

GEOLOGIC HISTORY
OF COASTAL PLAIN STREAMS
EASTERN PITT COUNTY, NORTH CAROLINA

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by
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ABSTRACT

A series of drill traverses were made across the Tar River and two of its tributaries, Green Mill Run and Chicod Creek, located in eastern Pitt County, North Carolina. Six post-Yorktown stratigraphic units were identified. Units Q_1 and Q_2 represent a transgressive sequence deposited in nearshore marine and estuarine environments when sea level rose to between 27 and 29 meters above the present level. These sediments were subsequently eroded from the stream valleys during later periods of emergence. Units Q_4 and Q_5 were deposited within the embayed estuaries of the drowned valley of the Tar River as sea level later rose to about +8 meters. Q_4 was deposited in the shallow nearshore margin of the embayment while Q_5 was deposited as soft muds further offshore. During the Late Wisconsin glacial stage, coarse arkosic sands of unit Q_6 were deposited in the Tar River Valley by a rejuvenated ancestral Tar River. Sediment filling the stream valleys of Chicod Creek and Green Mill Run forms unit Q_3 . A compound age for Q_3 is suggested as a result of sea level fluctuations; aggradation occurred when the stream valleys were inundated while erosion dominated during times of emergence.

The Tar River originated after deposition of the Yorktown Formation and occupies a low in the top of the Yorktown and older formations. Although the Tar was inundated during each transgression, the river re-established its former position with the following emergent period. Chicod Creek and Green Mill Run developed on the eroded surface of Q_1 and Q_2 and do not appear to be controlled by lows in the top of the Yorktown Formation.

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INTRODUCTION

During the Quaternary, wide fluctuations in eustatic sea level produced extensive marine regressions and transgressions across the gently seaward sloping Atlantic Coastal Plain. Coastal Plain streams evolved and adjusted rapidly in response to these variations in sea level with drainage systems alternately rejuvenated or drowned. A lowering of sea level resulted in fluvial erosion, downcutting, and extension of streams far out onto the continental shelf. Transgressing seas inundated the stream valleys, ultimately filling them with fluvial, estuarine and marine sediments. Therefore, today's Coastal Plain streams and stream valleys are a product of a complex set of interacting fluvial and marine processes which operated in response to the glacially induced sea level changes.

The object of this study was to examine three typical Coastal Plain streams and determine the history of their development during the Quaternary. This necessitated examining the stratigraphic, structural, sedimentologic, and geomorphic characteristics of the stream valleys and their associated stratigraphic units.

The three streams studied were Green Mill Run, Chicod Creek, and Tar River. (Figure 1). Green Mill Run and Chicod Creek are Coastal Plain tributary streams, located in eastern Pitt County, which flow northeast into the Tar River, a major Piedmont river of the North Carolina Coastal Plain. Table 1 lists some of the physiographic features of these three streams.

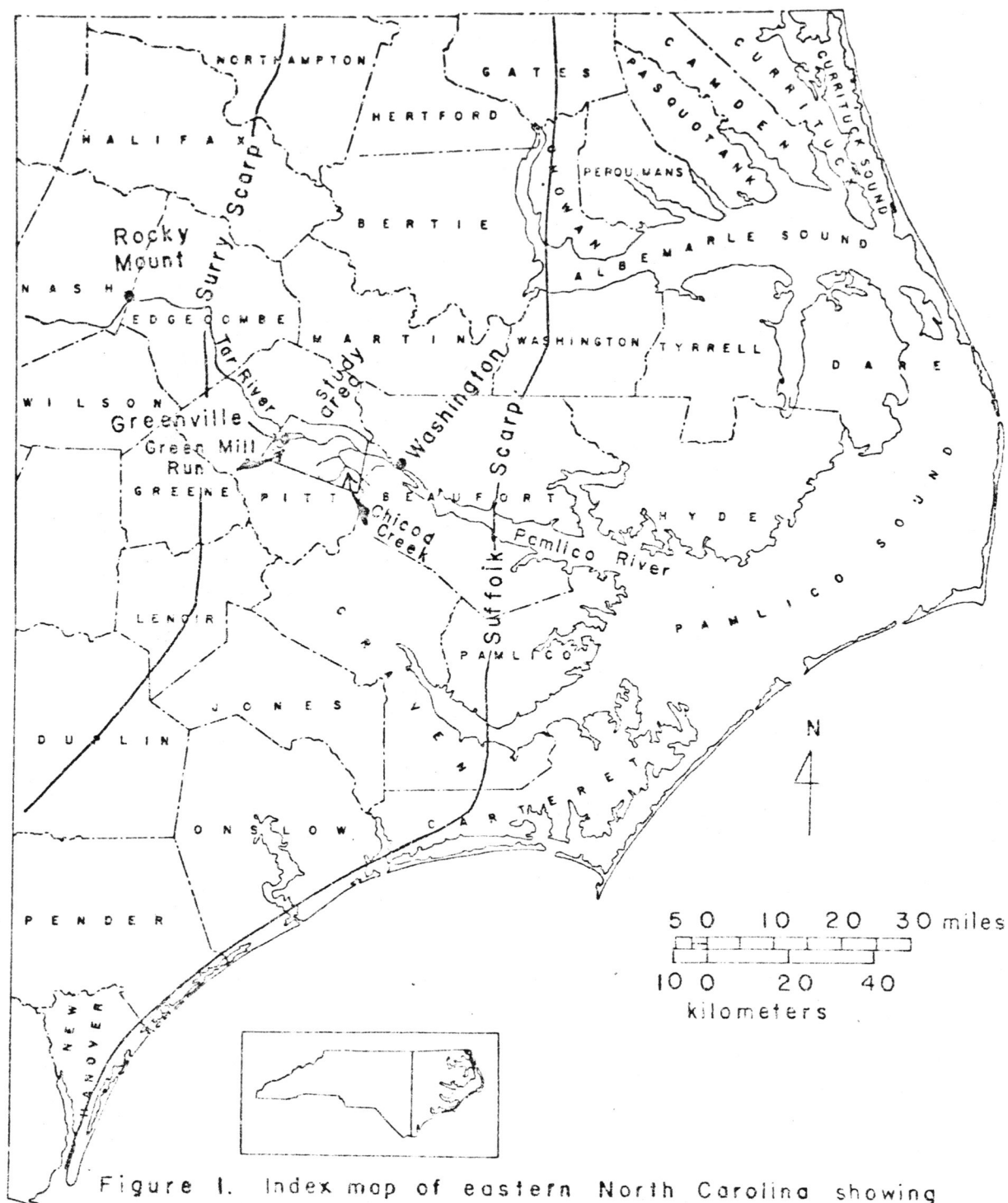


Figure 1. Index map of eastern North Carolina showing physical features, political boundaries, locations mentioned in text, and location of the Surry and Suffolk scarps.

Table 1. Some physiographic features of Chicod Creek, Green Mill Run, and Tar River (U.S. Army Corps of Engineers, 1973; Benton and Slaughter, 1971; U.S. Department of Agriculture, 1974a, 1974b).

Stream	Drainage Area	Length	Average Gradient	Relief
Tar River	7,900 sq. km	286 km	0.26 m/km	0-180 m
Coastal Plain portion of the Tar River	2,500 sq. km	128 km	0.13 m/km	0-17 m
Green Mill Run	36 sq. km	14.4 km	2 m/km	2-27 m
Chicod Creek	130 sq. km	24 km	0.75 m/km	0-18 m

The Tar River is a typical major Piedmont originating "red water" river of the southeastern United States. Headwaters of the Tar are in Person and ^{Wren} Caswell counties in northern North Carolina. The river flows in a general southeasterly direction and enters the Coastal Plain near Rocky Mount. East of Greenville, the Tar comes increasingly under the influence of the Pamlico River Estuary; the river meanders less, broadens, deepens (averaging 3 to 4.5 meters), and becomes more sluggish. Wind generated tides of up to 1 meter have been recorded at Greenville and current reversals are not uncommon (Hobbie, 1979). East of Washington, the Tar River valley becomes flooded as it merges into the brackish water Pamlico River Estuary.

Green Mill Run is a typical small stream within an urban area of the middle Coastal Plain. The stream has a well defined channel, segments of which have been channelized. These channelized reaches are characterized by steep spoil banks along the channel margin and flat, shallow, sandy channel bottoms with water depths normally less than

one third of a meter. The adjacent uplands are moderately to well drained and are dominated by the Norfolk-Exum-Goldsboro soil associations (Soil Conservation Service, 1974). Near the Tar River, Green Mill Run deepens and broadens as the stream flow becomes dominated by the Tar River water level.

Chicod Creek is a sluggish "black water" stream typical of lower Coastal Plain streams. For much of its course Chicod Creek has no single well defined channel within the floodplain but rather forms an intricate pattern of small anastomosing channels. Vegetation is dense and many fallen trees lie across these channels. During periods of heavy rainfall much of the floodplain is under water. In its lower portion, Chicod Creek also comes under the influence of the Tar River; the channel becomes wider and deeper, and the water level is largely controlled by that of the Tar River. In many places along this lower reach, water depths are 3 to 4 meters and there are deeper holes where depths exceed 8 meters (Benton and Slaughter, 1971). The adjacent uplands have moderately to poorly drained soils of the Lynchburg-Rains-Goldsboro, and Lenoir-Bladen-Craven soil associations (Soil Conservation Service, 1974).

FIELD METHODS

A series of traverses were surveyed approximately normal to the stream valleys of Green Mill Run, Chicod Creek, and Tar River (Figure 2). The location of each traverse was dependent upon the accessibility, abundance of water in the area, width of floodplain, and density of vegetation. Traverses across Green Mill Run were in areas of minimal urban development. A total of six traverses were made across Chicod Creek and two of its tributaries, three across Green Mill Run, and two across the Tar River. After choosing a site, a survey line was cleared across the floodplain and where possible onto the adjacent uplands. Traverses were surveyed with a hand level and tape,

Traverses on Chicod Creek were established near county roads. Elevation control was determined from nearby bridges that had been surveyed by the Soil Conservation Service, usually to the nearest hundredth of a foot. The Greenville Utilities Company furnished elevation control for the Tar River traverses. Elevations on Green Mill Run were determined with a Paulin Altimeter.

A wash boring technique, utilizing a two inch centrifugal water pump driven by a 2 1/2 horsepower gasoline engine was used to drill the holes (Figure 3). About 70 meters of 38 mm PVC pipe was used to transport the water from the pump to the drill site. Flexible plastic hoses were used to connect the PVC pipe to the pump and the drill which allowed for easier couplings and greater maneuverability during drilling. At the drill site the flexible hose was connected to a 38 mm brass venturi valve. While drilling, the valve was closed forcing water downward through a series of two meter long, 38 mm PVC drill rods.

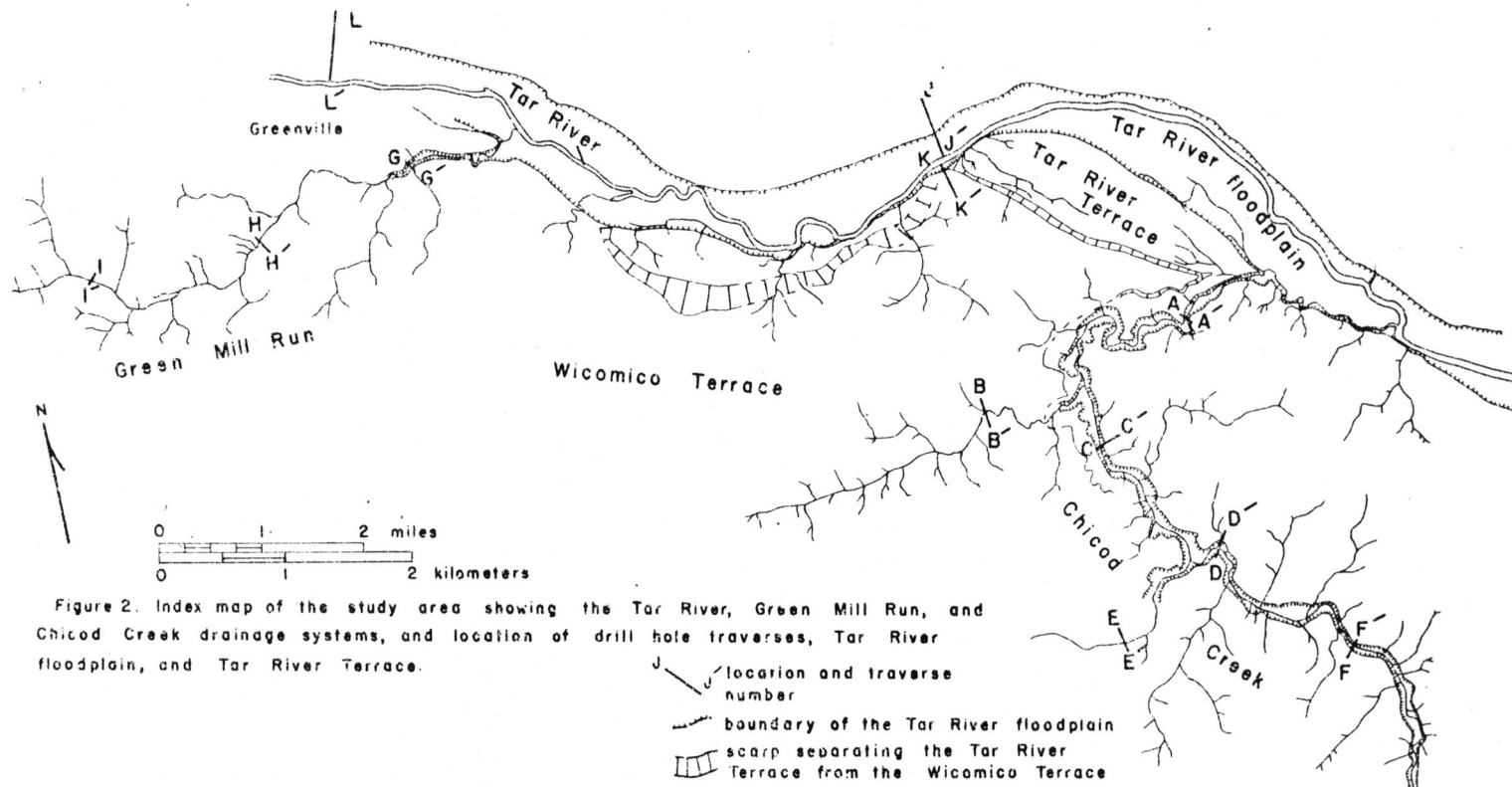


Figure 2. Index map of the study area showing the Tar River, Green Mill Run, and Chicod Creek drainage systems, and location of drill hole traverses, Tar River floodplain, and Tar River Terrace.



Figure 3: Photograph of drilling equipment.



Figure 4: Photograph of coring equipment.

After drilling almost two meters, the venturi valve was opened, allowing the water to be jetted to one side, while another two meter section of pipe was added to the drill stem. Where hole sites were over 70 meters from a water source, a 2,440 liter water tank mounted on a trailer was used to supply the water.

Washed samples were obtained to depths of 13 meters using this drilling technique. Employing drillers mud with a closed circulation system, drilling depths of 30 meters might be possible.

During drilling, changes in lithology were observed by noting water color, "feel" of the drill pipe, rate of penetration, and changes in sediment type. Where lithologic changes were noted, samples were taken and later examined with a microscope (see Appendix 1).

At the bottom of the hole, the string of 38 mm PVC drill pipe was left as casing while a 15 cm long core was taken. The core was obtained utilizing a 2 cm by 15 cm long galvanized nipple attached to a series of 3.2 cm diameter steel pipes. The 15 cm core barrel and steel rods were coupled together and lowered to the bottom of the hole. The core was obtained by pounding the steel rods with a sledge hammer.

There are advantages and disadvantages to using this drilling technique. The system proved most efficient for drilling in the harsh conditions of a stream floodplain in summer. Because of the inaccessibility of hole sites, dense underbrush, and soft miry floodplain, the equipment had to be compact and portable. The disadvantages inherent in any wash boring technique are low quality

samples and poor control in picking lithologic boundaries. The samples always contain cavings from higher up the hole. Also much of the silt and clay is washed away during drilling and not collected.

A second drilling technique was employed in an attempt to acquire core. This coring technique proved of limited value. A 5 meter aluminum tripod was set up over the hole site with a pulley at the apex (Figure 4). A rope through the pulley was connected to a 18 kg weight with a 30 cm metal rod which was used as a weight guide. A 7.6 cm PVC core pipe was then driven into the ground by raising and dropping the weight on the PVC pipe. The core and core barrel were retrieved by filling the empty portion of the PVC pipe with water and sealing it with a plumbers test plug. This prevented the core from sliding out of the PVC pipe during extraction. A chain was wrapped around the core barrel and connected to a hand winch attached to the apex of the tripod. Using the tripod as a brace, the core barrel was slowly extracted. The core was later extruded from the core barrel and stored in cardboard core boxes.

