-LM-06, State Project Number 6.169001T). After determining that the owners of Clayhill Farms were willing to negotiate sale of the property to the NCDOT, L&M performed a *Wetland Mitigation Site Feasibility Study* of the property in the fall of 1997 (96-LM-11, State Project Number 6.169001T). The NCDOT purchased the property in the summer of 1998. The following report describes the Site in detail and proposes methods for restoring and preserving the natural communities there to provide compensatory mitigation for wetland and stream impacts associated with future road construction projects in the region.

4.0 EXISTING AND HISTORIC CONDITIONS

The Site (NCDOT Site No. WOKCU0219022, L&M Site Nos. JO-6 and JO-7) includes two adjacent parcels of land totaling 355.6 acres (Jones County Tax Parcels 5369-20-8859-00 and 5369-40-3101-00). The Site is located in southwestern Jones County, North Carolina on the Hadnot Creek, NC and Stella, NC 7.5" U.S.G.S. Topographic Quadrangles (Figure 1, Vicinity Map). It is bordered to the north, east and west by the Croatan National Forest and to the south and east by various forested and residential parcels. It is bisected by Billy's Branch, a tributary to Hunters Creek.

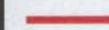


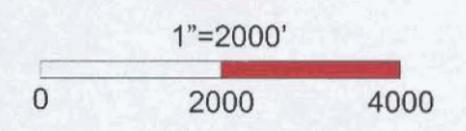
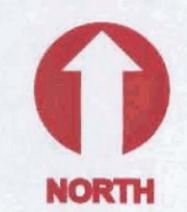
SOURCE: USGS STELLA & HADNOT CREEK, NORTH CAROLINA 7.5 MINUTE QUADRANGLE.

Clayhill Farms Wetland & Stream Mitigation Plan Report

Figure 1 Vicinity Map

Legend

-  Subject Property
-  On-site Reference Reach
-  Off-site Reference Reach
-  Vegetation Reference Area 1
-  Vegetation Reference Area 2



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4.1 Physiography

The Site is located in the Atlantic Coastal Plain physiographic province of North Carolina. This area is comprised of sediments that were deposited during transgressive-regressive cycles caused by past worldwide sea level fluctuations. In part, these fluctuations were the result of the expansion and recession of glacial ice caps. During interglacial periods, relatively high sea levels allowed for deposition of marine and shoreline sediments. Conversely, during glaciation, the falling sea level caused regression and eventual down cutting by streams and rivers (Soller and Mills 1991).

Based upon the *Geologic Map of North Carolina* (NCGS, 1985), the surficial sediments found on the Site are typical of the Duplin Formation. The Duplin Formation consists of bluish gray, shelly, medium-to coarse-grained sand, sandy marl, and limestone. In cross-section, the Site and vicinity are characterized by relatively flat lying sediments that gently fall to the southeast. Elevations on the Site range from approximately 20 to 36 feet above sea level (Figure 2).

4.2 Land Use History

The Site was logged in the early 1970s and portions of it were converted to agriculture. At that time, perimeter ditches and farm drainage ditches were excavated and Billy's Branch was channelized. Parallel drainage ditches in the western (poorly drained) farm fields were excavated 250 to 450 feet apart. Drainage ditches in the well drained eastern half of the property were placed at the bottom of topographic gradients within former drainage swales and stream channels. These ditches range from 600 to 1,700 feet apart.

The approximately 141.8 acres of the Site put into agricultural production in the 1970s were continuously farmed by Mr. Earl Jones and his family until the sale of the property to the NCDOT in 1998. The 213.8 acres of the property that are presently forested contain a mosaic of disturbed and natural communities. Of these 213.8 acres, approximately 19.0 acres remain relatively undisturbed hardwood dominated forest. The remaining 194.8 acres appears to have been clearcut in the 1970s and allowed to regenerate naturally into a mixed community of loblolly pine (*Pinus taeda*) and pond pine (*Pinus serotina*). Approximately 44 acres of pine forest on the western half of the property have been thinned in the past five years; the remaining forest has not been cut. Approximately 11.7 acres of forest were again clear-cut in early 1998 and have not been replanted.

4.3 Soils

4.3.1 General Soil Boundaries

On February 1 through 3, 1999, L&M supervised the completion of 20 soil borings throughout the Site in order to describe the Site soils/sediments and to facilitate aquifer permeability tests (Bouwer 1989). The soil borings were installed with an all terrain vehicle mounted drill rig. The borings were performed using a 4.25-inch (inside diameter) hollow stem auger and continuous split spoon sampling from the surface to approximately 15 feet below ground surface (bgs).

The *Soil Survey of Jones County, North Carolina* (USDA 1981) identifies five soil types within the Site, all of which are mineral soils. Soils samples were analyzed in the field for texture and color and

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Figure 2 General Site Map

Legend

-  Property Boundary
-  Centerline of Stream
-  Manmade Ditch
-  Road
-  Culvert
-  Pine Dominated Forest
-  Recently Clearcut Forest
-  Hardwood Dominated Forest
-  Groundwater Monitoring Well
-  DRAINMOD Well



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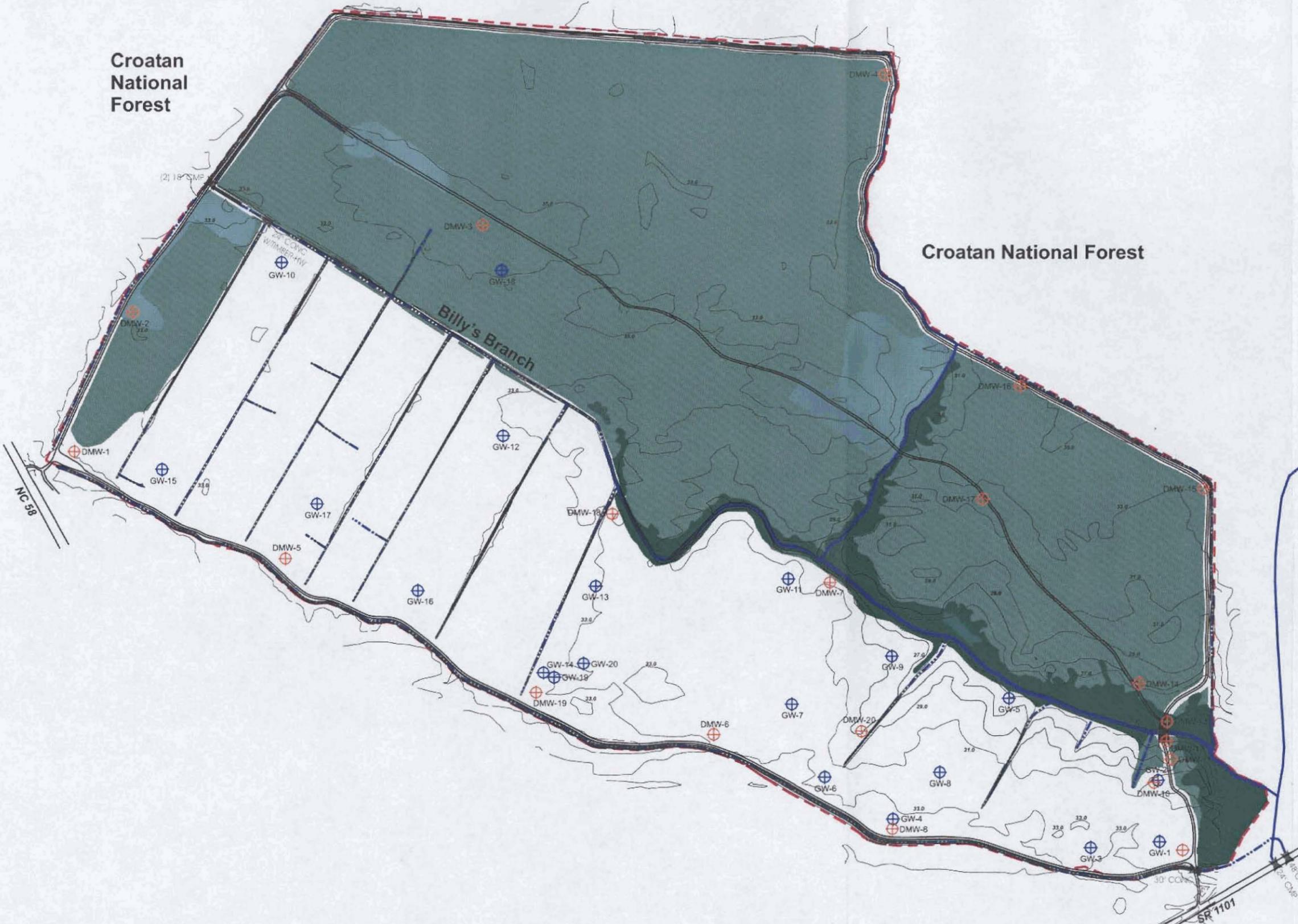
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were found to be as generally described in the soil survey. (Detailed soil boring logs are included as Appendix A). As was expected, however, the soil series boundaries depicted in the soil survey are general, and the actual soil series boundaries were found to vary some from those published. General soil boundaries and boring locations (indicated by the presence of DRAINMOD wells) are depicted on Figure 3. Figure 3 also illustrates where soils sampled for borings differed from soil survey mapping (USDA 1981).

The five soils confirmed to occur at the Site are listed and described as follows (in decreasing order of coverage):

1. **Onslow fine sandy loam (On)** - Spodic Paleudult: A nearly level, moderately well drained soil in interstream areas near drainageways. Typically, the surface layer is dark gray fine sandy loam 9 inches thick. The subsurface layer is pale brown loamy fine sand 6 inches thick. It has an intermittent thin hardpan. The subsoil is 61 inches thick. It is light olive brown and pale brown sandy clay loam in the upper part and gray and light brownish gray sandy loam in the lower part. The underlying material to a depth of 80 inches is light brownish gray sandy clay loam. The seasonal high water table is at a depth of 1.5 to 3.0 feet. It is not listed as a hydric soil in the 3rd Edition of *Hydric Soils of the United States* (USDA 1981, USDA 1991).
2. **Torhunta fine sandy loam (To)** - Typic Humaquept: A nearly level, very poorly drained soil in broad interstream areas and in depressions near shallow drainageways. Typically, the surface layer is fine sandy loam 15 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is 32 inches thick. It is dark gray fine sandy loam in the upper part and grayish brown sandy loam in the lower part. The underlying material to a depth of 72 inches is light brownish gray stratified loamy sand, sandy loam, and sand. The seasonal high water table is at a depth of 0.5 to 1.5 feet from December to May. It is listed as a hydric soil (USDA 1981, USDA 1991).
3. **Pantego loam (Pn)** - Umbric Paleaquult: A nearly level, very poorly drained soil on broad, smooth flats in interstream areas. Typically, the surface layer is black and very dark gray loam 15 inches thick. The subsoil is 53 inches thick. It is grayish brown sandy clay loam in the upper and middle parts and gray sandy clay loam in the lower part. The underlying material to a depth of 80 inches is greenish gray sandy clay loam. The seasonal high water table is at the surface or to a depth of 1.5 feet from December to May. It is listed as a hydric soil (USDA 1981, USDA 1991).
4. **Marvyn loamy sand, 6 to 15 percent slopes (MaC)** - Typic Hapludult: A well drained soil on side slopes near major drainageways. Typically, the surface layer is dark grayish brown loamy sand three inches thick. The subsurface layer is light yellowish brown loamy sand 14 inches thick. The subsoil is strong brown sandy clay loam 31 inches thick. The underlying material to a depth of 70 inches is reddish yellow sandy loam and yellow loamy sand. The seasonal high water table is below a depth of about 6 feet. It is not listed as a hydric soil (USDA 1981, USDA 1991).

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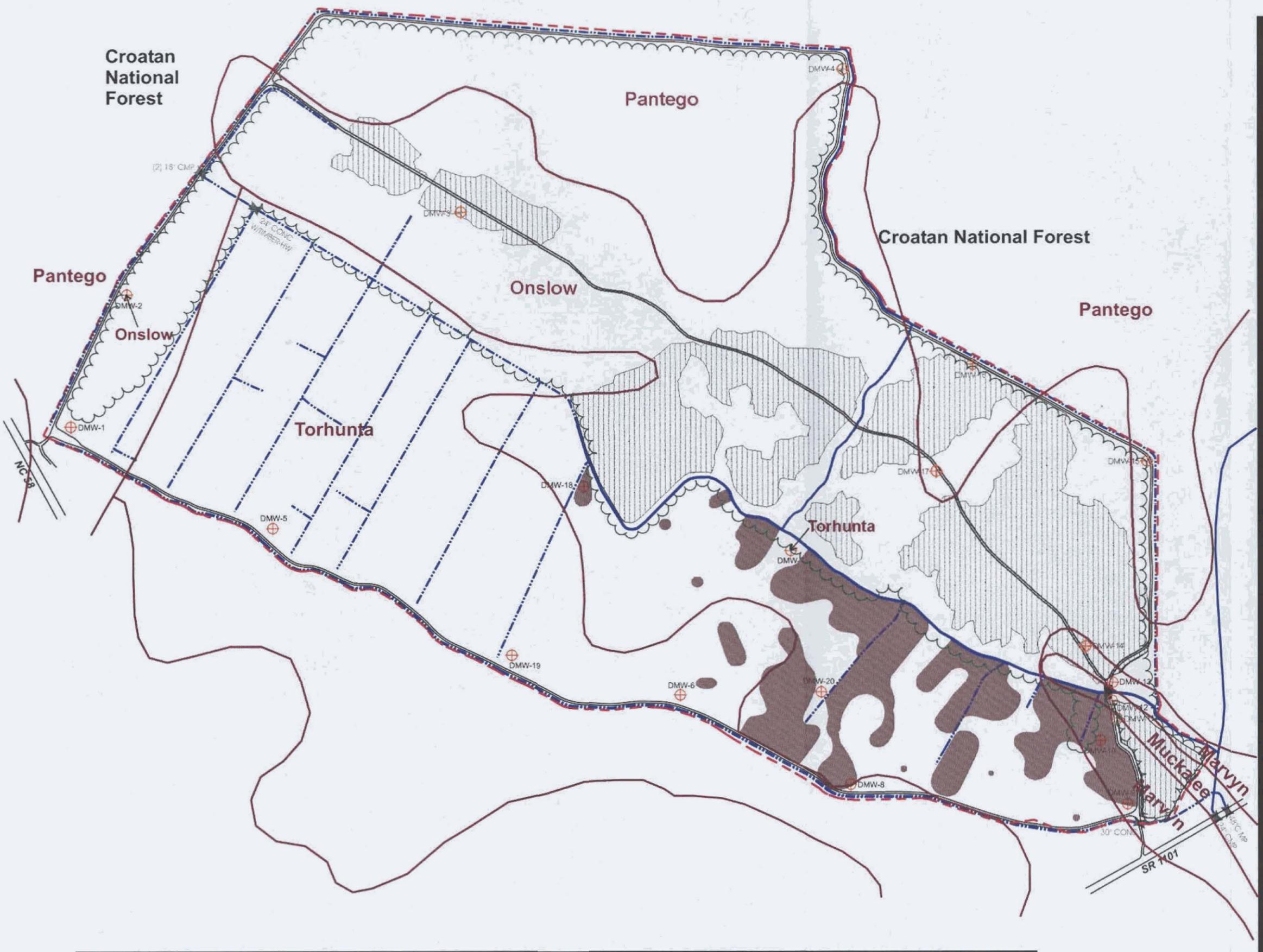
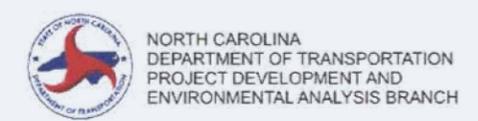
Figure 3 Soils Map

Legend

-  Property Boundary
-  Centerline of Stream
-  Manmade Ditch
-  Road
-  Culvert
-  DRAINMOD Well (Soil Boring)
-  General Soil Type Boundaries (From Soil Survey)
-  Non-Hydric Soils Approximated from Sampling
-  Non-Hydric Soils Approximated from Wetland Delineation
-  Forested Area



1"=500'



5. **Muckalee loam (Mk)** - Typic Haplaquod: A nearly level, poorly drained soil in drainageways. Typically, the surface layer is dark grayish brown loam and dark gray sandy loam 24 inches thick. The underlying material to a depth of 65 inches is mottled gray and grayish brown sand and greenish gray loamy sand. The seasonal high water table is at depth of 0.5 to 1.5 feet. It is listed as a hydric soil (USDA 1981, USDA 1991).

4.3.2 Hydric Soil Boundaries

The USDA Natural Resources Conservation Service (NRCS) performed a Prior-Converted (PC) Cropland Determination of the Site on July 19, 1990 (Appendix B). The fields have been in continuous cultivation from the mid-1970s to 1998. All of the fields mapped as containing significant amounts of Torhunta or Pantego were determined to be PC fields; the others were not. Sampling performed during the feasibility study of this property (L&M 1998) revealed that much of the area mapped as Onslow soil, and therefore considered to be non-hydric soil, was actually hydric soil.

In order to determine the location of hydric and non-hydric soils in the eastern farm fields more accurately, soil samples were taken on a 100-foot grid with a two-inch diameter Dutch-style auger to a depth of 24 inches and located by survey using a GPS-. If the soil sample collected met any one of the NRCS field indicators of hydric soils (USDA 1995), that sample was recorded as hydric. Of the 272 samples collected, only 34.1 percent (93) were determined to be non-hydric. Based on these samples, non-hydric soils within the farm fields were approximated as shown on Figure 3. Approximately 120.5 acres of the farm fields are on hydric soil and 21.3 acres are on non-hydric soil.

4.4 Groundwater Hydrology

4.4.1 DRAINMOD Groundwater Monitoring Wells

Subsequent to the soil boring activities, each boring was converted into a groundwater monitoring well for use in DRAINMOD (denoted as DMW on the figures). The wells were constructed with two-inch polyvinyl chloride (PVC) slotted casing from 14 feet bgs to 1.5 feet bgs. Attached to the slotted well casing was a solid section of pipe (riser) from 1.5 feet bgs to approximate 2.5 feet aboveground surface. The annular space was filled with filter sand from 15 feet bgs to 0.5 feet bgs and then the balance was completed with bentonite pellets to the surface (See boring logs for well construction details, Appendix A).

The wells were allowed to equilibrate for a period of approximately one-week before they were gauged with an electronic meter on February 17 and 18, 1999. Measurements were recorded to the nearest 0.01 foot and are listed in Table 1. Groundwater elevations ranged from 34.37 feet mean sea level (msl) to 19.41 feet msl. These water table elevations were extrapolated to produce the groundwater flow map included as Figure 4. As depicted on the map, groundwater at the Site is generally directed toward Billy's Branch and somewhat mimics the topography of the Site.

4.4.2 Remote Shallow Groundwater Monitoring Wells

Remote shallow groundwater monitoring wells were also installed on the Site to take continuous readings of the groundwater table (denoted as GW on figures). These wells are manufactured and sold by Remote Data Systems, Inc. and extend 20 inches below the soil surface. The wells are programmed

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Figure 4 Groundwater Flow Map

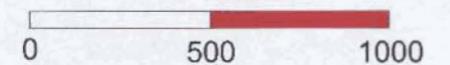
Legend

-  Property Boundary
-  Centerline of Stream
-  Manmade Ditch
-  Road
-  Culvert
-  Forested Area
-  Recently Clearcut Area
-  Groundwater Monitoring Well
-  DRAINMOD Well
-  Groundwater Contour (in feet)
-  Groundwater Flow Direction



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1"=500'



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Table 1. DRAINMOD monitoring well water table measurements (February 11, 1999).

Soil Type	Well Number	Depth to Water Table from Ground Surface (inches)
Onslow	DMW-2	19.20
	DMW-3	17.76
	DMW-18	41.76
	DMW-20	38.04
Torhunta	DMW-5	26.50
	DMW-6	34.32
	DMW-7	26.76
	DMW-8	3.24
	DMW-19	20.40
Pantego	DMW-1	17.52
	DMW-4	18.48
	DMW-15	35.76
	DMW-16	23.52
	DMW-17	18.12
Marvyn	DMW-9	104.52
	DMW-10	100.80
	DMW-11	76.56
	DMW-13	24.24
	DMW-14	46.68
Muckalee	DMW-12	44.88

to read the groundwater table once a day. The wells are downloaded once a month but can store data for over a year, as long as the batteries do not run down.

The wells were installed prior to the beginning of the growing season and all but two (GW 17 and 18) have functioned properly since the beginning of the growing season. As would be expected in a poorly drained soil which has been ditched, the water table is erratic. It drops below 12 inches bgs and remains there until a rain event. Following the rain event, the groundwater table recharges, often to the surface, and remains above 12 inches for 7 to 10 days before falling below 12 inches again. At no well has the groundwater table remained within 12 inches of the soil surface for five percent or more of the growing season. As such, none of these sites met the wetland hydrology criterion as detailed in the *Corps of Engineers Wetland Delineation Manual* (EL 1987). Neither well in the Marvyn soil has recorded a water level less than 20 inches from the surface any day since the wells were installed (prior to the beginning of the growing season) on February 19, 1999.

It should be noted that while rainfall was average for the three months, 6 months, and 12 months preceding the growing season (within 25 percent of mean precipitation), rainfall during the first two months of the growing season was abnormally low (68 percent of normal in March 1999 and 55 percent of normal in April 1999).

4.4.3 DRAINMOD

DRAINMOD (version 4.0/5.0, June 1994) is a Fortran based computer model that simulates the performance of drainage, sub-irrigation, and controlled drainage systems. The model was developed at North Carolina State University in the Department of Biological and Agricultural Engineering for application to agricultural drainage and water table management systems (Skaggs 1980). The basic assumptions/requirements for DRAINMOD are (1) the modeled areas are field-sized units with parallel ditches, (2) the region has a humid climate, and (3) the area has a shallow, unconfined aquifer.

DRAINMOD was adapted to wetland studies by including a subroutine calculation that accounts for the wetland hydrology (i.e., the number of consecutive days the water table is less than 12 inches from the ground surface during the growing season). For the purposes of this plan, DRAINMOD was used in the "wetland hydrology mode" in order to:

1. Simulate the existing site drainage to determine the areas effectively drained by present ditching (i.e., the areas not meeting the criteria for wetland hydrology), and
2. Simulate the predicted number of years each field would meet the criteria for wetland hydrology in pre- and post-restoration conditions.

In order to run DRAINMOD, the following previously published information was obtained:

1. 40 years (1951 to 1990) of hourly rainfall data and daily high and low temperature data from New Bern, N.C.,
2. Soil input characteristics as computed by DMSOIL for each soil type (Baumer and Rice 1988): soil-water characteristic curve, volume drained, infiltration/Green-Ampt parameter, and upward flux,
3. Dates of the local growing season (March 15 to November 11),
4. Wetland hydrology criteria (groundwater within 12 inches of the ground surface for 31 consecutive days 20 out of 40 years (12.5 percent of the growing season (EL 1987), and
5. Potential evapotranspiration (PET) factors.

In addition to the above data, L&M collected the following field data for each soil type:

1. Ditch size parameters,
2. Soil horizons and textures (Appendix A),
3. Static water table depths,
4. Average soil hydraulic conductivities (taken as an average over the entire screened section of well casing) (Appendix C-1), and
5. Average surface storage capacity (Appendix C-2).

Wetland hydrology for the site was simulated with DRAINMOD by uniquely modeling each of the five soil types with the present ditch system. DRAINMOD was used in the single ditch mode because of the high variability in ditch depths and widths. In running the program for a single ditch, the software assumes a second equally configured ditch is located parallel to the inputted ditch and that the two ditches are acting as a system. This simulation appeared to produce relatively accurate results when compared with the present site conditions. This is discussed in further detail in Section 5.1.1. Ditch

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Figure 5 DRAINMOD Existing Conditions

Legend

-  Property Boundary
-  Centerline of Stream
-  Manmade Ditch
-  Road
-  Culvert
-  DRAINMOD Well
-  Effectively Drained Areas (per DRAINMOD)
- D1** Ditch Numbers
- O-1** Field Numbers
-  Forested Area



1"=500'

0 500 1000



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spacing was manipulated to determine the current radii of influence of the field ditches (Appendix C-3).

The existing Site conditions modeling shows that ditches currently “effectively drain” portions of the agricultural fields at distances ranging from 43 feet to 312 feet for a total of 107.3 acres (Figure 5). The “effectively drained” areas are dependent upon numerous factors including the soil type, ditch size, topographic relief of the field, and hydraulic conductivity. Effectively drained means that saturation does not occur within 12 inches of the ground surface for 31 consecutive days or longer.

4.5 Surface Water Hydrology

4.5.1 Benthic Macroinvertebrate and Fisheries Resources

Benthic macroinvertebrate and fish samples were collected by NCDOT staff from two locations within the Site and at one location within the off-site reference reach shown on Figure 1 on April 2002. Results of these samplings are included as Appendix D.

4.5.2 Development of Hydraulic Geometry Relationships

Prior to initiating an on-site hydraulic analysis of Billy’s Branch, research was conducted to determine whether a regional curve for hydraulic geometry existed for the Upper Coastal Plain of North Carolina. Use of hydraulic geometry relationships is central to fluvial geomorphological restoration techniques developed by Luna Leopold (1994) and Dave Rosgen (1996) and recommended for use in the state of North Carolina by the North Carolina Wildlife Resources Commission (WRC 1998). Regional curves provide a relationship between various streams in a region by correlating drainage area size to bankfull discharge rates, cross-sectional area, width, and mean depth. Conversations with the Natural Resources Conservation Service (NRCS) confirmed that no regional curve existed for the Upper Coastal Plain of North Carolina.

L&M began procedures necessary to develop regional curves. The *Water Resources Data, North Carolina, Water Year 1997* (USGS 1998), was reviewed to identify river gage stations throughout the Upper Coastal Plain Region proximate to the Site. A total of 10 sites were identified for review of detailed data (expanded rating tables, summary of discharge measurement data (Form 9-207) obtained from the United State Geological Survey (USGS) in Raleigh. After a review of data and discussions with representatives of the USGS, eight of the 10 sites were dropped for the following reasons: too deep to be sampled using chest waders (five), shifting bed and thus changing rating curve (one), gage data only available for three years (one) and high levels of fecal coliform due to proximity of hog farm (one).

The remaining two sites were used to develop hydraulic geometry data and included: Contentnea Creek (Neuse River, gage station 02090380) and Mocosin Run (Neuse River gage station 0209096970). While regional curves become more accurate with data from numerous gage stations, data from these two reference sites were deemed sufficient for geometry relationships because the similarity in drainage area and land use characteristics to the restoration reach (Billy's Branch).

4.5.3 Geomorphological Description of the Reference Reaches

Reference reaches are utilized to describe the plan, profile, and cross-sectional attributes of a stable stream channel that is of the same stream type as that proposed at a restoration site. Knowing the dimensions, the bankfull discharge of the reference reach allows for the design of a stable stream at the proposed Site

The primary reference reach selected for this study is an unnamed tributary to Hunters Creek, a tributary of the White Oak River (Figure 1). It is the characteristics of the primary reference reach that were used to develop the restoration parameters for Billy's Branch. A secondary reference reach, located within the Site, is discussed separately and was utilized to further validate the most probable stream type of Billy's Branch prior to disturbance.

Primary Reference Reach

The primary reference reach is located within the Croatan National Forest, in Jones County, approximately 1.4 miles northeast of the Site. As with Billy's Branch, it drains to the White Oak River. The reference reach is located in Valley Type X (Rosgen 1996). These valleys are very wide with low relief typical of coastal plains, broad lacustrine and/or alluvial flats. The reference reach is located in 0.7 square mile watershed. The entire watershed is forested and contains a relatively mature forested wetland within the floodplain.

Based upon the hydraulic analysis generated from the gage station, Hunters Creek is projected to have bankfull discharge of 42 cubic feet per second (cfs), a bankfull cross-sectional area of 17 square feet, a bankfull width of 16 feet, and a bankfull average depth of 1.5 feet. Measurements of bankfull characteristics on-site compared favorably with a bankfull discharge of 40 cfs, a bankfull cross-sectional area of 14 square feet, a bankfull width of 17 feet, and a bankfull average depth of 0.81 feet. Typically cross-sectional area will have the best correlation with the values from the regional curves since it is an integration of width and depth (Dave Rosgen, personal communication). Typically average depth will be the least comparable to the data from reference data. The reference reach dimensions are also believed to be slightly less than those of the on-site reach because of agrarian and suburban land uses.

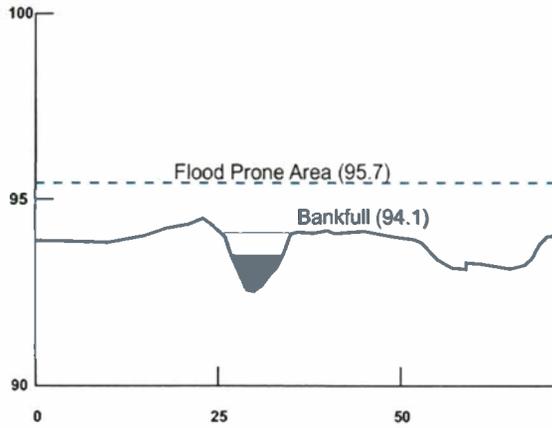
A complete Level II morphological description was performed on the reference reach. The morphological assessment included cross-sections, longitudinal profile, plan form geometry analysis, and channel material inventory. A summary of these findings and illustration of the channel's typical riffle cross-section are illustrated in Figure 6. The reach was classified as a C6 stream, characterized by a very high width/depth ratio (21) and channel substrates including sand, silt, and clay. Bank materials were identical to channel materials. Hunters Creek had a broad floodplain (entrenchment ratio of 16.4), a relatively low water surface slope (0.002 feet/foot), and a moderate sinuosity (1.2 to 1.8).

The characteristics of Hunters Creek were used as a basis to derive channel cross-sections, slope, and geometry for the restoration of Billy's Branch pursuant to the procedures described in *Applied River Morphology* (Rosgen 1996). This procedure was further simplified since the watershed size of Billy's Branch on-site is virtually identical to this reference reach (0.8 and 0.7 square miles, respectively).

Figure 6

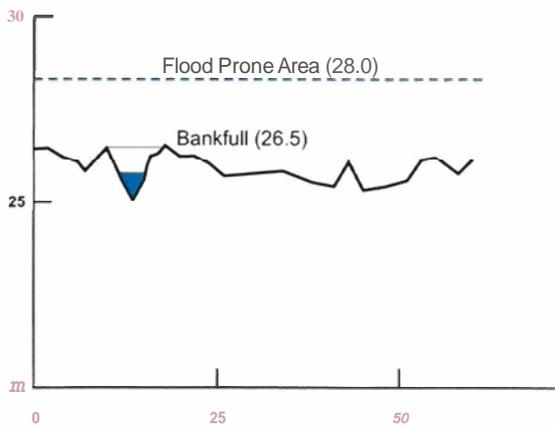
Clayhill Farms Wetland & Stream Mitigation Plan Report

Reference Reach Characteristics



Unnamed Tributary to Hunter's Creek

Stream Characteristics	
Stream Type:	C6
Bankfull Width (Wbkf):	17'
Mean Depth:	0.8'
Area (Abkf):	14 s.f.
WID Ratio:	21.3'
Maximum Depth:	2.0'
Width Floodplain:	279'
Entrenchment Ratio:	16.4'
Channel Material(D50):	<0.062mm
Water Surface Slope:	0.002 ft/ft
Channel Sinuosity:	1.2 -1.8
Meander Length:	107-140' (6-8 Wbkf)
Radius of Curve:	23-34'
Belt Width:	40'
Meander Width Ratio:	2.4
Critical Shear Stress:	0.09 lb/s.f.
Extrains:	6mm particle



Tributary of Billy's Branch

Stream Characteristics	
Stream Type:	C6
Bankfull Width (Wbkf)	8'
Mean Depth	0.75'
Area (Abkf)	6 s.f.
WID Ratio:	11.0
Maximum Depth	1.5'
Width Floodplain	>60'
Entrenchment Ratio	>7.5
Channel Material(D50)	0.62-0.125mm
Water Surface Slope	0.006 ft/ft
Channel Sinuosity	1.04



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SCALE H 1"=25'
V 1"=5'



Secondary Reference Reach

A relatively undisturbed, unnamed tributary to Billy's Branch was identified within the Site. A less complete Level II Assessment was performed on this tributary. The assessed reference reach is located upstream of the head-cut induced by the channelization (i.e., downcutting) of Billy's Branch. The purpose of the abbreviated Level II Assessment was to classify the stream and determine whether it was also a C Type stream. The stream was determined to be a C6 stream as was the primary reference reach (Figure 6). This corroboration of findings further strengthened the conclusion that Billy's Branch was most likely a C6 stream prior to channelization.

4.5.4 Morphological Analysis of Billy's Branch

Billy's Branch and the primary reference reach are located in Valley Type X (Rosgen 1996). Valley Type X is very wide with gentle slopes and extensive flood plains. This valley type includes coastal plains and broad lacustrine (lake) flats, both of which often contain peat bogs and/or extensive wetlands.

The length of Billy's Branch was divided into a total of seven nodes, six on-site and a seventh immediately downstream and off-site. This was done to develop data specific to various reaches of the stream, its watershed, and valley slope (Figure 7). Node points were also intentionally located immediately up stream and downstream of the large meander at the center of the site (nodes 3 and 4). This meander is believed to be a natural response to the valley's characteristics because it was illustrated on the USGS 7.5 minute quadrangle maps (Stella 1988, Hadnot Creek 1984), prior to the Site's conversion to agricultural use. Morphological measurements for nodes 1 through 6 are included in Appendix E.

The slope of the valley varies noticeably from the western half of the site to the eastern half. The slope between nodes 1 and 3 is virtually flat. The slope between node 1 and 2 is zero, with a slope between node 2 and 3 of 0.0009 ft/ft. The slope between node 3, at the top of the large meander, and node 6, at the confluence with the small tributary, is 0.004 ft/ft. It is steepest in the segment immediately below the large meander between nodes 4 and 5 (0.009 ft/ft). The valley is also flat between node 6 (on-site) and node 7 off-site.

As mentioned earlier, Billy's Branch was deepened and straightened in the mid 1970s to facilitate farming. The excavation of the stream also lowered the water table to facilitate the cultivation of commodity crops (see Section 4.4).

Three cross-sections were taken along Billy's Branch to perform a Level II Assessment. These locations roughly correlate with the locations of nodes 4, 5, and 6 (Figure 8). All three of the cross-sections are similar and describe a G6_c stream type (gully). Billy's Branch is narrow (width/depth ratio of five to six) and deep with a low sinuosity (K=1). This stream has been deepened (incised) to such an extent that its entrenchment ratio is very low (typically 1.4). Plotting the floodprone elevation indicated that these Billy's Branch no longer inundates the historic floodplain, relegating these areas as a terrace (abandoned floodplain). This was confirmed from the results of the HEC-2 model. Model results for the existing conditions indicated that the two-year flood is contained within the stream channel (does not exceed the elevations of the top of bank). The results of the HEC-2 model are described in further detail in Section 4.5.5.

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Figure 7 Drainage Areas, Nodes & Proposed Channel Characteristics

Legend

-  Property Boundary
-  Centerline of Stream
-  Manmade Ditch
-  Road
-  Culvert
-  Pine Dominated Forest
-  Recently Clearcut Forest
-  Hardwood Dominated Forest
- D1** Feeder Ditches



NORTH

1"=500'

0 500 1000

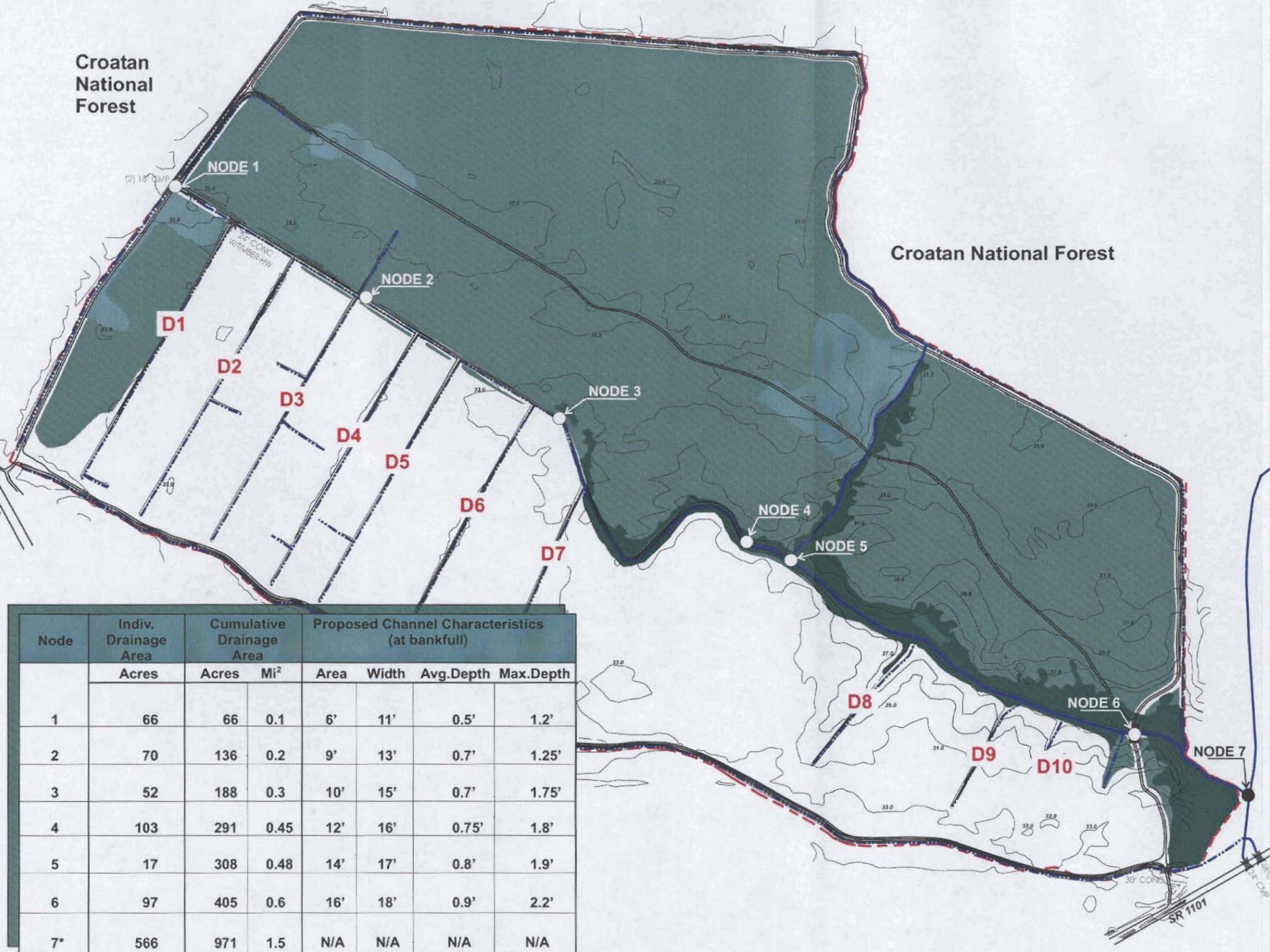


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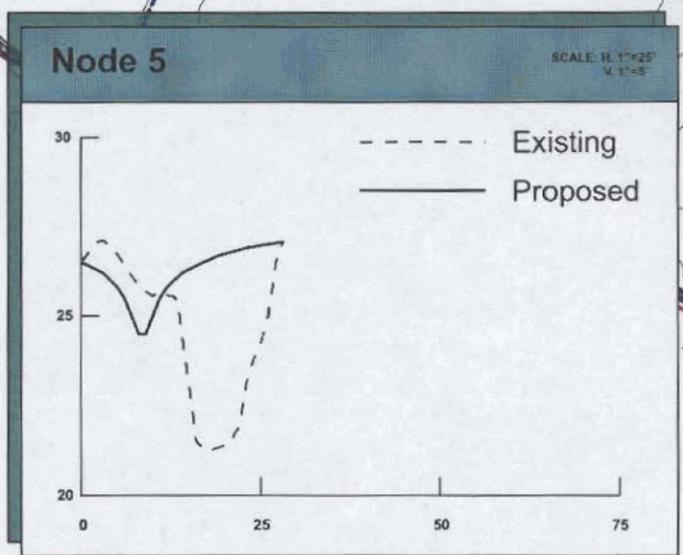
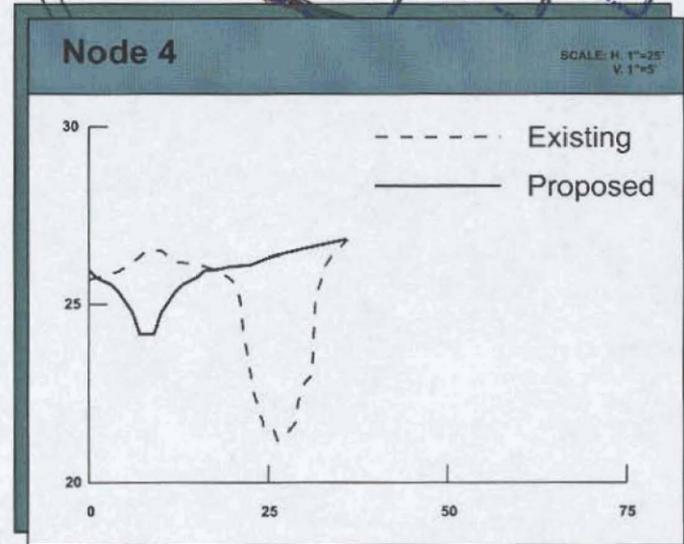
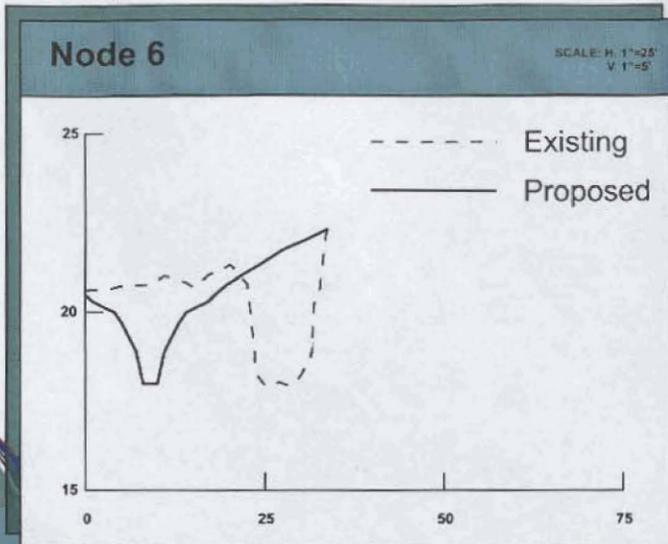
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Node	Indiv. Drainage Area		Cumulative Drainage Area		Proposed Channel Characteristics (at bankfull)			
	Acres	Acres	Mi ²	Area	Width	Avg.Depth	Max.Depth	
1	66	66	0.1	6'	11'	0.5'	1.2'	
2	70	136	0.2	9'	13'	0.7'	1.25'	
3	52	188	0.3	10'	15'	0.7'	1.75'	
4	103	291	0.45	12'	16'	0.75'	1.8'	
5	17	308	0.48	14'	17'	0.8'	1.9'	
6	97	405	0.6	16'	18'	0.9'	2.2'	
7*	566	971	1.5	N/A	N/A	N/A	N/A	

* Node 7 is off-site on private property, but was included as a contributing watershed to culverts beneath SR1101

Croatan National Forest

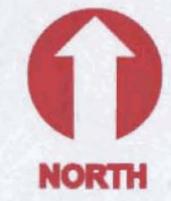


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**Figure 8
Existing & Proposed
Cross Sections**

Legend

- Property Boundary
- Centerline of Stream
- Manmade Ditch
- Road
- ✦ Culvert
- Pine Dominated Forest
- Recently Clearcut Forest
- Hardwood Dominated Forest



1"=500'



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4.5.5 Hydrology and Hydraulics of Billy's Branch and Feeder Ditches

A hydrologic and hydraulic analysis of the proposed wetland and stream mitigation and the adjacent drainage areas was performed to estimate the amount of surface water anticipated on-site during various rainfall events.

Soil Conservation Service TR-55 Method

Soil Conservation Service (SCS) TR-55 methodologies were employed for the hydrologic analysis to estimate the volume of runoff for select rainfall events, and to calculate runoff hydrographs. The design rainfalls of interest include the two-year and ten-year rainfall events of 24-hour duration. The 24-hour rainfall depths used for Jones County, North Carolina are 4.5 inches for the two-year rainfall and 6.72 inches for the ten-year rainfall.

The SCS methodology utilizes the time of concentration and the curve number methods to estimate the volume of runoff anticipated during a rainfall event. The time of concentration for each drainage area was estimated by using the kinematic wave formula for overland flow and estimating the velocity for concentrated flows. Curve numbers were estimated based upon soil types and land use. According to the Soil Survey of the watershed, the majority of the soils within the watershed are Onslow, Torhunta and Pantego. All of these loamy soils are classified as hydrologic soil group (HSG) "D" which indicates soils having very slow infiltration rate when thoroughly wet, and soils that have a permanent high water table.

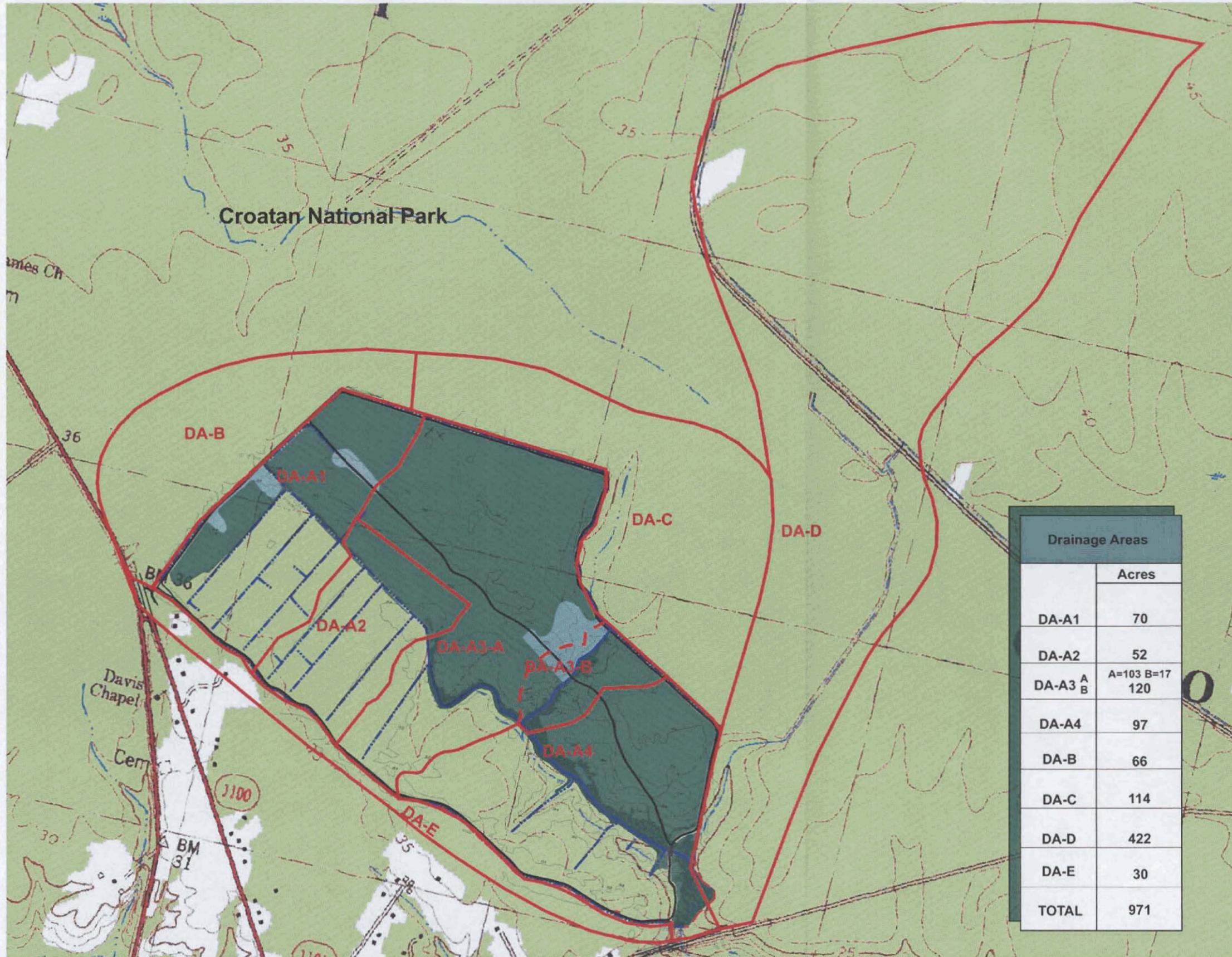
The 971 acre watershed consists mainly of forest and crop land (crop land on-site only). Based upon this land use and the underlying soil conditions, a curve number of 77 was utilized to estimate runoff from the different drainage areas.

The Rational Method

The Rational Method was used for the smaller drainage areas to estimate the volume of runoff anticipated during a rainfall event. The Rational Method utilizes the rainfall intensity, the runoff coefficient and the size of the drainage area to calculate the peak runoff ($Q = CIA$). The rainfall intensity was based on the intensity-duration-frequency tables for Jones County, North Carolina. The runoff coefficient was based upon the type of land use which was predominantly agricultural land for the small drainage areas of the feeder ditches.

The entire watershed drains through a 24-inch and a 48-inch corrugated metal pipe (CMP) that pass under State Road (SR) 1101. A culvert analysis was utilized to estimate the volume of runoff that can pass through these two downstream culverts. These culverts were modeled based upon a no downstream tailwater condition.

The entire 971 acre watershed consists mainly of five drainage areas that are separated by several ditch systems identified as DA (drainage areas) A, B, C, D and E (Figure 9). The drainage area within the Site (DA-A) is approximately 340 acres in size. This drainage area is surrounded on all four sides by drainage ditches. This surrounding ditch system drains south eastward along the north and south of the drainage area and outfalls through the two culverts located under SR 1101. The exterior ditch system establishes the size of the main drainage area, but a network of feeder ditches drains the farm fields to



Clayhill Farms Wetland & Stream Mitigation Plan Report

Figure 9 Drainage Areas of Billy's Branch

Legend

- - - Property Boundary
- Centerline of Stream
- - - Manmade Ditch
- Road
- Culvert
- Pine Dominated Forest
- Recently Clearcut Forest
- Hardwood Dominated Forest

Drainage Areas	
	Acres
DA-A1	70
DA-A2	52
DA-A3 ^A _B	A=103 B=17 120
DA-A4	97
DA-B	66
DA-C	114
DA-D	422
DA-E	30
TOTAL	971



NORTH
1"=1000'
Approximate



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Billy's Branch which acts as a collector ditch. Billy's Branch drains southeastward to the two culverts under SR 1101. The remaining four drainage areas are located around all four sides of the Site.

Drainage area "B" is approximately 66 acres in size and is located to the west of the Site. This drainage area drains through Billy's Branch to reach the two outfall culverts.

Drainage area "C" is approximately 114 acres and is located immediately north of the Site property. This area drains southward through the perimeter ditch and into Billy's Branch within the Site immediately downstream of node 6.

Drainage area "D" is approximately 422 acres and located northeast of drainage area "C". This drainage area drains southeastward through a tributary east of the Site. It discharges to Billy's Branch downstream of the Site (off-site) at node 7.

Drainage area "E" is approximately 30 acres and borders the Site to the south. This drainage area drains southeastward through the ditch located along the southern border of the Site and joins with Billy's Branch downstream of the subject property.

Water Surface Profile for Billy's Branch

In order to model the surface water profile of Billy's Branch, the peak flow rates for each individual drainage area had to be calculated along with the total peak flow rate from the watershed. The SCS methodology was used to estimate the peak flow rates for both the two-year and ten-year rainfall event and to estimate the time of concentration for the individual drainage areas. The peak time of concentration of 3.5 hours from drainage area "D" was then used to estimate the peak flow rate for the watershed. The SCS method has a time of concentration (T_c) limit of two hours. In order to represent the hydrograph for the 3.5 hour time of concentration, a modified hydrograph was produced based on the ratio of the peak runoff rates from the T_c of 2.0 hours and the T_c of 3.5 hours. The peak runoff rate of 323 cfs was used for the two-year rainfall event and 614 cfs was used for the ten-year rainfall event. Table 2 below shows the time of concentration and the peak runoff rates for each individual drainage area.

Table 2. Peak flow rates of each drainage area.

Drainage Area	Size of Drainage Area (acres)	Time of Concentration (hours)	Peak Runoff 2-Year Storm (cfs)	Peak Runoff 10-Year Storm (cfs)
A-1	70	1.87	35	67
A-2	52	2.14	57	110
A-3	120	2.38	105	201
A-4	97	2.64	138	264
B	66	1.54	38	73
C	114	1.79	59	113
D	422	3.56	142	270
E	30	2.11	14	27
Peak Runoff Rate Criteria	971	3.56	323	614

The two downstream outfall culverts (24-inch CMP and 48-inch CMP) were analyzed to see if they could convey the peak flow rates from the watershed's two-year and ten-year rainfall events. The culvert analysis showed that the peak flow rates will exceed the capacity of the combined two culverts and the stormwater runoff ponds behind the two existing outfall culverts.

The existing culvert condition was therefore modeled as a pond with the two culverts acting as the controlling outfall structures. The top elevation of SR 1101 at the location of the culverts was used as the maximum pond elevation. The model of the pond routing estimated a storage elevation of 22.7 feet for the two-year rainfall event. The estimate for the ten-year rainfall event was a storage elevation that exceeds the elevation of SR 1101.

A telephone conversation with the Regional North Carolina Maintenance Division and the Regional Highway Maintenance Engineer revealed that the Maintenance Division has not received a complaint of stormwater runoff overtopping SR 1101 at the location of these two culverts. Furthermore, the Maintenance Division has not had to perform any repairs at this location for as far back as the Maintenance Division representatives could remember.

Based on the information provided by the Regional Maintenance Division and the Regional Highway Maintenance Engineer, it was decided that the estimated peak flow rates for the ten-year rainfall event were too conservative. The estimated peak flow rates for the two-year rainfall event were therefore believed to be more realistic. The road elevation of SR 1101 is approximately 24.0 feet to 24.5 feet which is approximately 1.3 to 1.8 feet higher than the estimated two-year peak storage elevation 22.7 feet.

HEC-2 Analysis

The surface water profile of Billy's Branch was modeled using the HEC-2 program to analyze the existing and proposed peak flow depths within Billy's Branch and the amount of flooding outside of Billy's Branch as a consequence of modifying the ditch and longitudinal profiles. The model is based on several cross sections (nodes) located along Billy's Branch and the correlating peak stormwater runoff rates at those sections (Figure 9). The HEC-2 calculations and output is provided in Appendix F. As a means of being conservative, the peak runoff rate for each cross section (node) is based on the time of concentration for each smaller drainage area. The peak storage elevation of 22.7 feet (estimated from the pond routing model) was used to establish the tailwater elevation at the downstream end of Billy's Branch. Table 3 shows the estimated water surface elevations at the modeled cross sections (node) and their corresponding top of bank.

Table 3. Existing surface water profile of Billy's Branch.

Node #	Peak Stormwater Runoff (cfs)	Water Surface Elevation (ft)
7	323	22.70
6	176	22.69
5	148	24.57
4	143	24.49
3	95	31.81
2	73	32.71
1	38	32.94

4.6 Plant Communities

Approximately 213.8 acres of Clayhill Farms are presently forested, 11.7 acres have been recently clearcut, and 141.8 acres are fallow agricultural fields. As mentioned earlier, the Site was ditched and subsequently logged in the 1970s. Fire has been excluded from the property for at least the last 30 years, and was farmed continuously until 1998. The result of these manipulations has been that natural communities presently occur on only small, fragmented patches of the property. A list of all plant species identified during field investigations at the Site is included in Appendix G.

4.6.1 Pine Dominated Communities

Approximately 193.8 acres of the Site is 25 to 30 year old pine regeneration (Figure 2). Approximately 44.1 acres of this community (primarily in that area south of the dirt road bisecting the forest and west of the tributary to Billy's Branch) has been thinned in the past five years. The thinned area contains an overstory of loblolly pine and pond pine in the six-inch diameter class. The un-thinned area contains primarily loblolly pine in the four-inch diameter class.

Common understory trees include sweetgum (*Liquidambar styraciflua*), swamp blackgum (*Nyssa sylvatica* var. *biflora*), titi (*Cyrilla racemiflora*), sweet bay (*Magnolia virginiana*), red bay (*Persea borbonia*), laurel oak (*Quercus laurifolia*), and red maple (*Acer rubrum*). Post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) are present on the drier portions of the Site. The shrub layer is tall and dense, consisting primarily of inkberry (*Ilex glabra*). The herbaceous layer is sparse except along openings and in the ecotones between the pine and hardwood communities. Herbaceous species include mainly Virginia chain fern (*Woodwardia virginica*), bracken fern (*Pteridium aquilinum*), cinnamon fern (*Osmunda cinnamomea*), and dwarf huckleberry (*Gaylussacia dumosa*). A well developed vine layer exists, especially in the wetter portions of the site, and is comprised mainly of greenbriers (*Smilax laurifolia*, *S. rotundifolia*, and *S. bona-nox*) and yellow jessamine (*Gelsemium sempervirens*).

4.6.2 Hardwood Dominated Communities

About 19.0 acres of the property is hardwood dominated forest (Figure 2). Approximately 15.9 acres of this is mixed mesic hardwood forest with a variety of oaks (including water oak (*Quercus nigra*), laurel oak, post oak, blackjack oak, swamp chestnut oak (*Quercus michauxii*), and southern red oak (*Quercus falcata* var. *falcata*)), yellow-poplar (*Liriodendron tulipifera*), sweetgum, red maple and scattered loblolly pine in the overstory. American holly (*Ilex opaca*) is prevalent in the understory. This community occurs at the southeastern corner of the forested area, primarily on Marvyn soil.

The remaining 4.1 acres of hardwood forest is coastal plain bottomland hardwood forest. This forest type is primarily on Onslow and Muckalee soils and is adjacent to Billy's Branch and its tributaries. Due to the channelization of Billy's Branch, portions of this community (1.8 acres) have been drained and are no longer functioning as a floodplain, but rather a terrace. Approximately 2.3 acres of this community exists in its natural state. The 1.8 acres of drained bottomland hardwood forest adjacent to Billy's Branch still meet, marginally, the hydrology requirements of jurisdictional wetlands.

Common overstory trees in the bottomland hardwood forest include swamp blackgum, yellow-poplar, water oak, red maple, sweetgum, and scattered loblolly pine. This community has a fairly open

understory with a dense herbaceous layer including cinnamon fern, royal fern (*Osmunda regalis*), and netted chain fern (*Woodwardia areolata*).

4.6.3 Recent Clearcuts and Open Areas

Vegetation growth in both the fallow fields and the clearcuts is less than one year old and is typical of early successional communities in the coastal plain of North Carolina. The fields are dominated by field garlic (*Allium vineale*) and wild onion (*Allium canadense*), with toad-flax (*Linaria canadensis*), goldenrods (*Solidago* spp.), dog fennel (*Eupatorium capillifolium*), and ragweed (*Ambrosia artemisiifolia*) beginning to appear. The clearcuts are more diverse, with the seeds and rhizomes of many species having lain dormant in the litter layer until presented with the increased light intensities created by the clearcuts. Species here include those in the fallow fields, as well as pink sundew (*Drosera capillaris*), bladderwort (*Utricularia* sp.), dwarf azalea (*Rhododendron atlanticum*), orange milkwort (*Polygala lutea*), greenbriers, and Japanese honeysuckle (*Lonicera japonica*). The coppice (regeneration) of hardwood stumps also plays a major role in the clearcut areas.

4.6.4 Protected Species and Ecologically Significant Communities

While no specific protected species surveys were performed at the Site, no protected plant species were observed during the extensive fieldwork performed there. A letter received from the N. C. Natural Heritage Program November 19, 1997 stated that a recorded population of the State Endangered/Federal Species of Concern Carolina goldenrod (*Solidago pulchra*) occurs approximately 1.0 miles northwest of the property (L&M 1998). No plant species requiring Section 7 consultation are listed for Jones County.

The North Carolina Natural Heritage Program (NHP) maintains a list of natural communities they feel have ecological significance due to their rarity or pristineness. The Site is contiguous to the Registered Significant Natural Heritage Area (SNHA), the Croatan National Forest Megasite and lies approximately 1.0 miles northeast (upstream) of the Registered SNHA, the Hunters Creek Upland Forest. The latter contains four high quality natural areas: Dry Mesic Oak/Hickory Forest, Mixed Mesic Hardwood Forest, Cypress-Gum Swamp, and Coastal Plain Small Stream Swamp (Schafale and Weakley 1990).

4.7 Wetlands

The location of all jurisdictional wetland boundaries at the Site were flagged in the field during March and May 1999. All delineations were based on the *Corps of Engineers Wetland Delineation Manual* (EL 1987). Mr. Mike Bell, of the Wilmington District of the USACE, visited the Site in late March 1999 to review the wetland delineation in progress. A field map showing the approximate location of the flagged lines has been forward to Mr. Bell for review. Mr. Bell has indicated no concerns regarding the jurisdictional boundary delineation.

The NCDOT Division 2 Location and Surveys Unit (under the direction of Mr. Terry Wheeler, P.E., R.L.S.) located the flagged lines using GPS in May 1999 (Figure 10). Based upon this survey, 155.9 acres of the Site are presently jurisdictional wetlands. A survey exhibit was be forwarded to Mr. Bell for his signature in early July 1999.

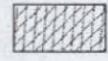
Croatan National Forest

Croatan National Forest

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Figure 10 Wetland Delineation Map

Legend

-  Property Boundary
-  Centerline of Stream
-  Manmade Ditch
-  Road
-  Culvert
-  Forested Area
-  Recently Clearcut Area
-  Groundwater Monitoring Well
-  DRAINMOD Well
-  Jurisdictional Wetlands
-  Uplands



NORTH

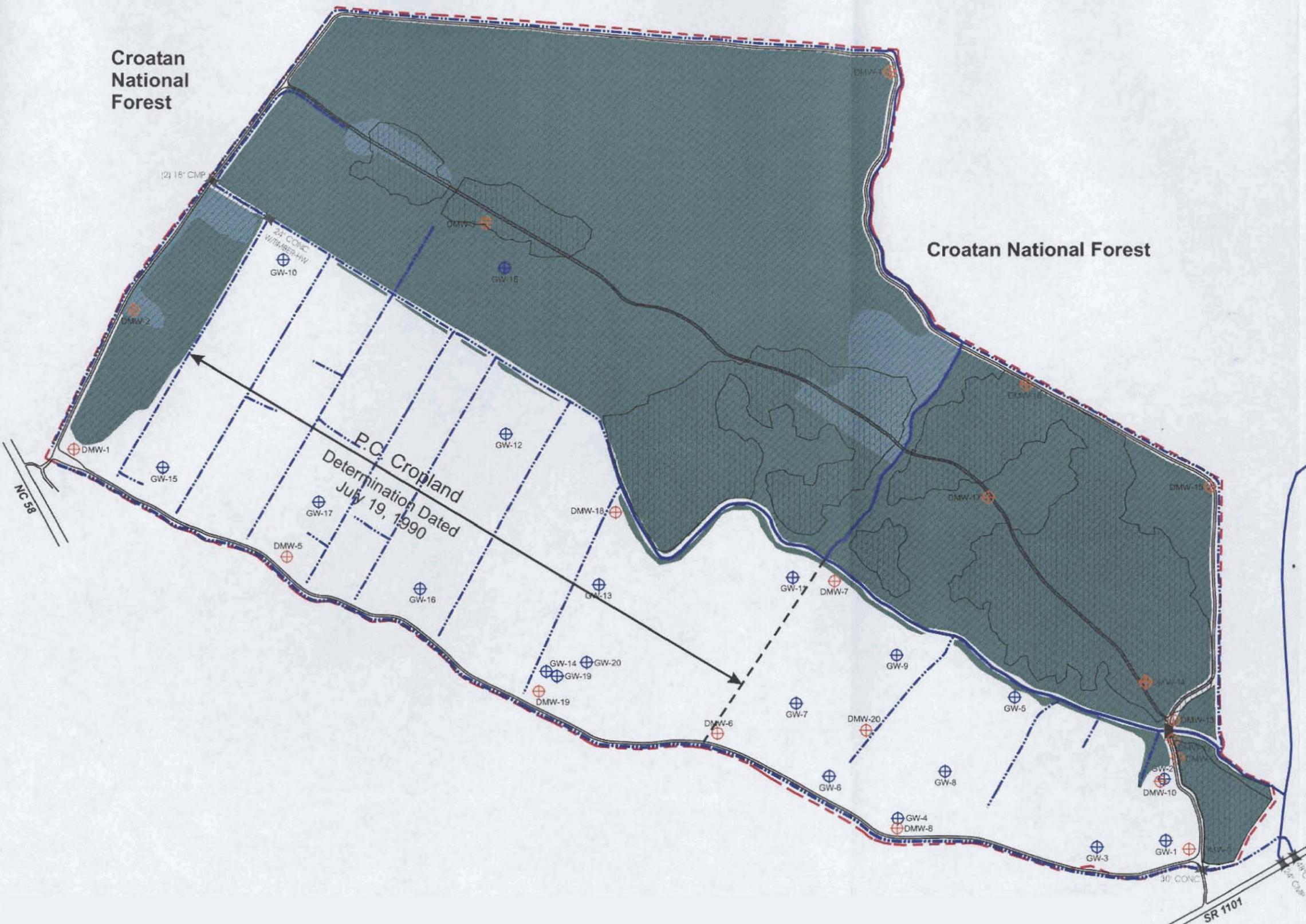
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4.8 Wildlife

4.8.1 Commonly Observed Species

The Site provides wildlife habitat typical of coastal plain pine flatwoods and mixed hardwood stands. White-tailed deer (*Odocoileus virginianus*) and black bears (*Ursus americanus*) are commonly observed, as well as many small mammals such as raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), gray foxes (*Urocyon cinereoargenteus*), red foxes (*Vulpes vulpes*), gray squirrels (*Sciurus carolinensis*), and eastern cottontails (*Sylvilagus floridanus*). There is no doubt that a number of songbirds, woodpeckers, owls and raptors also frequent the Site. A list of all wildlife species identified at the Site during field investigations (from visual observation or evidence of the animals) is included in Appendix G.

4.8.2 Protected Species

No specific protected species surveys have been performed at the Site to date. However, no protected animal species were observed during the extensive fieldwork performed there. A review of NHP records in June 1999 revealed a recorded occurrence of the State Significantly Rare/Federal Species of Concern Croatan crayfish (*Procambarus plumimanus*) at the southeastern corner of the property in 1975. Although not afforded protection under the Endangered Species Act, Federal Species of Concern are rare species which could be listed at any time.

The species description and biological conclusion of "No Effect" is included here for the only animal species requiring Section 7 consultation which is listed for Jones County, the red-cockaded woodpecker.

Picoides borealis (red-cockaded woodpecker) E

Family: Picidae

Federally Listed: October 13, 1970

Distribution in N.C.: The sandhills and southern coastal plain; scattered populations also live in the northern coastal plain and the extreme eastern Piedmont.

Species Account: "The red-cockaded woodpecker (RCW) is 18 to 20 centimeters long with a wing span of 35 to 38 centimeters. There are black and white horizontal stripes on its back, and its cheeks and underparts are white. Its flanks are black streaked. The cap and stripe on the side of the neck and the throat are black. The male has a small red spot on each side of the black cap. After the first post fledgling molt, fledgling males have a red crown patch. This woodpecker's diet is composed mainly of insects which include ants, beetles, wood-boring insects, caterpillars, and corn ear worms if available. About 16 to 18 percent of the diet includes seasonal wild fruit."

"Egg laying occurs during April, May, and June with the female utilizing her mate's roosting cavity for a nest. Maximum clutch size is seven eggs with the average being three to five eggs. From egg laying to fledging requires about 38 days, and then another several weeks are needed before the young become completely independent. Most often, the parent birds and some of their male offspring from previous years form a family unit called a group. A group may include one breeding pair and as many as seven other birds. Commonly, these groups are comprised of three to five birds.

Rearing the young birds becomes a shared responsibility of the group. However, a single pair can breed successfully without the benefit of the helpers” (USFWS).

Habitat: “Open stands of pines with a minimum age of 80 to 120 years, depending on the site, provide suitable nesting habitat. Longleaf pines (*Pinus palustris*) are most commonly used, but other species of southern pine are also acceptable. Dense stands (stands that are primarily hardwoods, or that have a dense hardwood understory) are avoided. Foraging habitat is provided in pine and pine hardwood stands 30 years old or older with foraging preference for pine trees 10 inches or larger in diameter. In good, well-stocked, pine habitat, sufficient foraging substrate can be provided on 80 to 125 acres.”

“Roosting cavities are excavated in living pines, and usually in those which are infected with a fungus producing what is known as red-heart disease. The cavity tree ages range from 63 to 300 plus years for longleaf, and 62 to 200 plus years for loblolly and other pines. The aggregate of cavity trees is called a cluster and may include 1 to 20 or more cavity trees on 3 to 60 acres. The average cluster is about 10 acres. Completed cavities in active use have numerous, small resin wells which exude sap. The birds keep the sap flowing apparently as a cavity defense mechanism against rat snakes and possibly other predators. The territory for a group averages about 200 acres, but observers have reported territories running from a low of around 60 acres, to an upper extreme of more than 600 acres. The expanse of territories is related to both habitat suitability and population density” (USFWS).

Biological Conclusion: No Effect

A letter received from the N. C. Natural Heritage Program (NHP) November 19, 1997, stated that a cavity tree was recorded on the southeastern corner of the property in 1975 and that two active colonies were observed on Forest Service Road 144 within one mile of the site in 1992 (L&M 1998). However, a review of NHP records in June 1999 revealed that the recorded occurrence of a cavity tree on the property was incorrect (the record was for the Croatan crayfish (*Procambarus plumimanus*) not the red-cockaded woodpecker).

A RCW assessment was prepared for the Site in August 2000 by Dr. J. H. Carter, III & Associates and is included as Appendix H. The result of this assessment was as follows:

“No suitable nesting habitat for RCWs was found on the Clayhill Farms property, and, although suitable habitat exists within 0.5 miles of the Clayhill Farms property, no evidence of recent RCW activity was found. The two RCW cavity trees within the 0.5-mile radius have been inactive since 1988 and are therefore considered to be abandoned. Since Clayhill Farms property is more than 0.5 miles away from active RCW clusters and the clusters within a 0.5-mile radius have been in-active for over five years, mitigation activities at Clayhill Farms will have no effect on the RCW.”

It is anticipated that due to the perpetual conservation easement that will be placed on the property, foraging and nesting habitat for the RCW will be created at the Site over coming decades. The forest management plan included as Appendix I addresses this issue further.

5.0 PROPOSED CONDITIONS

The following sections detail the proposed methods for restoring and preserving the natural communities at the Site. Conceptual plans are included to further depict the proposed conditions at the Site.

5.1 Hydrology Modifications

5.1.1 DRAINMOD Results

Site conditions at all ditches were simulated for existing and proposed conditions using DRAINMOD (as described in Section 4.3.3). “Wet years” are years in which the groundwater table remains *within 12 inches* of the ground surface for greater than 31 consecutive days (12.5 percent of the growing season). “Ponded years” are years in which the groundwater table remains *above* the ground surface for greater than 31 consecutive days. To be conservative, the 12.5 percent hydrology criterion was chosen instead of the five percent criterion.

All proposed conditions assume that Billy’s Branch would be filled to the present top of bank and that each ditch would be blocked to grade at their downstream confluence with Billy’s Branch. Table 4 lists the number of years (out of 40) for which the present fields would meet the 12.5 percent wetland criteria. A field was considered to possess wetland hydrology (and therefore no longer be effectively drained) if 50 percent (20 out of 40) or more of the years modeled were “wet years”. Figure 11 depicts those areas which would remain effectively drained after restoration. As indicated by the model, only field M-1 was effectively drained both before and after restoration (Figures 5 and 11).

The results of DRAINMOD indicate that under existing conditions many of the fields pond for durations exceeding the 12.5 percent wetland hydrology criterion in a majority of the 40-year modeling period. This finding conflicts with the comments of the previous owner who stated that the fields never had a flooding problem (long duration of inundation impairing crop yields). Unfortunately, the absence of a near surface groundwater table during the early growing season during the site analyses precluded a comparison of groundwater observations and model results.

To standardize DRAINMOD results, absolute values for post-restoration were not considered to be precise but were instead compared in relative terms to the pre-restoration results. For example, the number of years that the fields of Marvyn soil were saturated/ponded under post-restoration conditions did not increase substantially over pre-restoration conditions (an increase of only seven and four years respectfully). Conversely, the response of the Onslow fields was much more substantial) an average of 11 and 12 year increases in saturation and ponding respectively). The increases for Torhunta and Pantego fields were also quite substantial.

