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Pliocene and Pleistocene depositional environments on the York-James Peninsula, Virginia; a field guidebook

Gerald H. Johnson
Department of Geology

Carl H. Hobbs III
Virginia Institute of Marine Science

Recommended Citation
Johnson, G. H., & Hobbs, C. H. (1990) Pliocene and Pleistocene depositional environments on the York-James Peninsula, Virginia; a field guidebook. Virginia Institute of Marine Science, William & Mary. https://doi.org/10.25773/89ge-t255

PLIOCENE AND PLEISTOCENE DEPOSITIONAL ENVIRONMENTS ON THE YORK-JAMES PENINSULA, VIRGINIA

A FIELD GUIDEBOOK

Gerald H. Johnson
Department of Geology
College of William and Mary
Williamsburg, VA 23185

Carl H. Hobbs, III
School of Marine Science
College of William and Mary
Gloucester Point, VA 23062

June 1990

American Society of Limnology and Oceanography
1990 Meeting
College of William and Mary
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Field Trip 2
Geologic History of Lower Chesapeake Bay

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INTRODUCTION

The late Cenozoic deposits of southeastern Virginia represent a wide variety of depositional environments and record numerous marine transgressions. The formations range in age from Miocene to Holocene. This field trip provides an opportunity to visit and sample highly fossiliferous marine bay and fluvial-estuarine sediments exposed in river bluffs and borrow pits on the York-James Peninsula.

The authors have borrowed extensively from Johnson (1969), Johnson and others (1982), Johnson and Peebles (1985), Johnson and Ramsey (1987), and Johnson, Ward, and Peebles (1987). The authors thank Margaret Barker, Department of Geology, for her assistance in preparing the manuscript.

LATE TERTIARY AND QUATERNARY GEOLOGY OF THE LOWER COASTAL PLAIN

G. H. Johnson
College of William and Mary
Williamsburg, VA 23185

P. C. Peebles
Virginia Department of Transportation
Colonial Heights, VA 23824

INTRODUCTION

The sequence of strata exposed in southeastern Virginia (Figure 1) includes the Eastover, Yorktown, Chowan River, Bacons Castle, Windsor, Charles City, Chuckatuck, Shirley, Tabb, and Kennon Formations. Late Tertiary deposits were deposited under marine conditions whereas the Windsor and younger deposits accumulated in fluvial, estuarine, lagoonal, bay, barrier, and nearshore marine environments. The Eastover, Yorktown, and Chowan River formations contain diverse marine fossil assemblages and the Shirley, Tabb, and Kennon, terrestrial flora and fauna. The formations exhibit lateral and vertical variations in lithology and fauna that reflect local contemporaneous depositional conditions. Large and small-scale faults and folds occur in the Lower Coastal Plain. A stair-stepped landscape characterizes the topography of this area.

STRUCTURE

The late Cenozoic deposits of the Lower Coastal Plain overlie a thick sequence of Cretaceous to Miocene sediments in the Chesapeake-Delaware embayment (Murray, 1961). The Cretaceous deposits rest uncomformably on Triassic sedimentary rocks and older metamorphic and igneous rocks and constitute about two-thirds of the sediments beneath the Lower Coastal Plain. The loci of deposition of sediments shifted progressively southward during the late Tertiary and early Pleistocene time (Ward, 1984; Johnson and Peebles, 1985).

While folds and faults in Mesozoic rocks have been recognized for many years, they were not documented in Tertiary sediments of the Middle Coastal Plain until recently (Mixon and Newell, 1978; Dischinger, 1979). Broad folds, such as the York-James monocline (Ward and Blackwelder, 1980), trend northeast-southwest across the Lower

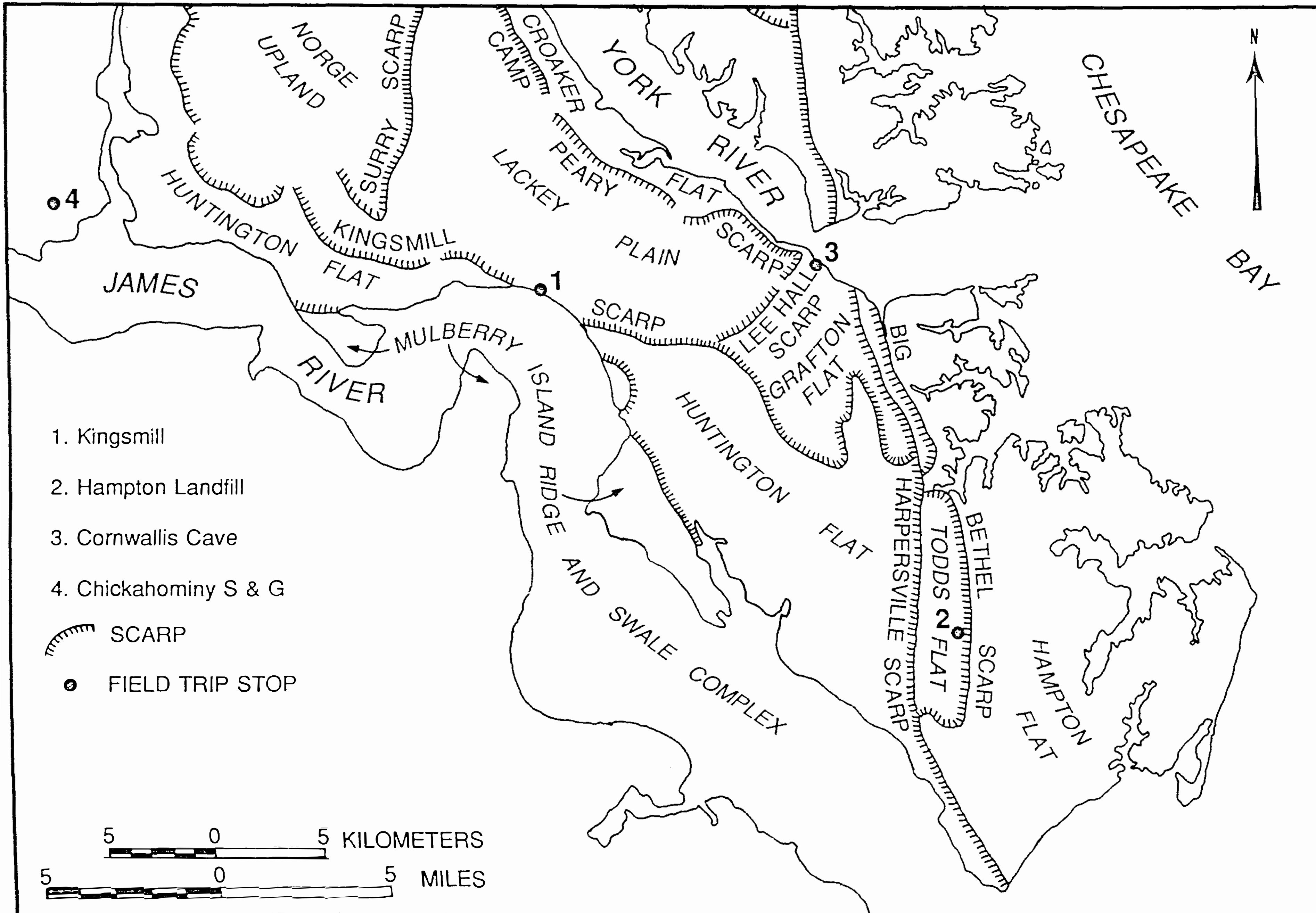


Figure 1. Map showing the geomorphic features and field trip stops on the York-James Peninsula.

Coastal Plain. High angle faulting has been invoked to account for the unusual depositional pattern, variations in thickness and structural features in the Yorktown and Chowan River in this area (Johnson and Peebles, 1985). Postulated late Pleistocene deformation of the outer Coastal Plain (Harrison and others, 1965; Oaks and Coch, 1973) remains unproven. Small-scale syndepositional faults and folds are common in late Tertiary and Pleistocene deposits. In addition, dissolution of calcareous sediments in the Yorktown Formation has produced collapse structures (Johnson and others, 1982).

MORPHOLOGY

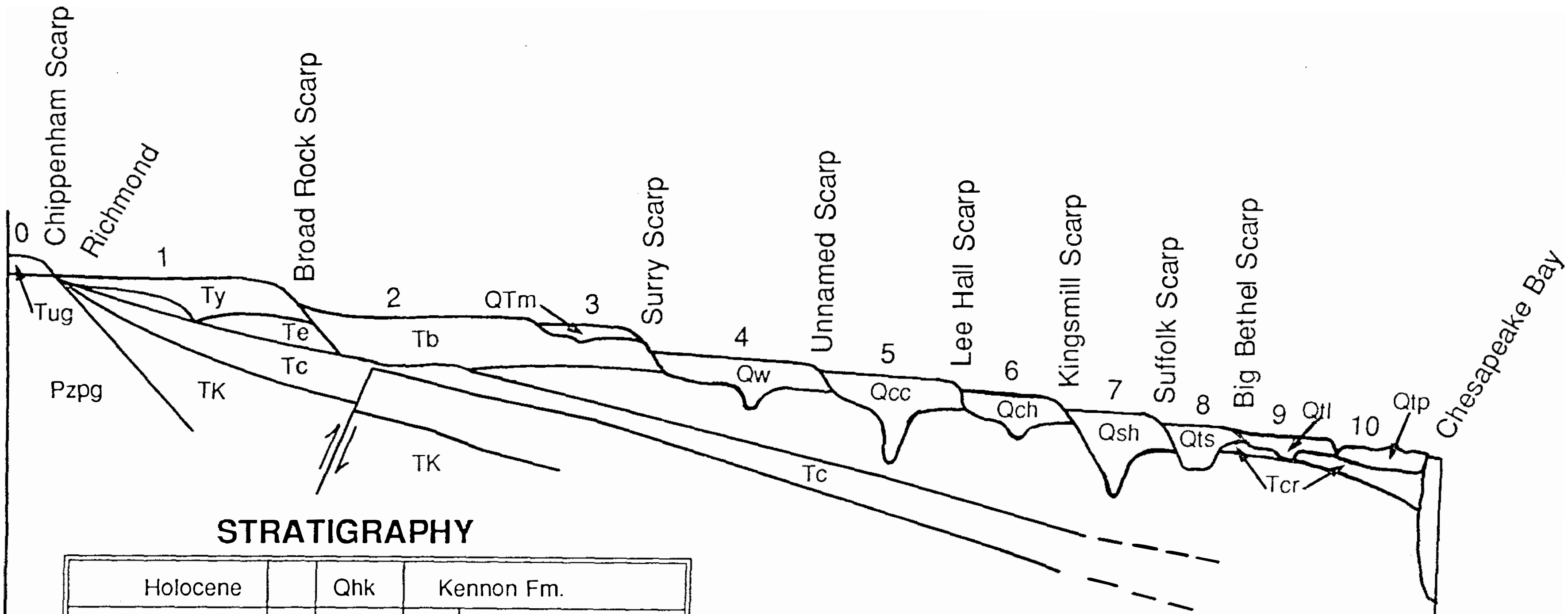
The topography of southeastern Virginia is characterized by a succession of coast-wise and riverine terraces (Figure 2; Table 1). The terraces are emergent plains formed under stream, estuarine, bay, or swamp and marsh conditions during the late Pliocene and Pleistocene and decrease in elevation seaward and toward the major rivers. The scarps, which were cut by shoreline erosion, maintain remarkably uniform elevations along the Atlantic Coastal Plain (Cooke, 1931; Colquhoun and others, in press). The number, origin, and age of the terraces has been the subject of much controversy (Cooke, 1931; Flint, 1940; Oaks and Coch, 1973).

The Surry scarp (Flint, 1940) marks the boundary between the Middle and Lower Coastal Plain. The toe of the scarp is at an elevation of about 27 m and is cut into Pliocene strata. The Lackey plain (Johnson, 1972) extends from the Surry scarp eastward to the Ruthville scarp and trends northeast-southwest across the innermost Lower Coastal Plain of Virginia. The plain, which reaches its maximum elevation of 27 m against the Surry scarp, slopes eastward to about 25 m at the crest of the Ruthville scarp. On the York-James Peninsula and near major rivers elsewhere the plain is extensively dissected. The Surry scarp was a fastland beach and the Lackey plain was covered by open bay when the Windsor Formation was deposited during the early Pleistocene.

A low scarp, the Ruthville, forms the boundary between the higher plains in southeastern Virginia and the Grove plain. The Grove plain extends from the base of the Ruthville scarp seaward to the Lee Hall or lower scarps and varies in elevation from 24 to 22 m. The Grove plain was formed as an estuarine-bay plain during the early Pleistocene.

The Lee Hall scarp separates the Grafton flat from higher plains to the west. The Grafton plain is bounded by the Lee Hall and the Kingsmill and Suffolk scarps. The flat ranges in elevation from about 19 m along the toe of the Lee Hall scarp to about 17 m near its eastern margin. During Chuckatuck time, the Lee Hall scarp was a mainland beach and the Grafton plain was covered by a precursor the Chesapeake Bay.

The Kingsmill scarp is the most continuous and, in many places, the most prominent scarp along major rivers in the Coastal Plain of Virginia. The base of the scarp ranges in elevation from 13 m to 14 m. The Huntington flat (Coch, 1971) is bounded landward by the Kingsmill and seaward by the Suffolk, Fort Eustis and, Harpersville scarps and



STRATIGRAPHY

Holocene		Qhk	Kennon Fm.
Pleistocene	U	Qtp Qtl Qts	Tabb: Poquoson Mbr. Lynnhaven Mbr. Sedgefield Mbr.
	M	Qsh	Shirley Fm.
	L	Qch Qcc Qw	Chuckatuck Fm. Charles City Fm. Windsor Fm.
		QTm?	"Moorings" Fm.
Pliocene	U L	Tb Tcr Ty	Barhamsville Fm. Chowan River Fm. Yorktown Fm.
Miocene	U	Te	Eastover Fm.
		Tc Tug TK Pzpg	Calvert Fm. Bon Air Gravel Undifferentiated Petersburg Granite

LANDFORMS

0 - Midlothian uplands
1 - Richmond plain
2 - Norge uplands
3 - Unnamed
4 - Lackey plain
5 - Grove plain
6 - Grafton plain
7 - Huntington flat
8 - Todds-Hornsbyville flat
9 - Hampton flat
10 - Mulberry Island and Plumtree Island ridge and swale area

(from Johnson and Peebles, 1983)

Figure 2. Generalized cross section of the York-James Peninsula showing the terraces and underlying stratigraphic units.