The success of this coring technique depends on the type of sediment and presence of roots or buried tree stumps which cause the brittle PVC pipe to crack and splinter. Outside the floodplain, compacted, impenetrable clayey sediments were impossible to core whereas water saturated sands in the floodplain were difficult to retain in the core barrel. Finally, because of the dense vegetation, sites had to be carefully selected to avoid the time consuming task of clearing a working area. Consequently, only five holes were drilled using the latter technique.

An attempt was made to extend the traverses further away from the stream valleys and onto the adjacent uplands. Drilling of the compacted, clayey sediments proved to be too difficult and time consuming. Consequently, a portable FS-3 facsimile seismograph manufactured by Hunttec, Inc. (70) Limited of Toronto, Canada was employed for stratigraphic extrapolation.

Green (1974) summarized the restrictions in the use of the seismograph. The seismic refraction method is applicable in situations where the velocity of each layer increases with depth. If a layer of substantial thickness has a greater velocity than the deeper layers no refracted arrivals from the deeper layers will be received. It was believed that the differences in degree of compaction between the Quaternary and older units of the Coastal Plain, as reported by Harrison, and others (1965), would allow detection of the Yorktown Unconformity. Other requirements of the refraction method are that the thickness of each layer is small in comparison to the length of the refraction spread (length of traverse). There must be few discontinuities in the interfaces between strata. Finally, if a hidden layer of some critical thickness is present, the depth calculations will be incorrect.

Seismic surveys were made in a variety of locations in eastern Pitt County. At all but one site, the depth determinations proved to be inconsistent, apparently for a variety of reasons. The one successful survey was located parallel to traverse E-E', adjacent to hole A. In most locations south of the Tar River a velocity reversal occurred between beds Q_1 and Q_2 with Q_2 having a much higher velocity than Q_1 .

Also it appeared that Q_2 is often as compacted as the formation underlying the Yorktown Unconformity. Stream floodplains proved to be poor sites for seismic surveys because of the abundant organics which tended to adsorb and attenuate the seismic waves. Seismic surveys in areas of unit Q_6 gave inconsistent results. Velocity variations in these Quaternary sediments made depth calculations questionable. Such changes in velocity could reflect a hidden layer or discontinuities in the sediments such as thin clay beds or organic-rich layers.

In summary, the portable seismograph proved to be of little value to this study. It appears that the stratigraphy of the near-surface sediments of eastern Pitt County may be too complex to allow for the application of the seismograph.

GEOLOGIC SETTING

Geomorphology of the Coastal Plain

Relict coastal terraces and scarps resulting from past sea level stands occur on the Atlantic Coastal Plain with varying degrees of preservation. The terraces form gently seaward sloping plains separated by slightly steeper scarps which are roughly parallel to the coastline. Slope of the scarps average two and a half degrees (Flint, 1940) and 4.6 to 6 meters in height. In general, these geomorphic features are progressively younger seaward indicating that the average interglacial-glacial sea level has gradually decreased through time (Fairbridge, 1960). Many attempts have been made to correlate these coastal features based upon the assumptions that (1) each terrace is underlain by sediments of the same age and origin, and (2) there has been little if any Coastal Plain deformation since their formation. Recent studies show that both assumptions are incorrect (Oaks and others, 1974; Dubar and others, 1974; Oaks and Dubar, 1974; Coch, 1965). These studies have shown that Coastal Plain terraces and scarps are usually underlain by numerous stratigraphic units, each of which may be of a different age and origin. For example, Oaks and others (1974) recognized four formations which underlie the Isle of Wight Plain (Wicomico Terrace) and several of these same formations are found under adjacent terraces. Coastal Plain deformation has been suspected for some time but it has only recently been demonstrated by Winker and Howard (1977). They show that deformation of the southeastern Coastal Plain, following persistent Cenozoic structural features, has occurred

throughout the Pleistocene.

Pitt County is located on the Wicomico Terrace of Richards (1950) and Cook (1936) and the Penholoway Terrace of Doering (1960). The term Wicomico is preferred as it has precedence, having been named by Dall in 1892. The Wicomico Terrace ranges in elevation from an average of 15 meters in easternmost Pitt County to 27 meters at the toe of the Surry Scarp in western Pitt County. The eastern edge of the Wicomico Terrace, marked by the Walterboro Scarp, is not well defined as shown by White (1966). He notes that the Walterboro Scarp is highly dissected and may have never been sharply defined. East of the Walterboro Scarp is the Talbot Plain (Daniels and others, 1977) which ranges in elevation from 6 to 17 meters. The eastern edge of the Talbot Plain is bounded by the Suffolk Scarp whose toe is 6 meters above sea level. In northeastern North Carolina and southeastern Virginia the Walterboro and Suffolk Scarps join to form one prominent scarp nearly 20 meters in relief (White, 1966).

The Coastal Plain river systems are normal to and cut across Coastal Plain terraces and scarps. These rivers exhibit a sequence of changes in geomorphology which Colquhoun (1966, 1969) has divided into two cycles consisting of five stages. As the average sea level dropped during the Pleistocene, streams in the western portion of the Coastal Plain became increasingly dominated by fluvial processes. This has resulted in downcutting and incising of the rivers to form narrow floodplains with steep valley walls of Colquhoun's continental emergent cycle (stage 1). Eastward, still within the emergent cycle the river meanders, the river valleys widen, and the underlying

sediments are point bar, floodplain and other related fluvial deposits of stage 2. Seaward of the emergent cycle the marine influence is increasingly evident. The rivers are characterized by broad floodplains that are separated from nearly flat upland terraces by narrow scarps; the river valleys broaden and exhibit less relief as sea level is approached. Finally the river valley merges with fresh water swamps and fringing marshes of the estuarine environment. This is Colquhoun's continental submerged cycle which is composed of three stages, the estuary, marsh and delta.

Geology of Eastern Pitt County

The Atlantic Coastal Plain consists of a Quaternary to Recent sediment cover deposited on a generally seaward dipping sequence of strata of Jurassic to Miocene and Pliocene age (LeGrand, 1961). These sediments rest on Precambrian to Paleozoic crystalline basement and thicken to the east forming a miogeocline according to Dietz (1972).

The sedimentary rocks underlying eastern Pitt County vary from 270 to 300 m in thickness and range in age from Lower Cretaceous to Recent (Brown and others, 1972). Table 2 is a generalized stratigraphic section for the study area. Figure 5 is a simplified, east-west cross-section through Pitt County showing the relationship of each formation and their average thickness. The lower Cretaceous sediments are too deeply buried to have had any direct influence on Pitt County streams. Therefore, only Upper Cretaceous and younger units will be described, using data from Brown (1959) and Sumison (1970).

The Upper Cretaceous Black Creek Formation is divided into a lower unnamed member and the upper Snow Hill Member. The lower member consists of alternating gray to black micaceous sands and clay with variable amounts of lignite, marcasite, and glauconite. The Snow Hill Member is predominantly interbedded, calcareous, fossiliferous, sands and clays which are locally indurated. The unnamed member and the Snow Hill Member are exposed along the Tar River, Contentnea Creek, and other streams in western Pitt County.

Period		Description	
Quaternary	Epoch	Unit	
	Pleistocene-Holocene	Units Q1-Q6	Red, blue, and gray, fine to coarse sands and clays. Units Q1 and Q2 were deposited in estuarine to nearshore-marine environments and blanket the interfluvial areas south of the Tar River. Units Q3, Q4, Q5, and Q6 were deposited in fluvial to estuarine environments within the Tar River and its tributary stream valleys. Considerable variation in thickness, generally ranging from 3 to 12 m
	Plio-Pleistocene?	Yorktown Formation	Fossiliferous sands and clays in the upper part, becoming more calcareous and clayey in the lower part. Deposited in a shallow open marine environment. Thickness in most places is between 10 and 33 m
	Eocene	Castle Hayne Limestone	Fossiliferous, calcareous sands and clays with common sandy, fossiliferous limestones. Glauconite, phosphorite, and pyrite occur as accessories. Deposited in shallow open marine environment. Restricted to the subsurface in easternmost Pitt County with a maximum thickness of about 25 m
	Paleocene	Beaufort Formation	Composition varies from green glauconitic sands to calcareous clay and silty clays with common indurated fossiliferous limestones. Deposited in a marine environment. Restricted to the subsurface in the eastern quarter of Pitt County. Maximum thickness is about 30 m
		Pee Dee Formation	Dark gray to green glauconitic sand in the upper part with gray massive clay in the lower part. Indurated fossiliferous beds occur throughout the formation. Deposited in a shallow water marine environment. Present over the eastern half of Pitt County with outcrops along many streams. Thickness ranges from 100 to over 300 m
Cretaceous		Black Creek Formation	Black to gray interbedded clays and calcareous fossiliferous, sandy clays with some indurated beds in the upper part (Snow Hill Member). The lower section consists of micaceous sands and clays with variable amounts of lignite, marcasite and glauconite. May be crossbedded or lenticular. Deposited in marine, nearshore to continental environments as evidenced by many complex facies changes. Underlies nearly all of Pitt County with the thickness ranging from 0 to about 150 m

Table 2. Generalized stratigraphic section of the Cretaceous through Quaternary in Pitt County (modified from Sumison, 1970; Brown, 1959).

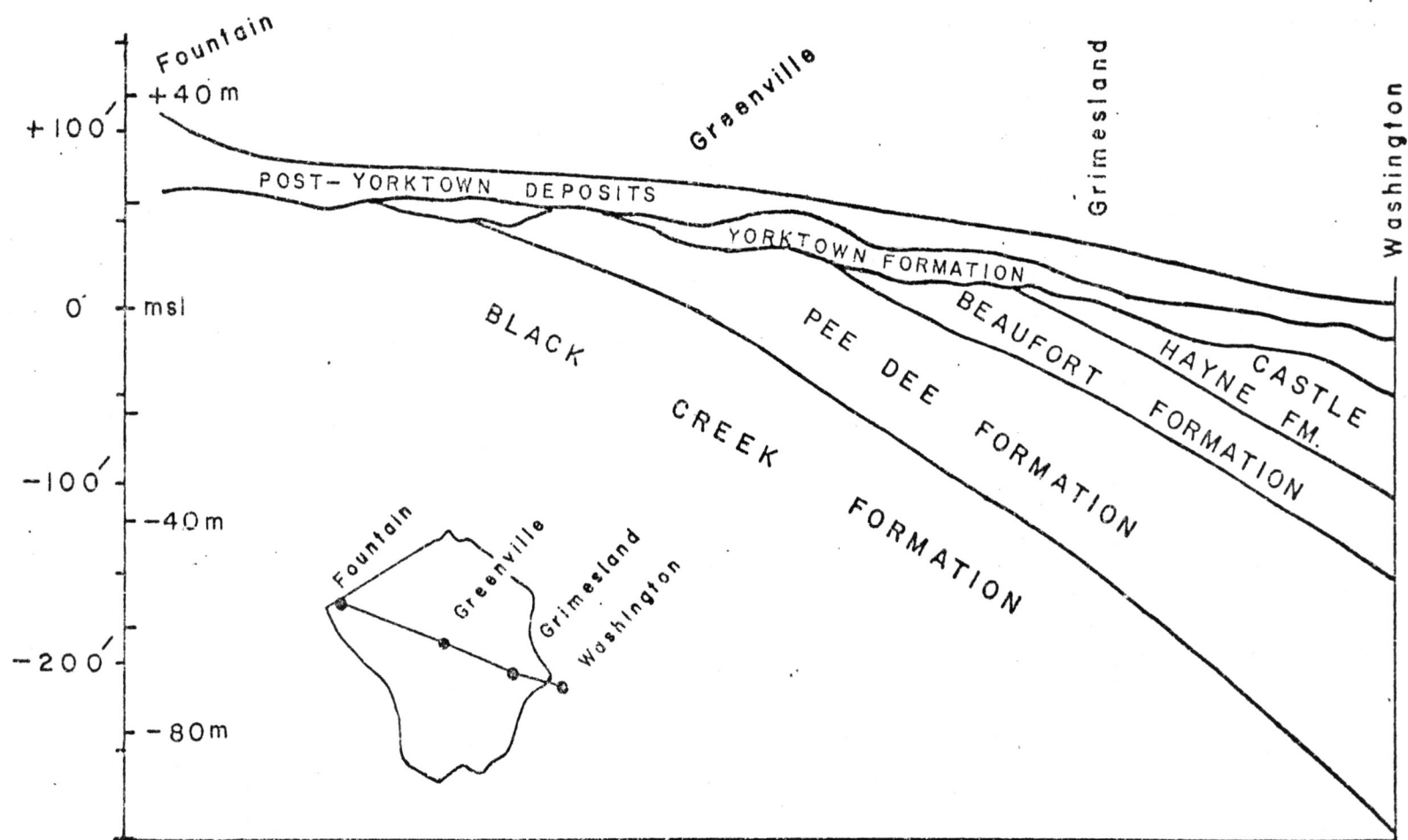


Figure 5. Generalized east-west geologic cross-section through Pitt County showing the location of Quaternary through Cretaceous strata (modified from Sumison, 1970; Brown, 1959).

Overlying the Black Creek Formation is the Upper Cretaceous Pee Dee Formation, a dark gray to bright green glauconitic sand in the upper part grading to a predominantly black massive marine clay in the lower portion. Indurated calcareous sand and shelly beds occur throughout the formation. Outcrops of the Pee Dee Formation occur along the Tar River from Greenville to the vicinity of Grimesland.

The Beaufort Formation of Paleocene age overlies the older Cretaceous formations. This formation is restricted to the subsurface of easternmost Pitt County and consists of glauconitic sand, calcareous and silty clays with abundant indurated shelly limestones.

The Eocene Castle Hayne Limestone also occurs only in easternmost Pitt County where it unconformably overlies the Beaufort or Pee Dee Formations. The Castle Hayne consists of white to light gray fossiliferous limestone interbedded with calcareous sands and clays, all exhibiting various degrees of induration. Glauconite and phosphorite occur as accessory minerals.

Unconformably resting on the Cretaceous to Eocene strata is the Yorktown Formation which underlies most of Pitt County and much of eastern North Carolina. The Yorktown is one of five formations in the Atlantic Coastal Plain of approximately the same age which were deposited during a major marine transgression that covered most of the Southeast Atlantic Coastal Plain (Richards, 1950).

The Yorktown Formation was named by Dana in 1863 to include all Miocene and Pliocene deposits of the Atlantic Coastal Plain. The stratigraphy of the Yorktown Formation in eastern North Carolina is poorly understood. Mansfield (1943) divided the Yorktown into two

zones; the lower zone is characterized as the Pecten lentonius Zone and the upper is characterized as the Turritella alticostata Zone. Mansfield described the lower zone as mainly a dark bluish green, medium to fine sandy clay with abundant shells. The upper zone contains less clay but more shells (Richards, 1950).

Schnitker (1970) was able to identify three zones in the Yorktown Formation from an outcrop on the Tar River just downstream from the mouth of Chicod Creek. These zones are from top to bottom:

Zone 3--Gray to yellow-brown silty and clayey sand with an abundance of Turritella.

Zone 2--Light gray-brown sand and clayey silt, lenticular, and characterized by Dosinia and Mercenaria.

Zone 1--Plastic, bluish-gray, slightly clayey and sandy silt with an abundance of Pecten.

Until recently most geologists have considered the Yorktown to be Late Miocene in age. However, more recent studies by Akers (1972) using planktonic foraminifera, Baum and Wheeler (1977) with vertebrate material and Hazel (1971) from a study of ostracodes have suggested a possible Pliocene age for at least a portion of the Yorktown.

A Pliocene age for the entire Yorktown is suggested by Dr. Joseph Hazel of the Smithsonian Institute (personal communication, 1974). He believes that the Yorktown transgression and regression took place during all of Pliocene (1.8 - 5.0 my) and that the Yorktown was subjected to erosion during the latter two-thirds of the Pliocene. Therefore, according to Hazel, the unconformity on top of the Yorktown is Pliocene or post-Pliocene, not post-Miocene. Furthermore, more recent studies by Gibson

and Snyder (Lucy Mauger, personal communication, 1978) suggest that the uppermost unit of the Yorktown (at least at Lee Creek Mine near Aurora, North Carolina) has been assigned to the Croatan Formation which may be Plio-Pleistocene in age.

A veneer of Quaternary sediment covers the Yorktown and older strata of the Atlantic Coastal Plain. Six Quaternary stratigraphic units ($Q_1 - Q_6$), described in subsequent chapters, were identified in eastern Pitt County. They consist almost entirely of terrigenous clastics which were deposited in a variety of near-shore marine to fluvial environments. Units Q_1 and Q_2 blanket the interstream areas south of the Tar River and were deposited in a transgressive nearshore-marine to estuarine complex. Units Q_3 , Q_4 , Q_5 and Q_6 were deposited as valley fill in Tar River and its tributary stream valleys.

Yorktown Unconformity

A major period of marine regression followed deposition of the Yorktown Formation. Most of the Coastal Plain and at least part of the Continental Shelf were exposed to erosion as evidenced by channels cut into and through the Yorktown Formation offshore of Virginia and North Carolina (Schiedler and Swift, 1972). This old surface will be called the Yorktown Unconformity.