Due to the topography of the Site in the vicinity of Billy’s Branch, DRAINMOD models Billy’s Branch to be six feet deep even if it is completely filled. As such, areas around Billy’s Branch are considered effectively drained by the model in post-restoration. However, Billy’s Branch will not effectively drain any areas after the Priority 1 restoration but is anticipated to raise the water table of adjacent areas and restore the former floodplain as discussed in Sections 5.1.2 to 5.1.5 below.

Croatan National Forest

Croatan National Forest

Clayhill Farms Wetland & Stream Mitigation Plan Report

Figure 11 DRAINMOD Proposed Conditions

Legend

- - - Property Boundary
- Centerline of Stream
- · - · - Manmade Ditch
- Road
- ⬠ Culvert
- ⊕ DRAINMOD Well
- Effectively Drained Areas (per DRAINMOD)
- Forested Area



1"=500'



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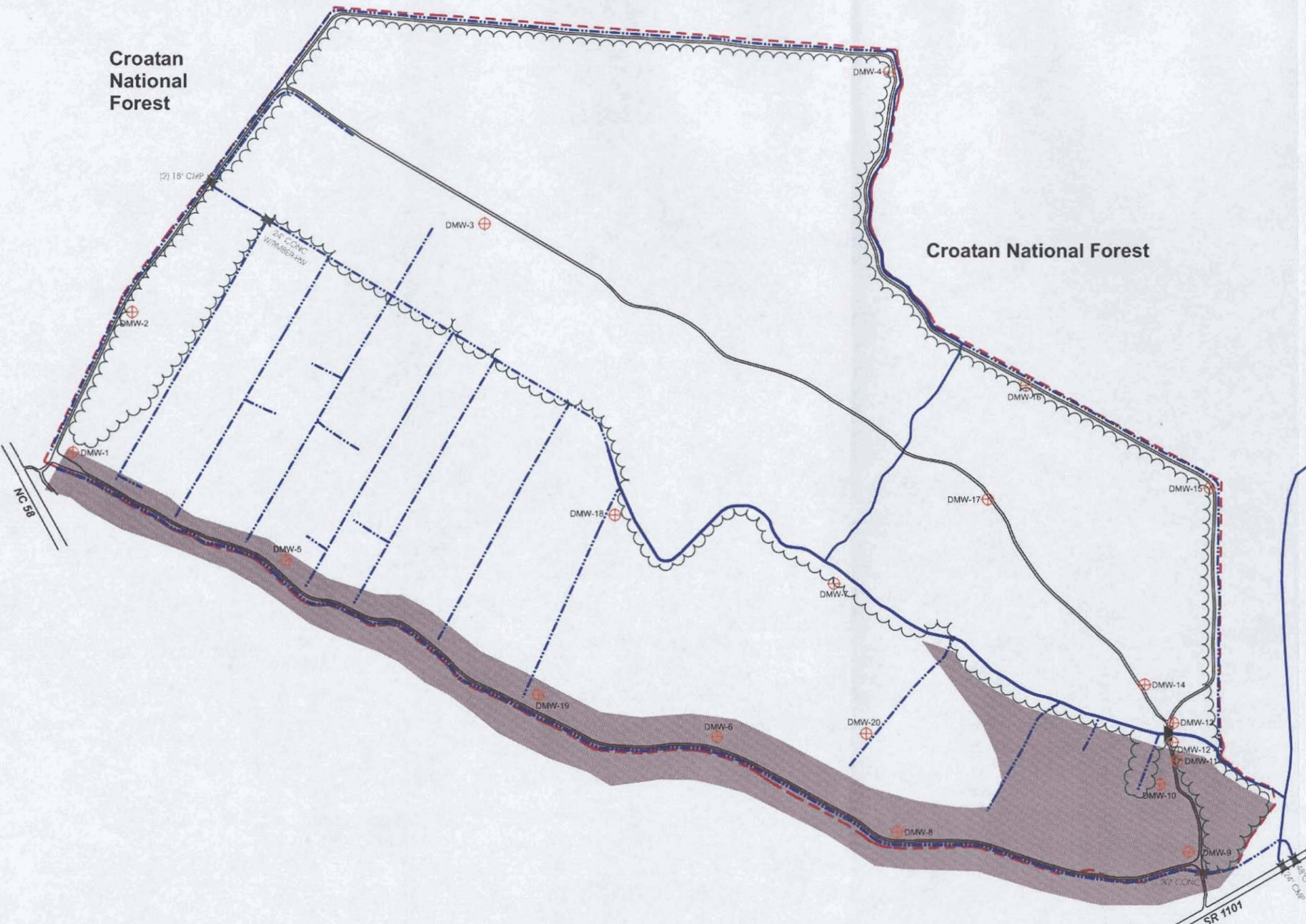


Table 4. Pre- and post-restoration DRAINMOD field simulations for the 40-year modeling period.

Soil Type	Field #	Pre-Restoration		Post-Restoration	
		Wet Years	Ponded Years	Wet Years	Ponded Years
Marvyn	M-1	7	2	14	6
	M-1 & 2*	14	6	28	12
Onslow	O-1	32	26	38	38
	O-2	20	15	33	30
	O-3	7	6	22	16
Torhunta	T-1N	29	20	40	39
	T-1S	33	33	40	38
	T-2N	29	20	40	39
	T-2S	33	33	40	38
	T-3N	29	20	40	39
	T-3S	33	33	40	38
	T-4N	25	13	40	39
	T-4S	29	23	40	36
	T-5N	33	27	39	39
	T-5S	33	33	40	39
	T-6	33	33	40	39
T-7	28	19	40	37	
Pantego	P-1N	33	30	40	40
	P-1S	36	34	40	40

*As shown on Figure 5, M-1 is the northern portion of the easternmost field and M-2 is the southern portion of that field. They were analyzed separately because ditch 11 does not extend into the southern portion of the field.

5.1.2 Proposed Cross-Sections and Geometry of Billy's Branch

The procedures used to develop the proposed restoration of Billy's Branch follow those developed by Dave Rosgen and presented in his course entitled "*Fluvial Geomorphology for Engineers*" and the paper entitled *A Geomorphological Approach to Restoration of Incised Rivers* (Rosgen 1997). Billy's Branch will be restored from a G6c to a C6 stream type. Both the primary reference reach (off-site) and the secondary reference reach (on-site) were C6 streams.

The proposed cross-sectional area of Billy's Branch for each node was derived by relating the area of the contributing watershed to the regional curve for drainage area versus stream cross-sectional area. Widths and average depths were derived for each node point using the width depth ratio calculated for the riffle section at the reference reach. These results and proposed maximum depths are tabulated on Figure 7.

Proposed stream geometry (meander length, radius of curvature, belt width) was then derived for each node of Billy's Branch. This was done by developing ratios from data derived from the reference reach. Each criterion mentioned above was calculated as a ratio of the width of the bankfull cross-section. These ratios were then multiplied by the bankfull width from each node of Billy's Branch to derive the geometry required at each node. An example of these findings is provided on Figure 12.

**Clayhill Farms
Wetland & Stream Mitigation
Plan Report**
**Figure 12
Existing & Proposed
Stream Plan View & Detail**

Legend

- Property Boundary
- Centerline of Stream
- Manmade Ditch
- Road
- Culvert
- Pine Dominated Forest
- Recently Clearcut Forest
- Hardwood Dominated Forest
- Floodplain Area
- New Stream
- Ditch Block/Fills
- Oxbow Lakes
- Borrow Area



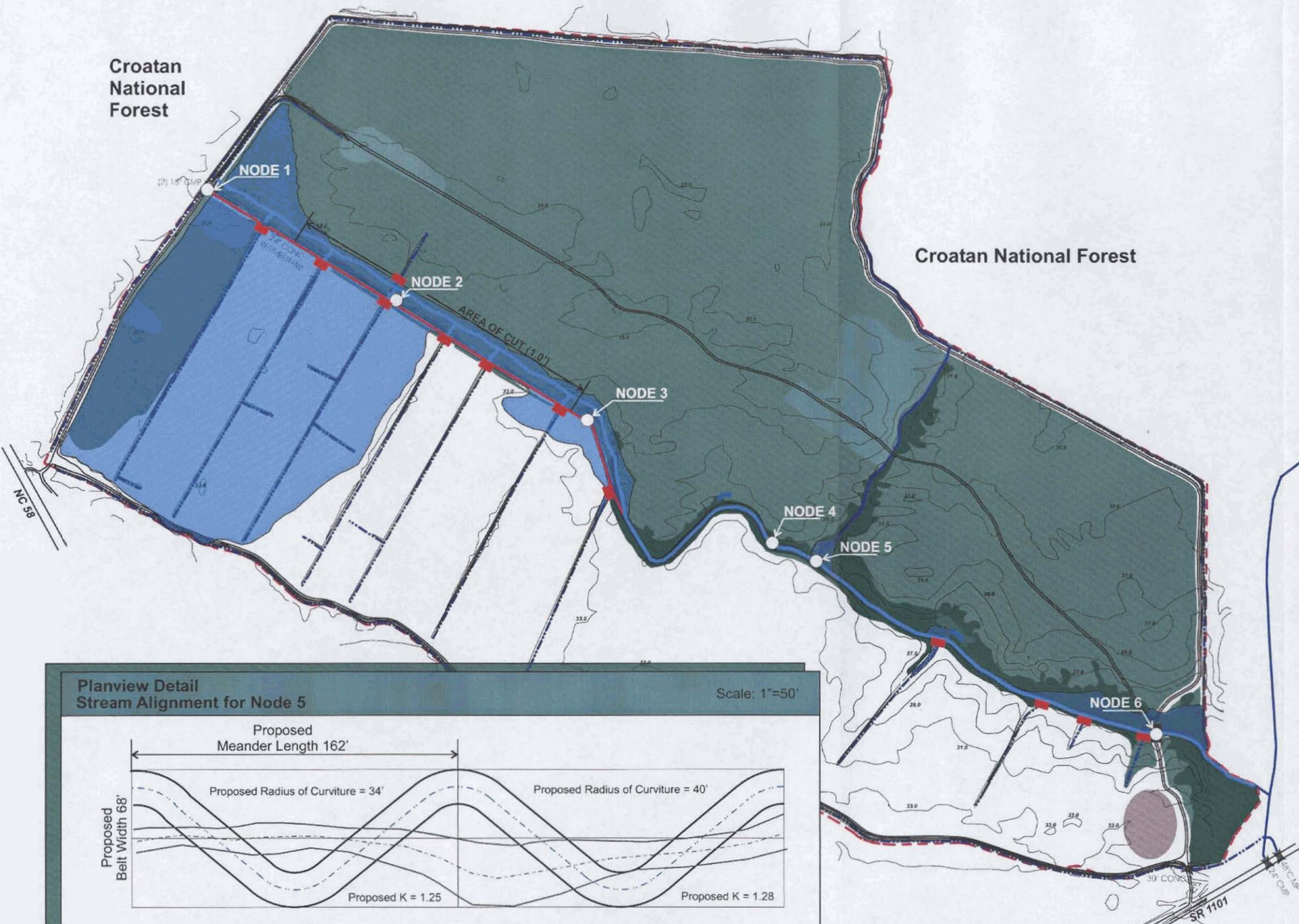
NORTH

1"=500'



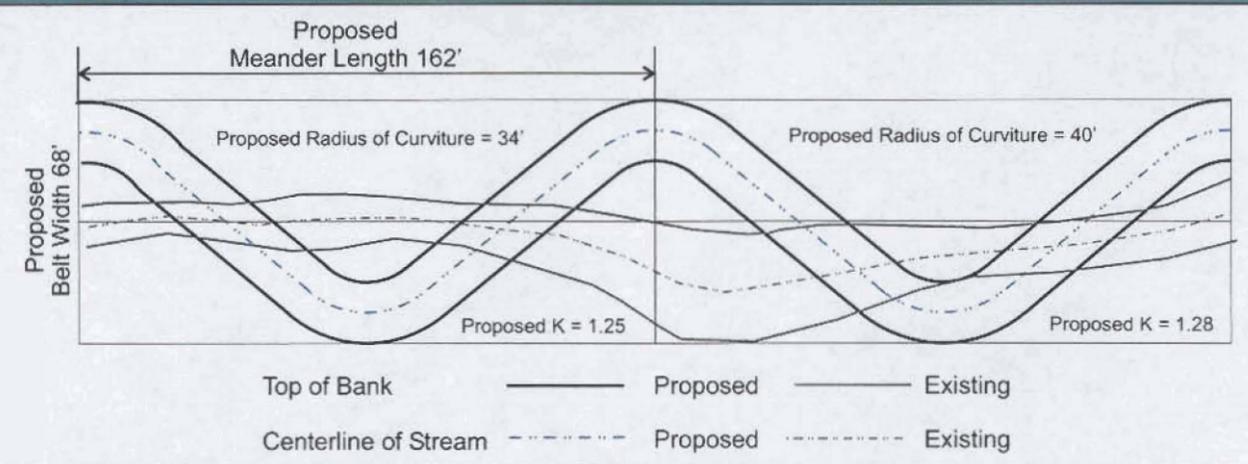
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***Note: Berm may be needed along western border of farm field bordering Croatan National Forest.**

**Planview Detail
Stream Alignment for Node 5** Scale: 1"=50'



The geometry for each node was then superimposed on topographic mapping (1 inch = 50 feet) provided by the NCDOT.

Given federal permitting policies and guidance, the NCDOT has documented the amount of perennial and intermittent stream length restored on-site consistent with the NCDOT's recommendation for the limits of perennial streams. Intermittent stream restoration will total 3,200 linear feet while perennial stream restoration will total 5,062 linear feet. In addition, the NCDOT believes, based on the Jones County Soil Survey, that the stream extended to the property's western boundary prior to agricultural use. As such, the proposed restoration is a complete ecological-system restoration approach.

5.1.3 Proposed Alignment of Billy's Branch

The assessment of stream restoration options for Billy's Branch followed that of Rosgen (*A Geomorphological Approach to Restoration of Incised Rivers*, 1997). The prioritization of restoration options described in the above mentioned manuscript is as follows (in descending order of preference):

- Convert G and/or F stream types to C and/or E types at elevations sufficient to restore the floodplain at the pre-disturbance elevation,
- Convert G and/or F stream types to C and/or E types and establish floodplain at current elevation or higher, but not as high as the pre-disturbance elevation,
- Stabilize the stream channel in place.

The objectives of this study were to re-establish a stable stream type and floodplain at the pre-disturbance elevation, or a necessary, to create the new stream channel within a newly constructed floodplain. Creation of a new stream channel avoids the problems of stabilizing a new stream bed within an existing channel (Dave Rosgen, personal communication). Material needed to fill the existing stream channel will come from the proposed stream excavation, the excavation of small, oxbow lakes proposed in the immediate vicinity (Dave Rosgen, personal communication), or from on-site borrow areas.

Representatives of Croatan National Forest were contacted and asked if the United States Forest Service (USFS) would be interested in allowing stream restoration on that portion of their property located between the Site and SR 1101. The USFS was not interested in restoring this relatively small reach. Therefore, the proposed stream restoration project will lie entirely within the Site and a grade control structure (e.g., step pool) will be needed to transition the streams slope from the Site to the adjacent Croatan National Forest.

In summary, the restoration goal for Billy's Branch is to restore the stream at elevations which would re-establish use of the historic floodplain or to place the stream in a new location (alignment) wherever possible as discussed above. Figure 12 illustrates the proposed stream's alignment and the typical plan view at node 5 as a representation of the general stream geometry. Final design of stream geometry will vary along each reach where practicable to give the stream a natural appearance. A more detailed analysis of meander geometry is provided below.

The bankfull critical shear stress at each node for Billy's Branch was calculated based on plan view, channel dimensions, and valley slope. These values were compared to the values for the reference

reach (0.09 lbs/ft²) and the particle sizes found within Billy's Branch. Shear stress is an important calculation because it indicates whether the stream has the power to entrain particles smaller, equal to, or larger than the particle sizes available to the channel when the stream is at its bankfull stage. A proposed stream design which generates a shear stress value in excess of that needed to move the particles available to the stream bed indicates that the stream may begin to scour or down-cut. Conversely, a proposed stream design with too little shear stress may not be able to transport its sediment load, causing sedimentation and aggradation in the channel.

The initial meander geometry calculated for nodes 1, 2 and 3 of Billy's Branch generated a shear stress that matched the reference reach and the particle size of the sediment. There is also adequate area upstream of node 3 to place the stream on a new alignment, as is preferred. The new alignment was placed in the woods immediately north of the existing stream. This alignment was selected to avoid losing wetland restoration opportunities in the Prior Converted cropland. This new alignment also allows the dirt road in the woods to be used for construction. Although the berm immediately south of the channelized stream will be used to fill in the existing channel, additional fill material will be needed. This additional fill will come from grading the floodplain along the proposed alignment. Approximately one foot of grading is proposed for floodplain excavation along this reach.

The initially proposed stream geometry between nodes 3 and 4 yielded shear stress values greater than the reference reach (0.3 versus 0.09 lb/ft², see Figure 13). Various options are available to decrease shear stress including increasing width/depth ratio, increasing sinuosity (decrease slope), increasing meander width ratio, and decreasing meander length and radius of curvature. Increasing the width/depth ratio were unsuccessful since the values necessary for width and depth were well outside the range observed at the reference reach (i.e., normalized for drainage area). Consequently, increases in sinuosity were attempted to decrease stream slope and thereby reduce shear stress (Figure 13). The only means available to reduce the shear stress was to increase sinuosity from 1.2 to 2.4. This was accomplished by having a meandering plan view follow the large, remnant meander pattern of Billy's Branch. This finding is significant because it confirms that the historic meander pattern (observed on USGS quadrangle maps prior to agricultural use) was needed to maintain a stable stream through this narrowing and relatively steep portion of the valley (see alternative versus proposed stream alignment, Figure 13).

The meander geometry between nodes 4 and 6 only requires a sinuosity of between 1.25 and 1.30 to generate acceptable shear stress values. An illustration of the restoration geometry is provided in Figure 12.

Once the plan, profile and cross sections were calculated, the data was then input into the HEC-2 model to determine peak flood elevations for the two-year storm and the peak discharge rate occurring at the culverts on SR 1101. This is further discussed in the Proposed Hydraulics section (5.1.4) of this report.

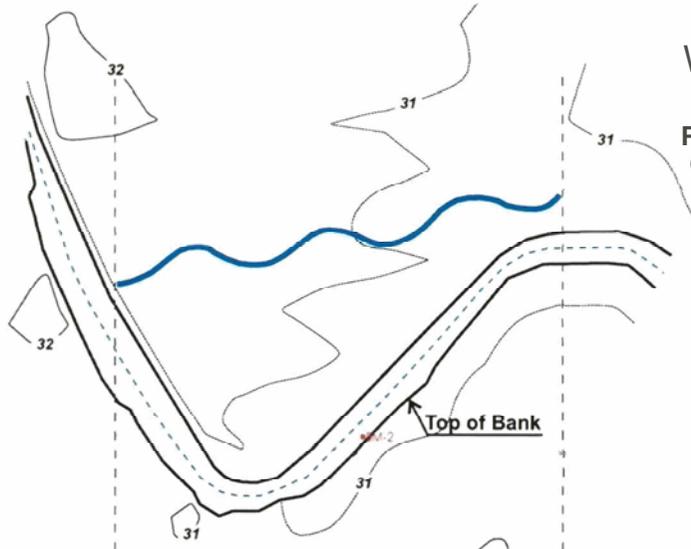
5.1.4 Proposed Hydraulics

The individual drainage areas and the time of concentration for the five drainage areas will remain the same under the proposed conditions. The five individual drainage areas will continue to drain into and pond behind the two outfall culverts (24-inch CMP and 48-inch CMP) located under SR 1101. The proposed conditions include 1) reducing the slope of the longitudinal profile, 2) increasing stream

Figure 13

Clayhill Farms Wetland & Stream Mitigation Plan Report

Proposed Stream Course Alignment & Corresponding Bankfull Shear Stress

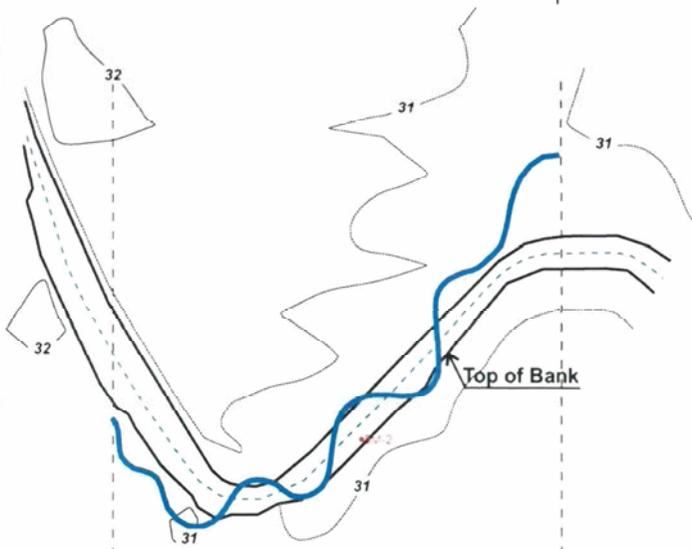
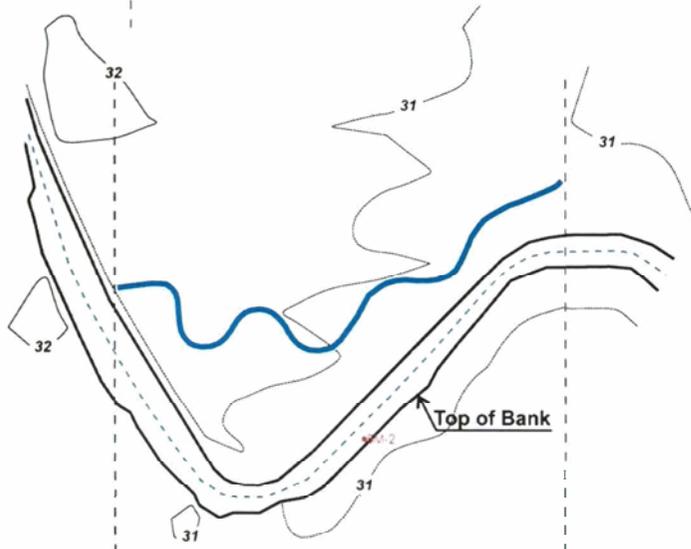


Alternative Stream A

Valley Slope: 0.0088
 Sinuosity: 1.2
 Stream Slope: 0.007
 Shear Stress: 0.3 lb/s.f.
 Entrain: 15mm particle

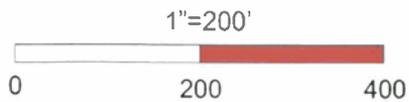
Alternative Stream B

Valley Slope: 0.0088
 Sinuosity: 1.75
 Stream Slope: 0.005
 Shear Stress: 0.22 lb/s.f.
 Entrain: 12mm particle



Proposed Stream C

Valley Slope: 0.0088
 Sinuosity: 2.4
 Stream Slope: 0.003
 Shear Stress: 0.16 lb/s/f/
 Extrain: 10mm particle



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length (due to increased sinuosity) and 3) reducing the cross-sectional area of Billy's Branch and 4) partially blocking the eleven feeder ditches that drain to Billy's Branch.

Feeder Ditches

As part of the proposed conditions, it was initially proposed that the existing feeder ditches be blocked only at each of their downstream ends (Figure 12).

The NCDOT's final design plans illustrate plugging and filling the agricultural ditches rather than only blocking them. Each ditch will be plugged with clay material for a distance of 15 to 20 feet. The remainder of the ditch will be backfilled with onsite material taken from the floodplain excavation or other upland areas.

Billy's Branch

The proposed conditions of Billy's Branch were modeled using the HEC-2 program. The existing total drainage area (971 acres) will not change, the peak time of concentration will not change, and the overall runoff curve numbers will remain the same. The runoff curve numbers for the areas that are being converted to wetlands will, over time, decrease under the proposed conditions. In order to be conservative with the model and to represent the early conditions during their conversion to wetlands (fallow fields), the existing curve numbers were used to generate the peak flow rates for the proposed conditions. The existing tailwater condition of 22.7 feet at the culverts beneath SR 1101 will remain the same for the proposed conditions of Billy's Branch. The HEC-2 model was revised to reflect the proposed longitudinal profile, stream length, and cross-sections generated from the fluvial geomorphological analysis. The proposed cross-sections were changed to reflect the smaller depth and width of the proposed Billy's Branch (Figure 8) channel which was based primarily on the data from the primary (off-site) reference reach.

Table 5 shows the peak flow rate, the top of bank elevation, and existing and proposed ditch conditions of Billy's Branch. One result from the HEC-2 model was that it indicated a "hydraulic jump" between nodes 4 and 5. This reflects an increase in velocity (energy) caused by valley slope increasing between these nodes while the stream channel dimensions and sinuosity remain relatively constant and the floodplain narrows. The resulting turbulent condition is a normal condition that generates rapids within streams. To reduce the potential for erosion in this area, the design calls for widening of the floodplain to accommodate an increased sinuosity and for the use of cross vanes as grade control.

Table 5. Proposed surface water profile of Billy's Branch.

Node #	Existing Conditions		Proposed Conditions	
	Peak Stormwater Runoff (cfs)	Water Surface Elevation (ft)	Peak Stormwater Runoff (cfs)	Water Surface Elevation (ft)
7	323	22.7	323	22.70
6	176	22.69	176	22.72
5	148	24.57	148	26.62
4	143	24.49	143	26.99
3	95	31.81	95	32.26
2	73	32.71	73	33.67
1	38	32.94	38	33.76

5.1.5 Floodplain Restoration

As mentioned previously, the existing geometry of Billy's Branch currently confines the two-year storm which indicates that the stream has abandoned its floodplain. The new floodplain generated by the proposed restoration of Billy's Branch is illustrated on Figure 12. Between nodes 1 and 2, the proposed stream will generate a floodplain approximately one foot higher (Table 6) and 1,650 feet wider than existing conditions (Figure 12).

Table 6. Existing and proposed peak flood elevations.

Node #	Existing Conditions (ft)	Proposed Conditions (ft)	Increase in Peak (ft)
1	32.9	33.8	0.9
2	32.7	33.7	1.0
3	31.8	32.3	0.5
4	24.5	27.0	2.5
5	24.6	26.6	2.0
6	22.7	22.7	0.0
7	22.7	22.7	0.0

Node 3 will generate a floodplain 0.5 feet higher than existing conditions. The 200-foot wide floodplain, while narrower than at nodes 1 and 2, fills the historic floodplain as evidenced by review of the ortho-topographic mapping provided by the NCDOT (Figure 12).

The flood elevations increase sharply between nodes 4 and 5 to approximately 2.3 feet above existing conditions, due to the constriction of the valley in this area. It is due to this constriction in the valley width that the floodplain is only 25 feet wide, except at the confluence with the unnamed tributary to the north. The floodplain of Billy's Branch extends approximately 170 feet up the unnamed tributary.

The flood elevations and floodplain widths remain constant between nodes 6 and 7, an area where the floodplain, on average is approximately 125 feet wide (Figure 12). Although the proposed stream channel at node 6 is shallower and narrower than the existing conditions, the floodplain is much wider than at nodes 4 and 5 upstream, providing more storage without a rise in the water elevation.

Node 7 is off-site and neither its cross-section nor slope can be altered. The flood elevation at node 7 is the same under proposed conditions as it is in existing conditions which confirms that the channel, meander and slope adjustments made within the Site appears to have no deleterious effect on downstream properties nor the culverts beneath SR 1101.

5.2 Conceptual Planting Plan

Natural plant communities are dependent primarily upon landscape position, soil type, and hydrology. The first step in determining which natural plant communities likely occurred at the Site was to find naturalized areas with similar characteristics (i.e., soil type, hydrology, and landscape position). These areas were found through review of published references and conversations with Mr. Richard LeBlond, Biologist with the North Carolina Natural Heritage Program (NHP). Once these sites were inventoried, the obtained data was compared to that in *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990). Combined with the data developed from the groundwater and surface water analyses, this data provide the basis for the proposed planting plan.

5.2.1 Reference Forests

Two reference forests were identified which had the same physical characteristics as the Site (Figure 1). Both were located in the Croatan National Forest. Vegetation Reference Area 1 was located on a tributary to Holston Creek approximately 1.7 miles northwest of the Site. Vegetation Reference Area 2 was located at the off-site stream reference reach approximately 1.3 miles east of the Site. The soil types found at the Site are not common in the vicinity and locating reference forests was difficult. All areas of Torhunta soil in the vicinity of the Site have been converted to agriculture or pine plantations. Pantego soil is similar to Torhunta and is found in locations adjacent to the Site. However, because the adjacent forest on these soil types are not considered to be in its natural state, due to past high-grading forestry practices, vegetation on Pantego soil was investigated but not sampled (see Section 5.2.2). A sample plot was not taken in the mesic pine flatwoods community investigated on Onslow soil because it has been burned too frequently to have characteristic vegetation.

A 50-foot diameter circular plot was taken on each soil type within each landscape position at both reference forest locations. The diameter at breast height (dbh) of every stem larger than one inch was measured and recorded, as was the percent cover (by species) of all species in the shrub and herbaceous layers. A total of six plots were sampled. Data from the sample plots are summarized in Table 7.

Table 7. Mean community characteristics for vegetation sample plots.

	Stems per Acre	Basal Area per Acre	Number of Species per Plot	Percent Hydrophytic Species per Plot	Species with IV \geq 10
Coastal Plain Bottomland Hardwood Forest	658	238	6.3	84	swamp blackgum ironwood American holly water oak sweetgum sweet bay bald cypress
Mixed Mesic Hardwood Forest	322	210	6.5	57	loblolly pine yellow-poplar flowering dogwood ironwood sweetgum water oak longleaf pine

An Importance Value (IV) was calculated for each tree species in each plot as follows. First, the density of all stems greater than one inch dbh was determined for each species on a per acre basis. For example, ironwood (*Carpinus caroliniana*) in plot 4 had 14 stems that were one inch in dbh or larger, therefore the stem density for ironwood is 311 stems per acre. Then, the basal area of each tree species (based on all stems) was determined and expressed in square feet (ft²) of basal area per acre. The corresponding value of ironwood in plot 4 was 31.02 ft²/acre. All density and basal area values within a plot were then divided by the total density and basal area for all species in the plot to derive the percentage of total density and basal area each species represented. Thus, the relativized values for

ironwood in plot 4 were $311 / 555 \times 100 = 11.01$ percent and $31.02 / 281.82 \times 100 = 56.00$ percent for density and basal area, respectively. The IV for each tree species was determined by averaging its relative density and relative basal area, yielding an IV of 33.50 for ironwood in plot 4. Species with an IV greater than ten are listed in Table 10.

5.2.2 Proposed Plant Communities

Mitigation opportunities for the Site will allow for the restoration, enhancement, and/or preservation of both riparian and non-riparian wetland plant communities. The plant communities that likely occurred historically on and around the Site was determined from data collected from the reference forests, descriptions of plant communities from *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990), and the hydrology modeling. Figure 14 depicts these plant communities and describes their landscape position, dominant species, and typical soil type. Four of these communities are proposed for the Site and include Coastal Plain Small Stream Swamp (32.3 acres), Non-riverine Wet Hardwood Forest (37.4 acres), Mesic Pine Flatwoods (22.4 acres), and Mixed Mesic Hardwood Forest (5.6 acres). In addition, wetland hydrology will be enhanced in (1.8 acres) the Coastal Plain Bottomland Hardwood Forest currently existing at the Site. The following sections detail each of these communities and list the species proposed for planting. Figure 15 depicts the planting zones for each of these communities.

Coastal Plain Small Stream Swamp

Coastal Plain Small Stream Swamp typically occurs in the floodplains of small, blackwater streams. This community typically grades upstream into an Atlantic White Cedar Forest and away from the channel to Non-riverine Wet Hardwood Forest or uplands. Coastal Plain Small Stream Swamp typically grades into Bottomland Hardwoods as the floodplain size increases downstream. The canopy is dominated by bald cypress (*Taxodium distichum*) and swamp blackgum. As noted in Section 5.1, the western-most fields on Torhunta soils (approximately 32.3 acres) will be located in the floodplain of the new stream and inundated during the two-year event. DRAINMOD predicts flooding/ponding in this area 38 out of 40 years. Therefore, a Coastal Plain Small Stream Swamp community is planned for this area.

Non-Riverine Wet Hardwood Forest

The forests on Pantego soil surrounding the Site presently exist as a Pond Pine Woodland. Pond Pine Woodlands typically occur on the edges of peatland communities, which are mostly absent in the vicinity of the Site. It is therefore, unlikely these forests exist in their natural condition. Historically, the Torhunta and Pantego soils at the Site most likely supported a Non-riverine Wet Hardwood Forest community.

Non-riverine Wet Hardwood Forests occur on poorly drained interstream flats which are saturated part of the year. Typically, these flats are near the highest parts of landscape. They are typically on poorly drained loamy or clayey mineral soils and are almost always jurisdictional wetlands. At least five of the following species should be planted on the Torhunta and Pantego soil: swamp chestnut oak (FACW-), laurel oak (FACW), cherrybark oak (*Quercus falcata* var. *pagodaefolia*, FAC+), yellow-poplar (FAC), American elm (*Ulmus americana*, FACW), swamp blackgum (OBL), and American holly (FAC-). Red maple (FAC) and sweetgum (FAC+) are important components of Non-riverine

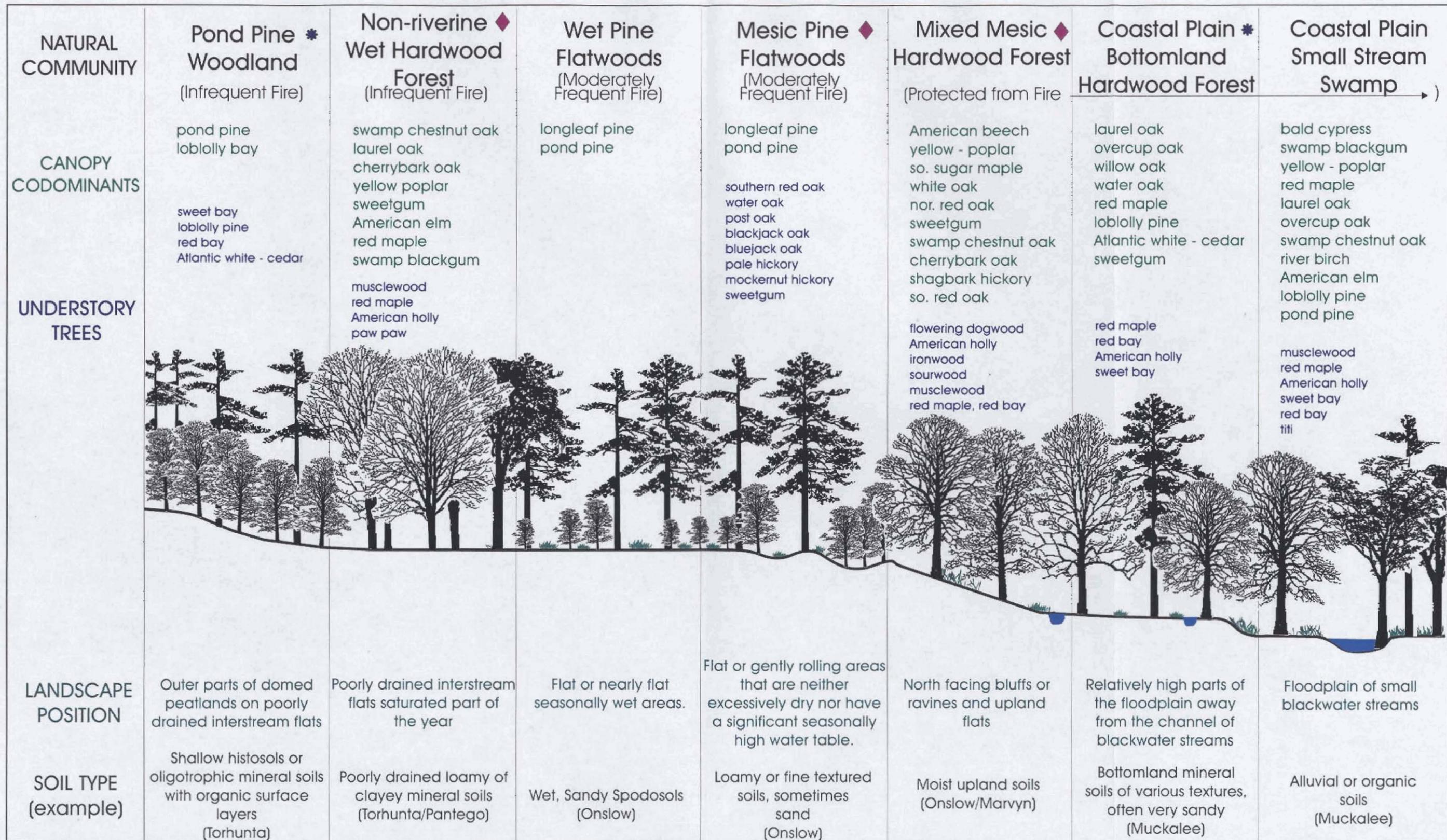


FIGURE 14
LANDSCAPE PROFILE OF NATURAL COMMUNITIES

NOTE: * Exists on site
◆ Proposed for site

Croatan National Forest

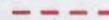
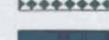
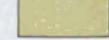
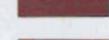
Croatan National Forest

NC 58

Clayhill Farms Wetland & Stream Mitigation Plan Report

Figure 15 Proposed Planting Plan

Legend

-  Property Boundary
-  Cypress-Gum Swamp Riverine Restoration
-  Non-Riverine Wet Hdwd Forest Wetland Restoration
-  Non-Riverine Wet Hdwd Forest Upland Restoration
-  Mesic Pine Flatwoods Wetland Restoration
-  Mesic Pine Flatwoods Upland Restoration
-  Mixed Mesic Hdwd Forest Wetland Restoration
-  Mixed Mesic Hdwd Forest Upland Restoration
-  Mixed Mesic Hdwd Forest Upland Preservation
-  Bottomland Hdwd Forest Wetland Enhancement
-  Bottomland Hdwd Forest Wetland Preservation
-  Bottomland Hdwd Forest Upland Preservation
-  Mixed Pine Regeneration Wetland Preservation
-  Mixed Pine Regeneration Upland Preservation

1"=500'



NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND
ENVIRONMENTAL ANALYSIS BRANCH

Wet Hardwood Forests but are not recommended for planting as they will likely regenerate naturally on the Site from adjacent areas.

Approximately 11.7 acres of this area is projected by DRAINMOD to remain effectively drained (and thus not exhibit wetland hydrology) because the southern perimeter ditch cannot be plugged (it is not completely owned by the NCDOT). Hydrology monitoring wells are located within this area, and may show this area of upland buffer to be smaller than that suggested by the modeling. If so, credit calculations may be adjusted to depict this area as wetland versus upland.

Mesic Pine Flatwoods

Mesic Pine Flatwoods occur on flat to gently rolling areas which are neither excessively dry nor have a significant seasonally high water table. In general, they are marginal wetlands. Mesic Pine Flatwoods have an open to nearly closed canopy of longleaf pine (*Pinus palustris*) and pond pine (*Pinus serotina*) with a diverse understory of hardwood trees. It is likely that most of the areas on the Site mapped in the soil survey as Onslow soils were this mixed pine community. Recommended plantings for the Onslow portions of the Site include only longleaf pine (FACU+) and pond pine (FACW+). Approximately 11.1 acres of this community is expected to be upland buffer due either to the presence of non-hydric soils or the drainage effect of the southern perimeter ditch. Approximately 2.2 acres of this community will be in the floodplain of the new stream after the ditches are blocked and Billy's Branch is restored.

Mixed Mesic Hardwood Forest (Coastal Plain Subtype)

All of the areas mapped as Marvyn soils and parts of the Onslow soil areas will be planted to reflect a Mixed Mesic Hardwood Forest community. This community will occur primarily below the 31.0-foot contour line on the eastern end of the Site. Parts of this community may become jurisdictional wetlands over time; however, due to the well drained nature of this soil most of it will remain simply as upland riparian buffer. Only 5.6 acres of this community is expected to meet the soil and hydrology criteria for jurisdictional wetlands. Mixed Mesic Hardwood Forests typically occur on north-facing bluffs or ravines on moist upland soils. This is the same landscape position that they will occupy at the Site. At least six of the following species should be planted in this area: yellow-poplar (FAC), water oak (FAC), swamp chestnut oak (FACW-), cherrybark oak (FAC+), ironwood (FAC), laurel oak (FACW), southern sugar maple (NI), and American beech (FACU). Sweetgum (FAC+) is an important component of this community but is not recommended for planting as it will likely regenerate naturally on the Site from adjacent areas.

Coastal Plain Bottomland Hardwood Forest (Blackwater Subtype)

Coastal Plain Bottomland Hardwood Forests occur on the relatively high parts of the floodplain of blackwater creeks and rivers. These portions of the floodplain are inundated in major flood events (i.e. 10-year storm) for as much as a day or two. They are saturated most of the year and are typically jurisdictional wetlands. They occur on bottomland mineral soils of various textures. At the Site, this community originally occurred on the northern side of Billy's Branch and along the north-south tributary of Billy's Branch in the center of the property. As mentioned previously, portions of this community have been drained to the point that it no longer functions as a floodplain due to the incision of Billy's Branch. Approximately 1.8 acres of this community will be enhanced from marginal

wetlands to the original floodplain community by the restoration of Billy's Branch. No additional plantings are recommended for this community.

6.0 SITE CONSTRUCTION AND PLANTING REQUIREMENTS

6.1 Site Construction

Site construction will include the following activities:

- Plugging and filling of feeder ditches and removal of crowning in fields.
- Clearing and grading necessary to create new stream alignment.
- Construction of a stable, meandering channel for the on-site reaches of Billy's Branch and unnamed tributary.
- Fill existing stream channel where necessary with on-site materials from excavated floodplain and other upland areas.
- Install a grade control structure at downstream end of Billy's Branch to allow stable transition to the downstream reach located within the Croatan National Forest.
- Removal of the bridge across Billy's Branch at the southeast portion of the Site.

6.2 Site Preparation and Planting Requirements

It is recommended that the Site be randomly shaped to establish irregular contours with high ridged areas (no more than 12 inches above average grade) and depression furrows (no more than 12 inches below average grade). This will increase surface storage at the mitigation site, restore natural microtopography to the Site, and provide microsites for planting trees to reduce seedling mortality due to high water tables (McKinney and Shear 1997, Tweedy and Evans 1999). In an effort to reduce compaction and create microtopography, the entire Site will be ripped or scarified. No other site preparation is recommended prior to planting.

Bare root seedlings will be planted on eight-foot centers throughout the planting zones, resulting in 680 trees per acre. In hardwood dominated communities, no more than 20 percent of plantings will be of any one species. Planting should occur outside of the growing season (i.e., between November and March) to allow the plants to acclimate during the dormant season.

The NCDOT will perform all of the construction with NCDOT forces and will utilize stream diversions throughout the entire length of the stream restoration project. The restored channel will be stabilized with coir fiber matting, live stakes, and seeding before turning the water into the newly constructed channel. In addition, root wads and other woody debris will be introduced during the construction of Billy's Branch to provide additional aquatic habitat.

7.0 MONITORING PLAN

All monitoring will be performed annually for five years following construction or until all success criteria have been met. An annual monitoring report will be submitted for the Site.

7.1 Wetland Mitigation Monitoring - Hydrology

NCDOT will locate on-site hydrology reference sites. The reference monitoring gauges will be placed at comparable elevations as those monitoring the restoration portions of the Site. Remote shallow groundwater monitoring gauges will be maintained and periodically downloaded until success criteria have been met.

The success criteria for wetland hydrology will include those areas that exhibit a hydroperiod of 12.5 percent or greater. In drought years, those gauges that fail to meet the 12.5 percent success criteria will be deemed successful if the hydroperiod is within 20 percent of the hydroperiod of the average for reference gauges.

7.2 Wetland Mitigation Monitoring - Vegetation

Quantitative vegetation sampling will be performed in the fall of each year. Plots measuring 50-foot by 50-foot will be established in each planting zone.

In each plot, species composition and density will be recorded. Photograph locations will be established for each plot. Any areas of the Site visually observed not meeting the established success criteria will also be noted.

A 320 stems per acre survival criterion for planted seedlings will be used to determine success for the first three years. The required survival criterion will decrease by 10 percent per year after the third year of vegetation monitoring (i.e., for an expected 290 stems per acre for year 5).

7.3 Stream Restoration Monitoring

The NCDOT will provide an "as-built" of the stream reach within 90 days after construction has been completed. The "as-built" will include dimension, profile, and plan view of the completed stream project. The "as-built" will serve as the baseline during the monitoring period.

During the annual review of the stream, the entire stream reach will be visually evaluated for any potential problem area such as stream bank instability, in-stream structure failure, or unsuccessful vegetation establishment. Permanent photo reference points along the stream will be established for annual monitoring.

The annual monitoring report will contain photographs and documentation of the stream during the monitoring period. Any remedial actions to the stream that are necessary will be coordinated with the agencies.

8.0 MITIGATION SUMMARY

8.1 Compensatory Wetland Mitigation Acreage

Table 8 details the wetland mitigation acres at the Site.

Table 8. Compensatory wetland credit calculations for the Clayhill Farms Mitigation Site.

Compensatory Mitigation Type	Acres		
	Riverine	Non-Riverine	Total
Wetland Restoration			
Cypress-gum headwater swamp	32.3		32.3
Non-riverine wet hardwood forest		37.4	37.4
Mesic pine flatwoods		22.4	22.4
Mixed mesic hardwood forest		5.6	5.6
<i>Total Wetland Restoration</i>	<i>32.3</i>	<i>65.4</i>	<i>97.7</i>
Wetland Enhancement			
Coastal Plain BLH	1.8		
<i>Total Wetland Enhancement</i>	<i>1.8</i>		<i>1.8</i>
Wetland Preservation			
Mixed pine regeneration		252.1	
Coastal Plain BLH	2.0		
<i>Total Wetland Preservation</i>	<i>2.0</i>	<i>152.1</i>	<i>154.1</i>
Upland Buffer Restoration			
Non-riverine wet hardwood forest		11.0	
Mesic pine flatwoods		17.3	
Mixed mesic hardwood forest		15.8	
<i>Total Upland Buffer Restoration</i>		<i>44.1</i>	<i>44.1</i>
Upland Buffer Preservation			
Mixed pine regeneration		45.3	
Mixed mesic hardwood forest		12.3	
Coastal Plain BLH		0.3	
<i>Total Upland Buffer Preservation</i>		<i>57.9</i>	<i>57.9</i>
Site Totals	36.1	319.5	355.6

8.2 Compensatory Stream Mitigation Length

Table 9 details the stream length calculations at the Site.

Table 9 . Compensatory stream credit calculations for the Clayhill Farms Mitigation Site.

Compensatory Mitigation Type	Linear Feet		
	Perennial	Intermittent	Total
Stream Restoration			
Billy's Branch	5,062	3,200	8,262
Upper tributary to Billy's Branch	70	0	70
<i>Total Stream Restoration</i>	<i>5,132</i>	<i>3,200</i>	<i>8,332</i>
Stream Preservation			
Upper tributary to Billy's Branch	1,280	0	1,280
<i>Total Stream Preservation</i>	<i>1,280</i>	<i>0</i>	<i>1,280</i>

9.0 DISPENSATION OF PROPERTY

The Site borders the Croatan National Forest to the west, north, and east. Therefore, USFS would be the preferred recipient of the land. Representatives for the Croatan Ranger District have expressed an interest in accepting eventual ownership of the Site and have stated that they see no problems regarding such a transfer.

The NCDOT will retain ownership of the Site until all mitigation activities are completed and the site is determined to be successful. A conservation easement or other restrictive covenant will be established for the property and recorded with the deed when transferred to the USFS to ensure that the property is managed for the purpose of wetland mitigation in perpetuity.

10.0 CONCLUSION

The results of the wetland and stream restoration plan for the Site were a product of an integrated analytical approach that evaluated the soils, groundwater hydrology, surface water hydrology and hydraulics, fluvial geomorphology, landscape position, vegetation, and wildlife. This analysis was further supported by analyzing the least disturbed plant communities endemic to the region located in areas with the same landscape positions, soils and proposed hydrology as that of the Clayhill Farms property. Stream restoration was based upon accepted procedures in fluvial geomorphology and hydraulics and utilized stream gage data and reference streams.

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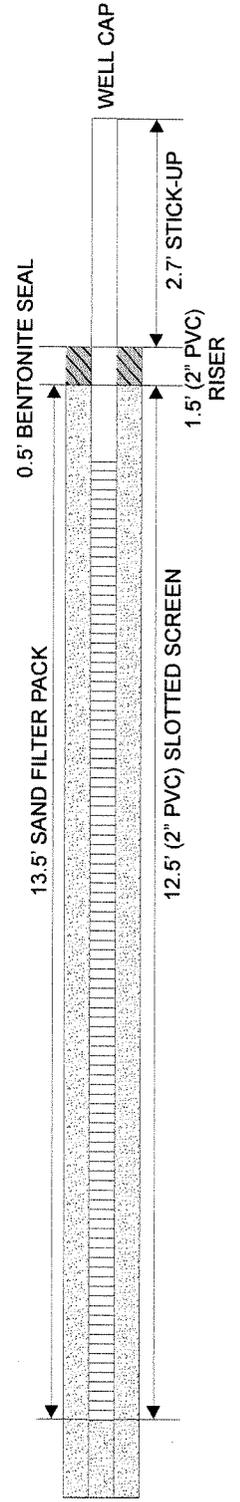
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APPENDIX A

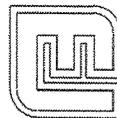
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 LOGGED BY: BCC
 SOIL TYPE: PANTEGO

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		2.5Y 2.5/1 BLACK	SANDY CLAY
		10YR 4/1 DARK GRAY	SANDY LOAM, GRAY MOTTLES (10YR 6/1)
-5		10YR 3/1 VERY DARK GRAY	SANDY LOAM
		10YR 3/1 VERY DARK GRAY	LOAMY SAND, FINE ROOTS
		10YR 5/1 GRAY	SILTY CLAY
-10		2.5Y 3/1 VERY DARK GRAY	SANDY LOAM
		5GY 4/1 DARK GREENISH GRAY	CLAY
		5GY 6/2 LT. OLIVE GRAY	SANDY CLAY LOAM
		5GY 4/1 DARK GREENISH GRAY	SILTY CLAY
-15		5GY 4/1 DARK GREENISH GRAY	BOTTOM OF WELL AT 14 FEET CLAY



SOIL BORING LOG
CLAYHILL FARMS



Langley and McDonald, P.C.

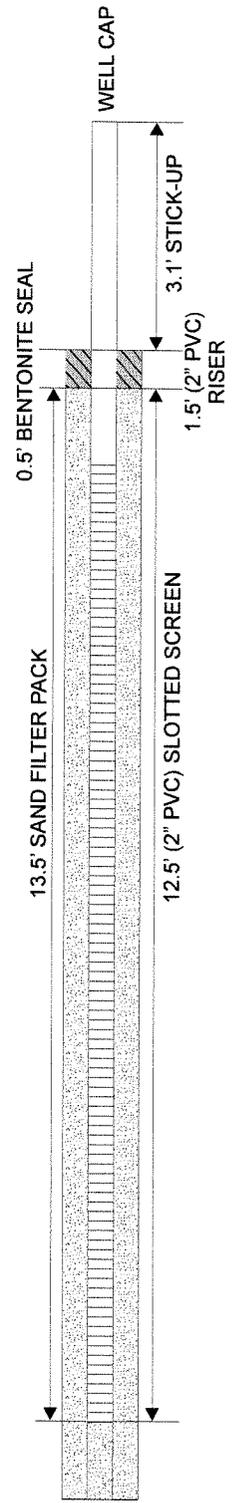
Engineers - Surveyors - Planners
 Landscape Architects - Environmental Consultants

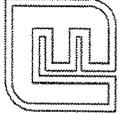
VIRGINIA BEACH

WILLIAMSBURG

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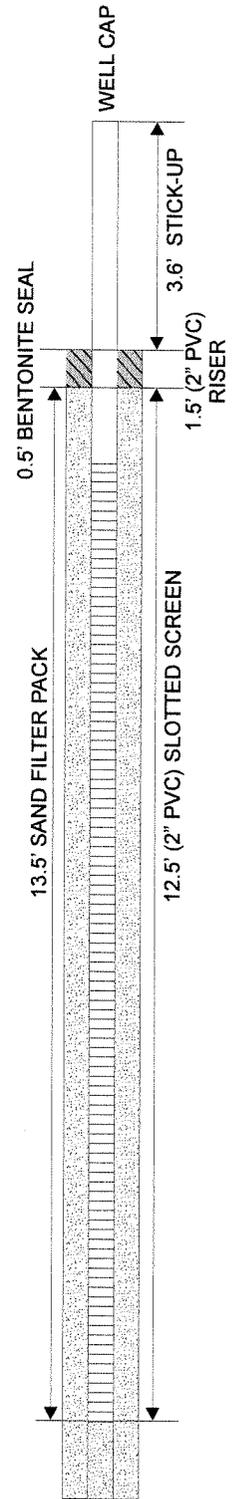
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			WATER LEVEL 4.88' BELOW TOP OF CASING
		2.5Y 6/4 LT. YELLOWISH BROWN	SANDY LOAM
-5		2.5Y 6/4 LT. YELLOWISH BROWN	SANDY LOAM
		2.5Y 5/2 GRAYISH BROWN	SANDY LOAM
-10		10YR 5/1 GRAY	SANDY LOAM
		10YR 5/1 GRAY	SANDY LOAM
			BOTTOM OF WELL AT 14 FEET
-15		5Y 7/1 LT. GRAY	SAND



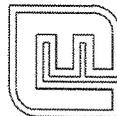
<h2 style="margin: 0;">SOIL BORING LOG</h2> <h2 style="margin: 0;">CLAYHILL FARMS</h2>	 <p style="margin: 0;">Langley and McDonald, P.C. <small>Engineers - Surveyors - Planners Landscape Architects - Environmental Consultants</small></p> <p style="margin: 0; font-size: small;">VIRGINIA BEACH WILLIAMSBURG</p>
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 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: ONSLOW

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		2.5Y 5/4 LT. OLIVE BROWN	SANDY LOAM, DARK GRAYISH BROWN MOTTLES (2.5Y 4/2) WATER LEVEL 4.88' BELOW TOP OF CASING
		2.5Y 6/4 LT. YELLOWISH BROWN	SANDY CLAY LOAM. BROWNISH YELLOW MOTTLES (10YR 6/8)
		2.5Y 6/2 LT. BROWNISH GRAY	SANDY CLAY LOAM (10YR 6/8)
-5		7.5YR 5/2 BROWN	LOAMY SAND
		7.5YR 7/1 LT. GRAY	SAND
-10		7.5YR 7/1 LT. GRAY	SAND
		7.5YR 7/1 LT. GRAY	SAND
		7.5YR 7/1 LT. GRAY	SAND
		7.5YR 7/1 LT. GRAY	SAND
-15		7.5YR 7/1 LT. GRAY	SAND



SOIL BORING LOG
CLAYHILL FARMS



Langley and McDonald, P.C.

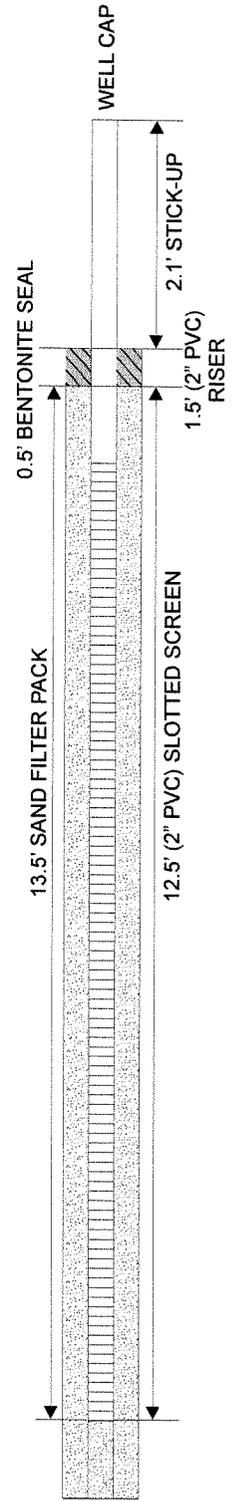
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VIRGINIA BEACH

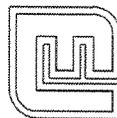
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 LOGGED BY: BCC
 SOIL TYPE: PANTEGO

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLACK	LOAM, FINE ROOTS
		2.5Y 5/2 GRAYISH BROWN	SANDY LOAM WATER LEVEL: 3.80' BELOW TOP OF CASING
		10YR 5/2 GRAYISH BROWN	SANDY LOAM
-5		10YR 5/2 GRAYISH BROWN	SANDY LOAM
		10YR 5/2 GRAYISH BROWN	SANDY LOAM
-10		5GY 5/1 LT. GREENISH GRAY	SANDY LOAM
		5GY 5/1 GREENISH GRAY	SANDY LOAM, INCREASING CLAY
			BOTTOM OF WELL AT 14 FEET
-15		5GY 5/1 GREENISH GRAY	SANDY CLAY



SOIL BORING LOG
CLAYHILL FARMS



Langley and McDonald, P.C.

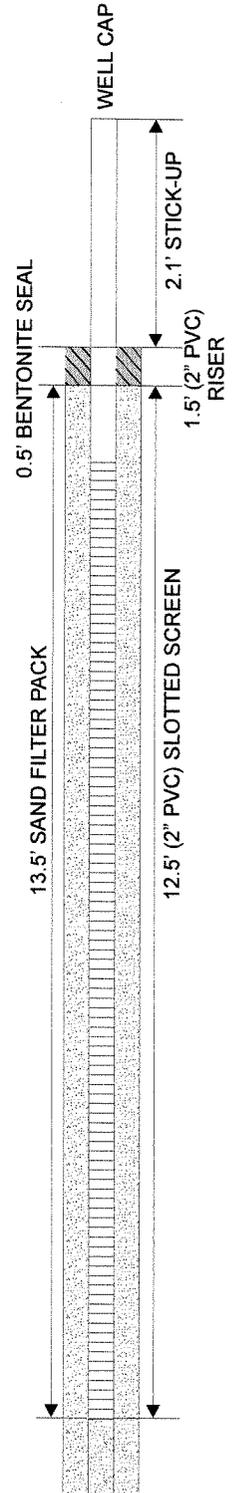
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VIRGINIA BEACH

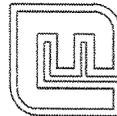
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 LOGGED BY: BCC
 SOIL TYPE: TORHUNTA

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLACK	SANDY LOAM, ROOTS
		10YR 3/1 VERY DARK GRAY	SANDY CLAY LOAM, FEW FINE ROOTS, SOME SMALL QUARTZ PEBBLES
			WATER LEVEL: 4.43' BELOW TOP OF CASING
		2.5Y 6/2 LT. BROWNISH GRAY	SANDY CLAY
		10YR 3/1 VERY DARK GRAY	SANDY CLAY
-5			
		7.5YR 5/2 BROWN	LOAMY SAND
		2.5YR 2.5/1 BLACK	SANDY LOAM
-10			
		10Y 5/1 GRAY	SANDY CLAY, VERY DARK GRAY MOTTLES (10Y 3/1)
		5GY 5/1 GREENISH GRAY	CLAY
-15			BOTTOM OF WELL AT 14 FEET



SOIL BORING LOG
CLAYHILL FARMS



Langley and McDonald, P.C.

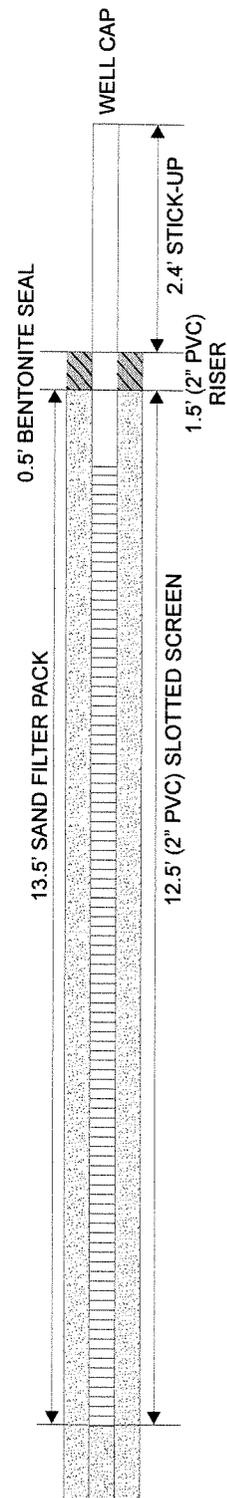
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VIRGINIA BEACH

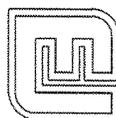
WILLIAMSBURG

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 LOGGED BY: BCC
 SOIL TYPE: TORHUNTA

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
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		2.5Y 5/2 GRAYISH BROWN	SANDY CLAY LOAM. OXIDIZED RHIZOSPHERE INDISTINCT LARGE MOTTLES (10YR 4/1)
		2.5Y 6/2 LT. BROWNISH GRAY	WATER LEVEL: 5.4' BELOW TOP OF CASING. SANDY CLAY, LARGE INDISTINCT MOTTLES (10YR 5/2)
-5		5YR 5/1 GRAY	SANDY LOAM
		10YR 5/3 BROWN	LOAMY SAND, LARGE INDISTINCT MOTTLES
-10		5GY 3/1 DARK GREENISH GRAY	SANDY LOAM
-15		5GY 3/1 DARK GREENISH GRAY	BOTTOM OF WELL AT 14 FEET SANDY LOAM



SOIL BORING LOG
CLAYHILL FARMS



Langley and McDonald, P.C.

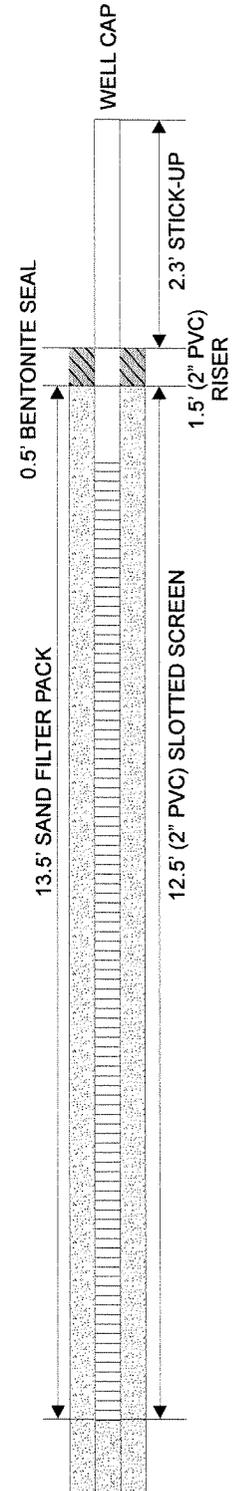
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 Landscape Architects - Environmental Consultants

VIRGINIA BEACH

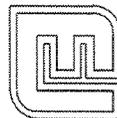
WILLIAMSBURG

WELL No: DMW-7
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/2/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: TORHUNTA

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10 YR 3/1 VERY DARK GRAY	SANDY LOAM, FINE ROOTS
		2.5Y 6/4 LT. YELLOWISH BROWN	SANDY CLAY LOAM, LARGE INDISTINCT MOTTLES (7.5Y 5/8)
			WATER LEVEL: 4.85' BELOW TOP OF CASING.
		2.5Y 6/2 LT. BROWNISH GRAY	SANDY LOAM, LARGE INDISTINCT MOTTLES (10YR 6/6)
-5		10YR 7/1 LT. GRAY	LOAMY SAND, MEDIUM INDISTINCT GRAY MOTTLES (N5/1)
-10		10YR 7/1 LT. GRAY	LOAMY SAND, MEDIUM INDISTINCT GRAY MOTTLES (N5/1)
-15		10YR 5/1 GRAY	SANDY LOAM BOTTOM OF WELL AT 14 FEET



SOIL BORING LOG
 CLAYHILL FARMS



Langley and McDonald, P.C.