TABLE 1. Summary of geomorphic features in the study area. Elevations given are for toes of scarps.

SOUTHSIDE HAMPTON ROADS		YORK-JAMES PENINSULA
(Oaks and Coch, 1973)		(Coch, 1971; Johnson, 1972, 1976; Johnson and others, 1982; Peebles, 1984; Peebles and others, 1985; Johnson and Berquist, 1989)
Prince George upland		Norge uplands
Sussex plain		
- Surry scarp-------------	27.0 m	--------------Surry scarp-------
		Lackey plain
	24.0 m	--------------Ruthville scarp---
Isle of Wight plain		Grove plain
	19.0 m	--------------Lee Hall scarp----
		Grafton plain
- Hazelton----Chippokes------ scarp scarp	14.0 m	--------------Kingsmill scarp---
Hall Pocosin		Huntington flat
- Suffolk scarp ------------	8.0 m	--------------Suffolk scarp ----
Churchland flat Fentress flat rise		Todds flat
- Hickory scarp ------------	5.5 m	--------------Big Bethel scarp--
Deep Creek swale Moutain Pleasant flat Oceana ridge		Hampton flat
- Diamond Springs scarp -----	3.5 m	-------------Ft. Eustis scarp--
Sand-ridge and Mud-flat		Mulberry Island flat Plumtree Island flat
Holocene marshes		Holocene marshes and swamps

ranges in elevation from 14 m to about 10.5 m. The plain was formed during the late middle Pleistocene by the ancestral James River estuary and adjoining ancestral Chesapeake Bay.

The Suffolk scarp and its extension, the Harpersville, can be traced over much of the Lower Atlantic Coastal Plain and divides the Huntington flat from the Churchland and Todds flats. The elevation of the toe of the Suffolk scarp is approximately 8 m. The Churchland and Todds flats lie between the Suffolk and the Hickory and Big Bethel scarps. The elevation of the Todds and Churchland flats decreases from about 9 m in the west to less than 8 m near their eastern extremities whereas the Fentress rise, the backslope of a drowned barrier, slopes westward from its crest. The topography of the Fentress rise and Churchland flat is essentially featureless but the Todds flat is surmounted by arcuate ridges and swales in the Hampton area. During Sedgefield time, the Churchland and Todds flat and western flank of the Fentress rise were flooded by the late Pleistocene ancestral Chesapeake Bay and its extension into the Dismal Swamp area; the Suffolk scarp was the mainland beach, and the crest of the Fentress rise and the lower Eastern Shore of Virginia were barriers.

The Hampton and Mount Pleasant flats slope eastward from the base of the Hickory and Big Bethel scarps (elevation approximately 6 m) to approximately 3.5 m near their eastern boundaries. The flats are nearly featureless and represent the emergent floor of the latest Pleistocene ancestral Chesapeake Bay and James River.

The Fort Eustis scarp is a low, discontinuous but widespread scarp with a toe elevation of approximately 3 m. Plumtree Island along the western edge of the Chesapeake Bay and Ragged Island, Mulberry Island, Hog Island and Jamestown Island exhibit a low, linear to arcuate ridge and swale topography. Relief between the ridges and swales is less than 2 m and the ridges rarely exceed an elevation of 3 m above sea level. Holocene marshes fill the swales. The ridges along the rivers are point-bar deposits and a succession of beach ridges along the Chesapeake Bay (Johnson, 1972).

Marshes along the modern Chesapeake Bay and its tributaries and the Great Dismal Swamp are the most extensive Holocene landforms in southeastern Virginia. The marshes are expanding landward in swales and lowlands along the Chesapeake and its tributaries. In the nontidal reaches of tributaries to the James and other major rivers, the marshes are successively replaced upstream by streams and floodplains. The Dismal Swamp, southeast of Suffolk, Virginia, was formed about 12,000 years ago as a marsh and became a swamp 3,500 years ago (Otte and Smith, 1985).

STRATIGRAPHY

Deposits ranging in age from Miocene to Holocene crop out along the margin of the Chesapeake Bay and the lower reaches of its major tributaries. The Eastover, Yorktown, Chowan River, Bacons Castle, Windsor, Charles City, Chuckatuck, Shirley, Tabb, and Kennon formations are recognized in this area. The absolute age of the Bacons Castle and formations as young as the Chuckatuck are not known. The age relationship of the Chowan River and Bacons Castle Formations is uncertain, but field relationships and inferences from the fauna suggest that the Chowan River is older than the Bacons Castle.

PLIOCENE SERIES

Introduction

Late Tertiary formations are relatively thin, tabular marine units with planar bases, thin basal transgressive pebbly sands and overall fining upward sequences. In addition, they contain warm temperate to subtropical molluscan-rich faunas. The Bacons Castle is transitional in character between the dominantly marine Tertiary formations and the fluvial-estuarine and marginal-marine Pleistocene units because it has a thick, basal fluvial facies near the Fall Zone, lacks a molluscan fauna, and contains a thick marine section.

Chowan River Formation

The Chowan River Formation (Blackwelder, 1981) of late Pliocene age consists of interbedded silty fine sand, clayey silt and biofragmental sand and is subdivided into two members, the Colerian Beach and Edenhouse. Deposits of the Chowan River are extensively exposed along the Chowan River in North Carolina; however, these deposits occur locally only in the subsurface and in borrow pits in southeastern Virginia. Because of the similarity in texture and mineralogy of the Chowan River and Yorktown formations, leaching renders them virtually indistinguishable. Previous workers have placed Chowan River deposits in the Great Bridge (Oaks and Coch, 1973; Mixon and others, 1982; Darby, 1983) or in the Yorktown (Oaks and Coch, 1973; Barker and Bjorken, 1978). The formation rests unconformably on the Yorktown and is unconformably overlain by the Tabb and Shirley formations and, locally by Holocene deposits. The Chowan River is sporadic in distribution, its thickness ranging from near zero east of the Suffolk scarp to more than 17 m in eastern Virginia Beach. The base of the Chowan River Formation is characterized by a discontinuous, pebbly to bouldery sand that rests on the Yorktown Formation. The largest boulders have a maximum diameter of 1 m and the basal lag deposits include a diverse suite of rocks from the Appalachian Highlands. Septate siderite nodules, ferricrete clasts, iron oxide-cemented burrows, and phosphate pebbles, which were eroded from the Yorktown Formation, are also present (Victor, 1983).

The basal lag deposits of the Chowan River Formation grade upward into fine to medium sand, interbedded silty sand, clayey silt and biofragmental sand. The clayey silt and silty sand contain bivalve ghosts and burrows. The biofragmental sand is cross- bedded and contains a diverse, warm, shallow-water fauna including Argopecten eboreus, Glycymeris, subovata, Ostrea compressirostra, Noetia limatula, Rangia, Corbicula, and Mercenaria.

Bacons Castle Formation

The Bacons Castle Formation (Coch, 1968) crops out west of the Surry scarp and beds considered Bacons Castle are encountered locally in deep stream cuts and borrow pits beneath the Lackey plain. The Bacons Castle Formation has been called the Sunderland (Wentworth, 1930; Cooke, 1931; and others) and the Columbia Formation or Group by others. This unit is more than 21 m thick west of Williamsburg and rests on older formations with a regional unconformity. The basal unit of the Bacons Castle is a thin, pebbly sand; this bed, which ranges in thickness from a few centimeters near Norge to more than 6 m in the Richmond area, grades upward into medium gray to reddish-brown, thin bedded and laminated silty clay and silty fine sand. The laminated deposits are more than 9 m thick in the Norge area. Flaser bedding and slump and flame structures are common. The uppermost part of the formation consists of light to medium gray, clayey sand that is differentially weathered. Near its western margin at the Fall Zone, the formation contains thick fluvial deposits that are localized near major Piedmont streams (Ramsey, 1986).

The Bacons Castle Formation was deposited during a marine transgression across a dissected late Pliocene landscape.

PLEISTOCENE SERIES

The Pleistocene formations were deposited under similar conditions on a dissected Coastal Plain during successive Pleistocene marine transgressions. The lower contacts with underlying units are highly undulatory and the basal unit of each Pleistocene formation is fluvial sediments that fills paleochannels. The overlying sediments in the formation are deposited in contiguous estuarine, bay, lagoonal, barrier and nearshore marine environments. The formations exhibit differing degrees of weathering and dissection.

Windsor Formation

The Windsor Formation (Coch, 1968), exposed in stream banks and roadcuts on the innermost Lower Coastal Plain, is the surficial deposit over most of the Lackey plain. The formation was deposited on a dissected coastal plain terrain; consequently this unit increases in thickness across pre-Windsor paleochannels and away from the Surry scarp to about 9 m at its eastern eroded margin. The paleochannels, which are cut into the Bacons Castle and older formations, are filled with gravelly sand and organic-rich sand and silt. Across the paleointerfluves the basal Windsor consists of a gray to yellowish-brown, pebbly sand that grades upward into a medium gray, cross-bedded, quartzose sand and pebbly silt. The upper Windsor is comprised of yellow to reddish-brown and gray sand, silt and clay. Plant detritus and burrows occur in the lower part of the formation. Sedimentary and biogenic structures have been destroyed by deep weathering. The Windsor Formation was deposited under marine or lagoonal conditions east of the Surry scarp and in a fluvial-estuarine environment along the major rivers during an early Pleistocene transgression.

Charles City Formation

The Charles City Formation was defined by Johnson and Berquist (1989) for upward fining sequence of gravelly sand and silty sand exposed along the James River. Previously this unit has been assigned to the Wicomico Formation (Wentworth, 1930; Cooke, 1931) and Windsor Formation (Coch, 1968). The formation is the surficial unit on the Grove plain along the principal rivers and on isolated coast- parallel terrace remnants in southeastern Virginia.

Along the major rivers, the Charles City is comprised of interbedded pebbly sand and coarse to medium-grained sand about 9 m thick that fills the deeper portions of paleochannels. The clasts are quartzose, matrix supported, and are usually clay coated. Cross-bedding is common and locally these beds are cemented by iron and manganese oxides. The gravelly sand grades upward into silty fine sand and clayey silt. The upper Charles City is massively bedded.

The Charles City exposed in coast-wise terrace remnants consists of a thin, basal gravelly sand that grades upward into a medium to fine sand and finally into an uppermost clayey, fine sandy silt. Except for medium bedded and locally cross-bedded sands near the base of the formation, bedding is rudimentary or absent. The middle and lower beds contain clay-lined, sand-filled burrows and numerous clay chips. The upper uneroded surface of the Charles City Formation exhibits a ridge and swale topography along the James and on coast-wise terraces is a flat, gently seaward sloping surface.

The Charles City was deposited under fluvial-estuarine conditions along the principal rivers and under by conditions on the coast-wise terraces. The formation is considered early Pleistocene in age (Johnson and Berquist, 1989).

Chuckatuck Formation

The Chuckatuck (Johnson and Berquist, 1989) is comprised of a fining upward sequence of river-parallel fluvial-estuarine and coast-parallel bay sediments; barrier and nearshore marine deposits, presumably once present to the east of existing exposures, were removed by post-Chuckatuck erosion. The formation has been previously mapped as the Wicomico (Wentworth, 1930; Cooke, 1931), Windsor Formation (Coch, 1968; Oaks and Coch, 1973) and the Chuckatuck Formation (Johnson and Peebles, 1986). The unconformity between the Chuckatuck and older formations has a relief or more than 8 m.

The fluvial-estuarine facies of the Chuckatuck occur in paleochannels cut into older Pleistocene and Tertiary formations. The channel deposits are poorly sorted, commonly cross-bedded, pebbly to cobbly sand. The clasts in the Chuckatuck are quartzose, in contrast to the immature suite of clasts in the overlying Shirley. Locally, organic-rich sand and silt and peat are intercalated with the gravelly sand. The basal gravelly sand and organic-rich silt are overlain by planar bedded and unstratified fine sand. The sand grades upward into gray, clayey silt and fine sandy silty clay.

The Chuckatuck beneath coast-wise terraces has sporadically distributed paleochannels filled with gravelly sand and organic-rich sand and silt and an overlying areally extensive, thin, pebbly to cobbly sand; this unit may be as much as 1.4 m thick and grades upward into a thick, medium to silty fine sand. Ophiomorphia burrows occur in the lower part of the formation. The uppermost Chuckatuck is a clayey fine sandy silt with rudimentary planar bedding.

The Chuckatuck, considered middle Pleistocene (Johnson and Berquist, 1989), contains no radiometrically datable material or definitive fossils.

Shirley Formation

The Shirley Formation (Johnson and Berquist, 1989) is the principal surficial deposit underlying the Huntington flat and is found locally in the subsurface to the east of the Big Bethel scarp. Formerly, the Shirley Formation was assigned to the Talbot Formation (Wentworth, 1930), the clayey sand facies of the Norfolk Formation (Oaks and Coch, 1973; Johnson, 1972, 1976; Mixon and others, 1982) and the Sand Bridge Formation (Oaks and Coch, 1973). The formation ranges in thickness from a featheredge against the Kingsmill scarp to the west to more than 24 m in paleochannels. The Shirley rests disconformably upon late Tertiary and older Pleistocene formations in the Lower Coastal Plain. Shirley sediments exhibit an overall upward- fining trend except in barrier deposits.