Even though this surface was subsequently buried under Quaternary deposits, it has greatly influenced the history and development of many Coastal Plain streams, especially those that are situated above buried channels cut into the Yorktown Unconformity. For example, the Pungo and Pamlico Rivers are situated above narrow channels cut deeply into the Yorktown Formation (Brown and Welby, 1970; Welby, 1971a,b). Although the information is less clear, Brown, and others (1972, plate 21) show that many of the major rivers along the North Carolina and Virginia coast follow paleovalleys cut into the Yorktown Unconformity. They believe these paleochannels developed during a period of emergence following deposition of the Yorktown Formation. According to Coch (1965),

"Location of existing stream valleys may be controlled by topographic lows in the top of the Yorktown Formation, and the drainages were concentrated in these topographic lows through all the periods of emergence that followed the transgression."

This implies that many Coastal Plain streams have probably occupied their present sites for a considerable length of time, possibly as far back as the Pliocene.

If the larger streams, such as the Roanoke and Tar, follow lows

in the Yorktown Unconformity, what about the smaller Coastal Plain streams such as Chicod Creek and Green Mill Run? If these smaller Coastal Plain streams are controlled by lows in the Yorktown topography, then the entire present drainage system in this part of eastern North Carolina is probably controlled by and reflects the paleodrainage of this ancient land surface. Therefore, in order to decipher the history of Green Mill Run, Chicod Creek, and Tar River, it was first necessary to identify and map the Yorktown Unconformity. Fortunately, recognition of the Yorktown Unconformity proved difficult in only a few cases.

The most important clue in recognizing the Yorktown Unconformity was the difference in degree of consolidation between the Quaternary deposits and the more compacted Yorktown and older formations. Engineering data on building foundations of the East Carolina University campus generally showed a dramatic decrease in penetration rates at the Yorktown Unconformity. Harrison and others (1965) suggest that this change in consolidation results from drying produced by a lowering of the water table during periods of lower sea level. They found that beds become increasingly more consolidated with depth possibly as a result of the increased weight of the sediments above the water table caused by a loss of buoyancy from the receding ground water. In addition, there is a basic lithologic difference between the Quaternary and older sediments. In eastern Pitt County, the Quaternary sediments are dominated by quartz sand with minor clay beds whereas the older beds are dominated by calcareous clay and silt.

Penetration of the post-Yorktown sediments was rapid except where units Q_2 and Q_5 were present. These units contained large percentages

of compacted clay and the penetration rate was very slow near the surface, rapidly increasing downward with an increase in sand content. Changes in consolidation were readily felt in the PVC pipe during drilling. When a major change in penetration rate occurred, a core was taken to identify the unit and to establish the presence of the Yorktown Unconformity.

In some holes along traverses J-J', L-L', A-A', and B-B', indurated beds were encountered which could not be cored. Since no cuttings were obtained, the identity of these beds is uncertain. The only known indurated beds in the Quaternary are occasional thin discontinuous iron oxide cemented sands usually capping less permeable Tertiary and older formations. Consequently, these iron cemented sands often indicate the Yorktown Unconformity.

In the Chicod Creek drill holes, the rock surfaces encountered are believed to be the top of the Beaufort Formation and Castle Hayne Limestone. The Quaternary sands overlying these rock surfaces contain well preserved fragile fossils and small fossiliferous limestone fragments indicative of the Castle Hayne. Also, Sumison (1970) showed that the Castle Hayne is near the land surface in this area of Chicod Creek. It is evident that the reworked Quaternary sands were largely derived from a calcareous, fossiliferous, phosphatic, glauconitic sand similar to that cored in hole B, traverse A-A'. The lithology of this core indicates the presence of the Beaufort Formation.

A Cretaceous age is postulated for the indurated bed encountered in traverses J-J' and L-L'. In hole D (J-J') over ten feet of Cretaceous strata overlay the indurated bed. Four holes drilled by the

North Carolina Department of Transportation across Tar River between traverses J-J' and L-L' penetrated an indurated bed (Gerald Bunch, personal communication, 1974). This indurated bed was below the Yorktown Formation and is believed to be of Cretaceous age since Cretaceous strata crop out on the river bluff about one kilometer to the south.

In addition to the changes in degree of consolidation, the Yorktown Unconformity can generally be recognized by differences in lithology between the Quaternary and older strata. Quaternary sediments contain no fossils except for those which are reworked from older beds. These fossils were usually fragmented and highly corroded. Also, a coarse sand and gravel occasionally occurs directly above the Yorktown Unconformity. The Yorktown Formation itself is readily identified by the abundant characteristic fossils and by its distinctive blue-gray color. In some holes across Green Mill Run however, sediments interpreted to be the Yorktown were unfossiliferous. The absence of fossils is thought to be due to leaching; in outcrop it is not uncommon to have nearly a meter of Yorktown clays which are partly oxidized and contain molds of dissolved shells. Below this zone the shells are soft and corroded. These grade downward into unaltered shells.

No attempt was made to differentiate between the various Cretaceous formations. They consisted of micaceous, silty clays and clayey silts often containing sparse foraminifera.

POST YORKTOWN STRATIGRAPHY

Stratigraphy of the Tributary Streams

Six major post-Yorktown stratigraphic units or facies have been identified in the study area. These units are labeled Q₁ through Q₆. Smaller and local subfacies of these major units are mapped and designated by a small letter symbol, for example bed Q_{2a}. The relative positions and stratigraphic relationships of these beds are shown in table 3, and in cross-sections A-A' through L-L' (figures 6-14 and 17-19).

Units Q₁ and Q₂

The oldest Quaternary beds in the study area, Q₁ and Q₂, are two facies of one transgressive sequence. Q₁ consists of fine to coarse quartz sand with variable amounts of clay. Small wood and plant fragments were encountered in holes A, B, and C traverse B-B'. Grain size often decreases upward as the clay content increases and Q₁ grades into Q₂.

In most areas Q₂ forms a protective cover over Q₁. Where Q₁ crops out it forms a sandy, gentle slope. Numerous springs emerge from these permeable sands and most upland irrigation ponds and shallow wells utilize Q₁ for a good supply of ground water.

Period	Unit	Description
Quaternary	Q ₆	Fine to coarse arkosic sands with scattered pebbles, cobbles, and boulders of metamorphic and igneous Piedmont rock fragments. Cross-bedded. Largely restricted to the margins of the Tar River valley. Deposited as fluvial, and to a minor extent eolian sands in the braided channel system of the ancestral Tar River. Thickness averages about 3 to 6 meters.
	Q ₅	Brown to gray clays to sandy clays. Forms a north-south wedge-shaped profile, elongated parallel to the Tar River valley. Deposited in a restricted, low energy Tar-Pamlico embayment when sea level was about 7 to 8 meters above present sea level. Maximum thickness is about 7 meters.
	Q ₄	Fine sands with minor coarse sands, in places containing abundant rounded, bored wood fragments. Carbonaceous, sandy clay interbeds are common. Deposited as a basal transgressive sequence in the ancestral Tar-Pamlico embayment with unit Q ₄ deposited offshore in deeper water. Usually only 1 or 2 meters thick.
	Q ₃	Fine to coarse sands and pebbles with isolated clay-rich lenses. Characterized by rapid facies changes and large variations in thickness. Deposited within stream valleys tributary to the Tar River.
	Q ₂	Red clays usually grading down to white and blue-gray clays. May be massive and mottled or bedded and laminated. Clay content decreases downward with an increase in sand to sandy clays and into unit Q ₁ . Low energy facies of unit Q ₁ . Deposited in estuarine to shallow marine environments.
	Q ₁	Mostly fine sands with scattered occurrences of fine carbonaceous material. Preserved only in the interstream areas south of the Tar River. Forms a basal sand of the Q ₁ - Q ₂ transgressive sequence.

Table 3. Stratigraphic section of the Quaternary deposits of eastern Pitt County, North Carolina.

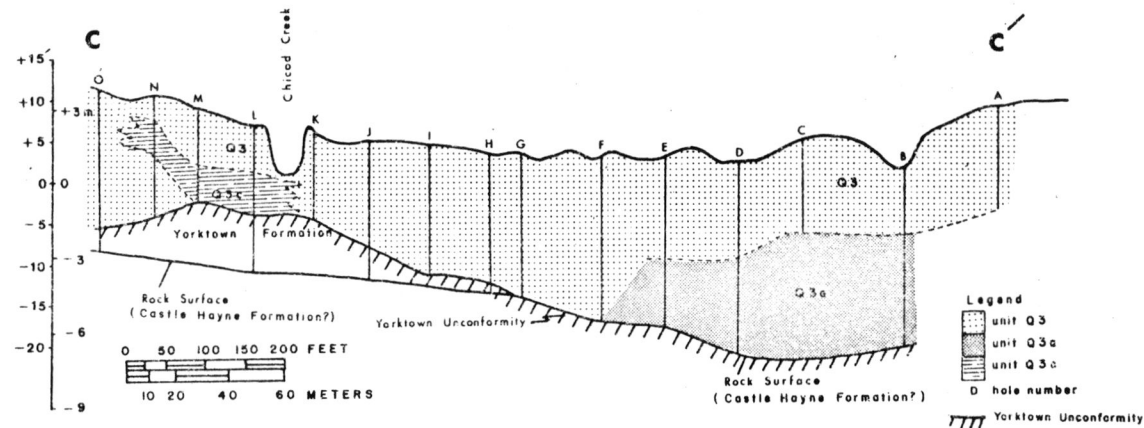


Figure 8. Geologic cross-section of Chicod Creek traverse C-C'

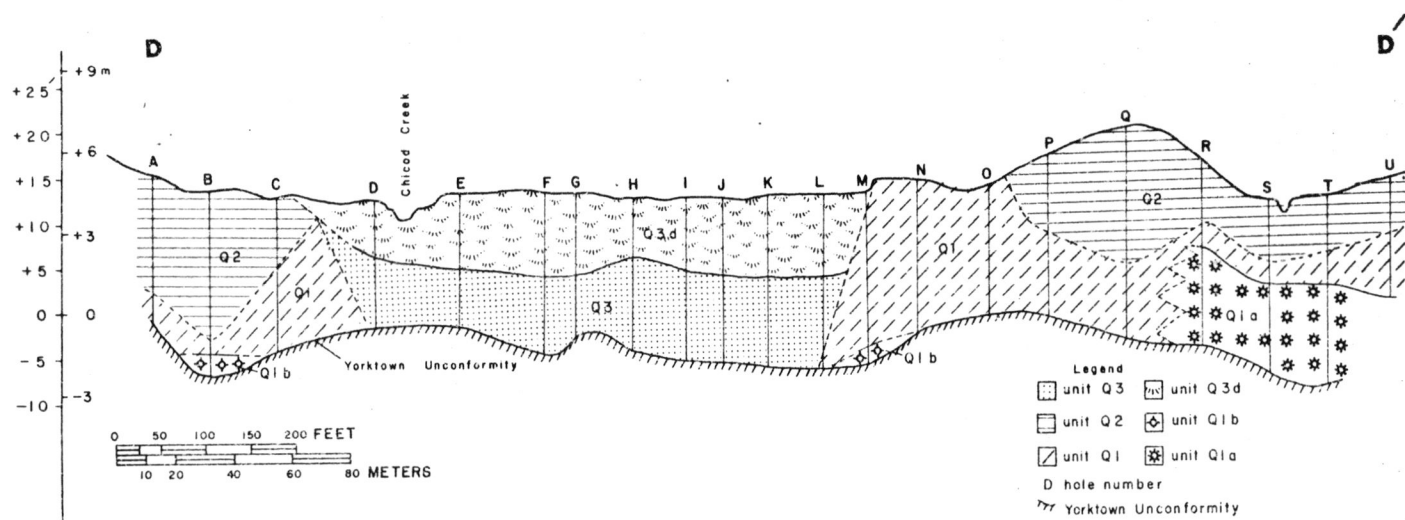


Figure 9. Geologic cross-section of Chicod Creek traverse D-D'

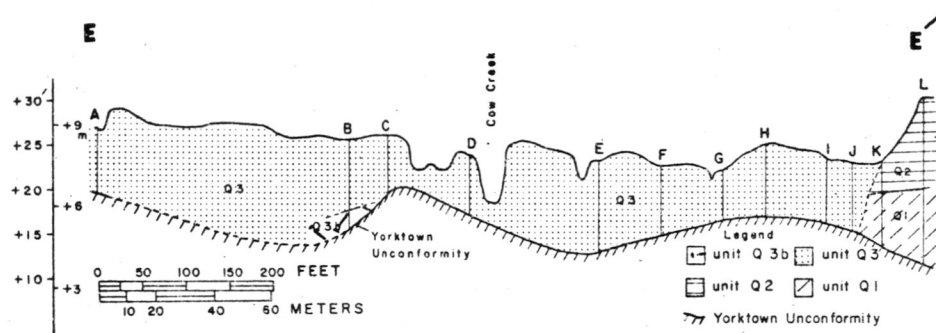


Figure 10. Geologic cross-section of Chicod Creek traverse E-E'

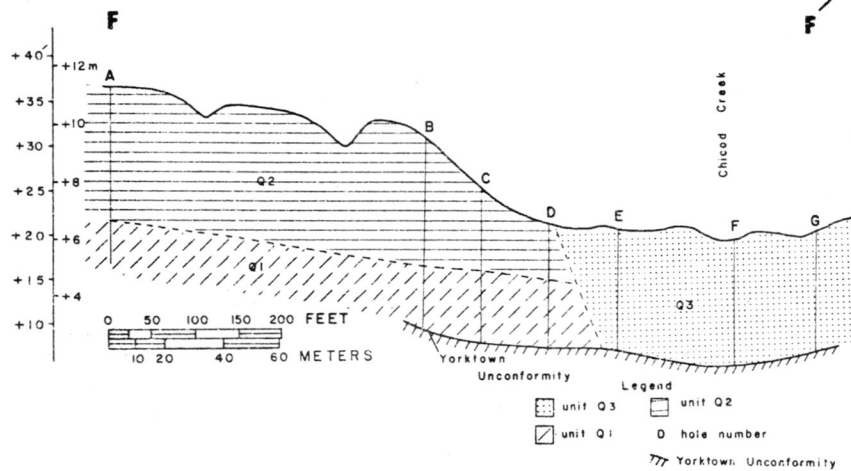


Figure 11. Geologic cross-section of Chicod Creek traverse F-F'

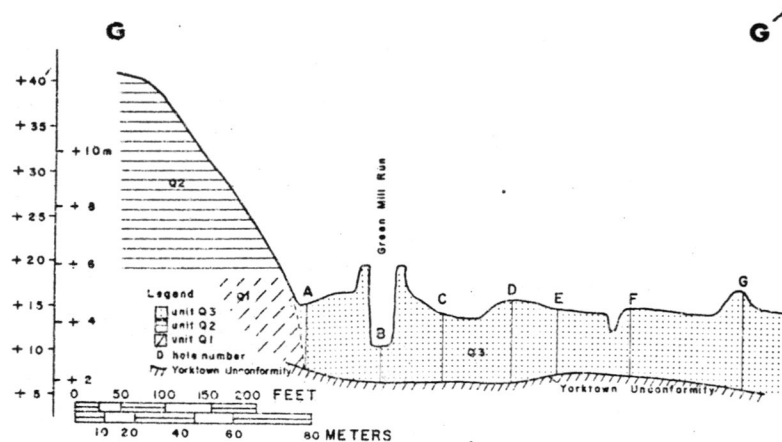


Figure 12. Geologic cross-section of Green Mill Run traverse G-G'

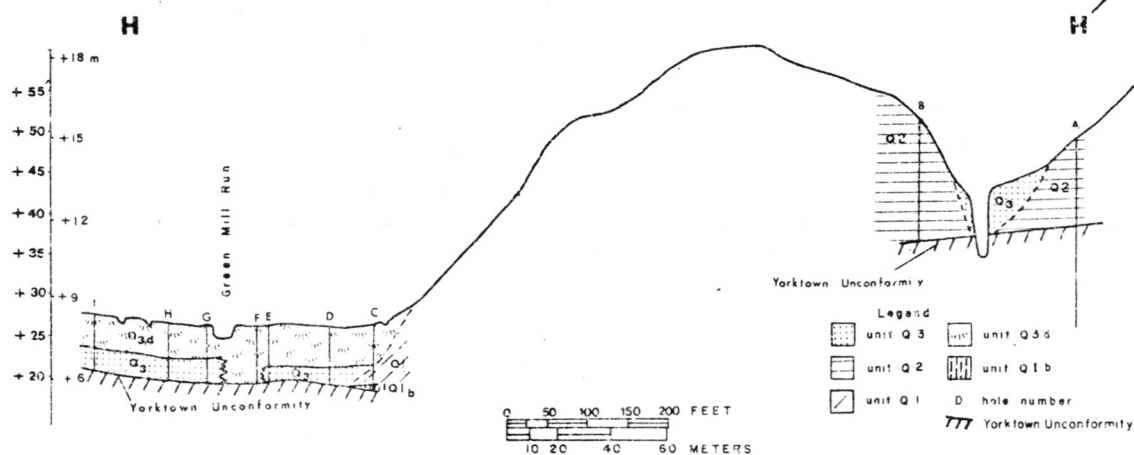


Figure 13. Geologic cross-section of Green Mill Run traverse H-H'

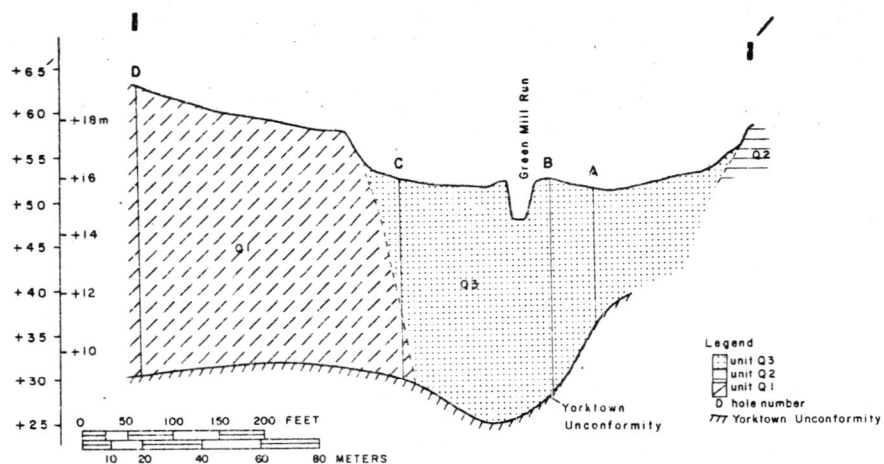


Figure 14. Geologic cross-section of Green Mill Run traverse I-I'

Unit Q₁ is subdivided into two subfacies. Bed Q_{1a} occurs in holes R to U, traverse D-D' and consists of a micaceous, clayey, silty, very fine sand with a trace of glauconite. A 3.4 meter core at hole T showed bedding to be irregular (up to four centimeters thick) with abundant ripple laminae.