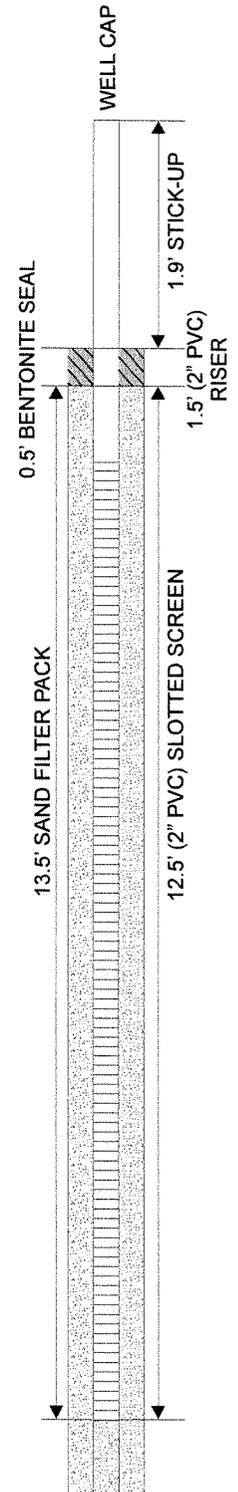
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VIRGINIA BEACH

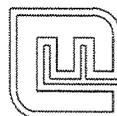
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 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/2/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: TORHUNTA

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLACK	SANDY LOAM, ROOTS, VEGETATION STATIC WATER LEVEL: 2.59' BELOW TOP OF CASING.
		10YR 5/1 GRAY	SANDY LOAM
		2.5Y 7/2 LT. GRAY	SANDY CLAY, FEW FINE MOTTLES, LARGE ROOTS
-5		10Y 5/1 GRAY	SANDY CLAY, LARGE ROOTS
		5GY 5/1 GREENISH GRAY	SANDY LOAM
-10		5GY 5/1 GREENISH GRAY	SANDY LOAM
-15			BOTTOM OF WELL AT 14 FEET GRADES TO SANDY CLAY



SOIL BORING LOG
CLAYHILL FARMS



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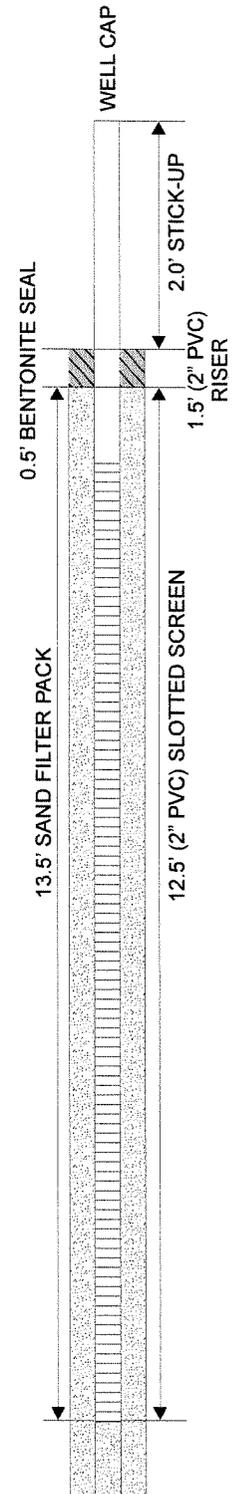
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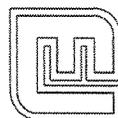
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 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/2/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: MARVYN

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 3/1 V. DK. GRAY	SANDY LOAM
		2.5Y 5/4 LT. OLIVE BRN.	SANDY LOAM, FEW ROOTS, LARGE INDISTINCT MOTTLES (10YR 2/2)
		2.5Y 7/6 YELLOW	SANDY CLAY LOAM, FEW FINE ROOTS
		2.5Y 7/2 LT. GRAY	SANDY LOAM, FINE INDISTINCT MOTTLES (10YR 6/6)
-5			
			WATER LEVEL: 10.96" BELOW TOP OF CASING.
-10			INDISTINCT MOTTLES, EVENTUALLY ALL ORANGE
			SANDY LOAM
-15		7.5YR 6/8 REDDISH YELLOW	BOTTOM OF WELL AT 14 FEET SANDY CLAY LOAM, 7.5YR 7/1 MOTTLES
		5GY 4/1 DK. GREENISH GRAY	SANDY CLAY



**SOIL BORING LOG
 CLAYHILL FARMS**



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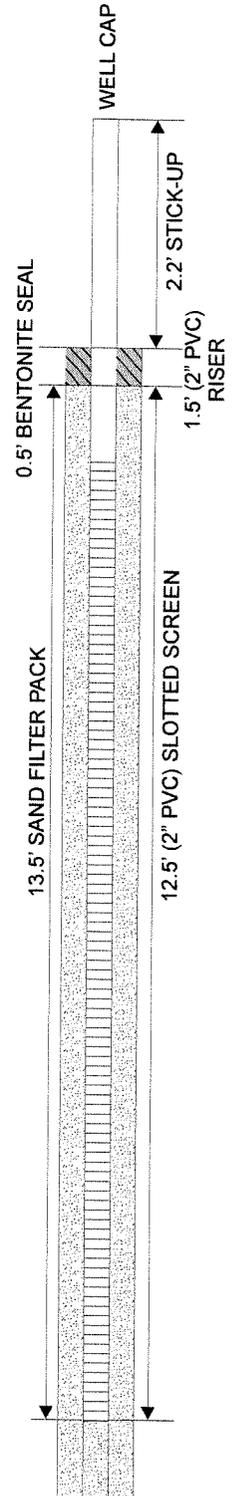
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VIRGINIA BEACH

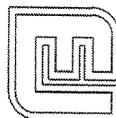
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WELL No: DMW-10
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/2/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: MARVYN

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		2.5Y 3/2 V.DK. GRAYISH BRN.	SANDY LOAM, ROOTS
		2.5Y 7/2 LT. GRAY	SANDY CLAY LOAM, MEDIUM INDISTINCT MOTTLES (10YR 2/2)
		2.5Y 6/4 LT. YELLOWISH BROWN	SANDY LOAM
-5		10YR 6/6 BROWNISH YELLOW	SANDY CLAY LOAM, SMALL INDISTINCT MOTTLES (10YR 5/1) STATIC WATER LEVEL: 10.96' BELOW TOP OF CASING.
-10		10YR 6/6 BROWNISH YELLOW	CLAY, LIGHT GRAY, LARGE INDISTINCT MOTTLES SANDY CLAY LOAM
			BOTTOM OF WELL AT 14 FEET
-15		10YR 6/6 BROWNISH YELLOW	SANDY LOAM



SOIL BORING LOG
 CLAYHILL FARMS



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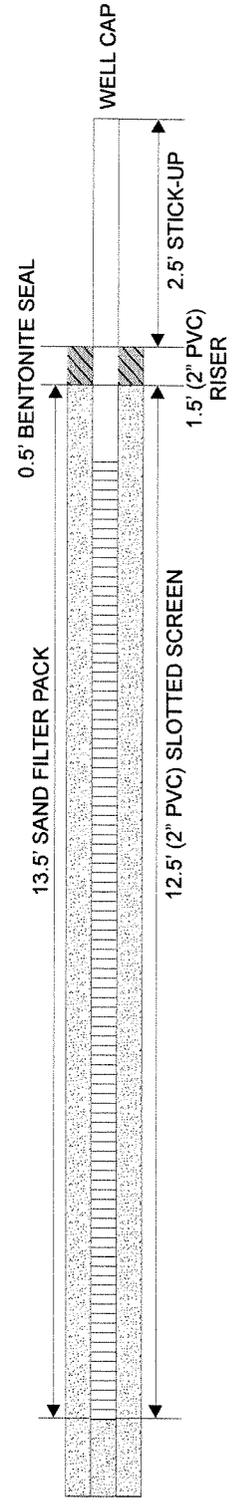
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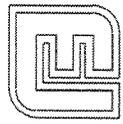
WILLIAMSBURG

WELL No: DMW-11
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/2/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: MARVYN

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/2 VY.DRK.BRN	SANDY LOAM, FEW ROOTS
		2.5Y 6/4 LT. YELLOWISH BROWN	SANDY CLAY LOAM
		10YR 6/4 LT. GRAY	SANDY CLAY, STRONG BROWN LARGE DISTINCT MOTTLES (7.5YR 5/8), FEW FINE ROOTS
			LOAMY SAND
-5			WATER LEVEL: 8.98' BELOW TOP OF CASING.
			SAND
-10		10YR 6/6 BROWNISH YELLOW	SANDY CLAY LOAM
			BOTTOM OF WELL AT 14 FEET
-15		5Y 4/1 DARK GREENISH GRAY	SANDY CLAY



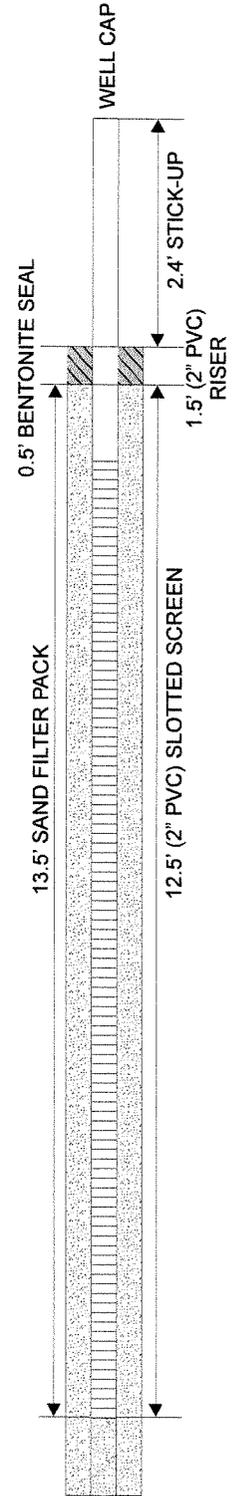
SOIL BORING LOG
CLAYHILL FARMS



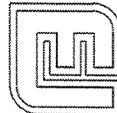
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 VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-12
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/2/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: MUCKALEE

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLK.	ORGANIC LAYER
		10YR 2/1 BLK.	LOAM, FINE ROOTS
		10YR 4/2 DARK GRAYISH BROWN	SANDY LOAM, VERY DARK BROWN, MEDIUM DISTINCT MOTTLES
			WATER LEVEL: 6.16' BELOW TOP OF CASING.
-5		10YR 6/1 GRAY	LOAMY SAND, LARGE DISTINCT GRAY MOTTLES (N 5/1)
-10		10YR 6/1 GRAY	SANDY CLAY
		10B 2.5/1 BLUISH BLACK	SANDY LOAM
-15		10B 2.5/1 BLUISH BLACK	BOTTOM OF WELL AT 14 FEET LOAMY SAND



**SOIL BORING LOG
 CLAYHILL FARMS**



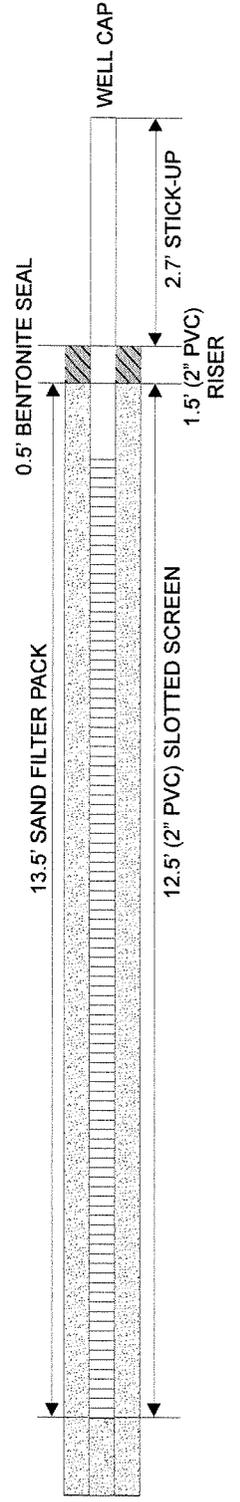
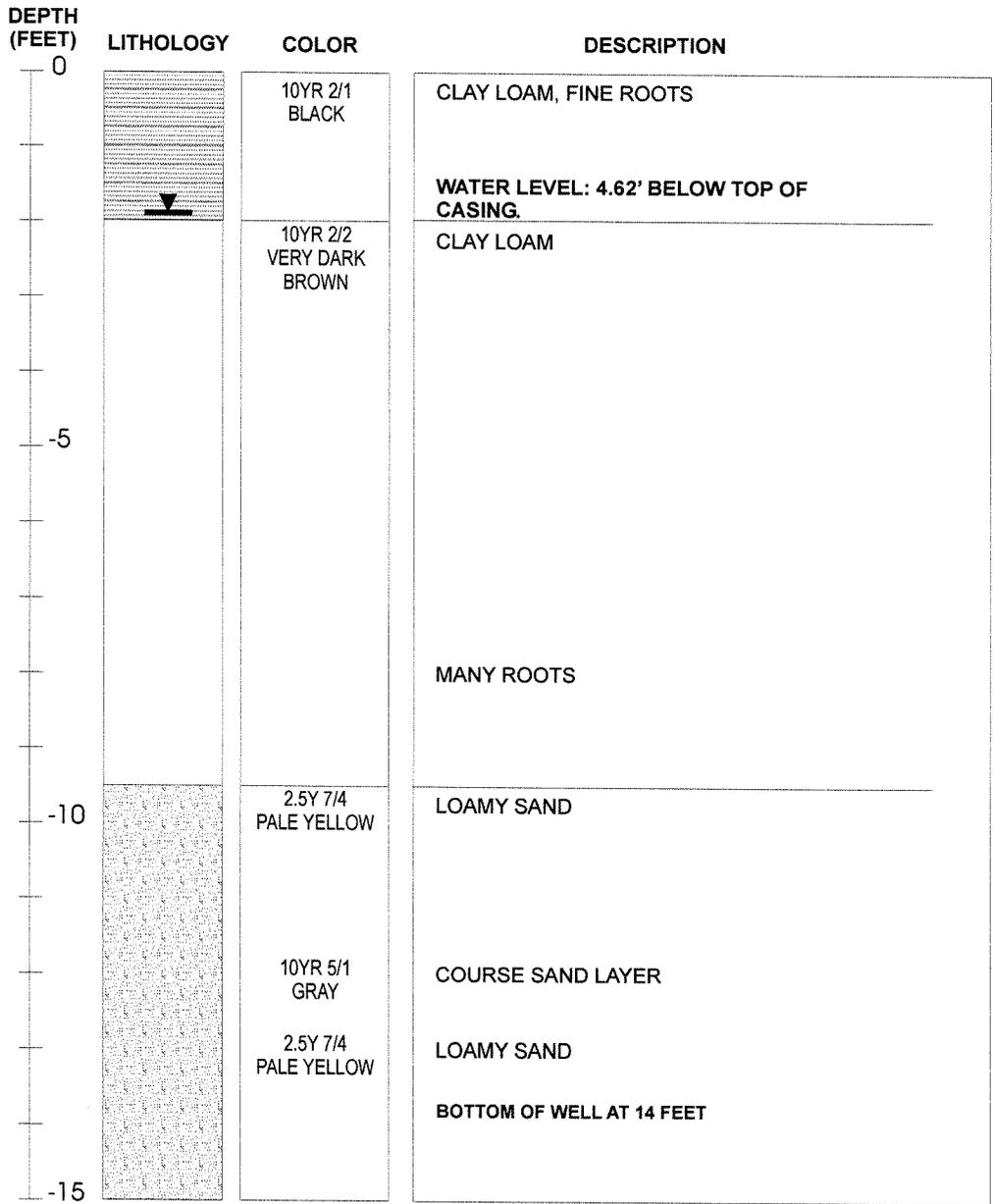
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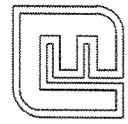
VIRGINIA BEACH

WILLIAMSBURG

WELL No: DMW-13
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/2/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: MARVYN



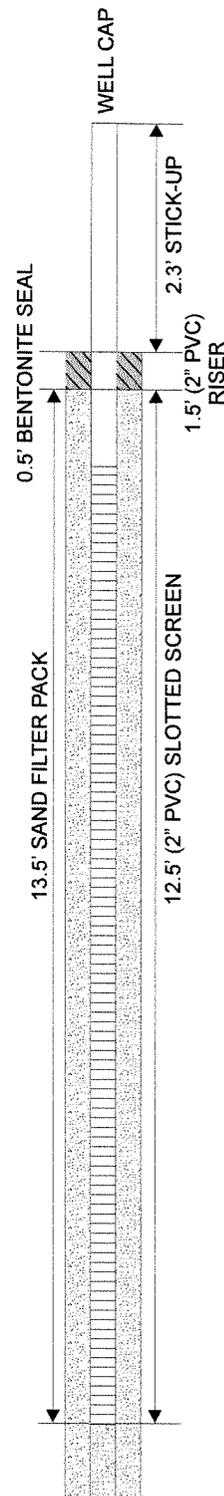
**SOIL BORING LOG
 CLAYHILL FARMS**



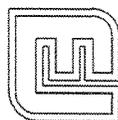
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 VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-14
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/2/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: MARVYN

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/2 V.DK.BRN	ORGANIC LAYER
		10YR 6/2 LT. BROWNISH GRAY	SANDY LOAM, OXIDIZED RHIZOSPHERE
		10YR 7/1 LT. GRAY	LOAMY SAND WATER LEVEL: 6.61' BELOW TOP OF CASING.
			COARSENING SAND COMPONENT
		10YR 6/8 BROWNISH YELLOW	LOAMY SAND
			BOTTOM OF WELL AT 14 FEET



SOIL BORING LOG
CLAYHILL FARMS



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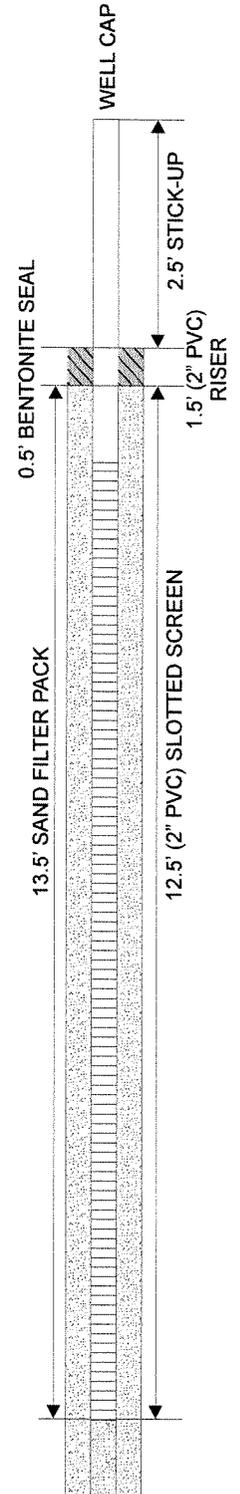
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VIRGINIA BEACH

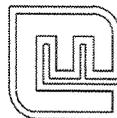
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WELL No: DMW-15
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/3/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: PANTEGO

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLACK	SANDY LOAM, FINE ROOTS COMMON
		10YR 5/2 GRAYISH BROWN	SANDY CLAY LOAM, FEW FINE ROOTS WATER LEVEL: 5.7' BELOW TOP OF CASING. GRADES TO LOAMY SAND
-10		10YR 5/1 GRAY	SANDY CLAY LOAM, VERY DARK GRAY, LARGE INDISINCT MOTTLES
-15		5GY 4/1 DARK GREENISH GRAY	SANDY CLAY, LARGE INDISTINCT MOTTLES (10B 3/1) BOTTOM OF WELL AT 14 FEET



**SOIL BORING LOG
 CLAYHILL FARMS**



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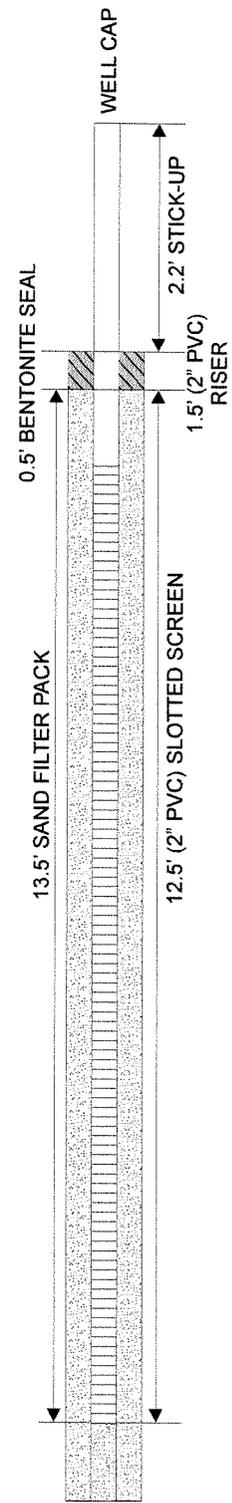
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VIRGINIA BEACH

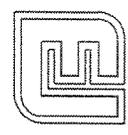
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 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/3/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: PANTEGO

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLACK	SANDY LOAM, COMMON ROOTS
		2.5Y 6/4 LT. YELLOWISH BROWN	SANDY CLAY LOAM, SMALL INDISTINCT MOTTLES (10YR 6/8)
		10YR 5/1 GRAY	STATIC WATER LEVEL: 4.46" BELOW TOP OF CASING. SANDY CLAY, LARGE INDISTINCT MOTTLES (10YR 6/8)
-5		7.5YR 4/1 DARK GRAY	LOAMY SAND
-10		10GY 3/1 DARK GREENISH GRAY	SANDY CLAY LOAM
-15			BOTTOM OF WELL AT 14 FEET



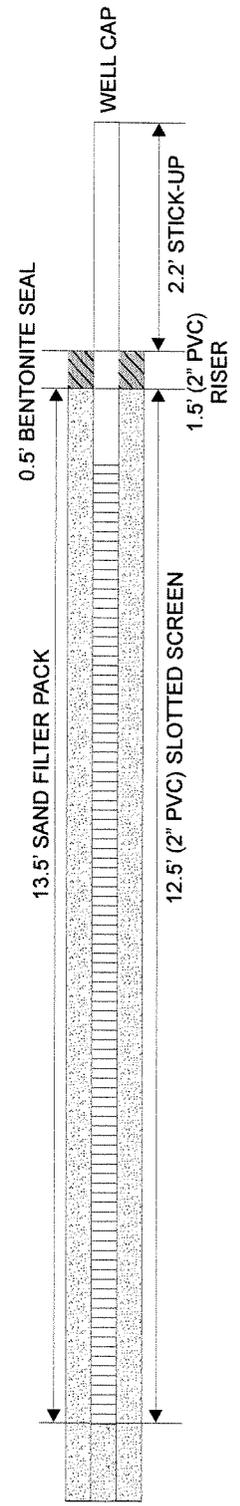
SOIL BORING LOG
CLAYHILL FARMS



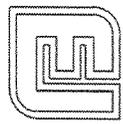
Langley and McDonald, P.C.
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 VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-17
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/3/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: PANTEGO

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLK.	LOAM
		2.5Y 6/2 LT. YELLOWISH BROWN	WATER LEVEL: 4.22" BELOW TOP OF CASING. SANDY LOAM, LARGE INDISTINCT COMMON MOTTLES (10YR 6/8)
-5		7.5YR 4/1 DARK GRAY	LOAMY SAND
-10		5Y 6/1 GRAY	LOAMY FINE SAND
		10G 4/1 DARK GREENISH GRAY	SANDY CLAY
			BOTTOM OF WELL AT 14 FEET
-15		N 5/1 GRAY	COURSE SAND



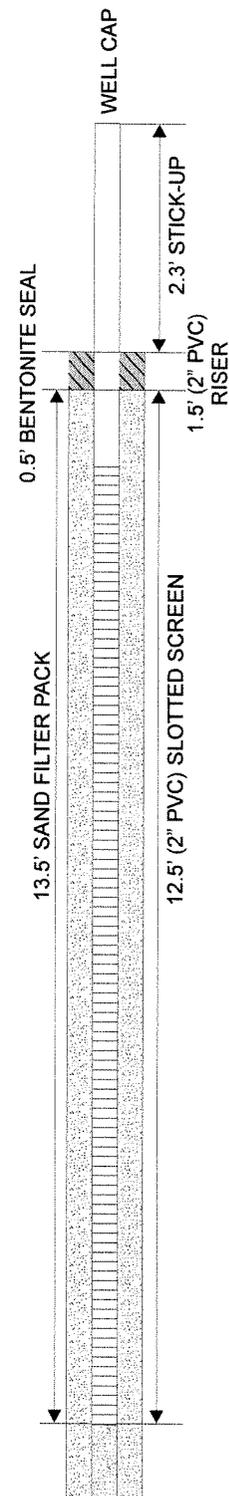
SOIL BORING LOG
CLAYHILL FARMS



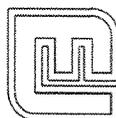
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 VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-18
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/3/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: ONSLOW

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLK.	LOAM
		10YR 5/2 GRAYISH BROWN	SANDY CLAY LOAM, BROWNISH YELLOW, MEDIUM INDISTINCT MOTTLES (10YR 6/8)
		7.5YR 5/3 BROWN	<p>WATER LEVEL: 6.01' BELOW TOP OF CASING.</p> LOAMY SAND
-5		7.5YR 5/3 BROWN	LOAMY SAND
-10		7.5YR 5/3 BROWN	LOAMY SAND. SOME DARK GRAY, LARGE INDISTINCT MOTTLES (N 4/1)
-15		10Y 3/1	SANDY CLAY LOAM BOTTOM OF WELL AT 14 FEET



SOIL BORING LOG
 CLAYHILL FARMS



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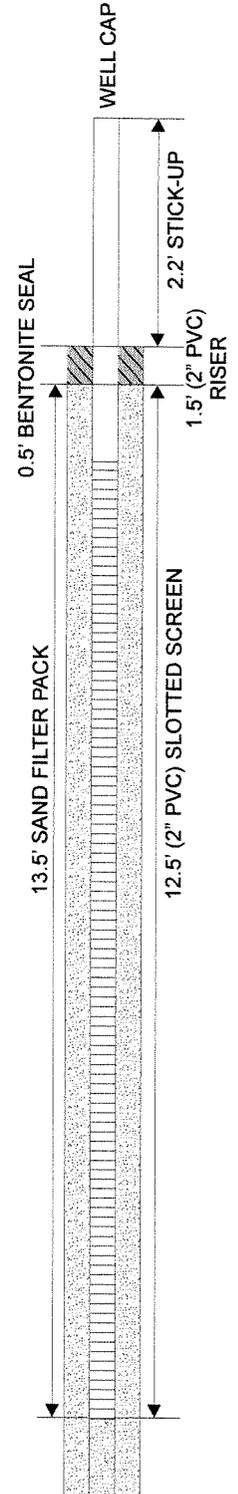
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VIRGINIA BEACH

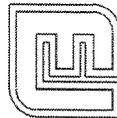
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 CLIENT: NCDOT
 DATE DRILLED: 2/3/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: TORHUNTA

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLACK	LOAM, COMMON ROOTS
			WATER LEVEL: 4.16' BELOW TOP OF CASING.
		2.5Y 6/2 LT. BROWNISH GRAY	SANDY LOAM, VERY DARK GRAYISH BROWN, LARGE INDISTINCT MOTTLES (10YR 3/2)
-5		2.5Y 6/2 LT. BROWNISH GRAY	LOAMY SAND
-10		10GY 2.5/1 DK. GREENISH GRAY	SANDY CLAY LOAM
-15		10GY 2.5/1	BOTTOM OF WELL AT 14 FEET SANDY CLAY LOAM



SOIL BORING LOG
CLAYHILL FARMS



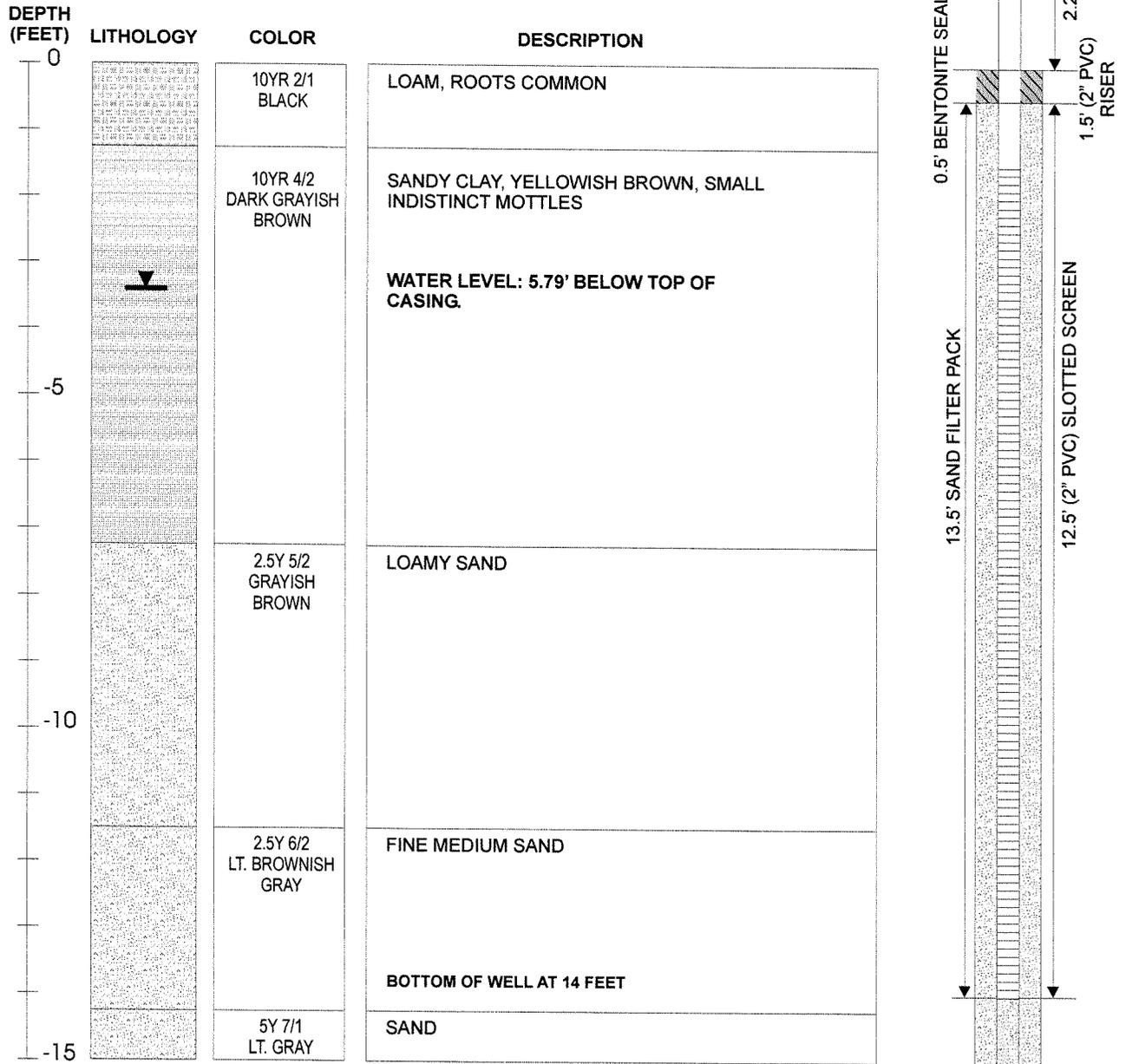
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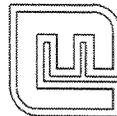
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WILLIAMSBURG

WELL No: DMW-20
 PROJECT: 1960024-203.00
 CLIENT: NCDOT
 DATE DRILLED: 2/3/99
 DRILLED BY: FISHBURNE DRILLING
 DRILLING METHOD: 4.25" ID HSA
 LOGGED BY: BCC
 SOIL TYPE: ONSLOW



**SOIL BORING LOG
 CLAYHILL FARMS**



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VIRGINIA BEACH

WILLIAMSBURG

APPENDIX B

NRCS PRIOR-CONVERTED CROPLAND DETERMINATION

12.20
PC
3
11.90
4
13.40
PC
5 8.50
PC
6 14.30
13.90
PC
7 14.70
13.90
PC
8
66.11
PC

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1128
1129

1
33
2
270

T1379
3
3.43

4
4.92

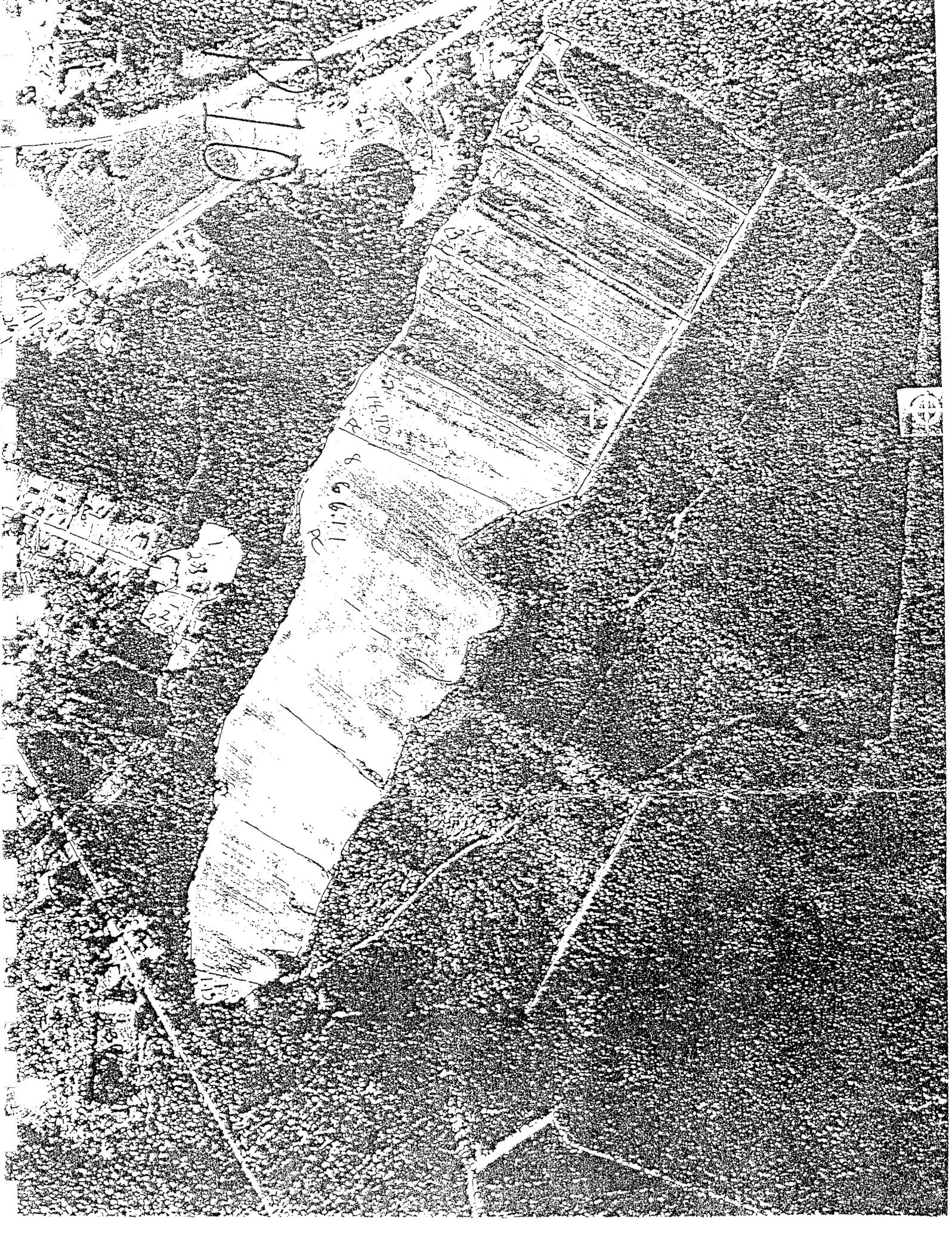
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of farm
6



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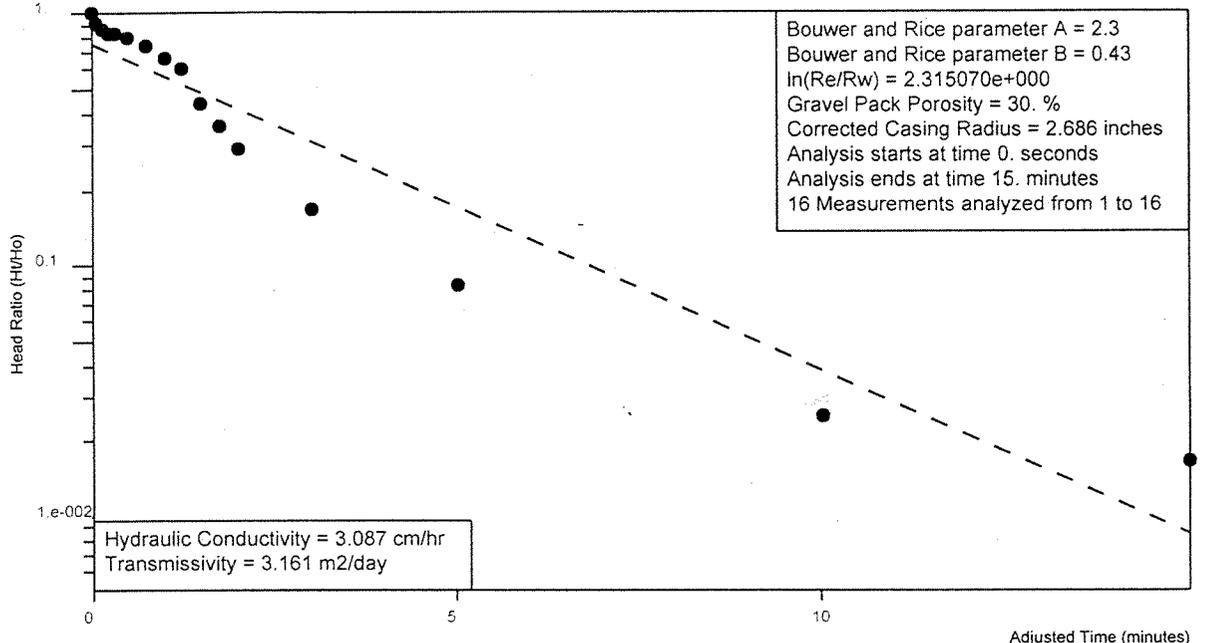


APPENDIX C

DRAINMOD & SURFACE WATER HYDROLOGY TECHNICAL APPENDIX

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-1



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

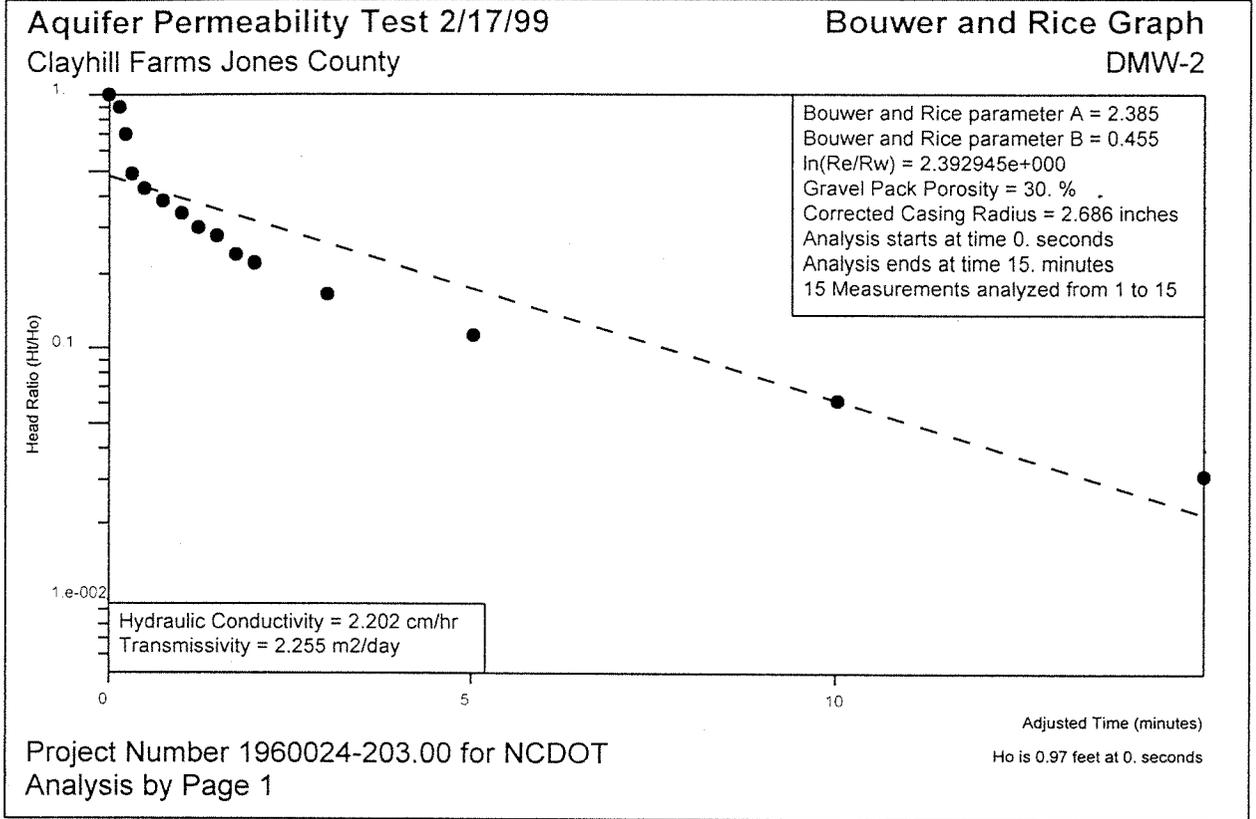
Ho is 1.2 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-1
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 3.05 feet
 Water Table to Screen Bottom: 10.95 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 16 time and drawdown measurements
 Maximum head is 1.2 feet
 Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	4.25	1.2	1.
2	8.3e-002	8.3e-002	4.15	1.1	0.9167
3	0.166	0.166	4.1	1.05	0.875
4	0.25	0.25	4.06	1.01	0.8417
5	0.333	0.333	4.05	1.	0.8333
6	0.5	0.5	4.01	0.96	0.8
7	0.75	0.75	3.94	0.89	0.7417
8	1.	1.	3.85	0.8	0.6667
9	1.25	1.25	3.78	0.73	0.6083
10	1.5	1.5	3.58	0.53	0.4417
11	1.75	1.75	3.48	0.43	0.3583
12	2.	2.	3.4	0.35	0.2917
13	3.	3.	3.25	0.2	0.1667
14	5.	5.	3.15	0.1	8.333e-002
15	10.	10.	3.08	3.e-002	2.5e-002
16	15.	15.	3.07	2.e-002	1.667e-002



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-2
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.88 feet
 Water Table to Screen Bottom: 12.22 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 0.97 feet

Minimum head is 0. feet

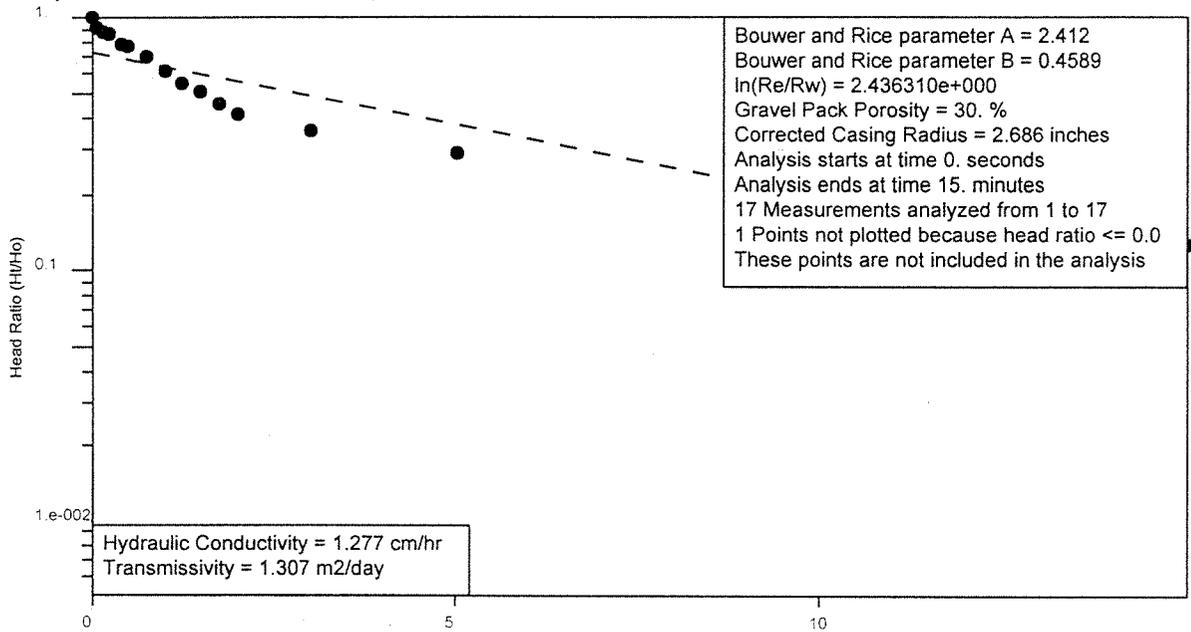
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.85	0.97	1.
2	0.166	0.166	5.76	0.88	0.9072
3	0.25	0.25	5.56	0.68	0.701
4	0.333	0.333	5.36	0.48	0.4948
5	0.5	0.5	5.3	0.42	0.433
6	0.75	0.75	5.25	0.37	0.3814
7	1.	1.	5.21	0.33	0.3402
8	1.25	1.25	5.17	0.29	0.299
9	1.5	1.5	5.15	0.27	0.2784
10	1.75	1.75	5.11	0.23	0.2371
11	2.	2.	5.09	0.21	0.2165
12	3.	3.	5.04	0.16	0.1649
13	5.	5.	4.99	0.11	0.1134
14	10.	10.	4.94	6.e-002	6.186e-002
15	15.	15.	4.91	3.e-002	3.093e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-3



Project Number 1960024-203.00 for NCDOT

Analysis by Page 1

Adjusted Time (minutes)

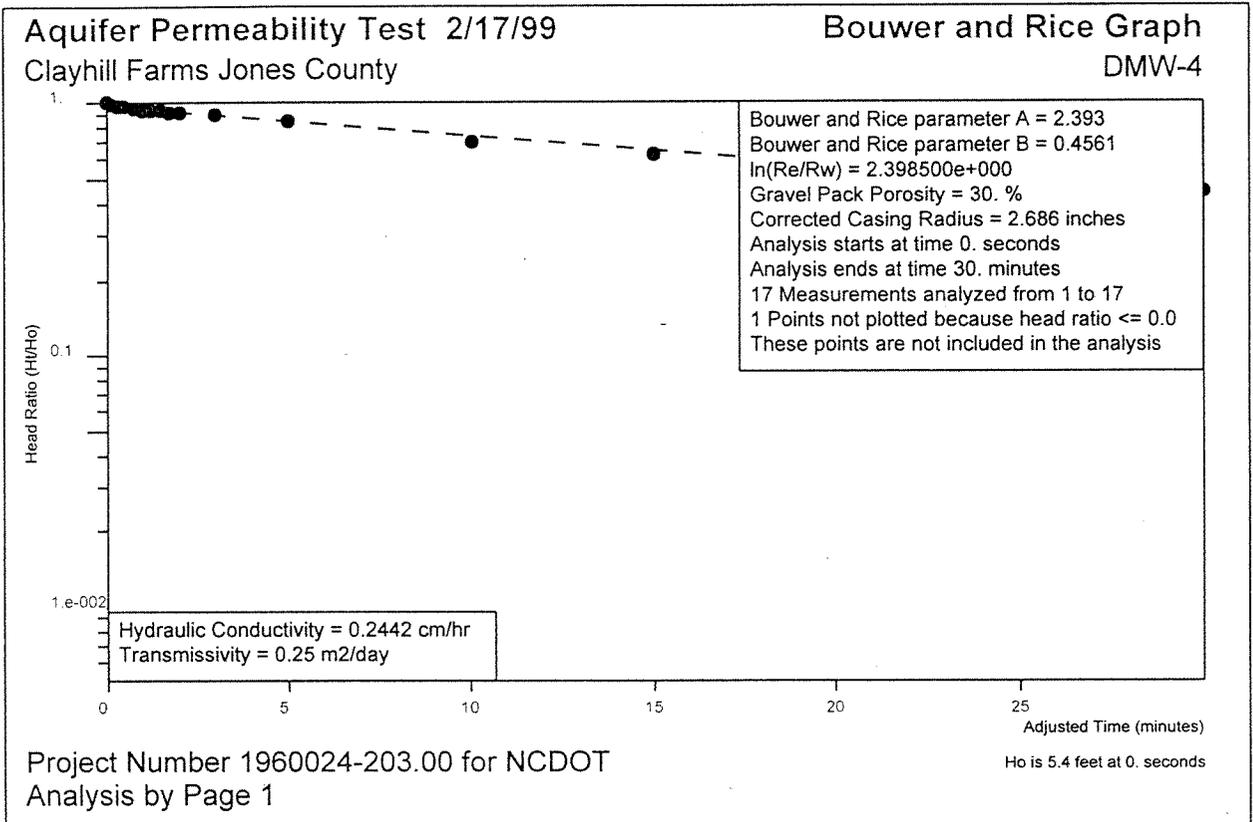
Ho is 4.9 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-3
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.88 feet
 Water Table to Screen Bottom: 12.72 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 17 time and drawdown measurements
 Maximum head is 4.9 feet
 Minimum head is -4.88 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	9.78	4.9	1.
2	8.3e-002	8.3e-002	9.36	4.48	0.9143
3	0.166	0.166	9.25	4.37	0.8918
4	0.25	0.25	9.1	4.22	0.8612
5	0.416	0.416	8.76	3.88	0.7918
6	0.5	0.5	8.64	3.76	0.7673
7	0.75	0.75	8.32	3.44	0.702
8	1.	1.	7.93	3.05	0.6224
9	1.25	1.25	7.6	2.72	0.5551
10	1.33	1.33	0.	-4.88	-0.9959
11	1.5	1.5	7.39	2.51	0.5122
12	1.75	1.75	7.1	2.22	0.4531
13	2.	2.	6.93	2.05	0.4184
14	3.	3.	6.63	1.75	0.3571
15	5.	5.	6.31	1.43	0.2918
16	10.	10.	5.82	0.94	0.1918
17	15.	15.	5.5	0.62	0.1265



Aquifer Permeability Test

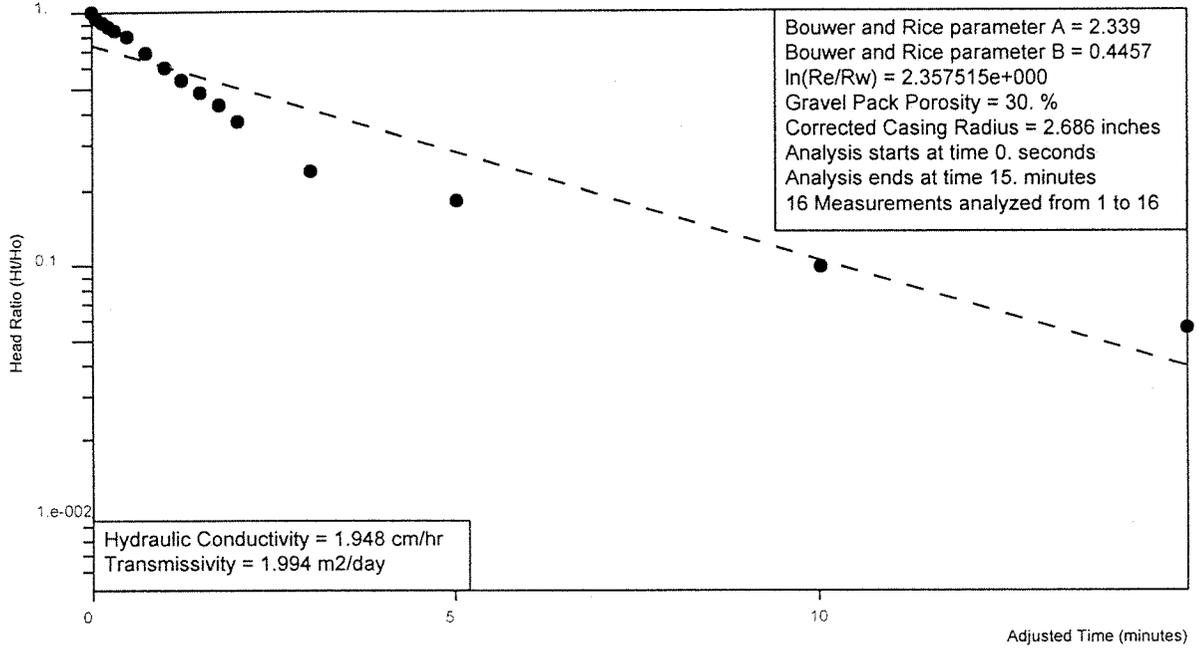
Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-4
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 3.8 feet
 Water Table to Screen Bottom: 12.3 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 17 time and drawdown measurements
 Maximum head is 5.4 feet
 Minimum head is -3.8 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	9.2	5.4	1.
2	0.166	0.166	9.12	5.32	0.9852
3	0.25	0.25	0.	-3.8	-0.7037
4	0.333	0.333	9.06	5.26	0.9741
5	0.5	0.5	9.01	5.21	0.9648
6	0.75	0.75	8.95	5.15	0.9537
7	1.	1.	8.9	5.1	0.9444
8	1.25	1.25	8.86	5.06	0.937
9	1.5	1.5	8.81	5.01	0.9278
10	1.75	1.75	8.77	4.97	0.9204
11	2.	2.	8.73	4.93	0.913
12	3.	3.	8.69	4.89	0.9056
13	5.	5.	8.39	4.59	0.85
14	10.	10.	7.62	3.82	0.7074
15	15.	15.	7.2	3.4	0.6296
16	20.	20.	6.84	3.04	0.563
17	30.	30.	6.2	2.4	0.4444

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-5



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 5.77 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-5
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.43 feet
 Water Table to Screen Bottom: 11.67 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

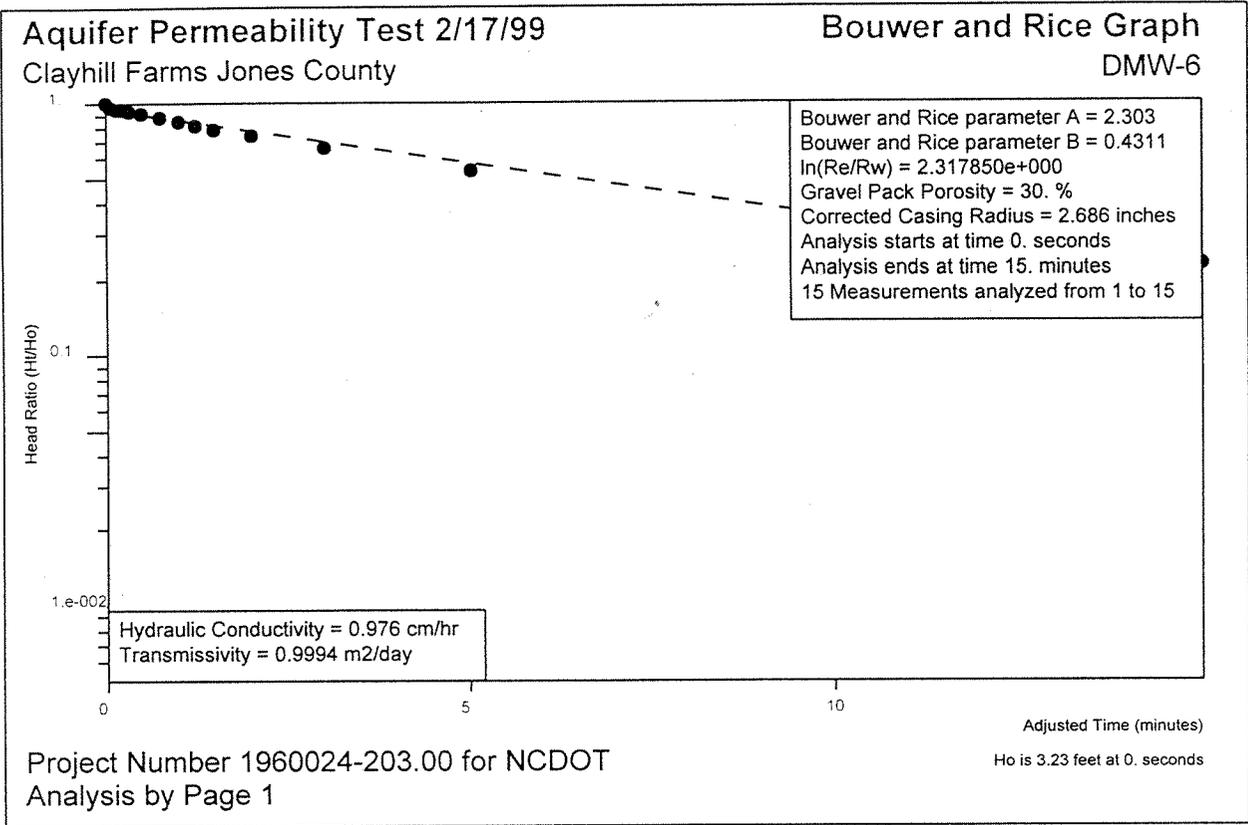
Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 5.77 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	10.2	5.77	1.
2	8.3e-002	8.3e-002	9.98	5.55	0.9619
3	0.166	0.166	9.7	5.27	0.9133
4	0.25	0.25	9.5	5.07	0.8787
5	0.333	0.333	9.3	4.87	0.844
6	0.5	0.5	9.04	4.61	0.799
7	0.75	0.75	8.41	3.98	0.6898
8	1.	1.	7.93	3.5	0.6066
9	1.25	1.25	7.53	3.1	0.5373
10	1.5	1.5	7.2	2.77	0.4801
11	1.75	1.75	6.9	2.47	0.4281
12	2.	2.	6.56	2.13	0.3692
13	3.	3.	5.79	1.36	0.2357
14	5.	5.	5.48	1.05	0.182
15	10.	10.	5.	0.57	9.879e-002
16	15.	15.	4.75	0.32	5.546e-002

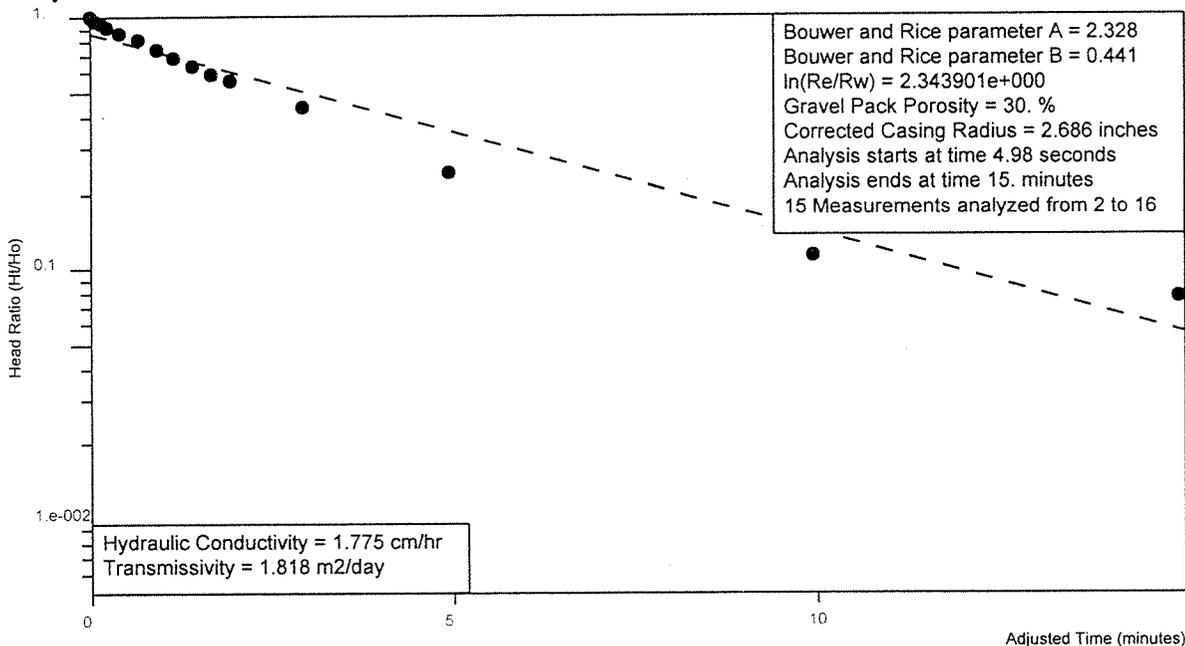


Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-7



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.68 feet at 4.98 seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-7
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.85 feet
 Water Table to Screen Bottom: 11.45 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 4.98 Seconds

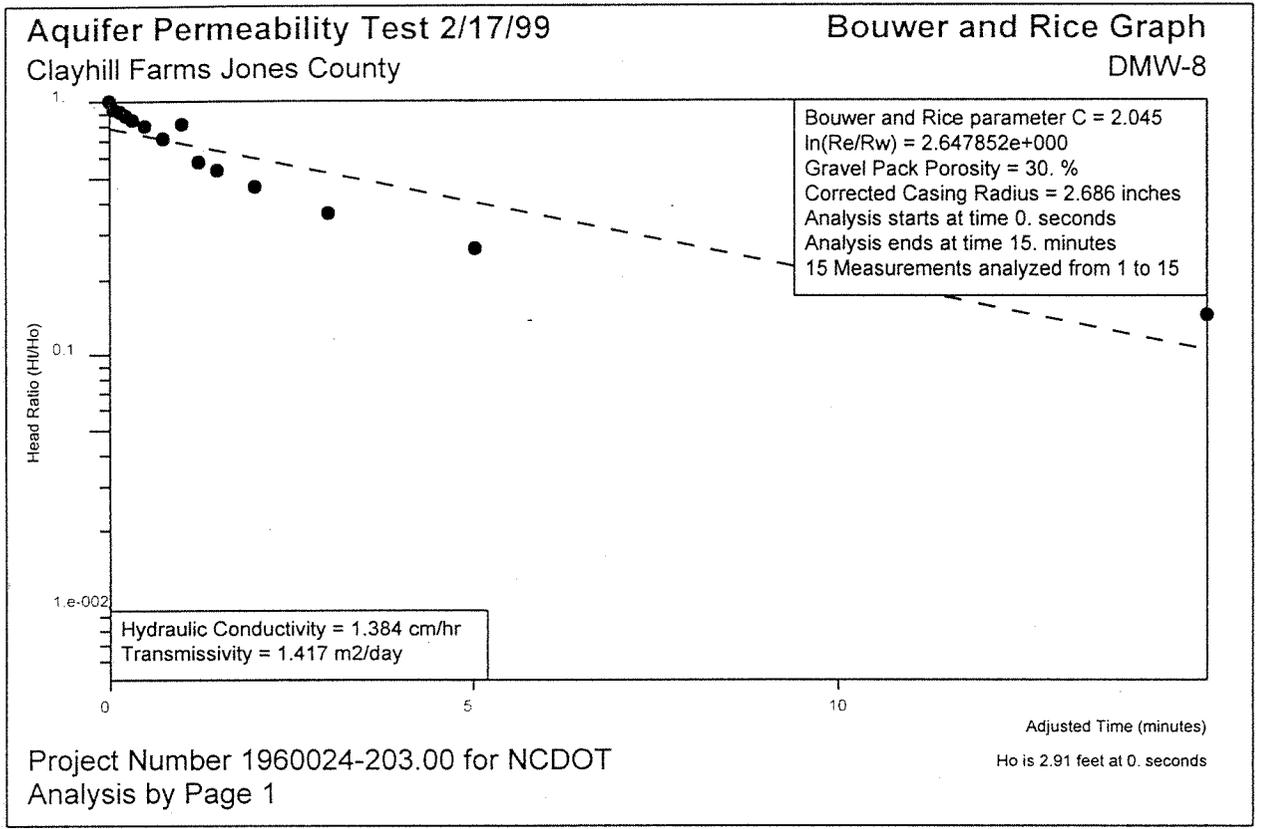
Test starts with trial 1

There are 16 time and drawdown measurements

Maximum head is 1.68 feet

Minimum head is -4.85 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-4.85	-2.887
2	8.3e-002	0.	6.53	1.68	1.
3	0.166	8.3e-002	6.49	1.64	0.9762
4	0.25	0.167	6.45	1.6	0.9524
5	0.333	0.25	6.38	1.53	0.9107
6	0.5	0.417	6.32	1.47	0.875
7	0.75	0.667	6.22	1.37	0.8155
8	1.	0.917	6.1	1.25	0.744
9	1.25	1.167	6.02	1.17	0.6964
10	1.5	1.417	5.93	1.08	0.6429
11	1.75	1.667	5.85	1.	0.5952
12	2.	1.917	5.8	0.95	0.5655
13	3.	2.917	5.59	0.74	0.4405
14	5.	4.917	5.25	0.4	0.2381
15	10.	9.917	5.04	0.19	0.1131
16	15.	14.92	4.98	0.13	7.738e-002



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-8
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 2.59 feet
 Water Table to Screen Bottom: 13.31 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

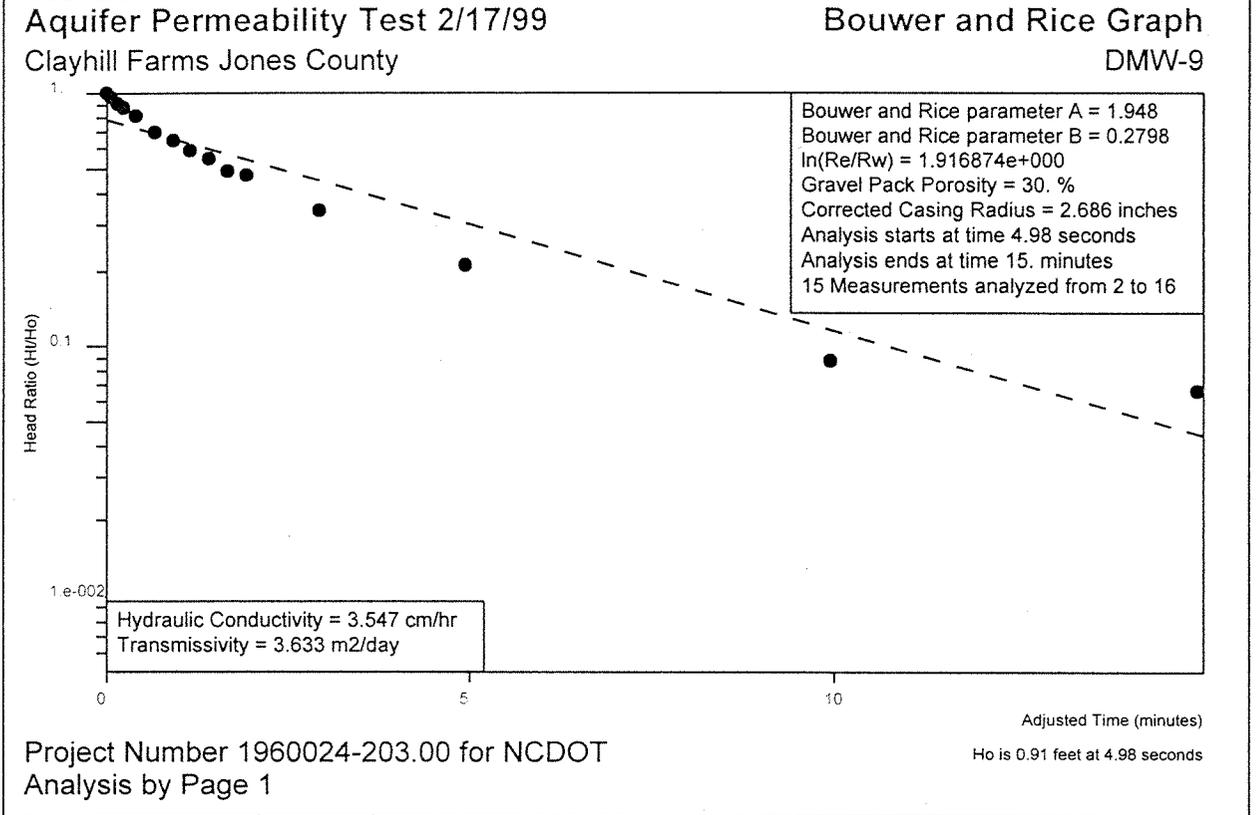
Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 2.91 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.5	2.91	1.
2	8.3e-002	8.3e-002	5.32	2.73	0.9381
3	0.166	0.166	5.25	2.66	0.9141
4	0.25	0.25	5.18	2.59	0.89
5	0.333	0.333	5.09	2.5	0.8591
6	0.5	0.5	4.92	2.33	0.8007
7	0.75	0.75	4.69	2.1	0.7216
8	1.	1.	4.98	2.39	0.8213
9	1.25	1.25	4.3	1.71	0.5876
10	1.5	1.5	4.16	1.57	0.5395
11	2.	2.	3.93	1.34	0.4605
12	3.	3.	3.65	1.06	0.3643
13	5.	5.	3.36	0.77	0.2646
14	10.	10.	3.12	0.53	0.1821
15	15.	15.	3.01	0.42	0.1443

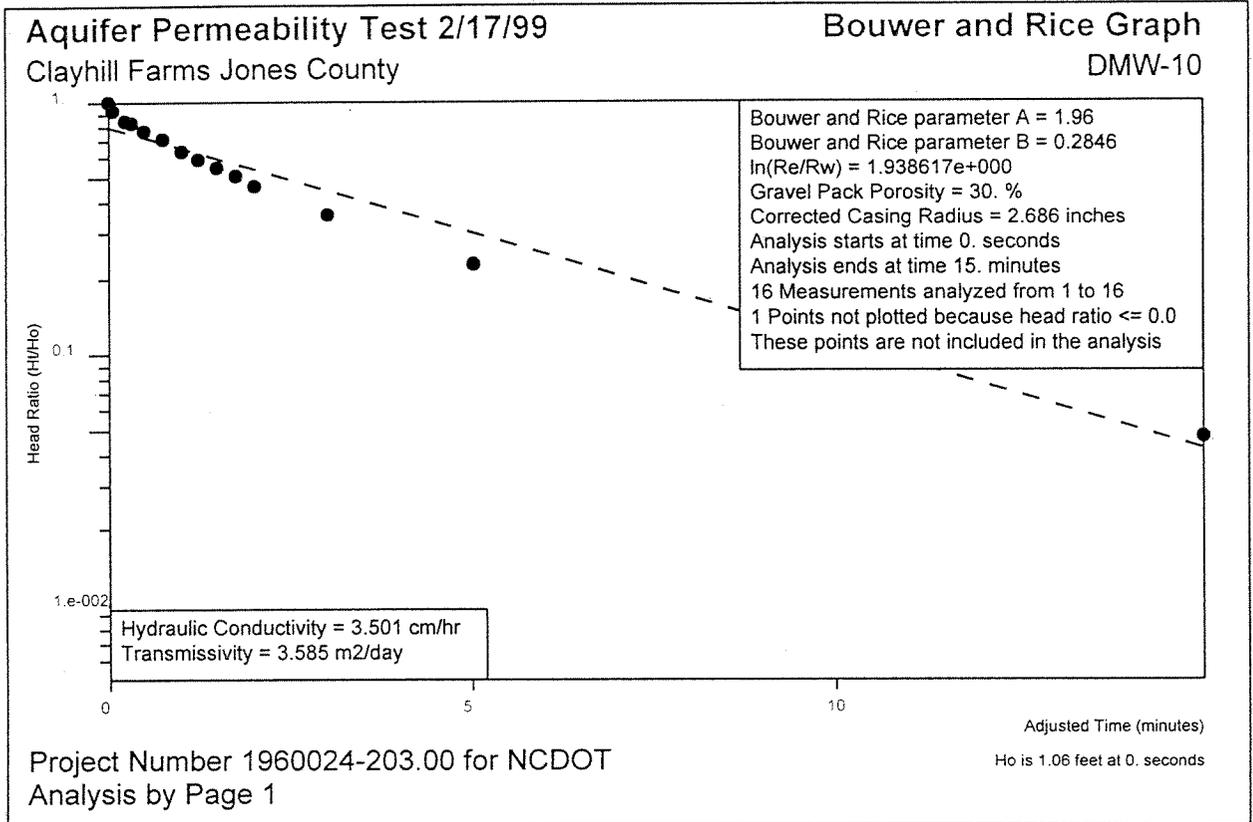


Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-9
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 10.96 feet
 Water Table to Screen Bottom: 5.04 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 4.98 Seconds
 Test starts with trial 1
 There are 16 time and drawdown measurements
 Maximum head is 0.91 feet
 Minimum head is -10.96 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-10.96	-12.04
2	8.3e-002	0.	11.87	0.91	1.
3	0.166	8.3e-002	11.84	0.88	0.967
4	0.25	0.167	11.8	0.84	0.9231
5	0.333	0.25	11.77	0.81	0.8901
6	0.5	0.417	11.7	0.74	0.8132
7	0.75	0.667	11.6	0.64	0.7033
8	1.	0.917	11.55	0.59	0.6484
9	1.25	1.167	11.5	0.54	0.5934
10	1.5	1.417	11.46	0.5	0.5495
11	1.75	1.667	11.41	0.45	0.4945
12	2.	1.917	11.39	0.43	0.4725
13	3.	2.917	11.27	0.31	0.3407
14	5.	4.917	11.15	0.19	0.2088
15	10.	9.917	11.04	8.e-002	8.791e-002
16	15.	14.92	11.02	6.e-002	6.593e-002



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-10
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 10.96 feet
 Water Table to Screen Bottom: 5.24 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

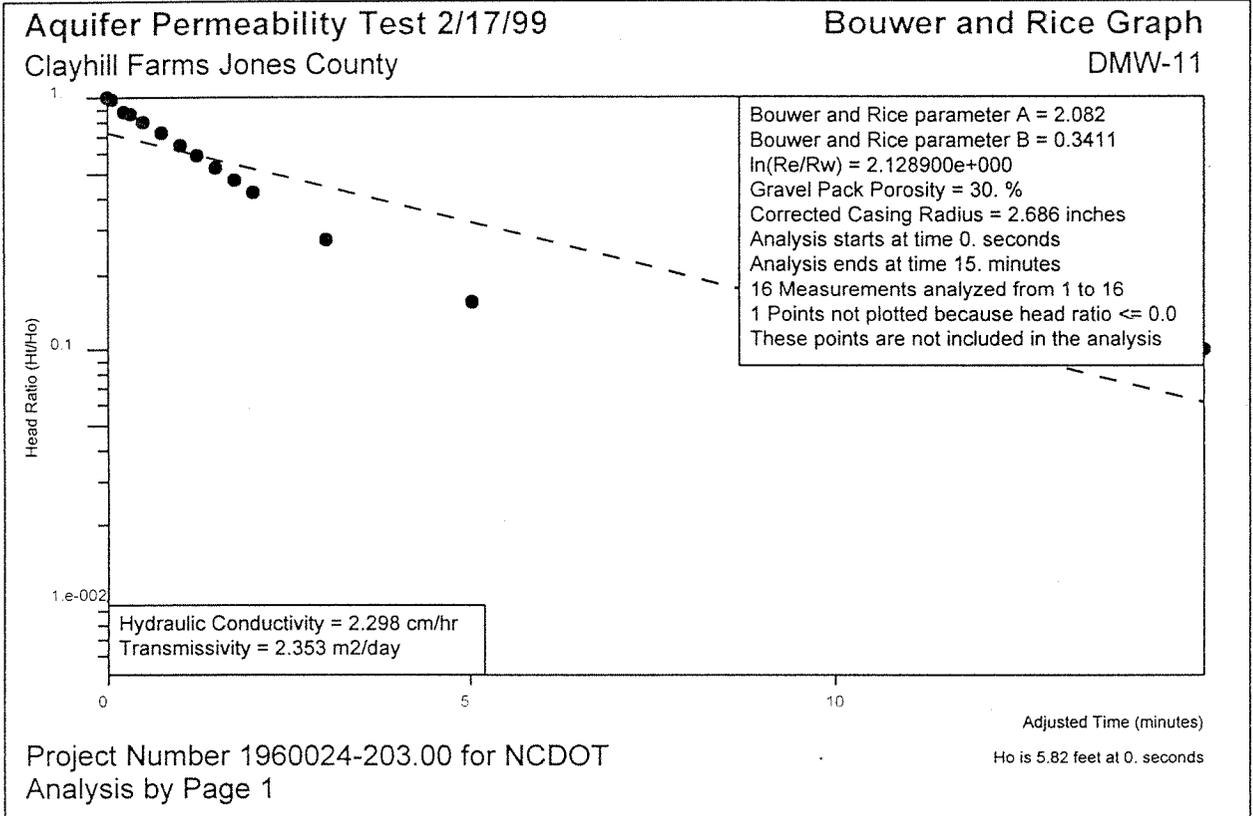
Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.06 feet

Minimum head is -6.e-002 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	12.02	1.06	1.
2	8.3e-002	8.3e-002	11.96	1.	0.9434
3	0.166	0.166	10.9	-6.e-002	-5.66e-002
4	0.25	0.25	11.86	0.9	0.8491
5	0.333	0.333	11.84	0.88	0.8302
6	0.5	0.5	11.78	0.82	0.7736
7	0.75	0.75	11.72	0.76	0.717
8	1.	1.	11.64	0.68	0.6415
9	1.25	1.25	11.59	0.63	0.5943
10	1.5	1.5	11.54	0.58	0.5472
11	1.75	1.75	11.5	0.54	0.5094
12	2.	2.	11.45	0.49	0.4623
13	3.	3.	11.34	0.38	0.3585
14	5.	5.	11.2	0.24	0.2264
15	10.	10.	11.09	0.13	0.1226
16	15.	15.	11.01	5.e-002	4.717e-002



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-11
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 8.98 feet
 Water Table to Screen Bottom: 7.52 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

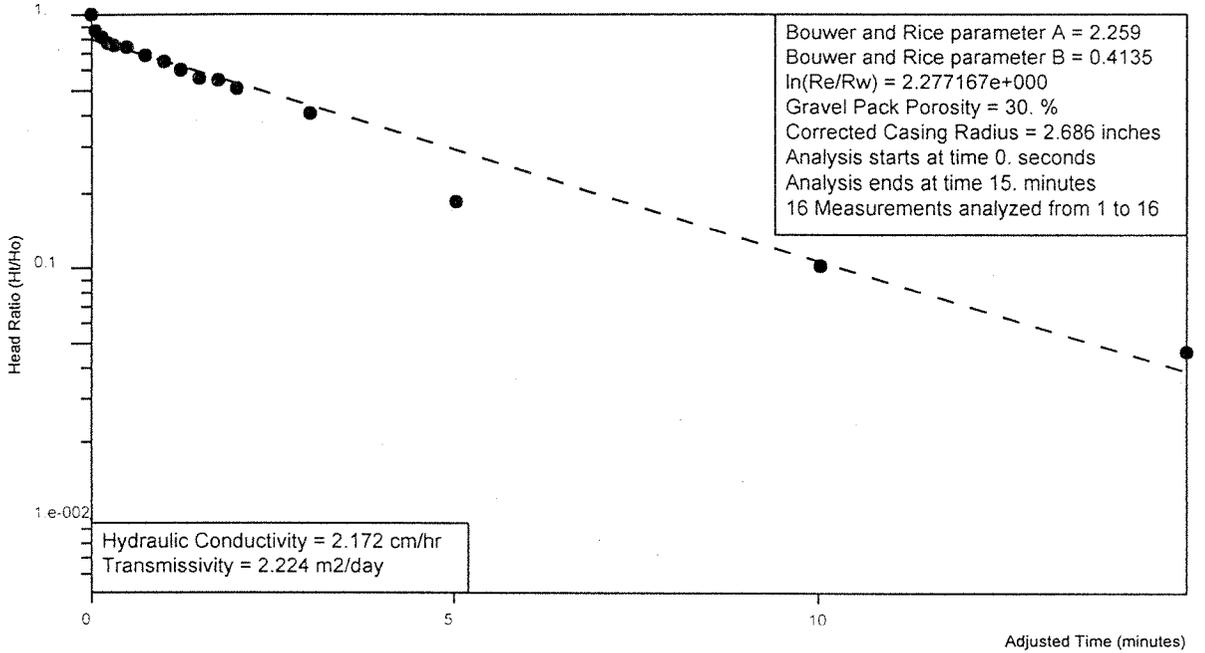
Maximum head is 5.82 feet

Minimum head is -8.98 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	14.8	5.82	1.
2	8.3e-002	8.3e-002	14.72	5.74	0.9863
3	0.166	0.166	0.	-8.98	-1.543
4	0.25	0.25	14.15	5.17	0.8883
5	0.333	0.333	14.	5.02	0.8625
6	0.5	0.5	13.67	4.69	0.8058
7	0.75	0.75	13.2	4.22	0.7251
8	1.	1.	12.75	3.77	0.6478
9	1.25	1.25	12.46	3.48	0.5979
10	1.5	1.5	12.08	3.1	0.5326
11	1.75	1.75	11.76	2.78	0.4777
12	2.	2.	11.45	2.47	0.4244
13	3.	3.	10.58	1.6	0.2749
14	5.	5.	9.89	0.91	0.1564
15	10.	10.	9.68	0.7	0.1203
16	15.	15.	9.56	0.58	9.966e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-12



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.08 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-12
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 6.16 feet
 Water Table to Screen Bottom: 10.24 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