A discontinuous pebbly to bouldery sand occurs at the base of the Shirley Formation. This unit contains clasts up to 1.4 m in diameter which are derived from the Appalachian Highlands and are matrix and clast supported. Planar and cross-stratified, well sorted, gray to light brown, fine pebbly sand intercalates with and overlies the basal gravel. Although predominately quartzose, the sands are locally feldspathic. The trough and planar crossbedding sets dip southeastward. Locally, the sand is cemented by iron and manganese oxides.

The lower and middle portions of the Shirley Formation, locally more than 4 m thick, contain laminated to massively bedded, gray, organic-rich silt and clay, and peat. The peat is fibrous to sapric, and contains selenite, in situ tree stumps and nuts, seeds and leaves of cypress, hickory, oak, pine, sweet gum and walnut. Intercalated, relatively thin beds of light gray to light brown, fine to coarse sand and silt comprise the middle part of the Shirley Formation. The interbedded sand and silt are cross- stratified and exhibit highly variable dip directions. Locally, flaser bedding is developed, especially in the estuarine sediments. Organic material is less abundant than in the lower Shirley, and marine burrows and Crassotrea virginica beds have been found at Fort Eustis on the York-James Peninsula.

The upper portion of the Shirley Formation consists of medium to thick bedded, gray, clayey sandy silt and silty clay. The silt, which is predominantly quartzose, contains disseminated mica, heavy minerals and organic matter. This part also contains scattered pebbles and grades laterally into pebbly sand near its most landward extent along the Kingsmill scarp. The bedding ranges in thickness from less than 5 cm in the lower part of this unit to more than 1.5 m in the upper part.

The Shirley formation in the Smithfield-Benns Church area consists of a basal cobble-pebble unit overlain by bluish-gray. fossiliferous silty fine sand and sandy silt. Locally, peat and an organic-rich silt containing tree stumps and other plant remains occur at the base of the fossiliferous silt and sand. These deposits range from thin to thick bedded and contain interbeds of fine sand and clayey silt. The fauna includes Mulina, Noetia, Epitonium, Nassarius, and other mollusks. A thin sheet of crossbedded pebbly, fine to medium sand overlies the fossiliferous sandy silt. Crossbeds dip predominantly westward. The lower part of this coarse sand unit grades westward into silty sands.

The Shirley was deposited under fluvial-estuarine conditions along the James and other rivers, and in a barrier setting to the east. Radiometric dates (Mixon and others, 1982) on beds believed coeval with the Shirley indicate that it is late middle Pleistocene in age.

Tabb Formation

The Tabb Formation (Johnson, 1976) is subdivided into the Sedgefield, Lynnhaven and, Poquoson members and, except for along the major rivers where the members crop out in low terraces, the formation is exposed only at the surface east of the Suffolk and Harpersville scarps. Previously, deposits of the Tabb Formation were mapped as the Great Bridge, Norfolk, Londonbridge, Kempsville and, Sand Bridge formations (Coch, 1968, 1971; Oaks and Coch, 1973; Johnson, 1972; Mixon and others, 1982; Darby, 1983). Peebles (1984) correlated deposits of the Tabb Formation from the York-James Peninsula, where it was originally defined, to similar sediments south of the James River. At most localities, the Sedgefield, Lynnhaven and Poquoson members of the Tabb Formation each consist of an upward-fining sedimentary sequence.

The Sedgefield Member of the Tabb Formation is the surficial deposit of the Todds and Churchland flats and the Fentress rise and is exposed in the Hampton landfill, Gomez and, Yadkin pits. The Sedgefield rests unconformably on the Yorktown, Chowan River, and Shirley Formations in southeastern Virginia (Pebbles and others, 1985). Along the Suffolk and Harpersville scarps the member thins to a featheredge but thickens eastward to more than 15 m in paleochannels in the Virginia Beach area. The paleochannels are lined with pebbly to cobbly sand and are filled with crossbedded fine to coarse sand, organic-rich silty clay and peat. Tree stumps in living position and other plant remains are found locally in the peat and organic rich clays.

The basal Sedgefield across the paleointerfluves is a gray to reddish- brown, pebbly to bouldery, clayey sand less than 30 cm thick. Except where leached, a Crassostrea biostrome is present above the gravelly sand. Locally, Mercenaria mercenaria replaces the oysters as the dominant species on sandy substrates at the base of the Sedgefield. On the York-James Peninsula, the gravelly sand upgrades into a gray to yellowish-brown, burrowed, quartzose, fine to medium sand which in turn grades vertically into a fine-sandy, clayey silt. Beneath the Fentress rise, the basal gravelly sand and oyster biostrome are overlain by gray, fine to medium, quartzose sand with abundant horizontal Mercenaria beds and serpulid worm-bryozoan bioherms. The associated fauna includes crab, Anadara, Polynices, Ensis and other mollusks. Overlying the Mercenaria-bearing sand is a pebbly, fine to coarse, cross-bedded sand occurring in lenses and sheets. It contains disarticulated shell ghosts of Mercenaria and Spisula oriented convex up. The cross-bedded sands are overlain by interbedded fine sand and clayey silt and by a poorly sorted clayey sand or silt. Scattered pebbles are common in the uppermost unit. A fossiliferous, nearshore, shallow marine sand of the Sedgefield occurs in the subsurface immediately east of the Hickory scarp in the Virginia Beach-Norfolk Area.

The late Pleistocene Sedgefield Member of the Tabb Formation was deposited in the first clearly defined ancestral Chesapeake Bay. The bay was open to the south into North Carolina and was confluent with major estuaries to the west.

The Lynnhaven Member is the surficial deposit in the Deep Creek swale, and on the Hampton and Mount Pleasant flats. The member varies in thickness from a featheredge at landward scarps to more than 3 m at its eastern extremity. On the York-James Peninsula, the lowermost bed of the Lynnhaven consists of a sporadic cobbly or pebbly, fine to coarse sand that grades upward into a clayey fine sand or silt with scattered pebbles and coarse sand. A pebbly to bouldery sand unit crops out locally along the Big Bethel scarp. South of the James River the lower Lynnhaven fills channels cut into the underlying Sedgefield Member. The channel sand is cross- bedded and is intercalated with silty clay and plant debris. The unconformity between the two members of the Tabb is lined with a sporadic pebbly sand. The basal pebbly bed grades upward into gray, fine sand and silty fine sand.

The Lynnhaven was deposited in a late Pleistocene ancestral Chesapeake Bay and associated barrier and fluvial-estuarine environments.

The Poquoson Member of the Tabb Formation is exposed in lowlying ridges and swales along the James and other coastal plain rivers and on the margins of the Chesapeake Bay, Back Bay and Eastern Shore. The member is comprised of a basal, gray, coarse to medium sand, locally containing pebbles and small cobbles, that grades upward into clayey fine sand and silt. The lower sand unit is thin to medium bedded and exhibits repetitive graded sand beds. In many places, this unit is inundated during high tides and is capped by Holocene storm deposits. Marshes occupy the swales that are at or near sea level.

The Poquoson Member was deposited as a succession of regressive beach ridges along the Chesapeake and as point bar deposits along the rivers. Although beds thought to be correlative to the Poquoson have been assigned a mid-Wisconsin age (Owens and Denny, 1979; Finkelstein, 1985), the evidence appears contradictory and the member is considered pre-Wisconsin late Pleistocene (50,000 years B.P.) in age.

HOLOCENE SERIES

Kennon Formation

The Kennon Formation (Johnson and Peebles, in preparation) includes contiguous marine, estuarine, paludal, fluvial and aeolian sediments deposited in and along streams (tidal and unidirectional), bays and nearshore marine environments during the latest Pleistocene and Holocene epochs. Deposits of this formation vary widely in thickness, mineral composition and fossil content but intergrade with one another and disconformably overlie Pleistocene deposits. The Kennon Formation in the lower Chesapeake Bay region began to form about 12,000 years ago. The Kennon includes the following sediments: floodplain and channel deposits, swamp and marsh deposits, tidal stream deposits including tidal flat and beach sediments, and bay and lagoonal deposits including tidal flat, beach and spit clastics.

STRATIGRAPHY OF THE EASTOVER AND YORKTOWN FORMATIONS IN SOUTHEAST VIRGINIA

Lauck W. Ward

(Extracted from Ward and Blackwelder, 1980)

MIOCENE SERIES

Eastover Formation

The Eastover Formation, named for a series of beds of silty sand, clay, and shelly fine sand in the Maryland, Virginia, and North Carolina Coastal Plain (Ward and Blackwelder, 1980), consists of two members. The lower member, the Claremont Manor, is a greenish-gray (5Y5/2), fine-grained clayey sand or sandy clay. The overlying Cobham Bay Member consists of units of fine- grained, well-sorted, shelly sand.

Claremont Manor Member

The Claremont Manor Member was named for the extensive exposures along the James River below Upper Chippokes Creek near Claremont Manor (Ward and Blackwelder, 1980). The type locality is 1.3 km below the mouth of Sunken Meadow Creek, Surry County, Virginia. The Claremont Manor consists of beds of poorly sorted, coarse to fine, silty and clayey sand that fines upward in many areas to clay. The lower contact of the Claremont Manor is sharp in most places, and phosphate nodules, bone, teeth, and pebbles are present at the boundary. Clay sequences generally mark the perimeter of the Claremont Manor basin; toward the center of eastern parts of the basin the sand content increases. Where fresh, most of these beds are greenish-gray (5YR5/2), but weather to an iron-stained tan (10YR8/6). The thickest known sequence of Claremont Manor is at Claremont where 24 m occurs in the subsurface and in outcrop. The poorly sorted, coarse, basal sand of the Claremont Manor differs from the underlying fine-grained, well-sorted shelly sand of the St. Marys Formation. The Cobham Bay Member, which overlies the Claremont Manor Member, differs in being well-sorted, less silty or clayey, and in having an abundance of well-preserved mollusks in thick beds.

The Claremont Manor basin covered most of the Virginia Coastal Plain and overlapped slightly into Maryland. The basin was open to the sea in the east but was bounded by an emerged part of southeastern Maryland to the north, and by the Virginia Piedmont to the west. It was bordered on the south by a tectonically active, high area in North Carolina that had been emergent since the deposition of the Pungo River Formation (upper lower to lower middle Miocene). The Claremont Manor Member is probably of early Tortonian Age, early late Miocene (Berggren and van Couvering, 1974). The lower part of the overlying Cobham Bay Member has been dated radiometrically (K/Ar) from glauconite at 8.7 ± 0.4 million years (Ward and Blackwelder, 1980).

The Claremont Manor sea is believed to have been open marine, but the molluscan species diversity is substantially lower than that of the preceding St. Marys Formation or of the later Cobham Bay Member. This condition may be a function of both lower temperature and chemical conditions in the embayment. The large percentage of silt and clay characteristic of the Claremont Manor may also have been an inhibiting factor to molluscan proliferation. Near the center of the embayment and in its easternmost exposures, diversity increases as does the sand content.

Cobham Bay Member

The Cobham Bay Member was named for exposures along the James River at Cobham Bay (Ward and Blackwelder, 1980). The type section is 0.8 km below Cobham Wharf, Surry County, Virginia. At Cobham Bay, the member reaches a thickness of 3.7 m and crops out from below Claremont Wharf to Lower Chippokes Creek. The Cobham Bay Member consists of a fine-grained, well-sorted shelly sand throughout most of its geographic extent. Only regionally; where structural or depositional features created barriers, were clays accumulated. However, these features are local and the Cobham Bay retains its clean, sandy, characteristics over most of the basin. Grayish blue (5PB5/2) where fresh, the Cobham Bay sediments weather to a yellowish orange (10YR8/6). Dips vary with local structural features, although the strike is approximately north-south. Throughout most of the basin, the normal seaward dip is maintained at a rate of approximately 1.0 m/km.

At Murfreesboro, North Carolina, and along the Nottoway River near Littleton, Sussex County, Virginia, the Cobham Bay Member overlies the light-gray sand and clay of the Cretaceous. However, over most of its geographic range, the Cobham Bay unconformably overlies the Claremont Manor Member. The Yorktown Formation overlies the Cobham Bay Member along the James River, Virginia, from Grove Wharf, James City County, to Sunken Meadows Creek in Surry County.

The Cobham Bay sea covered much of the Virginia Coastal Plain buy only very thin beds of the Cobham Bay are known as far south as the Nottoway and Meherrin Rivers. The Cobham Bay basin was bounded to the north by the uplifted coastal plain of southeastern Maryland, to the west by the Virginia Piedmont, and to the south by a structural high in the Neuse River area.

The Cobham Bay Member is of late Tortonian Age (middle late Miocene). As previously mentioned, a radiometric date on glauconite from the lower part of the Cobham Bay Member is 8.7 $\pm$ 0.4 million years (Ward and Blackwelder, 1980). Chesapecten middlesexensis, one of the characteristic species of the Cobham Bay Member, occurs in the Arca zone of the Miocene of Florida. The ostracode Aurila redbayensis is present in the upper part of the Cobham Bay in the shallow subsurface of the eastern shore of Virginia and in the Arca zone of western Florida (Hazel, written communication, 1975). The Arca zone has been placed in planktonic foraminifera zone N17 (Akers, 1972).

The Cobham Bay sediments were deposited in a shallow open-marine embayment. The abundant and varied molluscan assemblage indicates favorable substrates, abundant food supply, and warm-temperature to subtropical conditions. Two main molluscan biofacies are present throughout the basin. One consists of large numbers of the small bivalve, Spisula rappahannockensis Gardner. This species thrived in northern and northwestern sections of the basin and apparently preferred quiet, slightly more silty substrates, although they are present in low numbers throughout the basin. The other biofacies were dominated by large species of Chesapecten, Mercenaria, and Isognomon. These taxa apparently preferred higher energy conditions and clean sandy substrates.