Bed Q_{1b} is restricted to lows in the Yorktown Unconformity and consists of a light blue, sandy, silty clay. This bed could be part of the Yorktown Formation, however, the lack of fossils, easy penetration, and restriction to lows in typical Yorktown suggests that it is Quaternary in age.

Unit Q₂ overlies Q₁ and ranges from a massive clay to a highly cross-bedded clayey, fine to coarse sand. Some typical sedimentary structures found in the clayey sands are shown in figures 6 and 7. Cross-bedding is planar to tangential usually consisting of relatively pure clay alternating with laminae of clayey sand. Ripple laminae, as seen above the burrow in figure 6, are common. The coarse sand to small pebble-size grains in figure 7 are clay intraclasts reworked from older clay laminae. The upper part of Q₂ is highly weathered. Red or brownish-red colors grade downward to pale whites and finally to light blue-grays, slightly lighter than the Yorktown Formation. Many of the soils south of Tar River are derived from the weathering of Q₂ and in fields where the topsoil has been removed by erosion, the exposed reddish subsoil is unit Q₂.

Units Q₁ and Q₂ were found only in interstream areas south of Tar River, having been eroded from all larger stream valleys which were subsequently partly filled with a later sequence of sediments.

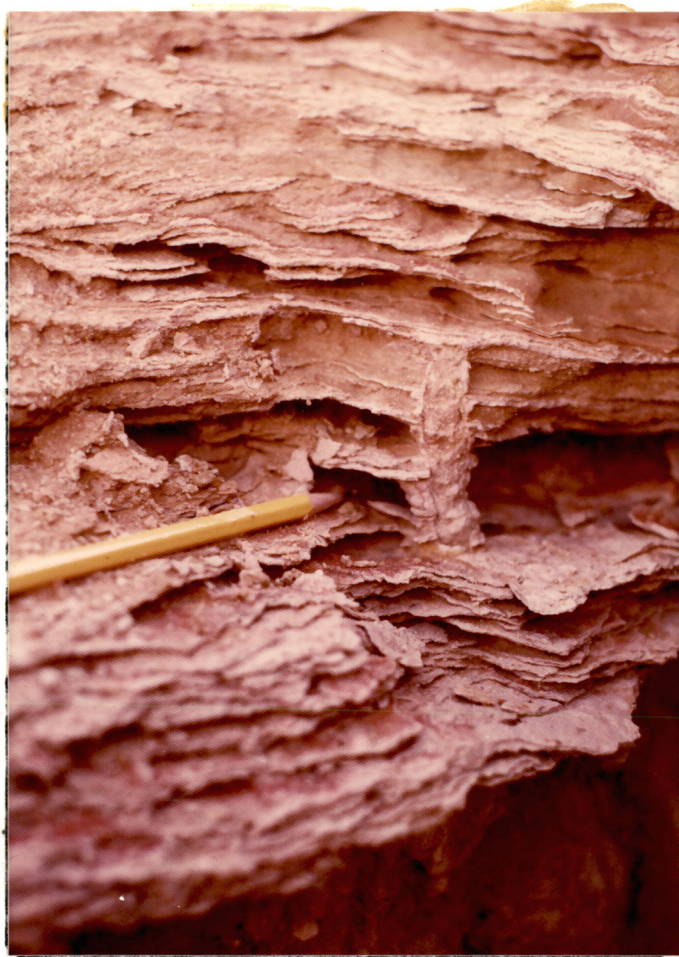


Figure 15. Photograph of Calanasa burrow in Unit Q2. Note the cross-bedded clayey sands above the burrow.

Figure 16. Photograph of planar cross-bedding in Unit Q2. Q2 becomes more massive and less sandy above the Calanasa burrow. Quarter for scale.



Unit Q₃

Unit Q₃ underlies the Green Mill Run and Chicod Creek floodplains. Q₃ consists of fine to coarse sands and pebbles with lesser amounts of clay. The sands are highly variable and individual beds could usually be traced for only short distances. Often there is an increase in reworked sediments with depth as evidenced by the downward increase of glauconite, phosphorite and shell fragments derived from the underlying Tertiary and Cretaceous strata. The clay occurs as isolated clay lenses or pods surrounded by Q₃ sands and as clay laminae only one or two centimeters thick. These clays probably formed as organic-rich floodplain overbank deposits.

The contact between units Q₃ and Q₂ is sharp and easily recognized whereas the contact between Q₃ and Q₁ is not so clear because both are of similar lithology. Also, erosion of Q₁ has contributed a considerable amount of sediment to Q₃, especially near their contact. Therefore, the contact between Q₁ and Q₃ is inferred by projecting the stream valley scarp downward to the Yorktown Unconformity.

There are four recognizable subfacies of Q₃; Q_{3a}, Q_{3b}, Q_{3c}, and Q_{3d}. Bed Q_{3a} consists of a fine to coarse sand of quartz, phosphorite, glauconite, and shell fragments. Samples contained up to fifty percent dark to light green glauconite. These glauconite grains occur in a variety of shapes with the most common being ovoid. The surface of many grains have a botryoidal appearance and the cracks or spaces between each lobe are filled with a dark reddish-brown iron oxide. Such glauconite grains are not unusual as Boyer and others (1977) describe similar sands from New Jersey.

Abundant, fragile, corroded shells and limestone rock fragments derived from the nearby Castle Hayne Limestone or possibly the Beaufort Formation occur with the phosphoritic-glaucinitic sands. The glauconite and phosphorite may have come from erosion of the fossiliferous quartz, phosphorite, glauconite sand which was cored in hole H, traverse A-A'. The contact between the glauconitic sands of unit Q_{3a} and the overlying sediments is sharp and easily recognized; during drilling the water color turns to a rusty brown due to the dissolved iron from oxidation of the glauconite.

Unit Q_{3b} occurs only in cross-section A-A' (Figure 8). This unit is composed of a distinct pale, brownish-gray clay bed. Within the clay are small plant fragments suggestive of some type of grass or reed. The clays are different from those of Q₂, being less compacted and more brown in color.

Holes L, M, and N on traverse C-C' contain an organic-rich fine to medium sand labeled Q_{3c}. Several cores taken at hole L show the section to consist mostly of small twigs and leaves dispersed in a fine to medium sand. Below the organic-rich sand is a 0.3 meter bed of plant remains composed of pine cones, bark, acorns, leaves, and twigs. One piece of wood taken from four meters below the surface (one meter below sea level) was carbon-14 dated at 7920 ± 130 years B.P. Underlying this bed of woody material is a 15 cm thick basal clayey, phosphoritic, quartz sand and gravel resting on the Yorktown Formation. The abundant pine and oak remains are indicative of hardwood forest that occupied this area about 8,000 B.P. (Whitehead, 1972).

Whitehead noted that the gradual growth of the Dismal Swamp in eastern

North Carolina progressively displaced the hardwood forests which were dominant about 8,000 B.P.

Other organic-rich sands encountered in traverse D-D' and H-H' were labeled Q_{3d}. The leaves and twigs of Q_{3d} are very fresh in appearance and are at or near the surface, with a maximum depth of burial of about two meters. The shallow depth of burial and fresh appearance of the plant remains suggest that Q_{3d} may be a much more recent overbank and floodplain deposit.

Environment of Deposition of Units Q₁, Q₂, and Q₃

The relationship between Q₁ and Q₂ and their environments of deposition are well illustrated in an outcrop located approximately one kilometer north of highway 264, adjacent to Green Mill Run. A basal, massive, medium to coarse quartz sand of Q₁ grades upward to a clayey fine quartz sand and sandy clay of Q₂. Within this gradational sequence are abundant burrows of the shrimp Calanasa major and V-shaped burrows of unknown origin. Q₂ is a wavy laminated to thinly bedded clayey sand which "drapes" over Q₁ to form a wedge-shaped unit. The clayey sand laminae result from variations in the sand-clay ratio and are parallel to the slightly dipping Q₁-Q₂ contact. These laminae show a variety of minor sedimentary features. The bedding is disrupted in places by small faults probably produced by dewatering and slumping during compaction. Several channels, about one-third meter in depth and width are cut into Q₂. They contain clay intraclasts floating in the clayey sand matrix of the channel fill. Small-scale ripple cross-bedding and larger-scale wedge-shaped planar cross-beds are common within the transitional area between Q₁ and Q₂. The Calanasa burrows

are found in association with the cross-bedded units as can be seen in figures 6 and 7. The upper part of this outcrop is comprised of a more massive reddish-brown sandy clay typical of Q₂.

Beds Q₁ and Q₂ underlie the interstream divides south of Tar River (figure 2). Their regional distribution is unknown but they extend beyond the study area and may be correlatable with the Windsor Formation in southeastern Virginia (Oaks and others, 1974). The Windsor Formation is described as follows (Oaks and others, 1974):

"The lower member consists of a light-gray medium to coarse grained sand and fine pebble gravel. Silt content gradually increases upward. The upper member consists of gray to purplish-gray clayey sand, silty sand, and silty clay. It is thick bedded and lacks obvious structures."

No fossils were found in the Windsor. The contact between the lower and upper members of the Windsor is gradational. Deposition in a beach and nearshore marine environment is postulated for the lower member and a lagoonal environment is inferred for the upper member. The Windsor Formation corresponds in distribution to the Wicomico Terrace (Isle of Wight Plain) located between the Suffolk and Surry Scarps. A maximum relative sea level rise to +34 meters is indicated during deposition of the upper member (Coch, 1968). The degree of weathering and stratigraphic relationship to adjacent formations suggest the Windsor is middle Pleistocene or possibly Sangamon in age (Coch, 1965).

Beds Q₁ and Q₂ are tentatively correlated with the lower and upper members of the Windsor respectively on the basis of their lithologic and stratigraphic similarities. Thus Q₁ and Q₂ correspond, at least in part, to Wentworth's (1930) Wicomico Formation.

Oaks and Dubar (1974) consider the Windsor to be equivalent to

the Waccamaw Formation in South Carolina. According to Dubar and others (1974), the upper member of the Waccamaw is a well sorted fine to medium sand, in places impregnated with humate. The lower member consists of clayey sands, fine to coarse sands, or very fine to fine sands, all containing abundant brackish-water to shallow-shelf faunal assemblages. The Waccamaw was deposited below the Surry Scarp during a sea level stand at +30 to +33 meters. A variety of facies are recognized in the Waccamaw. These range from open ocean to back barrier lagoon.

The outcrop of units Q_1 and Q_2 on Green Mill Run is interpreted to be a sand bar (Q_1) deposited in a tidal channel with the clay-rich sediments (Q_2) representing low energy tidal flat or marsh deposition which migrated over the channel sands. The Calanasa burrows indicate water of normal salinity and are usually regarded as beach-shoreface indicators. However C. major can exist on exposed channel sides of point bars where tidal currents are fairly strong and where the substrate is muddy sand to sandy mud (Howard and Frey, 1973). Deposition is thought to have occurred during a transgression. Q_1 was deposited in tidal and near-shore marine environments and Q_2 was deposited in tidal, lagoonal, and estuarine environments.

The sediments of unit Q_3 were deposited in stream valleys eroded in Q_1 and Q_2 during subsequent periods of emergence. According to Colquhoun (1966, 1969, and 1974), flat-floored, U-shaped stream valleys of the continental submerged cycle are underlain by sediments of three sequential stages of deltaic, marsh, and estuarine environments. Characteristic geometry and sediment types were developed during each

stage. The delta contains the coarser-grained sediment, the marsh is composed of organic-rich clays, and the estuarine stage contains finer-grained sands and clays. However, Colquhoun's work is only partly applicable to the Pitt County area since his studies were made on larger Coastal Plain trunk rivers in South Carolina where sediment loads are greater. Coastal Plain tributaries and small rivers such as the Tar have much lower levels of sediment transport. Furthermore, a large proportion of the suspended sediment load is deposited in the drowned mouths of tributary streams (Hartness, 1977). Upstream, deposition of coarser material is believed to be taking place by stream aggradation in response to a rising sea level. As sea level rises there is a broad transition zone where stream gradients decrease and velocities slacken upstream from the drowned stream valley. Consequently, the streams lose much of their coarser sediment load before reaching the estuary. Over a period of time stream aggradation would result in a thick sequence of valley fill composed of fluvially deposited sands. The rate of valley aggradation would be dependent on a variety of factors such as volume and type of sediment delivered to the system, flow characteristics of the stream, stream valley shape and gradient, and rate of sea level change.

Historical evidence supports the concept of stream aggradation. This process is often presented as evidence to support the continued need for channelization of Coastal Plain streams. It is argued that rates of stream aggradation have increased in response to increased areas of farmland. The clearing of forest and extensive cultivation which followed European settlement of the Coastal Plain and Piedmont

have accelerated erosion and denudation of the land surface (Meade, 1969). Trimble (1970) showed that parts of the Alcovy River in the Georgia Piedmont have aggraded over five meters within the last 100 years. The preliminary Environmental Impact Statement for Chicod Creek stated that erosion induced by cultural development has resulted in filling Chicod Creek with soils eroded from cultivated fields (U.S. Dept. of Agriculture, Soil Conservation Service, 1972). Thus it appears that man has accelerated a natural process that has been taking place for thousands of years.

The final Chicod Creek Environmental Impact Statement suggests that filling of Chicod Creek continues (U.S. Dept. of Agriculture, Soil Conservation Service, 1974a). According to this report, almost 9.5 million kg of sediment are entering Chicod Creek per year and only 75,000 kg per year are delivered to Tar River. If these estimates are correct, then some 9.3 million kg per year of sediment remain in the Chicod Creek drainage system. Over several hundred years this annual volume of sediment would be sufficient to cause considerable aggradation of the stream valley. However, I was unable to discern obvious recent valley fill. Cypress trees and stumps several hundred years or older which occur along or near the stream banks show no apparent signs of sediment burial. Usually only 30 to 60 cm of fairly recent floodplain sediments were encountered in drill holes. Except for bed Q_{3d}, no evidence was found to indicate a very recent age for Q₃ such as buried stumps, logs, floodplain soils, or plant material.

In the Roanoke Island area, the Holocene sea level rise began between 18,000 and 15,000 years ago when the sea stood nearly 100 meters

below present sea level (O'Connor and Riggs, 1977). Since then sea level has risen to its present position; the sea initially rose fairly rapidly and has most recently been rising relatively slowly. If the carbon-14 age date from Chicod Creek is valid, it would suggest that the creek has aggraded about four meters in the last 8,000 years as sea level rose from about -13 meters to its present level.

Chicod Creek and other streams on the lower Coastal Plain have been affected by the recent rise in sea level. But it is questionable whether all of Q₃ was deposited during the most recent sea level rise or if parts of the unit were deposited during earlier periods of submergence. For example, units Q₄ and Q₅ were deposited when sea level was at about +7 meters. This height would have been sufficient to drown the streams in the study area and elsewhere in eastern North Carolina. Thus Q₃ probably represents valley fill from more than one period of deposition.