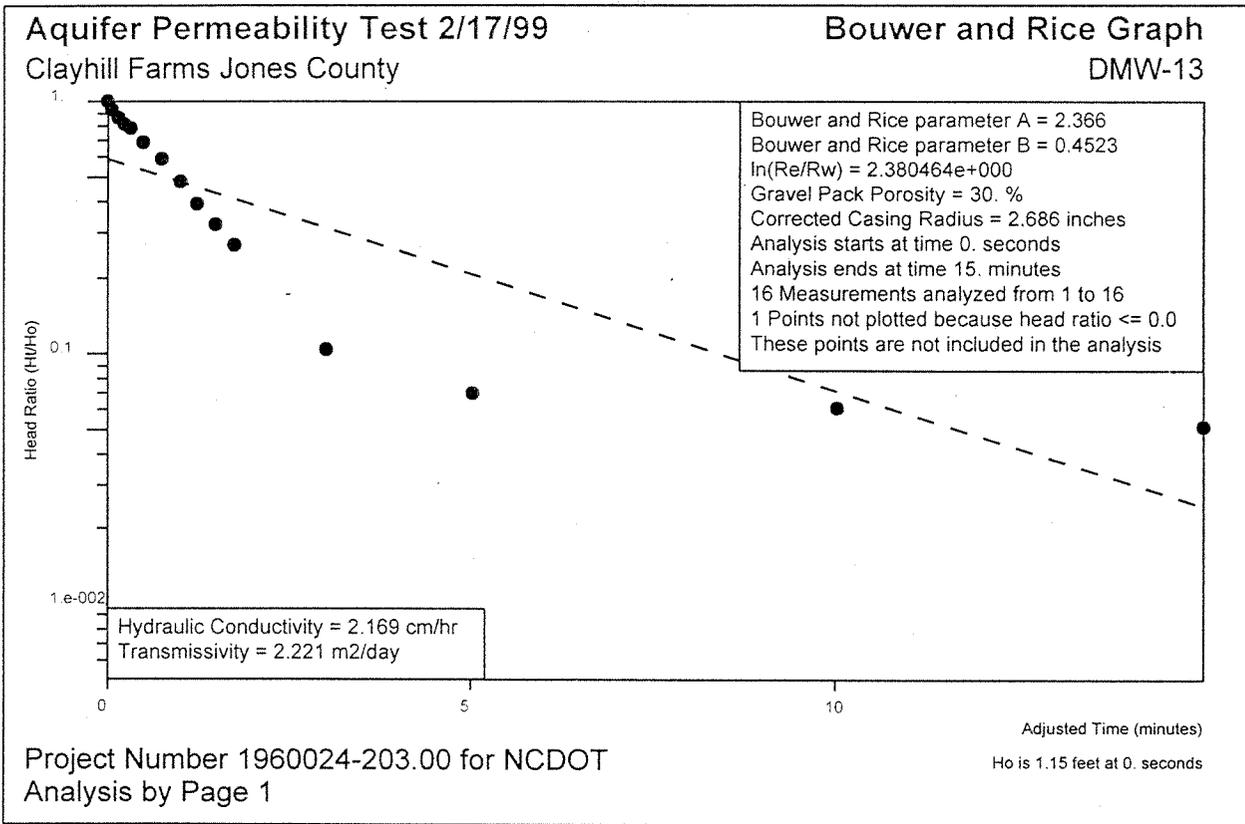
Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.08 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.24	1.08	1.
2	8.3e-002	8.3e-002	7.09	0.93	0.8611
3	0.166	0.166	7.05	0.89	0.8241
4	0.25	0.25	7.	0.84	0.7778
5	0.333	0.333	6.98	0.82	0.7593
6	0.5	0.5	6.96	0.8	0.7407
7	0.75	0.75	6.91	0.75	0.6944
8	1.	1.	6.86	0.7	0.6481
9	1.25	1.25	6.82	0.66	0.6111
10	1.5	1.5	6.77	0.61	0.5648
11	1.75	1.75	6.75	0.59	0.5463
12	2.	2.	6.71	0.55	0.5093
13	3.	3.	6.6	0.44	0.4074
14	5.	5.	6.36	0.2	0.1852
15	10.	10.	6.27	0.11	0.1019
16	15.	15.	6.21	5.e-002	4.63e-002



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-13
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.62 feet
 Water Table to Screen Bottom: 12.03 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 16 time and drawdown measurements
 Maximum head is 1.15 feet
 Minimum head is -4.62 feet

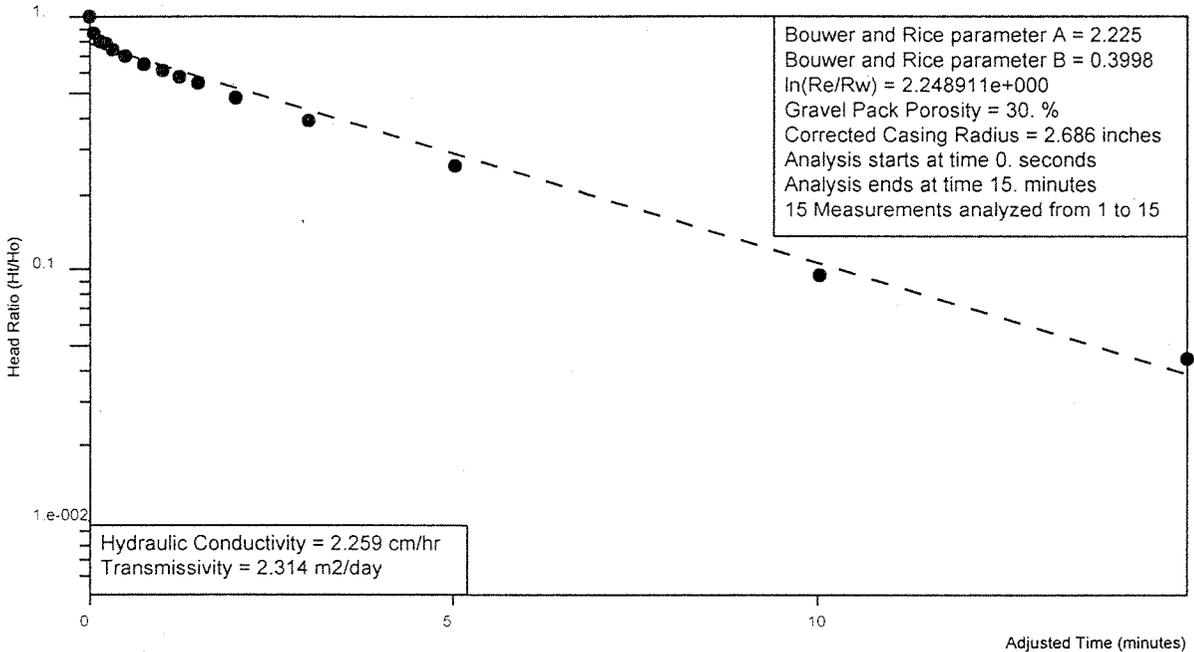
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.77	1.15	1.
2	8.3e-002	8.3e-002	5.7	1.08	0.9391
3	0.166	0.166	5.61	0.99	0.8609
4	0.25	0.25	5.57	0.95	0.8261
5	0.333	0.333	5.52	0.9	0.7826
6	0.5	0.5	5.41	0.79	0.687
7	0.75	0.75	5.3	0.68	0.5913
8	1.	1.	5.17	0.55	0.4783
9	1.25	1.25	5.07	0.45	0.3913
10	1.5	1.5	4.99	0.37	0.3217
11	1.75	1.75	4.93	0.31	0.2696
12	2.	2.	0.	-4.62	-4.017
13	3.	3.	4.74	0.12	0.1043
14	5.	5.	4.7	8.e-002	6.957e-002
15	10.	10.	4.69	7.e-002	6.087e-002
16	15.	15.	4.68	6.e-002	5.217e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-14



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.79 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-14
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 6.61 feet
 Water Table to Screen Bottom: 9.69 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

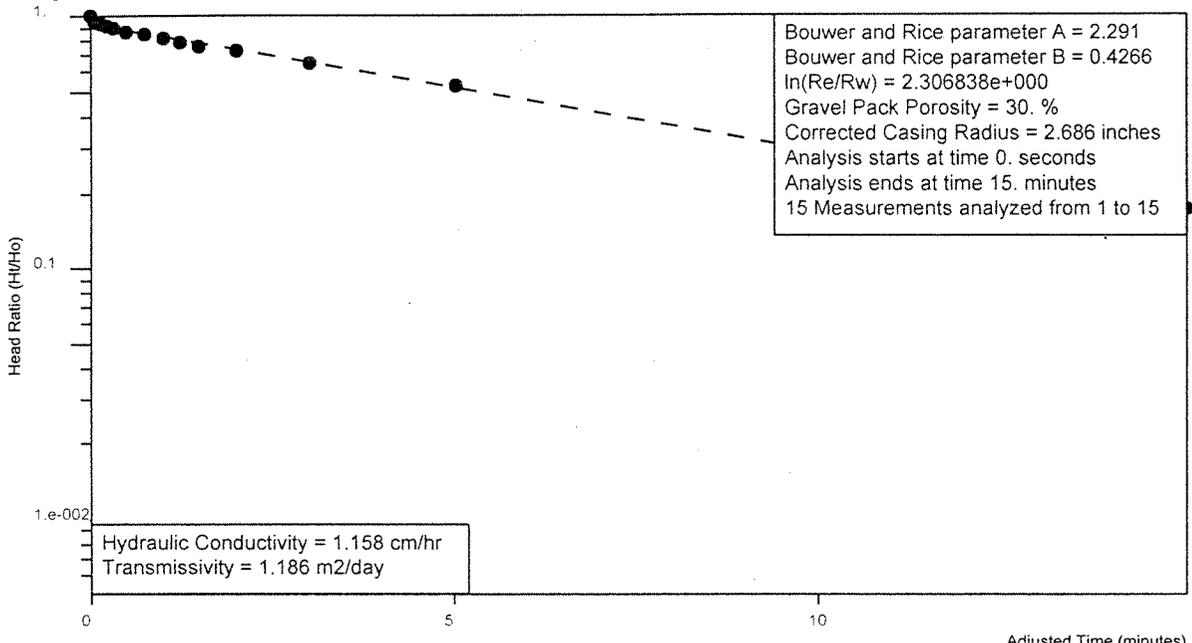
Maximum head is 1.79 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	8.4	1.79	1.
2	8.3e-002	8.3e-002	8.16	1.55	0.8659
3	0.166	0.166	8.06	1.45	0.8101
4	0.25	0.25	8.01	1.4	0.7821
5	0.333	0.333	7.95	1.34	0.7486
6	0.5	0.5	7.87	1.26	0.7039
7	0.75	0.75	7.78	1.17	0.6536
8	1.	1.	7.71	1.1	0.6145
9	1.25	1.25	7.65	1.04	0.581
10	1.5	1.5	7.59	0.98	0.5475
11	2.	2.	7.48	0.87	0.486
12	3.	3.	7.31	0.7	0.3911
13	5.	5.	7.07	0.46	0.257
14	10.	10.	6.78	0.17	9.497e-002
15	15.	15.	6.69	8.e-002	4.469e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-15



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.5 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-15
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 5.7 feet
 Water Table to Screen Bottom: 10.8 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

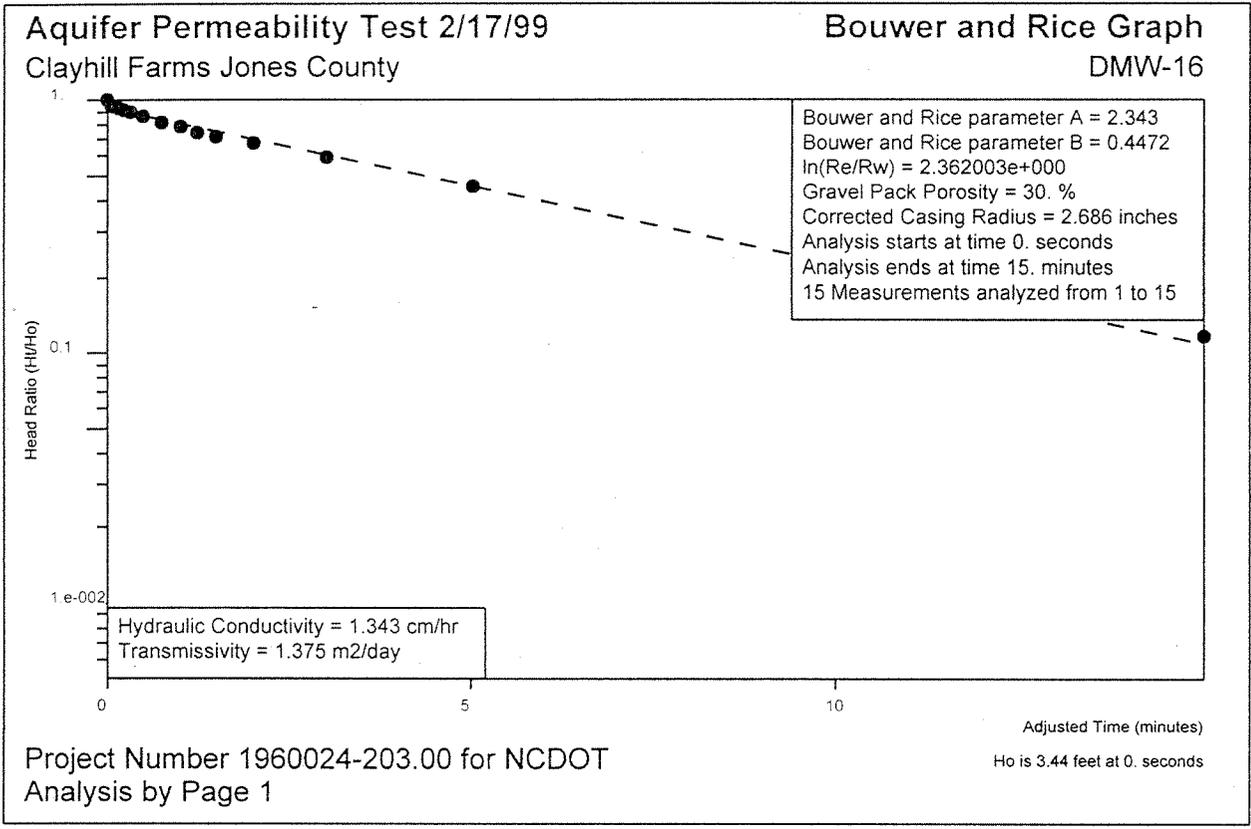
Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 1.5 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.2	1.5	1.
2	8.3e-002	8.3e-002	7.13	1.43	0.9533
3	0.166	0.166	7.1	1.4	0.9333
4	0.25	0.25	7.07	1.37	0.9133
5	0.333	0.333	7.05	1.35	0.9
6	0.5	0.5	7.01	1.31	0.8733
7	0.75	0.75	6.97	1.27	0.8467
8	1.	1.	6.92	1.22	0.8133
9	1.25	1.25	6.88	1.18	0.7867
10	1.5	1.5	6.84	1.14	0.76
11	2.	2.	6.79	1.09	0.7267
12	3.	3.	6.68	0.98	0.6533
13	5.	5.	6.49	0.79	0.5267
14	10.	10.	6.1	0.4	0.2667
15	15.	15.	5.96	0.26	0.1733



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-16
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.46 feet
 Water Table to Screen Bottom: 11.74 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

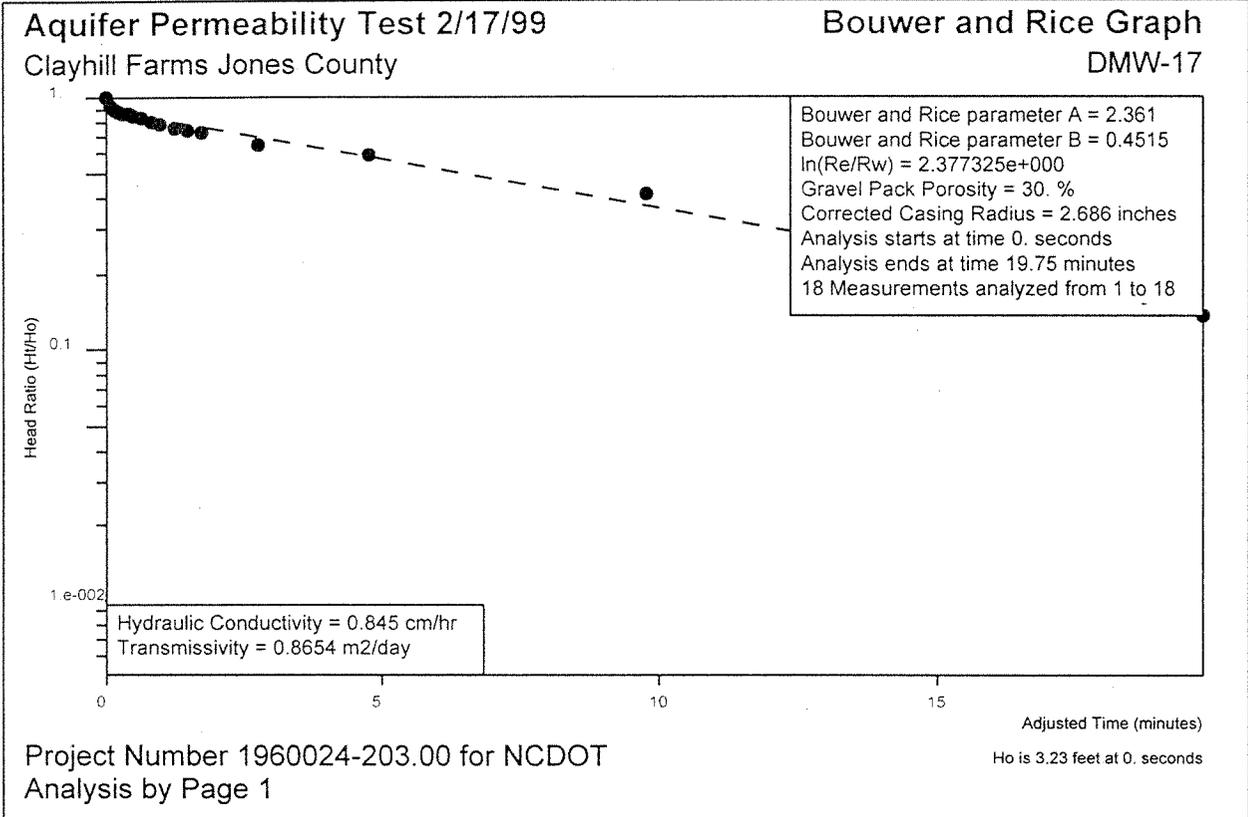
Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 3.44 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.9	3.44	1.
2	8.3e-002	8.3e-002	7.75	3.29	0.9564
3	0.166	0.166	7.66	3.2	0.9302
4	0.25	0.25	7.61	3.15	0.9157
5	0.333	0.333	7.55	3.09	0.8983
6	0.5	0.5	7.43	2.97	0.8634
7	0.75	0.75	7.29	2.83	0.8227
8	1.	1.	7.17	2.71	0.7878
9	1.25	1.25	7.04	2.58	0.75
10	1.5	1.5	6.94	2.48	0.7209
11	2.	2.	6.78	2.32	0.6744
12	3.	3.	6.5	2.04	0.593
13	5.	5.	6.03	1.57	0.4564
14	10.	10.	5.16	0.7	0.2035
15	15.	15.	4.86	0.4	0.1163



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-17
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.22 feet
 Water Table to Screen Bottom: 11.98 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 18 time and drawdown measurements

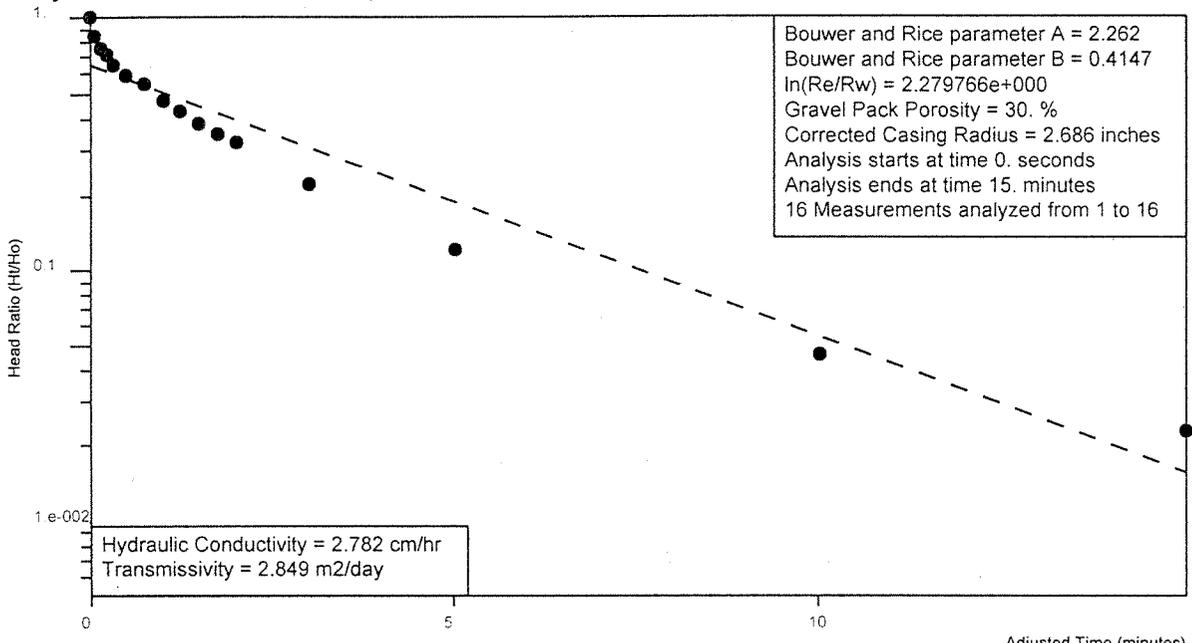
Maximum head is 3.23 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.45	3.23	1.
2	8.3e-002	8.3e-002	7.22	3.	0.9288
3	0.166	0.166	7.15	2.93	0.9071
4	0.25	0.25	7.09	2.87	0.8885
5	0.333	0.333	7.03	2.81	0.87
6	0.416	0.416	7.	2.78	0.8607
7	0.5	0.5	6.95	2.73	0.8452
8	0.666	0.666	6.9	2.68	0.8297
9	0.833	0.833	6.82	2.6	0.805
10	1.	1.	6.76	2.54	0.7864
11	1.25	1.25	6.69	2.47	0.7647
12	1.5	1.5	6.62	2.4	0.743
13	1.75	1.75	6.58	2.36	0.7307
14	2.75	2.75	6.35	2.13	0.6594
15	4.75	4.75	6.15	1.93	0.5975
16	9.75	9.75	5.55	1.33	0.4118
17	14.75	14.75	5.04	0.82	0.2539
18	19.75	19.75	4.66	0.44	0.1362

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-18



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.74 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-18
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 6.01 feet
 Water Table to Screen Bottom: 10.29 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.74 feet

Minimum head is 0. feet

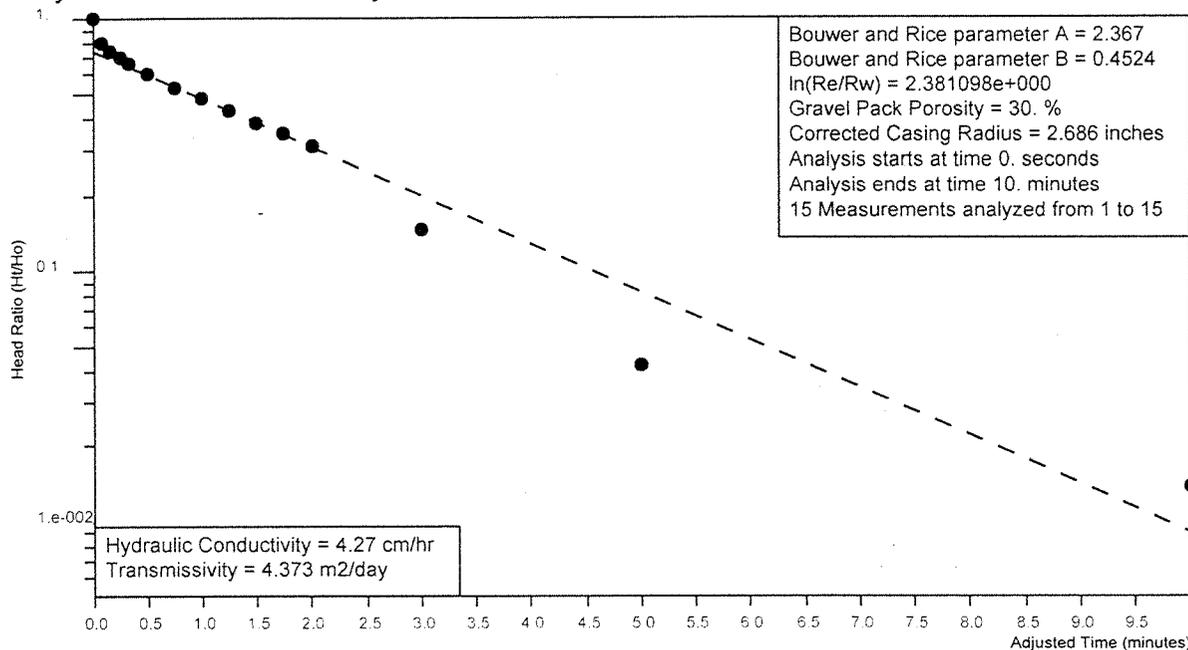
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.75	1.74	1.
2	8.3e-002	8.3e-002	7.5	1.49	0.8563
3	0.166	0.166	7.33	1.32	0.7586
4	0.25	0.25	7.25	1.24	0.7126
5	0.333	0.333	7.15	1.14	0.6552
6	0.5	0.5	7.04	1.03	0.592
7	0.75	0.75	6.96	0.95	0.546
8	1.	1.	6.84	0.83	0.477
9	1.25	1.25	6.76	0.75	0.431
10	1.5	1.5	6.68	0.67	0.3851
11	1.75	1.75	6.62	0.61	0.3506
12	2.	2.	6.57	0.56	0.3218
13	3.	3.	6.4	0.39	0.2241
14	5.	5.	6.22	0.21	0.1207
15	10.	10.	6.09	8.e-002	4.598e-002
16	15.	15.	6.05	4.e-002	2.299e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-19



Project Number 1960024-203.00 for NCDOT

Analysis by Page 1

Ho is 1.44 feet at 0. seconds

Aquifer Permeability Test

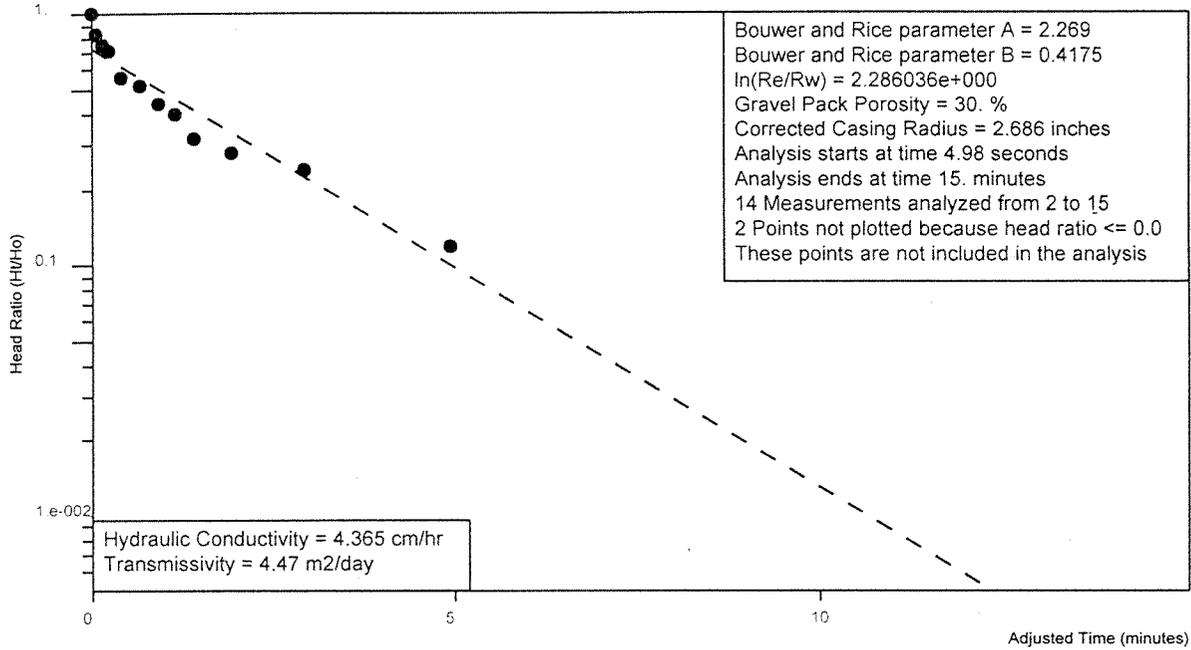
Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-19
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.16 feet
 Water Table to Screen Bottom: 12.04 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 15 time and drawdown measurements
 Maximum head is 1.44 feet
 Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.6	1.44	1.
2	8.3e-002	8.3e-002	5.31	1.15	0.7986
3	0.166	0.166	5.24	1.08	0.75
4	0.25	0.25	5.18	1.02	0.7083
5	0.333	0.333	5.12	0.96	0.6667
6	0.5	0.5	5.03	0.87	0.6042
7	0.75	0.75	4.93	0.77	0.5347
8	1.	1.	4.85	0.69	0.4792
9	1.25	1.25	4.78	0.62	0.4306
10	1.5	1.5	4.71	0.55	0.3819
11	1.75	1.75	4.66	0.5	0.3472
12	2.	2.	4.61	0.45	0.3125
13	3.	3.	4.37	0.21	0.1458
14	5.	5.	4.22	6.e-002	4.167e-002
15	10.	10.	4.18	2.e-002	1.389e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-20



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 0.25 feet at 4.98 seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-20
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 5.79 feet
 Water Table to Screen Bottom: 10.41 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 4.98 Seconds
 Test starts with trial 1
 There are 15 time and drawdown measurements
 Maximum head is 0.25 feet
 Minimum head is -5.79 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-5.79	-23.16
2	8.3e-002	0.	6.04	0.25	1.
3	0.166	8.3e-002	6.	0.21	0.84
4	0.25	0.167	5.98	0.19	0.76
5	0.333	0.25	5.97	0.18	0.72
6	0.5	0.417	5.93	0.14	0.56
7	0.75	0.667	5.92	0.13	0.52
8	1.	0.917	5.9	0.11	0.44
9	1.25	1.167	5.89	1.e-001	0.4
10	1.5	1.417	5.87	8.e-002	0.32
11	2.	1.917	5.86	7.e-002	0.28
12	3.	2.917	5.85	6.e-002	0.24
13	5.	4.917	5.82	3.e-002	0.12
14	10.	9.917	5.79	0.	0.
15	15.	14.92	5.79	0.	0.

Pantego Surface Storage Plot - 1 (PP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	23.5	3.3
2	21.7	1.5
3	25.9	5.7
4	24.7	4.5
5	25.7	5.5
6	23.0	2.8
7	24.0	3.8
8	25.3	5.1
9	22.0	1.8
10	21.4	1.2
11	21.0	0.8
12	21.8	1.6
13	25.0	4.8
14	25.5	5.3
15	23.5	3.3
16	23.7	3.5
17	25.3	5.1
18	24.0	3.8
19	22.0	1.8
20	25.0	4.8
21	26.2	6.0
22	26.8	6.6
23	27.4	7.2
24	26.9	6.7
25	25.2	5.0
26	22.4	2.2
27	23.2	3.0
28	22.7	2.5
29	24.9	4.7
30	20.2	0.0
31	21.7	1.5
32	20.4	0.2
33	23.7	3.5
34	23.0	2.8
35	22.7	2.5
36	23.7	3.5
37	24.9	4.7
38	23.9	3.7
39	26.5	6.3
40	26.0	5.8

max

min

Avg. = 3.71

Pantego Surface Storage Plot - 2 (PP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	23.5	5.3
2	24.7	6.5
3	25.9	7.7
4	25.4	7.2
5	25.5	7.3
6	22.6	4.4
7	24.7	6.5
8	23.9	5.7
9	25.2	7.0
10	25.6	7.4
11	26.5	8.3
12	25.0	6.8
13	23.0	4.8
14	18.2	0.0
15	22.8	4.6
16	26.5	8.3
17	25.5	7.3
18	26.2	8.0
19	28.7	10.5
20	29.4	11.2
21	29.8	11.6
22	26.9	8.7
23	28.6	10.4
24	29.5	11.3
25	26.5	8.3
26	28.8	10.6
27	27.2	9.0
28	28.0	9.8
29	25.9	7.7
30	27.3	9.1
31	25.7	7.5
32	26.4	8.2
33	25.4	7.2
34	23.9	5.7
35	23.5	5.3
36	23.0	4.8
37	22.5	4.3
38	23.0	4.8
39	23.6	5.4
40	25.0	6.8

min

max

Avg. = 7.28

Torhunta Surface Storage Plot - 1 (TP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	23.1	5.5
2	23.6	6.0
3	22.3	4.7
4	21.8	4.2
5	22.8	5.2
6	20.4	2.8
7	23.4	5.8
8	19.1	1.5
9	23.5	5.9
10	19.8	2.2
11	19.1	1.5
12	23.0	5.4
13	22.8	5.2
14	26.2	8.6
15	17.6	0.0
16	24.6	7.0
17	22.2	4.6
18	23.1	5.5
19	23.0	5.4
20	24.2	6.6
21	21.6	4.0
22	23.5	5.9
23	24.4	6.8
24	22.8	5.2
25	21.9	4.3
26	21.2	3.6
27	23.3	5.7
28	24.1	6.5
29	18.8	1.2
30	24.3	6.7
31	23.1	5.5
32	25.3	7.7
33	22.4	4.8
34	24.8	7.2
35	25.6	8.0
36	26.2	8.6
37	22.7	5.1
38	21.5	3.9
39	20.9	3.3
40	23.6	6.0

max
min

max

Avg. = 5.09

Torhunta Surface Storage Plot - 2 (TP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	28.0	7.6
2	25.0	4.6
3	24.6	4.2
4	26.4	6.0
5	26.0	5.6
6	25.0	4.6
7	22.9	2.5
8	20.4	0.0
9	23.0	2.6
10	22.5	2.1
11	23.6	3.2
12	20.8	0.4
13	25.1	4.7
14	25.0	4.6
15	25.0	4.6
16	22.8	2.4
17	25.6	5.2
18	25.4	5.0
19	29.7	9.3
20	26.5	6.1
21	26.5	6.1
22	24.0	3.6
23	26.7	6.3
24	27.0	6.6
25	27.0	6.6
26	24.1	3.7
27	26.4	6.0
28	29.3	8.9
29	27.4	7.0
30	24.3	3.9
31	28.0	7.6
32	28.5	8.1
33	25.6	5.2
34	29.0	8.6
35	29.5	9.1
36	26.5	6.1
37	28.0	7.6
38	28.4	8.0
39	28.7	8.3
40	24.9	4.5

min

max

Avg. = 5.43

Onslow Surface Storage Plot - 1 (OP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	23.8	3.1
2	24.6	3.9
3	26.9	6.2
4	26.2	5.5
5	24.5	3.8
6	23.7	3.0
7	25.1	4.4
8	25.6	4.9
9	25.6	4.9
10	26.4	5.7
11	26.5	5.8
12	22.9	2.2
13	26.3	5.6
14	28.2	7.5
15	29.4	8.7
16	27.4	6.7
17	26.2	5.5
18	27.5	6.8
19	28.4	7.7
20	25.9	5.2
21	26.7	6.0
22	24.8	4.1
23	24.2	3.5
24	23.2	2.5
25	23.1	2.4
26	23.0	2.3
27	20.9	0.2
28	24.1	3.4
29	24.2	3.5
30	21.4	0.7
31	24.5	3.8
32	23.6	2.9
33	21.4	0.7
34	20.7	0.0
35	21.2	0.5
36	22.4	1.7
37	23.1	2.4
38	25.5	4.8
39	24.4	3.7
40	24.0	3.3

max

min

Avg. = 3.99

Onslow Surface Storage Plot - 2 (OP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	20.0	1.4
2	20.5	1.9
3	20.5	1.9
4	20.0	1.4
5	19.4	0.8
6	21.2	2.6
7	19.6	1.0
8	19.5	0.9
9	20.9	2.3
10	21.6	3.0
11	21.8	3.2
12	22.4	3.8
13	25.4	6.8
14	24.0	5.4
15	24.7	6.1
16	23.3	4.7
17	28.3	9.7
18	27.4	8.8
19	28.6	10.0
20	30.4	11.8
21	30.0	11.4
22	28.7	10.1
23	29.8	11.2
24	29.3	10.7
25	26.3	7.7
26	26.7	8.1
27	27.0	8.4
28	26.5	7.9
29	25.8	7.2
30	24.8	6.2
31	26.5	7.9
32	23.8	5.2
33	24.5	5.9
34	24.8	6.2
35	22.9	4.3
36	23.4	4.8
37	19.8	1.2
38	19.2	0.6
39	18.6	0.0
40	20.4	1.8

max

min

Avg. = 5.36

Marvyn Surface Storage Plot - 1 (MP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	24.8	4.4
2	24.1	3.7
3	27.0	6.6
4	24.9	4.5
5	20.8	0.4
6	24.1	3.7
7	22.6	2.2
8	22.0	1.6
9	23.7	3.3
10	21.6	1.2
11	20.4	0.0
12	25.0	4.6
13	23.0	2.6
14	22.1	1.7
15	24.1	3.7
16	25.1	4.7
17	25.2	4.8
18	23.7	3.3
19	24.1	3.7
20	24.0	3.6
21	25.3	4.9
22	21.4	1.0
23	22.8	2.4
24	21.9	1.5
25	25.0	4.6
26	22.4	2.0
27	21.9	1.5
28	23.3	2.9
29	23.4	3.0
30	23.8	3.4
31	23.6	3.2
32	24.4	4.0
33	25.2	4.8
34	25.4	5.0
35	25.9	5.5
36	26.1	5.7
37	26.3	5.9
38	26.8	6.4
39	24.4	4.0
40	25.0	4.6

max

min

Avg. = 3.52

Marvyn Surface Storage Plot - 2 (MP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	27.5	2.0
2	28.7	3.2
3	30.6	5.1
4	30.4	4.9
5	30.3	4.8
6	30.5	5.0
7	29.8	4.3
8	30.9	5.4
9	31.0	5.5
10	31.4	5.9
11	30.2	4.7
12	31.5	6.0
13	28.5	3.0
14	29.7	4.2
15	29.7	4.2
16	30.0	4.5
17	27.3	1.8
18	27.6	2.1
19	29.3	3.8
20	25.6	0.1
21	27.4	1.9
22	26.6	1.1
23	26.4	0.9
24	25.5	0.0
25	26.4	0.9
26	26.7	1.2
27	27.3	1.8
28	28.2	2.7
29	27.9	2.4
30	26.6	1.1
31	26.1	0.6
32	26.2	0.7
33	27.8	2.3
34	27.8	2.3
35	29.5	4.0
36	26.8	1.3
37	27.4	1.9
38	27.7	2.2
39	29.6	4.1
40	30.4	4.9

max

min

Avg. = 2.97

Radii of Influence from Centerline of Ditch, by Soil Type (Effectively Drained Distance).

Soil Type	Ditch Number	Radius of Influence (feet)
Marvyn	M-10	135
	M-11	238
	M Perimeter-4	574
	M Perimeter-5	1,066
Onslow	O-1	160
	O-2	185
	O-3	155
	O-4	80
	O Perimeter-2	135
	O Perimeter-3	312
	O Perimeter-6	200
O Perimeter-7	125	
Pantego	P-1N	123
	P-1S	51
	P Perimeter-8	100
	P Perimeter-9	70
Torhunta	T-1N	123
	T-1S	59
	T-2N	129
	T-2S	59
	T-3N	129
	T-3S	59
	T-4N	129
	T-4S	95
	T-5N	140
	T-5S	58
	T-6	94
	T-7	58
	TP-1	135
	TP-2	136

APPENDIX D

BENTHIC MACROINVERTEBRATE AND FISHERIES SURVEYS



STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

LYNDO TIPPETT
SECRETARY

February 10, 2004

Memorandum To: Phillip Todd, Environmental Supervisor
Natural Environment Project Management Unit

From: Neil Medlin, Environmental Specialist
Natural Environment Biological Survey Unit

Subject: Benthic Macroinvertebrate Survey for Clayhill Farms
Mitigation Project, Jones County: TIP Number R-2105WM

Benthic macroinvertebrate and fish samples were collected from three locations associated with the Clayhill Farms Mitigation Project. Macroinvertebrates were collected on April 10, 2002, and fish collected on April 23, 2002. Fish collection methods and survey results were summarized in a prior memo (May 13, 2002).

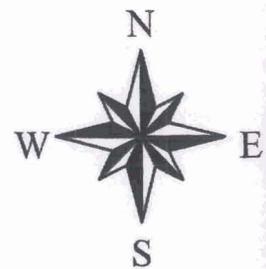
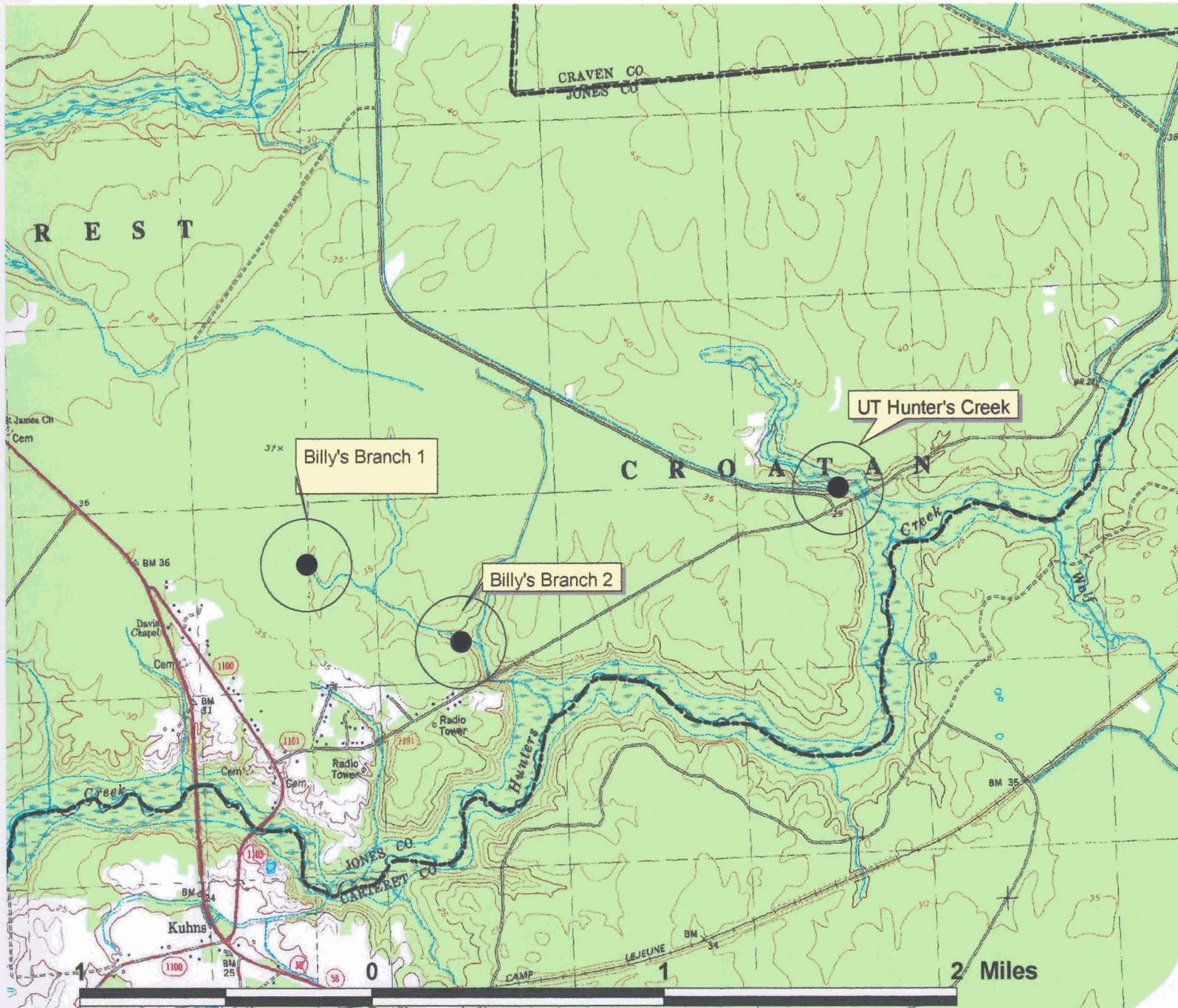
Sampling Locations (Figure 1)

Fish community and macroinvertebrate samples were taken from the same three locations. The most upstream sampling location, Site 1, was located on Billy's Branch below a beaver dam near the middle of the Clayhill Farms project. This location corresponds to Stations 34-37 off baseline as depicted on sheet P-8 of the site plans. Site 2 was the lower end of Billy's Branch in the area of a small metal bridge. This location corresponds to Stations 67-70 off baseline as depicted on sheet P-16 of the site plans. Site 3 on the UT Hunters Creek off Forest Service Road 126 was sampled as a reference location. Another location on the upper end of Billy's Branch had originally been proposed as a macroinvertebrate and fish sampling area. However, after a field evaluation of the area, it was determined that neither macroinvertebrate or fish samples could be effectively or safely collected due to high water levels in Billy's Branch caused by the beaver dam.

Macroinvertebrate Sample Methods

The Qual 5 method employed for sample collection was originally developed by the North Carolina Division of Water Quality (NCDWQ). This method should only be used for very small streams that will likely have few Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa but where other data are needed to assess differences in the benthic communities. This method includes one kick, one sweep, one leaf-pack sample, one log or rock wash and visual search inspection. Macroinvertebrates are separated from the rest of the sample material in the field ("picked") using forceps and white plastic

Figure 1. Clayhill Farms Sampling Locations



trays and preserved in glass vials containing 95% ethanol. Although NCDWQ now uses a Qual 4 collection method in lieu of the Qual 5 (NCDWQ SOP Manual, July 2003), NCDOT continues to use the Qual 5 method to maintain data consistency on long term monitoring projects and to maximize the number of taxa collected from sample locations.

Results (Table 1, Appendix 1)

The macroinvertebrate results for this survey were consistent with those found in other small coastal plain streams. Total taxa counts were low at all three sampling locations and EPT taxa were rare. The upstream site on Billy's Branch (Billy's Branch 1) had the lowest total taxa count but also had the only abundant EPT taxa (*Wormaldia sp.*, a Trichoptera) found during the survey. The upstream site had a nick point in the streambed that produced a small waterfall and area of high flow velocity. All of the *Wormaldia* were collected in or near this fast flow section. This unique microhabitat was not present at the other two sampling locations.

The downstream site on Billy's Branch (Billy's Branch 2) had the highest total taxa count of the three sites. However, this location also had the highest North Carolina Biotic Index (NCBI) values, indicating the most pollution tolerant macroinvertebrate community of the survey. Conversely, the reference location, UT Hunters Creek had the lowest NCBI value, indicating the least tolerant macroinvertebrate community.

Table 1. Taxa Richness

Taxa	Billy's Branch 1	Billy's Branch 2	UT Hunters
Trichoptera	2	1	3
Coleoptera	1	1	3
Odonata	2	2	0
Megaloptera	0	1	0
Diptera: Chironomidae	0	1	0
Misc. Diptera	3	7	6
Oligochaeta	1	4	2
Crustaea	3	2	2
Hemiptera	0	1	0
Total Taxa	12	20	16
NC Biotic Index	6.35	7.27	4.50

Appendix 1. Macroinvertebrate Taxa Richness and Relative Abundance

A=Abundant, C=Common, R=Rare

Taxa	Billys Br 1	Billys Br 2	UT Hunters
Oligochaeta			
Lumbricidae	R	C	C
Naididae		C	
Tubificidae w.h.c.		R	
<i>Spirosperma</i> sp.		R	R
Crustaea			
Cyclopoida	R		
<i>Caecidotea</i> sp.	C	A	C
<i>Crangonyx</i> sp.	A	A	A
Odonata			
<i>Boyeria vinosa</i>	R		
<i>Cordulegaster</i> sp.		R	
<i>Neurocordulia</i> sp.		R	
<i>Somatochlora</i> sp.	R		
Hemiptera			
<i>Hydrometra</i> sp.		R	
Megaloptera			
<i>Sialis</i> sp.		R	
Trichoptera			
<i>Cheumatopsyche</i> sp.			R
<i>Lepidostoma</i> sp.			C
<i>Isonychia</i> sp.	R	R	
<i>Wormaldia</i> sp.	A		
<i>Ptilostomis</i> sp.			C
Coleoptera			
<i>Hydaticus</i> sp.			R
<i>Hydroporus</i> sp.	C	C	C
<i>Stenelmis</i> sp.			C
Diptera			
<i>Atrichopogon</i> sp.		R	
<i>Chironomus</i> sp.		R	
<i>Cricotopus</i> sp.			R
<i>Polypedilum illinoense</i>		C	
<i>Psectrocladius</i> sp.		R	C
<i>Unniella multivirga</i>		C	A
<i>Simulium</i> sp.	C	C	A
<i>Chrysops</i> sp.			R
<i>Molophilus</i> sp.	R		
<i>Pseudolimnophila</i> sp.		C	R
<i>Tipula</i> sp.	R	C	



STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

LYNDO TIPPETT
SECRETARY

May 13, 2002

Memorandum To: Phillip Todd

From: Neil Medlin, ^{NM} Environmental Biologist
Project Development and Environmental Analysis Branch

Subject: Benthic Macroinvertebrate and Fisheries Surveys for Clayhill
Farms Mitigation Project, Jones County; TIP Number R-2105WM

Benthic macroinvertebrate and fish samples have been collected from three locations associated with the Clayhill Farms Mitigation project. Macroinvertebrates were collected on April 10, 2002, and fish were collected on April 23, 2002. The macroinvertebrate samples were preserved and will be identified by a NC Division of Water Quality (NCDWQ) certified laboratory. Collection methods and results will be addressed in a separate memo when the macroinvertebrate identifications are completed.

Sampling Locations (Figure 1, from Wetland and Stream Mitigation Report)

Fish community samples were collected from the same three locations as the macroinvertebrates. Site 1 was located on Billy's Branch below a beaver dam approximately midway of the Clayhill Farms project. This location corresponds to Stations 34-37 of baseline as depicted on sheet P-8 of the site plans. Site 2 was at the lower end of Billy's Branch in the area of the metal bridge. This location corresponds to Stations 67-70 of baseline as depicted on sheet P-16 of the site plans. Site 3 on UT Hunters Creek off Forest Service Road 126 was sampled as a reference location. Another location on the upper end of Billy's Branch had originally been proposed as a macroinvertebrate and fish sampling location. However, after a field evaluation of the area, it was determined that neither macroinvertebrate or fish samples could be effectively or safely collected due to high water levels in Billy's Branch caused by the beaver dam.

Methods

Fish were collected from 150 foot reaches from all three sample sites using a backpack electrofishing unit. A block net or natural barrier was used at the upstream end of each segment to prevent fish from leaving the reach. Two upstream passes were made at each location with the exception of Site 1. Due to the wet width of the stream being less than one meter and the unlikelyhood of any fish escaping the electrofishing field,

only one pass was made at this site. All fish were collected, identified, measured, and then released.

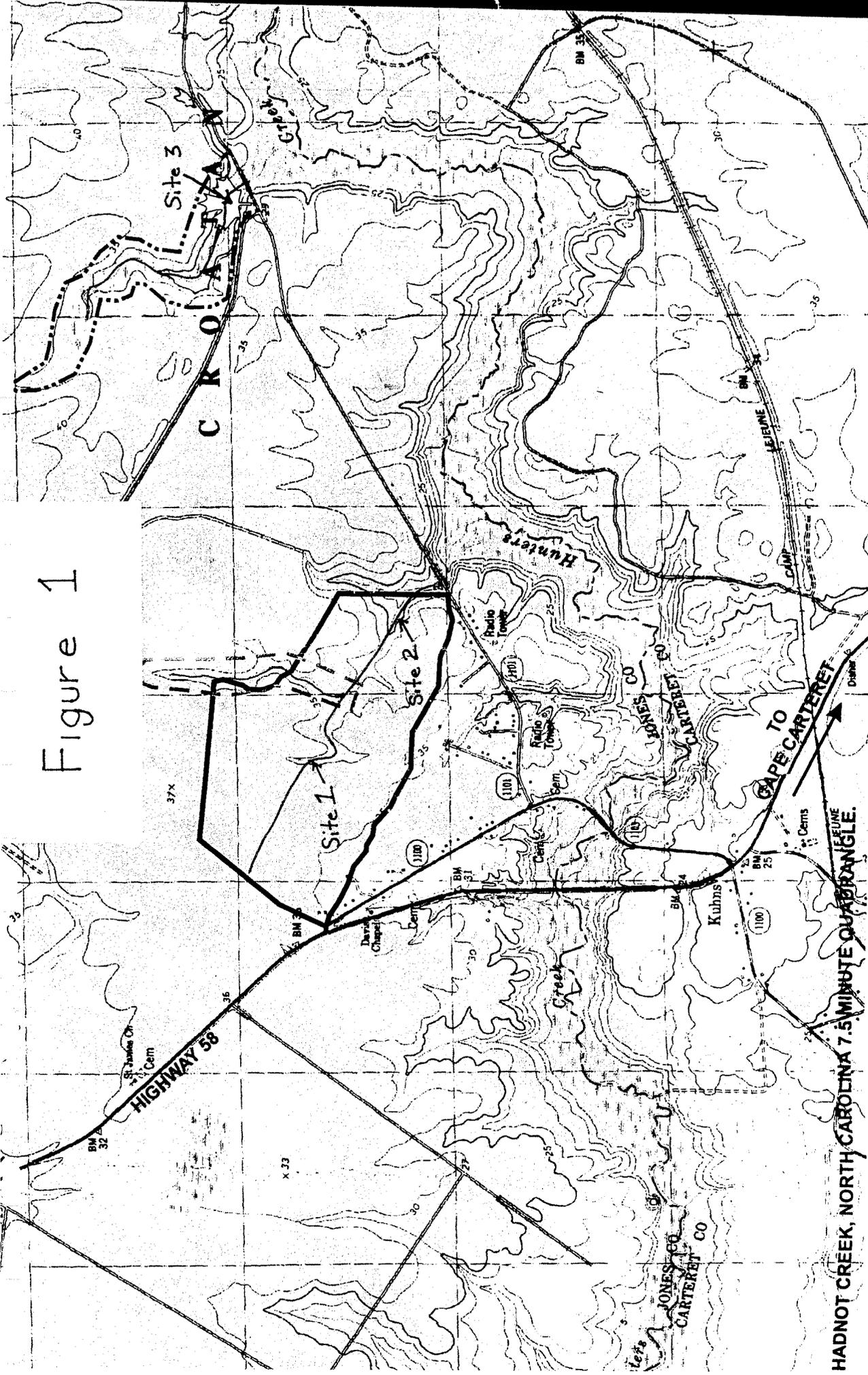
Results

Very few fish were collected from either location on Billy's Branch and only slightly more from the reference site on UT Hunters Creek. All species collected were typical outer coastal plain fish. Low species diversity and abundance are common in very small outer coastal plain streams as flows in these systems vary seasonally. Water levels and flows at the time the fish surveys were conducted were appreciably lower than roughly two weeks prior, when the macroinvertebrate samples were collected. Given the decrease in stream flows observed during the two week period in April, it is probable that during the minimal flow periods of summer and fall the number of fish in Billy's Branch and UT Hunters Creek would be even less than documented during this survey.

Fisheries Survey Results by Species with Number of Individuals Collected, Clayhill Farms Project, April 23, 2002. Site 1=Billy's Branch below beaver dam, Site 2=Billy's Branch at lower end of project, Site 3=UT Hunters Creek (Reference)

Species	Location		
	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>
Banded sunfish, <i>Enneacanthus obesus</i>	1		
Eastern mudminnow, <i>Umbra pygmaea</i>		1	1
Redfin pickerel, <i>Esox americanus</i>		1	
Pirate perch, <i>Aphredoderus sayanus</i>			1
Swampfish, <i>Chologaster cornuta</i>			5

Figure 1



HADNOT CREEK, NORTH CAROLINA 7.5 MINUTE QUADRANGLE.

APPENDIX E

MORPHOLOGICAL MEASUREMENT TABLE FOR BILLY'S BRANCH

NCDOT Clayhill Farms Wetland and Stream Mitigation Bank

March 4, 2002

Morphological Measurement Table

TIP R-2105 WM

Format: NCDENR Internal Technical Guide for Stream Work (April 2001)

State Project No. 169005T

Prepared By: LandMark Design Group

LMDG NO 1960024-210.00

Preparer: Robert Kerr

Variables	Existing Channel	Reference Reach	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6
			Station 10+00	Station 23+00	Station 35+00	Station 57+00	Station 62+00	Station 91+00
1 Stream Type	G6	C6	C6	C6	C6	C6	C6	C6
2 Drainage Area (mi ²)	0.8	0.7	0.1	0.2	0.3	0.45	0.48	0.6
3 Bankful Width	10	9	5.7	7.3	8.2	9.5	9.7	10.6
4 Bankful Mean Depth	2	0.98	0.6	0.8	0.9	1.0	1.1	1.2
5 Width/Depth Ratio*	5	9.2	9.1	9.2	9.2	9.2	9.2	9.2
6 Bankfill Cross-Sectional Area	19	8.84	3.6	5.9	7.3	9.9	10.2	12.3
7 Bank Mean Velocity	2.45	2.8	1.4	1.6	1.5	1.6	1.7	1.7
8 Bankfull Discharge, cfs	47	42	12.0	20.0	23.0	31.0	33.0	39.0
9 Bankfull Max Depth	2.6	1.46	1.0	1.3	1.4	1.6	1.7	1.8
10 Width of Floodprone Area	15	278.5	95	240	440	78	66	215
11 Entrenchment Ratio	1.5	30.9	16.6	32.7	53.7	8.2	6.8	20.2
12 Meander Length (avg)	NA	120	77	98	105	112	119	126
13 Ratio of Meander Length to Bankfull Width**	NA	13.3	13.4	13.4	12.8	11.8	12.3	11.9
14 Radius of Curvature	NA	31	20	25	27	28	31	32
15 Radius of Curvature to Bankfull Width	NA	3.44	3.5	3.4	3.3	2.9	3.2	3.0
16 Belt Width	NA	40	13.0	33.6	36.0	38.4	40.8	43.2
17 Meander Width Ratio (MWR)***	NA	4.4	2.3	4.6	4.4	4.0	4.2	4.1
18 Sinuosity (Stream Length/ Valley Length)	1.2	1.4	1.2	1.2	1.25	1.4	1.5	1.6
19 Valley Slope	0.004-0.009	0.0031	0.0006	0.0006	0.0024	0.0038	0.0033	0.0033
20 Average Slope	0.003-0.008	0.0020	0.0022	0.0005	0.0005	0.0019	0.0027	0.0022
21 Pool Slope	NA	0.0012	0.00132	0.00132	0.00132	0.00132	0.00132	0.00132
22 Ratio of Pool Slope to Average Slope	NA	0.6	0.6	0.6	0.6	0.6	0.6	0.6
23 Maximum Pool Depth	NA	2	1.4	1.8	2	2.3	2.4	2.6
24 Ratio of Pool Depth to Average Bankfull Depth	NA	2.0	2.2	2.2	2.2	2.2	2.3	2.2
25 Pool Width	NA	11.5	7.0	9.0	10.1	11.7	12.1	13.1
26 Ratio of Pool Width to Bankfull Width	NA	1.3	1.2	1.2	1.2	1.2	1.2	1.2
27 Ratio of Pool to Pool Spacing****	NA	51	35	49	53	56	60	63
28 Ratio of Pool-Pool Spacing to Bankfull Width**	NA	5.7	6.1	6.7	6.4	5.9	6.1	5.9
29 Ratio of Lowest Bank height to Bankfull height (or Max Bankfull Depth)	1.14	1	1	1	1	1	1	1

NA - Detailed design parameters were not measured on impacted reach since data would not be used for future design, therefore data as "Not Applicable".

* Width/Depth Ratio - C6 streams display lower W/D ratio than all other C stream types due to cohesive nature or stream bank materials (Applied River Morphology, D. Rosgen, 1996, pg 5-104).

** Lm/Wbkf = can be extremely high, as high as 15-16 for streams with cohesive banks (personal communication, D. Rosgen, November 2001).

*** MWR = can go above 4.0 for C6 streams (personal communication, D. Rosgen, November 2001).

**** Ratio of Pool Width to Bankfull Width will be higher for C6 streams since Lm/Wbkf is higher.

***** Ratio of Pool-Pool Spacing to Bankfull Width can be higher for C6 streams since Lm/Wbkf is higher.

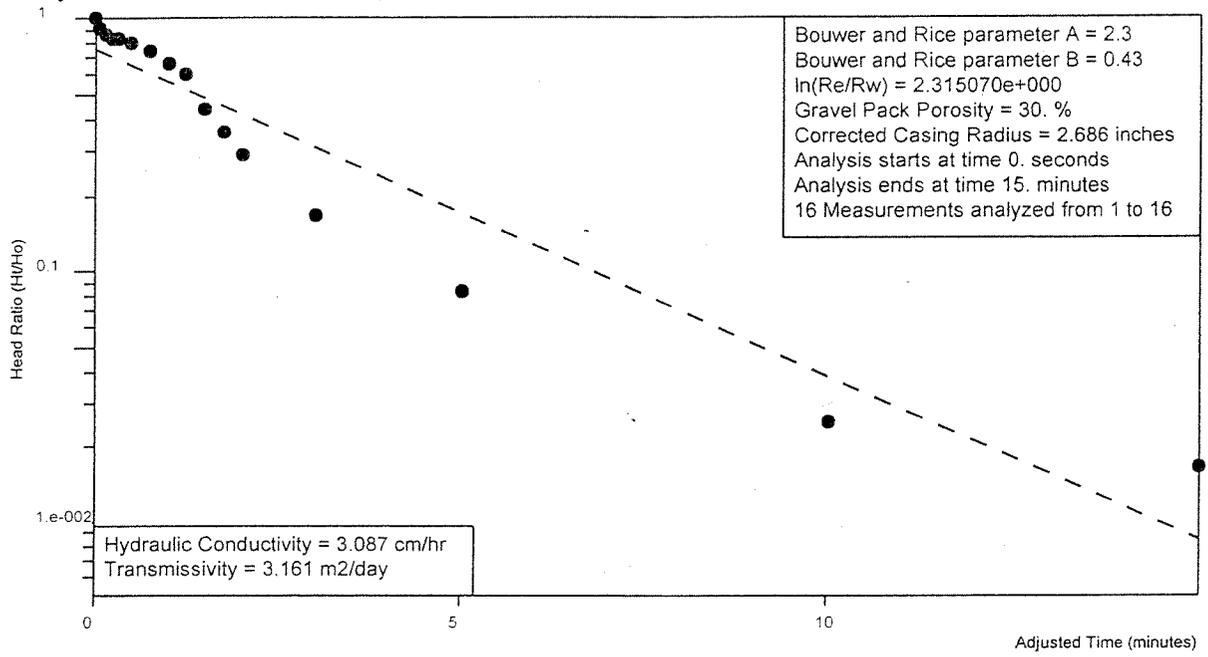
DESIGN CRITERIA

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bower and Rice Graph

DMW-1



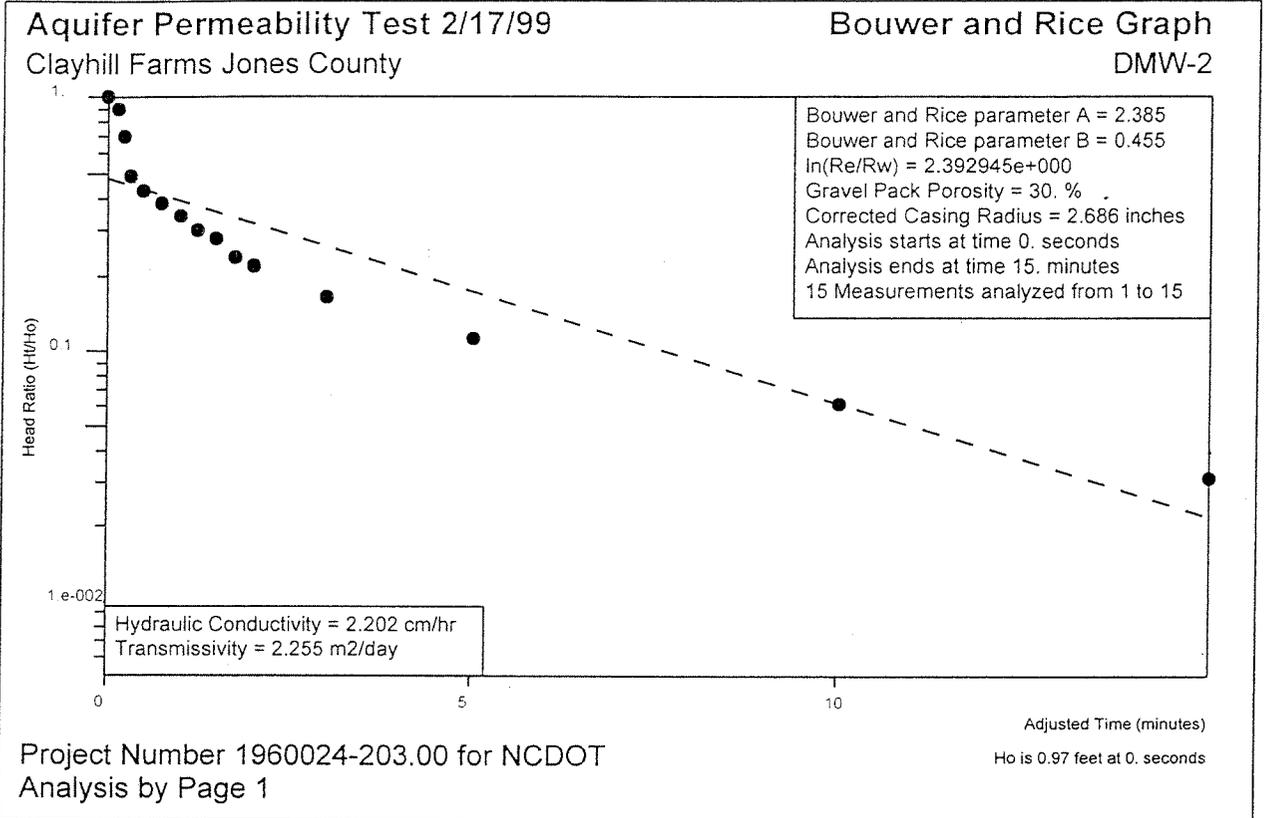
Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-1
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 3.05 feet
 Water Table to Screen Bottom: 10.95 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 16 time and drawdown measurements
 Maximum head is 1.2 feet
 Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	4.25	1.2	1.
2	8.3e-002	8.3e-002	4.15	1.1	0.9167
3	0.166	0.166	4.1	1.05	0.875
4	0.25	0.25	4.06	1.01	0.8417
5	0.333	0.333	4.05	1.	0.8333
6	0.5	0.5	4.01	0.96	0.8
7	0.75	0.75	3.94	0.89	0.7417
8	1.	1.	3.85	0.8	0.6667
9	1.25	1.25	3.78	0.73	0.6083
10	1.5	1.5	3.58	0.53	0.4417
11	1.75	1.75	3.48	0.43	0.3583
12	2.	2.	3.4	0.35	0.2917
13	3.	3.	3.25	0.2	0.1667
14	5.	5.	3.15	0.1	8.333e-002
15	10.	10.	3.08	3.e-002	2.5e-002
16	15.	15.	3.07	2.e-002	1.667e-002



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-2
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.88 feet
 Water Table to Screen Bottom: 12.22 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

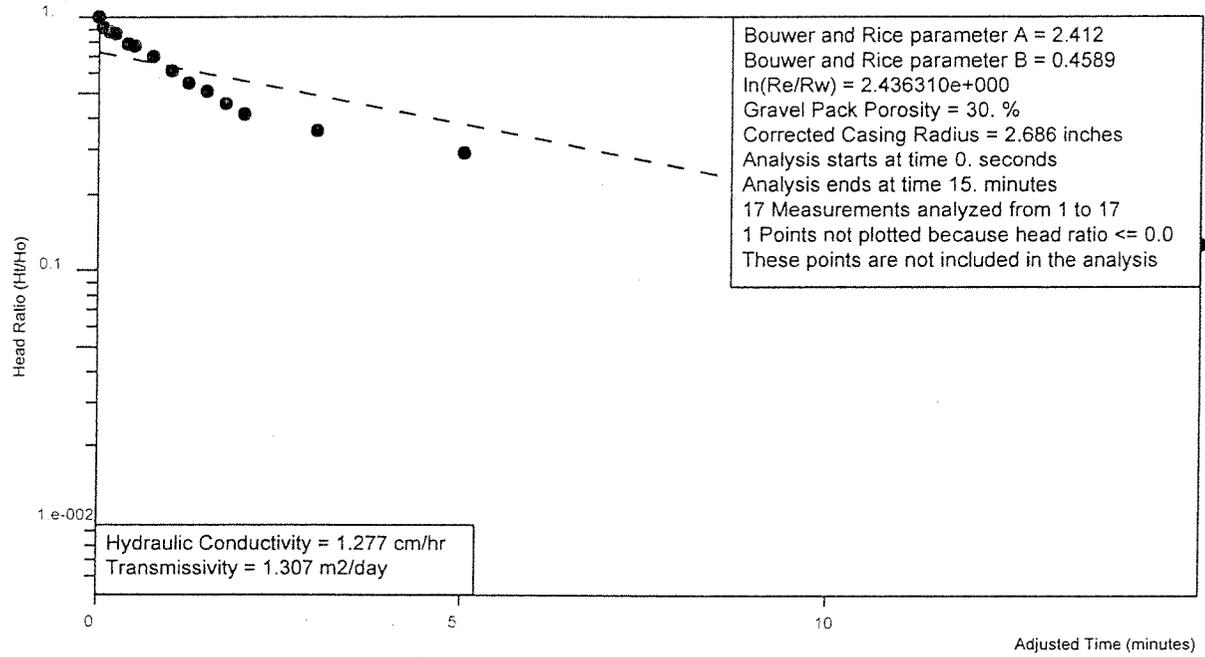
Maximum head is 0.97 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.85	0.97	1.
2	0.166	0.166	5.76	0.88	0.9072
3	0.25	0.25	5.56	0.68	0.701
4	0.333	0.333	5.36	0.48	0.4948
5	0.5	0.5	5.3	0.42	0.433
6	0.75	0.75	5.25	0.37	0.3814
7	1.	1.	5.21	0.33	0.3402
8	1.25	1.25	5.17	0.29	0.299
9	1.5	1.5	5.15	0.27	0.2784
10	1.75	1.75	5.11	0.23	0.2371
11	2.	2.	5.09	0.21	0.2165
12	3.	3.	5.04	0.16	0.1649
13	5.	5.	4.99	0.11	0.1134
14	10.	10.	4.94	6.e-002	6.186e-002
15	15.	15.	4.91	3.e-002	3.093e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bower and Rice Graph
DMW-3