Yorktown Formation

The Yorktown Formation consists of a basal, pebbly, coarse-grained sand unit, a shelly fine-grained sand unit, a very fine grained sandy clay unit, and an upper, sandy biogenic sand. These four units, named and described by Ward and Blackwelder (1980), are the Sunken Meadow Member, the Rushmere Member, the Morgarts Beach Member, and the Moore House Member. The original description of the Yorktown Formation (Clark and Miller, 1906) did not clearly designate a type locally but included beds at Yorktown, Virginia, and on the James River. The beds at Yorktown are now largely inaccessible because the cliffs have been obscured by riprap. A section near Rushmere, Isle of Wight County, was designated lectostratotype of the Yorktown Formation by Ward and Blackwelder (1980).

Sunken Meadow Member

The Sunken Meadow Member consists of a basal transgressive, coarse-to- medium, poorly sorted, very shelly sand. To the west, the lower contact of the member is marked by a coarse lag deposit. To the east the basal deposits are finer and are dominated by glauconitic and phosphatic fine shelly sand.

The Sunken Meadow unconformably overlies the Cobham Bay Member of the Eastover Formation in much of Virginia, and to the south it overlies older stratigraphic units. Throughout its extent, the lower contact is well defined. The Sunken Meadow is overlapped, apparently unconformably, in most of its extent by the Rushmere Member of the Yorktown Formation. The Sunken Meadow strikes northeast-southwest and dips at the average rate of 0.5 m/km, but thins to the west and south.

The Sunken Meadow Member occupied much of the eastern two-thirds of the Virginia Coastal Plain extending as far west as King and Queen, King William, New Kent, Charles City, Prince George, Sussex and Southampton Counties in Virginia. In North Carolina, the Member is found in Hertford, Bertie, and Beaufort Counties.

Molluscan assemblages from the Sunken Meadow indicate that normally saline, shallow-shelf conditions existed in the basin and that the sandy substrate was a favorable habitat in the mild temperate sea. Diversity among the mollusks was moderately high, although somewhat less than the Cobham Bay assemblages and the later Yorktown assemblages.

Rushmere Member

The Rushmere Member consists of a fine well-sorted shelly sand. Phosphatic sand and glauconite are common in amounts less than 10 percent. Some coarse sand and pebbles are present near its lower contact.

The Rushmere unconformably overlaps the Sunken Meadow Member over most of its extent but does rest on the Eastover Formation or granite saprolite in a few locations. The Rushmere is overlain throughout most of its areal extent by the clayey beds of the Morgarts Beach Member. The two beds are conformable and grade into each other. The Rushmere strikes approximately northeast- southwest in Virginia and approximately north-south in North Carolina. It dips at 0.5 m/km and is as much as 4.8 m thick in outcrop.

The Rushmere Member represents the maximum transgressive phase of the Yorktown formation and occupies most of the Virginia Coastal Plain. In North Carolina, the Rushmere basin covered the Coastal Plain north and northeast of the Neuse River. The western boundary of the basin was slightly west of the Fall Line. To the north, the emerged Maryland and northern Virginia coastal plains provided a boundary. To the south the partial barrier in the Neuse River area created a separate, though interconnected, basin that contained identical sediments but a more tropical molluscan assemblage.

The Rushmere sea was clearly an open-marine, shallow-shelf environment that conducive both to increased diversity and to large populations. The molluscan assemblages show a subtropical to tropical influence, especially in the eastern parts of the Yorktown basin. In the more shoreward areas, diversity decreases and many of the exotic tropical taxa are not present. South of the Neuse River barrier, the assemblage is predominantly tropical but retains many of the taxa of the northern Yorktown basin populations. Shallow, shoaling, offshore bar systems were present in the eastern areas in Nansemond, York, and Middlesex counties, Virginia.

Morgarts Beach Member

The emergence of offshore bars created a quiet lagoonal area to the west in which the fine sands, silts, and clays were deposited. Tilted bedding reflects the presence of these bars and, in the channels between them, the sand content is greater owing to higher energy conditions.

The Morgarts Beach Member overlies the Rushmere Member and coincides in geographic extent with that unit. This relationship is conformable, and in a few places the contact is gradational. The underlying Rushmere is more arenaceous and contains abundant mollusks. The Morgarts Beach is distinguished by its fine, clayey lithology and abundance of small bivalves, especially Mulinia congesta, which is sometimes found in very high densities. The Morgarts Beach conforms to the same strike and dip as the underlying Rushmere and attains an outcrop thickness of 6 m.

The Morgarts Beach occupies the same area as the Rushmere in Virginia and northeast North Carolina. South of and northeast North Carolina. south of this area, it loses its identity and probably grades into the lithology of the Rushmere.

Although the clayey beds of the Morgarts Beach were deposited behind protective barrier bars, there is no evidence of lowered salinities. Normal marine conditions apparently prevailed while fine clayey sediments formed a suitable substrate for the Mulina as well as Yoldia sp., Nuculana sp., Spisula delumbia and Turritella.

Moore House Member

The Moore House Member consists of sandy shell beds, cross-bedded shell hash, and bioclastic sands and locally is cemented to form a very indurated rock. It represents a separate transgression and reflects a renewal of higher current and wave energy conditions.

The Moore House Member unconformably overlies the Morgarts Beach Member in its outcrop area from Morgarts Beach to the vicinity of Rushmere on the right bank of the James River, Isle of Wight County, Virginia; at Grove Wharf, left bank of the James River, James City County, Virginia; and below Yorktown from Cornwallis Cave to the Moore House, right bank of the York River, York County, Virginia. At the abandoned Lone Star Cement Quarry near Chuckatuck, Nansemond County, Virginia, small remnants of the Moore House overlie the cross-bedded shell beds of the Chuckatuck bar system. The Moore House strikes northeast-southwest and dips at approximately 0.5 m/km, except locally where underlying structures affect the regional dip. The maximum thickness of this member in outcrop is 6 m.

The Moore House Member is not known from North Carolina except questionably at the Lee Cree Mine at Aurora and is mostly confined to the southeastern part of the Virginia Coastal Plain.

The Moore House Member reflects a progressively shallowing sea. Molluscan assemblages indicate normal salinities, but some of the highest beds in the Williamsburg area contain a few brackish- water mollusks. Locally, offshore bars were the site of rapid large-scale, cross-bedded sand deposition.

GEOLOGIC HISTORY OF THE CHESAPEAKE BAY
(G.H. Johnson and P.C. Peebles)

Chesapeake Bay is a geologically young water body with an ancient heritage. The bay, while taking its present form only a few thousand years ago, was preceded by other "Chesapeake bays" formed in response to sea level oscillations. During previous low stands of sea level, Chesapeake Bay drained and its basin was occupied by the deeply entrenched channels of the ancestral Susquehanna River and its tributaries (Colman and Hobbs, 1987, 1988; Colman and others, in press). At present, with rising sea level and varying rates of sediment influx from natural and man-made sources, the bay is continuing to reshape its shoreline. Recognition of the dynamic nature of the Chesapeake is a requisite to the best management of the bay and its tributaries and surrounding lands.

The fastlands bordering Chesapeake Bay are underlain by Pleistocene and late Tertiary deposits. Holocene deposits are continuing to accumulate in marshes and swamps and on the bay floor except where older sediments are locally exposed by scour.

The present landscape around the Bay is marked by a succession of terraces and intervening scarps that give it a stair-stepped appearance (Figure 2). The coast-parallel terraces slope gently toward the east whereas the riverine terraces are inclined toward the major streams. Older terraces are at higher elevations and are more intricately dissected due to mass-wastage and stream erosion. Whereas the coast-parallel terraces are underlain by fossiliferous lagoonal or bay sediments (Peebles, 1984; Peebles and others, 1984), the riverine terraces contain fluvial and paludal deposits capped by estuarine sediments (Johnson, 1976). The fluvial and paludal units incorporate abundant plant fossils; locally, oyster beds occur at the base of the otherwise sparsely fossiliferous estuarine sediments. The scarps which separate the terraces represent former estuarine, bay, or oceanic shorelines; the toe or lower slope of the scarp represents the approximate relative elevation of sea level at the time the scarp was cut. The scarps have suffered mass-wastage and stream erosion and are not as clearly defined as they were when they were formed.

In the last 25 million years, shallow seas repeatedly spread across the present Coastal Plain Province depositing relatively thin sheets of fossiliferous marine sand and silt with each incursion. The Chesapeake Group, comprised of the Calvert, Choptank, St. Marys, Eastover, Yorktown, Chowan River, and Bacons Castle formations, accumulated during these invasions of the sea. The shorelines of the Yorktown and Bacons Castle formations pass through or slightly west of Richmond. While these formations were being deposited, the Coastal Plain was undergoing reverse faulting and warping which resulted in the deformation of older deposits and the gradual shifting of the loci of marine deposition southward through Tertiary time. The presence of open marine deposits of the Chesapeake Group precludes the existence of Chesapeake Bay during the late Tertiary. In addition, these formations constitute the foundation upon which Chesapeake Bay rests.

During the early Pleistocene, the Chesapeake region lacked an Eastern Shore; the Susquehanna River flowed across the present Eastern Shore in deep valleys near Salisbury, Maryland, and, later, on the lower Eastern Shore. Sediments delivered to the headwaters of the Bay from glaciofluvial and other sources were distributed southward by nearshore and beach processes during the rise of sea level accompanying deglaciation. As the mass of sediment migrated southward, the valleys cut across the Eastern Shore during glacial episodes were progressively filled. Some valleys remained permanently buried; others, such as the James River valley, were later exhumed during successive low stands of sea level. The result of this activity during the early Pleistocene was the construction of the Eastern Shore portion of the Delmarva Peninsula as far south as the Maryland-Virginia state line. During the later Pleistocene, sediments continued to accrete both vertically in protected embayments and southward on the southern end of the Eastern Shore. On the western shore of Chesapeake Bay, the Windsor and Charles City formations were deposited during the early Pleistocene. Because of the unfavorable environment of deposition and the subsequent leaching of fossils, only trace fossils are preserved in these marine beds. The sequence of strata and the trace fossils in these formations indicate possible creation of an embayment that was open to the sea in the lower Tidewater area.

Sediments and fossils in middle Pleistocene formations offer the first evidence of a proto-Chesapeake Bay in the Chesapeake region. Although the Chuckatuck Formation is comprised of sediments deposited in a restricted marine environment, no fossils have been found to establish conclusively that a bay existed in this area during the early middle Pleistocene. Prior to the deposition of the Shirely Formation about 200,000 years ago, deep valleys were carved into the Lower Coastal Plain by the James and other major rivers. With the relative rise of sea level to about 14 m above its present level, these valleys were filled with fluvial, paludal, and estuarine deposits. The fluvial and paludal sediments of the Shirley Formation contain large tree trunks and abundant seeds and leaves. On the Northern Neck and on the York-James Peninsula, this formation also contains a molluscan community indicative of open to restricted bay conditions. At this time, the Eastern Shore and the Virginia Beach area were occupied by westward migrating barrier islands. With the passage of middle Pleistocene time, the barrier island complex south of the James River migrated westward and attached to the fastland near Smithfield, Virginia (Figure 3). The fastland shoreline of this proto-Chesapeake Bay is presently recorded by a scarp with a toe elevation of approximately 14 m.

With the growth of late Illinoian continental glaciers, sea level fell causing the proto-Chesapeake Bay to empty. The Susquehanna River progressively captured the drainage of the Potomac and Rappahannock rivers and possibly flowed eastward into the Atlantic Ocean across the lower Eastern Shore. The York and James rivers probably emptied into the Atlantic near the present mouth of Chesapeake Bay.

With the wastage of the Illinoian ice sheet, sea level rose, creating the Sedgefield phase of the ancestral Chesapeake Bay. Sediments gradually filled former stream valleys and accumulated in a protected embayment between the fastland and a complex of barrier islands and shoals that extended from the Eastern Shore southward into the North Carolina. The ancestral Chesapeake Bay during Sedgefield time was open on the southern end and was wider than the present Bay. South of the James, a narrow bay extended southward into the present Albemarle Sound area. At the time of maximum deglaciation during the Sangamonian time, sea level stood at a relative elevation of 9 to 11 m above present sea level and the western shore trended approximately north-south through Suffolk, Virginia (Figure 4).