Whether Chicod Creek and Green Mill Run follow lows in the underlying Yorktown Unconformity is not clear. The Yorktown Unconformity appears to be a very irregular surface, at least adjacent to the stream valleys. Cross-section D-D' shows no well developed low in the Yorktown Unconformity under the Chicod Creek valley whereas the valley overlies a prominent channel in the Yorktown in cross-section A-A'. In other areas the stream valley is adjacent to a low in the Yorktown Unconformity which appears to have had no affect on the stream. Therefore, the Yorktown Unconformity does not appear to have influenced the characteristics of Chicod Creek or Green Mill Run. This conclusion is supported by the lack of any observed sedimento-

logical change in beds Q_1 and Q_2 as they approach these stream valleys. Furthermore, the lows in the Yorktown Unconformity beneath Q_3 may have been produced during a later period of emergence when stream erosion and downcutting could have intersected the Yorktown Unconformity.

Stratigraphy of the Tar River Valley

Units Q₄ and Q₅

Units Q₄ and Q₅ are an interrelated sediment facies restricted to the Tar River Valley (figures 17-19). Unit Q₄ is composed of mostly fine to coarse-grained quartz sand which in places contains up to several percent phosphorite, glauconite, feldspar, and heavy minerals. The coarser sands usually occur in the lower part of Q₄ as seen in holes G (traverse J-J') and B (traverse L-L'). All holes drilled through Q₄ in traverse L-L' contained abundant wood and plant fragments in a matrix of fine-grained micaceous sand. Most of the organics are fragile, small leaf fragments and plant stems and the larger pieces of wood are highly rounded and often bored, probably by the boring clam Teredo (figure 20). Also, a boulder of carbonate cemented sandstone dredged from a sand pit adjacent to hole B contained soft unidentifiable shell fragments believed to have come from Unit Q₄.

Units Q₄ and Q₃ are similar in sediment character. However, when closely examined their differences stand out. For example, the clays in Q₄ are dark gray and micaceous whereas those of Q₃ tend to be brown. Also the sands of Q₄ are more homogenous, micaceous, and finer-grained than those of Q₃.

Unit Q₄ contains numerous thin, dark gray, micaceous, carbonaceous, fine sandy and silty clay beds and laminae. However, they are generally too thin and discontinuous to be mapped. The only exceptions occurred in holes D and E (traverse J-J') and A and B (traverse L-L') where distinctive clay beds, about 30 cm thick, were mapped as unit Q_{4a}.

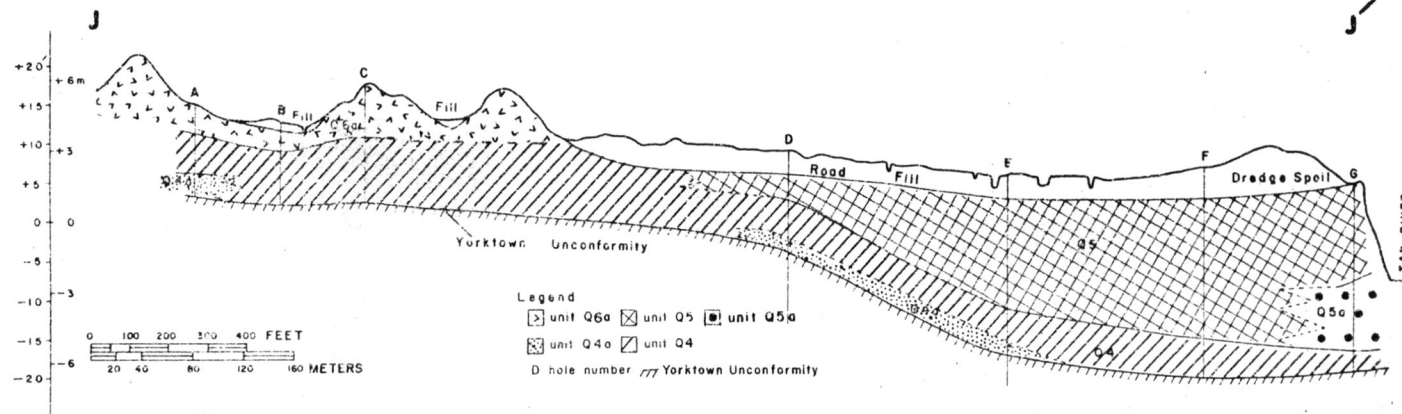


Figure 17. Geologic cross-section of Tar River traverse J-J'

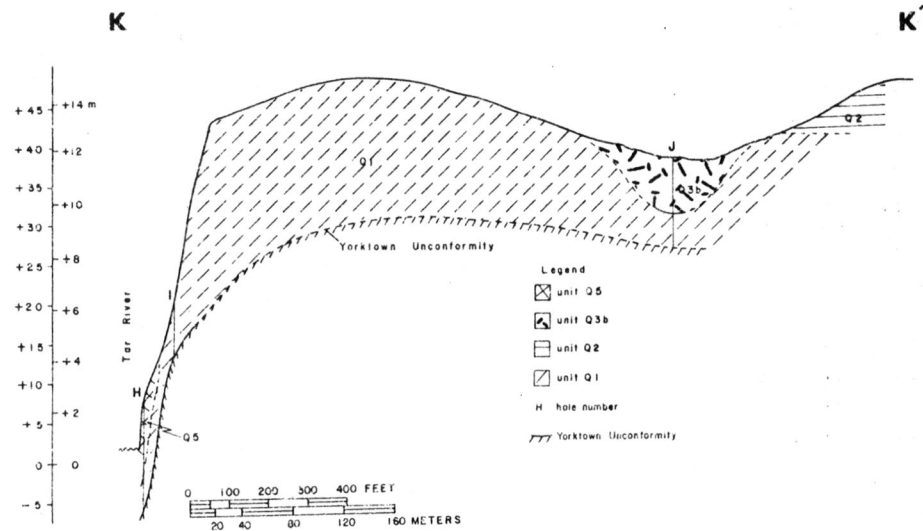


Figure 18. Geologic cross-section of Tar River traverse K-K'

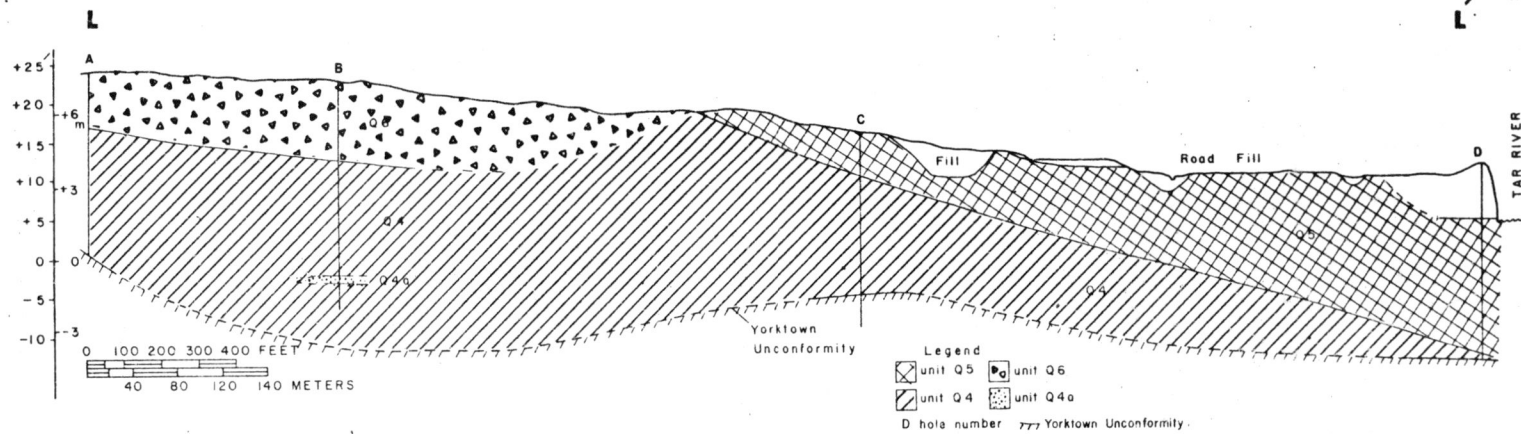


Figure 19. Geologic cross-section of Tar River traverse L-L'



Figure 20. Photograph of selected pieces of wood from bed Q₄. Although it cannot be seen, most pieces of wood are pitted with shallow borings produced by boring invertebrates.

Unit Q₅ overlies unit Q₄ and usually underlies 30 to 60 cm of recent floodplain deposits throughout most of the Tar River floodplain. This unit is a reddish-brown to pale gray and light blue-gray sandy to slightly silty clay with a sharp to gradational contact with Q₄. In hole G (traverse J-J') the gradational sequence is about three meters thick and is mapped as unit Q_{5a}. In a direction normal to the Tar River Valley, Q₅ exhibits a wedge-shaped cross-section which thickens toward the channel (figures 17 and 19). The Tar River has a strong tendency to be located along the southern margin of Q₅. Consequently, most of the Tar River floodplain, which is widest and best developed on the north side, is underlain by Q₅ whose impervious clays contribute to maintenance of the floodplain environment. South of Tar River Q₅ occurs as erosional remnants with the only known outcrop located at Rainbow Banks, about six kms southeast of Greenville. This outcrop of Q₅ is about two meters thick and consists of a gray, clayey sand.

Unit Q₆

Unit Q₆ is exposed in numerous sand pits occurring along the north side of Tar River from Tarboro to Washington. Q₆ is a sequence of fine to coarse, cross-bedded, arkosic, quartz sands and pebbles with minor cobbles and boulders. The sand is often subangular to angular with a trace to several percent of heavy minerals, and several percent or more of feldspar. In a sand pit 2.5 kms upstream from the Greenville airport and 1.5 km northeast of the Tar River, Q₆ contained boulders up to one-half a meter in diameter (figure 21). These boulders are comprised of a variety of Piedmont rock types such as "Carolina Slate",



Figure 21. Photograph showing samples of cobbles and boulders from bed Q₆ in a sand pit north of Tar River several kms north of Greenville, North Carolina.

diabase, schist, gneiss, vein quartz, and several types of granite. There are also rounded quartzite boulders similar to those of the Citronelle Formation. The size and lack of rounding suggests that they may have been rafted in the roots of floating logs. Similar boulders found in the Waccamaw Formation in southeastern North Carolina and coastal South Carolina are postulated to have been transported in this manner (Henry S. Johnson, personal communication, 1975). Also it is possible that these boulders could have been transported in floating blocks of ice.

Holes A, B, and C in traverse J-J' penetrated a medium well sorted, clean quartz sand, assigned to bed Q_{6a} which overlies Q₆. These sands comprise three separate ridges of one larger ridge which is approximately 400 meters wide. There are numerous ridges on the northern portion of the Tar River floodplain. Several outcrops of Q_{6a}, exposed along logging roads in the area of traverse J-J', show the unit to be composed of slightly weathered, structureless, light brown, fine to medium quartz sand. Another ridge shown at the edge of the river (traverse J-J') is composed of spoil dredged from the river in 1939 (U.S. Army Corps of Engineers, 1973). Another ridge located adjacent to the Tar River in traverse L-L' does not appear to be a spoil bank and is interpreted to be a natural levee.

The sediments of Q₆ are only slightly weathered. Soils are thin and the feldspars and heavy minerals are fresh in appearance. This suggests a young age for Q₆. Also, areas underlain by Q₆ exhibit a braided topography (Dubar and others, 1974). Braided topography consists of parallel to subparallel swales or ridges whose long axes

tend to parallel the river valley. Braided topography is evident on soil and topographic maps (figure 22). The pattern shown in figure 22 consists of parallel to near parallel groups of soil types which together form an overall sinuous belt paralleling the Tar River. The braided topography reflecting Q₆ has a relief of about two meters. Occasionally, ridges are much higher, an example being the ridge outlined on traverse J-J'.

Gravel and sand deposits, similar to Q₆, occur along Coastal Plain rivers from North Carolina to Georgia. These deposits are located north and east of these rivers, with lesser amounts occurring on the southern and western margins. Monrad (1972) concluded that similar sands were deposited by a braided stream in the Pee Dee River valley between 18,000 and 5,000 years ago. He believed that the meander scars on the surface of these sands were subsequently produced when the river migrated across this terrace. Crissman (1973) identified the same type of sand deposits in the Neuse River valley, North Carolina. He thought these sands were deposited about 5,000 years ago when stream discharge was much greater than at present. He believed that the sands were deposited as fluvial point bars by lateral migration of the Neuse River during the waning stages of the Late Wisconsin glaciation. Similar fluvial deposits along the Lumber, Pee Dee, and Waccamaw rivers in South Carolina and North Carolina are thought to have been deposited between 36,000 and 17,000 years ago (Dubar and others, 1974). They note that these fluvial sediments seldom exceed 10 meters in thickness.

Figure 22 (see next page). Aerial photo mosaic of the study area showing the pattern of soil types. Note the elongate soil pattern bordering the northern 3 km of the Tar River. A similar soil pattern is located to the south of the Tar River on the Tar River Terrace and within the large river meander near the center of the mosaic. Approximate scale is 1:15840 (1 cm = 0.16 km). Modified from U.S. Department of Agriculture, 1974.



Environment of Deposition of Units Q_4 , Q_5 , and Q_6

Beds Q_4 , Q_5 , and Q_6 are restricted to the Tar River Valley and its margins. Therefore, processes responsible for deposition of these units are closely associated with changes that have occurred in the river regime. The wedge-shaped cross-section and the linear trend parallel to the Tar River Valley indicate that deposition of Q_4 and Q_5 occurred in a narrow, restricted, asymmetric embayment on the order of about one kilometer wide. The waters in the embayment were probably brackish, as indicated by the abundance of bored wood in Q_4 . Q_4 and Q_5 form a transgressive sequence. Q_4 was deposited nearshore in shallow water while the muds of Q_5 formed further offshore in deeper, quieter water.

Q_4 and Q_5 were deposited in an estuary when sea level was about 8 meters above present level. A corresponding sea level rise has been noted elsewhere along the Atlantic Coastal Plain (Oaks and Dubar, 1974), who noted relative sea levels of between 6 and 8 meters for deposition of the Socastee, Londonbridge, and Sand Bridge formations. In eastern North Carolina the Pamlico sea stood at a relative elevation of +6 meters (Daniels and others, 1977). Q_4 and Q_5 may represent sediments deposited in the lower reaches of the drowned Tar River Valley during Pamlico time.

Following deposition of Q_4 and Q_5 , sea level dropped and unit Q_6 was deposited by a rejuvenated Tar River. Q_6 can be shown by its characteristic braided topographic pattern to extend across Pitt County parallel to the Tar River Valley. This would indicate that Q_6 once covered the Tar River Valley to a width of between two and three kilometers and to a depth of between 3 and 8 meters. Subsequent erosion

has removed most of Q_6 from the present Tar River floodplain.

THE TAR RIVER TERRACE

The Tar River occupies an asymmetric valley. The north side of the river is characterized by a broad floodplain having a gradual increase in elevation away from the river. In contrast, the south side has a generally narrow floodplain bordered by a steep valley scarp. Such an asymmetry is common to most Coastal Plain rivers in the southeast and is thought to have resulted from southward migration. Numerous theories have been offered to explain this phenomenon (Eakin, 1910; Hack, 1955; Schlee, 1957; White, 1966). These theories are summarized by Monrad (1972). In addition, some Coastal Plain rivers such as the James, Pee Dee, and Waccamaw are bordered by one or more terraces (Coch, 1965; Dunbar and others, 1974; Monrad, 1972). The Tar River is also bordered by a prominent terrace which is best developed on the south side of the river (figure 2) and is herein named the Tar River Terrace.

A terrace on the north side of the river is less clear, due mostly to a lack of good topographic maps. The land surface seems to rise at an even rate from the border of the floodplain to an elevation of about 12 meters. However, Benton and Slaughter (1971) note a terrace paralleling the north side of Tar River at an elevation of 12 to 18 meters. Also, White (1966) shows the presence of what he calls fluvial terraces on the northeast side of many Coastal Plain rivers including the Tar.

The Tar River Terrace consists of discontinuous segments with the intervening areas eroded by the Tar River and its tributaries.

The Tar River Terrace extends from at least 16 kms west of Tarboro, at an elevation of 21 to 24 meters, eastward to Washington where it disappears beneath the modern floodplain and the Pamlico River.

The Tar River Terrace extends about four miles up the western side of Chicod Creek and probably extends up other tributary stream valleys on the south side of the river. The 1902 and 1903 U.S.G.S. topographic maps and the 1974 U.S. Department of Agriculture soil maps show the location of the Tar River Terrace fairly well. Soils covering the terrace exhibit an elongate pattern parallel to the Tar River identical to the soil pattern in the areas north of the river which are underlain by unit Q_6 . The Tar River Terrace is bordered on the south by a steep scarp 7 to 13 meters high which rises onto the Wicomico Terrace (figure 2). Most of the scarp is erosional in origin, having been cut into beds Q_1 and Q_2 . The scarp is difficult to recognize in many places due to secondary modification. For example, where the scarp extends up Chicod Creek, a lobe of sand projects from the scarp onto the terrace. In other areas, such as along the scarp east of Hardee Creek and for most of Chicod Creek, stream dissection of the scarp has made its identification difficult.