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 4.9 feet at 0. seconds

Aquifer Permeability Test

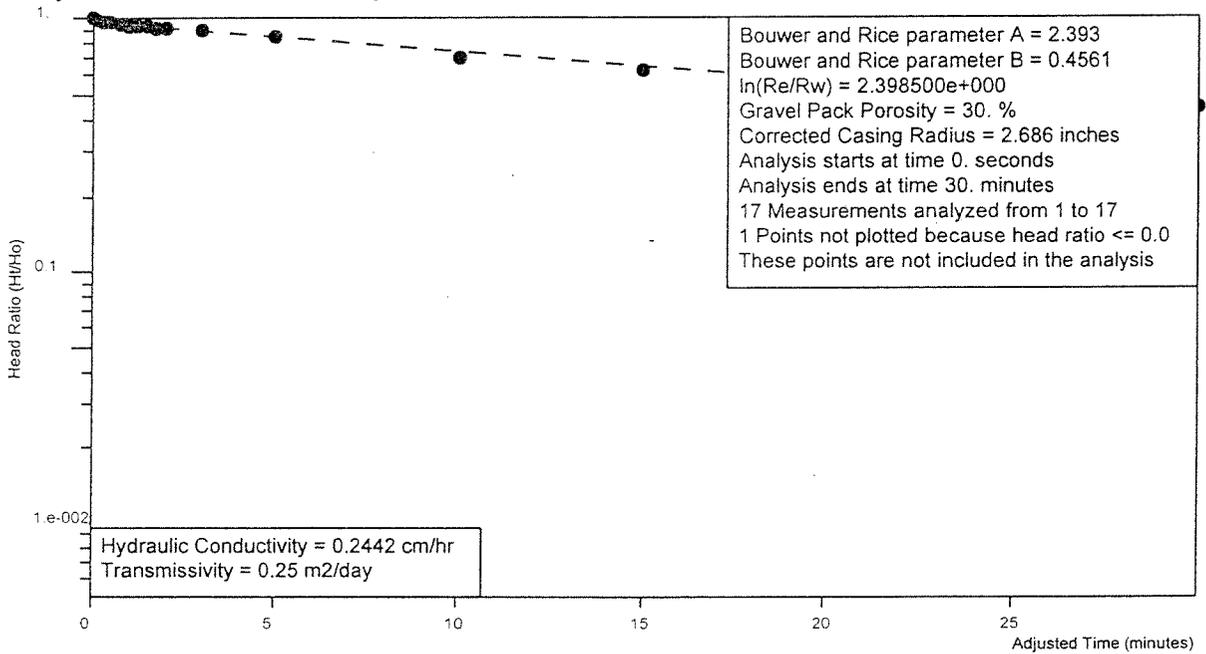
Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-3
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.88 feet
 Water Table to Screen Bottom: 12.72 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 17 time and drawdown measurements
 Maximum head is 4.9 feet
 Minimum head is -4.88 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	9.78	4.9	1.
2	8.3e-002	8.3e-002	9.36	4.48	0.9143
3	0.166	0.166	9.25	4.37	0.8918
4	0.25	0.25	9.1	4.22	0.8612
5	0.416	0.416	8.76	3.88	0.7918
6	0.5	0.5	8.64	3.76	0.7673
7	0.75	0.75	8.32	3.44	0.702
8	1.	1.	7.93	3.05	0.6224
9	1.25	1.25	7.6	2.72	0.5551
10	1.33	1.33	0.	-4.88	-0.9959
11	1.5	1.5	7.39	2.51	0.5122
12	1.75	1.75	7.1	2.22	0.4531
13	2.	2.	6.93	2.05	0.4184
14	3.	3.	6.63	1.75	0.3571
15	5.	5.	6.31	1.43	0.2918
16	10.	10.	5.82	0.94	0.1918
17	15.	15.	5.5	0.62	0.1265

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-4



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

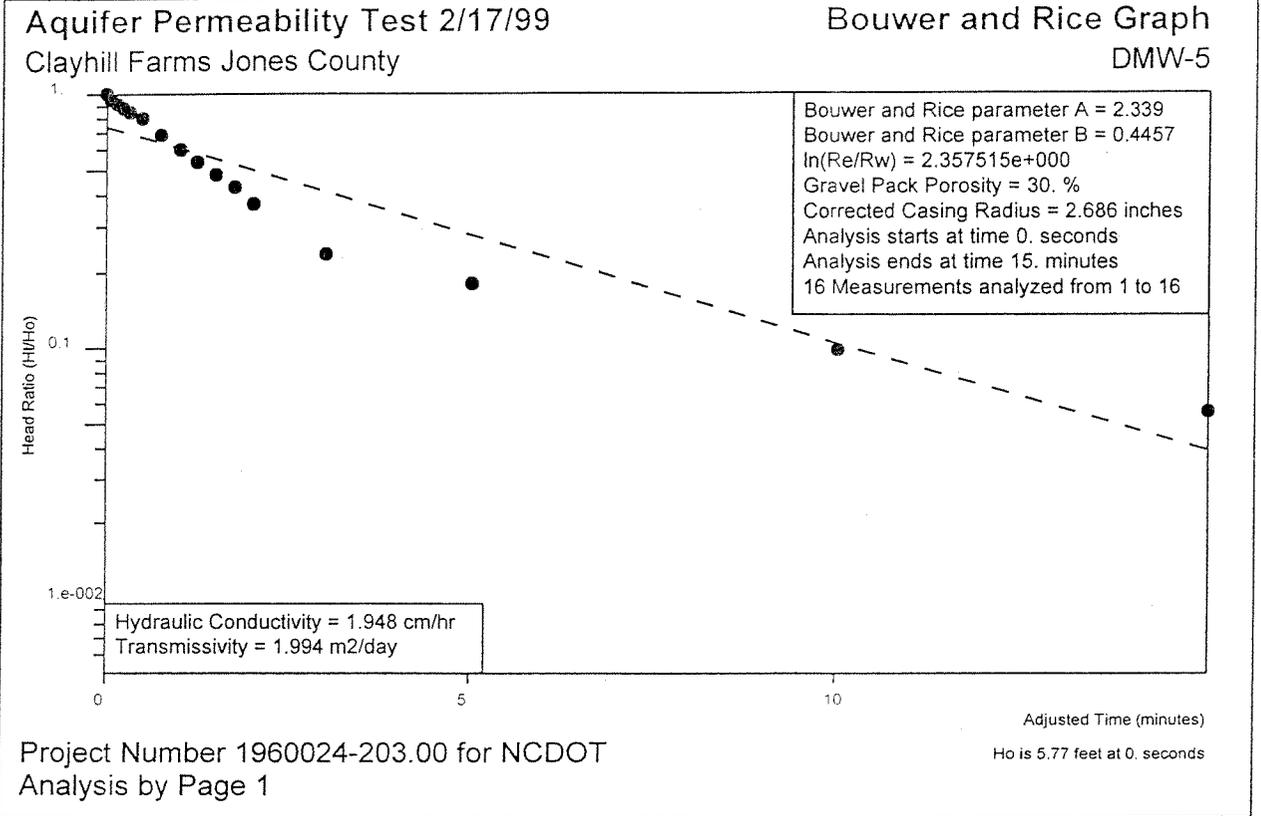
Ho is 5.4 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-4
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 3.8 feet
 Water Table to Screen Bottom: 12.3 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 17 time and drawdown measurements
 Maximum head is 5.4 feet
 Minimum head is -3.8 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	9.2	5.4	1.
2	0.166	0.166	9.12	5.32	0.9852
3	0.25	0.25	0.	-3.8	-0.7037
4	0.333	0.333	9.06	5.26	0.9741
5	0.5	0.5	9.01	5.21	0.9648
6	0.75	0.75	8.95	5.15	0.9537
7	1.	1.	8.9	5.1	0.9444
8	1.25	1.25	8.86	5.06	0.937
9	1.5	1.5	8.81	5.01	0.9278
10	1.75	1.75	8.77	4.97	0.9204
11	2.	2.	8.73	4.93	0.913
12	3.	3.	8.69	4.89	0.9056
13	5.	5.	8.39	4.59	0.85
14	10.	10.	7.62	3.82	0.7074
15	15.	15.	7.2	3.4	0.6296
16	20.	20.	6.84	3.04	0.563
17	30.	30.	6.2	2.4	0.4444



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-5
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.43 feet
 Water Table to Screen Bottom: 11.67 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 16 time and drawdown measurements
 Maximum head is 5.77 feet
 Minimum head is 0. feet

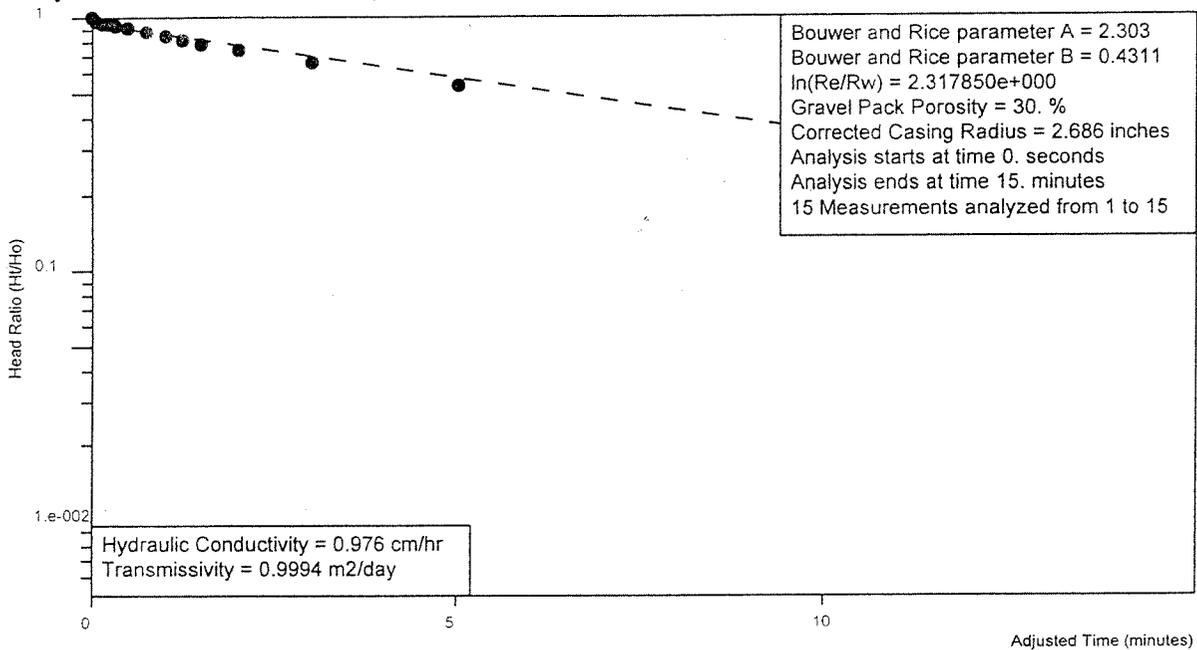
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	10.2	5.77	1.
2	8.3e-002	8.3e-002	9.98	5.55	0.9619
3	0.166	0.166	9.7	5.27	0.9133
4	0.25	0.25	9.5	5.07	0.8787
5	0.333	0.333	9.3	4.87	0.844
6	0.5	0.5	9.04	4.61	0.799
7	0.75	0.75	8.41	3.98	0.6898
8	1.	1.	7.93	3.5	0.6066
9	1.25	1.25	7.53	3.1	0.5373
10	1.5	1.5	7.2	2.77	0.4801
11	1.75	1.75	6.9	2.47	0.4281
12	2.	2.	6.56	2.13	0.3692
13	3.	3.	5.79	1.36	0.2357
14	5.	5.	5.48	1.05	0.182
15	10.	10.	5.	0.57	9.879e-002
16	15.	15.	4.75	0.32	5.546e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

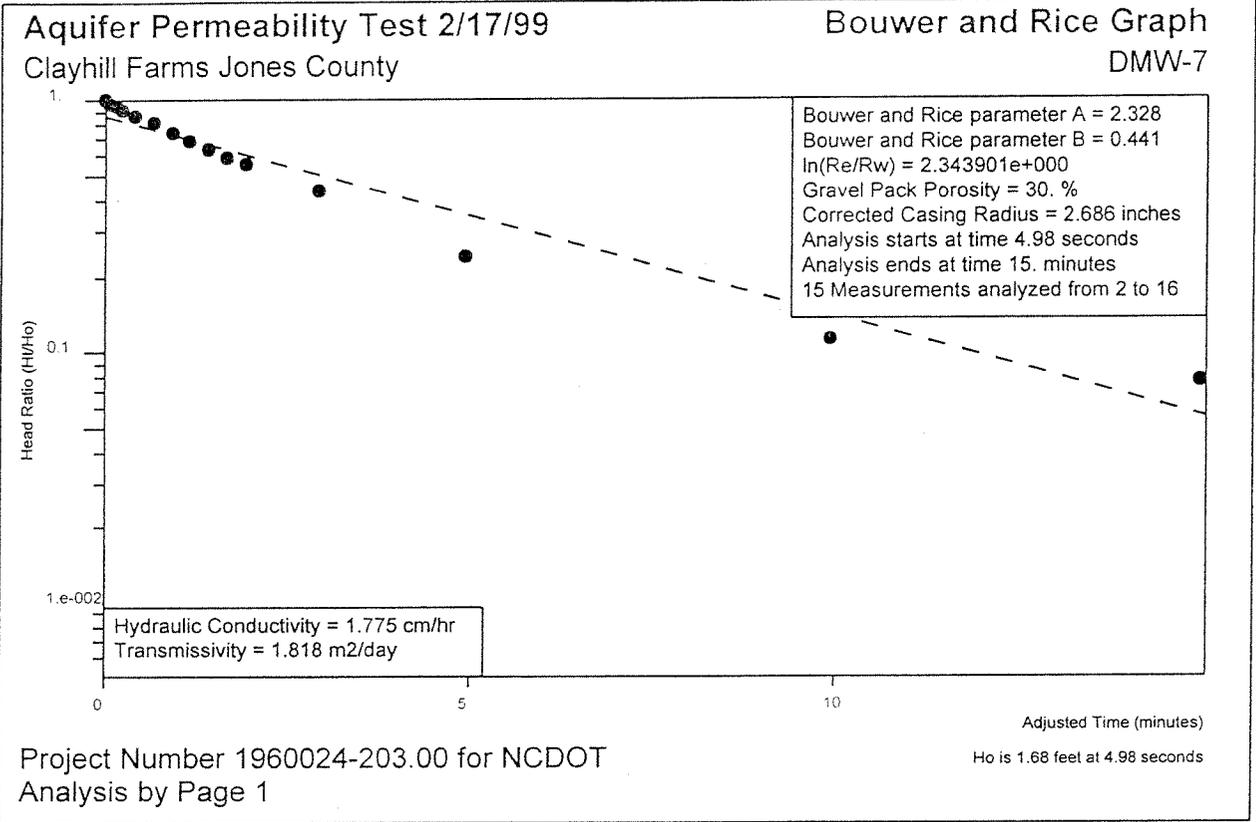
Bower and Rice Graph

DMW-6



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 3.23 feet at 0. seconds



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-7
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.85 feet
 Water Table to Screen Bottom: 11.45 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 4.98 Seconds

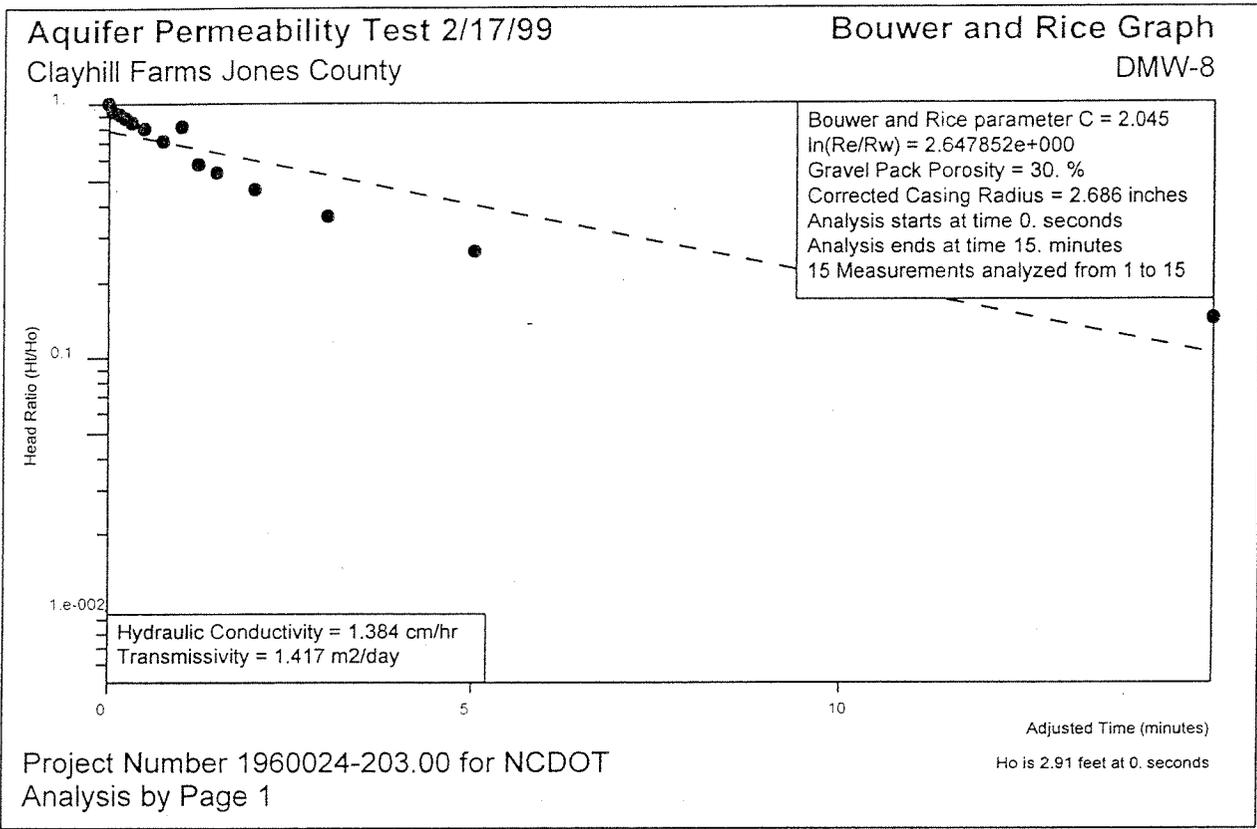
Test starts with trial 1

There are 16 time and drawdown measurements

Maximum head is 1.68 feet

Minimum head is -4.85 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-4.85	-2.887
2	8.3e-002	0.	6.53	1.68	1.
3	0.166	8.3e-002	6.49	1.64	0.9762
4	0.25	0.167	6.45	1.6	0.9524
5	0.333	0.25	6.38	1.53	0.9107
6	0.5	0.417	6.32	1.47	0.875
7	0.75	0.667	6.22	1.37	0.8155
8	1.	0.917	6.1	1.25	0.744
9	1.25	1.167	6.02	1.17	0.6964
10	1.5	1.417	5.93	1.08	0.6429
11	1.75	1.667	5.85	1.	0.5952
12	2.	1.917	5.8	0.95	0.5655
13	3.	2.917	5.59	0.74	0.4405
14	5.	4.917	5.25	0.4	0.2381
15	10.	9.917	5.04	0.19	0.1131
16	15.	14.92	4.98	0.13	7.738e-002



Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-8
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 2.59 feet
 Water Table to Screen Bottom: 13.31 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

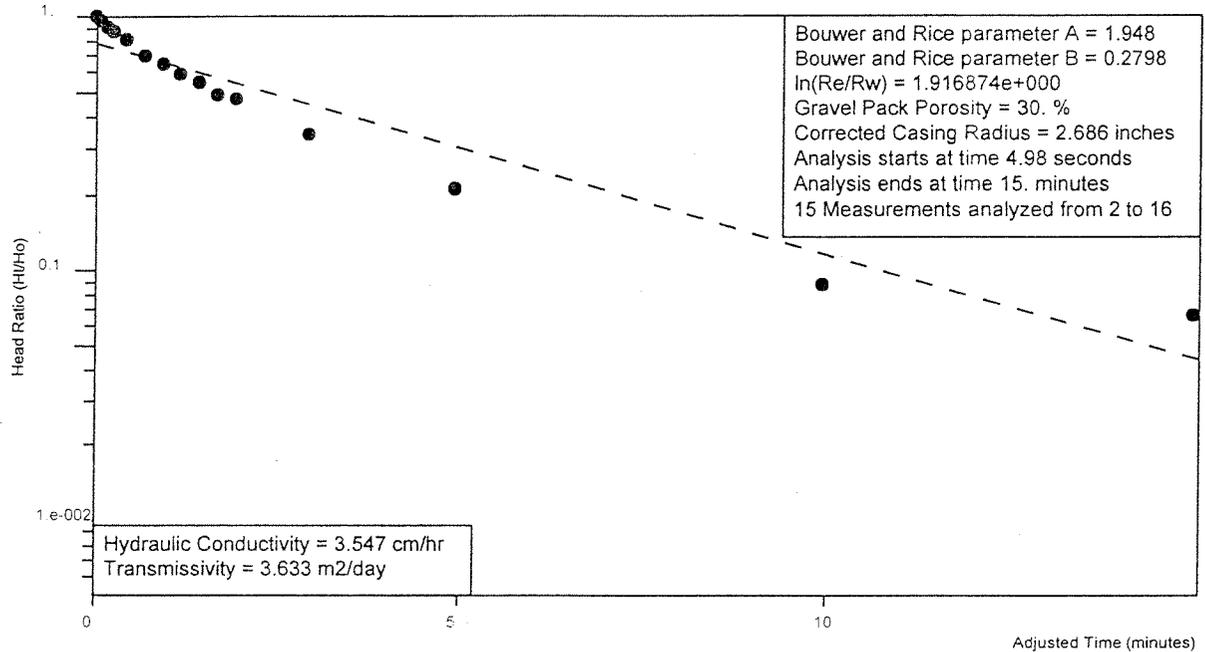
Maximum head is 2.91 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.5	2.91	1.
2	8.3e-002	8.3e-002	5.32	2.73	0.9381
3	0.166	0.166	5.25	2.66	0.9141
4	0.25	0.25	5.18	2.59	0.89
5	0.333	0.333	5.09	2.5	0.8591
6	0.5	0.5	4.92	2.33	0.8007
7	0.75	0.75	4.69	2.1	0.7216
8	1.	1.	4.98	2.39	0.8213
9	1.25	1.25	4.3	1.71	0.5876
10	1.5	1.5	4.16	1.57	0.5395
11	2.	2.	3.93	1.34	0.4605
12	3.	3.	3.65	1.06	0.3643
13	5.	5.	3.36	0.77	0.2646
14	10.	10.	3.12	0.53	0.1821
15	15.	15.	3.01	0.42	0.1443

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bower and Rice Graph
DMW-9



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 0.91 feet at 4.98 seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-9
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 10.96 feet
 Water Table to Screen Bottom: 5.04 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 4.98 Seconds

Test starts with trial 1

There are 16 time and drawdown measurements

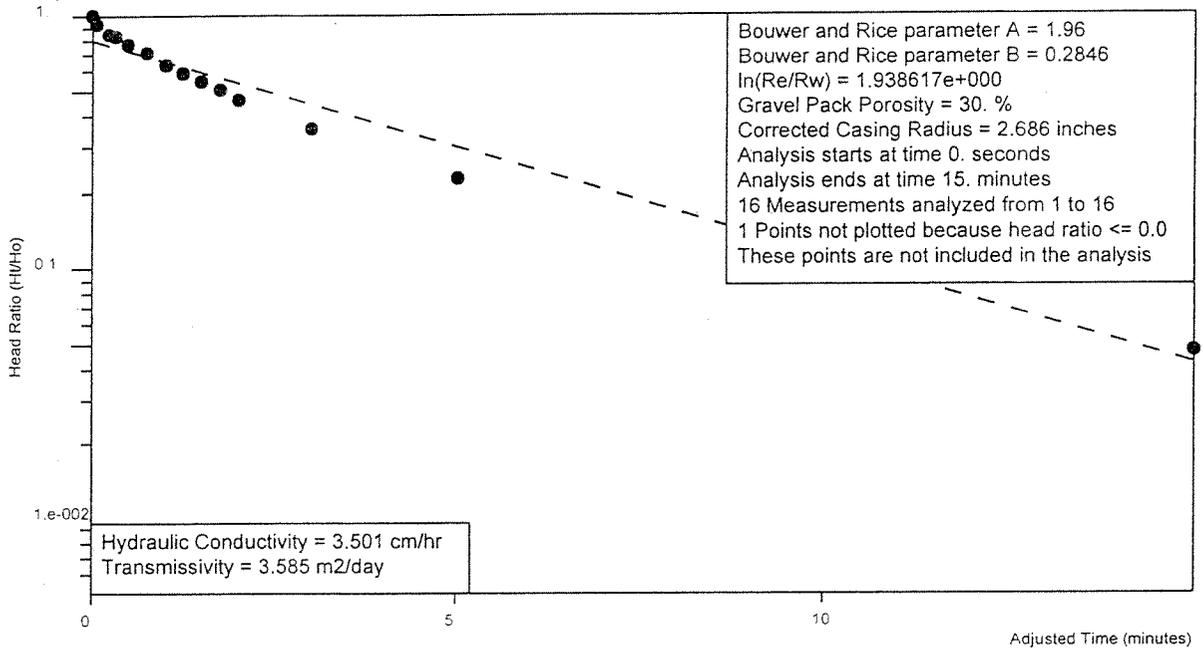
Maximum head is 0.91 feet

Minimum head is -10.96 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-10.96	-12.04
2	8.3e-002	0.	11.87	0.91	1.
3	0.166	8.3e-002	11.84	0.88	0.967
4	0.25	0.167	11.8	0.84	0.9231
5	0.333	0.25	11.77	0.81	0.8901
6	0.5	0.417	11.7	0.74	0.8132
7	0.75	0.667	11.6	0.64	0.7033
8	1.	0.917	11.55	0.59	0.6484
9	1.25	1.167	11.5	0.54	0.5934
10	1.5	1.417	11.46	0.5	0.5495
11	1.75	1.667	11.41	0.45	0.4945
12	2.	1.917	11.39	0.43	0.4725
13	3.	2.917	11.27	0.31	0.3407
14	5.	4.917	11.15	0.19	0.2088
15	10.	9.917	11.04	8.e-002	8.791e-002
16	15.	14.92	11.02	6.e-002	6.593e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-10



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.06 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-10
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 10.96 feet
 Water Table to Screen Bottom: 5.24 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

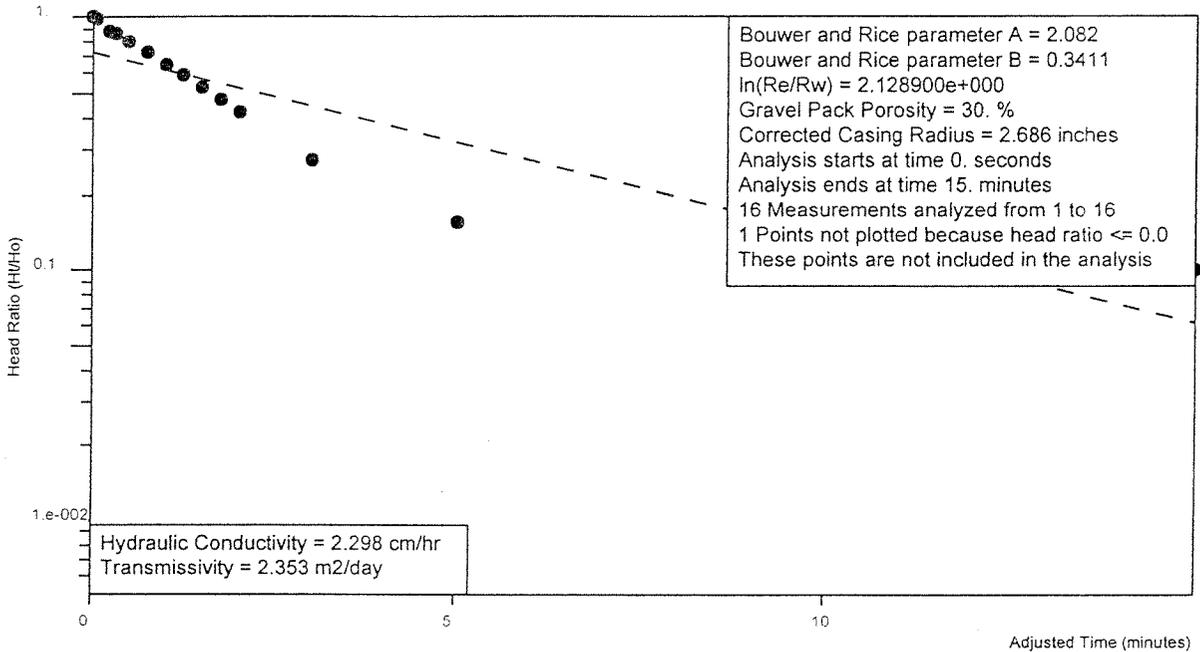
Maximum head is 1.06 feet

Minimum head is -6.e-002 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	12.02	1.06	1.
2	8.3e-002	8.3e-002	11.96	1.	0.9434
3	0.166	0.166	10.9	-6.e-002	-5.66e-002
4	0.25	0.25	11.86	0.9	0.8491
5	0.333	0.333	11.84	0.88	0.8302
6	0.5	0.5	11.78	0.82	0.7736
7	0.75	0.75	11.72	0.76	0.717
8	1.	1.	11.64	0.68	0.6415
9	1.25	1.25	11.59	0.63	0.5943
10	1.5	1.5	11.54	0.58	0.5472
11	1.75	1.75	11.5	0.54	0.5094
12	2.	2.	11.45	0.49	0.4623
13	3.	3.	11.34	0.38	0.3585
14	5.	5.	11.2	0.24	0.2264
15	10.	10.	11.09	0.13	0.1226
16	15.	15.	11.01	5.e-002	4.717e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-11



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 5.82 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-11
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 8.98 feet
 Water Table to Screen Bottom: 7.52 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

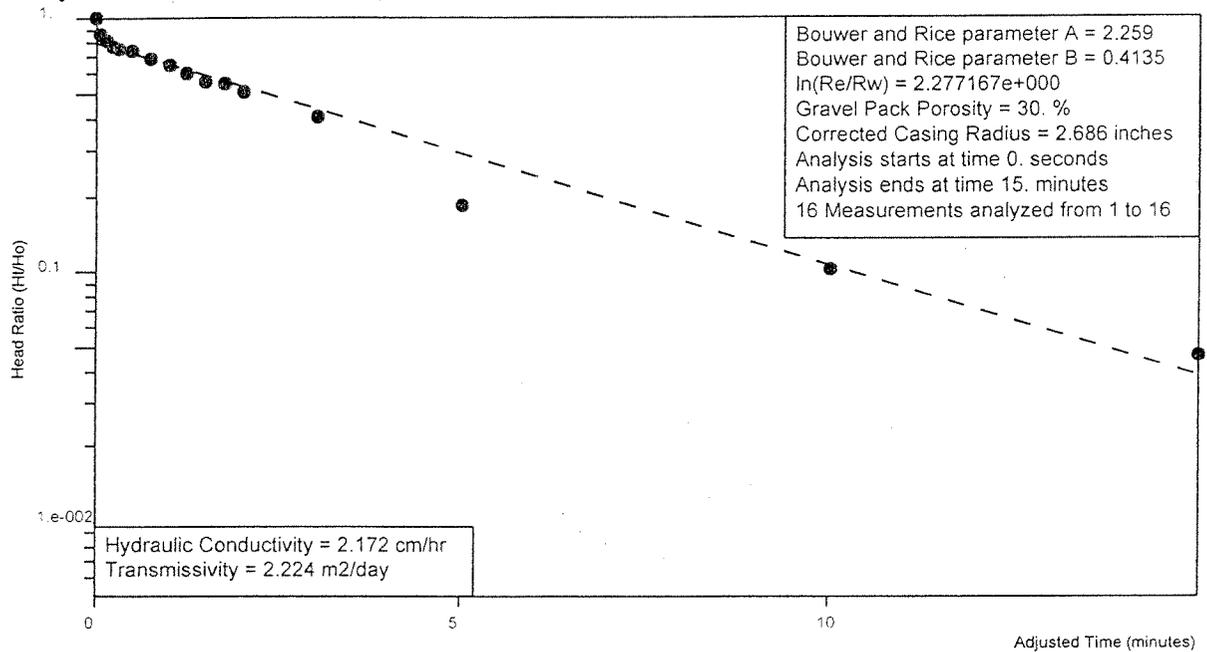
Maximum head is 5.82 feet

Minimum head is -8.98 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	14.8	5.82	1.
2	8.3e-002	8.3e-002	14.72	5.74	0.9863
3	0.166	0.166	0.	-8.98	-1.543
4	0.25	0.25	14.15	5.17	0.8883
5	0.333	0.333	14.	5.02	0.8625
6	0.5	0.5	13.67	4.69	0.8058
7	0.75	0.75	13.2	4.22	0.7251
8	1.	1.	12.75	3.77	0.6478
9	1.25	1.25	12.46	3.48	0.5979
10	1.5	1.5	12.08	3.1	0.5326
11	1.75	1.75	11.76	2.78	0.4777
12	2.	2.	11.45	2.47	0.4244
13	3.	3.	10.58	1.6	0.2749
14	5.	5.	9.89	0.91	0.1564
15	10.	10.	9.68	0.7	0.1203
16	15.	15.	9.56	0.58	9.966e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bower and Rice Graph
DMW-12



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.08 feet at 0. seconds

Aquifer Permeability Test

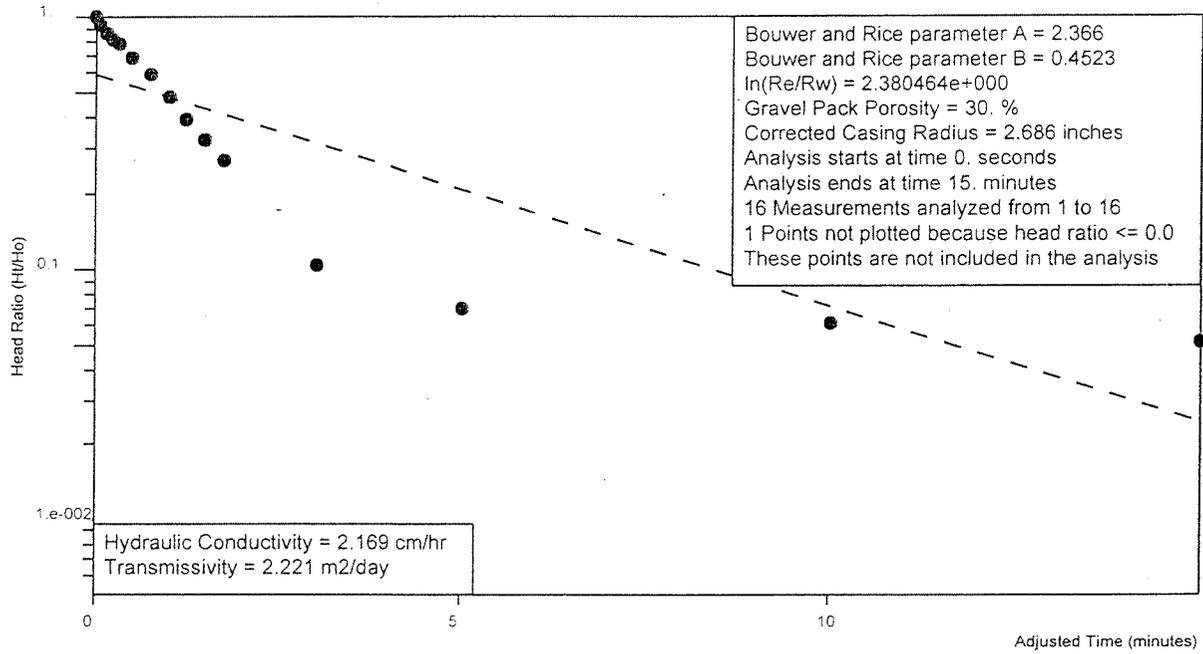
Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-12
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 6.16 feet
 Water Table to Screen Bottom: 10.24 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 16 time and drawdown measurements
 Maximum head is 1.08 feet
 Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.24	1.08	1.
2	8.3e-002	8.3e-002	7.09	0.93	0.8611
3	0.166	0.166	7.05	0.89	0.8241
4	0.25	0.25	7.	0.84	0.7778
5	0.333	0.333	6.98	0.82	0.7593
6	0.5	0.5	6.96	0.8	0.7407
7	0.75	0.75	6.91	0.75	0.6944
8	1.	1.	6.86	0.7	0.6481
9	1.25	1.25	6.82	0.66	0.6111
10	1.5	1.5	6.77	0.61	0.5648
11	1.75	1.75	6.75	0.59	0.5463
12	2.	2.	6.71	0.55	0.5093
13	3.	3.	6.6	0.44	0.4074
14	5.	5.	6.36	0.2	0.1852
15	10.	10.	6.27	0.11	0.1019
16	15.	15.	6.21	5.e-002	4.63e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-13



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.15 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-13
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.62 feet
 Water Table to Screen Bottom: 12.03 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

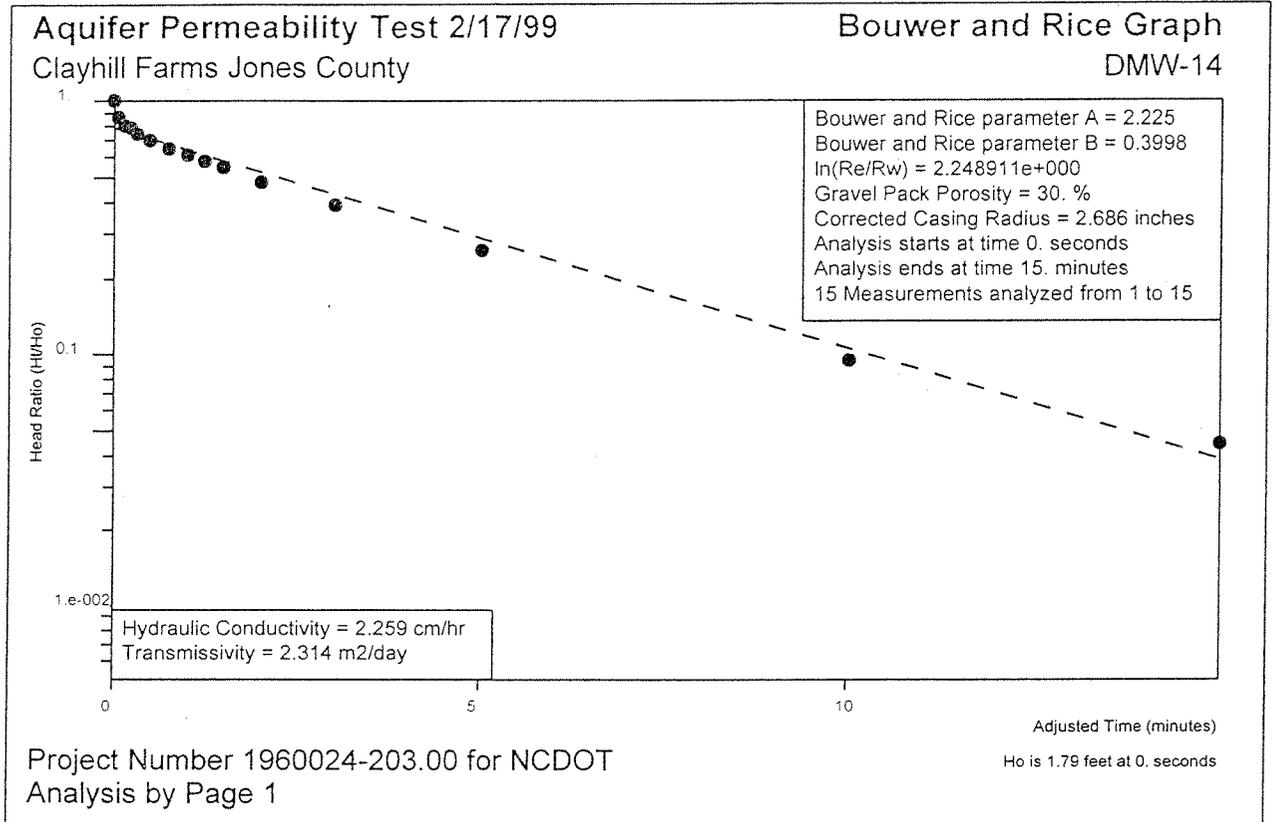
Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.15 feet

Minimum head is -4.62 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.77	1.15	1.
2	8.3e-002	8.3e-002	5.7	1.08	0.9391
3	0.166	0.166	5.61	0.99	0.8609
4	0.25	0.25	5.57	0.95	0.8261
5	0.333	0.333	5.52	0.9	0.7826
6	0.5	0.5	5.41	0.79	0.687
7	0.75	0.75	5.3	0.68	0.5913
8	1.	1.	5.17	0.55	0.4783
9	1.25	1.25	5.07	0.45	0.3913
10	1.5	1.5	4.99	0.37	0.3217
11	1.75	1.75	4.93	0.31	0.2696
12	2.	2.	0.	-4.62	-4.017
13	3.	3.	4.74	0.12	0.1043
14	5.	5.	4.7	8.e-002	6.957e-002
15	10.	10.	4.69	7.e-002	6.087e-002
16	15.	15.	4.68	6.e-002	5.217e-002



Aquifer Permeability Test

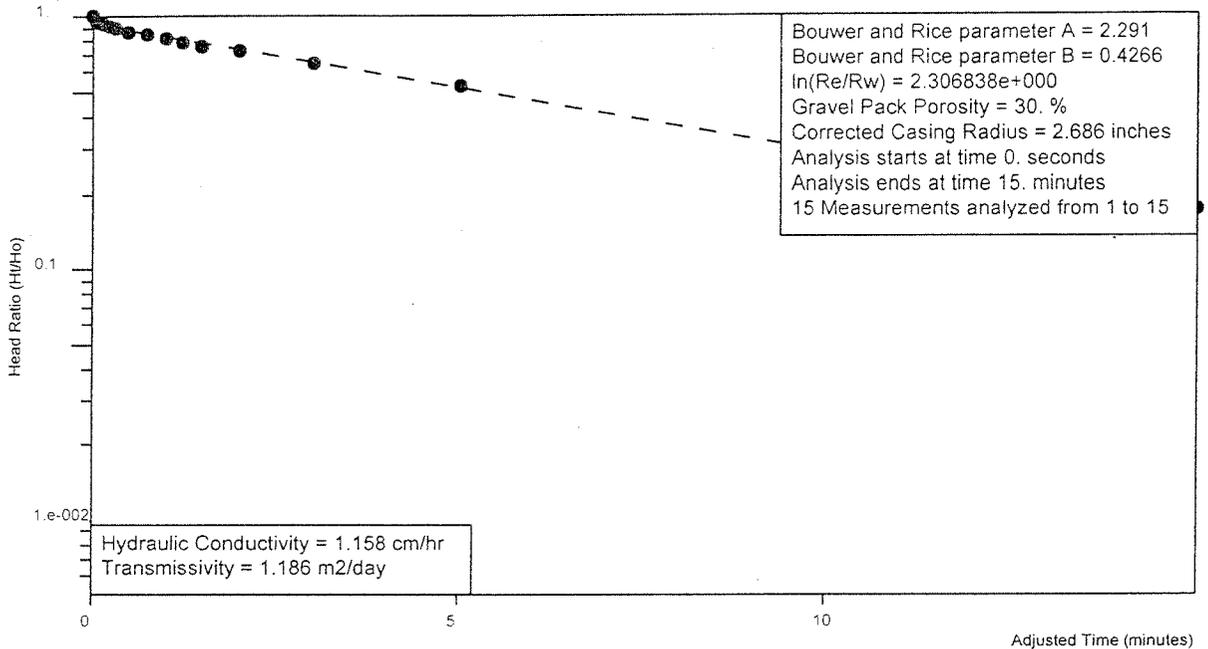
Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-14
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 6.61 feet
 Water Table to Screen Bottom: 9.69 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 15 time and drawdown measurements
 Maximum head is 1.79 feet
 Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	8.4	1.79	1.
2	8.3e-002	8.3e-002	8.16	1.55	0.8659
3	0.166	0.166	8.06	1.45	0.8101
4	0.25	0.25	8.01	1.4	0.7821
5	0.333	0.333	7.95	1.34	0.7486
6	0.5	0.5	7.87	1.26	0.7039
7	0.75	0.75	7.78	1.17	0.6536
8	1.	1.	7.71	1.1	0.6145
9	1.25	1.25	7.65	1.04	0.581
10	1.5	1.5	7.59	0.98	0.5475
11	2.	2.	7.48	0.87	0.486
12	3.	3.	7.31	0.7	0.3911
13	5.	5.	7.07	0.46	0.257
14	10.	10.	6.78	0.17	9.497e-002
15	15.	15.	6.69	8.e-002	4.469e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-15



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.5 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-15
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 5.7 feet
 Water Table to Screen Bottom: 10.8 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

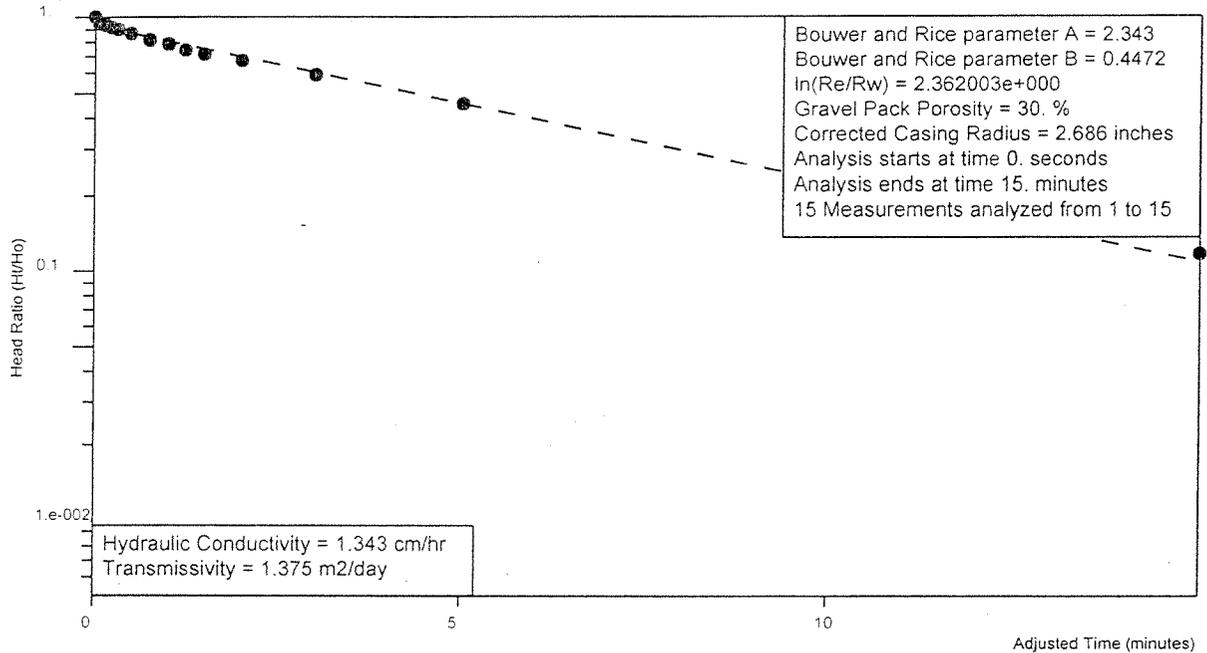
Maximum head is 1.5 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.2	1.5	1.
2	8.3e-002	8.3e-002	7.13	1.43	0.9533
3	0.166	0.166	7.1	1.4	0.9333
4	0.25	0.25	7.07	1.37	0.9133
5	0.333	0.333	7.05	1.35	0.9
6	0.5	0.5	7.01	1.31	0.8733
7	0.75	0.75	6.97	1.27	0.8467
8	1.	1.	6.92	1.22	0.8133
9	1.25	1.25	6.88	1.18	0.7867
10	1.5	1.5	6.84	1.14	0.76
11	2.	2.	6.79	1.09	0.7267
12	3.	3.	6.68	0.98	0.6533
13	5.	5.	6.49	0.79	0.5267
14	10.	10.	6.1	0.4	0.2667
15	15.	15.	5.96	0.26	0.1733

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-16



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 3.44 feet at 0. seconds

Aquifer Permeability Test

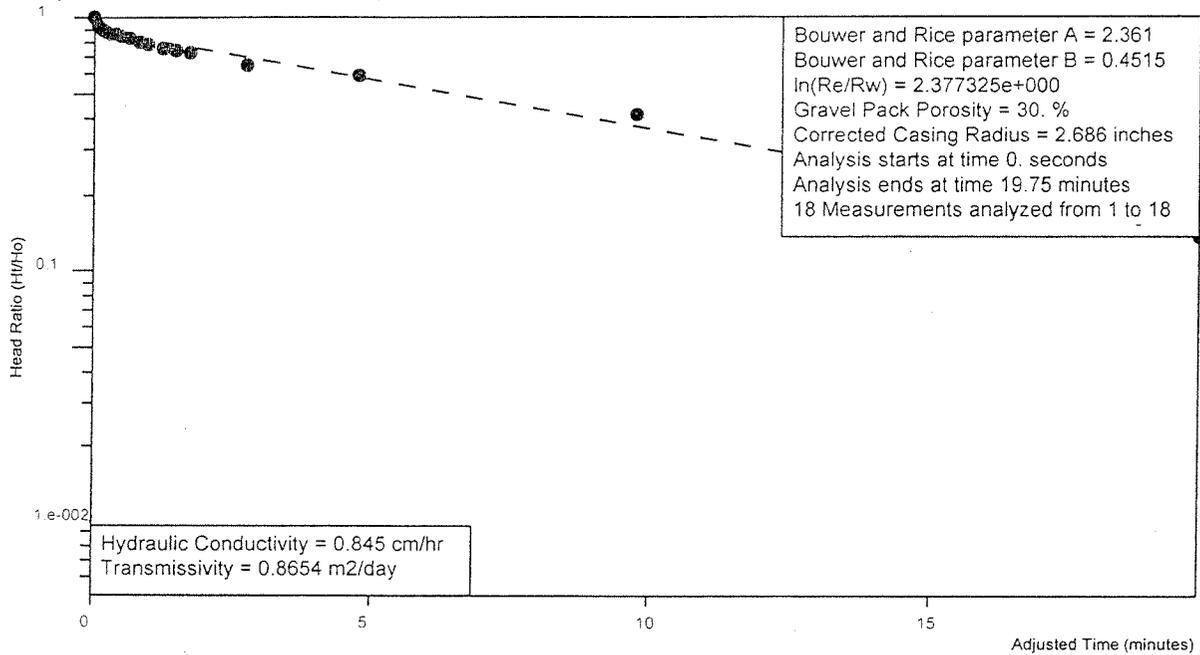
Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-16
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.46 feet
 Water Table to Screen Bottom: 11.74 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 15 time and drawdown measurements
 Maximum head is 3.44 feet
 Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.9	3.44	1.
2	8.3e-002	8.3e-002	7.75	3.29	0.9564
3	0.166	0.166	7.66	3.2	0.9302
4	0.25	0.25	7.61	3.15	0.9157
5	0.333	0.333	7.55	3.09	0.8983
6	0.5	0.5	7.43	2.97	0.8634
7	0.75	0.75	7.29	2.83	0.8227
8	1.	1.	7.17	2.71	0.7878
9	1.25	1.25	7.04	2.58	0.75
10	1.5	1.5	6.94	2.48	0.7209
11	2.	2.	6.78	2.32	0.6744
12	3.	3.	6.5	2.04	0.593
13	5.	5.	6.03	1.57	0.4564
14	10.	10.	5.16	0.7	0.2035
15	15.	15.	4.86	0.4	0.1163

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-17



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Adjusted Time (minutes)
Ho is 3.23 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-17
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.22 feet
 Water Table to Screen Bottom: 11.98 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 18 time and drawdown measurements

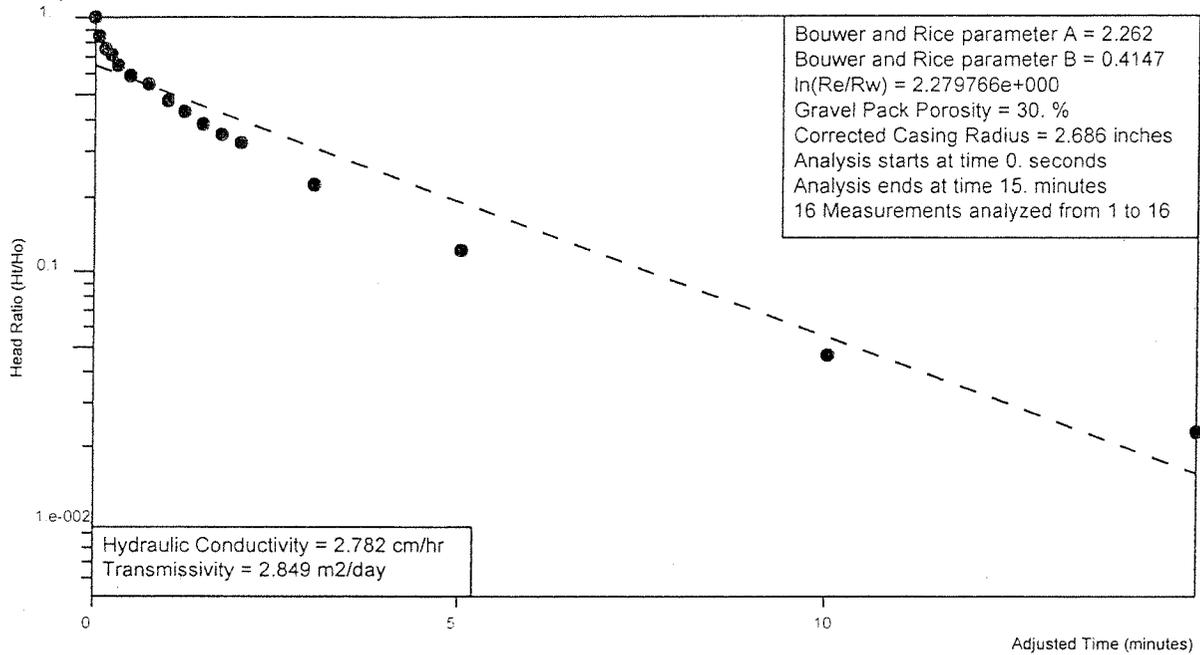
Maximum head is 3.23 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.45	3.23	1.
2	8.3e-002	8.3e-002	7.22	3.	0.9288
3	0.166	0.166	7.15	2.93	0.9071
4	0.25	0.25	7.09	2.87	0.8885
5	0.333	0.333	7.03	2.81	0.87
6	0.416	0.416	7.	2.78	0.8607
7	0.5	0.5	6.95	2.73	0.8452
8	0.666	0.666	6.9	2.68	0.8297
9	0.833	0.833	6.82	2.6	0.805
10	1.	1.	6.76	2.54	0.7864
11	1.25	1.25	6.69	2.47	0.7647
12	1.5	1.5	6.62	2.4	0.743
13	1.75	1.75	6.58	2.36	0.7307
14	2.75	2.75	6.35	2.13	0.6594
15	4.75	4.75	6.15	1.93	0.5975
16	9.75	9.75	5.55	1.33	0.4118
17	14.75	14.75	5.04	0.82	0.2539
18	19.75	19.75	4.66	0.44	0.1362

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bower and Rice Graph
DMW-18



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.74 feet at 0. seconds

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-18
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 6.01 feet
 Water Table to Screen Bottom: 10.29 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

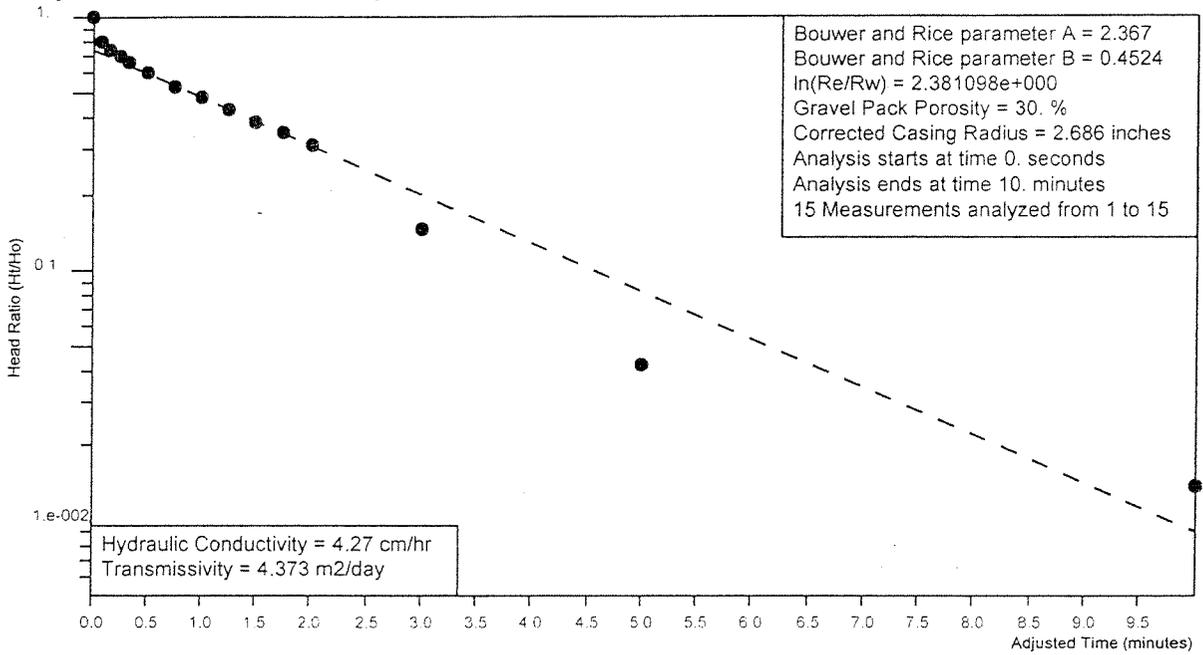
Maximum head is 1.74 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.75	1.74	1.
2	8.3e-002	8.3e-002	7.5	1.49	0.8563
3	0.166	0.166	7.33	1.32	0.7586
4	0.25	0.25	7.25	1.24	0.7126
5	0.333	0.333	7.15	1.14	0.6552
6	0.5	0.5	7.04	1.03	0.592
7	0.75	0.75	6.96	0.95	0.546
8	1.	1.	6.84	0.83	0.477
9	1.25	1.25	6.76	0.75	0.431
10	1.5	1.5	6.68	0.67	0.3851
11	1.75	1.75	6.62	0.61	0.3506
12	2.	2.	6.57	0.56	0.3218
13	3.	3.	6.4	0.39	0.2241
14	5.	5.	6.22	0.21	0.1207
15	10.	10.	6.09	8.e-002	4.598e-002
16	15.	15.	6.05	4.e-002	2.299e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-19



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.44 feet at 0. seconds

Aquifer Permeability Test

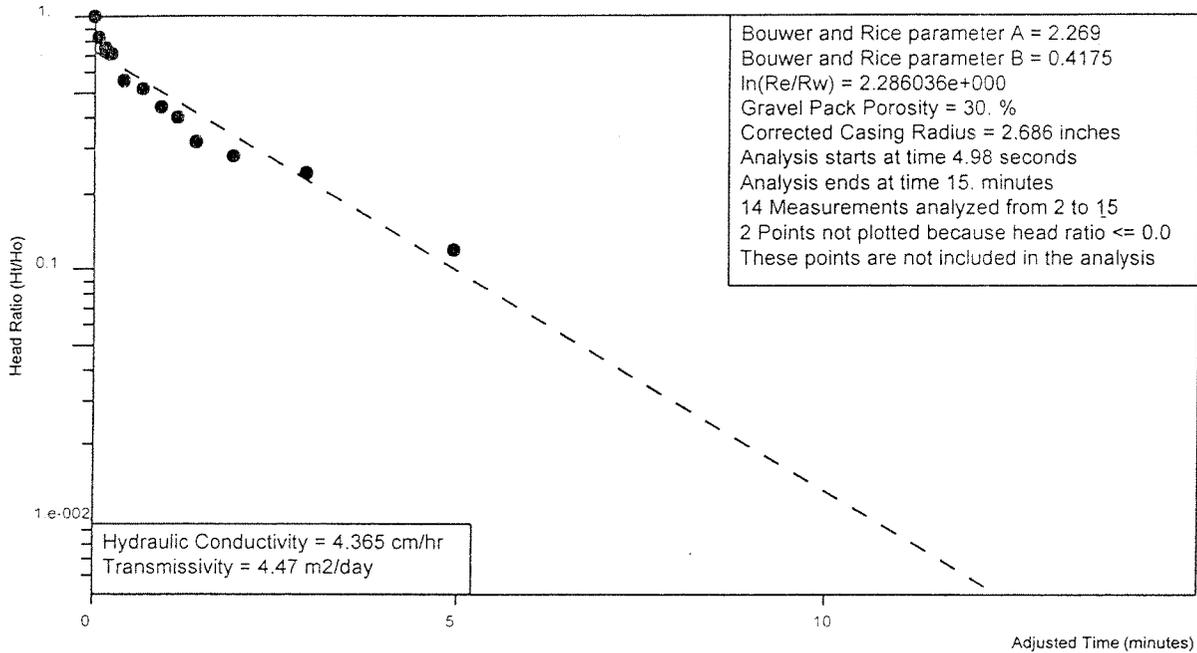
Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-19
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 4.16 feet
 Water Table to Screen Bottom: 12.04 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 0. Seconds
 Test starts with trial 0
 There are 15 time and drawdown measurements
 Maximum head is 1.44 feet
 Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.6	1.44	1.
2	8.3e-002	8.3e-002	5.31	1.15	0.7986
3	0.166	0.166	5.24	1.08	0.75
4	0.25	0.25	5.18	1.02	0.7083
5	0.333	0.333	5.12	0.96	0.6667
6	0.5	0.5	5.03	0.87	0.6042
7	0.75	0.75	4.93	0.77	0.5347
8	1.	1.	4.85	0.69	0.4792
9	1.25	1.25	4.78	0.62	0.4306
10	1.5	1.5	4.71	0.55	0.3819
11	1.75	1.75	4.66	0.5	0.3472
12	2.	2.	4.61	0.45	0.3125
13	3.	3.	4.37	0.21	0.1458
14	5.	5.	4.22	6.e-002	4.167e-002
15	10.	10.	4.18	2.e-002	1.389e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-20



Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name: Clayhill Farms
 Location: Jones County
 Test Date: 2/17/99
 Client: NCDOT
 Project Number: 1960024-203.00

Well Label: DMW-20
 Aquifer Thickness: 14. feet
 Screen Length: 12.5 feet
 Casing Radius: 0.8 inches
 Effective Radius: 4.75 inches
 Gravel Pack Porosity: 30. %
 Corrected Casing Radius: 2.686 inches
 Static Water Level: 5.79 feet
 Water Table to Screen Bottom: 10.41 feet
 Anisotropy Ratio: 0.
 Time Adjustment: 4.98 Seconds

Test starts with trial 1

There are 15 time and drawdown measurements

Maximum head is 0.25 feet

Minimum head is -5.79 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-5.79	-23.16
2	8.3e-002	0.	6.04	0.25	1.
3	0.166	8.3e-002	6.	0.21	0.84
4	0.25	0.167	5.98	0.19	0.76
5	0.333	0.25	5.97	0.18	0.72
6	0.5	0.417	5.93	0.14	0.56
7	0.75	0.667	5.92	0.13	0.52
8	1.	0.917	5.9	0.11	0.44
9	1.25	1.167	5.89	1.e-001	0.4
10	1.5	1.417	5.87	8.e-002	0.32
11	2.	1.917	5.86	7.e-002	0.28
12	3.	2.917	5.85	6.e-002	0.24
13	5.	4.917	5.82	3.e-002	0.12
14	10.	9.917	5.79	0.	0.
15	15.	14.92	5.79	0.	0.

DESIGN CRITERIA

DEPTH-DURATION-FREQUENCY TABLE

DURATION	2-yr [in]	5-yr [in]	10-yr [in]	25-yr [in]	50-yr [in]	100-yr [in]
5 min	0.49	0.55	0.60	0.68	0.74	0.80
10 min	0.82	0.94	1.03	1.17	1.29	1.40
15 min	1.05	1.21	1.33	1.52	1.66	1.81
30 min	1.52	1.84	2.07	2.41	2.67	2.93
60 min	2.00	2.49	2.83	3.33	3.72	4.10
2 hr	2.28	2.85	3.26	3.84	4.30	4.75
3 hr	2.55	3.22	3.69	4.36	4.88	5.40
6 hr	3.25	4.15	4.78	5.67	6.36	7.05
12 hr	3.88	4.98	5.75	6.84	7.68	8.53
24 hr	4.50	5.81	6.72	8.01	9.01	10.00

INTENSITY-DURATION-FREQUENCY TABLE

DURATION	2-yr [in/hr]	5-yr [in/hr]	10-yr [in/hr]	25-yr [in/hr]	50-yr [in/hr]	100-yr [in/hr]
5 min	5.88	6.63	7.23	8.15	8.87	9.60
10 min	4.92	5.65	6.20	7.05	7.71	8.38
15 min	4.20	4.84	5.33	6.07	6.66	7.24
30 min	3.03	3.67	4.14	4.81	5.34	5.86
60 min	2.00	2.49	2.83	3.33	3.72	4.10
2 hr	1.14	1.43	1.63	1.92	2.15	2.37
3 hr	0.85	1.07	1.23	1.45	1.63	1.80
6 hr	0.54	0.69	0.80	0.94	1.06	1.18
12 hr	0.32	0.42	0.48	0.57	0.64	0.71
24 hr	0.19	0.24	0.28	0.33	0.38	0.42

IDF EQUATIONS

R	g	h	
2	163	23	$I_r = g / (h + T_d)$
5	211	27	VALID ONLY UP
10	245	29	TO 2 HOURS
25	293	31	
50	331	33	$T_d = \text{duration (mins)}$
100	369	34	

INPUT

Duration	2-yr P [in]	100-yr P [in]	Source
5 min	0.49	0.80	NOAA HYDRO-35
15 min	1.05	1.81	NOAA HYDRO-35
60 min	2.00	4.10	NOAA HYDRO-35
24 hr	4.50	10.00	USWB TP-40



Langley and McDonald, P.C.

ENGINEERS • SURVEYORS • PLANNERS
LANDSCAPE ARCHITECTS • ENVIRONMENTAL CONSULTANTS

VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject NC - CLAYHILL

Project No. _____

Client _____

Computed By MWM Checked by _____

Date _____ Sheet No. _____

MANNING ROUGHNESS COEFFICIENT

N

OPEN CHANNEL, EXCAVATED - CHANNELS
NOT MAINTAINED, CLEAN BOTTOM
BRUSH ON SIDES 0.05

OPEN CHANNEL, EXCAVATED - EARTH
UNIFORM SECTION, GRASS & WEEDS 0.022

SHEET FLOW MANNINGS ROUGHNESS COEF

WOODS 0.40
FALLOW ($\leq 20\%$) 0.06

RATIONAL FORMULA

RUNOFF COEF (C)

AGRICULTURAL LAND BARE PAKED SOIL (ROUGH) 0.35

AGRICULTURAL LAND (CULTIVATED) ROWS 0.35

HEAVY SOIL, NO CROP

RUNOFF CURVE No. (SCS METHOD)

WOODS - GOOD (HYDRO-SOIL GROUP "D") 77
GOOD = WOODS ARE PROTECTED FROM GRAZING,
AND LITTER AND BRUSH ADEQUATELY
COVER THE SOIL.



Langley and McDonald, P.C.

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VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject NC - CLAYHILL

Project No. _____

Client _____

Computed By MWM Checked by _____

Date _____ Sheet No. _____

MANNING ROUGHNESS COEFFICIENT

N

OPEN CHANNEL, EXCAVATED - CHANNEL
NOT MAINTAINED, WEEDS & BRUSH UNCUT
CLEAN BOTTOM, BRUSH ON SIDES

0.05

OPEN CHANNEL, EXCAVATED - EARTH
UNIFORM SECTION, GRASS & WEEDS

0.022

OPEN CHANNEL, EXCAVATED - EARTH
FAIRLY UNIFORM SECTION,
DENSE WEEDS OR AQUATIC PLANTS

0.035

NATURAL STREAM CHANNEL -
MINOR STREAM - DENSE GROWTH OF
WEEDS

0.035

NATURAL STREAM CHANNEL -
FLOOD PLAINS - CULTIVATED -
NO CROPS

0.04

NATURAL STREAM CHANNEL -
BRUSH & TREES

0.06

TABLE 2.8.2

Manning roughness coefficients, n^1

	Manning's n range ²		Manning's n range ²
I. Closed conduits:		IV. Highway channels and swales with maintained vegetation⁴	
A. Concrete pipe.....	0.011-0.013	A. Depth of flow up to 0.7 foot:	
B. Corrugated-metal pipe or pipe-arch:		1. Bermudagrass, Kentucky bluegrass, buffalograss:	
1. 2½ by ½-in. corrugation (riveted pipe): ³		a. Mowed to 2 inches.....	0.07-0.045
a. Plain or fully coated.....	0.024	b. Length 4-6 inches.....	0.09-0.05
b. Paved invert (range values are for 25 and 50 percent of circumference paved):		2. Good stand, any grass:	
(1) Flow full depth.....	0.021-0.018	a. Length about 12 inches.....	0.18-0.09
(2) Flow 0.8 depth.....	0.021-0.016	b. Length about 24 inches.....	0.30-0.15
(3) Flow 0.6 depth.....	0.019-0.013	3. Fair stand, any grass:	
2. 6 by 2-in. corrugation (field bolted).....	0.03	a. Length about 12 inches.....	0.14-0.08
C. Vitrified clay pipe.....	0.012-0.014	b. Length about 24 inches.....	0.25-0.13
D. Cast-iron pipe, uncoated.....	0.013	B. Depth of flow 0.7-1.5 feet:	
E. Steel pipe.....	0.009-0.011	1. Bermudagrass, Kentucky bluegrass, buffalograss:	
F. Brick.....	0.014-0.017	a. Mowed to 2 inches.....	0.05-0.035
G. Monolithic concrete:		b. Length 4 to 6 inches.....	0.06-0.04
1. Wood forms, rough.....	0.015-0.017	2. Good stand, any grass:	
2. Wood forms, smooth.....	0.012-0.014	a. Length about 12 inches.....	0.12-0.07
3. Steel forms.....	0.012-0.013	b. Length about 24 inches.....	0.20-0.10
H. Cemented rubble masonry walls:		3. Fair stand, any grass:	
1. Concrete floor and top.....	0.017-0.022	a. Length about 12 inches.....	0.10-0.06
2. Natural floor.....	0.019-0.025	b. Length about 24 inches.....	0.17-0.09
I. Laminated treated wood.....	0.015-0.017	V. Street and expressway gutters:	
J. Vitrified clay liner plates.....	0.015	A. Concrete gutter, troweled finish.....	0.012
II. Open channels, lined⁴ (straight alignment):³		B. Asphalt pavement:	
A. Concrete, with surfaces as indicated:		1. Smooth texture.....	0.013
1. Formed, no finish.....	0.013-0.017	2. Rough texture.....	0.016
2. Trowel finish.....	0.012-0.014	C. Concrete gutter with asphalt pavement:	
3. Float finish.....	0.013-0.015	1. Smooth.....	0.013
4. Float finish, some gravel on bottom.....	0.015-0.017	2. Rough.....	0.015
5. Gunite, good section.....	0.016-0.019	D. Concrete pavement:	
6. Gunite, wavy section.....	0.018-0.022	1. Float finish.....	0.014
B. Concrete, bottom float finished, sides as indicated:		2. Broom finish.....	0.016
1. Dressed stone in mortar.....	0.015-0.017	E. For gutters with small slope, where sediment may accumulate, increase above values of n by.....	0.002
2. Random stone in mortar.....	0.017-0.020	VI. Natural stream channels:⁴	
3. Cement rubble masonry.....	0.020-0.025	A. Minor streams ⁵ (surface width at flood stage less than 100 ft.):	
4. Cement rubble masonry, plastered.....	0.016-0.020	1. Fairly regular section:	
5. Dry rubble (riprap).....	0.020-0.030	a. Some grass and weeds, little or no brush.....	0.030-0.035
C. Gravel bottom, sides as indicated:		b. Dense growth of weeds, depth of flow materially greater than weed height.....	0.035-0.05
1. Formed concrete.....	0.017-0.020	c. Some weeds, light brush on banks.....	0.035-0.05
2. Random stone in mortar.....	0.020-0.023	d. Some weeds, heavy brush on banks.....	0.05-0.07
3. Dry rubble (riprap).....	0.023-0.033	e. Some weeds, dense willows on banks.....	0.06-0.08
D. Brick.....	0.014-0.017	f. For trees within channel, with branches submerged at high stage, increase all above values by.....	0.01-0.02
E. Asphalt:		2. Irregular sections, with pools, slight channel meander; increase values given in 1a-e about.....	0.01-0.02
1. Smooth.....	0.013	3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:	
2. Rough.....	0.016	a. Bottom of gravel, cobbles, and few boulders.....	0.04-0.05
F. Wood, planed, clean.....	0.011-0.013	b. Bottom of cobbles, with large boulders.....	0.05-0.07
G. Concrete-lined excavated rock:		B. Flood plains (adjacent to natural streams):	
1. Good section.....	0.017-0.020	1. Pasture, no brush:	
2. Irregular section.....	0.022-0.027	a. Short grass.....	0.030-0.035
III. Open channels, excavated⁴ (straight alignment,³ natural lining):		b. High grass.....	0.035-0.05
A. Earth, uniform section:		2. Cultivated areas:	
1. Clean, recently completed.....	0.016-0.018	a. No crop.....	0.03-0.04
2. Clean, after weathering.....	0.018-0.020	b. Mature row crops.....	0.035-0.045
3. With short grass, few weeds.....	0.022-0.027	c. Mature field crops.....	0.04-0.05
4. In gravelly soil, uniform section, clean.....	0.022-0.025	3. Heavy weeds, scattered brush.....	0.05-0.07
B. Earth, fairly uniform section:		4. Light brush and trees: ¹⁰	
1. No vegetation.....	0.022-0.025	a. Winter.....	0.05-0.06
2. Grass, some weeds.....	0.025-0.030	b. Summer.....	0.06-0.08
3. Dense weeds or aquatic plants in deep channels.....	0.030-0.035	5. Medium to dense brush: ¹⁰	
4. Sides clean, gravel bottom.....	0.025-0.030	a. Winter.....	0.07-0.11
5. Sides clean, cobble bottom.....	0.030-0.040	b. Summer.....	0.10-0.16
C. Dragline excavated or dredged:		6. Dense willows, summer, not bent over by current.....	0.15-0.20
1. No vegetation.....	0.028-0.033	7. Cleared land with tree stumps, 100-150 per acre:	
2. Light brush on banks.....	0.035-0.050	a. No sprouts.....	0.04-0.05
D. Rock:		b. With heavy growth of sprouts.....	0.06-0.08
1. Based on design section.....	0.035	8. Heavy stand of timber, a few down trees, little undergrowth:	
2. Based on actual mean section:		a. Flood depth below branches.....	0.10-0.12
a. Smooth and uniform.....	0.035-0.040	b. Flood depth reaches branches.....	0.12-0.16
b. Jagged and irregular.....	0.040-0.045	Major streams (surface width at flood stage more than 100 ft.): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of n may be somewhat reduced. Follow recommendation in publication cited ⁴ if possible. The value of n for larger streams of most regular section, with no boulders or brush, may be in the range of.....	
E. Channels not maintained, weeds and brush uncut:			0.028-0.033
1. Dense weeds, high as flow depth.....	0.08-0.12		
2. Clean bottom, brush on sides.....	0.05-0.08		
3. Clean bottom, brush on sides, highest stage of flow.....	0.07-0.11		
4. Dense brush, high stage.....	0.10-0.14		

0.035

0.04

0.06

0.022

0.035

0.05

TABLE 5-2
VALUES OF RUNOFF COEFFICIENT (C) FOR RATIONAL FORMULA

Land Use	C	Land Use	C
Business: Downtown areas Neighborhood areas	0.70-0.95 0.50-0.70	Lawns: Sandy soil, flat, 2% Sandy soil, average, 2-7% Sandy soil, steep, 7% Heavy soil, flat, 2% Heavy soil, average, 2-7% Heavy soil, steep, 7%	0.05-0.10 0.10-0.15 0.15-0.20 0.13-0.17 0.18-0.22 0.25-0.35
Residential: Single-family areas Multi units, detached Multi units, attached Suburban	0.30-0.50 0.40-0.60 0.60-0.75 0.25-0.40	Agricultural land: Bare packed soil * Smooth * Rough Cultivated rows * Heavy soil, no crop * Heavy soil, with crop * Sandy soil, no crop * Sandy soil, with crop Pasture * Heavy soil * Sandy soil Woodlands	0.30-0.60 0.20-0.50 0.30-0.60 0.20-0.50 0.20-0.40 0.10-0.25 0.15-0.45 0.05-0.25 0.05-0.25
Industrial: Light areas Heavy areas	0.50-0.80 0.60-0.90	Streets: Asphaltic Concrete Brick	0.70-0.95 0.80-0.95 0.70-0.85
Parks, cemeteries	0.10-0.25	Unimproved areas	0.10-0.30
Playgrounds	0.20-0.35	Drives and walks	0.75-0.85
Railroad yard areas	0.20-0.40	Roofs	0.75-0.95

Note: The designer must use judgement to select the appropriate "C" value within the range. Generally, larger areas with permeable soils, flat slopes and dense vegetation should have the lowest C values. Smaller areas with dense soils, moderate to steep slopes, and sparse vegetation should be assigned the highest C values.