Minor variations in the continental ice sheet in Greenland and Antarctica caused water-level oscillations in the ancestral Bay. When sea level fell below and returned to about 6 m above present relative sea level, the Lynnhaven phase of the Chesapeake was created and was similar in appearance to the ancestral Chesapeake Bay of Sedgefield time. The western shore trended approximately north-south just west of Hampton, Virginia, and the emergent Sedgefield barrier complex and the Eastern Shore formed the eastern shoreline in Virginia (Mixon, 1985). With the growth of continental ice sheets during the late Sangamonian

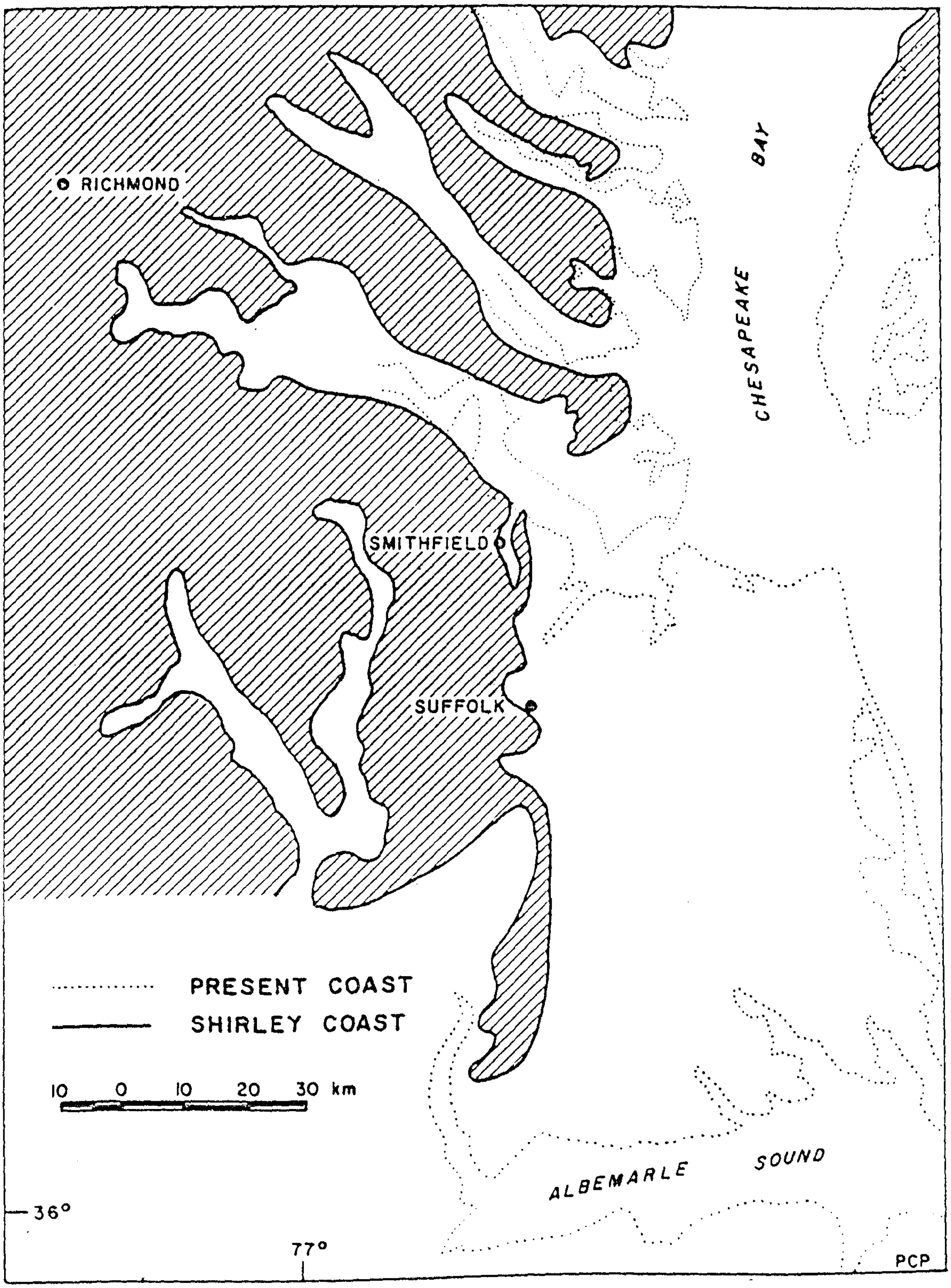


Figure 3. A map indicating the position of the shoreline in the lower Chesapeake region during late Shirley time.

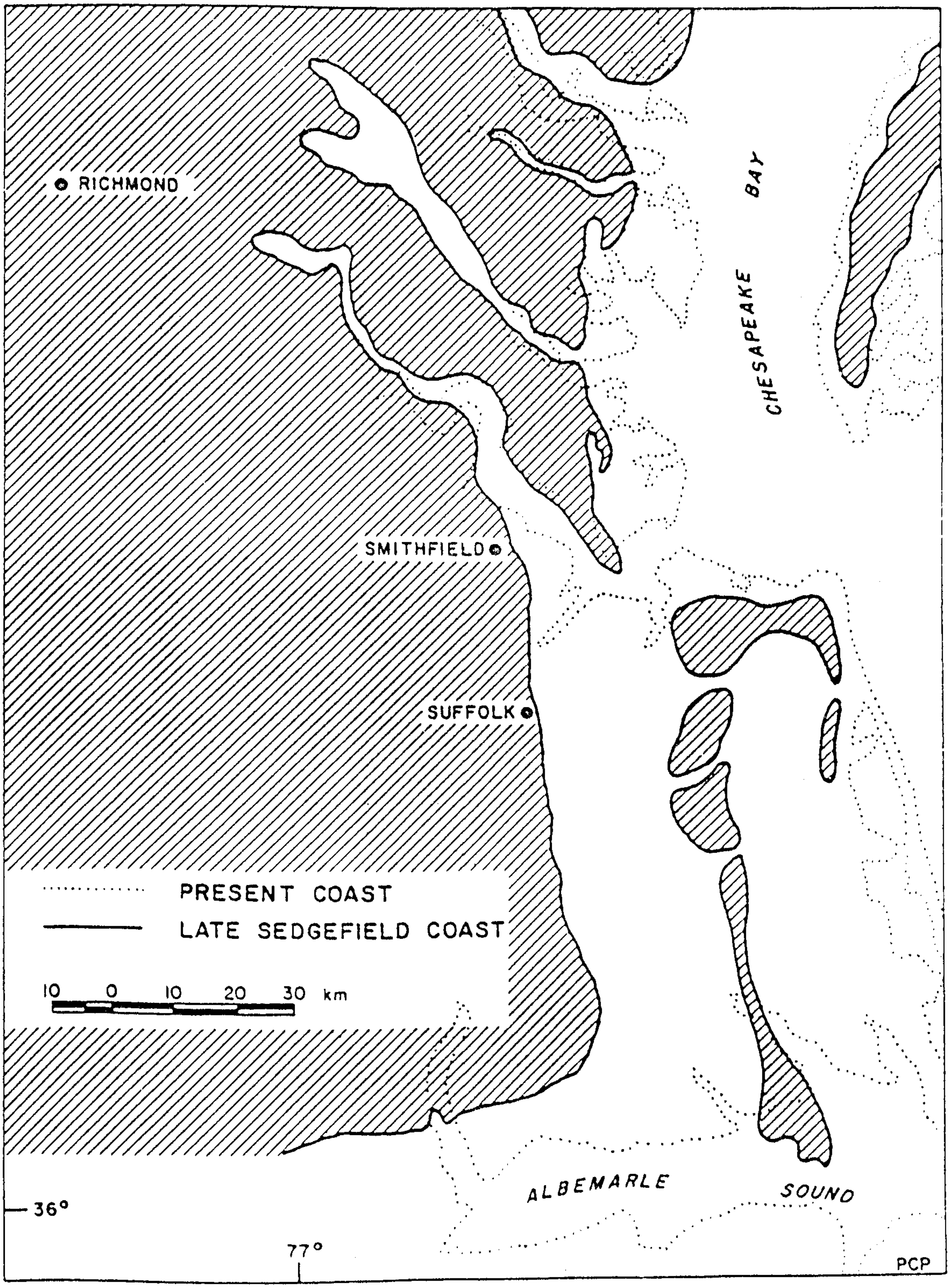


Figure 4. A map indicating the position of the shoreline in the lower Chesapeake region during the Sedgefield phase of the ancestral Chesapeake Bay.

and early Wisconsin times, the ancestral Chesapeake Bay began to shrink. A series of ridges developed along the receding shoreline in the lower bay, on the east side of the Eastern Shore, and in the Back Bay-Albemarle Sound area. This phase, the Poquoson phase of the ancestral Chesapeake Bay, was formed when sea level was 3 to approximately 1.5 m below present sea level about 65,000 years ago.

With the growth of glaciers during the Wisconsin Glaciation, the ancestral Chesapeake Bay of Poquoson time was destroyed as sea level ultimately fell to 90 m below present sea level. During this low stand of sea level, the Susquehanna River extended its course through the present Chesapeake Bay mouth and across the inner continental Shelf where it emptied into the Atlantic Ocean about 80 km off the present coast. At this time, approximately 19,000 years ago, the Susquehanna and its tributaries cut their valley floors to greater than 50 m below present sea level in the Hampton Roads and lower Chesapeake Bay area and eroded most of the older Pleistocene deposits in the Chesapeake lowland.

Between 18,000 and 5,000 years B.P., continental glaciers wasted rapidly, causing a gradual sea level rise marked by minor regressions. The Chesapeake lowland was consequently flooded to about 4 to 6 m below present sea level. At this time the bay assumed its present configuration, although it was slightly reduced in area. The courses of the paleochannels of the Susquehanna system have been mapped by Colman and Hobbs (1987, 1988) and Colman and others (in press).

In response to the rise of sea level in the last 5,000 years, the shoreline has shifted inland as low-lying areas were flooded and shoreline erosion cut away the fastland. As sea level reached the elevation of older, long abandoned bay floors, such as the floor of the Poquoson phase, salt marshes developed across the flats forming the broad and highly productive marshes of the Chesapeake Bay.

In historic times, the rise of sea level by two to three feet has contributed to the enlargement of the Bay by inundation of low-lying areas and by the erosion of the shoreline by wave and current action. Concurrent with this adjustment of the shoreline, sediment from natural and man-made sources, primarily agricultural and forestral activities, has filled the Bay at or exceeding the rate of sea level rise in many areas.

The future of the Bay will be controlled by natural and man-made causes. Sea level, which has been rising at an accelerating rate in the last 100 years, will continue to rise causing erosion and flooding of low-lying coastal areas, especially during tropical and northeastern storms. Until sea level reaches the elevation of another terrace, the broad marshes of the Chesapeake will shrink in area as they are squeezed between shoreline erosion structures and the erosion along their bay side margin. Judging from the regional geologic history, there will be variations of sea level with attendant shoreline changes and depositional processes and the Chesapeake Bay will continue to be a dynamically changing system.

REFERENCES CITED

Akers, W. H., 1972. Planktonic Foraminifera and biostratigraphy of some Neogene formations northern Florida and Atlantic Coastal Plain. Tulane Studies in Geology and Paleontology, v. 9, n. 1-4, 139 p.

Barker, W. J. and E. D. Bjorken, 1978. Geology of the Norfolk south quadrangle, Virginia. Virginia Division of Mineral Resources Publication 9, text and 1:24,000 map.

Berggren, W. A. and J. A. van Couvering, 1974. The late Neogene biostratigraphy, geochronology, and paleoclimatology of the last 15 million years in marine and continental sequences. Palaeogeography, Plaeoclimatology and Palaeoecology, v. 6, n. 1-2, 216 p.

Blackwelder, B. W., 1981. Stratigraphy of Upper Pliocene and Lower Pliocene and Lower Pleistocene marine and estuarine deposits of northeastern North Carolina and southeastern Virginia. U. S. Geological Survey Bulletin 1502-B, pp.11-24.

Clark, W. B. and B. L. Miller, 1906. A brief summary of geology of the Virginia coastal Plain. Virginia Geological Survey Bulletin 2, pp. 1-24.

Coch, N. K., 1968. Geology of the Benns Church, Smithfield, Windsor, and Chuckatuck quadrangles, Virginia. Virginia Division of Mineral Resources Report of Investigations 17, 40 pp.

Coch, N. K., 1971. geology of the Newport news South and bowers Hill quadrangles, Virginia. Virginia division of Mineral Resources Report of Investigations 28, 26 p.

Colman, S. M. and C. H. Hobbs, III, 1987. Quaternary geology of the southern part of the Chesapeake Bay. U. S. Geological Survey Miscellaneous Field Studies Map MF-1948-A.

________________________________, 1988. Quaternary geology of the northern Virginia part of the Chesapeake Bay. U. S. Geological Survey Miscellaneous Field Studies Map MF-1948-B.

Colman, S. M., J. P. Halka, and C. H. Hobbs, III, in press. A summary of the geological evolution of Chesapeake Bay, Eastern United States. Proceedings of the U. S. Geological Survey Workshop on the Atlantic Coastal Plain, U. S. Geological Survey Circular.

Colquhoun, D. J., G. H. Johnson, and P. C. Peebles, in press. Quaternary non-glacial geology of the Atlantic coastal Plain. in Morrison, R. B. (ed.). Quaternary non-glacial geology of the conterminous United States. Geological Society of America Decade of North American Geology Centennial volume.

Cooke., C. W., 1931. Seven coastal terraces in the southeastern United States. Washington Academy of Science Journal, v. 21, p. 503-513.

Darby, D. A., 1983. Sedimentology, diagenesis and stratigraphy of Pleistocene coastal deposits in southeastern Virginia. Virginia Geologic Field Conference, 15th Annual Conference, Old Dominion University, 37 p.

Dischinger, J. B., 1979. Late Mesozoic and Cenozoic stratigraphic and structural framework near Hopewell, Virginia. Unpublished M. S. Thesis, University of North Carolina, Chapel Hill.

Finkelstein, K., 1986. The late Quaternary evolution of a twin barrier-island complex, Cape Charles, Virginia. Ph.D. dissertation, School of Marine Science, College of William and Mary, Virginia Institute of Marine Science, 215 p.

Flint, R. F., 1940. Pleistocene features of the Atlantic Coastal Plain. American Journal of Science, v. 238, p.757-787.

Harrison, W. R., J. Malloy, G. A. Rusnak, and J. Terasmae, 1965. Possible late-Pleistocene uplift, Chesapeake Bay entrance. Journal of Geology, v. 13, p. 201-209.

Johnson, G. H., 1969. Geology of the Lower York-James Peninsula and the south bank of the James River. College of William and Mary, Department of Geology Guidebook No. 1, 33 p.

______________, 1972. Geology of the Yorktown, Poquoson West, and Poquoson East quadrangles, Virginia. Virginia Division of Mineral Resources Report of Investigations 30, 57 p.

______________, 1976. Geology of the Mulberry Island, Newport News North, and Hampton quadrangles, Virginia. Virginia Division of Mineral Resources Report of Investigations 41, 72 p.

Johnson, G. H. and C. R. Berquist, Jr., 1989. Geology and mineral resources of the Brandon and Norge quadrangles, Virginia. Virginia Division of Mineral Resources Publication 87, 28 p.

Johnson, G. H., C. R. Berquist, Jr., K. Ramsey, and P. C. Peebles, 1982. Guidebook to the late Cenozoic geology of the lower York-James Peninsula, Virginia. College of William and Mary, Department of Geology Guidebook No. 3, 58 p.