The sediments underlying the Tar River Terrace are cross-bedded, fine to coarse arkosic sands. These sediments were well exposed during the construction of a sewer system east of Hardee Creek. In some places the ditches were deep enough to expose the underlying Yorktown Formation at depths of about 3 meters. Outcrops of these sands are found in numerous irrigation ponds, and with some digging they can be exposed in the scarp separating the Tar River Terrace from

the Tar River floodplain. Also numerous springs originate where this scarp intersects the top of the Yorktown Formation.

GEOLOGIC HISTORY

During the emergence of the Atlantic Coastal Plain following deposition of the Yorktown and related Tertiary formations, an irregular unconformity was developed on the exposed surface of the Yorktown. Piedmont rivers extended eastward over the exposed Yorktown sediments as a network of Coastal Plain tributaries formed. Subsequent changes in sea level have resulted in the deposition of numerous Quaternary stratigraphic units which record a series of submergent and emergent cycles.

Detailed stratigraphic mapping in southeastern Virginia has delineated six post-Yorktown submergent-emergent cycles which are represented by the following sediment units: (1) Sedley-Bacons Castle, (2) "Moorings", (3) Windsor, (4) Great Bridge-Norfolk-Kempsville, (5) Londonbridge-Sand Bridge, and (6) various Holocene units (Coch, 1965; Oaks, 1965; Oaks and Coch, 1973; Oaks and Dubar, 1974; Oaks and others, 1974). Units of each group were deposited during submergent phases of emergent-submergent cycles. Their work has resulted in the following interpretation. The Sedley Formation extends west of the Surry Scarp, followed by a drop in sea level and deposition of the Bacons Castle. The second submergent-emergent cycle began when the shoreline of the "Moorings" sea formed the Surry Scarp at +37 to +38 meters with lagoonal sediments deposited further west. The Windsor sea transgressed to the base of the Surry Scarp at elevations between +27 and +30 meters. Following deposition of the Windsor, the sea receded east to the location of the present coast. The sea transgressed to between +13 and +15 meters to form the Suffolk

Scarp and deposit the Norfolk Formation. Sea level then dropped to between +16 and +7 meters to form the Kempsville Formation followed by further regression to -3 meters. The last Pleistocene sea level rise, to between +7 and +8 meters, resulted in deposition of the London-bridge and Sand Bridge formations over 40,000 years ago. The subsequent Holocene deposits resulted from the rise in sea level during the last 18,000 to 15,000 years.

In a similar fashion, submergent-emergent cycles have been recorded by post-Yorktown units identified within the study area of eastern Pitt County. Table 4 shows the correlation of four post-Yorktown units with those in the surrounding areas. Following the creation of the Yorktown Unconformity, the first transgressive sequence deposited beds Q_1 and Q_2 in nearshore-estuarine environments. Subsequent erosion by Tar River and its tributaries removed these units from large areas north of the Tar River and from the larger tributary stream valleys. Within the study area Q_1 and Q_2 are restricted to interfluves south of the Tar River and form the surface of the Wicomico Terrace.

Beds Q_1 and Q_2 are thought to be equivalent to the Windsor Formation in southeastern Virginia (Coch, 1965) and the Waccamaw Formation in South Carolina and southeastern North Carolina (Oaks and others, 1974). Oaks and Dubar (1974) suggest a stratigraphic correlation between the Windsor and Waccamaw formations. They also suggest that an unnamed unit traced along the eastern edge of the Surry Scarp in central North Carolina may correlate with the Windsor and Waccamaw. This unnamed unit consists of a lower coarse-grained sand unit and an

Table 4. Correlation of stratigraphic units in southeastern Virginia, eastern North Carolina, and South Carolina with those in eastern Pitt County, North Carolina.

Southeastern Virginia (Oaks and others, 1974)	Southeastern North Carolina and South Carolina (Dubar and others, 1974)	Eastern Pitt County (This paper)
Londonbridge and Sand Bridge formations	Socastee Formation and Pamlico morphostratigraphic unit	Units Q ₄ and Q ₅
Norfolk Formation	Canepatch Formation	No recognized equivalent unit in the study area
Windsor Formation	Waccamaw Formation	Units Q ₁ and Q ₂

upper fine-grained sand unit. Daniels and others, (1969) show that this unit is truncated by the Surry Scarp at Fountain in western Pitt County. I believe that Units Q₁ and Q₂ probably extend west to the eastern edge of the Surry Scarp and are facies equivalents with the unnamed unit of Daniels and others (1969).

The characteristics of Q₁ and Q₂ are very similar to those of the Windsor Formation. The lack of fossils and more extensive nearshore-lagoonal facies in southeastern Virginia and central North Carolina suggest a more restricted marine environment in these areas in contrast with the more open marine conditions of the Waccamaw in South Carolina.

Following deposition of Q₁ and Q₂ the sea retreated to a position east of the study area. No evidence exists for a subsequent rise in sea level higher than +15 meters; thus Q₁ and Q₂ in the interflaves have apparently been exposed to weathering and erosion since their emergence.

The evidence of a second submergent cycle comes from other studies in southeastern Virginia, North Carolina, and South Carolina. A marine

transgression of +13.7 to +15.2 meters is indicated by deposition of the Norfolk Formation in Virginia and the Canepatch Formation in South Carolina. According to Oaks and others (1974), the Norfolk consists of a coarse-grained lower member, restricted to areas east of the Suffolk Scarp, and an upper member which is divided into eight facies. Only two facies extend west of the Suffolk Scarp; one forms the surface of the Hall Pocosin Flat in northeastern North Carolina and the second forms flat-topped stream valley fill. In South Carolina, the Canepatch consists of nine facies with a maximum submergence of +13.7 meters (Dubar and others, 1974). In eastern North Carolina Dubar and others (1974) correlate the Flanner Beach Formation with the Canepatch. They suggest that the Flanner Beach sediments accumulated in a brackish-water embayment behind the Reelsboro Barrier (Suffolk Scarp). A maximum sea level rise of +12 to +13 meters is indicated. In eastern North Carolina Daniels and others (1977) consider their Talbot Morphostratigraphic unit to comprise the lower part of the Reelsboro Formation with a maximum sea level stand of about +15 meters.

A sea level rise of between 12 and 15 meters would inundate large areas of eastern Pitt County and would drown nearly all stream valleys in the study area. The resulting sedimentation would produce the flat-topped valley fill of unit Q₃ similar to the valley fill of the Norfolk Formation west of the Suffolk Scarp in southeastern Virginia. Inundation of the Tar River would have produced an extensive estuarine embayment which would have extended west of Tarboro and covered most of the Tar River Terrace and a wide belt of land north of the Tar. One area north of the Tar which would have been submerged is Grindle

Pocosin located about 6 km north of Greenville. Grindle Pocosin is a gently sloping plain ranging in elevation between +12 and +15 meters and is underlain by clay-rich sediments. Grindle Pocosin may be of a similar origin and age to the Hall Pocosin Flat described by Oaks and others (1974).

Units Q₄ and Q₅ were deposited at a lower sea level stand. The highest elevation of Q₅ suggests a minimum sea level of around +7.6 meters, sufficient to inundate the Tar River Valley. Q₄ was deposited in shallow brackish water very close to shore while Q₅ formed as soft muds in deeper, quieter water. This setting is almost identical to the one found today along the Pamlico River.

The stream valleys of Green Mill Run and Chicod Creek were also partly submerged during this time. The sediments that were deposited in their valleys are indistinguishable from other valley fill and therefore classified with unit Q₃.

A corresponding sea level rise, following the earlier submergent-emergent cycle that deposited the Norfolk and Canepatch is observed by Oaks and Dubar (1974). They note the deposition of numerous units such as the Socastee, Londonbridge, Sand Bridge and Pamlico when sea level was at approximately +8 meters. In eastern North Carolina, Daniels and others (1977) show a relative elevation of +6 meters during the Pamlico high stand of sea level.

Following deposition of Q₄ and Q₅, sea level dropped to a position far out on the Continental Shelf. During this period of emergence and prior to the Holocene rise in sea level, a rejuvenated Tar River transported and deposited a sequence of mostly coarse arkosic sands of Unit

Q₆. Most of the Tar River Valley was filled by these sediments to depths of from 3 to 8 meters.

The ancestral Tar River which deposited Q₆ was a high discharge stream choked with sediment, much larger than the modern Tar River. This change in the river's regime may have been in response to changing climatic conditions during the Holocene. Pollen studies by Whitehead (1972) show a unidirectional climatic amelioration from conditions comparable to those in New England during the full Wisconsin glaciation to a climate comparable to the present by 8,000 B.P. The change from boreal to more temperate climatic conditions may have been accompanied by increased runoff, possibly from meltwater in the Tar River's headwaters. As the river debouched upon the gently sloping Coastal Plain the reduction in gradient and competency would trigger deposition and filling of the river channel and formation of a braided river system.

The Tar River has only recently evolved to its present character. Therefore a large percentage of its bedload is composed of this relict sediment, which was deposited at greater discharge velocities. The modern Tar River may be incompetent to transport this sediment, which may in part account for the lack of a delta at the river mouth.

All evidence indicates that the Tar River has maintained its present position through each submergent-emergent cycle. The evidence is less clear for the tributary streams, Chicod Creek and Green Mill Run. There are no obvious channels in the Yorktown Unconformity beneath the present position of these streams. This would indicate no strong control on their development by the Yorktown Unconformity. Instead, it appears that these two streams originated on the exposed Wicomico

surface following deposition of units Q_1 and Q_2 . Green Mill Run and Chicod Creek developed during times of emergence followed by filling of the stream valleys during periods of submergence. Therefore, the valley fill of Q_3 appears to be of more than one age with evidence of at least four episodes of submergence during which parts or all of these stream valleys could have been filled. Also sedimentation was not restricted to the drowned segments of the stream valleys. This is illustrated by the upstream aggradation of Chicod Creek where filling began over 8,000 years ago when sea level was at -12 meters. The continuing rise in sea level has resulted in a progressive filling of the lower segments of streams in the study area. A large percentage of the suspended sediment is transported into swamps and tributary streams along the Tar River. The coarser clastics are deposited by fluvially aggrading streams, within a broad transition zone where velocities decrease, near the upper reaches of the drowned Tar River Valley.

CONCLUSIONS

A summary of the geologic and resulting stratigraphic units of the Coastal Plain streams of eastern Pitt County, North Carolina is presented below. The geologic history is presented in order of interpreted occurrence from oldest to youngest.

1. Regression of the Yorktown sea was followed by the erosional development of the Yorktown Unconformity and creation of the ancestral Tar River Valley.
2. Marine transgression, probably to the base of the Surry Scarp at +27 to +30 meters, produced the nearshore marine and lagoonal or estuarine environments in which units Q_1 and Q_2 were deposited. The Windsor and Waccamaw formations in southeastern Virginia and South Carolina, respectively, are considered to be lateral equivalents.
3. Marine regression followed causing Q_1 and Q_2 to be eroded from the present stream valleys.
4. Possible marine transgression to around +15 meters is indicated from other Coastal Plain studies. However no clear record of this transgression exists in the study area.
5. Possible regression of sea level to a location east of the study area took place along with the rejuvenation of Coastal Plain streams.
6. Marine transgression proceeded to an elevation of about +7.6 meters. The lower reaches of Tar River were embayed with units Q_4 and Q_5 deposited within the estuary. Q_4 was deposited in shallow water close to shore while Q_5 was deposited as soft muds in deeper water.

7. Sea level dropped to a position far out on the Continental Shelf.
Unit Q₆ was deposited by a rejuvenated Tar River.
8. Holocene rise in sea level began between 15,000 and 18,000 years ago and continues today with a gradual drowning of coastal lowlands and upstream inundation of the lower Coastal Plain streams. The uppermost sequence of unit Q₃ was deposited.

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APPENDIX

A total of 100 holes were drilled within the study area. Most observations of sediment characteristics were made on cuttings as each hole was drilled. Later, a binocular study was made of the sampled core and cuttings. Because of their generally poor quality, most descriptions given of the cuttings list only the general sediment type and average grain size. All down-hole footage is given in meters.

The following abbreviations are used to denote each Tertiary or Cretaceous formation penetrated in the drill hole:

Yorktown Formation	Ty
Beaufort Formation	Tb
Castle Hayne Limestone	Tch
Cretaceous undifferentiated	K

Depth (in meters)	Type of drill hole information	Description	Unit
<u>Cross-section A-A', Chicod Creek</u>			
<u>Hole A</u>			
0-4	cuttings	Fine to coarse quartz sand with a 4 cm basal quartz, glauconite, phosphorite gravel--drilling water turns brown in color	Q ₃
4		Yorktown Unconformity	
4-4.2	15 cm core	Clayey, silty, very fine to coarse quartz sand, light gray, trace of phosphorite	Ty(?)
<u>Hole B</u>			
0-4.5	cuttings	Medium to coarse quartz sand, clean and well sorted	Q ₃
4.5-5.1	cuttings	Fine to medium quartz sand with about 20% of nearly equal amounts of phosphorite and glauconite sand grains	Q _{3a} or Q ₃
5.1		Yorktown Unconformity	
5.1-5.3	15 cm core	Very fine, slightly quartzose carbonate with 10 to 20% mixed glauconite and phosphorite, well compacted and hard to core	Tb(?)
<u>Hole C</u>			
0-4.5	cuttings	Fine to coarse quartz sand	Q ₃
4.5-5	cuttings	Fine to medium phosphorite, glauconite, quartz sand	Q _{3a}
5		Yorktown Unconformity	
5	no sample	Rock surface	Tch(?)

Depth (in meters)	Type of drill hole information	Description	Unit
<u>Hole D</u>			
0-2.4	cuttings	Fine to coarse quartz sand	Q ₃
2.4-4.2	cuttings	Blue, silty clay with scattered plant remains which resemble reeds, very stiff and hard to drill	Q _{3b}
4.2-7.3	cuttings	Fine to coarse glauconite, phosphorite, quartz sand with reworked fossils-- water color turns brown	Q _{3a}
7.3		Yorktown Unconformity	
7.3	no sample	Rock surface	Tch(?)
<u>Hole E</u>			
0-3.5	cuttings	Slightly clayey quartz sand	Q ₃
3.5-5	cuttings	About equal amounts of fine to coarse glauconite, phosphorite, quartz sand	Q _{3a}
5		Yorktown Unconformity	
5	no sample	Rock surface	Tch(?)
<u>Hole F</u>			
0-4.7	cuttings	Fine to coarse quartz sand	Q ₃
4.7		Yorktown Unconformity	
4.7-4.9	core	Fine quartzose, silty clay trace of phosphorite	Ty
4.9	no sample	Rock surface	Tch(?)
<u>Hole G</u>			
0-4.7	cuttings	Fine to medium quartz sand	Q ₃
4.7-5	cuttings	Fine to coarse quartzose (50%), phosphorite (50%), glauconite (Tr) sand	Q _{3a}

Depth (in meters)	Type of drill hole information	Description	Unit
5	no sample	Yorktown Unconformity	
5		Rock surface	Tch(?)

