COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES

GEOLOGY OF THE WILLIAMSBURG, HOG ISLAND, AND BACONS CASTLE QUADRANGLES, VIRGINIA

KENNETH F. BICK
and
NICHOLAS K. COCH

REPORT OF INVESTIGATIONS 18

VIRGINIA DIVISION OF MINERAL RESOURCES

James L. Calver
Commissioner of Mineral Resources and State Geologist

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GEOLOGY OF THE WILLIAMSBURG, HOG ISLAND, AND BACONS CASTLE QUADRANGLES, VIRGINIA

By

Kenneth F. Bick[1] and Nicholas K. Coch[2]

ABSTRACT

Sediments in the Williamsburg, Hog Island, and Bacons Castle quadrangles, southeastern Virginia Coastal Plain, range in age from Miocene to Pleistocene. The Miocene St. Marys and Yorktown formations, which are shallow-water marine and littoral deposits, are unconformably overlain by unfossiliferous gravels, sands, silts, and clays. Post-Miocene units are the Pliocene and/or Pleistocene Sedley and Bacons Castle formations, the Pleistocene Windsor and Norfolk formations, and Holocene sediments. The Sedley is of probable fluvial-estuarine origin; the Bacons Castle is fluvial; the Windsor is estuarine-littoral; the Norfolk is fluvial-estuarine; and the Holocene sediments are estuarine. Complex cut-and-fill relationships exist between each of these post-Miocene formations; a complete sequence is nowhere present, and any of the stratigraphic units may locally overlie Miocene formations.

Four dissected plains separated by scarps dominate the morphology. In order of characteristic altitude (and decreasing age) the plains are: 120-foot plain, 90-foot plain, 70-foot plain, and 45-foot plain. The Surry scarp separates the 120-foot and 90-foot plains, and three local scarps separate the 45-foot plain from higher plains; the 90-foot and 70-foot plains are not sharply demarcated. Each plain is the dissected depositional surface of a sedimentary unit. The surface of the Bacons Castle formation forms the 120-foot plain; the Windsor Formation, the 90-foot and 70-foot plains; and the Norfolk Formation, the 45-foot plain.

Following post-Yorktown emergence and erosion, the Sedley and Bacons Castle formations were deposited during two episodes of aggradation which were separated by a period of degradation. Following post-Bacons Castle erosion, the sequence of events was deposition (Windsor Formation), erosion, deposition (Norfolk Formation), erosion, and deposition (Holocene sediments). Maximum relative sea level was + 100 to 110 feet during Windsor

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deposition and + 45 to 50 feet during Norfolk deposition; these formations are correlated with interglacial stages. A tentative Yarmouth age for the Windsor and a Sangamon age for the Norfolk are assigned.

INTRODUCTION

The Williamsburg, Hog Island, and Bacons Castle quadrangles, in southeastern Virginia, comprise an area of 164 square miles bounded by parallels 37° 00′ and 37° 22′ 30″ and meridians 76° 37′ 30″ and 76° 45′ (Figure 1). The area, which is predominantly rural, includes portions of the counties of Isle of Wight and Surry south of the James River and James City and York north of the James River. Williamsburg is the only urban center within the quadrangles, although there are several small communities, of which Bacons Castle is the largest. The Williamsburg quadrangle is served by Interstate Highway 64, U. S. Highway 60, and State Highway 143, all of which are roughly parallel and trend from southeast to northwest across the quadrangle (Plate 1). State Highway 31 leads southwestward from Williamsburg and State Highway 5, in the southwest corner of the Williamsburg quadrangle, extends northwestward to Richmond. The James River is not traversed in the area of this report, but is crossed by a ferry at State Highway 31 about 4 miles to the west. The major highway in the Bacons Castle quadrangle is State Highway 10 that extends from southeast to northwest across the quadrangle (Plate 3). An extensive network of secondary roads, paved and unpaved, connects with the major highways in all of the quadrangles (Plates 1, 2, 3).

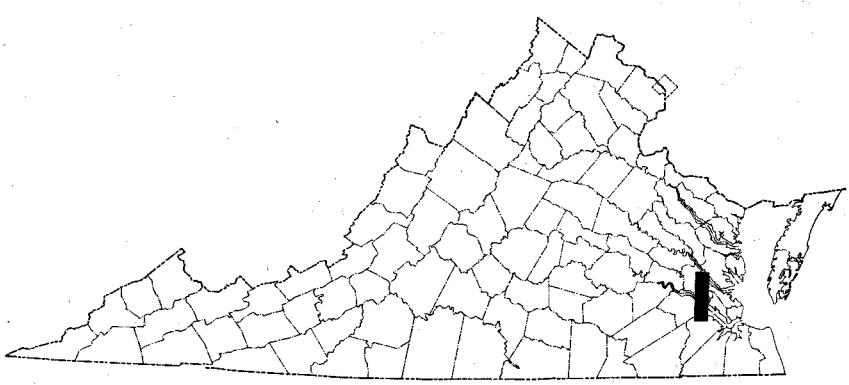

Figure 1. Index map showing location of area studied.