Source: American Society of Civil Engineers

TABLE 5-3
ROUGHNESS COEFFICIENTS
(MANNING'S "N") FOR SHEET FLOW

<u>Surface Description</u>	<u>n¹</u>
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses ²	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods ³ :	
Light underbrush	0.40
Dense underbrush	0.80

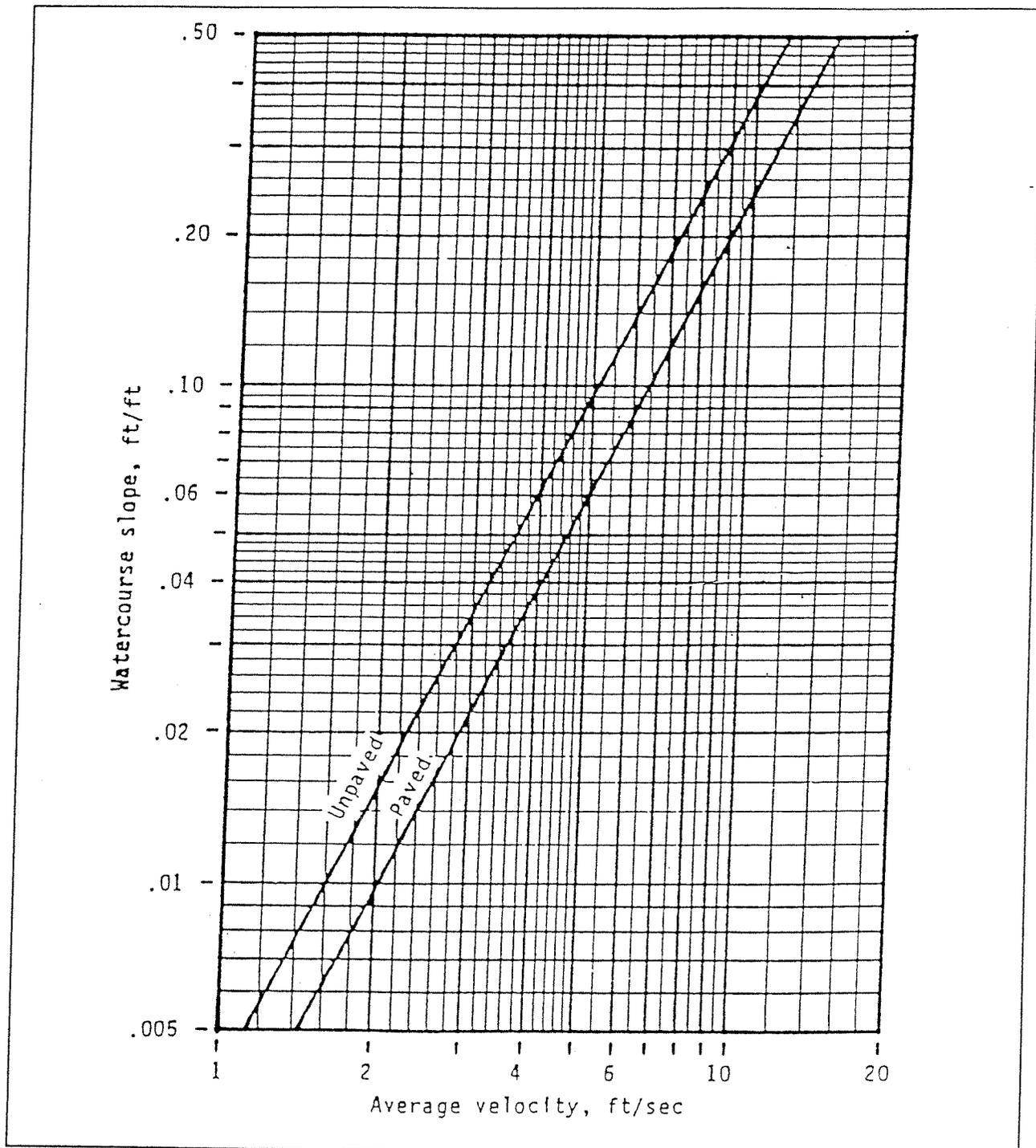
¹ The "n" values are a composite of information compiled by Engman (1986).

² Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

³ When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: USDA-SCS

AVERAGE VELOCITIES FOR ESTIMATING TRAVEL TIME FOR SHALLOW CONCENTRATED FLOW



Source: USDA-SCS

Plate 5-23

APPENDIX F

STORMWATER CALCULATIONS (HEC-2 ANALYSIS)

STORMWATER CALCULATIONS

TABLE OF CONTENTS

- 1 DESIGN CRITERIA
- 2 HEC 2 RUNS
(Existing conditions and proposed conditions)
- 3 TAILWATER CONDITION UPSTREAM OF OUTFALL CULVERTS
(Calculated as a pond with existing culverts acting as control outfall structures)
- 4 WATERSHED TO THE OUTFALL CULVERTS
(Individual drainage area – peak runoff rates)
- 5 FLOW RATES THROUGH EXISTING DOWNSTREAM CULVERTS
- 6 FUTURE CONDITIONS OF THE FEEDER DITCHES
(Weir set within downstream end of the ditches)
- 7 FLOW RATE WITHIN EXISTING FEEDER DITCHES
(Located within proposed wetland area)

HEC 2

(Existing conditions and proposed conditions)

HEC 2 RUNS

EXISTING CONDITIONS – 2 YEAR

STARTING PROFILE NUMBER 1

Computed Water Surface Elev.

CWSEL – Cross Section	7	22.70
	6	22.69
	5	24.57
	4	24.49
	3	31.81
	2	32.71
	1	32.94

PROPOSED CONDITIONS

CWSEL – Cross Section	7	22.70
	6	22.72
	5	26.62
	4	26.99
	3	32.26
	2	33.67
	1	33.76

THIS RUN EXECUTED 3JUN99 11:59:27

HEC-2 WATER SURFACE PROFILES

Version 4.6.0; February 1991

T1 CLAYHILL STREAM RESTORATION
T2 L&M JOB
T3 EXISTING CONDITIONS - 2-YR STORM

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
0	0	0	0	0	0	323	22.7	0		
NC	0.06	0.06	0.035	0.1	0.3					
X1	7	9	43.0	195.0	0	0	0			
GR	25.0	0.0	21.0	97.0	20.0	125.0	16.0	137.0	16.0	146.0
GR	18.0	152.0	20.0	187.0	20.0	335.0	25.0	390.0		
X1	6	13	44.5	54.5	300	300	300			
X2	176	0	0	0						
GR	25.0	0.0	19.0	38.5	22.6	42.5	20.5	44.5	18.5	45.5
GR	18.0	48.0	18.0	52.0	18.9	53.5	20.8	54.5	21.0	66.0
GR	24.0	165.0	24.0	235.0	25.0	250.0				
X1	5	10	10.0	193.0	1920	1920	1920			
X2	148	0	0	0						
GR	31.0	0.0	30.0	100.0	27.0	165.0	24.2	168.0	21.5	172.0
GR	21.5	177.0	25.9	187.0	26.5	193.0	27.0	227.0	30.0	350.0
X1	4	8	86.0	100.0	23.0	23.0	23.0			
X2	143	0	0	0						
GR	31.0	0.0	30.0	35.0	26.1	86.0	21.5	90.5	21.8	95.0
GR	25.8	100.0	26.0	103.0	32.0	221.0				
NC	0.04	0.06	0.035	0.1	0.3					
X1	3	7	7.0	240.0	1520	1520	1520			
X2	95	0	0	0						
GR	33.0	0.0	32.0	168.0	31.0	223.0	28.0	229.0	28.0	232.0
GR	32.0	240.0	33.0	463.0						
X1	2	12	590.0	608.0	1160	1160	1160			
X2	73	0	0	0						
GR	33.5	0.0	33.5	500.0	33.5	560.0	33.1	578.0	33.0	590.0
GR	29.0	592.0	29.0	602.0	34.0	608.0	35.0	615.0	34.1	630.0
GR	34.0	730.0	35.0	860.0						

X1	1	10	590.0	608.0	1040	1040	1040			
X2	38	0	0	0						
GR	33.5	0.0	33.0	400.0	33.1	578.0	33.0	590.0	29.0	592.0
GR	29.0	602.0	34.0	608.0	33.0	617.0	33.5	700.0	34.0	775.0

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*PROF 1

CCHV= .100 CEHV= .300

*SECNO 7.000

7.000	6.70	22.70	.00	22.70	22.70	.00	.00	.00	25.00
323.0	.0	197.7	125.3	.0	377.0	439.7	.0	.0	20.00
.00	.00	.52	.29	.000	.035	.060	.000	16.00	55.77
.000038	0.	0.	0.	0	0	0	.00	308.93	364.70

*SECNO 6.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .15

6.000	4.69	22.69	.00	.00	22.74	.04	.02	.01	20.50
176.0	43.4	91.2	41.4	53.9	42.4	68.6	3.4	1.4	20.80
.06	.81	2.15	.60	.060	.035	.060	.000	18.00	14.74
.000514	300.	300.	300.	1	0	0	.00	107.45	122.19

*SECNO 5.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .27

5.000	3.07	24.57	.00	.00	24.89	.31	2.07	.08	31.00
148.0	.0	148.0	.0	.0	33.1	.0	7.7	4.2	26.50
.18	.00	4.48	.00	.000	.035	.000	.000	21.50	167.60
.004940	1920.	1920.	1920.	4	0	0	.00	16.38	183.98

*SECNO 4.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .62

4.000	2.99	24.49	.00	.00	25.16	.67	.17	.11	26.10
143.0	.0	143.0	.0	.0	21.7	.0	7.8	4.2	25.80
.18	.00	6.59	.00	.000	.035	.000	.000	21.50	87.57
.012173	23.	23.	23.	2	0	0	.00	10.79	98.37

CCHV= .100 CEHV= .300

SECNO	DEPTH	CWSEL	CRWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 3.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.78

3.000	3.81	31.81	.00	.00	31.85	.04	6.62	.06	33.00
95.0	.0	95.0	.0	.0	57.5	.0	9.1	5.4	32.00
.43	.00	1.65	.00	.000	.035	.000	.000	28.00	178.79
.001693	1520.	1520.	1520.	6	0	0	.00	60.82	239.61

*SECNO 2.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.63

2.000	3.71	32.71	.00	.00	32.74	.03	.89	.00	33.00
73.0	.0	73.0	.0	.0	48.8	.0	10.6	6.4	34.00
.65	.00	1.50	.00	.000	.035	.000	.000	29.00	590.15
.000377	1160.	1160.	1160.	4	0	0	.00	16.30	606.45

*SECNO 1.000

1.000	3.94	32.94	.00	.00	32.95	.01	.20	.00	33.00
38.0	.0	38.0	.0	.0	52.7	.0	11.8	6.8	34.00
1.05	.00	.72	.00	.000	.035	.000	.000	29.00	590.03
.000082	1040.	1040.	1040.	2	0	0	.00	16.71	606.74

PROFILE FOR STREAM EXISTING CONDITIONS - 2-

PLOTTED POINTS (BY PRIORITY) E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

ELEVATION 16. 18. 20. 22. 24. 26. 28. 30. 32. 34.
 SECNO CUMDIS

7.00	0. I	R	E	L						
100.	C I	R	E	L	M					
200.	C I	R	L	E	M					
6.00	300. C	I	LR	E	M					
400.	C I	L	E	M						
500.	C I	RL	WE	M						
600.	C I	R	L	E	M					
700.	C I	R	L	WE	M					
800.	C I	R	E	M						
900.	C I	R	WE	L	M					
1000.	C I	R	WE	L	M					
1100.	C I	R	WE	L	M					
1200.	C I	R	WE	L	M					
1300.	C I	WE	L	M						
1400.	C I	WE	L	M						
1500.	C I	WE	R	L	M					
1600.	C I	WE	R	L	M					
1700.	C I	WE	R	L	M					
1800.	C I	WE	R	L	M					
1900.	C I	WE	R	L	M					
2000.	C I	WE	R	M	L					
2100.	C I	WE	R	M	L					
2200.	C I	WE	R	M	L					
5.00	2300. C	I	WE	R	M	L				
4.00	2400. C	I	WE	R	L	M				
2500.	C I	WE	R	L	M					
2600.	C I	WE	R	L	M					
2700.	C I	WE	R	L	M					
2800.	C I	WE	R	L	M					
2900.	C I	WE	R	L	M					
3000.	C I	WE	R	L	M					
3100.	C I	WE	R	L	M					
3200.	C I	WE	R	L	M					
3300.	C I	WE	R	L	M					
3400.	C I	WE	R	L	M					
3500.	C I	WE	R	L	M					
3600.	C I	WE	R	L	M					
3700.	C I	WE	R	L	M					
3.00	3800. C	I	WE	R	L	M				
3900.	C I	WE	R	L	M					
4000.	C I	WE	R	L	M					
4100.	C I	WE	R	L	M					
4200.	C I	WE	R	L	M					
4300.	C I	WE	R	L	M					
4400.	C I	WE	R	L	M					
4500.	C I	WE	R	L	M					
4600.	C I	WE	R	L	M					
4700.	C I	WE	R	L	M					
4800.	C I	WE	R	L	M					
4900.	C I	WE	R	L	M					

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2.00 5000. C . . . . . I . . . EL MR
5100. C . . . . . I . . . EL MR
5200. C . . . . . I . . . EL MR
5300. C . . . . . I . . . EL MR
5400. C . . . . . I . . . EL MR
5500. C . . . . . I . . . EL MR
5600. C . . . . . I . . . EL MR
5700. C . . . . . I . . . EL MR
5800. C . . . . . I . . . WE MR
5900. C . . . . . I . . . E MR
1.00 6000. C . . . . . I . . . E MR

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Run Date: 3JUN99 Run Time: 11:59:27 HMVersion: 6.20 Data File: A:EXIST2B.TXT

Page 5

THIS RUN EXECUTED 3JUN99 11:59:27

HEC-2 WATER SURFACE PROFILES

Version 4.6.0; February 1991

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

EXISTING CONDITIONS - 2-

SUMMARY PRINTOUT TABLE 150

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
7.000	.00	.00	.00	16.00	323.00	22.70	.00	22.70	.38	.52	816.74	525.78
* 6.000	300.00	.00	.00	18.00	176.00	22.69	.00	22.74	5.14	2.15	164.86	77.62
* 5.000	1920.00	.00	.00	21.50	148.00	24.57	.00	24.89	49.40	4.48	33.07	21.06
* 4.000	23.00	.00	.00	21.50	143.00	24.49	.00	25.16	121.73	6.59	21.70	12.96
* 3.000	1520.00	.00	.00	28.00	95.00	31.81	.00	31.85	16.93	1.65	57.47	23.09
* 2.000	1160.00	.00	.00	29.00	73.00	32.71	.00	32.74	3.77	1.50	48.77	37.59
1.000	1040.00	.00	.00	29.00	38.00	32.94	.00	32.95	.82	.72	52.71	41.90

EXISTING CONDITIONS - 2-

SUMMARY PRINTOUT TABLE 150

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
7.000	323.00	22.70	.00	.00	.00	308.93	.00
* 6.000	176.00	22.69	.00	-.01	.00	107.45	300.00
* 5.000	148.00	24.57	.00	1.88	.00	16.38	1920.00
* 4.000	143.00	24.49	.00	-.09	.00	10.79	23.00
* 3.000	95.00	31.81	.00	7.32	.00	60.82	1520.00
* 2.000	73.00	32.71	.00	.90	.00	16.30	1160.00
1.000	38.00	32.94	.00	.23	.00	16.71	1040.00

SUMMARY OF ERRORS AND SPECIAL NOTES

WARNING SECNO= 6.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 5.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 4.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 2.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

Normal program termination

```
*****
* HEC-2 WATER SURFACE PROFILES *
*                               *
* Version 4.6.0; February 1991 *
*                               *
* RUN DATE 3JUN99 TIME 13:30:10 *
*****
* U.S. ARMY CORPS OF ENGINEERS *
* HYDROLOGIC ENGINEERING CENTER *
* 609 SECOND STREET, SUITE D *
* DAVIS, CALIFORNIA 95616-4687 *
* (916) 756-1104 *
*****
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X X XXXXXXXX XXXXX XXXXX
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X X X X X
X X X X X X
X X XXXXXXXX XXXXX XXXXXXXX
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:::
::: FULL MICRO-COMPUTER IMPLEMENTATION :::
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HAESTAD METHODS

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37 Brookside Road * Waterbury, Connecticut 06708 * (203) 755-1666

THIS RUN EXECUTED 3JUN99 13:30:10

 HEC-2 WATER SURFACE PROFILES

Version 4.6.0; February 1991

T1 CLAYHILL STREAM RESTORATION
 T2 L&M JOB
 T3 FUTURE CONDITIONS - 2-YR STORM

JI	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	0	0	0	0	323	22.7	0		
NC	0.06	0.06	0.035	0.1	0.3					
X1	7	10	43.0	195.0	0	0	0			
GR	25.0	0.0	21.0	97.0	20.0	130.0	19.0	137.0	17.5	139.0
GR	17.5	141.0	19.0	143.0	20.0	150.0	20.0	335.0	25.0	390.0
X1	6	13	44.5	54.5	300	300	390			
X2	176	0	0	0						
GR	25.0	0.0	19.0	38.0	20.5	41.0	20.0	45.0	18.0	49.0
GR	18.0	51.0	20.0	55.0	20.5	59.0	20.8	63.0	21.0	66.0
GR	24.0	165.0	24.0	235.0	25.0	250.0				
X1	5	10	10.0	193.0	1920	1920	2500			
X2	148	0	0	0						
GR	31.0	0.0	30.0	100.0	26.0	166.5	25.5	171.5	24.2	173.5
GR	24.2	176.5	25.5	178.5	26.0	183.5	27.0	227.0	30.0	350.0
X1	4	10	86.0	100.0	23	23	30	0		
X2	143	0	0	0						
GR	31.0	0.0	30.0	35.0	26.0	85.0	25.5	89.0	24.3	92.0
GR	24.3	94.0	25.5	97.0	26.0	101.0	26.0	103.0	32.0	221.0
NC	0.04	0.06	0.035	0.1	0.3					
X1	3	9	7.0	240.0	1520	1520	1980			
X2	95	0	0	0						
GR	33.0	0.0	32.0	168.0	31.0	223.0	30.9	227.0	29.8	229.0
GR	29.8	230.5	30.9	233.0	31.5	237.0	33.0	463.0		
X1	2	12	590.0	608.0	1160	1160	1180			
X2	73	0	0	0						
GR	33.5	0.0	33.5	500.0	33.5	560.0	33.0	593.5	32.5	597.5
GR	31.8	599.5	31.8	600.5	32.5	602.5	33.0	606.5	34.1	630.0
GR	34.0	730.0	35.0	860.0						

X1	1	11	590.0	608.0	1040	1040	1060			
X2	38	0	0	0						
GR	33.5	0.0	33.0	400.0	33.1	578.0	33.0	594.5	32.5	597.0
GR	32.0	599.5	32.0	600.5	32.5	603.0	33.0	605.5	33.5	700.0
GR	34.0	775.0								

SECNO	DEPTH	CWSEL	CRWS	WSELK	EG	HV	HL	OLOSS	L-BANK	ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK	ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA	
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST	

*PROF 1

CCHV= .100 CEHV= .300

*SECNO 7.000

7.000	5.20	22.70	.00	22.70	22.70	.00	.00	.00	25.00
323.0	.0	102.6	220.4	.0	180.6	539.6	.0	.0	20.00
.00	.00	.57	.41	.000	.035	.060	.000	17.50	55.77
.000076	0.	0.	0.	0	0	0	.00	308.93	364.70

*SECNO 6.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .22

6.000	4.72	22.72	.00	.00	22.75	.03	.04	.01	20.50
176.0	44.4	68.9	62.7	52.9	34.3	87.7	3.3	1.5	18.00
.07	.84	2.01	.71	.060	.035	.060	.000	18.00	14.41
.000465	300.	390.	300.	0	0	0	.00	108.53	122.93

*SECNO 5.000

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED

5.000	2.42	26.62	26.62	.00	27.00	.38	2.77	.11	31.00
148.0	.0	135.8	12.2	.0	26.3	8.5	8.3	5.4	26.00
.21	.00	5.16	1.45	.000	.035	.060	.000	24.20	156.13
.016160	1920.	2500.	1920.	20	11	0	.00	54.49	210.63

*SECNO 4.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.63

4.000	2.69	26.99	.00	.00	27.28	.28	.26	.01	26.00
143.0	7.2	110.0	25.7	6.2	22.9	16.7	8.4	5.4	25.50
.21	1.17	4.80	1.55	.060	.035	.060	.000	24.30	72.58
.005694	23.	30.	23.	2	0	0	.00	49.95	122.53

CCHV= .100 CEHV= .300

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK	ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK	ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA	
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST	

*SECNO 3.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.44

3.000	2.46	32.26	.00	.00	32.27	.01	4.97	.03	33.00
95.0	.0	74.7	20.3	.0	70.2	44.5	11.6	11.0	31.50
.77	.00	1.06	.46	.000	.035	.060	.000	29.80	122.92
.001210	1520.	1980.	1520.	8	0	0	.00	229.85	352.76

*SECNO 2.000

3280 CROSS SECTION 2.00 EXTENDED .18 FEET

2.000	1.87	33.67	.00	.00	33.68	.01	1.40	.00	33.50
73.0	39.2	31.8	2.0	98.0	29.6	4.9	15.0	22.3	33.00
1.23	.40	1.08	.41	.040	.035	.060	.000	31.80	.00
.001180	1160.	1180.	1160.	5	0	0	.00	620.92	620.92

*SECNO 1.000

3280 CROSS SECTION 1.00 EXTENDED .26 FEET

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 4.93

1.000	1.76	33.76	.00	.00	33.76	.00	.08	.00	33.10
38.0	31.2	3.9	2.9	331.2	26.1	53.5	21.5	38.6	33.00
4.24	.09	.15	.05	.040	.035	.060	.000	32.00	.00
.000013	1040.	1060.	1040.	4	0	0	.00	739.22	739.22

PROFILE FOR STREAM FUTURE CONDITIONS - 2-YR

PLOTTED POINTS (BY PRIORITY) E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

ELEVATION 18. 20. 22. 24. 26. 28. 30. 32. 34. 36.
 SECNO CUMDIS

```

7.00 0. I . R . E . L .
    200. CI R . . E . M .
6.00 400. CI . L . E . M .
    600. C IR . L . E . M .
    800. C IR . L WE . M .
    1000. C IR . L E . M .
    1200. C . IR . WE . M .
    1400. C . IR . WEL . M .
    1600. C . IR . WE L M .
    1800. C . IR . WE L M .
    2000. C . IR . WE L M .
    2200. . C . IR WE . LM .
    2400. . C . IR WE . LM .
    2600. . . IR WE . ML .
    2800. . . I CR WE . ML .
5.00 3000. . . IR WE . ML .
4.00 3200. C . . I R L WE . M .
    3400. C . . I R L WE . M .
    3600. C . . I R L WE . M .
    3800. C . . I R L WE . M .
    4000. C . . I R L WE . M .
    4200. C . . I R L WE . M .
    4400. C . . I R WE . M .
    4600. C . . I R WE . M .
    4800. C . . I R EL M .
3.00 5000. C . . . I R EL .
    5200. C . . . I R EL .
    5400. C . . . I R EL .
    5600. C . . . I R EL .
    5800. C . . . I R E .
    6000. C . . . I R E .
2.00 6200. C . . . I R LE .
    6400. C . . . I R LE .
    6600. C . . . I RLME .
    6800. C . . . I RLME .
    7000. C . . . I LME .
1.00 7200. C . . . I LME .
    
```

THIS RUN EXECUTED 3JUN99 13:30:10

HEC-2 WATER SURFACE PROFILES
Version 4.6.0: February 1991

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

FUTURE CONDITIONS - 2-YR

SUMMARY PRINTOUT TABLE 150

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRWS	EG	10*KS	VCH	AREA	.01K
7.000	.00	.00	.00	17.50	323.00	22.70	.00	22.70	.76	.57	720.24	369.35
* 6.000	390.00	.00	.00	18.00	176.00	22.72	.00	22.75	4.65	2.01	174.81	81.65
* 5.000	2500.00	.00	.00	24.20	148.00	26.62	26.62	27.00	161.60	5.16	34.79	11.64
* 4.000	30.00	.00	.00	24.30	143.00	26.99	.00	27.28	56.94	4.80	45.75	18.95
* 3.000	1980.00	.00	.00	29.80	95.00	32.26	.00	32.27	12.10	1.06	114.66	27.31
2.000	1180.00	.00	.00	31.80	73.00	33.67	.00	33.68	11.80	1.08	132.53	21.25
* 1.000	1060.00	.00	.00	32.00	38.00	33.76	.00	33.76	.13	.15	410.78	104.72

FUTURE CONDITIONS - 2-YR

SUMMARY PRINTOUT TABLE 150

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
7.000	323.00	22.70	.00	.00	.00	308.93	.00
* 6.000	176.00	22.72	.00	.02	.00	108.53	390.00
* 5.000	148.00	26.62	.00	3.90	.00	54.49	2500.00
* 4.000	143.00	26.99	.00	.37	.00	49.95	30.00
* 3.000	95.00	32.26	.00	5.27	.00	229.85	1980.00
2.000	73.00	33.67	.00	1.41	.00	620.92	1180.00
* 1.000	38.00	33.76	.00	.09	.00	739.22	1060.00

SUMMARY OF ERRORS AND SPECIAL NOTES

WARNING SECNO= 6.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO= 5.000 PROFILE= 1 CRITICAL DEPTH ASSUMED

CAUTION SECNO= 5.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY

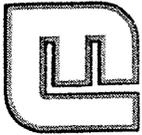
CAUTION SECNO= 5.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO= 4.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 1.000 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

Normal program termination



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VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject _____

Project No. _____

Client _____

Computed By _____ Checked by _____

Date _____ Sheet No. _____

DISTANCE BETWEEN NODES.

NODE	LENGTH OF	STREAMS		SINUOSITY	PROPOSED DISTANCE
	FLOODPLAIN	EXIST. DIST.			
1 TO 2	1,040	1,040'		x1.02	1060
2 " 3	1,160	1,160		x1.02	1180
3 " 4	1520	1,520		1.3	1980
4 " 5	230'	230		1.3	300
5 " 6	1920	1920		1.3	2500
6 " 7	300	300		1.3	390
7 to Culverts	≈600	≈600			NO Δ's (OFF SITE)

Σ of stream length on site Node 1-7 = 6,170 l.f.

7,410 l.f.
(overall 1,20 increase.)



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Date _____ Sheet No. _____

NODE 1

EXIST

FACING UPSTREAM

PROPOSED

	HOR	VERT		HOR	VERTIC.
1	2 L 592	29.0	599.5	0.5' L	32' elev
2	10 L 590	33.0	597	3.0' L	32.5
3	22 L 578	33.1	594.5	5.5' L	33.0
	20' L	32.5	578	22 L	33.1
4	200 L 400	33.0	400	200 L	33.0
5	600 0	33.5			
<hr/>					
6	2 R 602	29.0			
7	8 R 608	34.0	600.5	0.5' R	32'
			603	3.0' R	32.5
			605.5	5.5' R	33.0
8	17R 617	33.0			
9	100'R 700	33.5			
10	175' R 775	34.0			



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Subject _____

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Client _____

Computed By _____ Checked by _____

Date _____ Sheet No. _____

NODE Z

FACING UPSTREAM.

EXIST.

PROPOSED

	Hor		VER
1	2	L 592	29.0
2	10	L 590	33.0
3	22	L 578	33.1
4	40'	560	33.5
5	100'	500	33.5
6	600	0	33.5

	H	V
	599.5	0.5' L 31.75
	597.5	2.5' L 32.5
	593.5	6.0' L 33

7	2	R 602	29.0
8	8	R 608	34.0
9	15	R 615	35.0
10	30	R 630	34.1
11	130	R 730	34
12	260	R 830	35

Prop.

	600.5	0.5' R	31.75
	602.5	2.5' R	32.5
	606.5	6.5' R	33



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Subject _____

Project No. _____

Client _____

Computed By _____ Checked by _____

Date _____ Sheet No. _____

NODE 3

L = FACING UPSTREAM

EXIST.

PROP

	HOR.		V.
1	1' L	229	28'
2	7' L	223	31
	///	///	///
3	62' L	168	32
4	230' L	0	33

	HOR		V
	0.5' L	229.5	29.75
	3' L	227	30.9
	7' L	223	31.0
	62	168	32
	230	0	33

5	2' R	232	28'
6	10 R	240	32'
7	233	463	33'

230.5	0.5' R	29.75
233	3' R	30.9
237	7' R	31.5
463	233	33



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Subject _____

Project No. _____

Client _____

Computed By _____ Checked by _____

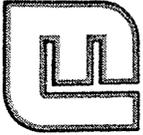
Date _____ Sheet No. _____

NODE 4.

EXISTING
Retaining Upstream

Proposed

	Horiz.	Vertical		H	V
1	2.5' L 90.5	21.5'		1' L 92	24.3
2	7.0' L 86.0	26.1		4' L 89	25.5
3	58.0' L 35.0	30.0		8' L 85	26.0
4	93' 0	31.0 elev.		58 35	30
				93 0	31
5	2 R 95	21.8		1 R 92	24.3
6	7' R 100	25.8		4 R 99	25.5
7	10' R 103	26.0		8 R 101	26.0
8	128' R 221	32		10' R 103	26
				128 R 221	32.



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Subject _____

Project No. _____

Client _____

Computed By _____ Checked by _____

Date _____ Sheet No. _____

NODE S

Existing
L side facing

Upstream
Vertical

Proposed

	Horiz		Vertical		H.-		V-
1	3' L	172	21.5		1.5' L	173.5	24.2
2	7' L	168	24.2		3.5' L	171.5	25.5
3	10' L	165	27.0		8.5 L.	166.5	26.0
4	75' L	100	30.0	} same			
5	175' L	0	31.0				

6	2' R	177	21.5		1.5' R	176.5	24.2
7	10' R	189	25.9		3.5 R	178.5	25.5
8	18' R	193	26.5		8.5 R.	183.5	26.0
9	52' R	227	27.0	} ← off. set to avoid Creeks floodplain. } same →			
10	175' R	350	30.0				



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Subject _____

Project No. _____

Client _____

Computed By _____ Checked by _____

Date _____ Sheet No. _____

NOTE. 6

DISTANCE OF NO

Horizontal location

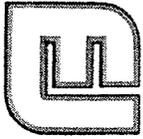
Existing
Elev.

L facing upstream

PROPOSED

PROPOSED

Location	Distance	Existing Elev.		PROPOSED DISTANCE.	PROPOSED ELEV.S
Σ from E.					
48	2L	18.0	1	1L 49	18
45.5	4.5'L	18.9	2	5L 45	20
44.5	5.5'L	20.5	3	—	—
42.5	7.5'L	22.6	4	9L 41	20.5
38	12.0'L	19.0	5	12 38	19.
0	50.0'L	25.0	6	50 0	25
52	2.0R	18.0	7	1R 51	18
53.5	3.5R	18.9	8	5R 55	20
54.5	4.5R	20.8	9	9R 59	20.5
66.0	16.0R	21.0	10	66	21.0
165.0	115.0R	24.0	11	63	20.8
235.0	185.0R	24.0	12		
250.0	200.0R	25.0	13		



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Subject _____

Project No. _____

Client _____

Computed By _____ Checked by _____

Date _____ Sheet No. _____

NODE 7

EXISTING

PROPOSED

HORIZONTAL

VERTICAL

HORIZ

VERTICAL

from 0

L facing Upstream

3'L	137'	16 elev	1
15'L	125	20	2
43'L	97	21	3
140'L	0	25	4
6'R	146	16	5
12'R	152	18	6
47'R	187	20	7
195'R	335	20	8
250	390	25	9

1'L	139'	17.5
3'L	137	19.0
10'L	130	20.0
1'R	141	17.5
3'R	143	19.0
10'R	150	20.0

Pantego Surface Storage Plot - 1 (PP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	23.5	3.3
2	21.7	1.5
3	25.9	5.7
4	24.7	4.5
5	25.7	5.5
6	23.0	2.8
7	24.0	3.8
8	25.3	5.1
9	22.0	1.8
10	21.4	1.2
11	21.0	0.8
12	21.8	1.6
13	25.0	4.8
14	25.5	5.3
15	23.5	3.3
16	23.7	3.5
17	25.3	5.1
18	24.0	3.8
19	22.0	1.8
20	25.0	4.8
21	26.2	6.0
22	26.8	6.6
23	27.4	7.2
24	26.9	6.7
25	25.2	5.0
26	22.4	2.2
27	23.2	3.0
28	22.7	2.5
29	24.9	4.7
30	20.2	0.0
31	21.7	1.5
32	20.4	0.2
33	23.7	3.5
34	23.0	2.8
35	22.7	2.5
36	23.7	3.5
37	24.9	4.7
38	23.9	3.7
39	26.5	6.3
40	26.0	5.8

max

min

Avg. = 3.71

Pantego Surface Storage Plot - 2 (PP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	23.5	5.3
2	24.7	6.5
3	25.9	7.7
4	25.4	7.2
5	25.5	7.3
6	22.6	4.4
7	24.7	6.5
8	23.9	5.7
9	25.2	7.0
10	25.6	7.4
11	26.5	8.3
12	25.0	6.8
13	23.0	4.8
14	18.2	0.0
15	22.8	4.6
16	26.5	8.3
17	25.5	7.3
18	26.2	8.0
19	28.7	10.5
20	29.4	11.2
21	29.8	11.6
22	26.9	8.7
23	28.6	10.4
24	29.5	11.3
25	26.5	8.3
26	28.8	10.6
27	27.2	9.0
28	28.0	9.8
29	25.9	7.7
30	27.3	9.1
31	25.7	7.5
32	26.4	8.2
33	25.4	7.2
34	23.9	5.7
35	23.5	5.3
36	23.0	4.8
37	22.5	4.3
38	23.0	4.8
39	23.6	5.4
40	25.0	6.8

min

max

Avg. = 7.28

Torhunta Surface Storage Plot - 1 (TP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	23.1	5.5
2	23.6	6.0
3	22.3	4.7
4	21.8	4.2
5	22.8	5.2
6	20.4	2.8
7	23.4	5.8
8	19.1	1.5
9	23.5	5.9
10	19.8	2.2
11	19.1	1.5
12	23.0	5.4
13	22.8	5.2
14	26.2	8.6
15	17.6	0.0
16	24.6	7.0
17	22.2	4.6
18	23.1	5.5
19	23.0	5.4
20	24.2	6.6
21	21.6	4.0
22	23.5	5.9
23	24.4	6.8
24	22.8	5.2
25	21.9	4.3
26	21.2	3.6
27	23.3	5.7
28	24.1	6.5
29	18.8	1.2
30	24.3	6.7
31	23.1	5.5
32	25.3	7.7
33	22.4	4.8
34	24.8	7.2
35	25.6	8.0
36	26.2	8.6
37	22.7	5.1
38	21.5	3.9
39	20.9	3.3
40	23.6	6.0

max
min

max

Avg. = 5.09

Torhunta Surface Storage Plot - 2 (TP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	28.0	7.6
2	25.0	4.6
3	24.6	4.2
4	26.4	6.0
5	26.0	5.6
6	25.0	4.6
7	22.9	2.5
8	20.4	0.0
9	23.0	2.6
10	22.5	2.1
11	23.6	3.2
12	20.8	0.4
13	25.1	4.7
14	25.0	4.6
15	25.0	4.6
16	22.8	2.4
17	25.6	5.2
18	25.4	5.0
19	29.7	9.3
20	26.5	6.1
21	26.5	6.1
22	24.0	3.6
23	26.7	6.3
24	27.0	6.6
25	27.0	6.6
26	24.1	3.7
27	26.4	6.0
28	29.3	8.9
29	27.4	7.0
30	24.3	3.9
31	28.0	7.6
32	28.5	8.1
33	25.6	5.2
34	29.0	8.6
35	29.5	9.1
36	26.5	6.1
37	28.0	7.6
38	28.4	8.0
39	28.7	8.3
40	24.9	4.5

min

max

Avg. = 5.43

Onslow Surface Storage Plot - 1 (OP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	23.8	3.1
2	24.6	3.9
3	26.9	6.2
4	26.2	5.5
5	24.5	3.8
6	23.7	3.0
7	25.1	4.4
8	25.6	4.9
9	25.6	4.9
10	26.4	5.7
11	26.5	5.8
12	22.9	2.2
13	26.3	5.6
14	28.2	7.5
15	29.4	8.7
16	27.4	6.7
17	26.2	5.5
18	27.5	6.8
19	28.4	7.7
20	25.9	5.2
21	26.7	6.0
22	24.8	4.1
23	24.2	3.5
24	23.2	2.5
25	23.1	2.4
26	23.0	2.3
27	20.9	0.2
28	24.1	3.4
29	24.2	3.5
30	21.4	0.7
31	24.5	3.8
32	23.6	2.9
33	21.4	0.7
34	20.7	0.0
35	21.2	0.5
36	22.4	1.7
37	23.1	2.4
38	25.5	4.8
39	24.4	3.7
40	24.0	3.3

max

min

Avg. = 3.99

Onslow Surface Storage Plot - 2 (OP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	20.0	1.4
2	20.5	1.9
3	20.5	1.9
4	20.0	1.4
5	19.4	0.8
6	21.2	2.6
7	19.6	1.0
8	19.5	0.9
9	20.9	2.3
10	21.6	3.0
11	21.8	3.2
12	22.4	3.8
13	25.4	6.8
14	24.0	5.4
15	24.7	6.1
16	23.3	4.7
17	28.3	9.7
18	27.4	8.8
19	28.6	10.0
20	30.4	11.8
21	30.0	11.4
22	28.7	10.1
23	29.8	11.2
24	29.3	10.7
25	26.3	7.7
26	26.7	8.1
27	27.0	8.4
28	26.5	7.9
29	25.8	7.2
30	24.8	6.2
31	26.5	7.9
32	23.8	5.2
33	24.5	5.9
34	24.8	6.2
35	22.9	4.3
36	23.4	4.8
37	19.8	1.2
38	19.2	0.6
39	18.6	0.0
40	20.4	1.8

max

min

Avg. = 5.36

Marvyn Surface Storage Plot - 1 (MP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	24.8	4.4
2	24.1	3.7
3	27.0	6.6
4	24.9	4.5
5	20.8	0.4
6	24.1	3.7
7	22.6	2.2
8	22.0	1.6
9	23.7	3.3
10	21.6	1.2
11	20.4	0.0
12	25.0	4.6
13	23.0	2.6
14	22.1	1.7
15	24.1	3.7
16	25.1	4.7
17	25.2	4.8
18	23.7	3.3
19	24.1	3.7
20	24.0	3.6
21	25.3	4.9
22	21.4	1.0
23	22.8	2.4
24	21.9	1.5
25	25.0	4.6
26	22.4	2.0
27	21.9	1.5
28	23.3	2.9
29	23.4	3.0
30	23.8	3.4
31	23.6	3.2
32	24.4	4.0
33	25.2	4.8
34	25.4	5.0
35	25.9	5.5
36	26.1	5.7
37	26.3	5.9
38	26.8	6.4
39	24.4	4.0
40	25.0	4.6

max

min

Avg. = 3.52

Marvyn Surface Storage Plot - 2 (MP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)
1	27.5	2.0
2	28.7	3.2
3	30.6	5.1
4	30.4	4.9
5	30.3	4.8
6	30.5	5.0
7	29.8	4.3
8	30.9	5.4
9	31.0	5.5
10	31.4	5.9
11	30.2	4.7
12	31.5	6.0
13	28.5	3.0
14	29.7	4.2
15	29.7	4.2
16	30.0	4.5
17	27.3	1.8
18	27.6	2.1
19	29.3	3.8
20	25.6	0.1
21	27.4	1.9
22	26.6	1.1
23	26.4	0.9
24	25.5	0.0
25	26.4	0.9
26	26.7	1.2
27	27.3	1.8
28	28.2	2.7
29	27.9	2.4
30	26.6	1.1
31	26.1	0.6
32	26.2	0.7
33	27.8	2.3
34	27.8	2.3
35	29.5	4.0
36	26.8	1.3
37	27.4	1.9
38	27.7	2.2
39	29.6	4.1
40	30.4	4.9

max

min

Avg. = 2.97

Radii of Influence from Centerline of Ditch, by Soil Type (Effectively Drained Distance).

Soil Type	Ditch Number	Radius of Influence (feet)
Marvyn	M-10	135
	M-11	238
	M Perimeter-4	574
	M Perimeter-5	1,066
Onslow	O-1	160
	O-2	185
	O-3	155
	O-4	80
	O Perimeter-2	135
	O Perimeter-3	312
	O Perimeter-6	200
O Perimeter-7	125	
Pantego	P-1N	123
	P-1S	51
	P Perimeter-8	100
	P Perimeter-9	70
Torhunta	T-1N	123
	T-1S	59
	T-2N	129
	T-2S	59
	T-3N	129
	T-3S	59
	T-4N	129
	T-4S	95
	T-5N	140
	T-5S	58
	T-6	94
	T-7	58
	TP-1	135
	TP-2	136

**TAILWATER CONDITION UPSTREAM
OF OUTFALL CULVERTS**

**(Calculated as a pond with existing culverts
acting as control outfall structures)**

```

*****
*
* North Carolina - Clayhill Farmhill Farm Mitigation *
* Existing Drainage Conditions *
* Total Drainage Area *
*
*
* 2 - YEAR *
*
*****
    
```

Inflow Hydrograph: NC-MFY2 .HYD
 Rating Table file: NC-CLY .PND

----INITIAL CONDITIONS----
 Elevation = 14.00 ft
 Outflow = 0.50 cfs
 Storage = 0.00 ac-ft

GIVEN POND DATA

INTERMEDIATE ROUTING
 COMPUTATIONS

ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + 0 (cfs)
14.00	0.5	0.000	0.0	0.5
14.50	3.8	0.004	0.3	4.1
15.00	9.9	0.018	1.5	11.4
15.50	18.7	0.067	5.4	24.1
16.00	30.5	0.192	15.5	46.0
16.50	44.3	0.430	34.7	79.0
17.00	58.9	0.816	65.8	124.7
17.50	74.2	1.387	111.8	186.0
18.00	88.7	2.178	175.7	264.4
18.50	102.1	3.226	260.3	362.4
19.00	114.8	4.568	368.5	483.3
19.50	125.9	6.238	503.2	629.1
20.00	134.6	8.273	667.4	802.0
20.50	142.7	10.689	862.3	1005.0
21.00	150.3	13.496	1088.7	1239.0
21.50	157.5	16.724	1349.0	1506.5
22.00	164.5	20.401	1645.7	1810.2
22.50	171.0	24.557	1980.9	2151.9
23.00	177.4	29.222	2357.2	2534.6
23.50	183.6	34.425	2776.9	2960.5
24.00	189.6	40.195	3242.4	3432.0
24.50	195.4	46.561	3755.9	3951.3

Time increment (t) = 0.300 hrs.

ond File: NC-CLY .PND
 Inflow Hydrograph: NC-MFY2 .HYD
 Outflow Hydrograph: NC-OUT2 .HYD

INFLOW HYDROGRAPH

ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - 0 (cfs)	2S/t + 0 (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	4.00	-----	-0.5	0.5	0.50	14.00
11.300	6.00	10.0	-7.1	9.5	8.33	14.87
11.600	8.00	14.0	-5.3	6.9	6.10	14.69
11.900	10.00	18.0	-8.9	12.7	10.77	15.05
12.200	13.00	23.0	-9.5	14.1	11.78	15.11
12.500	20.00	33.0	-13.1	23.5	18.31	15.48
12.800	23.00	43.0	-13.7	29.9	21.84	15.63
13.100	32.00	55.0	-14.6	41.3	27.94	15.89
13.400	44.00	76.0	-12.5	61.4	36.94	16.23
13.700	73.50	117.5	-0.2	105.0	52.61	16.78
14.000	126.00	199.5	46.0	199.3	76.65	17.58
14.300	206.00	332.0	170.5	378.0	103.74	18.56
14.600	287.00	493.0	408.2	663.5	127.63	19.60
14.900	333.50	620.5	741.8	1028.7	143.47	20.55
15.200	338.20	671.7	1103.5	1413.5	155.00	21.33
15.500	322.00	660.2	1436.8	1763.7	163.43	21.92
15.800	275.20	597.2	1696.5	2034.0	168.76	22.33
16.100	231.00	506.2	1859.0	2202.7	171.85	22.57
16.400	192.00	423.0	1935.7	2282.0	173.18	22.67
16.700	160.60	352.6	1941.7	2288.3	173.28	22.68
17.000	133.00	293.6	1890.5	2235.3	172.39	22.61
17.300	116.80	249.8	1798.8	2140.3	170.78	22.48
17.600	102.00	218.8	1680.7	2017.6	168.44	22.30
17.900	90.00	192.0	1541.3	1872.7	165.69	22.09
18.200	80.80	170.8	1387.6	1712.1	162.24	21.84
18.500	73.00	153.8	1224.8	1541.4	158.30	21.56
18.800	65.20	138.2	1055.7	1363.0	153.64	21.23
19.100	58.40	123.6	882.6	1179.3	148.36	20.87
19.400	53.60	112.0	710.0	994.6	142.29	20.47
19.700	48.80	102.4	542.4	812.4	135.02	20.03
20.000	44.00	92.8	382.8	635.2	126.21	19.52
20.300	41.80	85.8	242.1	468.6	113.26	18.94
20.600	39.50	81.3	129.8	323.4	96.77	18.30
20.900	37.30	76.8	50.6	206.6	78.01	17.63
21.200	35.00	72.3	6.3	122.9	58.33	16.98
21.500	32.80	67.8	-10.4	74.1	42.25	16.43
21.800	30.50	63.3	-13.9	52.9	33.37	16.10
22.100	28.70	59.2	-14.9	45.3	30.13	15.98
22.400	27.80	56.5	-14.7	41.6	28.10	15.90
22.700	26.90	54.7	-14.5	40.0	27.29	15.86
23.000	26.00	52.9	-14.4	38.4	26.38	15.83
23.300	25.10	51.1	-14.3	36.7	25.48	15.79
23.600	24.20	49.3	-14.1	35.0	24.58	15.75
23.900	23.30	47.5	-14.0	33.4	23.68	15.71
24.200	22.40	45.7	-13.9	31.7	22.78	15.67

ond File: NC-CLY .PND
 Inflow Hydrograph: NC-MFY2 .HYD
 Outflow Hydrograph: NC-OUT2 .HYD

INFLOW HYDROGRAPH

ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.500	21.50	43.9	-13.7	30.0	21.88	15.63
24.800	20.60	42.1	-13.6	28.4	20.98	15.60
25.100	19.70	40.3	-13.5	26.7	20.08	15.56
25.400	18.80	38.5	-13.4	25.0	19.18	15.52
25.700	17.90	36.7	-13.0	23.3	18.17	15.47
26.000	17.00	34.9	-12.4	21.9	17.18	15.41

***** SUMMARY OF ROUTING COMPUTATIONS *****

Pond File: NC-CLY .PND
Inflow Hydrograph: NC-MFY2 .HYD
Outflow Hydrograph: NC-OUT2 .HYD

Starting Pond W.S. Elevation = 14.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 338.20 cfs
Peak Outflow = 173.28 cfs
Peak Elevation = 22.68 ft

***** Summary of Approximate Peak Storage *****

Initial Storage = 0.00 ac-ft
Peak Storage From Storm = 26.22 ac-ft

Total Storage in Pond = 26.22 ac-ft

Warning: Inflow hydrograph truncated on left side.
Warning: Inflow hydrograph truncated on right side.

TR-55 TABULAR HYDROGRAPH METHOD
 Type III Distribution
 (24 hr. Duration Storm)

Executed: 06-02-1999 15:47:09
 Watershed file: --> NC-CLY2 .WSD
 Hydrograph file: --> NC-CLY2 .HYD

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 Existing Drainage Conditions
 Total Drainage

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used
total	971.40	77.0	2.00	1.50	4.50	2.21	.13 .10

* Travel time from subarea outfall to composite watershed outfall point.
 Total area = 971.40 acres or 1.5178 sq.mi
 Peak discharge = 604 cfs

>>>> Computer Modifications of Input Parameters <<<<

Subarea Description	Input Values		Rounded Values		Ia/p Interpolated (Yes/No)	Ia/p Messages
	Tc (hr)	* Tt (hr)	Tc (hr)	* Tt (hr)		
total	2.00	1.56	2.00	1.50	No	--

* Travel time from subarea outfall to composite watershed outfall point.

SCS ALLOWS A MAX T_c OF 2.0 HRS
 MODIFIED GENERATED HYDROGRAPH TO REPRESENT
 THE PEAK FLOW RATE OF 349 CFS FOR A
 TIME OF CONCENTRATION (T_c) OF 3.5 HOURS.

TR-55 TABULAR HYDROGRAPH METHOD
 Type III Distribution
 (24 hr. Duration Storm)

Executed: 06-02-1999 15:47:09
 Watershed file: --> NC-CLY2 .WSD
 Hydrograph file: --> NC-CLY2 .HYD

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 Existing Drainage Conditions
 Total Drainage

MODIFY HYDROGRAPH TO
 REPRESENT THE PEAK FLOW
 RATE OF 349 CFS.

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
Total	7	10	13	17	20	23	23	27	30
Total (cfs)	7	10	13	17	20	23	23	27	30
	4	6	8	10	12	13	13	16	17

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
Total	34	34	37	40	50	60	77	104	151
Total (cfs)	34	34	37	40	50	60	77	104	151
	20	20	21	23	29	35	44	60	87

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
Total	218	356	496	604	557	423	309	231	184
Total (cfs)	218	356	496	604	557	423	309	231	184
	126	206	287	349	322	244	179	133	106

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
Total	148	104	77	50	30
Total (cfs)	148	104	77	50	30
	86	60	44	29	17

>>>> HYDROGRAPH PRINTOUT <<<<<

06-03-1999 16:41:29

Hydrograph file: NC-MFY2 .HYD

HYDROGRAPH ORDINATES (cfs)

Time increment = 0.300 Hours

Time on left represents time for first Q in each row.

Time Hours	Time on left represents time for first Q in each row.						
11.000	4.00	6.00	8.00	10.00	13.00	20.00	23.00
13.100	32.00	44.00	73.50	126.00	206.00	287.00	333.50
15.200	338.20	322.00	275.20	231.00	192.00	160.60	133.00
17.300	116.80	102.00	90.00	80.80	73.00	65.20	58.40
19.400	53.60	48.80	44.00	41.80	39.50	37.30	35.00
21.500	32.80	30.50	28.70	27.80	26.90	26.00	25.10
23.600	24.20	23.30	22.40	21.50	20.60	19.70	18.80
25.700	17.90	17.00					

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*****
*
* North Carolina - Clayhill Farmhill Farm Mitigation *
* Existing Drainage Conditions *
* Total Drainage Area *
*
*
*
*****
    
```

10 - YEAR

Inflow Hydrograph: NC-MFY10.HYD
 Rating Table file: NC-CLY .PND

----INITIAL CONDITIONS----
 Elevation = 14.00 ft
 Outflow = 0.50 cfs
 Storage = 0.00 ac-ft

GIVEN POND DATA

INTERMEDIATE ROUTING
 COMPUTATIONS

ELEVATION (ft)	OUTFLOW (cfs)	STORAGE (ac-ft)	2S/t (cfs)	2S/t + 0 (cfs)
14.00	0.5	0.000	0.0	0.5
14.50	3.8	0.004	0.3	4.1
15.00	9.9	0.018	1.5	11.4
15.50	18.7	0.067	5.4	24.1
16.00	30.5	0.192	15.5	46.0
16.50	44.3	0.430	34.7	79.0
17.00	58.9	0.816	65.8	124.7
17.50	74.2	1.387	111.8	186.0
18.00	88.7	2.178	175.7	264.4
18.50	102.1	3.226	260.3	362.4
19.00	114.8	4.568	368.5	483.3
19.50	125.9	6.238	503.2	629.1
20.00	134.6	8.273	667.4	802.0
20.50	142.7	10.689	862.3	1005.0
21.00	150.3	13.496	1088.7	1239.0
21.50	157.5	16.724	1349.0	1506.5
22.00	164.5	20.401	1645.7	1810.2
22.50	171.0	24.557	1980.9	2151.9
23.00	177.4	29.222	2357.2	2534.6
23.50	183.6	34.425	2776.9	2960.5
24.00	189.6	40.195	3242.4	3432.0
24.50	195.4	46.561	3755.9	3951.3

Time increment (t) = 0.300 hrs.

ond File: NC-CLY .PND
 Inflow Hydrograph: NC-MFY10.HYD
 Outflow Hydrograph: NC-OUT10.HYD

INFLOW HYDROGRAPH

ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - 0 (cfs)	2S/t + 0 (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	8.00	-----	-0.5	0.5	0.50	14.00
11.300	11.00	19.0	-11.1	18.5	14.82	15.28
11.600	15.00	26.0	-9.7	14.9	12.30	15.14
11.900	18.00	33.0	-13.0	23.3	18.11	15.47
12.200	26.00	44.0	-13.8	31.0	22.43	15.66
12.500	37.00	63.0	-14.5	49.2	31.83	16.05
12.800	44.00	81.0	-11.7	66.5	39.09	16.31
13.100	61.50	105.5	-4.3	93.8	49.05	16.66
13.400	85.00	146.5	15.7	142.2	63.27	17.14
13.700	140.50	225.5	72.4	241.2	84.41	17.85
14.000	240.00	380.5	229.7	452.9	111.61	18.87
14.300	392.00	632.0	587.7	861.7	136.98	20.15
14.600	548.00	940.0	1211.7	1527.7	157.99	21.53
14.900	636.50	1184.5	2046.1	2396.2	175.09	22.82
15.200	645.20	1281.7	2951.2	3327.8	188.27	23.89
15.500	614.00	1259.2	3819.6	4210.4	195.40	24.50
15.800	525.20	1139.2	4568.0	4958.8	195.40	24.50
16.100	440.80	966.0	5143.2	5534.0	195.40	24.50
16.400	365.20	806.0	5558.4	5949.2	195.40	24.50
16.700	306.00	671.2	5838.8	6229.6	195.40	24.50
17.000	255.00	561.0	6009.0	6399.8	195.40	24.50
17.300	223.80	478.8	6097.0	6487.8	195.40	24.50
17.600	195.00	418.8	6125.0	6515.8	195.40	24.50
17.900	171.00	366.0	6100.2	6491.0	195.40	24.50
18.200	153.40	324.4	6033.8	6424.6	195.40	24.50
18.500	139.00	292.4	5935.4	6326.2	195.40	24.50
18.800	124.60	263.6	5808.2	6199.0	195.40	24.50
19.100	112.00	236.6	5654.0	6044.8	195.40	24.50
19.400	103.00	215.0	5478.2	5869.0	195.40	24.50
19.700	94.00	197.0	5284.4	5675.2	195.40	24.50
20.000	85.00	179.0	5072.6	5463.4	195.40	24.50
20.300	80.70	165.7	4847.5	5238.3	195.40	24.50
20.600	76.30	157.0	4613.7	5004.5	195.40	24.50
20.900	72.00	148.3	4371.2	4762.0	195.40	24.50
21.200	67.60	139.6	4120.0	4510.8	195.40	24.50
21.500	63.30	130.9	3860.1	4250.9	195.40	24.50
21.800	58.90	122.2	3591.5	3982.3	195.40	24.50
22.100	55.40	114.3	3320.5	3705.8	192.66	24.26
22.400	53.70	109.1	3050.5	3429.6	189.57	24.00
22.700	52.00	105.7	2784.0	3156.2	186.09	23.71
23.000	50.30	102.3	2521.2	2886.3	182.52	23.41
23.300	48.50	98.8	2262.7	2620.0	178.64	23.10
23.600	46.80	95.3	2009.2	2358.0	174.45	22.77
23.900	45.10	91.9	1761.0	2101.1	170.03	22.43
24.200	43.40	88.5	1519.0	1849.5	165.25	22.06

ond File: NC-CLY .PND
 Inflow Hydrograph: NC-MFY10.HYD
 Outflow Hydrograph: NC-OUT10.HYD

INFLOW HYDROGRAPH

ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	I1+I2 (cfs)	2S/t - O (cfs)	2S/t + O (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
24.500	41.60	85.0	1284.5	1604.0	159.75	21.66
24.800	39.90	81.5	1058.6	1366.0	153.72	21.24
25.100	38.20	78.1	842.7	1136.7	146.98	20.78
25.400	36.50	74.7	639.0	917.4	139.21	20.28
25.700	34.70	71.2	450.2	710.2	129.98	19.73
26.000	33.00	67.7	283.1	517.9	117.44	19.12

***** SUMMARY OF ROUTING COMPUTATIONS *****

Pond File: NC-CLY .PND
Inflow Hydrograph: NC-MFY10.HYD
- Outflow Hydrograph: NC-OUT10.HYD

Starting Pond W.S. Elevation = 14.00 ft

***** Summary of Peak Outflow and Peak Elevation *****

Peak Inflow = 645.20 cfs
Peak Outflow = 195.40 cfs
Peak Elevation = 24.50 ft

>>>>> Warning, pond overtopped during routing. <<<<<<
The calculated peak outflow/elevation is invalid.

TR-55 TABULAR HYDROGRAPH METHOD
 Type III Distribution
 (24 hr. Duration Storm)

Executed: 06-02-1999 14:10:00
 Watershed file: --> NC-CLY .WSD
 Hydrograph file: --> NC-CLY .HYD

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 Existing Drainage Conditions
 Total Drainage

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input/used
total	971.40	77.0	2.00	1.50	6.72	4.12	.09 .10

* Travel time from subarea outfall to composite watershed outfall point.
 Total area = 971.40 acres or 1.5178 sq.mi
 Peak discharge = 1126 cfs

>>>> Computer Modifications of Input Parameters <<<<

Subarea Description	Input Values		Rounded Values		Ia/p Interpolated (Yes/No)	Ia/p Messages
	Tc (hr)	* Tt (hr)	Tc (hr)	* Tt (hr)		
total	2.00	1.56	2.00	1.50	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.

SCS ALLOWS A MAXIMUM T_C OF 2.0 HRS
 MODIFIED GENERATED HYDROGRAPH TO REPRESENT
 THE PEAK FLOW RATE OF 666 CFS FOR A
 TIME OF CONCENTRATION (T_C) OF 3.5 HOURS,

TR-55 TABULAR HYDROGRAPH METHOD
 Type III Distribution
 (24 hr. Duration Storm)

Executed: 06-02-1999 14:10:00
 Watershed file: --> NC-CLY .WSD
 Hydrograph file: --> NC-CLY .HYD

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 Existing Drainage Conditions
 Total Drainage -

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
Total	13	19	25	31	38	44	44	50	56
Total (cfs)	13	19	25	31	38	44	44	50	56
MODIFY	8	11	15	18	22	26	26	30	33

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
Total	63	63	69	75	94	113	144	194	281
Total (cfs)	63	63	69	75	94	113	144	194	281
	37	37	41	44	56	67	85	115	166

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
Total	406	663	926	1126	1038	788	575	431	344
Total (cfs)	406	663	926	1126	1038	788	575	431	344
	240	392	548	666	614	466	340	255	203

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
Total	275	194	144	94	56
Total (cfs)	275	194	144	94	56
	163	115	85	56	33

= 0.59

Executed 06-02-1999 16:46:31
Constructed file:
NC-MFY10.HYD

File Summary for Constructed Hydrograph

VOLUME = 8,456,580 cu.ft. = 194.14 ac-ft

Warning: Left side of hydrograph truncated. Hydrograph volume incomplete.
Warning: Right side of hydrograph truncated. Hydrograph volume incomplete.

Time (hrs)	Flow (cfs)
-----	-----
11.00	8.0
11.30	11.0
11.60	15.0
11.90	18.0
12.20	26.0
12.50	37.0
12.80	44.0
13.10	61.5
13.40	85.0
13.70	140.5
14.00	240.0
14.30	392.0
14.60	548.0
14.90	636.5
15.20	645.2
15.50	614.0
15.80	525.2
16.10	440.8
16.40	365.2
16.70	306.0
17.00	255.0
17.30	223.8
17.60	195.0
17.90	171.0
18.20	153.4
18.50	139.0
18.80	124.6
19.10	112.0
19.40	103.0
19.70	94.0
20.00	85.0
20.30	80.7
20.60	76.3
20.90	72.0
21.20	67.6
21.50	63.3
21.80	58.9
22.10	55.4

S/N:

North Carolina - Clayhill Farm Mitigation Site
 Existing Drainage Conditions
 Total Drainage Area

CALCULATED 06-02-1999 17:32:14
 DISK FILE: NC-CLY .VOL

Planimeter scale: 1 inch = 1 ft.

Elevation (ft)	Planimeter (sq.in.)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	* Volume (acre-ft)	Volume Sum (acre-ft)
13.77	0.00	0.00	0.00	0.00	0.00
15.00	1,960.00	0.04	0.04	0.02	0.02
20.00	194,280.00	4.46	4.95	8.26	8.27
22.50	415,780.00	9.54	20.53	17.11	25.38
25.00	637,285.00	14.63	35.99	29.99	55.38

$$IA = (\text{sq. rt}(\text{Area1}) + ((E_i - E_1) / (E_2 - E_1)) * (\text{sq. rt}(\text{Area2}) - \text{sq. rt}(\text{Area1})))^2$$

where: E1, E2 = Closest two elevations with planimeter data
 E_i = Elevation at which to interpolate area
 Area1, Area2 = Areas computed for E1, E2, respectively
 IA = Interpolated area for E_i

* Incremental volume computed by the Conic Method for Reservoir Volumes.

$$\text{Volume} = (1/3) * (EL2 - EL1) * (\text{Area1} + \text{Area2} + \text{sq. rt.}(\text{Area1} * \text{Area2}))$$

where: EL1, EL2 = Lower and upper elevations of the increment
 Area1, Area2 = Areas computed for EL1, EL2, respectively
 Volume = Incremental volume between EL1 and EL2

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

North Carolina - Clayhill Farm Mitigation Site
Existing Drainage Conditions
Total Drainage

***** COMPOSITE OUTFLOW SUMMARY *****

Elevation (ft)	Q (cfs)	Contributing Structures
-----	-----	-----
14.00	0.5	4
14.50	3.8	4
15.00	9.9	4
15.50	18.7	4
16.00	30.5	4
16.50	44.3	4
17.00	58.9	4
17.50	74.2	4
18.00	88.7	4
18.50	102.1	4
19.00	114.8	4
19.50	125.9	4
20.00	134.6	4
20.50	142.7	4
21.00	150.3	4
21.50	157.5	4
22.00	164.5	4
22.50	171.0	4
23.00	177.4	4
23.50	183.6	4
24.00	189.6	4
24.50	195.4	4
25.00	0.0	

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

North Carolina - Clayhill Farm Mitigation Site
Existing Drainage Conditions
Total Drainage

Outlet Structure File: NC-CLY .STR
Planimeter Input File: NC-CLY .VOL
Rating Table Output File: NC-CLY .PND

Min. Elev.(ft) = 14 Max. Elev.(ft) = 25 Incr.(ft) = .5

Additional elevations (ft) to be included in table:

* * * * *

SYSTEM CONNECTIVITY

Structure	No.	Q Table	Q Table
-----	---	-----	-----
TABLE	1		-> 1
CULVERT-CR	2		-> 2
CULVERT-CR	3	+ 2	-> 4
NULL STRUC	4	? 1	-> 5

Outflow rating table summary was stored in file:
NC-CLY .PND

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

North Carolina - Clayhill Farm Mitigation Site
Existing Drainage Conditions
Total Drainage

>>>>> Structure No. 1 <<<<<<
(Input Data)

TABLE

Input your own rating table.

E1 (ft) =13.77 E2 (ft) =14.5

Constant (ft) added to each elevation was:

Elev. (ft)	Q (cfs)
-----	-----
13.77	0
14.5	5

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

```
*****  
North Carolina - Clayhill Farm Mitigation Site  
Existing Drainage Conditions  
Total Drainage
```

```
*****
```

```
>>>>> Structure No. 2 <<<<<<  
(Input Data)
```

```
CULVERT-CR  
Circular Culvert (With Inlet Control)
```

```
E1 elev.(ft)?      13.77  
E2 elev.(ft)?      25  
Diam. (ft)?        4  
Inv. el.(ft)?      13.77  
Slope (ft/ft)?     .0208  
T1 ratio?  
T2 ratio?  
K Coeff.?          0.0340  
M Coeff.?          1.5  
c Coeff.?          .0553  
Y Coeff.?          .54  
Form 1 or 2?      1  
Slope factor?     -0.5
```

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

North Carolina - Clayhill Farm Mitigation Site
Existing Drainage Conditions
Total Drainage

>>>>> Structure No. 3 <<<<<<
(Input Data)

CULVERT-CR
Circular Culvert (With Inlet Control)

E1 elev.(ft)?	15.08
E2 elev.(ft)?	25
Diam. (ft)?	2
Inv. el.(ft)?	15.08
Slope (ft/ft)?	.0042
T1 ratio?	
T2 ratio?	
K Coeff.?	.0340
M Coeff.?	1.5
c Coeff.?	.0553
Y Coeff.?	.54
Form 1 or 2?	1
Slope factor?	-0.5

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

North Carolina - Clayhill Farm Mitigation Site
Existing Drainage Conditions
Total Drainage

>>>>> NULL Structure <<<<<<
(Input Data)

NULL STRUC
Null Structure -- Add/check between tables

4 ? 1 -> 5

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

North Carolina - Clayhill Farm Mitigation Site
Existing Drainage Conditions
Total Drainage

Outflow Rating Table for Structure #1
TABLE Input your own rating table.