Cross-section B-B', Chicod Creek

Hole A

0-2.7	cuttings	One-half to one meter of stiff yellow clay grading to a fine sandy clay	Q ₂
2.7-8.3	cuttings	Fine to medium sand with scattered small plant fragments	Q ₁
8.3		Yorktown Unconformity	
8.3	cuttings	Fossiliferous, sandy blue clay	Ty

Hole B

0-1.8	cuttings	Sandy (quartz) clay to clayey sand, gradual downward increase in sand	Q ₂
1.8-8.3	cuttings	Fine to medium quartz sand with abundant small plant fragments	Q ₁
8.3		Yorktown Unconformity	
8.3-8.5	cuttings	Fossiliferous, sandy blue clay	Ty

Hole C

0-1	cuttings	Fine quartz sand	Q ₂
1-4.1	cuttings	Fine to medium clayey quartz sand to clean sand with small plant fragments	Q ₁
4.1		Yorktown Unconformity	

Depth (in meters)	Type of drill hole information	Description	Unit
4.1-4.3	15 cm core	Light gray, fossiliferous, silty, clayey, fine to medium quartz sand, trace of phosphorite	Ty
<u>Hole D</u>			
0-2	cuttings	Fine to coarse sand	Q ₃
2		Yorktown Unconformity	
2-2.2	cuttings	Fossiliferous, clayey quartz sand	Ty
<u>Hole E</u>			
0-2.3	cuttings	Fine to coarse quartz sand	Q ₃
2.3		Yorktown Unconformity	
2.3-2.5	cuttings	Fossiliferous, clayey quartz sand	Ty
<u>Hole F</u>			
0-2.3	cuttings	Fine to coarse quartz sand	Q ₃
2.3		Yorktown Unconformity	
2.3-2.5	cuttings	Fossiliferous, clayey quartz sand	Ty
<u>Hole G</u>			
0-1	cuttings	Fine to coarse quartz sand	Q ₃
		Yorktown Unconformity	
1-1.2	15 cm core	Fossiliferous, clayey quartz sand, 1-3% phosphorite	Ty
<u>Hole H</u>			
0-2.9	cuttings	Fine to coarse quartz sand	Q ₁ (?)
2.9		Yorktown Unconformity	

Depth (in meters)	Type of drill hole information	Description	Unit
2.9-3.1	cuttings	Fossiliferous, clayey quartz sand	Ty
<u>Hole I</u>			
0-1.5	cuttings	Fine, sandy (quartz), brown clay grading to a clayey sand	Q ₂
1.5-5.9	cuttings	Gray, clayey quartz sand	Q ₁
5.9		Yorktown Unconformity	
5.9-6.1	15 cm core	Gray, silty clay, no fossils	Ty

Cross-section C-C', Chicod Creek

<u>Hole A</u>			
0-3.8	cuttings	Fine to coarse quartz sand	Q ₃
3.8-3.9	cuttings	Fine to medium quartz, phosphorite, glauconite sand (phosphorite plus glauconite is 50% of one sample; also contains scattered pebbles of quartz, phosphorite, and dolo- mite. One dolomite fragment contained a Turretella cast probably from the Castle Hayne Limestone	Q _{3a}
<u>Hole B</u>			
0-2.4	cuttings	Fine quartz sand, clean and well sorted	Q ₃
2.4-5.8	cuttings	Fine to coarse glauconite, phosphorite, quartz sand with small pebbles of phos- phorite and quartz	Q _{3b}
5.8		Yorktown Unconformity	
5.8	no sample	Rock surface	Tch(?)

Depth (in meters)	Type of drill hole information	Description	Unit
<u>Hole C</u>			
0-3.5	cuttings	Fine to coarse quartz sand	Q ₃
3.5-3.7	cuttings	Fine to coarse glauconite, phosphorite, quartz sand	Q _{3a}
<u>Hole D</u>			
0-3.6	cuttings	Fine to coarse quartz sand and pea-size pebbles	Q ₃
3.6-7.3	cuttings	Fine to coarse, phosphorite, glauconite, quartz, dolo- mite sand	Q _{3a}
7.3		Yorktown Unconformity	
7.3	no sample	Rock surface	
<u>Hole E</u>			
0-1.2	cuttings	Dark brown, sandy (quartz) clay	Q ₃
1.2-6.2	cuttings	Fine to coarse quartz sand, at 3 to 5 meters glauconite and phosphorite first appear and increase in abundance downward (3 holes drilled 2 meters apart)	Q ₃ to Q _{3a}
6.2		Yorktown Unconformity	
6.2	no sample	Rock surface	Tch(?)
<u>Hole F</u>			
0-6.2	cuttings	Fine quartz sand, no glau- conite or phosphorite	Q ₃
6.2		Yorktown Unconformity	
6.2	no sample	Rock surface	Tch(?)
<u>Hole G</u>			
0-5.3	cuttings	Fine quartz sand	Q ₃

Depth (in meters)	Type of drill hole information	Description	Unit
5.3		Yorktown Unconformity	
5.3	no sample	Rock surface	Tch(?)
<u>Hole H</u>			
0-4.5	cuttings	Fine quartz sand, basal meter consists of coarse phosphorite, glauconite, quartz sand and pebbles	Q ₃
4.5		Yorktown Unconformity	
4.5-4.7	15 cm core	Calcareous, fine to coarse glauconite, phosphorite (10%), quartz sand, occasional fossil fragments	Ty
4.7	no sample	Rock surface	Tch(?)
<u>Hole I</u>			
0-4.7	cuttings	Fine to medium quartz sand, trace of glauconite and phosphorite in the basal meter	Q ₃
4.7		Yorktown Unconformity	
4.7-4.9	15 cm core	Fine to medium phosphorite, glauconite (12%), quartz sand, the Yorktown Formation is unusually sandy in holes I-0	Ty
<u>Hole J</u>			
0-3.9	cuttings	Fine to coarse quartz sand, trace of glauconite and phosphorite	Q ₃
3.9		Yorktown Unconformity	
3.9-5.1		Fossiliferous, gray, very slightly clayey, fine to medium quartz sand, trace of glauconite and phosphorite	Ty
5.1	no sample	Rock surface	Tch(?)

Depth (in meters)	Type of drill hole information	Description	Unit
<u>Hole K</u>			
0-3.2	cuttings	Fine quartz sand	Q ₃
3.2		Yorktown Unconformity	
3.2-3.4	cuttings	Fossiliferous, fine to medium quartz sand with trace of glauconite and phosphorite	Ty
<u>Hole L</u>			
0-1.4	cuttings	Organic rich, fine, sandy (quartz) clay, sand content increases with depth	Q ₃
1.4-3.3	core and cuttings	Fine quartz sand with wood fragments such as acorn nuts, leaves, pine cone, tree stems. The lower 5 cm consists of phosphorite, glauconite, and quartz pebbles and sand. A wood fragment from between 3.3 to 3.5 meters was dated at 7920 ± 130 years B.P.	Q _{3c}
3.3		Yorktown Unconformity	
3.3-5.6	cuttings, top 2 cm cored	Fossiliferous, gray, very slightly clayey, fine to medium quartz sand, trace of glauconite and phosphorite	Ty
5.6	no sample	Rock surface	Tch(?)
<u>Hole M</u>			
0-2.1	cuttings	Clayey fine quartz sand	Q ₃
2.1-2.3	cuttings	Sandy (quartz) clay with abundant small wood fragments	Q _{3c}
2.3-3.6	cuttings	Fine quartz sand with scattered wood fragments, trace of phosphorite	Q _{3c}

Depth (in meters)	Type of drill hole information	Description	Unit
3.6		Yorktown Unconformity	
3.6-3.8	cuttings	Fossiliferous, gray clayey, quartz sand	Ty
<u>Hole N</u>			
0-0.8	cuttings	Interbedded, fine to coarse quartz sand and partly iron cemented, clayey, fine to coarse quartz sand laminae	Q ₃
0.8-2.1	cuttings	Fine quartz sand containing abundant wood fragments	Q _{3c}
2.1-4.4	cuttings	Clean, fine to coarse quartz sand	Q ₃
4.4		Yorktown Unconformity	
4.4-4.6	cuttings	Fossiliferous, gray, slightly clayey, quartz sand	Ty
<u>Hole O</u>			
0-5	cuttings	Fine to coarse quartz sand	Q ₃
5		Yorktown Unconformity	
5-5.9	cuttings	Very fossiliferous, gray, slightly clayey, fine quartz sand	Ty
5.9	no sample	Rock surface	Tch(?)

Cross-section D-D', Chicod Creek

<u>Hole A</u>			
0-3.9	cuttings	Red to brown clay, becoming white downward, laminated with quartz, sandy clay	Q ₂
3.9-5	cuttings	Fine quartz sand	Q ₁

Depth (in meters)	Type of drill hole information	Description	Unit
5		Yorktown Unconformity	
5-5.2	cuttings	Fossiliferous, very stiff, blue clay	Ty
<u>Hole B</u>			
0-4.5	cuttings	Pale white clay	Q ₂
4.5-5.5	cuttings	White sandy (quartz) clay	Q ₁
5.5-6.2	cuttings	White to gray silty clay, possible Yorktown Formation but contained no fossils and easily drilled	Q _{1b}
6.2		Yorktown Formation	
6.2-6.4	cuttings	Stiff blue clay with few fossils	Ty
<u>Hole C</u>			
0-2.5	cuttings	Red to brown clay	Q ₂
2.5-5.3	cuttings	Fine to coarse quartz sand	Q ₁
5.3		Yorktown Unconformity	
5.3-5.5	15 cm core	Light gray, slightly clayey, silty, fine to coarse quartz sand with sparse fossils	Ty
<u>Hole D</u>			
0-2.2	cuttings	Slightly clayey quartz sand	Q _{3d} (?)
2.2-4.4	cuttings	Fine to coarse quartz sand	Q ₃
4.4		Yorktown Unconformity	
4.4-4.6	cuttings	Light gray, clayey, quartz sand with sparse fossils	Ty
<u>Hole E</u>			
0-3.0	cuttings	Clayey quartz sand, some organics	Q _{3d} (?)

Depth (in meters)	Type of drill hole information	Description	Unit
3.0-4.5	cuttings	Fine to medium quartz sand	Q ₃
4.5		Yorktown Unconformity	
4.5-4.7	cuttings	Light gray, slightly fossiliferous, clayey, quartz sand	Ty
<u>Hole F</u>			
0-3.4	cuttings	Clayey quartz sand	Q _{3d} (?)
3.4-5.5	cuttings	Fine to medium quartz sand	Q ₃
5.5		Yorktown Unconformity	
5.5-5.7	cuttings	Light gray, slightly fossiliferous, clayey, quartz sand	Ty
<u>Hole G</u>			
0-2.7	cuttings	Sandy (quartz), gray clay, appears to be recent floodplain clay	Q _{3d}
2.7-4.8	cuttings	Medium to coarse quartz sand with clay laminae	Q ₃
4.8		Yorktown Unconformity	
4.8-5.0	cuttings	Fossiliferous, gray, clayey quartz sand	Ty
<u>Hole H</u>			
0-2.1	cuttings	Sandy (quartz), gray clay	Q _{3d}
2.1-5.2	cuttings	Fine quartz sand with clay laminae	Q ₃
5.2		Yorktown Unconformity	
5.2-5.4	cuttings	Fossiliferous, gray, clayey quartz sand	Ty
<u>Hole I</u>			
0-2.7	cuttings	Sandy (quartz) clay	Q _{3d}

Depth (in meters)	Type of drill hole information	Description	Unit
2.7-5.6	cuttings	Fine to medium quartz sand with abundant clay laminae in the lower half	Q ₃
5.6		Yorktown Unconformity	
5.6-5.8	cuttings	Fossiliferous, gray, clayey, quartz sand	Ty
<u>Hole J</u>			
0-2.7	cuttings	Sandy (quartz), gray clay	Q _{3d}
2.7-5.5	cuttings	Medium to coarse quartz sand with abundant wood fragments, clay laminae became abundant in the lower half. The lower one-half meter consists of phosphorite and quartz pebbles and sand	Q ₃
5.5		Yorktown Unconformity	
5.5-5.7	cuttings	Fossiliferous, gray, clayey, quartz sand	Ty
<u>Hole K</u>			
0-2.7	cuttings	Sandy (quartz), gray clay	Q _{3d}
2.7-5.8	cuttings	Medium to coarse quartz sand with a basal one-third meter of phosphorite and quartz pebbles	Q ₃
5.8		Yorktown Unconformity	
5.8-6.0	cuttings	Fossiliferous, gray, clayey, quartz sand	Ty
<u>Hole L</u>			
0-2.7	cuttings	Sandy (quartz), gray clay	Q _{3d}
2.7-5.8	cuttings	Medium to coarse quartz sand with clay laminae increasing with depth	Q ₃

Depth (in meters)	Type of drill hole information	Description	Unit
5.8		Yorktown Unconformity	
5.8-6.0	cuttings	Fossiliferous, gray, clayey, quartz sand	Ty
<u>Hole M</u>			
0-5.2	cuttings	Fine to coarse quartz sand	Q ₁
5.2-5.8	cuttings	Blue, sandy (quartz), silty clay similar to the York- town Formation but containing no fossils and easy to drill	Q _{1b}
5.8		Yorktown Unconformity	
5.8-6.0	cuttings	Fossiliferous, gray, clayey, quartz sand	Ty
<u>Hole N</u>			
0-4.5	cuttings	Fine to coarse quartz sand	Q ₁
4.5-5.1	cuttings	Blue, silty clay with no fossils, soft and easy to drill	Q _{1b}
5.1		Yorktown Unconformity	
5.1-5.3	cuttings	Fossiliferous, gray, clayey, quartz sand	Ty
<u>Hole O</u>			
0-4.4	cuttings	Fine to medium quartz sand	Q ₁
4.4		Yorktown Unconformity	
4.4-4.6	cuttings	Fossiliferous, gray, clayey, quartz sand	Ty
<u>Hole P</u>			
0-2.4	cuttings	Red to brown, grading down- ward to white clay	Q ₂
2.4-5.8	cuttings	Fine quartz sand	Q ₁

Depth (in meters)	Type of drill hole information	Description	Unit
5.8		Yorktown Unconformity	
5.8-6.0	cuttings	Fossiliferous, gray, clayey quartz sand	Ty
<u>Hole Q</u>			
0-4.5	cuttings	Downward gradational color sequence from reddish-brown at the surface, through pale white, to blue-gray clay	Q ₂
4.5-7.1	cuttings	Fine quartz sand	Q ₁
7.1		Yorktown Unconformity	
7.1-7.3	cuttings	Fossiliferous, gray, clayey, quartz sand	Ty
<u>Hole R</u>			
0-2.1	cuttings	Reddish-brown grading downward to white clay	Q ₂
2.1-3.1	cuttings	Sandy (quartz), reddish- brown clay	Q ₂ or Q ₁
6.2	cuttings	Soft, silty, sandy (quartz), blue clay	Q _{1a}
6.2		Yorktown Unconformity	
6.2-6.4	cuttings	Fossiliferous, gray, clayey quartz sand	Ty
<u>Hole S</u>			
0-2.1	cuttings	Red grading downward to white clay	Q ₂
2.1-2.9	cuttings	Clayey, fine quartz sand to sandy clay	Q ₂
2.9-3.3	cuttings	Sandy (quartz), blue clay with fragments of plant material	Q ₁

Depth (in meters)	Type of drill hole information	Description	Unit
3.3-5.9	cuttings	Light blue, clayey quartz sand, no fossils, easy to drill	Q _{1a}
5.9		Yorktown Unconformity	
5.9-6.1	cuttings	Fossiliferous, gray, clayey quartz sand	Ty
<u>Hole T</u>			
0-1.8	cuttings	Red, stiff clay	Q ₂
1.8-3	cuttings	Gray, clayey, fine quartz sand	Q ₁
3.0-6.4	cored	Blue-gray, micaceous, clayey, silty, very fine sand, ripple laminated	Q _{1a}
6.4		Yorktown Unconformity	
6.4-6.6	cuttings	Stiff, fossiliferous, gray, clayey quartz sand	Ty
<u>Hole U</u>			
0-1.8	cuttings	Red, stiff clay	Q ₂
1.8-4.1	cuttings	Clayey, fine quartz sand	Q ₁
4.1-4.3	15 cm core	Gray, very slightly clayey, very slightly micaceous (1%), silt to very fine quartz sand	Q _{1a}

Cross-section E-E', Chicod Creek

<u>Hole A</u>			
0-2.3	cuttings	Fine to medium quartz sand	Q ₃ or Q ₁
2.3		Yorktown Unconformity	
2.3-2.5	cuttings	About equal amounts of silt, clay and quartz sand with a trace of glauconite and phosphorite, very fossiliferous	Ty

Depth (in meters)	Type of drill hole information	Description	Unit
<u>Hole B</u>			
0-2.4	cuttings	Fine to medium quartz sand, trace of phosphorite	Q ₃ or Q ₁
2.4-3.3	cuttings	Blue clay (no fossils) very similar in appearance to bed Q _{1b}	Q _{1b} or Q _{3b}
2.3		Yorktown Unconformity	
2.3-2.5	cuttings	Typical Yorktown Formation as penetrated in hole A	Ty
<u>Hole C</u>			
0-2.0	cuttings	Fine to medium quartz sand	Q ₃ possibly Q ₁
2.0		Yorktown Unconformity	
2.0-2.2	cuttings	Characteristic "marl" of the Yorktown with equal amounts of quartz sand, clay, silt, and fossils	Ty
<u>Hole D</u>			
0-2.0	cuttings	Fine to medium quartz sand	Q ₃
2.0		Yorktown Unconformity	
2.0-2.2	core from adjacent marl pit	Very fine quartz sand, clay, and silt, fossiliferous, 1-5% phosphorite and glauconite	Ty
<u>Hole E</u>			
0-3.3	cuttings	Fine quartz sand	Q ₃
3.3		Yorktown Unconformity	
3.3-3.5	cuttings	Typical Yorktown as in holes C and D	Ty
<u>Hole F</u>			
0-2.4	cuttings	Fine quartz sand	Q ₃