Johnson, G. H. and N. K. Coch, 1969. A coquina facies in the Yorktown Formation near Chuckatuck, Virginia and it geological implications (abs.). Abstracts for 1968, Geological Society of America Special Paper 121, p. 448.

Johnson, G. H. and P. C. Peebles, 1985. The late Cenozoic geology of southeastern Virginia. in Johnson, G. H., P. C. Peebles, L. J. Otte, and B. J. Smith, The late Cenozoic geology of southeastern Virginia and Great Dismal Swamp. American Association of Petroleum Geologists Eastern Section Field Trip 1 Guidebook, p. 1-30.

______________________________, 1986. Quaternary geologic map of the Hatteras 4^o x 6^o quadrangle, United States. in Richmond, G. M., D. S. Fullerton, and D. L. Weide, (eds.), Quaternary Geologic Atlas of the United States. United States Geological Survey Miscellaneous Map I-1420 (NJ-18).

Johnson, G. H., and K. Ramsey, 1987. Geology and geomorphology of the York-James peninsula, Virginia. Field trip guide book for the Atlantic Coastal Plain Geological Association, Department of Geology, College of William and Mary, 69 p.

Johnson, G. H., L. W. Ward, and P. C. Peebles, 1987. Stratigraphy and paleontology of Pliocene and Pleistocene deposits of southeastern Virginia. in Whittecar, G. R. (ed.) Geological excursions in Virginia and North Carolina. Geological Society of America Southeastern Section, 36th Annual Meeting, p. 189-218.

Mansfield, W. C., 1943. Stratigraphy of the Miocene of Virginia and the Miocene and Pliocene of North Carolina. in Gardner, J. Mollusca from the miocene and lower Pliocene of Virginia and North Carolina, Part 1, Pelecypoda. U. S. Geological Survey Professional Paper 199-A, p. 1-19.

Mixon, R. B., 1985. Stratigraphic and geomorphic framework of uppermost Cenozoic deposits in the southern Delmarva peninsula, Virginia and Maryland. U. S. Geological Survey Professional Paper 1067-6, 53 p.

Mixon, R. B. and W. L. Newell,W. L., 1978. The faulted Coastal Plain margin at Fredericksburg, Virginia. Tenth Annual Virginia Field Conference.

Mixon, R. B., B. J. Szabo, and J. B. Owens, 1982. Uranium series dating of Pleistocene deposits, Chesapeake Bay area, Virginia and Maryland. U. S. Geological Survey Professional Paper 1167-E., p. E1-E18.

Murray, G. E., 1961. Geology of the Atlantic and Gulf Coastal province of North America. Harper and brothers, 692 p.

Oaks, R. Q. and N. K. Coch, 1973. Post-Miocene stratigraphy and morphology, southeastern Virginia. Virginia division of Mineral Resources bulletin 82, 135 p.

Otte, L. J. and B. J. Smith, 1985. Origin and development of the Great Dismal Swamp, Virginia nd North Carolina. in Johnson, G. H., P. C. Peebles, L. J. Otte, and B. J. Smith, The late Cenozoic geology of southeastern Virginia and Great Dismal Swamp. American Association of Petroleum Geologists Eastern Section Field Trip 1 Guidebook, p. 50-68.

Owens, J. P. and C. S. Denny, 1979. Upper Cenozoic deposits of the central Delmarva Peninsula, Maryland and Delaware. U. S. Geological Survey Professional Paper 1067-A, 28 p.

Peebles, P. C., 1984. Late Cenozoic landforms, stratigraphy and history of sea level oscillations of southeastern Virginia and northeastern North Carolina. Ph.D. Dissertation, School of Marine Science, College of William and Mary, Virginia Institute of Marine Science, 227 p.

Peebles, P. C., G. H. Johnson, and C. R. Berquist, Jr., 1985, The middle and late Pleistocene stratigraphy of the outer coastal plain in southeastern Virginia. Virginia Minerals, v. 30, p. 13-22.

Ramsey, K., 1986, Localization of transgressive tidal flat deposition by pre-transgression topography, Bacons Castle Formation (Pliocene), York-James Peninsula, Virginia (abs.). Society of Economic Paleontologists and Mineralogists Annual Midyear Meeting Abstracts with Programs, v. 3, p. 93.

Victor, A. E., 1983. Allochthonous clasts occurring in the Chowan River Formation (Upper Pliocene) of southeastern Virginia (abs.). Virginia Journal of Science, v. 34, n.3, p. 177.

Ward, L. W., 1984. Stratigraphy of outcropping Tertiary beds along the Pamunkey River - Central Virginia Coastal Plain. in Ward, L. W. and Krafft, K. (eds.) Stratigraphy and paleontology of the outcropping Tertiary beds in the Pamunkey river region, central Virginia coastal Plain - Guidebook for Atlantic Coastal Plain Geological Association 1984 field trip. Atlantic Coastal Plain Geological Association, p. 11-77.

Ward, L. W. and Blackwelder, B. W., 1980. Stratigraphic revision of Upper Miocene and Lower Pliocene beds of the chesapeake Group, Middle Atlantic Coastal Plain. U. S. Geological Survey Bulletin 1482-D, p. D1-D61.

Wentworth, C. K., 1930. Sand and gravel resources of the coastal Plain of Virginia. Virginia Geological Survey Bulletin 32, 146 p.

ROAD LOG AND DESCRIPTION OF STOPS
(Williamsburg 7 1/2' quadrangle)

Assemble in front of Phi Beta Kappa Hall, College of William and Mary. This flat area lies on the Lackey Plain, which is 24 to 27 m above sea level and is underlain by the Windsor formation.

0.1	0.1	Turn right on Jamestown Road.
1.3	1.4	Turn left (SE) onto Virginia Highway 199.
4.0	5.4	Turn right (E) onto U.S. Highway 60.
0.7	6.1	Turn right (S) onto Kingsmill road into Kingsmill on the James development.
0.2	6.3	Entrance gate of Kingsmill on the James.
0.7	7.0	Turn left (E) onto Wareham Pond Road.
0.6	7.6	Gate into wooded area of former U.S. Army Camp Wallace. Proceed ahead through forest.
0.5	8.1	Turn right (W) onto loop road and proceed toward the James River.
0.1	8.2	Stop and disembark. Proceed right (S) along the grassed roadway.

STOP 1. Bluffs along the James River, Kingsmill on the James.
Refer to Figure 5.

Material from the borrow pit was excavated and used as the principal fill for the dam in the Busch Gardens area. Subsequently, drainage from the pit spilled over the bluffs eroding the major exposure which we will investigate at this stop. BEWARE OF VERTICAL CLIFFS.

Shell beds of the Yorktown Formation crop out in the bluffs are overlain disconformably by tidal flat and lagoonal deposits of the Bacons Castle(?) and Windsor formations, respectively. The Yorktown Formation is comprised of a series of fossiliferous sands that change in texture, mineralogy and fossil content upward. These changes reflect changing morphology of the basin, depth, salinity and wave and current conditions.

The lowermost beds (sand and sandy shell facies) consist of fine quartzose sand with increasing shell content upward. The sand contains subordinate amounts of calcareous material, glauconite, and heavy minerals. Although bedding is not apparent on first inspection, careful study of the disarticulated pecten shells reveals sand waves with wavelengths of 5 to 10 feet (1.5 to 3.0 m) and amplitudes of up to 2 feet (0.6). The principal fossils in the lower sand are <u>Placopecten clintonius, Chesapecten jeffersonius,</u> and <u>Carditamera granulata.</u> Few <u>Dentalium, Ecphora</u> and other mollusks are found. In the sandy shell, the shell content increases as <u>Chesapecten jeffersonius, Ostrea compressirostra,</u> and <u>Ostrea</u> sp. become more abundant. Lesser members

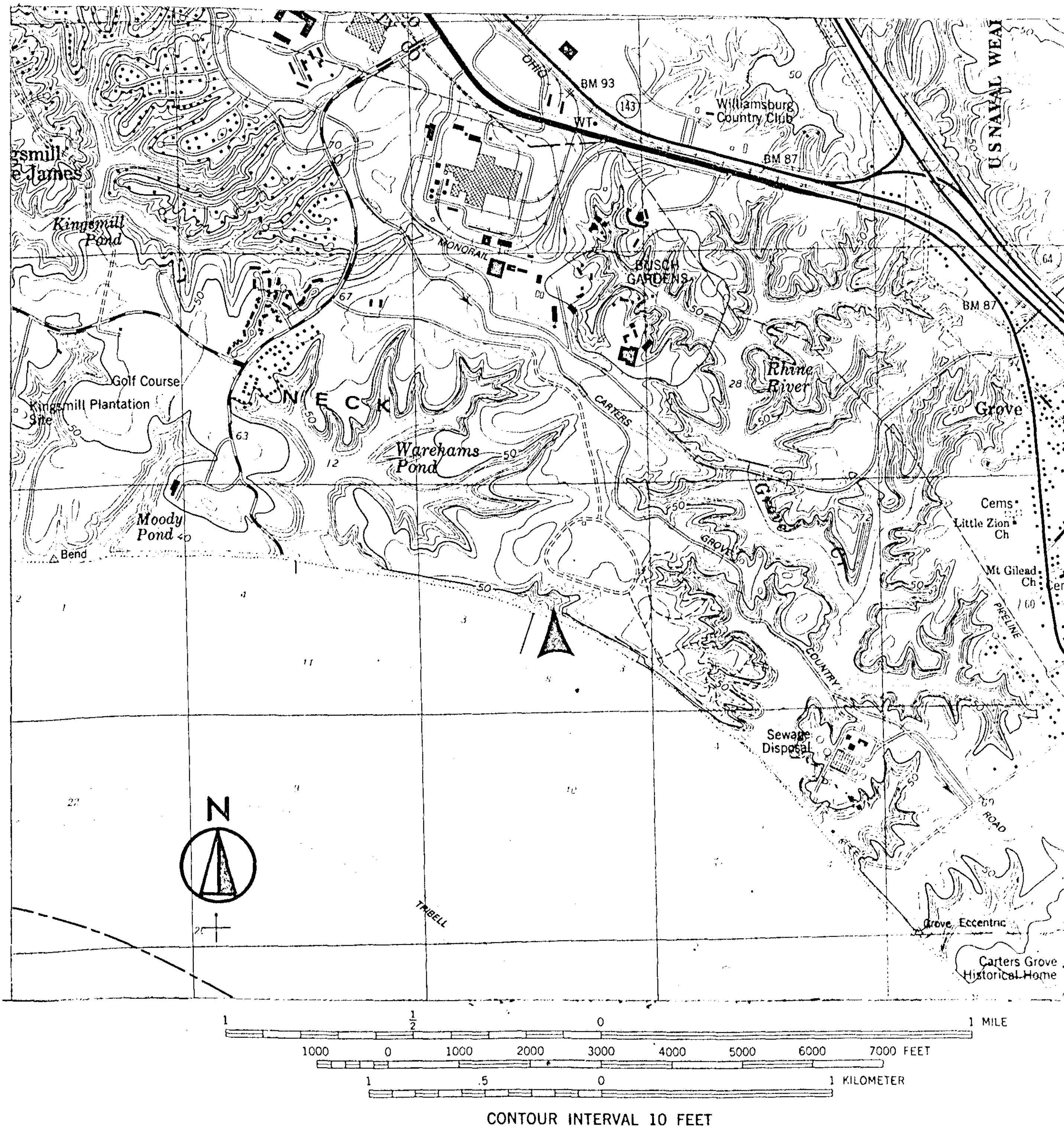


Figure 5. Map showing the location of the stop at Kingsmill on the James, James City County, Virginia. (Hog Island 7.5 minute quadrangle.)

of this community include Dentalium, Kuphus, Phacoides, Balanus, Crassetella, Chama, Panopea, and Glycymeris. The Chesapecten accentuate the bedding. The contact between the sandy shell and Chama facies has scattered bone debris and quartz and phosphate pebbles. The contact is about 13.5 feet (4.1 m) above sea level. The sand and sandy shell facies are equivalent to Zone 1, or the Placopecten clintonius zone of Mansfield (1943). These facies were deposited under shallow, open marine conditions.

The overlying Chama facies is fossiliferous, quartzose fine sand and calcareous, fine to coarse sand with increasing amounts of silt, clay and glauconite. The fauna is dominated by Chama congregata and differs in species, species diversity and abundance of shell from the adjacent beds. The lower part of this sequence is a shelly sand with abundant disarticulated and planar oriented Crassetella and Dosinia. Chama congregata become abundant in the overlying beds. The Chama, which are a sessile attached species, occur in colonies or as disarticulated valves. Larger colonies reach more than 1.4 feet (0.4 m) vertically. Laterally, the sparsely fossiliferous areas between colonies are filled with biofragmental sand. Besides Chama, the fauna contains Barbatia, Noetia, abundant encrusting, ramose and mammallate bryozoans, and Balanus. Thin beds containing fragmental Septastrea marylandica and disarticulated Chesapecten are found with the Chama bed. The Chama beds, the lowermost part of Mansfield's zone 2, were deposited in a more protected marine environment when a barrier complex (the crossbedded sand facies) developed to the east in response to differential warping of the Pliocene continental shelf near Yorktown.

The sandy silt facies, which overlies the Chama beds with a gradational contact, consists of clayey silty fine sand with interbedded quartzose, biofragmental sands. The repetitive sequence of silty fine sand grades upward into the fine to coarse shelly biofragmental sand. The former are dominated by Pseudochama corticosa. Panopea, a deep burrowing clam, occurs in the biofragmental sands along with abundant Mulinia and a diverse assemblage of mollusks, gastropods, scaphopods, barnacles and echinoids. The Pseudochama-Panopea beds are about 15 feet (4.5 m) thick and were formed in a somewhat restricted marine environment that existed west of the barrier near Yorktown.