Elevation (ft)	Q (cfs)	Computation Messages
14.00	1.6	Interpolated from input table
14.50	0.0	E = or > E2=14.5
15.00	0.0	E = or > E2=14.5
15.50	0.0	E = or > E2=14.5
16.00	0.0	E = or > E2=14.5
16.50	0.0	E = or > E2=14.5
17.00	0.0	E = or > E2=14.5
17.50	0.0	E = or > E2=14.5
18.00	0.0	E = or > E2=14.5
18.50	0.0	E = or > E2=14.5
19.00	0.0	E = or > E2=14.5
19.50	0.0	E = or > E2=14.5
20.00	0.0	E = or > E2=14.5
20.50	0.0	E = or > E2=14.5
21.00	0.0	E = or > E2=14.5
21.50	0.0	E = or > E2=14.5
22.00	0.0	E = or > E2=14.5
22.50	0.0	E = or > E2=14.5
23.00	0.0	E = or > E2=14.5
23.50	0.0	E = or > E2=14.5
24.00	0.0	E = or > E2=14.5
24.50	0.0	E = or > E2=14.5
25.00	0.0	E = or > E2=14.5

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

 North Carolina - Clayhill Farm Mitigation Site
 Existing Drainage Conditions
 Total Drainage

Outflow Rating Table for Structure #2
 CULVERT-CR Circular Culvert (With Inlet Control)

***** INLET CONTROL ASSUMED *****

Elevation (ft)	Q (cfs)	Computation	Messages
14.00	0.5	Equ.1: HW =.23	dc=.197 Ac=.23
14.50	3.8	Equ.1: HW =.73	dc=.564 Ac=1.081
15.00	9.9	Equ.1: HW =1.23	dc=.918 Ac=2.175
15.50	17.9	Equ.1: HW =1.73	dc=1.244 Ac=3.332
16.00	27.1	Equ.1: HW =2.23	dc=1.54 Ac=4.459
16.50	37.4	Equ.1: HW =2.73	dc=1.822 Ac=5.57
17.00	48.1	Equ.1: HW =3.23	dc=2.078 Ac=6.594
17.50	59.5	Equ.1: HW =3.73	dc=2.324 Ac=7.572
18.00	70.6	Equ.1: HW =4.23	dc=2.539 Ac=8.415
18.50	81.6	Equ.1: HW =4.73	dc=2.737 Ac=9.164
19.00	92.3	Transition: HW =5.23	
19.50	101.5	Submerged: HW =5.73	
20.00	108.3	Submerged: HW =6.23	
20.50	114.8	Submerged: HW =6.73	
21.00	120.9	Submerged: HW =7.23	
21.50	126.6	Submerged: HW =7.73	
22.00	132.2	Submerged: HW =8.23	
22.50	137.3	Submerged: HW =8.73	
23.00	142.5	Submerged: HW =9.23	
23.50	147.4	Submerged: HW =9.73	
24.00	152.2	Submerged: HW =10.23	
24.50	156.8	Submerged: HW =10.73	
25.00	0.0	E = or > E2=25	

Used Unsubmerged Equ. Form (1) for elev. less than 18.78 ft
 Used Submerged Equation for elevations greater than 19.43 ft
 HW=Headwater (ft) dc=Critical depth (ft) Ac=Area (sq.ft) at dc

Transition flows interpolated from the following values:
 E1=18.78 ft; Q1=87.96 cfs; Dc=2.84 ft; E2=19.43 ft; Q2=100.53 cfs

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

North Carolina - Clayhill Farm Mitigation Site
Existing Drainage Conditions
Total Drainage

Outflow Rating Table for Structure #3
CULVERT-CR Circular Culvert (With Inlet Control)

***** INLET CONTROL ASSUMED *****

Elevation (ft)	Q (cfs)	Computation	Messages
14.00	0.0	E < Inv.El.= 15.08	
14.50	0.0	E < Inv.El.= 15.08	
15.00	0.0	E < Inv.El.= 15.08	
15.50	0.8	Equ.1: HW =.42	dc=.309 Ac=.309
16.00	3.4	Equ.1: HW =.92	dc=.647 Ac=.880
16.50	6.9	Equ.1: HW =1.42	dc=.929 Ac=1.43
17.00	10.9	Equ.1: HW =1.92	dc=1.182 Ac=1.932
17.50	14.7	Equ.1: HW =2.42	dc=1.381 Ac=2.313
18.00	18.1	Submerged: HW =2.92	
18.50	20.5	Submerged: HW =3.42	
19.00	22.5	Submerged: HW =3.92	
19.50	24.4	Submerged: HW =4.42	
20.00	26.2	Submerged: HW =4.92	
20.50	27.8	Submerged: HW =5.42	
21.00	29.4	Submerged: HW =5.92	
21.50	30.9	Submerged: HW =6.42	
22.00	32.3	Submerged: HW =6.920	
22.50	33.7	Submerged: HW =7.420	
23.00	35.0	Submerged: HW =7.920	
23.50	36.2	Submerged: HW =8.42	
24.00	37.4	Submerged: HW =8.92	
24.50	38.6	Submerged: HW =9.42	
25.00	0.0	E = or > E2=25	

Used Unsubmerged Equ. Form (1) for elev. less than 17.6 ft
Used Submerged Equation for elevations greater than 17.93 ft
HW=Headwater (ft) dc=Critical depth (ft) Ac=Area (sq.ft) at dc

Transition flows interpolated from the following values:
E1=17.6 ft; Q1=15.55 cfs; Dc=1.42 ft; E2=17.93 ft; Q2=17.77 cfs

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

North Carolina - Clayhill Farm Mitigation Site
Existing Drainage Conditions
Total Drainage

Outflow Rating Table 4
Table 4 = 2 + 3

Elevation (ft)	Q (cfs)	Contributing Structures
14.00	0.5	2
14.50	3.8	2
15.00	9.9	2
15.50	18.7	2 +3
16.00	30.5	2 +3
16.50	44.3	2 +3
17.00	58.9	2 +3
17.50	74.2	2 +3
18.00	88.7	2 +3
18.50	102.1	2 +3
19.00	114.8	2 +3
19.50	125.9	2 +3
20.00	134.6	2 +3
20.50	142.7	2 +3
21.00	150.3	2 +3
21.50	157.5	2 +3
22.00	164.5	2 +3
22.50	171.0	2 +3
23.00	177.4	2 +3
23.50	183.6	2 +3
24.00	189.6	2 +3
24.50	195.4	2 +3
25.00	0.0	-

Outlet Structure File: NC-CLY .STR

POND-2 Version: 5.20

S/N:

Date Executed:

Time Executed:

North Carolina - Clayhill Farm Mitigation Site
Existing Drainage Conditions
Total Drainage

Outflow Rating Table 5
Table 5 = 1 ? 4

Elevation (ft)	Q (cfs)	Contributing Structures
14.00	0.5	4
14.50	3.8	4
15.00	9.9	4
15.50	18.7	4
16.00	30.5	4
16.50	44.3	4
17.00	58.9	4
17.50	74.2	4
18.00	88.7	4
18.50	102.1	4
19.00	114.8	4
19.50	125.9	4
20.00	134.6	4
20.50	142.7	4
21.00	150.3	4
21.50	157.5	4
22.00	164.5	4
22.50	171.0	4
23.00	177.4	4
23.50	183.6	4
24.00	189.6	4
24.50	195.4	4
25.00	0.0	-

WATERSHED TO THE OUTFALL CULVERTS

(Individual drainage area – peak runoff rates)

Storm Drain Design Computations

Langley and McDonald, P.C.

Subject: N. C. CLAYHILL
Location CLAYHILL, North Carolina

2 & 10 YEAR DESIGN STORMS
EXISTING LAND USE

Job No. 1960024-203.00 Date: 05/07/97
Computed By: MWM Checked By:

File Name: Exist Cond - Main Ditch.xls

STORM DRAIN DESIGN COMPUTATIONS

Drainage Area	Drainage AREA AC. No.	CURVE	Tc CONC. hrs	2 Yr cfs	RUNOFF "Q" 10 Yr cfs
A1	70	77.00	1.87	35	67
A2	122	77.00	2.14	57	110
A3	243	77.00	2.38	105	201
A4	340	77.00	2.64	138	264
B	66	77.00	1.54	38	73
C	114	77.00	1.79	59	113
D	422	77.00	3.56	142	270
E	30	77.00	2.11	14	27
Total	972				

Total Drainage D.A. (A + B + C + D + E =) 3.56 614

Total Drainage (Minus Drainage Area D) 2.64 349 666

Sheet Flow

Drainage Area	Flow Length	2-Yr Rainfall Slope	Time of Concentration	Shallow		Channel Flow				Total Travel Time				
				Conc. Flow	Flow	Cross Sec Area	Wetted perimeter	Hydraulic Radius	Slope		Mannings velocity	Flow Length	Travel Time	
D	0.40	200.00	4.50	0.0036	1.08	18.90	18.90	1.48	0.0009	0.050	1.16	6000	1.43	3.56
B	0.40	200.00	4.50	0.0020	0.22	0.00	0.00	#DIV/0!			#DIV/0!		0.00	1.54
C	0.40	200.00	4.50	0.0020	0.47	0.00	0.00	#DIV/0!			#DIV/0!		0.00	1.79
Alt. C	0.40	200.00	4.50	0.0020	0.05	22.00	14.90	1.48	0.0010	0.050	1.22	2900	0.66	2.03
E	0.40	100.00	4.50	0.0100	0.00	12.00	11.70	1.03	0.0010	0.050	0.96	5900	1.71	2.11
Alt. E	0.40	200.00	4.50	0.0100	0.00	12.00	11.70	1.03	0.0010	0.050	0.96	2400	0.70	1.39
A1	0.40	200.00	4.50	0.0020	0.17	18.00	14.00	1.29	0.0015	0.050	1.37	1850	0.38	1.87
lt. A Drainage Ditch														
A2	Include travel time of A1													
A3	Include travel time of A2													
A4	Include travel time of A3													

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - TOTAL OF (DA A,B,C,& E Minus D)

CALCULATED
 DISK FILE: DA-TTL-1.GPD

Drainage Area	(acres)	858.4	---->	1.3413	sq.mi.
Runoff Curve Number	(CN)	77			
Time of Concentration, Tc	(hrs)	2.64			
Rainfall Distribution	(Type)	III			
Pond and Swamp Areas	(%)	5	---->	42.9	acres

	Storm #1	Storm #2	Storm #3
	-----	-----	-----
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	164	168	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	349	666	0

Summary of Computations for qu

Ia/p #1	0.100	0.100	0.000
C0 #1	2.473	2.473	0.000
C1 #1	-0.518	-0.518	0.000
C2 #1	-0.171	-0.171	0.000
qu (csm) #1	167.576	167.576	0.000
Ia/p #2	0.300	0.100	0.000
C0 #2	2.396	2.473	0.000
C1 #2	-0.512	-0.518	0.000
C2 #2	-0.132	-0.171	0.000
qu (csm) #2	143.505	167.576	0.000
* qu (csm)	164	168	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(\text{qu}) = \text{C0} + (\text{C1} * \log(\text{Tc})) + (\text{C2} * (\log(\text{Tc}))^2)$$

$$\text{qp (cfs)} = \text{qu(csm)} * \text{Area(sq.mi.)} * \text{Q(in.)} * (\text{Pond \& Swamp Adj.})$$

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - TOTAL OF (DA A,B,C,D & E)

CALCULATED
 DISK FILE: DA-TTL .GPD

Drainage Area (acres) 971.4 ---> 1.5178 sq.mi.
 Runoff Curve Number (CN) 77
 Time of Concentration, Tc (hrs) 3.56
 Rainfall Distribution (Type) III
 Pond and Swamp Areas (%) 5 ---> 48.6 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	134	137	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	323	614	0

Summary of Computations for qu

Ia/p #1	0.100	0.100	0.000
C0 #1	2.473	2.473	0.000
C1 #1	-0.518	-0.518	0.000
C2 #1	-0.171	-0.171	0.000
qu (csm) #1	136.554	136.554	0.000
Ia/p #2	0.300	0.100	0.000
C0 #2	2.396	2.473	0.000
C1 #2	-0.512	-0.518	0.000
C2 #2	-0.132	-0.171	0.000
qu (csm) #2	118.481	136.554	0.000
* qu (csm)	134	137	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(\text{qu}) = \text{C0} + (\text{C1} * \log(\text{Tc})) + (\text{C2} * (\log(\text{Tc}))^2)$$

$$\text{qp (cfs)} = \text{qu(csm)} * \text{Area(sq.mi.)} * \text{Q(in.)} * (\text{Pond \& Swamp Adj.})$$

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - A1

CALCULATED
 DISK FILE: DA-A1 .GPD

Drainage Area (acres) 70 ---> 0.1094 sq.mi.
 Runoff Curve Number (CN) 77
 Time of Concentration, Tc (hrs) 1.9
 Rainfall Distribution (Type) III
 Pond and Swamp Areas (%) 5 ---> 3.5 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	202	207	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	35	67	0

Summary of Computations for qu

Ia/p #1	0.100	0.100	0.000
C0 #1	2.473	2.473	0.000
C1 #1	-0.518	-0.518	0.000
C2 #1	-0.171	-0.171	0.000
qu (csm) #1	206.713	206.713	0.000
Ia/p #2	0.300	0.100	0.000
C0 #2	2.396	2.473	0.000
C1 #2	-0.512	-0.518	0.000
C2 #2	-0.132	-0.171	0.000
qu (csm) #2	175.090	206.713	0.000
* qu (csm)	202	207	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$

$$qp \text{ (cfs)} = qu(\text{csm}) * \text{Area}(\text{sq.mi.}) * Q(\text{in.}) * (\text{Pond \& Swamp Adj.})$$

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - A2

CALCULATED
 DISK FILE: DA-A2 .GPD

Drainage Area (acres) 122 ---> 0.1906 sq.mi.
 Runoff Curve Number (CN) 77
 Time of Concentration, Tc (hrs) 2.1
 Rainfall Distribution (Type) III
 Pond and Swamp Areas (%) 5 ---> 6.1 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	189	194	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	57	110	0

Summary of Computations for qu

Ia/p #1	0.100	0.100	0.000
C0 #1	2.473	2.473	0.000
C1 #1	-0.518	-0.518	0.000
C2 #1	-0.171	-0.171	0.000
qu (csm) #1	194.254	194.254	0.000
Ia/p #2	0.300	0.100	0.000
C0 #2	2.396	2.473	0.000
C1 #2	-0.512	-0.518	0.000
C2 #2	-0.132	-0.171	0.000
qu (csm) #2	165.023	194.254	0.000
* qu (csm)	189	194	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

2

$$\log(\text{qu}) = C0 + (C1 * \log(\text{Tc})) + (C2 * (\log(\text{Tc}))^2)$$

$$\text{qp (cfs)} = \text{qu(csm)} * \text{Area(sq.mi.)} * \text{Q(in.)} * (\text{Pond \& Swamp Adj.})$$

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - A3

CALCULATED
 DISK FILE: DA-A3 .GPD

Drainage Area	(acres)	243	---	>	0.3797 sq.mi.
Runoff Curve Number	(CN)	77			
Time of Concentration, Tc	(hrs)	2.4			
Rainfall Distribution	(Type)	III			
Pond and Swamp Areas	(%)	5	---	>	12.2 acres

	Storm #1	Storm #2	Storm #3
	-----	-----	-----
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	174	178	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	105	201	0

Summary of Computations for qu

Ia/p #1	0.100	0.100	0.000
C0 #1	2.473	2.473	0.000
C1 #1	-0.518	-0.518	0.000
C2 #1	-0.171	-0.171	0.000
qu (csm) #1	178.379	178.379	0.000
Ia/p #2	0.300	0.100	0.000
C0 #2	2.396	2.473	0.000
C1 #2	-0.512	-0.518	0.000
C2 #2	-0.132	-0.171	0.000
qu (csm) #2	152.215	178.379	0.000
* qu (csm)	174	178	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$

$$qp \text{ (cfs)} = qu(\text{csm}) * \text{Area}(\text{sq.mi.}) * Q(\text{in.}) * (\text{Pond \& Swamp Adj.})$$

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - A4

CALCULATED
 DISK FILE: DA-A4 .GPD

Drainage Area (acres) 340 ---> 0.5313 sq.mi.
 Runoff Curve Number (CN) 77
 Time of Concentration, Tc (hrs) 2.64
 Rainfall Distribution (Type) III
 Pond and Swamp Areas (%) 5 ---> 17.0 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	164	168	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	138	264	0

Summary of Computations for qu

Ia/p #1	0.100	0.100	0.000
C0 #1	2.473	2.473	0.000
C1 #1	-0.518	-0.518	0.000
C2 #1	-0.171	-0.171	0.000
qu (csm) #1	167.576	167.576	0.000
Ia/p #2	0.300	0.100	0.000
C0 #2	2.396	2.473	0.000
C1 #2	-0.512	-0.518	0.000
C2 #2	-0.132	-0.171	0.000
qu (csm) #2	143.505	167.576	0.000
* qu (csm)	164	168	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$

$$qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond \& Swamp Adj.)$$

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - B

CALCULATED
 DISK FILE: DA-B .GPD

Drainage Area	(acres)	66	---	>	0.1031 sq.mi.
Runoff Curve Number	(CN)	77			
Time of Concentration, Tc	(hrs)	1.5			
Rainfall Distribution	(Type)	III			
Pond and Swamp Areas	(%)	5	---	>	3.3 acres

	Storm #1	Storm #2	Storm #3
	-----	-----	-----
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	232	238	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	38	73	0

Summary of Computations for qu

Ia/p #1	0.100	0.100	0.000
C0 #1	2.473	2.473	0.000
C1 #1	-0.518	-0.518	0.000
C2 #1	-0.171	-0.171	0.000
qu (csm) #1	237.998	237.998	0.000
Ia/p #2	0.300	0.100	0.000
C0 #2	2.396	2.473	0.000
C1 #2	-0.512	-0.518	0.000
C2 #2	-0.132	-0.171	0.000
qu (csm) #2	200.452	237.998	0.000
* qu (csm)	232	238	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$

$$qp \text{ (cfs)} = qu(\text{csm}) * \text{Area}(\text{sq.mi.}) * Q(\text{in.}) * (\text{Pond \& Swamp Adj.})$$

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - C

CALCULATED
 DISK FILE: DA-C .GPD

Drainage Area	(acres)	114	---	>	0.1781 sq.mi.
Runoff Curve Number	(CN)	77			
Time of Concentration, Tc	(hrs)	1.8			
Rainfall Distribution	(Type)	III			
Pond and Swamp Areas	(%)	5	---	>	5.7 acres

	Storm #1	Storm #2	Storm #3
	-----	-----	-----
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	208	214	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	59	113	0

Summary of Computations for qu

Ia/p #1	0.100	0.100	0.000
C0 #1	2.473	2.473	0.000
C1 #1	-0.518	-0.518	0.000
C2 #1	-0.171	-0.171	0.000
qu (csm) #1	213.641	213.641	0.000
Ia/p #2	0.300	0.100	0.000
C0 #2	2.396	2.473	0.000
C1 #2	-0.512	-0.518	0.000
C2 #2	-0.132	-0.171	0.000
qu (csm) #2	180.694	213.641	0.000
* qu (csm)	208	214	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

2

$$\log(\text{qu}) = C0 + (C1 * \log(\text{Tc})) + (C2 * (\log(\text{Tc}))^2)$$

$$\text{qp (cfs)} = \text{qu(csm)} * \text{Area(sq.mi.)} * \text{Q(in.)} * (\text{Pond \& Swamp Adj.})$$

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - D

CALCULATED
 DISK FILE: DA-D .GPD

Drainage Area	(acres)	422	---	>	0.6594 sq.mi.
Runoff Curve Number	(CN)	77			
Time of Concentration, Tc	(hrs)	3.5			
Rainfall Distribution	(Type)	III			
Pond and Swamp Areas	(%)	5	---	>	21.1 acres

	Storm #1	Storm #2	Storm #3
	-----	-----	-----
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	135	138	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	142	270	0

Summary of Computations for qu

Ia/p	#1	0.100	0.100	0.000
C0	#1	2.473	2.473	0.000
C1	#1	-0.518	-0.518	0.000
C2	#1	-0.171	-0.171	0.000
qu (csm)	#1	138.202	138.202	0.000
Ia/p	#2	0.300	0.100	0.000
C0	#2	2.396	2.473	0.000
C1	#2	-0.512	-0.518	0.000
C2	#2	-0.132	-0.171	0.000
qu (csm)	#2	119.812	138.202	0.000
* qu (csm)		135	138	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$

$$qp \text{ (cfs)} = qu \text{ (csm)} * \text{Area (sq.mi.)} * Q \text{ (in.)} * (\text{Pond \& Swamp Adj.})$$

>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
 EXISTING DRAINAGE CONDITIONS
 DRAINAGE AREA - E

CALCULATED
 DISK FILE: DA-E .GPD

Drainage Area (acres) 30 ---> 0.0469 sq.mi.
 Runoff Curve Number (CN) 77
 Time of Concentration, Tc (hrs) 2.1
 Rainfall Distribution (Type) III
 Pond and Swamp Areas (%) 5 ---> 1.5 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	2	10	
Rainfall, P, 24-hr (in)	4.5	6.72	
Initial Abstraction, Ia (in)	0.597	0.597	0.597
Ia/p Ratio	0.133	0.089	0.000
Unit Discharge, * qu (csm/in)	189	194	0
Runoff, Q (in)	2.21	4.12	0.00
Pond & Swamp Adjustment Factor	0.72	0.72	0.72
PEAK DISCHARGE, qp (cfs)	14	27	0

Summary of Computations for qu

Ia/p #1	0.100	0.100	0.000
C0 #1	2.473	2.473	0.000
C1 #1	-0.518	-0.518	0.000
C2 #1	-0.171	-0.171	0.000
qu (csm) #1	194.254	194.254	0.000
Ia/p #2	0.300	0.100	0.000
C0 #2	2.396	2.473	0.000
C1 #2	-0.512	-0.518	0.000
C2 #2	-0.132	-0.171	0.000
qu (csm) #2	165.023	194.254	0.000
* qu (csm)	189	194	0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
 If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(\text{qu}) = C0 + (C1 * \log(\text{Tc})) + (C2 * (\log(\text{Tc}))^2)$$

$$\text{qp (cfs)} = \text{qu (csm)} * \text{Area (sq.mi.)} * \text{Q (in.)} * (\text{Pond \& Swamp Adj.})$$

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location DRAINAGE AREA - A1 Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_c through subarea _____

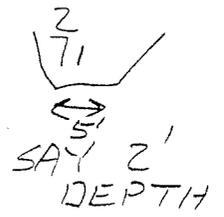
NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID	ALT 1	ALT 2
1. Surface description (table 3-1)		WOODS	DRAINAGE DITCH-3
2. Manning's roughness coeff., n (table 3-1) ..		0.40	
3. Flow length, L (total L \leq 300 ft) ft		200	
4. Two-yr 24-hr rainfall, P_2 in		4.5	
5. Land slope, s ft/ft		0.001	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t hr			0.73 =

Shallow concentrated flow	Segment ID		
7. Surface description (paved or unpaved)		UNPVD	
8. Flow length, L ft		600	
9. Watercourse slope, s ft/ft		0.001	
10. Average velocity, V (figure 3-1) ft/s		1.0	
11. $T_t = \frac{L}{3600 V}$ Compute T_t hr			+ =

Channel flow	Segment ID		
12. Cross sectional flow area, a ft ²		18	
13. Wetted perimeter, p_w ft		14	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft		0.78	
15. Channel slope, s ft/ft		0.0015	
16. Manning's roughness coeff., n		0.05	
17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V ft/s			
18. Flow length, L ft		1850	
19. $T_t = \frac{L}{3600 V}$ Compute T_t hr			+ =
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr			=



MANNINGS EXCAVATED OPEN CHANNEL CLEAN BOTTOM, BRUSH ON SIDES

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/25/99
 Location DRAINAGE AREA "AZ" Checked _____ Date _____

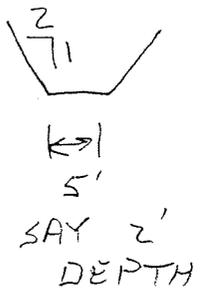
Circle one: Present Developed _____
 Circle one: T_c T_c through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
 Include a map, schematic, or description of flow segments.

<u>Sheet flow</u> (Applicable to T_c only)	Segment ID		
1. Surface description (table 3-1)	<u>A1</u>	<u>+AZ</u>	
2. Manning's roughness coeff., n (table 3-1) ..			
3. Flow length, L (total L \leq 300 ft)			ft
4. Two-yr 24-hr rainfall, P_2			in
5. Land slope, s			ft/ft
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t		+	=

<u>Shallow concentrated flow</u>	Segment ID		
7. Surface description (paved or unpaved)			
8. Flow length, L			ft
9. Watercourse slope, s			ft/ft
10. Average velocity, V (figure 3-1)			ft/s
11. $T_t = \frac{L}{3600 V}$ Compute T_t		+	=

<u>Channel flow</u>	Segment ID		
12. Cross sectional flow area, a		<u>18</u>	ft ²
13. Wetted perimeter, p_w		<u>14</u>	ft
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r			ft
15. Channel slope, s		<u>0.0013</u>	ft/ft
16. Manning's roughness coeff., n		<u>0.05</u>	
17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V			ft/s
18. Flow length, L		<u>1250</u>	ft
19. $T_t = \frac{L}{3600 V}$ Compute T_t		+	=
20. Watershed or subarea T_c or T_t (add T_c in steps 6, 11, and 19)			hr



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MJM Date 5/25/99
 Location DRAINAGE AREA "A3" Checked _____ Date _____

Circle one: Present Developed _____
 Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID	
1. Surface description (table 3-1)		A2 + A3
2. Manning's roughness coeff., n (table 3-1) ..		
3. Flow length, L (total L \leq 300 ft)	ft	
4. Two-yr 24-hr rainfall, P_2	in	
5. Land slope, s	ft/ft	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	+ =

Shallow concentrated flow	Segment ID	
7. Surface description (paved or unpaved)		
8. Flow length, L	ft	
9. Watercourse slope, s	ft/ft	
10. Average velocity, V (figure 3-1)	ft/s	
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	+ =

Channel flow	Segment ID	
12. Cross sectional flow area, a	ft ²	18
13. Wetted perimeter, p_w	ft	14
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	
15. Channel slope, s	ft/ft	0.0030
16. Manning's roughness coeff., n		
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s	
18. Flow length, L	ft	1650
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	+ =
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr	



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MIWM Date 5/25/99
 Location DRAINAGE AREA "A4" Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

Segment ID

1. Surface description (table 3-1)
2. Manning's roughness coeff., n (table 3-1) ..
3. Flow length, L (total L \leq 300 ft) ft
4. Two-yr 24-hr rainfall, P_2 in
5. Land slope, s ft/ft
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t hr

A3 +	AA
+	=

Shallow concentrated flow

Segment ID

7. Surface description (paved or unpaved)
8. Flow length, L ft
9. Watercourse slope, s ft/ft
10. Average velocity, V (figure 3-1) ft/s
11. $T_t = \frac{L}{3600 V}$ Compute T_t hr

+	=

Channel flow

Segment ID

12. Cross sectional flow area, a ft²
13. Wetted perimeter, p_w ft
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft
15. Channel slope, s ft/ft
16. Manning's roughness coeff., n
17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V ft/s
18. Flow length, L ft
19. $T_t = \frac{L}{3600 V}$ Compute T_t hr
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr

	30
	18
	0.0032
	2250
+	=



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location DRAINAGE AREA "B" Checked _____ Date _____

Circle one: Present Developed _____
 Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

<u>Sheet flow</u> (Applicable to T_c only)	Segment ID		
1. Surface description (table 3-1)		WOODS	
2. Manning's roughness coeff., n (table 3-1) ..		0.40	
3. Flow length, L (total L \leq 300 ft)	ft	200	
4. Two-yr 24-hr rainfall, P_2	in	4.5	
5. Land slope, s	ft/ft	0.002	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr		+ =

<u>Shallow concentrated flow</u>	Segment ID		
7. Surface description (paved or unpaved)		UNPVD	
8. Flow length, L	ft	800	
9. Watercourse slope, s	ft/ft	0.002	
10. Average velocity, V (figure 3-1)	ft/s	1.0	
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.22	+ =

<u>Channel flow</u>	Segment ID		
12. Cross sectional flow area, a	ft ²		
13. Wetted perimeter, p_w	ft		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft		
16. Manning's roughness coeff., n			
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft		
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr		+ =
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr		

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/21/99
 Location DRAINAGE AREA "C" Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

<u>Sheet flow</u> (Applicable to T_c only)	Segment ID		
1. Surface description (table 3-1)	WOODS		
2. Manning's roughness coeff., n (table 3-1) ..	0.40		
3. Flow length, L (total L \leq 300 ft) ft	200		
4. Two-yr 24-hr rainfall, P_2 in	4.5		
5. Land slope, s ft/ft	0.002		
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t hr	+ []	= []	

<u>Shallow concentrated flow</u>	Segment ID		
7. Surface description (paved or unpaved)	UNPAVD		
8. Flow length, L ft	1700		
9. Watercourse slope, s ft/ft	0.002		
10. Average velocity, V (figure 3-1) ft/s	1.0		
11. $T_t = \frac{L}{3600 V}$ Compute T_t hr	0.47 + []	= []	

<u>Channel flow</u>	Segment ID		
12. Cross sectional flow area, a ft ²			
13. Wetted perimeter, p_w ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft			
15. Channel slope, s ft/ft			
16. Manning's roughness coeff., n			
17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V ft/s			
18. Flow length, L ft			
19. $T_t = \frac{L}{3600 v}$ Compute T_t hr	+ []	= []	
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr			[]

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/20/99
 Location DRAINAGE AREA - ID Checked _____ Date _____
 Circle one: Present Developed 415 Ac
 Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

- Segment ID _____
1. Surface description (table 3-1)
 2. Manning's roughness coeff., n (table 3-1) ..
 3. Flow length, L (total L \leq 300 ft) ft
 4. Two-yr 24-hr rainfall, P_2 in
 5. Land slope, s ft/ft
 6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t hr

WOODS	
0.40	
200	
4.5	
0.0036	
	+
	=

Shallow concentrated flow

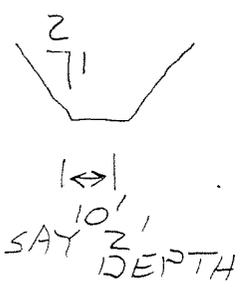
- Segment ID _____
7. Surface description (paved or unpaved)
 8. Flow length, L ft
 9. Watercourse slope, s ft/ft
 10. Average velocity, V (figure 3-1) ft/s
 11. $T_t = \frac{L}{3600 V}$ Compute T_t hr

3900	
0.0016	
1.0	
1.08	+
	=

Channel flow

- Segment ID _____
12. Cross sectional flow area, a ft²
 13. Wetted perimeter, p_w ft
 14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft
 15. Channel slope, s ft/ft
 16. Manning's roughness coeff., n
 17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V ft/s
 18. Flow length, L ft
 19. $T_t = \frac{L}{3600 V}$ Compute T_t hr
 20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr

28	
18.9	
0.0009	
0.05	
6000	
	+
	=



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location DRAINAGE AREA "E" Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_t through subarea _____

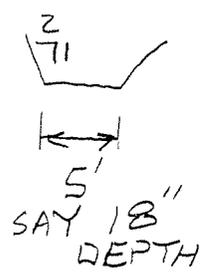
NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID	ALT 1	ALT 2
1. Surface description (table 3-1)		WOODS	WOODS
2. Manning's roughness coeff., n (table 3-1) ..			
3. Flow length, L (total L \leq 300 ft) ft		100	200
4. Two-yr 24-hr rainfall, P_2 in		4.5	4.5
5. Land slope, s ft/ft		0.01	0.01
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t hr		+	=

Shallow concentrated flow	Segment ID		
7. Surface description (paved or unpaved)			
8. Flow length, L ft			
9. Watercourse slope, s ft/ft			
10. Average velocity, V (figure 3-1) ft/s			
11. $T_t = \frac{L}{3600 V}$ Compute T_t hr		+	=

Channel flow	Segment ID		
12. Cross sectional flow area, a ft ²		12	12
13. Wetted perimeter, p_w ft		11.7	11.7
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft			
15. Channel slope, s ft/ft			
16. Manning's roughness coeff., n		0.05	
17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V ft/s			
18. Flow length, L ft		5,900	2,400
19. $T_t = \frac{L}{3600 V}$ Compute T_t hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr			



**FLOW RATES THROUGH
EXISTING DOWNSTREAM CULVERTS**

Rating Table Report Location-1

Range Data:

	Minimum	Maximum	Increment
Allowable HW Elev	15.00	25.00	0.50 ft

HW Elev (ft)	Discharge (cfs)	(1) HW Elev	(1) Discharge	(1) Dn V	(2) HW Elev	(2) Discharge	(2) Dn V
15.00	6.52	15.00	6.52	4.87	-9,999.00	0.00	0.00
15.50	13.05	15.50	12.49	5.90	15.50	0.56	2.38
16.00	22.66	16.00	20.06	6.76	16.00	2.61	3.60
16.50	34.78	16.50	28.99	7.50	16.50	5.79	4.55
17.00	48.66	17.00	39.04	8.11	17.00	9.62	5.38
17.50	63.53	17.50	49.95	8.64	17.50	13.59	6.14
18.00	78.15	18.00	61.45	9.10	18.00	16.70	6.73
18.50	92.51	18.50	73.29	9.50	18.50	19.22	7.23
19.00	106.74	19.00	85.21	9.83	19.00	21.54	7.73
19.50	120.67	19.50	96.98	10.06	19.50	23.69	8.22
20.00	134.07	20.00	108.36	10.21	20.00	25.72	8.71
20.50	142.37	20.50	114.76	10.54	20.50	27.62	9.20
21.00	150.22	21.00	120.82	10.87	21.00	29.40	9.68
21.50	157.47	21.50	126.59	11.19	21.50	30.88	10.09
22.00	164.40	22.00	132.11	11.51	22.00	32.30	10.50
22.50	171.05	22.50	137.41	11.82	22.50	33.65	10.89
23.00	177.46	23.00	142.51	12.13	23.00	34.95	11.28
23.50	183.64	23.50	147.43	12.44	23.50	36.20	11.65
24.00	189.61	24.00	152.20	12.74	24.00	37.42	12.02
24.50	195.41	24.50	156.82	13.05	24.50	38.59	12.38
25.00	201.03	25.00	161.30	13.35	25.00	39.73	12.73

Culvert Designer/Analyzer Report

Location-1

Analysis Component			
Storm Event	Design	Discharge	45.00 cfs
Peak Discharge Method: User-Specified			
Design Discharge	45.00 cfs	Check Discharge	0.00 cfs
Tailwater Conditions: Constant Tailwater			
Tailwater Elevation	N/A ft		

Name	Description	Discharge	HW Elev	Velocity
Culvert-1	1-48 inch Circular	36.40 cfs	16.87 ft	7.97 ft/s
Culvert-2	1-24 inch Circular	8.61 cfs	16.87 ft	5.17 ft/s
Weir	Not Considered	N/A	N/A	N/A
Total	-----	45.01 cfs	16.87 ft	N/A

Culvert Designer/Analyzer Report Location-1

Component: Culvert-1

Culvert Summary			
Computed Headwater Elevation	16.87 ft	Discharge	36.40 cfs
Inlet Control HW Elev	16.45 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev	16.87 ft	Control Type	Outlet Control
Headwater Depth/ Height	0.78		
Grades			
Upstream Invert	13.77 ft	Downstream Invert	13.04 ft
Length	35.00 ft	Constructed Slope	0.020857 ft/ft
Hydraulic Profile			
Profile	S2	Depth, Downstream	1.57 ft
Slope Type	Steep	Normal Depth	1.57 ft
Flow Regime	Supercritical	Critical Depth	1.80 ft
Velocity Downstream	7.97 ft/s	Critical Slope	0.012693 ft/ft
Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		
Outlet Control Properties			
Outlet Control HW Elev	16.87 ft	Upstream Velocity Head	0.69 ft
Ke	0.90	Entrance Loss	0.62 ft
Inlet Control Properties			
Inlet Control HW Elev	16.45 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	12.6 ft ²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Designer/Analyzer Report Location-1

Component: Culvert-2

Culvert Summary			
Computed Headwater Elevation	16.87 ft	Discharge	8.61 cfs
Inlet Control HW Elev	16.72 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev	16.87 ft	Control Type	Outlet Control
Headwater Depth/ Height	0.90		
Grades			
Upstream Invert	15.08 ft	Downstream Invert	14.97 ft
Length	26.00 ft	Constructed Slope	0.004231 ft/ft
Hydraulic Profile			
Profile	M2	Depth, Downstream	1.05 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.05 ft
Velocity Downstream	5.17 ft/s	Critical Slope	0.016950 ft/ft
Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.00 ft
Section Size	24 inch	Rise	2.00 ft
Number Sections	1		
Outlet Control Properties			
Outlet Control HW Elev	16.87 ft	Upstream Velocity Head	0.21 ft
Ke	0.90	Entrance Loss	0.19 ft
Inlet Control Properties			
Inlet Control HW Elev	16.72 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	3.1 ft ²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Rating Table Report Culvert-1

Range Data:

	Minimum	Maximum	Increment
Allowable HW Elev	15.00	25.00	0.50 ft

HW Elev (ft)	Discharge (cfs)	(I) HWi	(O) HWo	(D) Dn V	(D) Dn depth
15.00	6.52	14.74	15.00	4.87	0.65
15.50	12.49	15.18	15.50	5.90	0.90
16.00	20.06	15.62	16.00	6.76	1.14
16.50	28.99	16.09	16.50	7.50	1.39
17.00	39.04	16.57	17.00	8.11	1.63
17.50	49.95	17.08	17.50	8.64	1.87
18.00	61.45	17.59	18.00	9.10	2.12
18.50	73.29	18.12	18.50	9.50	2.36
19.00	85.21	18.66	19.00	9.83	2.61
19.50	96.98	19.24	19.50	10.06	2.87
20.00	108.36	20.00	19.99	10.21	3.15
20.50	114.76	20.50	20.19	10.54	3.23
21.00	120.82	21.00	20.42	10.87	3.31
21.50	126.59	21.50	20.68	11.19	3.37
22.00	132.11	22.00	20.98	11.51	3.43
22.50	137.41	22.50	21.37	11.82	3.49
23.00	142.51	23.00	21.77	12.13	3.53
23.50	147.43	23.50	22.15	12.44	3.58
24.00	152.20	24.00	22.53	12.74	3.61
24.50	156.82	24.50	22.90	13.05	3.65
25.00	161.30	25.00	23.27	13.35	3.68

Culvert Analysis Report

Culvert-1

Culvert Summary			
Computed Headwater Elevation	16.87 ft	Discharge	36.40 cfs
Inlet Control HW Elev	16.45 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev	16.87 ft	Control Type	Outlet Control
Headwater Depth/ Height	0.78		
Grades			
Upstream Invert	13.77 ft	Downstream Invert	13.04 ft
Length	35.00 ft	Constructed Slope	0.020857 ft/ft
Hydraulic Profile			
Profile	S2	Depth, Downstream	1.57 ft
Slope Type	Steep	Normal Depth	1.57 ft
Flow Regime	Supercritical	Critical Depth	1.80 ft
Velocity Downstream	7.97 ft/s	Critical Slope	0.012693 ft/ft
Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		
Outlet Control Properties			
Outlet Control HW Elev	16.87 ft	Upstream Velocity Head	0.69 ft
Ke	0.90	Entrance Loss	0.62 ft
Inlet Control Properties			
Inlet Control HW Elev	16.45 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	12.6 ft ²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Rating Table Report Culvert-2

Range Data:

	Minimum	Maximum	Increment
Allowable HW Elev	15.00	25.00	0.50 ft

HW Elev (ft)	Discharge (cfs)	(I) HWi	(O) HWo	(D) Dn V	(D) Dn depth
15.00	0.00	-9,999.00	-9,999.00	0.00	0.00
15.50	0.56	15.42	15.50	2.38	0.26
16.00	2.61	15.87	16.00	3.60	0.56
16.50	5.79	16.35	16.50	4.55	0.85
17.00	9.62	16.85	17.00	5.38	1.11
17.50	13.59	17.35	17.50	6.14	1.33
18.00	16.70	17.77	18.00	6.73	1.47
18.50	19.22	18.23	18.50	7.23	1.58
19.00	21.54	18.75	19.00	7.73	1.66
19.50	23.69	19.30	19.50	8.22	1.73
20.00	25.72	19.86	20.00	8.71	1.78
20.50	27.62	20.43	20.50	9.20	1.82
21.00	29.40	21.00	21.00	9.68	1.85
21.50	30.88	21.50	21.43	10.09	1.88
22.00	32.30	22.00	21.86	10.50	1.89
22.50	33.65	22.50	22.28	10.89	1.91
23.00	34.95	23.00	22.71	11.28	1.92
23.50	36.20	23.50	23.14	11.65	1.93
24.00	37.42	24.00	23.56	12.02	1.94
24.50	38.59	24.50	23.98	12.38	1.94
25.00	39.73	25.00	24.41	12.73	1.95

Culvert Analysis Report Culvert-2

Culvert Summary			
Computed Headwater Elevation	16.87 ft	Discharge	8.61 cfs
Inlet Control HW Elev	16.72 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev	16.87 ft	Control Type	Outlet Control
Headwater Depth/ Height	0.90		
Grades			
Upstream Invert	15.08 ft	Downstream Invert	14.97 ft
Length	26.00 ft	Constructed Slope	0.004231 ft/ft
Hydraulic Profile			
Profile	M2	Depth, Downstream	1.05 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.05 ft
Velocity Downstream	5.17 ft/s	Critical Slope	0.016950 ft/ft
Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.00 ft
Section Size	24 inch	Rise	2.00 ft
Number Sections	1		
Outlet Control Properties			
Outlet Control HW Elev	16.87 ft	Upstream Velocity Head	0.21 ft
Ke	0.90	Entrance Loss	0.19 ft
Inlet Control Properties			
Inlet Control HW Elev	16.72 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	3.1 ft ²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

**FUTURE CONDITIONS OF
THE FEEDER DITCHES**

**(Weir set within downstream
end of the ditches)**

Storm Drain Design Computations

Langley and McDonald, P.C.

Subject: N. C. CLAYHILL
Location CLAYHILL, North Carolina

File Name: Future Cond - 2yr - Weir.xls

2 YEAR DESIGN STORM
PROPOSED LAND USE

Job No. 1960024-203.00 Date: 05/07/97
Computed By: MWM Checked By:

STORM DRAIN DESIGN COMPUTATIONS

DITCH	Drainage AREA AC. Ac.	Runoff COEF. (C)	C x A		Tc CONC. Min.	INTEN In/Hr	RUNOFF "Q" INCR. cfs	Weir LENGTH Ft	Weir Eq. Head over Weir Ft	Weir Set below Top of Bank Ft	Height Over Top of Bank Ft
			INCR.	ACC.							
1	12.10	0.35	4.24	4.24	13.45	4.47	18.94	10.0	0.74	0.5000	0.2
2	12.60	0.35	4.41	4.41	14.75	4.32	19.04	10.0	0.74	0.5000	0.2
3	12.40	0.35	4.34	4.34	31.79	2.97	12.91	12.0	0.50	0.5000	0.0
4	8.70	0.35	3.05	3.05	13.88	4.42	13.46	11.0	0.55	0.5000	0.0
5	9.50	0.35	3.33	3.33	14.78	4.31	14.35	14.0	0.49	0.5000	0.0
6	15.50	0.35	5.43	5.43	18.05	3.97	21.54	14.5	0.63	0.5000	0.1
7	8.60	0.35	3.01	3.01	19.70	3.82	11.49	14.0	0.42	0.5000	-0.1
8	11.64	0.35	4.07	4.07	14.75	4.32	17.59	16.0	0.51	0.5000	0.0
9	4.30	0.35	1.51	1.51	11.92	4.67	7.03	18.0	0.26	0.5000	-0.2
10	3.70	0.35	1.30	1.30	15.37	4.25	5.50	24.0	0.18	0.5000	-0.3

IDF EQUATION

R	g	h
2.00	163.00	23.00
5.00	211.00	27.00
10.00	245.00	29.00

$$I_r = g / (h = T_d)$$

Weir Equation

$$Q = C_w L H^{3/2}$$

$$C_w = 3.0$$

Sheet Flow

DITCH	Flow Mnings	Length	2-Yr Rainfall	Slope	Time of Concentration
1	0.06	175.00	4.50	0.0029	0.22
2	0.06	175.00	4.50	0.0023	0.25
3	0.06	165.00	4.50	0.0003	0.53
4	0.06	200.00	4.50	0.0035	0.23
5	0.06	210.00	4.50	0.0033	0.25
6	0.06	230.00	4.50	0.0024	0.30
7	0.06	240.00	4.50	0.0021	0.33
8	0.06	240.00	4.50	0.0100	0.18
9	0.06	250.00	4.50	0.0080	0.20
10	0.06	200.00	4.50	0.0037	0.23

Shallow

Conc. Flow	Cross Area	Wetted perimeter	Hydraulic Radius
	2.50	6.00	0.42
	3.10	5.80	0.53
	3.30	6.80	0.49
	5.00	7.00	0.71
	4.00	6.50	0.62
	3.50	6.40	0.55
	5.00	7.50	0.67
0.07	4.20	5.70	0.74
	6.00	8.40	0.71
0.03	25.10	22.80	1.10

Channel Flow

Channel flow is disregarded in the proposed condition.

Slope	Mannings	velocity	Flow Length	Travel Time	Total Travel Time
0.0009	0.022	1.13	1250	0.31	0.22
0.0016	0.022	1.78	1300	0.20	0.25
0.0018	0.022	1.77	1300	0.20	0.53
0.0017	0.022	2.23	1300	0.16	0.23
0.0028	0.022	2.59	1300	0.14	0.25
0.0017	0.022	1.86	1250	0.19	0.30
0.0037	0.022	3.14	1000	0.09	0.33
0.0078	0.022	4.87	450	0.03	0.25
0.0110	0.022	5.67	500	0.02	0.20
0.0150	0.022	8.85	130	0.00	0.26

Storm Drain Design Computations

Langley and McDonald, P.C.

Subject: N. C. CLAYHILL

Location CLAYHILL, North Carolina

File Name Future Cond - 10yr - Weir.xls

10 YEAR DESIGN STORM
PROPOSED LAND USE

Job No. 1960024-203.00

Date: 05/07/97

Computed By: MWM

Checked By:

STORM DRAIN DESIGN COMPUTATIONS

DITCH	Drainage AREA AC.	Runoff COEF. (C)	C x A		Tc CONC.	INTEN In/Hr	RUNOFF "Q" INCR. cfs	Weir LENGTH Ft	Weir Eq. Head over Weir Pt	Weir Set below Top of Bank Pt	Height Over Top of Bank Ft
			INCR.	ACC.							
1	12.10	0.35	4.24	4.24	13.45	5.77	24.44	10.0	0.87	0.5000	0.4
2	12.60	0.35	4.41	4.41	14.75	5.60	24.69	10.0	0.88	0.5000	0.4
3	12.40	0.35	4.34	4.34	31.79	4.03	17.49	12.0	0.62	0.5000	0.1
4	8.70	0.35	3.05	3.05	13.88	5.71	17.40	11.0	0.65	0.5000	0.2
5	9.50	0.35	3.33	3.33	14.78	5.60	18.61	14.0	0.58	0.5000	0.1
6	15.50	0.35	5.43	5.43	18.05	5.21	28.25	14.5	0.75	0.5000	0.2
7	8.60	0.35	3.01	3.01	19.70	5.03	15.14	14.0	0.51	0.5000	0.0
8	11.64	0.35	4.07	4.07	14.75	5.60	22.81	16.0	0.61	0.5000	0.1
9	4.30	0.35	1.51	1.51	11.92	5.99	9.01	18.0	0.30	0.5000	-0.2
10	3.70	0.35	1.30	1.30	15.37	5.52	7.15	24.0	0.21	0.5000	-0.3

IDF EQUATION

R	g	h
2.00	163.00	23.00
5.00	211.00	27.00
10.00	245.00	29.00

Ir = g/(h = Td)

Weir Equation

Q=Cw L H ^{3/2}

Cw = 3.0

Sheet Flow

DITCH	Flow Mnings Length	2-Yr Rainfall Slope	Time of Concentration
1	0.06 175.00	4.50 0.0029	0.22
2	0.06 175.00	4.50 0.0023	0.25
3	0.06 165.00	4.50 0.0003	0.53
4	0.06 200.00	4.50 0.0035	0.23
5	0.06 210.00	4.50 0.0033	0.25
6	0.06 230.00	4.50 0.0024	0.30
7	0.06 240.00	4.50 0.0021	0.33
8	0.06 240.00	4.50 0.0100	0.18
9	0.06 250.00	4.50 0.0080	0.20
10	0.06 200.00	4.50 0.0037	0.23

Shallow

Conc. Flow	Crss Sec Area	Wetted perimeter	Hydraulic Radius	Slope	Mannings velocity
	2.50	6.00	0.42	0.0009	0.022
	3.10	5.80	0.53	0.0016	0.022
	3.30	6.80	0.49	0.0018	0.022
	5.00	7.00	0.71	0.0017	0.022
	4.00	6.50	0.62	0.0028	0.022
	3.50	6.40	0.55	0.0017	0.022
	5.00	7.50	0.67	0.0037	0.022
0.07	4.20	5.70	0.74	0.0078	0.022
	6.00	8.40	0.71	0.0110	0.022
0.03	25.10	22.80	1.10	0.0150	0.022

Channel Flow Channel flow is disregarded in the proposed condition.

DITCH	Flow Length	Travel Time	Total Travel Time
1	1250	0.31	0.22
2	1300	0.20	0.25
3	1300	0.20	0.53
4	1300	0.16	0.23
5	1300	0.14	0.25
6	1250	0.19	0.30
7	1000	0.09	0.33
8	450	0.03	0.25
9	500	0.02	0.20
10	130	0.00	0.26

FLOW RATE WITHIN EXISTING FEEDER DITCHES

(Located within proposed wetland area)

Storm Drain Design Computations

Langley and McDonald, P.C.

Subject: N. C. CLAYHILL

Location CLAYHILL, North Carolina

File Name:

Exist Cond - 2yr - Ditches.xls

2 YEAR DESIGN STORM
EXISTING LAND USE

Job No. 1960024-203.00

Date: 05/07/97

Computed By: MWM

Checked By:

STORM DRAIN DESIGN COMPUTATIONS

DITCH	Drainage	Runoff	C x A		Tc	RUNOFF "Q"			INVERTS			DITCH		WATER	TOP OF	
	AREA AC. Ac.	COEF. (C)	INCR.	ACC.	CONC. Min.	INTEN In/Hr	INCR. cfs	ACC. cfs	UP	DOWN	LENGTH Ft	SLOPE Ft/Ft	CAPACITY cfs	VELOCITY fps	SURFACE ELEV.	BANK ELEV.
1	12.10	0.35	4.24	4.24	31.88	2.97	12.58	12.58	32.00	31.00	1090.00	0.0009	41.6	1.7	32.0	33.0
2	12.60	0.35	4.41	4.41	26.92	3.27	14.40	14.40	32.00	30.00	1270.00	0.0016	79.8	2.4	31.3	33.0
3	12.40	0.35	4.34	4.34	44.03	2.43	10.55	10.55	32.20	30.00	1250.00	0.0018	101.1	2.2	31.0	33.0
4	8.70	0.35	3.05	3.05	23.60	3.50	10.65	10.65	32.00	29.90	1260.00	0.0017	62.0	2.2	31.0	33.1
5	9.50	0.35	3.33	3.33	23.15	3.53	11.75	11.75	32.40	29.10	1180.00	0.0028	136.4	2.7	30.6	33.2
6	15.50	0.35	5.43	5.43	29.23	3.12	16.93	16.93	31.00	29.00	1200.00	0.0017	95.4	2.4	30.5	32.0
7	8.60	0.35	3.01	3.01	25.01	3.40	10.22	10.22	32.20	28.60	970.00	0.0037	167.3	2.8	29.7	32.0
8	11.64	0.35	4.07	4.07	16.29	4.15	16.90	16.90	26.30	22.00	550.00	0.0078	127.7	4.0	22.9	25.0
9	4.30	0.35	1.51	1.51	13.39	4.48	6.74	6.74	29.30	24.00	480.00	0.0110	230.6	2.2	24.2	26.0
10	3.70	0.35	1.30	1.30	15.62	4.22	5.47	5.47	27.00	25.00	130.00	0.0154	415.0	1.9	24.1	26.2

IDF EQUATION

R	g	h
2.00	163.00	23.00
5.00	211.00	27.00
10.00	245.00	29.00

$$I_r = g / (h = T_d)$$

DITCH	Sheet Flow			Channel Flow								Flow Length	Travel Time	Total Travel Time			
	Flow Mnings	Length	2-Yr Rainfall Slope	Time of Concentration	Shallow Conc. Flow	Crss Sec Area	Wetted perimeter	Hydraulic Radius	Slope	Mannings	velocity						
1	0.06	175.00	4.50	0.0029	0.22												
2	0.06	175.00	4.50	0.0023	0.25		2.50	6.00	0.42	0.0009	0.022	1.13	1250	0.31		0.53	
3	0.06	165.00	4.50	0.0003	0.53		3.10	5.80	0.53	0.0016	0.022	1.78	1300	0.20		0.45	
4	0.06	200.00	4.50	0.0035	0.23		3.30	6.80	0.49	0.0018	0.022	1.77	1300	0.20		0.73	
5	0.06	210.00	4.50	0.0033	0.25		5.00	7.00	0.71	0.0017	0.022	2.23	1300	0.16		0.39	
6	0.06	230.00	4.50	0.0024	0.30		4.00	6.50	0.62	0.0028	0.022	2.59	1300	0.14		0.39	
7	0.06	240.00	4.50	0.0021	0.33		3.50	6.40	0.55	0.0017	0.022	1.86	1250	0.19		0.49	
8	0.06	240.00	4.50	0.0100	0.18		5.00	7.50	0.67	0.0037	0.022	3.14	1000	0.09		0.42	
9	0.06	250.00	4.50	0.0080	0.20	0.07	4.20	5.70	0.74	0.0078	0.022	4.87	450	0.03		0.27	
10	0.06	200.00	4.50	0.0037	0.23	0.03	6.00	8.40	0.71	0.0110	0.022	5.67	500	0.02		0.22	
							0.03	25.10	22.80	1.10	0.0150	0.022	8.85	130	0.00		0.26
												0.022					

Storm Drain Design Computations

Langley and McDonald, P.C.

10 YEAR DESIGN STORM
EXISTING LAND USE

STORM DRAIN DESIGN COMPUTATIONS

Subject: N. C. CLAYHILL
Location: CLAYHILL, North Carolina

File Name: Exist Cond - 10yr - Ditches.xls

Job No. 1960024-203.00 Date: 05/07/97
Computed By: MWM Checked By:

DITCH	Drainage	Runoff	C x A		Tc	RUNOFF "Q"				INVERTS			DITCH		WATER	TOP OF
	AREA AC.	COEF. (C)	INCR.	ACC.	CONC.	INTEN	INCR.	ACC.	UP	DOWN	LENGTH	SLOPE	CAPACITY	VELOCITY	SURFACE	BANK
	Ac.				Min.	In/Hr	cfs	cfs			Ft	Ft/Ft	cfs	fps	ELEV.	ELEV.
1	12.10	0.35	4.24	4.24	31.88	4.02	17.04	17.04	32.00	31.00	1090.00	0.0009	41.6	1.7	32.3	33.0
2	12.60	0.35	4.41	4.41	26.92	4.38	19.32	19.32	32.00	30.00	1270.00	0.0016	79.8	2.4	31.6	33.0
3	12.40	0.35	4.34	4.34	44.03	3.35	14.56	14.56	32.20	30.00	1250.00	0.0018	101.1	2.2	31.2	33.0
4	8.70	0.35	3.05	3.05	23.60	4.66	14.18	14.18	32.00	29.90	1260.00	0.0017	62.0	2.2	31.3	33.1
5	9.50	0.35	3.33	3.33	23.15	4.70	15.62	15.62	32.40	29.10	1180.00	0.0028	136.4	2.7	30.7	33.2
6	15.50	0.35	5.43	5.43	29.23	4.21	22.83	22.83	31.00	29.00	1200.00	0.0017	95.4	2.4	30.6	32.0
7	8.60	0.35	3.01	3.01	25.01	4.54	13.65	13.65	32.20	28.60	970.00	0.0037	167.3	2.8	29.8	32.0
8	11.64	0.35	4.07	4.07	16.29	5.41	22.04	22.04	26.30	22.00	550.00	0.0078	127.7	4.0	23.6	25.0
9	4.30	0.35	1.51	1.51	13.39	5.78	8.70	8.70	29.30	24.00	480.00	0.0110	230.6	2.2	24.3	26.0
10	3.70	0.35	1.30	1.30	15.62	5.49	7.11	7.11	27.00	25.00	130.00	0.0154	415.0	1.9	24.2	26.2

IDF EQUATION

R	g	h	Ir = g/(h = Td)
2.00	163.00	23.00	
5.00	211.00	27.00	
10.00	245.00	29.00	

DITCH	Sheet Flow			Channel Flow										Total Travel Time	
	Flow	2-Yr Rainfall	Time of Concentration	Conc. Flow	Crss Area	Sec Wetted perimeter	Hydraulic Radius	Slope	Mannings velocity	Flow Length	Travel Time				
1	0.06	175.00	4.50	0.0029	0.22	2.50	6.00	0.42	0.0009	0.022	1.13	1250	0.31	0.53	
2	0.06	175.00	4.50	0.0023	0.25	3.10	5.80	0.53	0.0016	0.022	1.78	1300	0.20	0.45	
3	0.06	165.00	4.50	0.0003	0.53	3.30	6.80	0.49	0.0018	0.022	1.77	1300	0.20	0.73	
4	0.06	200.00	4.50	0.0035	0.23	5.00	7.00	0.71	0.0017	0.022	2.23	1300	0.16	0.39	
5	0.06	210.00	4.50	0.0033	0.25	4.00	6.50	0.62	0.0028	0.022	2.59	1300	0.14	0.39	
6	0.06	230.00	4.50	0.0024	0.30	3.50	6.40	0.55	0.0017	0.022	1.86	1250	0.19	0.49	
7	0.06	240.00	4.50	0.0021	0.33	5.00	7.50	0.67	0.0037	0.022	3.14	1000	0.09	0.42	
8	0.06	240.00	4.50	0.0100	0.18	0.07	4.20	5.70	0.74	0.0078	0.022	4.87	450	0.03	0.27
9	0.06	250.00	4.50	0.0080	0.20	6.00	8.40	0.71	0.0110	0.022	5.67	500	0.02	0.22	
10	0.06	200.00	4.50	0.0037	0.23	0.03	25.10	22.80	1.10	0.0150	0.022	8.85	130	0.00	0.26

Worksheet ditch -1
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 1
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data				
Channel Slope	0.000900 ft/ft			
Water Surface Elevation	32.03	ft		
Elevation range: 31.00 ft to 33.90 ft.				
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-12.00	33.30	-12.00	30.00	0.022
0.00	33.90			
3.50	31.00			
9.00	31.00			
12.50	33.00			
30.00	33.00			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	12.58	cfs
Flow Area	7.27	ft ²
Wetted Perimeter	9.20	ft
Top Width	8.56	ft
Height	1.03	ft
Critical Depth	31.52	ft
Critical Slope	0.009682	ft/ft
Velocity	1.73	ft/s
Velocity Head	0.05	ft
Specific Energy	32.08	ft
Froude Number	0.33	

Ditch 1 Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 1
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.000900 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	31.00	33.00	0.25 ft

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
31.00	0.022	0.00	0.00	
31.25	0.022	1.11	0.76	
31.50	0.022	3.59	1.15	
31.75	0.022	7.19	1.45	
32.00	0.022	11.86	1.70	
32.25	0.022	17.61	1.92	
32.50	0.022	24.46	2.11	
32.75	0.022	32.43	2.29	
33.00	0.022	41.56	2.46	

Worksheet DA 2
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 2
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data				
Channel Slope	0.001600 ft/ft			
Water Surface Elevation	31.33 ft			
Elevation range: 30.00 ft to 33.70 ft.				
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-12.00	33.70	-12.00	38.00	0.022
0.00	33.70			
6.00	33.00			
11.00	30.00			
13.50	30.00			
18.00	33.00			
25.00	33.50			
38.00	33.60			

Results	
Wtd. Mannings Coefficient	0.022
Discharge	14.40 cfs
Flow Area	6.10 ft ²
Wetted Perimeter	7.47 ft
Top Width	6.70 ft
Height	1.33 ft
Critical Depth	30.84 ft
Critical Slope	0.009311 ft/ft
Velocity	2.36 ft/s
Velocity Head	0.09 ft

Worksheet DA 2
Worksheet for Irregular Channel

Specific Energy	31.41	ft
Froude Number	0.44	
Flow is subcritical.		

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 2
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.001600 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	30.00	33.50	0.25 ft

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
30.00	0.022	0.00	0.00	
30.25	0.022	0.69	0.96	
30.50	0.022	2.32	1.41	
30.75	0.022	4.84	1.75	
31.00	0.022	8.31	2.03	
31.25	0.022	12.81	2.29	
31.50	0.022	18.42	2.52	
31.75	0.022	25.23	2.73	
32.00	0.022	33.30	2.94	
32.25	0.022	42.72	3.13	
32.50	0.022	53.56	3.32	
32.75	0.022	65.90	3.50	
33.00	0.022	79.82	3.67	

Table
Rating Table for Irregular Channel

Rating Table				
Water Surface				
Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
33.25	0.022	82.41	3.24	
33.50	0.022	94.27	3.08	

Worksheet DA 3
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 3
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data					
Channel Slope		0.001800	ft/ft		
Water Surface Elevation	31.00		ft		
Elevation range: 30.00 ft to 33.10 ft.					
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness	
-19.50	33.00	-19.50	30.50	0.022	
0.00	33.00				
7.00	30.00				
10.00	30.00				
14.00	33.00				
30.50	33.10				

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	10.55	cfs
Flow Area	4.81	ft ²
Wetted Perimeter	7.19	ft
Top Width	6.66	ft
Height	1.00	ft
Critical Depth	30.63	ft
Critical Slope	0.009681	ft/ft
Velocity	2.19	ft/s
Velocity Head	0.07	ft
Specific Energy	31.07	ft
Froude Number	0.45	

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 3
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.001800 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	31.00	33.00	0.25 ft

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
31.00	0.022	10.55	2.19	
31.25	0.022	16.27	2.47	
31.50	0.022	23.39	2.72	
31.75	0.022	32.02	2.96	
32.00	0.022	42.25	3.18	
32.25	0.022	54.18	3.39	
32.50	0.022	67.90	3.59	
32.75	0.022	83.51	3.78	
33.00	0.022	101.10	3.97	

Worksheet DA 4
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 4
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data					
Channel Slope	0.001700 ft/ft				
Water Surface Elevation	31.01	ft			
Elevation range: 29.90 ft to 33.30 ft.					
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness	
-17.00	33.10	-17.00	33.00	0.022	
0.00	33.10				
5.50	29.90				
8.00	29.90				
13.00	33.10				
19.50	33.30				
33.00	33.30				

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	10.65	cfs
Flow Area	4.81	ft ²
Wetted Perimeter	6.77	ft
Top Width	6.15	ft
Height	1.11	ft
Critical Depth	30.60	ft
Critical Slope	0.009658	ft/ft
Velocity	2.22	ft/s
Velocity Head	0.08	ft
Specific Energy	31.09	ft

Worksheet DA 4
Worksheet for Irregular Channel

Froude Number 0.44
Flow is subcritical.

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 4
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.001700 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	29.90	33.10	0.25 ft

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
29.90	0.022	0.00	0.00	
30.15	0.022	0.72	0.98	
30.40	0.022	2.41	1.45	
30.65	0.022	5.04	1.80	
30.90	0.022	8.68	2.10	
31.15	0.022	13.41	2.36	
31.40	0.022	19.32	2.60	
31.65	0.022	26.50	2.82	
31.90	0.022	35.04	3.03	
32.15	0.022	45.01	3.23	
32.40	0.022	56.50	3.42	
32.65	0.022	69.59	3.61	
32.90	0.022	84.36	3.79	

Table
Rating Table for Irregular Channel

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
33.15	0.022	62.52	2.37	

Worksheet DA 5
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 5
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data					
Channel Slope	0.002800 ft/ft				
Water Surface Elevation	30.57	ft			
Elevation range: 29.10 ft to 33.20 ft.					
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness	
-18.00	33.20	-18.00	32.00	0.022	
0.00	33.10				
10.00	29.10				
16.00	33.00				
32.00	33.20				

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	11.75	cfs
Flow Area	4.36	ft ²
Wetted Perimeter	6.65	ft
Top Width	5.93	ft
Height	1.47	ft
Critical Depth	30.26	ft
Critical Slope	0.009848	ft/ft
Velocity	2.70	ft/s
Velocity Head	0.11	ft
Specific Energy	30.68	ft
Froude Number	0.55	
Flow is subcritical.		

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 5
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.002800 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	29.10	33.20	0.25 ft

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
29.10	0.022	0.00	0.00	
29.35	0.022	0.10	0.83	
29.60	0.022	0.66	1.31	
29.85	0.022	1.96	1.72	
30.10	0.022	4.21	2.09	
30.35	0.022	7.64	2.42	
30.60	0.022	12.42	2.73	
30.85	0.022	18.74	3.03	
31.10	0.022	26.75	3.31	
31.35	0.022	36.62	3.58	
31.60	0.022	48.50	3.84	
31.85	0.022	62.53	4.10	
32.10	0.022	78.86	4.34	

Table
Rating Table for Irregular Channel

Rating Table			
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
32.35	0.022	97.63	4.58
32.60	0.022	118.96	4.81
32.85	0.022	142.99	5.04
33.10	0.022	136.43	4.17

Worksheet DA 6
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 6
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data				
Channel Slope	0.001700 ft/ft			
Water Surface Elevation	30.49	ft		
Elevation range: 29.00 ft to 32.00 ft.				
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-21.00	32.00	-21.00	29.00	0.022
0.00	32.00			
8.00	29.00			
9.00	29.00			
16.50	32.00			
29.00	32.00			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	16.93	cfs
Flow Area	7.18	ft ²
Wetted Perimeter	9.23	ft
Top Width	8.67	ft
Height	1.49	ft
Critical Depth	30.04	ft
Critical Slope	0.009037	ft/ft
Velocity	2.36	ft/s
Velocity Head	0.09	ft
Specific Energy	30.57	ft
Froude Number	0.46	

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 6
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.001700 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	29.00	32.00	0.25 ft

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
29.00	0.022	0.00	0.00	
29.25	0.022	0.36	0.86	
29.50	0.022	1.44	1.26	
29.75	0.022	3.48	1.58	
30.00	0.022	6.68	1.86	
30.25	0.022	11.24	2.13	
30.50	0.022	17.33	2.37	
30.75	0.022	25.14	2.60	
31.00	0.022	34.82	2.82	
31.25	0.022	46.53	3.04	
31.50	0.022	60.43	3.24	
31.75	0.022	76.65	3.44	
32.00	0.022	95.35	3.63	

Worksheet DA 7
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\inc clayhill\exist co.fm2
Worksheet	Ditch 7
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data					
Channel Slope	0.003700 ft/ft				
Water Surface Elevation	29.67	ft			
Elevation range: 28.60 ft to 33.10 ft.					
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness	
-13.00	32.50	-13.00	37.00	0.022	
0.00	32.60				
3.00	32.10				
10.00	28.60				
11.00	29.00				
13.00	29.00				
19.00	33.10				
37.00	32.70				

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	10.22	cfs
Flow Area	3.69	ft ²
Wetted Perimeter	6.66	ft
Top Width	6.12	ft
Height	1.07	ft
Critical Depth	29.49	ft
Critical Slope	0.010001	ft/ft
Velocity	2.77	ft/s
Velocity Head	0.12	ft

Worksheet DA 7
Worksheet for Irregular Channel

Specific Energy	29.79	ft
Froude Number	0.63	
Flow is subcritical.		

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 7
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.003700 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	28.60	32.60	0.25 ft

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
28.60	0.022	0.00	0.00	
28.85	0.022	0.14	0.97	
29.10	0.022	0.97	1.28	
29.35	0.022	3.91	2.06	
29.60	0.022	8.58	2.63	
29.85	0.022	15.02	3.10	
30.10	0.022	23.33	3.52	
30.35	0.022	33.64	3.89	
30.60	0.022	46.06	4.24	
30.85	0.022	60.73	4.56	
31.10	0.022	77.77	4.87	
31.35	0.022	97.30	5.16	
31.60	0.022	119.44	5.44	

Table
Rating Table for Irregular Channel

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
31.85	0.022	144.32	5.71	
32.10	0.022	172.06	5.98	
32.35	0.022	196.87	6.03	
32.60	0.022	167.33	4.45	

Worksheet DA 8
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 8
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data					
Channel Slope	0.007800 ft/ft				
Water Surface Elevation	22.93	ft			
Elevation range: 22.00 ft to 26.10 ft.					
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness	
-14.50	25.70	-14.50	36.00	0.022	
0.00	25.10				
9.00	23.70				
11.00	22.00				
12.50	22.00				
13.50	23.60				
21.00	25.00				
36.00	26.10				

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	8.64	cfs
Flow Area	2.18	ft ²
Wetted Perimeter	4.04	ft
Top Width	3.18	ft
Height	0.93	ft
Critical Depth	22.85	ft
Critical Slope	0.011154	ft/ft
Velocity	3.96	ft/s
Velocity Head	0.24	ft

Worksheet DA 8
Worksheet for Irregular Channel

Specific Energy	23.18	ft
Froude Number	0.84	
Flow is subcritical.		

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 8
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.007800 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	22.00	25.70	0.25 ft

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
22.00	0.022	0.00	0.00	
22.25	0.022	0.87	2.02	
22.50	0.022	2.84	2.91	
22.75	0.022	5.80	3.56	
23.00	0.022	9.83	4.09	
23.25	0.022	14.98	4.56	
23.50	0.022	21.35	4.99	
23.75	0.022	27.06	4.97	
24.00	0.022	34.32	4.75	
24.25	0.022	47.52	4.88	
24.50	0.022	66.98	5.16	
24.75	0.022	93.44	5.51	
25.00	0.022	127.71	5.89	

Table
Rating Table for Irregular Channel

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
25.25	0.022	156.43	5.67	
25.50	0.022	200.70	5.61	
25.75	0.022	271.36	5.86	

Worksheet
Worksheet for Irregular Channel

Project Description	
Project File	c:\i&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 9
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data					
Channel Slope	0.011000 ft/ft				
Water Surface Elevation	24.19	ft			
Elevation range: 24.00 ft to 27.10 ft.					
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness	
-17.00	27.10	-17.00	33.00	0.022	
0.00	26.00				
8.00	24.00				
15.00	24.00				
20.50	26.10				
33.00	26.70				

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	3.11	cfs
Flow Area	1.42	ft ²
Wetted Perimeter	8.29	ft
Top Width	8.24	ft
Height	0.19	ft
Critical Depth	24.18	ft
Critical Slope	0.012974	ft/ft
Velocity	2.19	ft/s
Velocity Head	0.07	ft
Specific Energy	24.26	ft
Froude Number	0.93	

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 9
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.011000 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	24.00	26.70	0.25 ft

Rating Table				
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)	
24.00	0.022	0.00	0.00	
24.25	0.022	5.11	2.61	
24.50	0.022	17.02	3.93	
24.75	0.022	35.16	4.94	
25.00	0.022	59.76	5.80	
25.25	0.022	91.18	6.55	
25.50	0.022	129.83	7.23	
25.75	0.022	176.14	7.87	
26.00	0.022	230.56	8.46	
26.25	0.022	260.88	7.89	
26.50	0.022	310.71	7.56	
26.75	0.022	395.02	7.70	

Worksheet DA 10
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 10
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data					
Channel Slope	0.015400 ft/ft				
Water Surface Elevation	24.11	ft			
Elevation range: 24.00 ft to 26.50 ft.					
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness	
-15.00	26.50	-15.00	35.00	0.022	
0.00	26.10				
7.50	24.00				
18.50	24.00				
27.00	26.00				
35.00	26.30				

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	2.43	cfs
Flow Area	1.28	ft ²
Wetted Perimeter	11.90	ft
Top Width	11.88	ft
Height	0.11	ft
Critical Depth	24.11	ft
Critical Slope	0.014808	ft/ft
Velocity	1.90	ft/s
Velocity Head	0.06	ft
Specific Energy	24.17	ft
Froude Number	1.02	

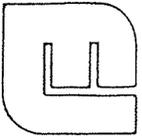
Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 10
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.015400 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	24.00	26.30	0.25 ft

Rating Table			
Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
24.00	0.022	0.00	0.00
24.25	0.022	9.42	3.15
24.50	0.022	30.97	4.78
24.75	0.022	63.18	6.05
25.00	0.022	106.05	7.11
25.25	0.022	159.91	8.05
25.50	0.022	225.22	8.90
25.75	0.022	302.51	9.69
26.00	0.022	392.31	10.42
26.25	0.022	418.82	9.18



Length bet. X-S $32 + 36 = 4950'$

X-S 32 inV = 17.0

X-S 36 inV = 29.0

$$\text{SLOPE} = \frac{29 - 17}{4950} = 0.002$$

DITCH 1: DA = 12.1 AC

$$\text{SLOPE OF DITCH} = \frac{32.0 - 31.0}{1090} = 0.0009$$

DITCH 2: DA = 12.6 AC

$$\text{SLOPE OF DITCH} = \frac{32.0 - 30.0}{1270} = 0.0016$$

DITCH 3: DA = 12.4 AC

$$\text{SLOPE OF DITCH} = \frac{32.2 - 30.0}{1250} = 0.0018$$

DITCH 4: DA = 8.7 AC

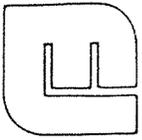
$$\text{SLOPE OF DITCH} = \frac{32.0 - 29.9}{1260} = 0.0017$$

DITCH 5: DA = 9.5 AC

$$\text{SLOPE OF DITCH} = \frac{32.4 - 29.1}{1180} = 0.0028$$

DITCH 6: DA = 15.5 AC

$$\text{SLOPE OF DITCH} = \frac{31.0 - 29.0}{1200} = 0.0017$$



Langley and McDonald, P.C.