Depth (in meters)	Type of drill hole information	Description	Unit
2.4		Yorktown Unconformity	
2.4-2.6	cuttings	Cuttings identical to those of the above holes	Ty
<u>Hole G</u>			
0-1.7	cuttings	Very fine to fine yellowish-brown quartz sand, trace of glauconite and phosphorite, at 1.7 meters is a coarser basal quartz sand with about 15% brown and black phosphorite and reworked shell fragments from Ty	Q ₃
1.7		Yorktown Unconformity	
1.7-1.9	cuttings	Typical "marl" of the Yorktown Formation	Ty
<u>Hole H</u>			
0-2.6	cuttings	Yellowish-brown, fine quartz sand	Q ₃
2.6		Yorktown Unconformity	
2.6-2.8	cuttings	Silty, sandy (quartz), gray clay with few fossils	Ty
<u>Hole I</u>			
0-2.4	cuttings	Yellowish-brown, fine quartz sand	Q ₃
2.4		Yorktown Unconformity	
2.4-2.6	cuttings	Silty, sandy (quartz), gray clay with few fossils	Ty
<u>Hole J</u>			
0-2.3	cuttings	Yellowish-brown, fine quartz sand	Q ₃
2.3		Yorktown Unconformity	

Depth (in meters)	Type of drill hole information	Description	Unit
2.3-2.5	cuttings	Silty, sandy (quartz), gray clay with few fossils	Ty
<u>Hole K</u>			
0-1.2	cuttings	Reddish-brown grading downward to white clay	Q ₂
1.2-2.9	cuttings	Coarse quartz sand	Q ₁
2.9		Yorktown Unconformity	
2.9-3.1	cuttings	Silty, sandy (quartz), gray clay with few fossils	Ty

Cross-section F-F', Chicod Creek

<u>Hole A</u>			
0-3.2	cuttings	Mottled, reddish-brown and gray, stiff clay, silt content increases downward	Q ₂
3.2-4.7	cuttings and 15 cm core	Slightly clayey, silty, very fine to fine quartz sand with a trace of glauconite and phosphorite	Q ₁
<u>Hole B</u>			
0-2.7	cuttings	Reddish-brown grading downward to a white clay	Q ₂
2.7-6.6	cuttings	Slightly clayey, fine quartz sand, trace of phosphorite and glauconite	Q ₁
6.6		Yorktown Unconformity	
6.6-6.8	cuttings	Silty, sandy (quartz), gray clay with fossils	Ty
<u>Hole C</u>			
0-1.1	cuttings	Fine, sandy (quartz), silty, reddish-brown to light gray clay	Q ₂

Depth (in meters)	Type of drill hole information	Description	Unit
1.1-5.2	cuttings	Gray clay grading downward to a gray, clayey quartz sand	Q ₁
5.2		Yorktown Unconformity	
5.2-5.4	cuttings	Silty, sandy (quartz), fossiliferous, gray clay	Ty
<u>Hole D</u>			
0-2	cuttings	Stiff gray clay grading downward to a blue-gray clay	Q ₂
2-4.2	cuttings	Sandy (quartz) clay grading down to a fine to medium quartz sand	Q ₁
4.2		Yorktown Unconformity	
4.2-4.4	cuttings	Silty, sandy (quartz), fossiliferous, gray clay	Ty
<u>Hole E</u>			
0-4.1	cuttings	Fine to medium quartz sand	Q ₃
4.1		Yorktown Unconformity	
4.1-4.3	15 cm core	Light gray, slightly clayey, fossiliferous, fine to coarse quartz sand, trace of phosphorite	Ty
<u>Hole F</u>			
0-4.2	cuttings	Fine to medium quartz sand	Q ₃
4.2		Yorktown Unconformity	
4.2-4.4	15 cm core	Light gray, slightly clayey, fossiliferous, fine to coarse quartz sand, trace of phosphorite	Ty

Depth (in meters)	Type of drill hole information	Description	Unit
<u>Hole G</u>			
0-4.1	cuttings	Fine to medium quartz sand	Q ₃
4.1		Yorktown Unconformity	
4.1-4.3	cuttings	Silty, sandy (quartz), fossiliferous, gray clay	Ty
<u>Cross-section G-G', Green Mill Run</u>			
<u>Hole A</u>			
0-2.2	cuttings	Fine to coarse quartz sand	Q ₃
2.2		Yorktown Unconformity	
2.2-2.4	15 cm core	Clayey, very fine, sandy (quartz) silt with a trace of glauconite	Ty
<u>Hole B</u>			
0-1.3	cuttings	Phosphorite and quartz pebbles and coarse sand with a few wood fragments, drilled in the bed of a channelized segment of Green Mill Run	Q ₃
1.3		Yorktown Unconformity	
1.3-1.5	cuttings	Gray, clayey, silty, fossil- iferous, fine to coarse quartz sand	Ty
<u>Hole C</u>			
0-1.4	cuttings	Fine to coarse quartz sand with a few wood fragments	Q ₃
1.4-2.3	cuttings	Clayey sand with a basal, pebbly, coarse, phosphorite and quartz sand	Q ₃

Depth (in meters)	Type of drill hole information	Description	Unit
2.3		Yorktown Unconformity	
2.3-2.5	15 cm core	Light gray, silty, slightly clayey, fine quartz sand with few fossils, trace of glauconite and phosphorite	Ty
<u>Hole D</u>			
0-1.8	cuttings	Fine, light yellow quartz sand	Q ₃
1.8-2.9	cuttings	Fine to medium quartz sand	Q ₃
2.9		Yorktown Unconformity	
2.9-3.1	15 cm core	Light gray, silty, slightly clayey, fine quartz sand with few fossils, trace of glauconite and phosphorite	Ty
<u>Hole E</u>			
0-1.9	cuttings	Fine to medium quartz sand	Q ₃
1.9-2.0	cuttings	Basal pebble and coarse sand of quartz and phosphorite	Q ₃
2.0		Yorktown Unconformity	
2-2.2	cuttings	Gray, silty, clayey, fossiliferous, quartz sand	Ty
<u>Hole F</u>			
0-2.6	cuttings	Quartz sand with a thin one to 5 cm thick basal gravel of quartz and phosphorite	Q ₃
2.6		Yorktown Unconformity	
2.6-2.8	15 cm core	Silty, calcareous, slightly clayey quartz and glauconite (5-10%) sand, trace of phosphorite	Ty

Depth (in meters)	Type of drill hole information	Description	Unit
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Hole G

0-3.2	cuttings	Fine to coarse quartz sand	Q ₃
3.2		Yorktown Unconformity	
3.2-3.4	cuttings	Silty, calcareous, slightly clayey, quartz-glaconite-phosphorite sand	Ty

Cross-section H-H', Green Mill RunHole A

0-3.3	cuttings	Reddish-brown grading to white sandy (quartz) sand	Q ₂
3.3		Yorktown Unconformity	
3.3-7.1	cuttings	Light gray to pale orange, slightly clayey, silty, very fine quartz sand. Cretaceous strata outcrop in the adjacent stream bed	K

Hole B

0-4.5	cuttings	Reddish-brown clay grading to white sandy (quartz) clay	Q ₂
4.5		Yorktown Unconformity	
4.5-4.7	cuttings	Light gray to pale orange, slightly clayey, silty, very fine quartz sand	K

Hole C

0-1.5	cuttings	Slightly clayey and sandy (quartz) peat	Q _{3d}
1.5-2	cuttings	Fine to coarse quartz sand	Q ₃ or Q ₁
2-2.4	cuttings	Silty, sandy (quartz), blue clay, trace of glauconite (no fossils)	Q _{1b}

Depth (in meters)	Type of drill hole information	Description	Unit
2.4		Yorktown Unconformity	
2.4-2.6	cuttings	Fossiliferous, clayey, silty quartz sand	Ty
<u>Hole D</u>			
0-1.5	cuttings	Slightly clayey, slightly sandy (quartz) peat	Q _{3d}
1.5-2.1	cuttings	Fine to medium quartz sand	Q ₃
2.1		Yorktown Unconformity	
2.1-2.3	cuttings	Fossiliferous, clayey, silty quartz sand	Ty
<u>Hole E</u>			
0-1.5	cuttings	Slightly clayey and sandy (quartz) peat	Q _{3d}
1.5-2.0	cuttings	Coarse quartz sand	Q ₃
2.0		Yorktown Unconformity	
2.0-2.2	cuttings	Fossiliferous, clayey, silty quartz sand	Ty
<u>Hole F</u>			
0-2.1	cuttings	Slightly clayey and sandy (quartz) peat	Q _{3d}
2.1		Yorktown Unconformity	
2.1-2.3	cuttings	Fossiliferous, clayey, silty quartz sand	Ty
<u>Hole G</u>			
0-1.2	cuttings	Slightly clayey, sandy peat	Q _{3d}
1.2-1.5	cuttings	Fine to medium quartz sand	Q ₃
1.5-2.2	cuttings	Organic rich (mostly leaves), fine to medium quartz sand (the organics are probably cavings from up the hole)	Q ₃

Depth (in meters)	Type of drill hole information	Description	Unit
2.2		Yorktown Unconformity	
2.2-2.4	15 cm core	Gray, fossiliferous, slightly clayey, slightly calcareous, fine sandy (quartz) silt, trace of phosphorite	Ty
<u>Hole H</u>			
0-1.2	cuttings	Slightly clayey and sandy (quartz) peat	Q _{3d}
1.2-2.1	cuttings	Fine to coarse quartz sand	Q ₃
2.1		Yorktown Unconformity	
2.1-2.3	cuttings	Slightly clayey, calcareous, fossiliferous, sandy (quartz) silt	Ty

Cross-section I-I', Green Mill Run

<u>Hole A</u>			
0-4.5	cuttings	Fine to coarse quartz sand Unit Q ₁ outcrops about 61 meters to the west	Q ₃ or Q ₁
4.5		Yorktown Unconformity	
4.5-4.7	15 cm core	Gray, slightly clayey, calcareous, silty, fossiliferous, fine quartz sand, trace of phosphorite	Ty
<u>Hole B</u>			
0-7.4	cuttings	Pea-sized pebbles and fine to coarse quartz sand, trace of phosphorite, contains thin clay and iron cemented sand laminae	Q ₃
7.4		Yorktown Unconformity	

Depth (in meters)	Type of drill hole information	Description	Unit
7.4-7.6	15 cm core	Light gray, calcareous, slightly clayey, silty, fossiliferous, fine quartz sand	Ty
<u>Hole C</u>			
0-6.8	cuttings	Fine to coarse quartz sand	Q ₃
6.8		Yorktown Unconformity	
6.8-7.0	cuttings	Clayey, silty, fossiliferous quartz sand	Ty
<u>Hole D</u>			
0-9.8	cuttings	Fine to very coarse quartz sand	Q ₃ or Q ₁
9.8		Yorktown Unconformity	
9.8-10.0	cuttings	Clayey, silty, fossiliferous quartz sand	Ty

Cross-section J-J', and K-K', Tar River

<u>Hole A</u>			
0-1.2	cuttings	Fine to medium quartz sand	Q _{6a}
1.2-2.7	cuttings	Fine to coarse quartz sand, 1-2% feldspar	Q ₆
2.7-3.6	cuttings	Gray clay containing sparse plant fragments	Q _{4a}
3.6		Yorktown Unconformity	
3.6-3.8	15 cm core	Light gray, clayey, silty, fossiliferous, fine to medium quartz sand	Ty
<u>Hole B</u>			
0-1.2	cuttings	Yellow, fine quartz sand with hard, white clay laminae	Q _{6a}

Depth (in meters)	Type of drill hole information	Description	Unit
1.2-3.2	cuttings	Fine to coarse quartz sand, trace of phosphorite, glauconite, and feldspar	Q ₆
3.2		Yorktown Unconformity	
3.2-3.4	cuttings	Light gray, clayey, silty, fossiliferous quartz sand	Ty
<u>Hole C</u>			
0-2.1	cuttings	Light yellow, fine quartz sand	Q _{6a}
2.1-4.6	cuttings	Fine to coarse quartz sand with pebbles of quartz, glauconite, phosphorite, rock fragments	Q ₆
4.6		Yorktown Unconformity	
4.6-4.8	cuttings	Light gray, clayey, silty, fossiliferous quartz sand	Ty
<u>Hole D</u>			
0-1	cuttings	Fine quartz sand (road fill)	
1-1.9	cuttings	Blue-gray slightly sandy clay with a downward increase in sand	Q ₅
1.9-3.3	cuttings	Fine to medium quartz sand with a trace of phosphorite	Q ₄
3.3-3.9	cuttings	Black, sticky, very fine, slightly sandy (quartz), silty, micaceous clay	Q _{4a}
3.9		Yorktown Unconformity(?)	
3.9-6.8	cuttings	Gray, fine to medium, phosphorite-glauconite (30%), quartz, sandy clay	K(?)
6.8	no sample	Rock surface	

Depth (in meters)	Type of drill hole information	Description	Unit
<u>Hole E</u>			
0-1	cuttings	Quartz sand (road fill)	
1-4.2	cuttings	Brown to gray, fine to coarse, sandy (quartz) clay	Q5
4.2-5.5	cuttings	Brown to gray, clayey, very fine to coarse quartz sand	Q4
5.5-6.1	cuttings	Light blue clay	Q4a
6.1		Yorktown Unconformity	
6.1-39.5	15 cm core	Dark gray, slightly sandy (glauconite and quartz), slightly clayey, calcareous silt with a few scattered microfossils	K
<u>Hole F</u>			
0-1.2	cuttings	Quartz sand (road fill)	
1.2-6.7	cuttings	Light gray, slightly silty clay grading to fine to coarse sand of Q4	Q5
6.7-8.2	cuttings	Very fine to coarse quartz sand	Q4
8.2		Yorktown Unconformity	
8.2	no sample	Rock surface	K(?)
<u>Hole G</u>			
0-3.6	cuttings	Light blue, slightly silty clay with organics	Q5
3.6-7	cuttings	Sandy (quartz) clay rapidly grading in one meter to a clayey, fine quartz sand with a trace of glauconite and phosphorite, abundant organics in the upper meter, grain size increases downward	Q5a

Depth (in meters)	Type of drill hole information	Description	Unit
7-7.8	cuttings	Fine to coarse quartz sand, trace of glauconite, 1-2% feldspar and rock fragments	Q ₆
7.8		Yorktown Unconformity	
7.8	no sample	Rock surface	K(?)
<u>Hole H</u>			
0-4.2	cuttings	Gray, sandy (quartz) clay, sand content increases down- ward, the lower meter becomes very sandy (hole was drilled five meters away from the edge of the Tar River)	Q ₅
4.2		Yorktown Unconformity	
4.2-4.4	cuttings	Gray, fossiliferous, sandy (quartz) clay, the upper half meter of cuttings contain fossil molds	Ty
<u>Hole I</u>			
0-2.4	cuttings	Fine to coarse quartz sand	Q ₁
2.4		Yorktown Unconformity	
2.4-2.6	cuttings	Blue-gray, silty, sandy (quartz), fossiliferous clay, scattered outcrops of the Yorktown Formation and over- lying sands occur along the south bank of Tar River from Greenville to the eastern- most edge of the study area	Ty
<u>Hole J</u>			
0-2.1	cuttings	Gray, stiff clay	
2.1-3.5	cuttings	Fine to coarse quartz sand, the lower 30 cm is a coarse arkosic sand	Q ₁

Depth (in meters)	Type of drill hole information	Description	Unit
3.5		Yorktown Unconformity(?)	
3.5	no sample	Very hard layer--no core taken. Bed Q ₂ outcrops on a hill about 100 meters south of hole J	Ty(?)

Cross-section L-L', Tar River

Hole A

0-2.4	cuttings	Fine to coarse, pebbly quartz sand	Q ₆
2.4-6.5	cuttings	Micaceous, very fine quartz with abundant wood and plant fragments. Much of the organics are very fine grained and color the water black	Q ₄
6.5-6.7	15 cm core	Hard, blue clay with several cm of fine quartz sand in the bottom of the core (no fossils)	Q _{4a}

Hole B

0-3	cuttings	Fine to coarse quartz sand with numerous clay laminae	Q ₆
3-3.3	cuttings	Coarse, pebbly (pea-size) quartz sand	Q ₆
3.3-7.6	cuttings	Micaceous, fine to medium with minor coarse quartz sand, occasional clay laminae, abundant wood and plant fragments color the drilling water black	Q ₄
7.6-7.9	cuttings	Black, sticky clay	Q _{4a}
7.9-9.1	cuttings	Fine, clean quartz sand. Hole collapsed due to the loss of circulation in this porous sand	Q ₄

Depth (in meters)	Type of drill hole information	Description	Unit
<u>Hole C</u>			
0-1.8	cuttings	Brown to gray, sandy (quartz) clay	Q5
1.8-6.4	cuttings	Micaceous, very fine to coarse quartz sand with abundant wood and plant fragments which color the drilling water black	Q4
6.4		Yorktown Unconformity	
6.4-6.6	15 cm core	Black, micaceous, carbon- aceous (wood and plant fragments), very fine, sandy (quartz), silty clay, contains few microfossils	K
<u>Hole D</u>			
0-2.1	cuttings	Fine quartz sand	
2.1-7.1	cuttings	Variegated, stiff, blue and white clay	Q5
7.1-7.6	cuttings	Fine quartz sand with abundant plant and wood fragments	Q4
7.6		Yorktown Unconformity	
7.6	no sample	Rock surface	K(?)