The Pseudochama-Panopea bed grades upward into a biofragmental sand. This bed, about 3.5 feet (1.1 m) thick, is partially cemented into a coquinite by sparry calcite, precipitated in a freshwater ground water regime. The fauna in this bed is dominated by Petaloconchus and contains abundant Amphistegina, Petaloconchus and contains abundant Amphistegina, Marginella, and Astarte. This bed was deposited in a shoaling setting with moderately strong wave and current activity.

The contact between the Yorktown and beds of the overlying Bacons Castle(?) laminated beds is obscured by spoil and slump material. The Bacons Castle(?) is composed of gray, reddish-pink to yellowish, fine sandy silt or fine sand. Flaser bedding is common in these deposits. In addition, channel fill deposits and contorted bedding and faulted beds were exposed in the north wall of the borrow pit when it was active. The Bacons Castle(?) Formation was deposited under intertidal and subtidal conditions.

The overlying Windsor Formation is composed of a basal fine to medium, feldspathic, cross-stratified sand with scattered pebbles near its base. The sands grade upward into gray mottled reddish-pink fine sandy clayey silt and silty clay.

RETURN TO VEHICLE AND CONTINUE ON LOOP ROAD.

0.6	8.8	Turn right (N) onto access road and return to Wareham Pond Road.
1.1	9.9	Turn right (N) onto Kingsmill Road. Pass through gate and proceed ahead.
0.9	10.8	Turn left (W) onto U.S. Highway 60 West.
0.6	11.4	Turn left (S) onto State Highway 199 access road. Proceed northeast on State Highway 199.
1.0	12.4	Turn right (SE) onto Interstate Highway 64.
6.5	18.9	Descend the Lee Hall Scarp.
0.8	19.7	Descend the Kingsmill scarp.
10.6	30.3	Turn right (S) onto access road to U.S. Highway 17 Northl (J.Clyde Morris Boulevard). Proceed north.
0.9	31.2	Turn right (E) onto Harpersville Road.
		Bear left (E) onto Saunders Road and descend the Harpersville scarp to the Todds flat.
2.0	33.2	Turn right (S) onto State Road 600 (Big Bethel Road).
1.1	34.3	Turn right (W) onto Hampton Landfill access road. Enter City of Hampton landfill, formerly the Big Bethel pit of the Williams Corporation of Virginia.

STOP 2. City of Hampton landfill
Refer to Figure 6.

The Big Bethel pit is operated by Williams Corporation of Virginia as a borrow pit for sand from the Tabb, Shirley, and Yorktown formations and as a municipal landfill. The pit is approximately 0.8 miles (1.3 km) long and is located on the Todds flat. The Yorktown, Chowan River, Shirley, and Tabb formations are exposed in the pit.

The Yorktown formation, which is excavated from the base of the pit, is composed of greenish-gray, fossiliferous, interbedded and intergrading silty fine sand and fine to coarse biofragmental sand. The silty fine sand is composed principally of quartz but contains varying amounts of calcite, aragonite, glauconite, clay and heavy minerals. The biofragmental sand beds are 1.1 to 3.6 feet (0.3 to 1.1 m) thick, are composed mostly of molluscan debris, and are accentuated by *Crepidula* biostromes. *Crepidula* is the dominant element in the fauna; other gastropods, especially *Turritella*, bivalves, bryozoans, and barnacles occur in moderate abundance. The sediments contain numerous burrows and are bioturbated.

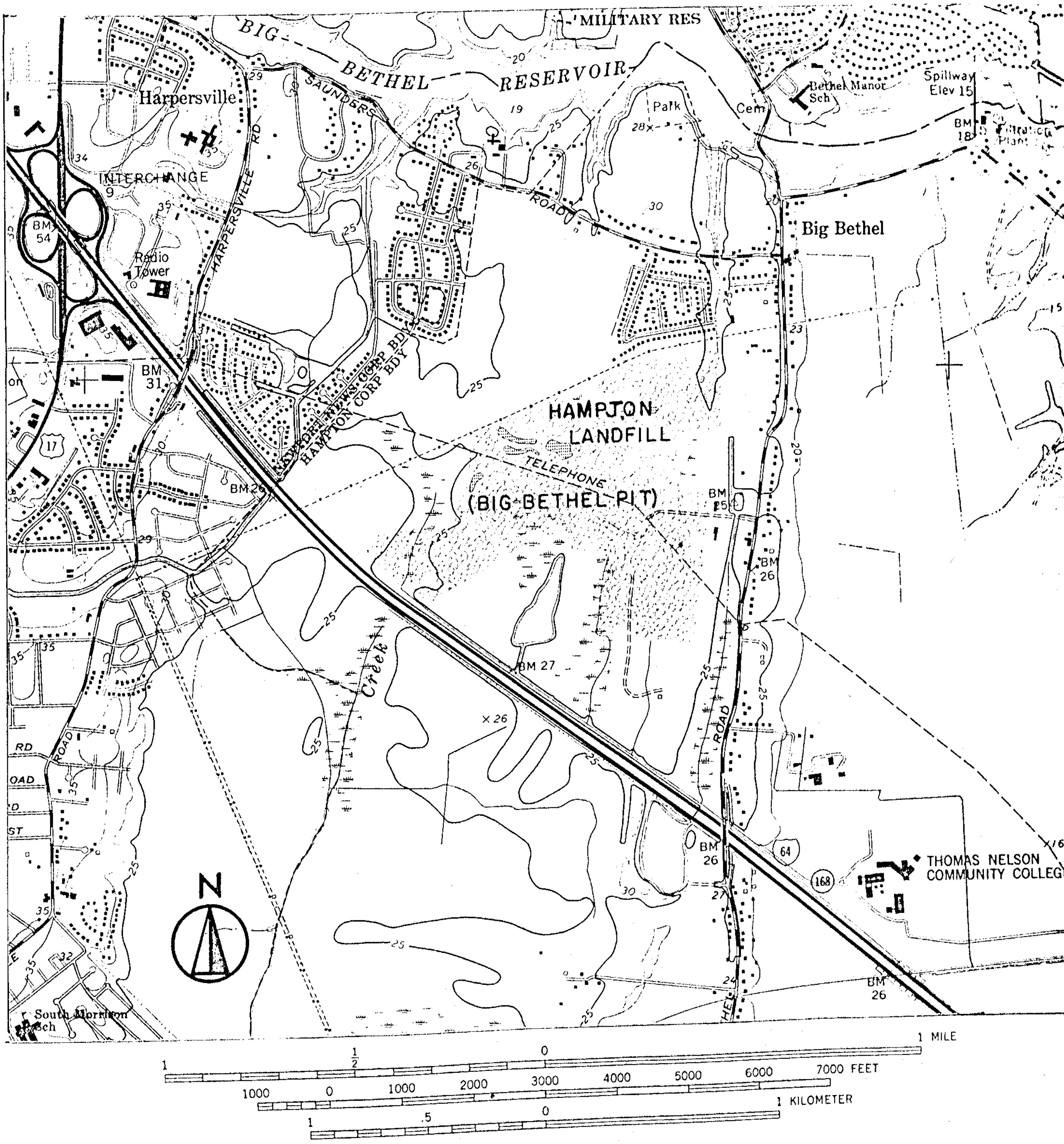


Figure 6. Map showing the location of the Hampton Landfill (Big Bethel Pit). (Newport News North 7.5 minute quadrangle.)

The Yorktown has been leached by groundwater and by plants, yielding a nonfossiliferous greenish-blue silt or silty fine sand residue. Below this weathering zone locally, Crepidula and other undisturbed shells with voids have been filled with sparry calcite crystal from meteoritic water. The Yorktown in the Big Bethel pit was deposited under marine conditions that varied from quiet to wave and current-swept shelf conditions.

The Shirley Formation is absent in the northeastern corner of the pit, occurs as lenticular valley fills in the central part of the pit, and rests disconformably on the Yorktown Formation. The gravelly sand facies of the Shirley is comprised of a complex interbedded and intergrading (1) pebbly to cobbly sand, (2) cross-bedded and planar-bedded fine to coarse sand, (3) massively-bedded clayey sand with ironstone nodules, (4) medium to thick-bedded dark to medium gray clay, (5) organic-rich silts and clays, and (6) gypsiferous, fibrous and woody peat bodies. The cobbles are sedimentary, metamorphic and igneous rock types and are derived from the Piedmont, Blue Ridge and Valley and Ridge provinces. The flora in the Shirley Formation contains seeds, leaves, pine cones, and wood fragments from cypress, oak, black gum, pine, beech, willow, and wax myrtle. Tree stumps up to 9 feet (2.7 m) in diameter are common within the pit. Similar floral-rich fossil assemblages are known from the Shirley in the Lee pit in James City County, the Chickahominy Sand and Gravel pit in Charles City County, and the Shirley pits in Henrico County. At Fort Eustis on the Hog Island, the upper part of the gravelly sand facies of the Shirley Formation contains a molluscan assemblage with abundant Crassostrea virginica. The uppermost part of the Shirley Formation at the Big Bethel pit was eroded by the advancing Sedgefield bay. The sediments of the Shirley formation were deposited under fluvial, paludal and estuarine conditions along the ancestral James River during late middle Pleistocene time.

The Sedgefield Member of the Tabb formation overlies both the Yorktown and Shirley formations at the Big Bethel pit. The lower foot (0.3 m) of the Sedgefield consists of a gray to reddish-brown, fossiliferous, pebbly to cobbly sand. Burrows that penetrate into the underlying Yorktown and Shirley formations are filled with Sedgefield sediments. The middle and upper parts of the Sedgefield are composed of a fining upward sequence of burrowed, quartzose sand. Locally, a clayey silt caps the sequence. The member is approximately 9 feet (2.7 m) thick. Crassostrea virginica and Mercenaria mercenaria are the most abundant species in the lower Sedgefield; Urosalpinx, Cliona, Polynices, Cryptopleura, Ensis and encrusting bryozoans are present also. The Sedgefield Member accumulated in the shallow water of the ancestral Chesapeake Bay under brackish water conditions.

RETURN TO BIG BETHEL ROAD, turn left and proceed north.

2.4	36.7	Turn left (NW) on State Highway 134. The Big Bethel scarp is on the right.
2.1	38.8	Turn right (N) on access road to U.S. Highway 17.
5.7	44.5	Stop Light. Turn right (N) (Coast Guard sign) on to State Route 704, Cook Road.

1.7 46.2 Turn left (W) on State Highway 238.

1.0 47.2 Intersection of State Highway 238 and Comte de Grasse Street.Turn right (north) onto Comte de Grasse and descend. The street is named for the French naval commander who blockaded the Chesapeake and prevented the British from being resupplied or escaping during the American Revolutionary War.

0.1 48.2 Intersection of Comte de Grasse and Water Street. Turn left (west) on Water Street. The bluffs along this reach of the York River is cut into cross-bedded biofragmental sands of the Yorktown Formation (Moore House Member). The pier with the coffer dam on the right is the site of a sunken British ship, scuttled during the Battle of Yorktown. The ship was partially excavated by the Virginia Historical Landmarks Commission. The Virginia Institute of Marine Science is located on the north bank of the York River (north end of the Coleman Bridge).

0.1 48.3 Turn left (S) into parking area for Cornwallis Cave

STOP 3. Cornwallis Cave
Refer to Figure 7.

Cornwallis Cave is a two-room cave cut by humans. After British General Cornwallis retreated to Yorktown, he was forced by French and American artillery to occupy a "grotto" along the York River. This "cave" is the only "grotto" along the river and has become known as "Cornwallis Cave." The rectangular recesses in the wall outside the cave supported beams installed by the Confederate command to fortify the cave in 1862. The Confederate army used the cave as an ammunition storage area.

The cave is cut into the Moore House Member of the Yorktown Formation (Ward and Blackwelder, 1980), Ophiomorpha burrows are common in the coquina. The cross-bedded coquina is comprised of broken shell material, principally mollusks. The cross sets are composed of fine to coarse-grained sands that are usually graded. The sets range in thickness from 7 to 40 cm (3 to 18 in.) and dip westward at 18°. The crossbeds extend below grade at the cave and are truncated at the top. The sequence is more than 6 m (20 feet) thick at this locality and can be traced southward across the Peninsula in the subsurface. To the southeast, the individual crossbeds thin to less than 1 m (3 feet) thick. The coquina represents a major shoal or submarine barrier complex that developed on a submarine structural high (Johnson and Coch, 1969). The structural high appears to be related to the warping that created the York-James monocline.

CONTINUE WESTWARD ON WATER STREET.

0.3 48.6 Stop sign. Intersection of Water Street and Ballard Street. Proceed ahead (west) on Water Street.

0.2 48.8 Yorktown Creek.