ENGINEERS • SURVEYORS • PLANNERS
LANDSCAPE ARCHITECTS • ENVIRONMENTAL CONSULTANTS

VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject CLAYHILL

Project No. _____

Client _____

Computed By DBS Checked by _____

Date 3/16/99 Sheet No 2

DITCH 7: DA = 8.6 AC

$$\text{SLOPE OF DITCH} = \frac{32.2 - 28.6}{470} = 0.0037$$

DITCH 8: DA = 11.6 AC

$$\text{SLOPE OF DITCH} = \frac{26.3 - 22.0}{550} = 0.0078$$

DITCH 9: DA = 4.3 AC

$$\text{SLOPE OF DITCH} = \frac{29.3 - 24.0}{480} = 0.011$$

DITCH 10: DA = 3.7 AC

$$\text{SLOPE OF DITCH} = \frac{27 - 25}{130} = 0.015$$

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99

Location INTERIOR DITCH #1 Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T _c only)	Segment ID		
1. Surface description (table 3-1)		FALLOW ≤ 20%	
2. Manning's roughness coeff., n (table 3-1) ..		0.06	
3. Flow length, L (total L ≤ 300 ft)	ft	175	
4. Two-yr 24-hr rainfall, P ₂	in	4.5	
5. Land slope, s	ft/ft	0.0029	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T _t	hr	+ =	[]

INV. UP =
33.5
T.B. 33.0

Shallow concentrated flow	Segment ID		
7. Surface description (paved or unpaved)			
8. Flow length, L	ft		
9. Watercourse slope, s	ft/ft		
10. Average velocity, V (figure 3-1)	ft/s		
11. $T_t = \frac{L}{3600 V}$ Compute T _t	hr	+ =	[]

Channel flow	Segment ID		
12. Cross sectional flow area, a	ft ²	2.5	
13. Wetted perimeter, p _w	ft	6	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft	0.0009	
16. Manning's roughness coeff., n		0.022	
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft	1250	
19. $T_t = \frac{L}{3600 V}$ Compute T _t	hr	+ =	[]
20. Watershed or subarea T _c or T _t (add T _c in steps 6, 11, and 19)	hr		[]

$\sqrt{\frac{2}{3}}$ / 1' DEPTH
4'
SAY HALF FULL 0.5' DEPTH

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location INTERIOR DITCH #2 Checked _____ Date _____

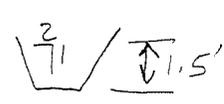
Circle one: Present Developed _____
 Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID		
1. Surface description (table 3-1)		FALLOW = 2070	INV UP 33.4 TOP OF BANK 33.0
2. Manning's roughness coeff., n (table 3-1) ..		0.06	
3. Flow length, L (total L < 300 ft)	ft	175	
4. Two-yr 24-hr rainfall, P_2	in	4.5	
5. Land slope, s	ft/ft	0.0023	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	+ [] = []	

Shallow concentrated flow	Segment ID		
7. Surface description (paved or unpaved)			
8. Flow length, L	ft		
9. Watercourse slope, s	ft/ft		
10. Average velocity, V (figure 3-1)	ft/s		
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	+ [] = []	

Channel flow	Segment ID		
12. Cross sectional flow area, a	ft ²	3.1	
13. Wetted perimeter, p_w	ft	5.8	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft	0.0016	
16. Manning's roughness coeff., n		0.022	
17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s		3' SAY 0.7' DEPTH
18. Flow length, L	ft	1300	
19. $T_t = \frac{L}{3600 v}$ Compute T_t	hr	+ [] = []	
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr		

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location INTERIOR DITCH #3 Checked _____ Date _____

Circle one: Present Developed _____
 Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID	
1. Surface description (table 3-1)		FALLOW ≤ 20%
2. Manning's roughness coeff., n (table 3-1) ..		0.06
3. Flow length, L (total L ≤ 300 ft)	ft	165'
4. Two-yr 24-hr rainfall, P_2	in	4.5
5. Land slope, s	ft/ft	0.003
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	+ [] = []

INV UP
33.5

TOP OF
BANK
33.0

Shallow concentrated flow	Segment ID	
7. Surface description (paved or unpaved)		
8. Flow length, L	ft	
9. Watercourse slope, s	ft/ft	
10. Average velocity, V (figure 3-1)	ft/s	
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	+ [] = []

Channel flow	Segment ID	
12. Cross sectional flow area, a	ft ²	3.3
13. Wetted perimeter, p_w	ft	6.8
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	
15. Channel slope, s	ft/ft	0.0018
16. Manning's roughness coeff., n		0.022
17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s	
18. Flow length, L	ft	1300
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	+ [] = []
20. Watershed or subarea T_c or T_t (add T_c in steps 6, 11, and 19)	hr	[]

SAY
0.7' DEPTH

2.5'
T1 / 1.5'

← 3'

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location INTERIOR DITCH #4 Checked _____ Date _____

Circle one: Present Developed _____
 Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.
 Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID

1. Surface description (table 3-1)			
2. Manning's roughness coeff., n (table 3-1) ..			
3. Flow length, L (total L \leq 300 ft)	ft		
4. Two-yr 24-hr rainfall, P_2	in		
5. Land slope, s	ft/ft		
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr		

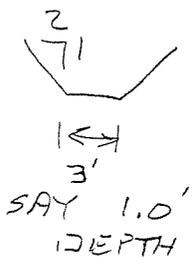
INV 33.7
 INV 33.0

Shallow concentrated flow Segment ID

7. Surface description (paved or unpaved)			
8. Flow length, L	ft		
9. Watercourse slope, s	ft/ft		
10. Average velocity, V (figure 3-1)	ft/s		
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr		

Channel flow Segment ID

12. Cross sectional flow area, a	ft ²		
13. Wetted perimeter, p_w	ft		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft		
16. Manning's roughness coeff., n			
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft		
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr		
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr		



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99

Location INTERIOR DITCH #5 Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Segment ID	
1. Surface description (table 3-1)		<u>FALLOW</u> <u>≤ 70%</u>
2. Manning's roughness coeff., n (table 3-1) ..		<u>0.06</u>
3. Flow length, L (total L ≤ 300 ft)	ft	<u>210</u>
4. Two-yr 24-hr rainfall, P_2	in	<u>4.5</u>
5. Land slope, s	ft/ft	<u>0.0033</u>
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	<input type="text"/> + <input type="text"/> = <input type="text"/>

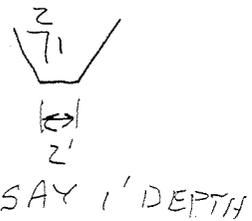
INV 33.7
TB 33.0

Shallow concentrated flow

	Segment ID	
7. Surface description (paved or unpaved)		
8. Flow length, L	ft	
9. Watercourse slope, s	ft/ft	
10. Average velocity, V (figure 3-1)	ft/s	
11. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	<input type="text"/> + <input type="text"/> = <input type="text"/>

Channel flow

	Segment ID	
12. Cross sectional flow area, a	ft ²	<u>4</u>
13. Wetted perimeter, p_w	ft	<u>6.5</u>
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	
15. Channel slope, s	ft/ft	<u>0.0028</u>
16. Manning's roughness coeff., n		<u>0.022</u>
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s	
18. Flow length, L	ft	<u>1300</u>
19. $T_t = \frac{L}{3600 V}$ Compute T_t	hr	<input type="text"/> + <input type="text"/> = <input type="text"/>
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr	<input type="text"/>



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location INTERIOR DITCH #6 Checked _____ Date _____

Circle one: Present Developed _____
 Circle one: T_c T_c through subarea _____

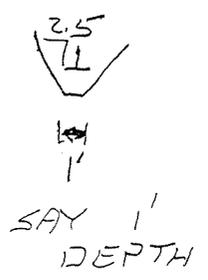
NOTES: Space for as many as two segments per flow type can be used for each worksheet.
 Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T _c only)	Segment ID	
1. Surface description (table 3-1)		FALLOW
2. Manning's roughness coeff., n (table 3-1) ..		0.06
3. Flow length, L (total L ≤ 300 ft)	ft	230
4. Two-yr 24-hr rainfall, P ₂	in	4.5
5. Land slope, s	ft/ft	0.0024
6. $T_c = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T _c	hr	<input type="text"/> + <input type="text"/> = <input type="text"/>

INV 33.5
TB 33.0

Shallow concentrated flow	Segment ID	
7. Surface description (paved or unpaved)		
8. Flow length, L	ft	
9. Watercourse slope, s	ft/ft	
10. Average velocity, V (figure 3-1)	ft/s	
11. $T_c = \frac{L}{3600 V}$ Compute T _c	hr	<input type="text"/> + <input type="text"/> = <input type="text"/>

Channel flow	Segment ID	
12. Cross sectional flow area, a	ft ²	3.5
13. Wetted perimeter, p _w	ft	6.4
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	
15. Channel slope, s	ft/ft	0.0017
16. Manning's roughness coeff., n		0.022
17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s	
18. Flow length, L	ft	1250
19. $T_c = \frac{L}{3600 v}$ Compute T _c	hr	<input type="text"/> + <input type="text"/> = <input type="text"/>
20. Watershed or subarea T _c or T _t (add T _c in steps 6, 11, and 19)	hr	<input type="text"/>



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location INTERIOR DITCH #7 Checked _____ Date _____
 Circle one: Present Developed _____
 Circle one: T_c T_c through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

- Segment ID
1. Surface description (table 3-1)
 2. Manning's roughness coeff., n (table 3-1) ..
 3. Flow length, L (total L \leq 300 ft) ft
 4. Two-yr 24-hr rainfall, P_2 in
 5. Land slope, s ft/ft
 6. $T_c = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_c hr

FALLOW $\leq 20\%$	
0.06	
240	
4.5	
0.0021	
	+ =

INV 33.5
TOP OF BANK 33.0

Shallow concentrated flow

- Segment ID
7. Surface description (paved or unpaved)
 8. Flow length, L ft
 9. Watercourse slope, s ft/ft
 10. Average velocity, V (figure 3-1) ft/s
 11. $T_c = \frac{L}{3600 V}$ Compute T_c hr

	+ =

Channel flow

- Segment ID
12. Cross sectional flow area, a ft²
 13. Wetted perimeter, p_w ft
 14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft
 15. Channel slope, s ft/ft
 16. Manning's roughness coeff., n
 17. $v = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V ft/s
 18. Flow length, L ft
 19. $T_c = \frac{L}{3600 V}$ Compute T_c hr
 20. Watershed or subarea T_c or T_t (add T_c in steps 6, 11, and 19) hr

5	
7.5	
0.0037	
0.022	
1000	
	+ =


3'
SAY 1' DEPTH

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99

Location INTERIOR DITCH #8 Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_c through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T _c only)	Segment ID		
1. Surface description (table 3-1)	WOODS		ELEV. 34.0
2. Manning's roughness coeff., n (table 3-1) ..	0.40		ELEV. 31.7
3. Flow length, L (total L ≤ 300 ft)	240	ft	
4. Two-yr 24-hr rainfall, P ₂	4.5	in	
5. Land slope, s	0.01	ft/ft	
6. $T_c = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T _c		hr	

Shallow concentrated flow	Segment ID		
7. Surface description (paved or unpaved)	UNPAVD		ELEV 31.7
8. Flow length, L	380	ft	TIB 28.0
9. Watercourse slope, s	0.01	ft/ft	
10. Average velocity, V (figure 3-1)	1.6	ft/s	
11. $T_c = \frac{L}{3600 V}$ Compute T _c	0.07	hr	

Channel flow	Segment ID		
12. Cross sectional flow area, a	4.2	ft ²	1.2
13. Wetted perimeter, p _w	5.7	ft	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r		ft	
15. Channel slope, s	0.0078	ft/ft	
16. Manning's roughness coeff., n	0.022		SAY 1.5' DEPTH
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V		ft/s	
18. Flow length, L	450	ft	
19. $T_c = \frac{L}{3600 V}$ Compute T _c		hr	
20. Watershed or subarea T _c or T _c (add T _c in steps 6, 11, and 19)		hr	

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location INTERIOR DITCH #9 Checked _____ Date _____

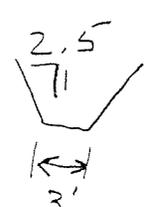
Circle one: Present Developed _____
 Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

<u>Sheet flow</u> (Applicable to T _c only)	Segment ID		
1. Surface description (table 3-1)		WOODS	ELEV 34.0
2. Manning's roughness coeff., n (table 3-1) ..		0.40	T.B 32
3. Flow length, L (total L ≤ 300 ft)	ft	250	
4. Two-yr 24-hr rainfall, P ₂	in	4.5	
5. Land slope, s	ft/ft	0.008	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T _t	hr	+ =	=

<u>Shallow concentrated flow</u>	Segment ID		
7. Surface description (paved or unpaved)			
8. Flow length, L	ft		
9. Watercourse slope, s	ft/ft		
10. Average velocity, V (figure 3-1)	ft/s		
11. $T_t = \frac{L}{3600 V}$ Compute T _t	hr	+ =	=

<u>Channel flow</u>	Segment ID		
12. Cross sectional flow area, a	ft ²	6.0	
13. Wetted perimeter, p _w	ft	8.4	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		2.5 
15. Channel slope, s	ft/ft	0.011	
16. Manning's roughness coeff., n		0.022	
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s		3' SAY 1.0 DEPTH
18. Flow length, L	ft	500	
19. $T_t = \frac{L}{3600 V}$ Compute T _t	hr	+ =	=
20. Watershed or subarea T _c or T _t (add T _t in steps 6, 11, and 19)	hr		=

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By MWM Date 5/19/99
 Location INTERIOR DITCH #10 Checked _____ Date _____

Circle one: Present Developed _____
 Circle one: T_c T_c through subarea _____

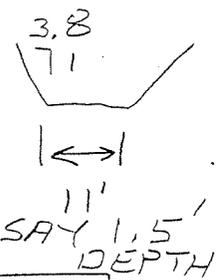
NOTES: Space for as many as two segments per flow type can be used for each worksheet.
 Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T _c only)	Segment ID		
1. Surface description (table 3-1)		WOODS	
2. Manning's roughness coeff., n (table 3-1) ..		0.40	
3. Flow length, L (total L ≤ 300 ft)	ft	200	
4. Two-yr 24-hr rainfall, P ₂	in	4.5	
5. Land slope, s	ft/ft	0.0037	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T _t	hr	+	=

Shallow concentrated flow	Segment ID		
7. Surface description (paved or unpaved)			
8. Flow length, L	ft	230	
9. Watercourse slope, s	ft/ft	0.018	
10. Average velocity, V (figure 3-1)	ft/s	2.2	
11. $T_t = \frac{L}{3600 V}$ Compute T _t	hr	+	=

Channel flow	Segment ID		
12. Cross sectional flow area, a	ft ²	25.1	
13. Wetted perimeter, p _w	ft	22.8	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft	0.015	
16. Manning's roughness coeff., n		0.022	
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft	130	
19. $T_t = \frac{L}{3600 V}$ Compute T _t	hr	+	=
20. Watershed or subarea T _c or T _t (add T _t in steps 6, 11, and 19)	hr		=

ELEV.
32.2
TB
28.0



APPENDIX G

SPECIES LISTS

Vegetation Identified at Clayhill Farms

<i>Acer rubrum</i>	red maple
<i>Aronia arbutifolia</i>	red chokeberry
<i>Arundinaria gigantea</i>	giant cane
<i>Clethra alnifolia</i>	sweet pepperbush
<i>Cornus alternifolia</i>	alternate leaved dogwood
<i>Cyrilla racemiflora</i>	titi
<i>Diospyros virginiana</i>	persimmon
<i>Drosera capillaris</i>	pink sundew
<i>Euonymus americanus</i>	strawberry bush
<i>Gaylussacia frondosa</i>	dwarf huckleberry
<i>Gelsemium sempervirens</i>	yellow jessamine
<i>Gordonia lasianthus</i>	loblolly bay
<i>Ilex coriacea</i>	gallberry
<i>Ilex glabra</i>	inkberry
<i>Leucothoe axillaris</i>	dog hobble
<i>Liquidambar styraciflua</i>	sweetgum
<i>Liriodendron tulipifera</i>	yellow-poplar
<i>Lyonia lucida</i>	fetterbush
<i>Magnolia virginiana</i>	sweet bay
<i>Myrica cerifera</i>	wax myrtle
<i>Nyssa sylvatica</i> var. <i>biflora</i>	swamp blackgum
<i>Osmunda cinnamomea</i>	cinnamon fern
<i>Osmunda regalis</i>	royal fern
<i>Persea borbonia</i>	red bay
<i>Pinus serotina</i>	pond pine
<i>Pinus taeda</i>	loblolly pine
<i>Polygala lutea</i>	orange milkwort
<i>Polystichum acrosticoides</i>	Christmas fern
<i>Pteridium aquilinum</i>	bracken fern
<i>Quercus nigra</i>	water oak
<i>Quercus marilandica</i>	blackjack oak
<i>Quercus phellos</i>	willow oak
<i>Quercus stellata</i>	post oak
<i>Rhododendron atlanticum</i>	dwarf azalea
<i>Sambucus canadensis</i>	elderberry
<i>Sassafras albidum</i>	sassafras
<i>Smilax bona-nox</i>	saw greenbrier
<i>Smilax laurifolia</i>	laurel-leaf greenbrier
<i>Smilax rotundifolia</i>	common greenbrier
<i>Symplocos tinctoria</i>	sweet leaf
<i>Toxicodendron radicans</i>	poison ivy
<i>Utricularia</i> sp.	bladderwort
<i>Vaccinium corymbosum</i>	highbush blueberry
<i>Viola</i> sp.	violet
<i>Vitis aestivalis</i>	fox grape
<i>Woodwardia areolata</i>	netted chain fern
<i>Woodwardia virginica</i>	Virginia chain fern

Wildlife Observed at Clayhill Farms
(from visual observation or indication of animals)

<i>Agelaius phoeniceus</i>	red-winged blackbird
<i>Anolis carolinensis</i>	green anole
<i>Buteo jamaicensis</i>	red-tail hawk
<i>Canis domesticus</i>	feral dog
<i>Cardinalis cardinalis</i>	cardinal
<i>Cathartes aura</i>	turkey vulture
<i>Chelydra serpentina</i>	common snapping turtle
<i>Chrysemys picta</i>	eastern painted turtle
<i>Clemmys guttata</i>	spotted turtle
<i>Cnemidophorus sexlineatus</i>	six-lined racerunner
<i>Colinus virginianus</i>	bobwhite quail
<i>Coluber constrictor</i>	northern black racer
<i>Didelphis virginiana</i>	Virginia opossum
<i>Elaphe guttata</i>	corn snake
<i>Elaphe obsoleta</i>	black rat snake
<i>Eumeces fasciatus</i>	five-lined skink
<i>Eumeces laticeps</i>	broadhead skink
<i>Felis familiaris</i>	feral cat
<i>Lampropeltis getula</i>	eastern kingsnake
<i>Melanerpes carolinus</i>	red-bellied woodpecker
<i>Meleagris gallopavo</i>	turkey
<i>Odocoileus virginianus</i>	white-tailed deer
<i>Opheodrys aestivus</i>	rough green snake
<i>Picoides pubescens</i>	downy woodpecker
<i>Procyon lotor</i>	raccoon
<i>Sceloporus undulatus</i>	northern fence lizard
<i>Sciurus carolinensis</i>	gray squirrel
<i>Sialia sialis</i>	eastern blue bird
<i>Sternotherus odoratus</i>	common musk turtle
<i>Sylvilagus floridanus</i>	eastern cottontail rabbit
<i>Thamnophis sirtalis</i>	eastern garter snake
<i>Urocyon cinereoargenteus</i>	gray fox
<i>Ursus americanus</i>	black bear
<i>Vulpes vulpes</i>	red fox
<i>Zenaida macroura</i>	mourning dove

APPENDIX H

RED-COCKADED WOODPECKER ASSESSMENT –
PREPARED BY DR. J. H. CARTER III & ASSOCIATES INC.

**RED-COCKADED WOODPECKER ASSESSMENT
FOR
CLAYHILL FARMS MITIGATION SITE
NCDOT T.I.P. NO. R-2105WM
JONES COUNTY, NORTH CAROLINA**

Prepared by:
Dr. J.H. Carter III and Ms. Alicia G. Jackson
Dr. J.H. Carter III & Associates Inc.
P.O. Box 891
Southern Pines, N.C. 28388

Submitted 14 August 2000
to:
N.C. Department of Transportation
Project Development and Environmental Analysis Branch
P.O. Box 25201
Raleigh, NC 27611

**RED-COCKADED WOODPECKER ASSESSMENT
FOR
CLAYHILL FARMS MITIGATION SITE
JONES COUNTY, NORTH CAROLINA
NCDOT T.I.P. NO. R-2105WM**

INTRODUCTION

The North Carolina Department of Transportation (NCDOT) purchased Clayhill Farms, a 355.6 acre (ac.) property in Jones County, North Carolina, as a wetlands mitigation site for future NCDOT construction projects (Figure 1). A wetland and stream mitigation plan was written for the property, which includes plans to restore drained farm and timberland to its probable natural condition via rerouting an existing stream, filling in ditches and planting natural hydrophytic vegetation in former croplands (Langley and McDonald, P.C. 1999). This Assessment reports findings of a red-cockaded woodpecker (*Picoides borealis*) (RCW) survey on the Clayhill Farms property and the surrounding 0.5 mile radius, and addresses the possibility of using the property for RCW mitigation in the future.

PROJECT AREA

The project area is located in southwestern Jones County, in the east-central Coastal Plain of North Carolina. The topography is nearly level except for gentle to moderate slopes along drainages. Sandy loams and loamy sands are the predominant soil types in the project area.

Historically, the principal upland community type was Mesic Pine Flatwoods, which was dominated by longleaf pine (*Pinus palustris*). This community occurred on coarse to fine sands, sandy loams and loamy sands and was characterized by frequent fires, a sparse to open understory and a diverse herbaceous flora dominated by Carolina wiregrass (*Aristida stricta*). Mesic Mixed Hardwood Forest (Coastal Plain Subtype) occurred in upland areas that were protected from fire by topography and moisture. Soils were sandy loams and loamy sands and vegetation consisted of varying mixtures of mesophytic trees, shrubs and herbs.

Historical wetland communities in the immediate project area included Coastal Plain Small Stream Swamp (Blackwater Subtype), Cypress/Gum Swamp, Pond Pine Woodland, Wet

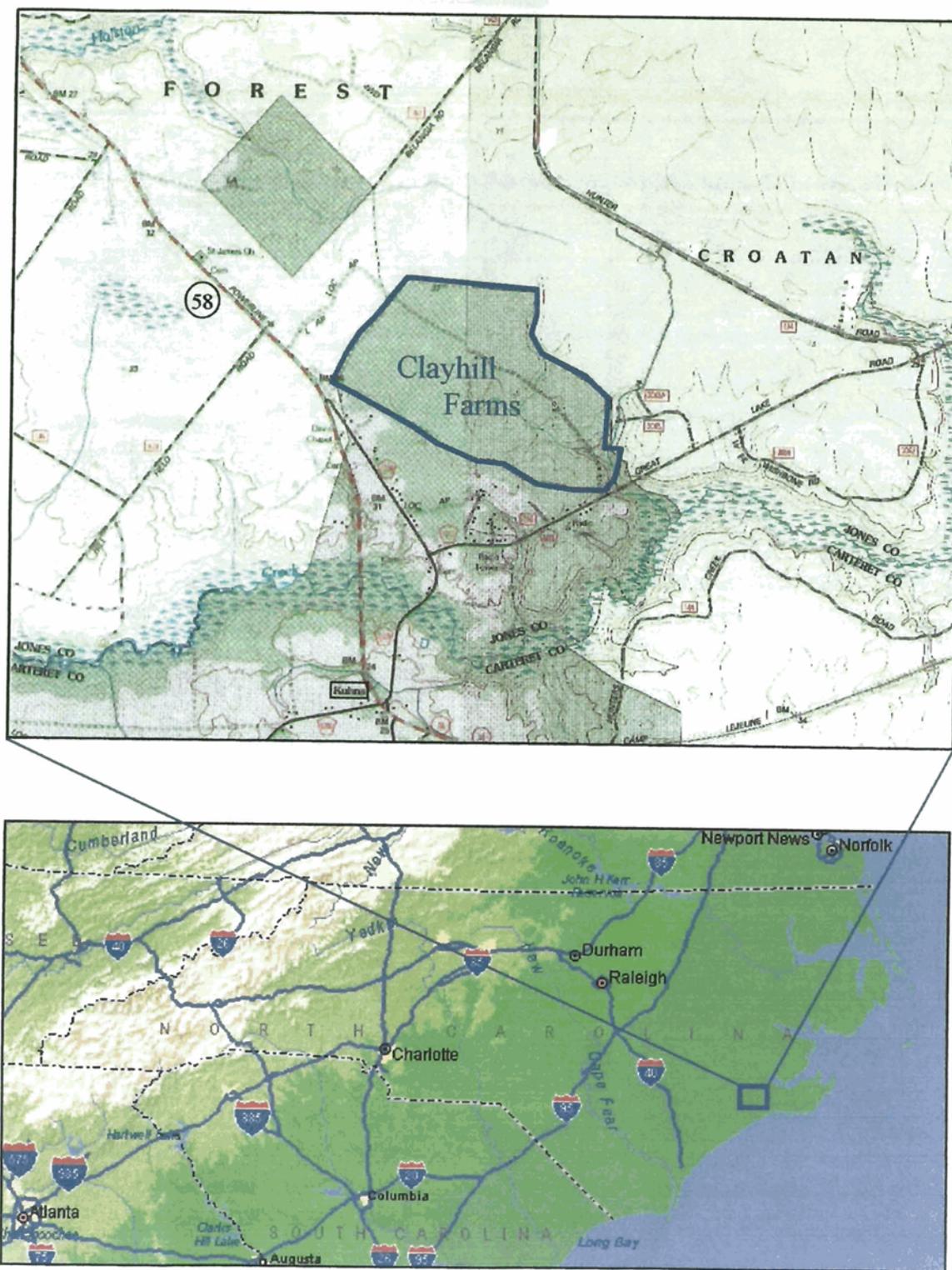


Figure 1. Clayhill Farms project site, Jones County, North Carolina.

Pine Flatwoods and High Pocosin. These communities occurred on wet, acidic, sandy and/or organic soils.

PROJECT SITE/ HISTORY

Clayhill Farms is located in southwestern Jones County, North Carolina, near the intersection of N.C. Highway 58 and SR 1101 (Figure 1). It is bordered to the east, north and west by the Croatan National Forest (CNF) and to the south by private property. It is divided by Billy's Branch, a tributary of Hunter's Creek.

The entire 355.6 ac. property appears to have been clearcut in the mid-1970s, with the exception of 19.0 ac. of hardwoods around Billy's Branch and a small tributary in the west-central portion of the property. The southern portion was used as agricultural fields, while the remaining land was allowed to regenerate with pines. Wetter areas were drained via ditches around the property and perpendicular to the stream through the portion south of Billy's Branch (Langley and McDonald, P.C. 1999).

Clayhill Farms now consists of 19.0 ac. of hardwood forest, 141.8 ac. of fallow agricultural land and 193.8 ac. of natural pine regeneration (Langley and McDonald, P.C. 1999).

Hydric soils on the property and surrounding area are fine sandy loams and loams, primarily the Pantego, Torhunta and Rains series. Non-hydric soils are Onslow fine sandy loam and Goldsboro loamy sand.

Natural conditions have been significantly altered by ditching, clearcuts and fire suppression, making determination of natural community types more difficult. Mapped soil types (National Cooperative Soil Survey 1981, Langley and McDonald, P.C. 1999), the composition of neighboring vegetative communities and the known history of the property suggest the following natural community types historically occurred onsite: Mesic Pine Flatwoods, Wet Pine Flatwoods, Pond Pine Woodland and High Pocosin. Today, existing conditions most closely resemble these community types, though vegetation and natural hydrology have been altered.

PROJECT DESCRIPTION

Clayhill Farms will be used by NCDOT to mitigate for wetlands altered in future NCDOT construction projects. The mitigation plan involves restoring an existing stream channel, filling ditches and planting native vegetation, thereby restoring approximately 65 acres of wetland on prior-converted croplands. Approximately 1.8 acres of forested land will be cleared to reroute Billy's Branch, which was channelized and deepened in the 1970s. This change will increase the length of the stream onsite from 6170 linear feet (ft.) to 7410 linear ft., more closely resembling the natural curvature of the stream (Langley and McDonald, P.C. 1999).

METHODS

Between 5 July and 27 July 2000, employees of Dr. J.H. Carter III & Associates, Inc. (JCA Inc.) surveyed potential RCW habitat on the project site and within the surrounding 0.5 mi. radius for evidence of RCW activity. Ground survey methodology varied according to size of the area and vegetation. Generally, 2 biologists walked parallel transects 50 to 100 feet apart. Transects were spaced to provide visual coverage for all potential cavity trees. Treeless residential areas, clearcuts and hardwood stands were not surveyed due to lack of potential RCW habitat. Generally, pine plantations less than 30 years old containing no older trees were not surveyed, however, wide transects were walked through such stands to confirm the absence of older trees.

RESULTS AND DISCUSSION

The red-cockaded woodpecker is a small black and white bird endemic to mature, fire-maintained pine forests in the southeastern United States, where it was historically common. It excavates nest and roost cavities in live pines generally >100 years old and requires a large area of mature (≥ 30 years old) pines for foraging habitat. The RCW is listed as endangered by the U.S. Fish and Wildlife Service (USFWS) and the State of North Carolina.

Suitable RCW nesting habitat is defined as pine or pine-hardwood stands (>50% pine) containing at least scattered pines over 60 years of age, hardwood-pine ($\geq 50\%$ hardwood) stands over 60 years of age and adjacent to pine or pine-hardwood stands ≥ 30 years of age or stands containing sawtimber-sized pines (≥ 9.0 inches diameter at breast height (dbh)). Foraging habitat

is defined as pine or pine-hardwood stands over 30 years of age contiguous to and within 0.5 mi. of an RCW colony (Henry 1989).

Clayhill Farms and suitable RCW habitat within a 0.5 mi. radius were surveyed for evidence of RCWs between 5 and 27 July 2000. No active RCW cavity trees were found in the survey area.

RESULTS- CLAYHILL FARMS PROPERTY

The wooded portion of the Clayhill Farms property is forested with either pines 20-30 years old or mature hardwoods, neither of which is considered suitable habitat for RCW nesting or foraging.

Existing pine regeneration stands on the property have been significantly altered from their natural state, but most closely resemble the Mesic Pine Flatwoods, Wet Pine Flatwoods and Pond Pine Woodland community types. These stands are densely forested with pines 4-6 in. dbh, 20-30 years of age.

Areas resembling Mesic Pine Flatwoods communities have a dense overstory of loblolly pine (*Pinus taeda*), a moderately dense midstory of sweetgum (*Liquidambar styraciflua*), a moderately dense understory of wax myrtle (*Myrica cerifera*) and water oak (*Quercus nigra*), and a moderately dense vine layer of muscadine grape (*Vitis rotundifolia*) (Figure 2).

Areas resembling Wet Pine Flatwoods communities, though greatly altered from their original state, have a moderate to dense overstory of loblolly pine, a moderately dense sweetgum midstory (20-30 ft. tall), a dense understory containing gallberry (*Ilex glabra*), sweetgum, sweet pepperbush (*Clethra alnifolia*), water oak, sweetleaf (*Symplocos tinctoria*), red maple (*Acer rubrum*), wax myrtle, blackgum (*Nyssa sylvatica*) and titi (*Cyrilla racemiflora*) and a sometimes dense vine layer of muscadine grape and greenbriers (*Smilax* spp.). One Wet Pine Flatwoods site north of the dirt road bisecting the property and east of the small clearcut has been thinned within the past few years. This area has the same dominant species, but has a more open midstory, denser understory and denser low shrub/herbaceous layer (Figure 3). There are some patches of dead trees in Wet Pine Flatwoods on the property, most likely killed by southern pine beetles (*Dendroctonus frontalis*). The overstory is dead in these areas, allowing the understory to become very thick, especially the vine layer (Figure 4).



Figure 2. Mesic Pine Flatwoods behind equipment shed on center road.



Figure 3. Thinned Wet Pine Flatwoods on Clayhill Farms property.

Areas resembling Pond Pine Woodland contain a moderate to dense canopy of pond pine (*Pinus serotina*) and loblolly pine, a dense midstory of sweetgum, red maple and swamp blackgum (*Nyssa biflora*) and loblolly bay (*Gordonia lasianthus*), and a dense understory of gallberry, redbay (*Persea palustris*), blueberry (*Vaccinium* sp.), fetterbush (*Lyonia lucida*) and switchcane (*Arundinaria tecta*). Parts of this community, south of the dirt road bisecting the property, have been thinned. These thinned areas have a more open midstory and denser understory and low shrub/ herbaceous layers, with rushes (*Juncus* spp.), meadow-beauties (*Rhexia* spp.), pennywort (*Hydrocotyle* sp.), orange milkwort (*Polygala lutea*) and sphagnum moss (*Sphagnum* sp.).

Langley and McDonald, P.C. (1999) describes the pines on Clayhill Farms as 25-30 years old. JCA Inc. staff aged 6 trees across the property that ranged from 20 to 24 years of age. The 1974 U.S. Geological Survey orthophotographs for Stella and Hadnot Creek quads show the site clearcut, with areas of bare soil and patches of vegetation, but it is not possible to determine if the vegetation is pine regeneration or shrubs.

Hardwood stands occur around Billy's Branch and its tributaries and on 15.9 ac. in the southeast corner of the property. These areas were not cut with the rest of the property and can be seen on the 1974 U.S. Geological Survey orthophotographs. These stands have a hardwood overstory with scattered second-growth loblolly pines and a dense hardwood midstory. These areas contain the only pines old enough to support a natural RCW cavity, but there are very few pines and the hardwood component is higher than that typically considered as RCW habitat (Henry 1989).

RESULTS- SURROUNDING AREA

Residential areas south of the property are partially cleared and generally forested with sparse loblolly pine ranging in age from sapling to second-growth and various ornamentals. The forested area south of SR 1101 and west of the radio tower was cut 3-4 years ago and is now vegetated with dense loblolly and pond pine regeneration ≤ 10 ft. tall, blackgum, sweet pepperbush, waxmyrtle, sweetgum, gallberry and titi.

The majority of suitable RCW habitat was found on the approximately 160,000 ac. Croatan National Forest (CNF), which is comprised mostly of extensive loblolly, longleaf and pond pine stands. Areas surveyed are the same community types as on the Clayhill Farms

property, with the addition of High Pocosin, but are more mature and closer to their natural condition.

Mesic Pine Flatwoods areas on the Croatan typically have an uneven-aged, moderately dense canopy of longleaf pine mixed with some loblolly pine. Fire suppressed areas have a moderately dense midstory of sweetgum, red maple, water oak and a dense 10-15 ft. tall understory of midstory species, gallberry, blueberry, redbay and pine regeneration. A sparse to moderately dense low shrub/ herbaceous layer consists of cane, some Carolina wiregrass and dangleberry (*Gaylussacia frondosa*). Areas that have been burned within the past few years have similar species composition, but with a light to moderately dense understory 3-10 ft. tall and a moderately dense to dense low shrub/ herbaceous layer with more wiregrass. One area on the CNF east of CNF Forest Route 163 has a moderately dense to dense overstory of uneven-aged longleaf and pond pine (Figure 5). This area has been burned regularly so that a dense understory of switchcane has become established, with scattered 3-6 ft. tall sweet pepperbush, gallberry and sweetleaf, and a sparse low shrub/ herbaceous layer of dangleberry and bracken fern (*Pteridium aquilinum*). Several Mesic Pine Flatwoods areas contain scattered old-growth pines, with trees averaging 70-80 years of age, but ranging to 108+.

Wet Pine Flatwoods on the CNF typically have an uneven-aged loblolly, longleaf and pond pine overstory. Some Wet Pine Flatwoods areas have been burned within the past 3-4 years. These areas have a light midstory of sweetgum and red maple and a light understory of fetterbush, sweetleaf, redbay and bayberry (*Myrica heterophylla*). The low shrub/ herbaceous layer ranges from moderately dense to dense and contains gallberry, sweet pepperbush, switchcane, blueberry and cinnamon fern (*Osmunda cinnamomea*). Fire-suppressed Wet Pine Flatwoods habitats on the CNF have a midstory denser with species as listed above, and a dense understory 10-15 ft. tall consisting of species listed above, loblolly pine saplings and water oak. Many of these areas contain at least scattered old-growth pines.

Two abandoned RCW cavity trees were found by JCA staff in 1999 in Wet Pine Flatwoods on the CNF, within 0.5 mile of Clayhill Farms. These trees are located west of the property and east of N.C. 58, and are considered to be part of Cluster CNF 63 (Carter and Pegram 1999). The tree with tag number FS 229 was relocated in this survey and was found to be a relic start with pileated woodpecker (*Dryocopus pileatus*) damage. This tree was considered to have inactive starts with pileated damage in 1999. The other cavity tree was not found in this



Figure 4. Southern pine beetle-killed stand in Wet Pine Flatwoods in the northwest section of Clayhill Farms, south of the perimeter road.



Figure 5. Longleaf/ pond pine Mesic Pine Flatwoods stand east of CNF Forest Route 163, north of Clayhill Farms.

survey, but had a possibly complete inactive cavity with some pileated damage in 1999. These cavity trees are in an area that has been burned relatively regularly.

Pond Pine Woodland habitats on the CNF are forested with pond pine. Areas that have been burned within the past few years, in particular an area west of N.C. 58 and south of Hill Field Rd. (CNF Forest Route 603), have dead standing pines, a sparse overstory and a dense, 5 ft. tall understory primarily of redbay and laurel-leaf greenbrier (*Smilax laurifolia*). The majority of the Pond Pine Woodland communities in the area have not been burned and contain a light to moderately dense pond pine canopy, a sparse red maple and sweetgum midstory and a dense 10-30 ft. tall understory of fetterbush, titi, red maple, loblolly bay, redbay and sweetbay (*Magnolia virginiana*). Herbaceous ground cover is sparse except in openings and ditches, where netted chain-fern (*Woodwardia areolata*), cinnamon fern and sphagnum moss occur.

High pocosins within the 0.5 mi. radius of the property have a sparse overstory of pond pine, red maple, loblolly bay and swamp blackgum and a moderately dense to dense understory of fetterbush, gallberry, titi, sweetbay and redbay. Trees in pocosins are typically smaller in height and dbh than those in other habitat types.

NEIGHBORING RCW CLUSTERS

At the end of 1999, 55 active RCW clusters were located on the CNF, including approximately 44 breeding groups (Simon 2000). The closest known active RCW clusters to Clayhill Farms are at least 1.0 mile away (Figure 6). Cluster CNF 44, approximately 1.5 mi north-northwest of Clayhill Farms, has contained a solitary male since 1996 and CNF 69, approximately 1.1 mi. southeast of Clayhill, had a breeding pair in 1999. CNF 63 is approximately 0.2 mi. west of the property, but since it has been inactive since before 1988 it is considered to be abandoned. The two cavity trees found by JCA, Inc. in 1999 were considered to be part of this cluster (See Results- Surrounding Area). CNF E4 (also CNF 904) is an artificial cavity cluster approximately 0.5 mi. east of the property that has been inactive since its creation in 1990-1991. CNF 59, approximately 1.1 mi west of the property, has been inactive since 1993 (Walters and Goodson 1991; Walters, Meekins and Zaebst 1996; Simon 2000; map provided by Croatan National Forest).

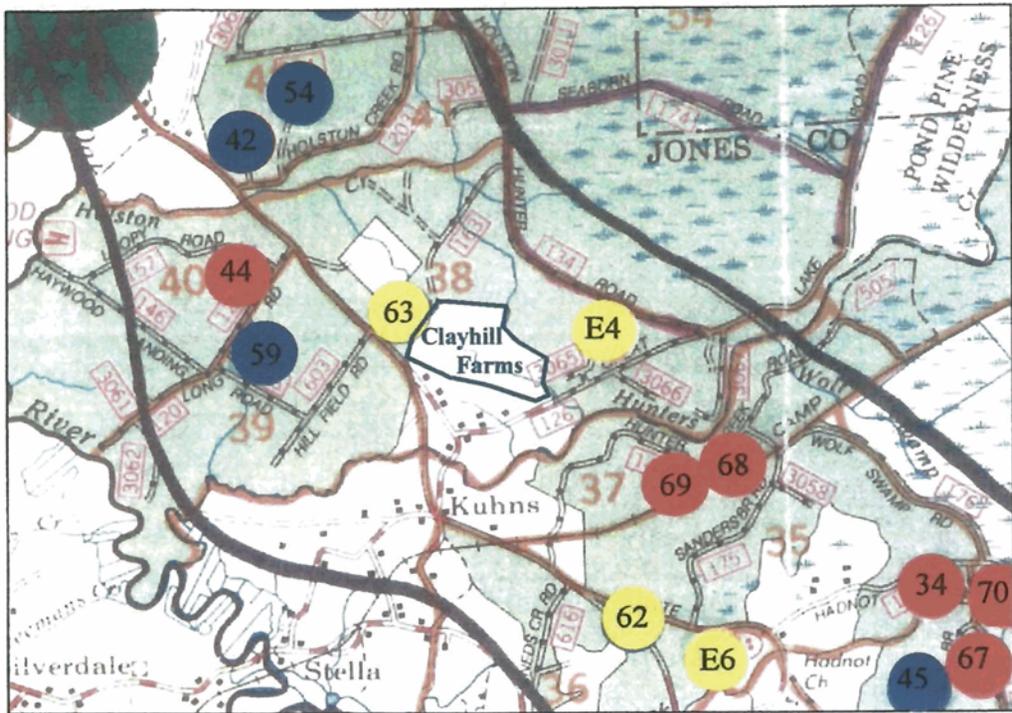


Figure 6. Location and status of neighboring RCW clusters on the Croatan National Forest (CNF), from CNF map dated 8/95 and updated with CNF 1999 data

- Active
- Inactive
- Abandoned

Since Clayhill Farms is more than 0.5 miles away from any active RCW clusters and the clusters within a 0.5 radius have been inactive for over 5 years, mitigation activities at Clayhill Farms will have *no effect* on the RCW.

Biological Conclusion- No Effect

MITIGATION POTENTIAL

Clayhill Farms currently contains 194.8 ac. of pine forest. Since these pines are between 20 and 30 years of age, there is currently little to no suitable nesting or foraging habitat for the RCW on the Clayhill Farms property.

Artificial cavities for RCWs can be excavated 2 ways: drilling cavities or inserting artificial nest boxes (inserts). To be suitable for drilling, a pine has to be at least 10.5 in. diameter at cavity height (generally 22 ft. above ground) with a minimum of 7 inches of heartwood and a maximum of 3.5 in. sapwood. These requirements are seldom met by trees under 75 years of age; generally, suitable trees are over 95 years of age (Copeyon 1990, Taylor and Hooper 1991). For inserts, the main requirement is a minimum diameter of 15 in. at cavity height, regardless of age (Allen 1991).

The only pines currently on the Clayhill Farms property large and old enough to support an RCW cavity are the very sparse, scattered second-growth loblolly pines in the hardwood drains and in the southeast corner of the property. These areas would naturally be hardwood-dominated forest and are to be managed as Mixed Mesic Hardwood Forest and Coastal Plain Bottomland Hardwood Forest in the mitigation plan by Langley & McDonald (1994).

Using an average age of 25 years, the trees on Clayhill Farms could meet the minimum RCW foraging habitat requirements as early as 2005. Most likely, the pines on the property will not be suitable for cavity provisioning by drilling until 2050. Since age is not as much of a factor with cavity inserts, provisioning of cavities using this technique would be possible as soon as the trees reach 15 inches in diameter at cavity height and other general RCW habitat requirements are met. It is difficult to predict when the trees will reach this diameter, since growth is affected by water availability, soil nutrients, basal area of the stand and length of growing season.

Federal guidelines for RCW foraging habitat require a minimum pine basal area (BA) of 8,490 sq. ft. and 6,350 pine stems \geq 10 inches dbh for each RCW cluster (USFWS 1985). This requirement can be met with a minimum of 125 acres in preferred habitat, which is defined as

pine stands over 30 years of age with a BA ≥ 60 ft.²/ac., more than 24 pines/ac. ≥ 10 in. dbh, and with ≥ 40 percent in stands at least 60 years of age. More acreage is needed when the habitat does not meet these conditions (Henry 1989).

It is unlikely that Clayhill Farms itself will have enough pines ≥ 10 in. dbh by 2005 to be considered as sufficient foraging habitat for a RCW cluster. However, areas on the CNF within a 0.5 mile radius of Clayhill Farms do have suitable RCW nesting and foraging habitat, and some areas appear to be burned regularly. Many of these stands could support an artificial RCW cluster with either drilled cavities or inserts. If RCWs were to colonize a cluster within 0.5 mile of Clayhill Farms, they could use Clayhill Farms for foraging when the trees are an average of 30 years old, or in 5-10 years. Also, if RCWs were to eventually colonize an artificial cluster on Clayhill Farms, they would have access to foraging substrate on the surrounding CNF property.

Recommended management of the pine stands on the property to improve or create RCW habitat includes periodic thinning and maintaining 20-25 ft. between pines to minimize the risk of infestation and spread of southern pine beetles. The hardwood understory should be controlled via mechanical means or burning. Encroachment of hardwoods in pine stands is generally not tolerated by RCWs, so it is recommended that the hardwood BA be kept below 20 ft.²/ac. Burning regularly is the most effective, natural and least costly means of maintaining the open understory preferred by RCWs, but mechanical clearing and herbicides are also used. Care must be taken to ensure that the fire does not get so hot as to damage the overstory trees (U.S. Fish and Wildlife Service 1985).

The wetland mitigation plan for Clayhill Farms includes plans to restore 41.9 ac. of Mesic Pine Flatwoods on fallow agricultural lands (Langley & McDonald, P.C.). If this area is properly managed, it too could eventually be foraging and/ or nesting habitat for RCWs. However, this is a naturally fire-maintained community type and the surrounding areas are to be managed as Non-Riverine Wet Hardwood Forest and Mesic Mixed Hardwood Forest, both fire-sensitive communities (Langley & McDonald 1994). For this reason, care must be taken to keep the fire out of these hardwood communities.

CONCLUSIONS

Restoration activities on the Clayhill Farms Mitigation property will have **no effect** on the endangered RCW. No suitable nesting habitat for RCWs was found on the Clayhill Farms property, and although suitable habitat exists within 0.5 miles of the Clayhill Farms property, no evidence of recent RCW activity was found. The two RCW cavity trees within the 0.5 mile radius have been inactive since 1988 and are therefore considered to be abandoned.

Clayhill Farms could be suitable for RCW mitigation credits in a minimum of 30 years. However, if a neighboring RCW cluster on the CNF was to become active, or if a new cluster was created on the CNF, Clayhill Farms could possibly be used as foraging habitat in 5-10 years, with appropriate management.

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APPENDIX I

FOREST MANAGEMENT PLAN

FOREST MANAGEMENT PLAN

for the

CLAYHILL FARMS MITIGATION SITE JONES COUNTY, NORTH CAROLINA

PREPARED FOR THE

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Project Development & Environmental Analysis Unit

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Issued: July 2004

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1.0 SITE LOCATION & VICINITY

The North Carolina Department of Transportation (NCDOT) Clayhill Farms Mitigation Site is located in southwestern Jones County, North Carolina on the Hadnot Creek, NC and Stella, NC 7.5" USGS topographic quadrangle (Figure 1, Vicinity Map). It is bordered to the north, east, and west by the Croatan National Forest and the south and east by various privately owned forested and residential parcels. The 355.60-acre property currently consists of approximately 214 acres of pine forest (a mixture of both loblolly pine (*Pinus taeda*) and pond pine (*Pinus serotina*)) and ±141 acres of fallow agricultural fields.

2.0 OBJECTIVES & METHODOLOGY

A forest inventory was conducted on the Clayhill Farms site by Carolina Silvics, Inc. in August 2003 to quantify habitat suitability for the federally endangered red-cockaded woodpecker (*Picoides borealis*) (RCW). The property was divided into seven inventory areas (stands) delineated by roads, paths, canals, and/or management history (Figure 2, Forest Stand Map). The inventory consisted of 47 measurement points located throughout the forested portion of the property.

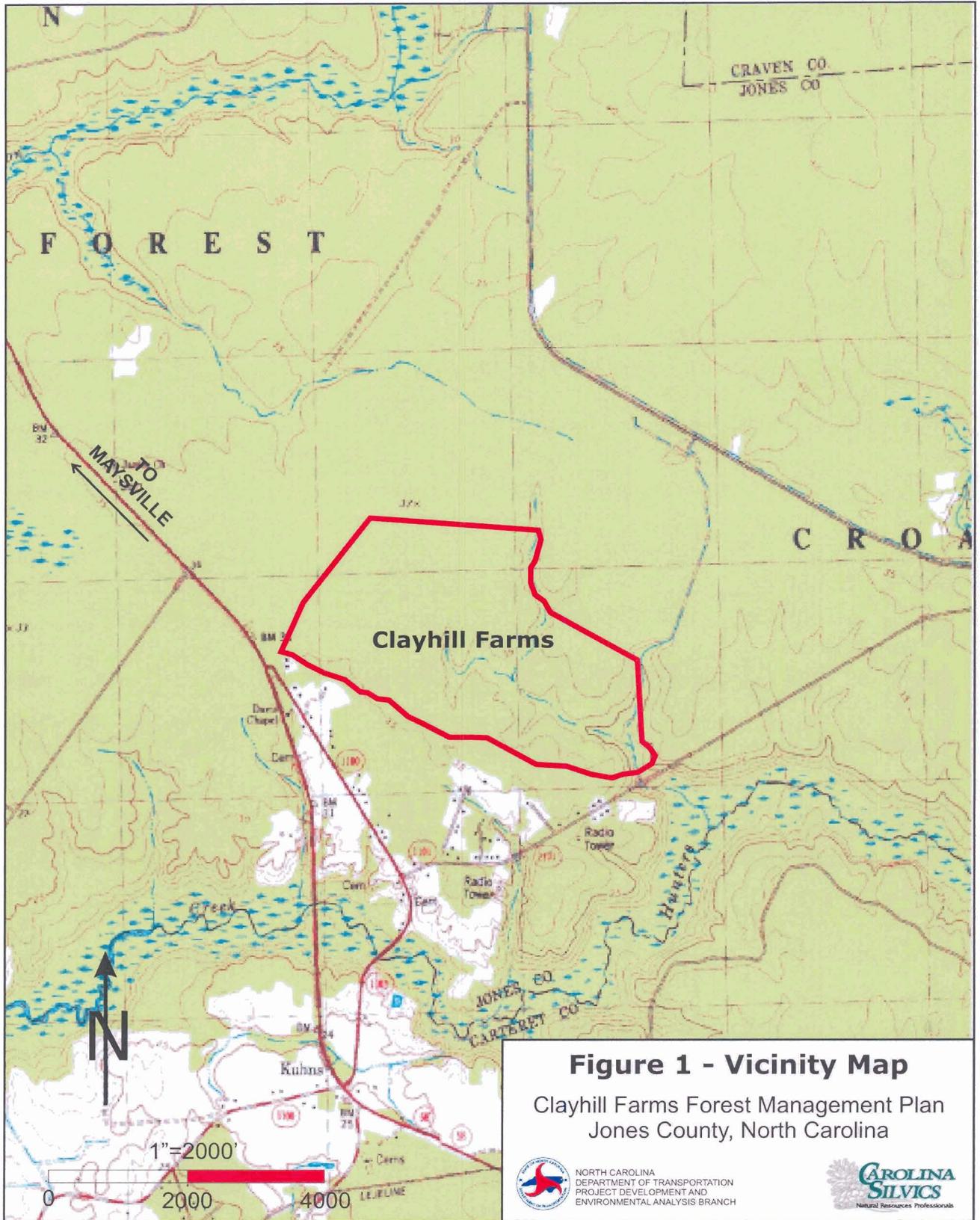
At each point, variable plots were measured using a 10-factor prism. The diameter at breast height (DBH), total height, and species was recorded for each tree counted as "in." All "in" trees were measured regardless of size or species. The distance to any borderline trees was measured using a 75-foot logger's tape. DBH's were taken with tree calipers; a hypsometer was used to measure height. At least one tree per measurement point was aged using an increment borer with three years added to the number of rings at DBH to determine age. Additionally, a 1/500-acre plot was established at each point to count the number of woody plants in the understory. The complete inventory data can be found in Appendix A.

3.0 EXISTING RCW HABITAT CONDITIONS

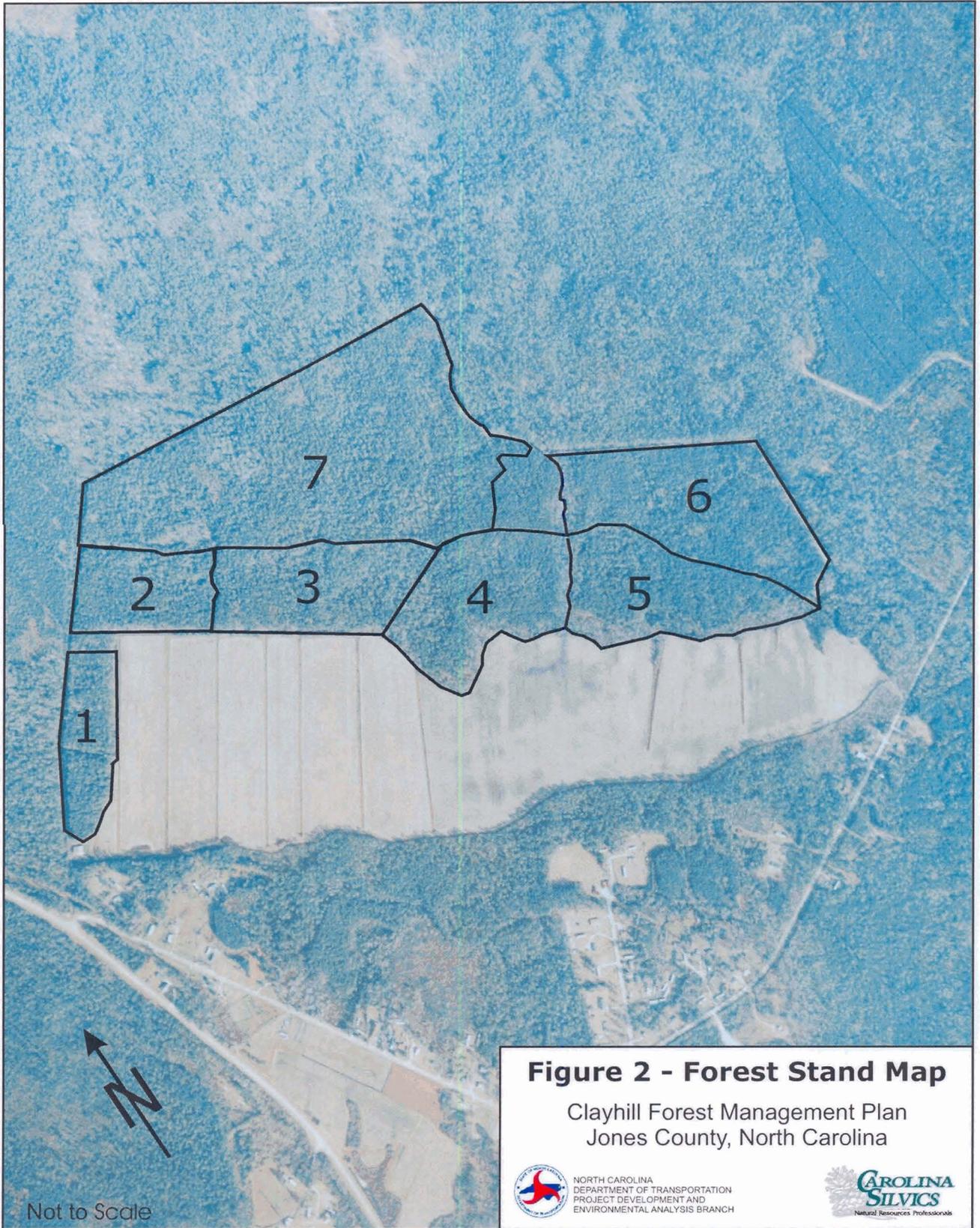
Inventory data important to the management of RCWs are summarized in Table 1.

There are two types of habitat requirements for the RCW: nesting and foraging. Nesting habitat requires the presence of suitable cavity trees. In general, the birds prefer open pine stands at least 60 years of age. The stand may be even-aged or have clumps of older trees contained within it (Henry 1989, p.6). Stands that have a dense hardwood understory are avoided. There is currently no nesting habitat available at the Clayhill Farms site due to the young tree age (5 to 25) and the density of the hardwood understory and midstory.

Foraging habitat may be managed under two sets of guidelines; the recovery standard and the managed stability standard (USFWS 2003, p.292). The recovery standard is for management with a goal of increasing population size used primarily on federal and state lands. The managed stability standard is used primarily on private lands to maintain population size. The recovery standard is more restrictive with respect to the pine stocking level requirements. It also requires a minimum tree age of 60,



SOURCE: USGS STELLA & HADNOT CREEK, NORTH CAROLINA 7.5 MINUTE QUADRANGLE.



whereas the managed stability standard requires a minimum stand age of 30. Since the recovery standard requires 20 ft² of basal area to be pines 60 years old or older, none of the acreage will qualify until the stands have reached that age. The stand ages are close to the minimum age of 30 years as specified in the managed stability standard; therefore, the goal should be to maintain the stands to meet the less restrictive standard while insuring that the recovery standard guidelines will be met when the trees have reached sufficient age. Table 1 provides general stand composition details. Table 2 shows which stands currently meet the various parameters under the managed stability guidelines. Table 3 gives the same information for the recovery standard. In tables 2 and 3, if a parameter is not met by a particular stand, management techniques are given which, if applied correctly, bring the stand into compliance. These techniques are detailed in section 4 of this document and are as follows: prescribed burning (designated by the letter B in the tables), natural stand aging and development (A), and tree removal (ie. Thinning, R).

Table 1. Forest inventory data for RCW-specific density parameters.

Stand	Overstory & Midstory				Woody Understory		
	Pine	Hardwood	Total	Average Age	Stems per acre	Most Common Spp.	
1	TPA <10"	29	273	302	22	4,250	red maple
	TPA ≥10"	67	7	74			
	BA <10"	10	22.5	32.5			
	BA ≥10"	50	0	50			
2	TPA <10"	32	752	784	23	5,667	sweetgum ink berry
	TPA ≥10"	62	0	62			
	BA <10"	3	30	33			
	BA ≥10"	47	0	47			
3	TPA <10"	81	116	197	22	6,000	sweetgum red maple
	TPA ≥10"	42	0	42			
	BA <10"	16	10	26			
	BA ≥10"	32	0	32			
4	TPA <10"	165	42	207	25	9,500	sweetgum red maple wax myrtle
	TPA ≥10"	65	0	65			
	BA <10"	48	4	52			
	BA ≥10"	44	0	44			
5	TPA <10"	85	7	92	23	4,400	sweetgum ink berry
	TPA ≥10"	71	5	76			
	BA <10"	26	2	28			
	BA ≥10"	48	2	0			
6	TPA <10"	134	60	194	23	4,750	sweetgum ink berry red maple
	TPA ≥10"	67	0	67			
	BA <10"	36	10	46			
	BA ≥10"	43	0	43			
7	TPA <10"	118	70	188	25	7,055	sweetgum ink berry red maple
	TPA ≥10"	53	1	54			
	BA <10"	31	9	40			
	BA ≥10"	34	1	35			

*TPA = trees per acre BA = basal area

Table 2. Current conditions--Managed Stability Parameters

	Stand						
	1	2	3	4	5	6	7
Stands 30 yrs old or older	A	A	A	A	A	A	A
40-70 ft ² of pines at least 10" DBH	√	√	A	√	√	√	A
<20 ft ² of pines less than 10" DBH	√	√	√	A,R	A,R	A,R	A,R
Hardwood understory sparse	B	B	B	B	B	B	B
Total basal area less than 80 ft ²	√	R	√	R	√	R	√

Table 3. Current conditions--Recovery Standard Parameters

	Stand						
	1	2	3	4	5	6	7
Stands 60 yrs old or older	A	A	A	A	A	A	A
At least 20 ft ² of pines at least 14" DBH	A	A	A	√	A	A	A
At least 18 TPA of pines at least 14" DBH	A	A	A	√	A	A	A
0-40 ft ² of pines 10-14" DBH	A,R	√	√	A,R	A,R	√	√
Less than 10 ft ² and 20 TPA of pines <10"	A,R	A,R	A,R	A,R	A,R	A,R	A,R
At least 40 ft ² of pines 10" DBH or greater	√	√	A	√	√	√	A
Hardwood understory sparse	B	B	B	B	B	B	B
Overstory hardwood TPA <30% total TPA	B,R	B,R	B,R	√	√	√	√

Approximately 43 acres of the Clayhill Farms site have been thinned by removing pine pulpwood from the overstory (stands 1, 2, and 3 – Figure 2, Forest Stand Map). These stands have a larger percentage of stocking with pines 10 inches or greater than the unthinned stands (stands 4 through 7); however, there is no evidence that the hardwoods have been controlled, and, as such, they exhibit the dense understory characteristics that RCWs avoid.

Clayhill Farms contains a contiguous pine forest with approximately 10,000 pine stems over 10 inches DBH and 11,000 sq.ft. of pine basal area. The foraging range for birds in a colony site is given as 0.5 miles (Henry 1989, p.7). At its widest, the forested portion of Clayhill Farms is about 2700 feet, or 0.51 miles, wide. If suitable nesting habitat is available on adjacent land, birds should be able to utilize part or all of any suitable foraging habitat provided on the Clayhill Farms property. In the process of conducting the forest inventory, the path along the property line shared with the Croatan National Forest was traveled by all-terrain vehicle (ATV). Portions of the national forest adjoining the Clayhill property appeared to contain suitable nesting habitat characterized by large pines with an open understory. Since there is currently no suitable nesting habitat on Clayhill Farms, the best prospect for use by RCWs is to provide a high quality foraging habitat for any birds nesting on adjacent property.

4.0 PROPOSED MANAGEMENT GOALS & ACITIVITIES

Prescribed burning, thinning, and natural stand development should provide foraging habitat in about 5 years. Time will provide the required nesting habitat. In about 35 years, the current trees will old enough to be utilized for cavity trees. In addition, the current young pine regeneration and any pine planted as part of restoration activities will provide additional foraging habitat. To maximize RCW habitat potential on newly planted pine areas in the wetland restoration area, these areas should be

located no further than 300 feet away from existing pine stands. In addition, they should be at least 10 acres in size and 5 chains (330 feet) wide. RCWs will utilize pond, longleaf (*Pinus palustris*), or loblolly pines. Of these three species, longleaf pine is the most tolerant to frequent burning, especially at a young age. Growth time to 10 inches DBH may be shortened by silvicultural techniques such as chemical weed control and fertilization.

4.1 Prescribed Burning

Since adequate pine stocking is currently available at the site, the most pressing course of action is to control the midstory and understory hardwoods by prescribed burning. Burning should begin as soon as possible and continue yearly until the hardwoods are controlled. If there is adequate fuel to burn every year, this should be done for 2 or 3 years. Once the understory is controlled, burning should continue at 2 to 3 year intervals in perpetuity.

Creation of a burning plan is recommended. A burning plan will identify any smoke sensitive areas off property, specify appropriate weather parameters such as wind speed and direction, and address any other issues such as problem soils. The burning plan will also set guidelines for evaluation of burning success and specific timing for subsequent burns.

Fire line maintenance will not be difficult due to the presence of old roads and paths around and through the property. A bulldozer may be required to initially install fire lines adjacent to the cutover stream corridor and young pine regeneration. An agricultural type tractor can be used to disk the fire lines prior to burning. Figure 3 shows the proposed locations of fire lines. Pine regeneration in the recently clear-cut areas and the wetland restoration area (currently fallow agricultural fields) should be protected from fire until they are big enough to include in the burning program (about age 15).

In addition to controlling hardwoods, prescribed burning reduces the risk of wildfire by lowering the amount of fuel on the tract. Creation of the above-described fire lines on the property and semi-annual prescribed burning should eliminate any wildfire concerns on the property. Also, other animal species such as northern bobwhite quail (*Colinus virginianus*) and wild turkey (*Meleagris gallopapa*) will benefit from periodic burning.

4.2 Thinning

Some parts of Clayhill Farms can be commercially thinned (Figure 4). Stands 4, 5, and 6 are especially suited to this due to a high percentage of upland soils (Langley & McDonald, PC 1999, Section 3.3). Pines less than 10 inches DBH and all merchantable hardwoods should be removed. In these three stands, if only pines greater than 10-inches DBH are left, the stands will have 44, 48, and 43 sq.ft. respectively, of basal area remaining in suitable RCW trees (managed stability standard). Stands 1, 2, and 3 have already been thinned and should be left to grow for the time being. Stand 7 may be thinned, but some trees less than 10 inches DBH should be left due to the lower overall stocking of this stand.

The logging contractor should be made aware of the size limitations before beginning work so that removal of 10-inch or greater DBH pines can be minimized. If desired, the trees not to be harvested can be marked with paint. Typically, trees are marked at ground level with a spot of paint and at DBH

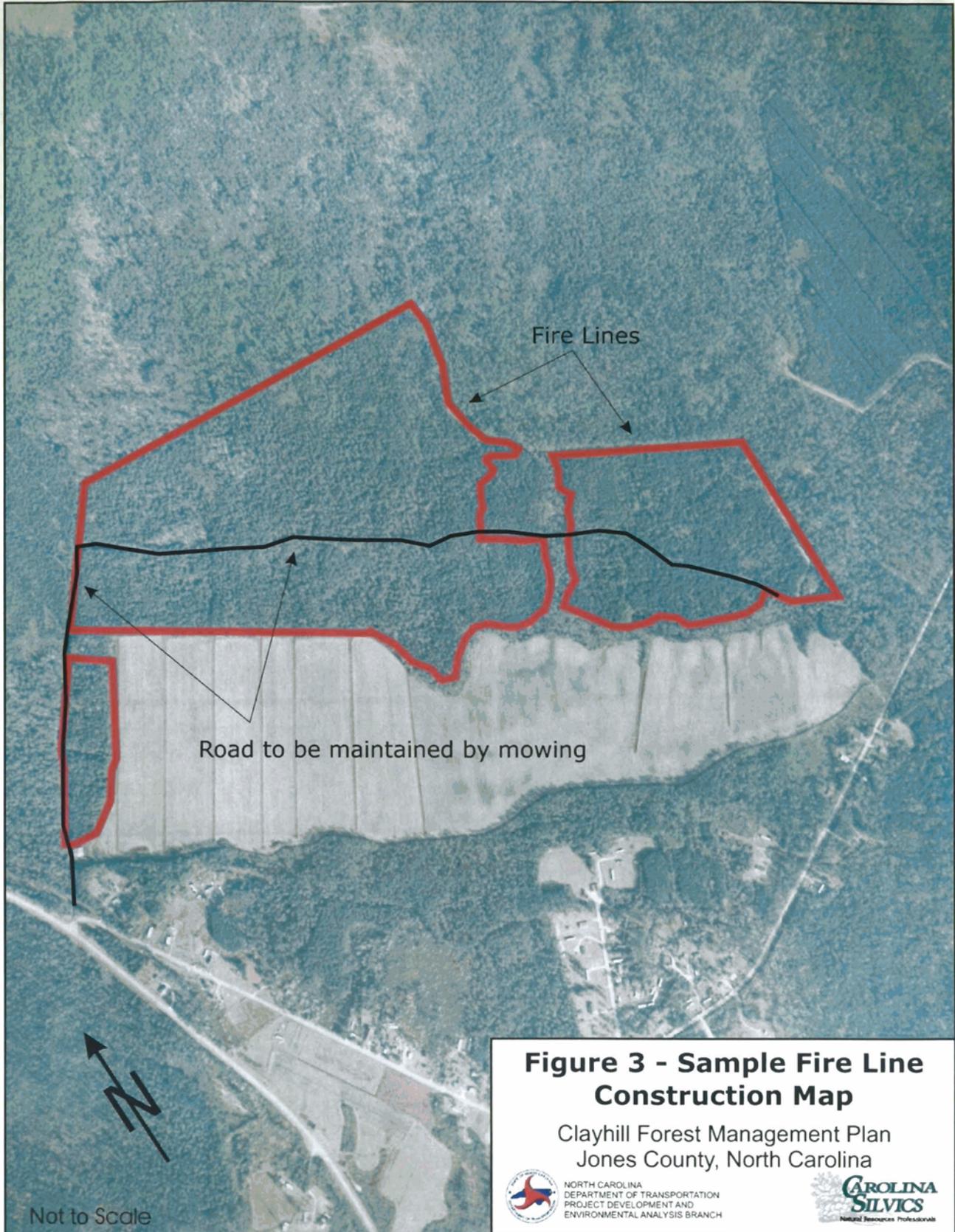


Figure 3 - Sample Fire Line Construction Map

Clayhill Forest Management Plan
Jones County, North Carolina



NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND
ENVIRONMENTAL ANALYSIS BRANCH



SOURCE: NCDOT PHOTOGRAMMETRY

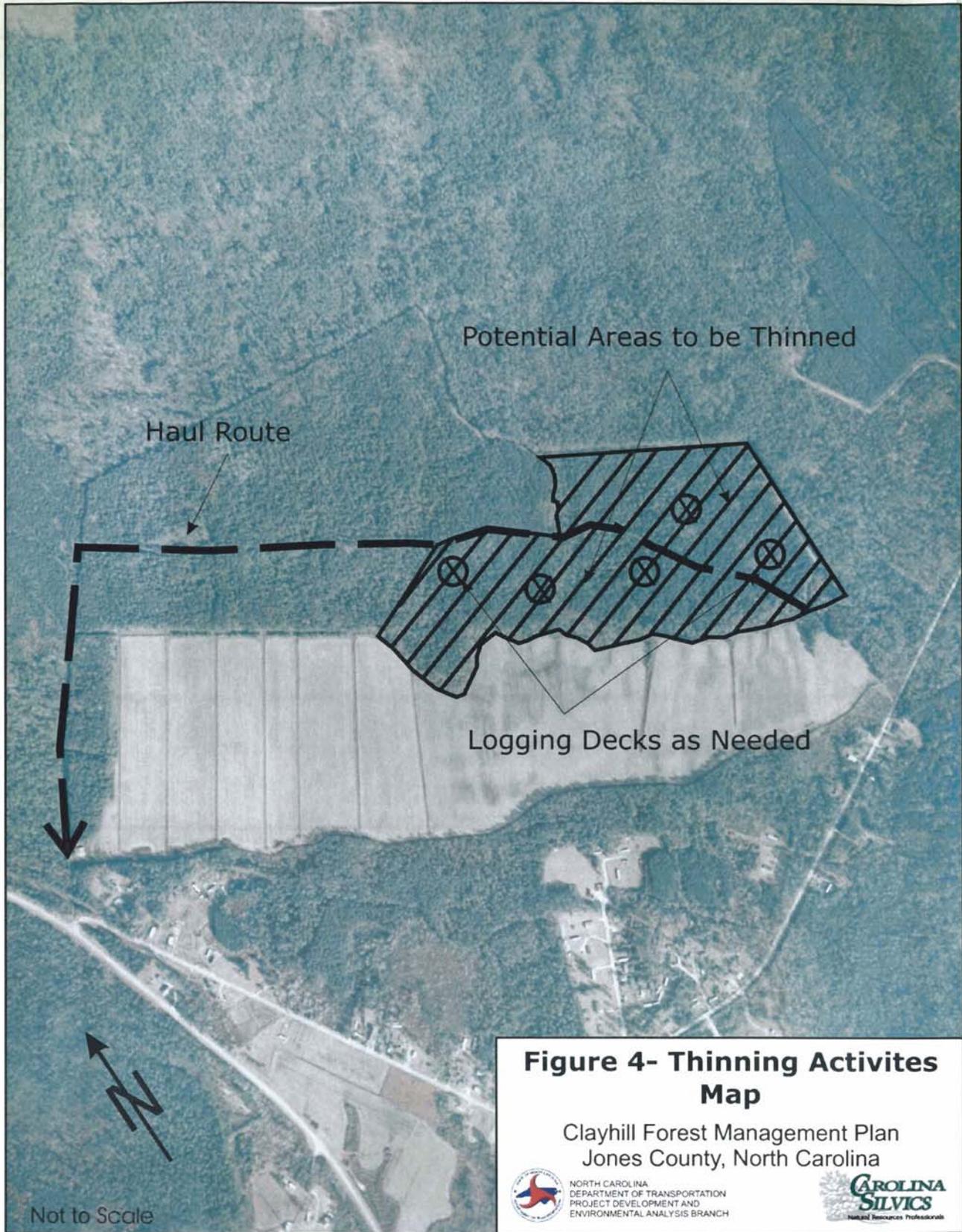


Figure 4- Thinning Activities Map

Clayhill Forest Management Plan
Jones County, North Carolina



NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND
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SOURCE: NCDOT PHOTOGRAMMETRY

with a band of paint encircling the tree. This allows the equipment operator to easily identify which trees not to cut, and also allows identification of stumps of trees which are mistakenly harvested.

Road work should be allowed in order to facilitate the logging operation, including periodic mowing of the interior road. This will also maintain the interior road as a fire break. Logging decks should be allowed as needed and left up to the logging contractor. These small areas will have only an insignificant impact on the RCW habitat. In addition, conveniently placed decks lead to shorter and fewer skid trails, thereby reducing rutting and soil compaction.

4.3 Natural stand development

Stands naturally change over time. In general, in fully stocked stands like the ones at Clahill Farms, the aging process tends to reduce the number of trees per acre of shade intolerant species like southern yellow pines. Tree diameter of these same species is increased. In the absence of fire, species composition also changes to include more shade tolerant hardwood species. With some stands, like stand #7, the aging process along with burning is all that is necessary to create foraging habitat. Since the management goal is to have a pine forest at least 60 years of age, all of the stands will undergo significant natural changes by the time the recovery standard guidelines are met. The aging process, along with fire, will increase the habitat for RCW over the coming decades.

4.4 Management Activity Schedule

Year 1

- Create a burning plan
- Establish fire lines in accordance with plan
- Maintain/repair interior logging road
- Acquire a thinning contractor/contract
- Mark trees for thinning
- Thin and burn as weather conditions allow
- Coordinate management activities with adjacent landowners

Years 2 and subsequent

- Burn as per schedule established in burning plan

Year 15

- Evaluate young pines for potential thinning and entry into burning program
- Re-asses management plan and adjust as conditions dictate
- Re-inventory all stands to evaluate stocking levels and progress towards the recovery standard

5.0 REFERENCES

Henry, V.G. 1989. Guidelines for Preparation of Biological Assessments and Evaluations for the Red-cockaded Woodpecker. U.S. Fish and Wildlife Service Southeast Region, Atlanta, Georgia.

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