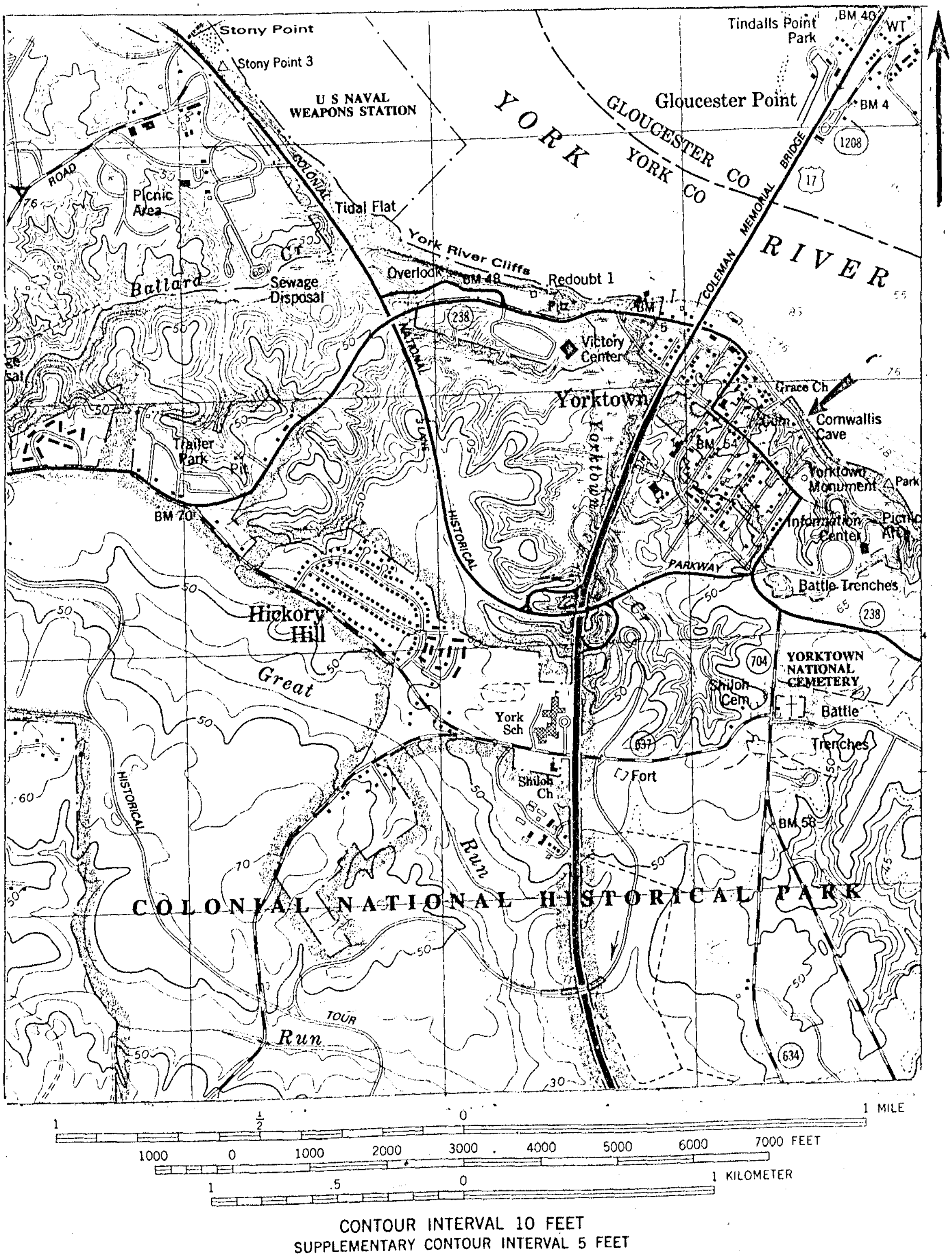


Figure 7. Map showing the location of Cornwallis Cave, Yorktown, Virginia. (Northeast corner of the Yorktown 7.5 minute quadrangle.)

0.3 49.1 Intersection of State Highway 238 and the entrance to the Yorktown Victory Center and the access road and to the Colonial Parkway. Turn right (northwest) on the Colonial Parkway access road. The Victory Center is operated by the Jamestown-Yorktown Foundation. The Victory Center is built upon a clayey silt and sand sequence beneath the estuarine equivalent of the Grafton flat. The Fusiliers Redoubt, a British defensive position on the right, is being destroyed by erosion by the York River. The French Trench is about 150 m (500 feet) to the west.

0.4 49.5 Turn right (west) onto the Colonial Parkway.

0.4 49.9 Ascend to the Croaker flat. The Croaker flat, the equivalent of the Huntington flat along the James River, extends along both banks of the York River from Yorktown to the lower reaches of the Pamunkey and Mattaponi rivers. The Colonial Parkway crosses the dissected Croaker flat between Yorktown and Felgates Creek. The Pleistocene deposits along the narrower terrace remanents of the south bank are thinner than on the north bank. On the south bank the Shirley Formation is comprised of fine sand, silt and clay and overlies the fossiliferous Yorktown Formation. Locally the Yorktown is differentially leached and cemented. Aragonitic fossils have been preferentially leached; the unleached shells (pectens, oysters, and others) are cemented by calcitic cements. The Yorktown beds dip westward in this area.

(Clay Bank 7 1/2′ quadrangle)

1.4 51.3 Sandy Spit on right (N). The spit, which is fed by sand eroded from the bluffs upstream, has grown eastward about 60 m during the last 20 years.

0.5 51.8 Cross Indian Field Creek.

0.9 52.7 Bellefield Plantation. During the early decades of this century the Bellefield bluffs were eroding and exceptional outcrops of the Yorktown Formation were exposed (Mansfield, 1943). Shoreline protection devices have destroyed these exposures. The piers of the Cheatham Annex facilities of the U.S. Navy are visible to the right front (NW). The reach of the York River between Yorktown and West Point, where the Pamunkey and Mattaponi rivers join to form the York, is nearly straight.

0.7 53.4 Cross Felgates Creek. Ascent to the Lackey plain.

1.2 54.6 Cross Kings Creek.

(Williamsburg 7 1/2′ quadrangle)

1.3	55.9	Intersection of Colonial Parkway and the access road to Virginia Highway 199. Turn right on to the access road.
0.05	56.0	Intersection of State Highway 199 and the access road. Turn left on State Highway 199. Do not enter Cheatham Annex.
2.0	58.0	Overpass over U.S. Interstate 64.
1.0	59.0	Overpass over U.S. Highway 143 and the Chesapeake and Ohio Railroad tracks.
4.1	63.1	Intersection of Virginia Highway 199 at Jamestown Road (State Highway 31).
0.5	63.6	Intersection of Virginia Highway 199 and John Tyler Highway, (State Highway 5). Turn left (west) on John Tyler Highway.
-		Descend Kingsmill scarp to the dissected Huntington flat. Powhatan Creek which flows at the base of the scarp obscures the Kingsmill at this point.
-		Descend the Big Bethel scarp.
8.5	72.1	Chickahominy River.
-		Ascend the Big Bethel scarp.
1.2	73.3	Turn left (S) on Chickahominy Sand and Gravel Pit Haul Road.

STOP 4 Henry S. Branscombe Chickahominy Sand and Gravel Company Pit.
Refer to Figure 8.

The Chickahominy pit is one of the principal sources of sand, fill material and gravel on the York-James Peninsula. After the overburden is removed and the sand extracted from the pit, it is washed, sorted and stockpiled. Several grades of sand are processed and sold from the pit. **<u>This is a hard hat area.</u>**

The pit is located on a ridge and swale terrain at the southern edge of the Huntington flat. Relief on the swale is about 4 m (15 feet) and it may have been inundated during the deposition of the Tabb Formation.

The exposed stratigraphic sequence in the pit is comprised of a basal gravelly sand with discontinuous bodies of peat and organic-rich silt and clay, an overlying bedded sand and upper mantle of silt, clay and fine sand (Figure 9). The gravelly sand is highly variable in texture and bedding properties both laterally and vertically. Overall, the sequence fines upward but beds within the sand body are graded. In the lower part of the pit, sand bodies are lenticular in cross section, discontinuous, cobbly at the base and prominently cross-bedded. The suite of cobble and boulders consists abundant quartz-rich rocks and lesser amounts of granites, mafic rocks, graphitic schists, phyllite, slate, and greenschist. The sand is predominantly quartzose; feldspar is commonly present.

The morphology and sedimentary structures of the sand bodies indicate that the sand bodies were deposited as point bars.

End of field trip.

Return to Route 5 and follow back to Williamsburg.

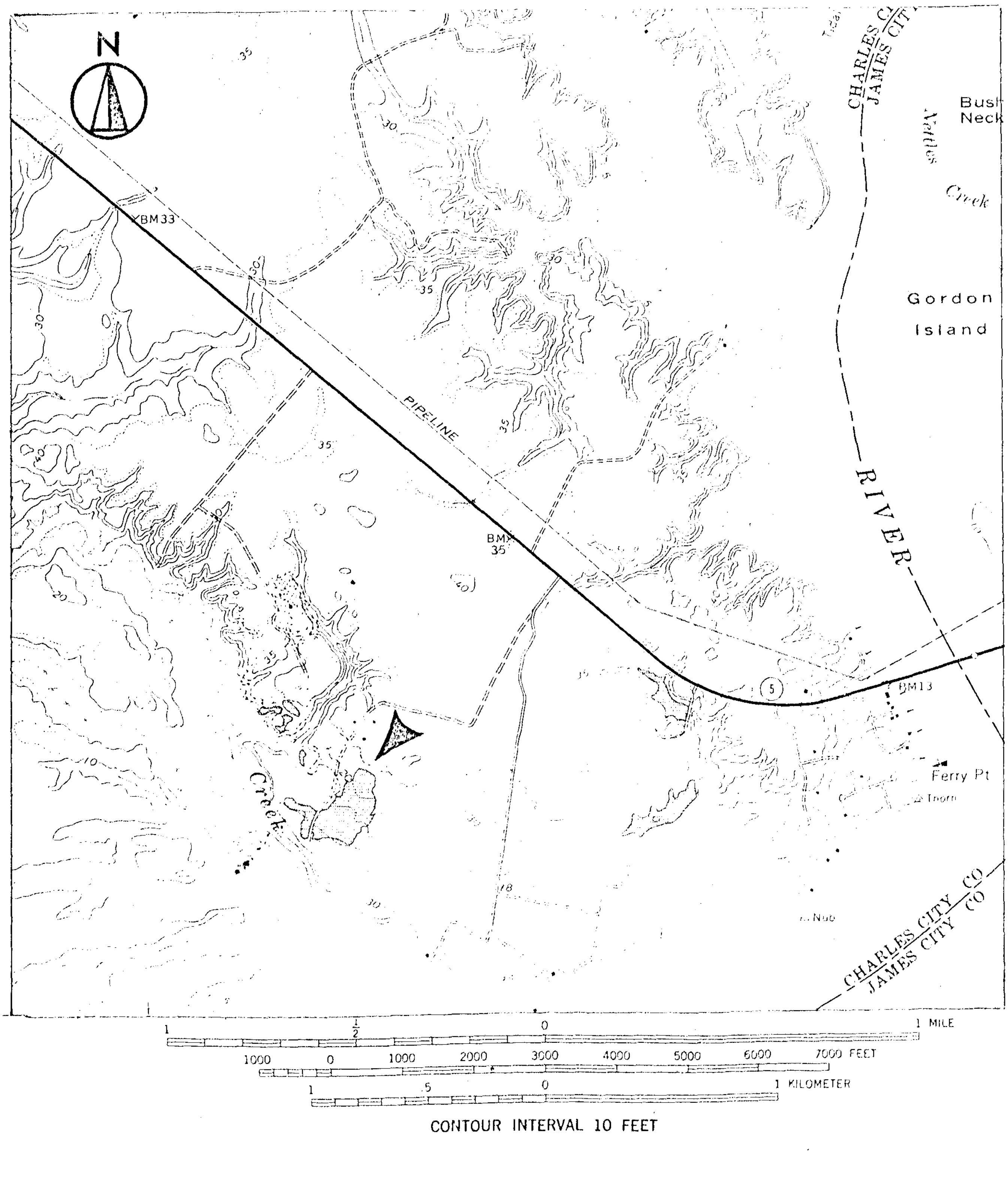
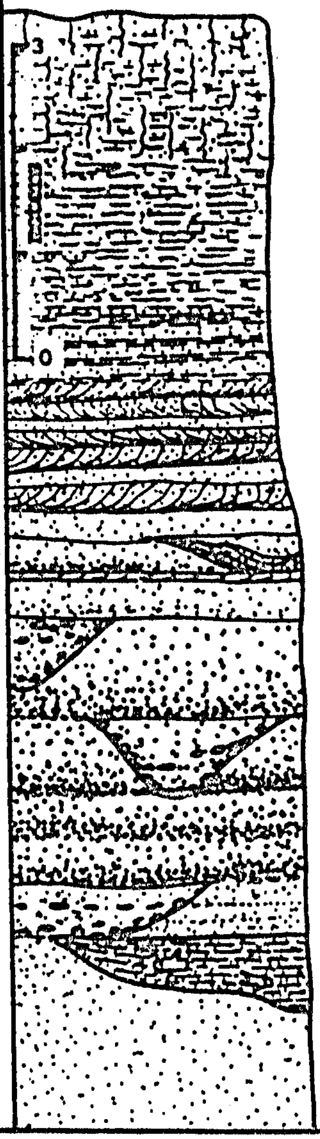


Figure 8. Map showing the location of the Chickahominy Sand and Gravel Pit, Charles City County, Virginia. (Brandon 7.5 minute quadrangle.)

Series	Formation	
		STOP 6. Exposure in the Chickahominy pit, Henry S. Branscombe Inc., 1.4 km south of Virginia Highway 5 and 1.2 km above mouth of Tomahund Creek, Charles City County, Virginia, Brandon 7.5 minute quadrangle. U.T.M. location: Zone 18, 4,124,750 m.N., 330,800 m.E. Elevation of ground surface is about 11 m (36 feet).

Pleistocene — Middle — Shirley



SHIRLEY FORMATION
Silt, fine sand and clay; medium gray to light brown, mottled with reddish and yellowish brown; quartzose, clay; bedding massive, lower portion laminated to thin-bedded and cross-laminated; gradational into underlying unit.

Sand, fine; yellowish brown; quartzose, feldspathic, micaceous; well sorted to poorly sorted, cross-bedded, bidirectional cross bedding; gradational into underlying bed;

Sand, pebbly to cobbly, rarely with boulders; medium gray to light yellowish brown; quartzose, feldspathic, little mica, with clasts of diverse lithologies; cross-bedded, lenticular sand bodies.

Silt, clayey; medium to dark gray; clay, quartzose, selenitic, micaceous with varying amounts of organic matter; bedding thick to medium; wood, leaves and disseminated plant detritus.

Sand, fine to coarse; light to medium gray; below water level.

Figure 9. Stratigraphic sequence in the Chickahominy Sand and Gravel pit, Charles City County, Virginia.