The Williamsburg, Hog Island, and Bacons Castle quadrangles lie almost wholly within the drainage basins of the James and York rivers, both of which flow southeastward into Chesapeake Bay. Streams in the southwest quarter of the Bacons Castle quadrangle flow into the Blackwater River that discharges southward into Pamlico Sound, North Carolina. The divide between the James and York basins trends roughly from northwest to southeast across the central portion of the Williamsburg quadrangle. Both rivers are estuaries, as are the lower courses of their tributaries.

The major tributary to the York River is Queens Creek; other tributaries to the York are Skimino Creek, Carter Creek, and King Creek. Major streams flowing southward to the James River on the York-James Peninsula are College Creek, its tributary Halfway Creek, and Mill Creek. Lawnes Creek, Pooles Creek, and Lower Chippokes Creek drain the northern half of the Bacons Castle quadrangle and the southern part of the Hog Island quadrangle into the James River. The Pagan River in the southeast quarter of the Bacons Castle quadrangle flows to the James River. Stallings River drains the southwest quarter of the Bacons Castle quadrangle to the Blackwater River. All tributaries to the James and York rivers flow in narrow steep-walled valleys except in their lower tidal reaches where the valleys widen and meandering patterns are common.

Field work in the Williamsburg quadrangle and that part of the Hog Island quadrangle north of the James River was carried on intermittently from June 1963 to January 1968 by K. F. Bick. The Virginia Division of Mineral Resources supported the work during the summer of 1964 and financed a drilling program that resulted in 44 test holes, most of which penetrated the top of the Miocene formations (Table 1). The drilling consisted of standard auger boring with split-spoon samples taken at 5-foot intervals. Bick accompanied the drillers in order to record lithologic information and to note significant data that might not later be available from samples taken at 5-foot intervals. Data were gathered on some holes without sampling, thus allowing more holes to be drilled in the time alloted. Fifty representative samples from the various post-Miocene formations were subjected to size analysis by sieving and pipetting and to flotation methods for the purpose of recovering any microfauna that might be present; heavy-mineral separations were made on 10 samples.

Table 1.—Summary of data from test holes.

Hole Number	Altitude Top of Hole (Feet)	Total Depth (Feet)	Formations* Penetrated
W-1961	82	31	Qw, QTs, Ty
W-1962	75	43	"
W-1963	61	31	"
W-1964	45	41	Qn, Ty
W-1965	38	61	"
W-1966	68	41	Qw, QTs, Ty
W-1967	75	46	"
W-1968	50	31	"
W-1969	91	56	"
W-1970	70	56	"
W-1971	60	51	"
W-1972	58	46	"
W-1973	89	46	"
W-1974	86	36	"
W-1975	87	61	"
W-1976	72	26	"
W-1977	73	36	"
W-1978	29	51	Qn, Ty
W-1979	63	31	Qw, QTs, Ty
W-1980	76	61	Qw ?
W-1981	87	41	Qw, QTs, Ty
W-1982	60	21	"
W-1983	86	61	"
W-1984	84	61	"
W-1985	72	26	"
W-1986	38	56	Qn, Ty
W-1987	40	46	Qw, QTs, Ty
W-1988	60	36	"
W-1989	21	26	QTs, Ty
W-1990	72	41	Qw, QTs, Ty
W-1991	55	51	"
W-1992	64	41	Qn, QTs, Ty
W-1993	49	31	Qw, QTs, Ty
W-1994	48	41	"
W-1995	68	41	"
W-2261	21	26	Qn
W-2262	27	26	Qn
W-2263	44	31	Qn, Ts

Hole Number	Altitude Top of Hole (Feet)	Total Depth (Feet)	Formations* Penetrated
W-2264	72	45	Qw, QTbc, Ty
W-2265	77	31	Qw, QTbc, QTs, Ty
W-2266	95	41	Qw, QTbc, Ty
W-2267	69	26	"
W-2268	84	36	"
W-2269	93	61	Qw, QTbc, QTs, Ty
W-2270	105	66	"
W-2271	108	55	"
W-2272	82	37	"
W-2273	81	26	Qw, QTbc, Ty
W-2274	83	26	Qw, QTbc, QTs, Ty
W-2275	82	51	Qw, QTbc, Ty
W-2276	75	44	Qw, QTbc, QTs, Ty
W-2277	60	36	Qw, QTs, Ty
W-2278	112	46	QTbc, Ty
W-2279	100	48	Qw, QTbc, QTs, Ty
W-2280	84	23	Qw, QTs, Ty
W-2281	95	35	Qw, QTbc, QTs, Ty
W-2282	94	21	Qw, QTbc,
W-2283	95	47	Qw, QTbc, QTs, Ty
W-2284	84	45	"
W-2285	76	32	"
W-2286	72	37	"
W-2287	116	40	QTbc, Ty
W-2288	117	46	QTbc ?
W-2289	105	55	QTbc, QTs, Ty
W-2290	98	43	"
W-2291	87	41	Qw, QTbc, QTs, Ty
W-2292	82	40	"
W-2293	78	60	"
W-2294	78	36	"
W-2295	76	30	Qw, QTs, Ty
W-2296	73	34	"
W-2297	75	41	"
W-2298	88	41	Qw, QTbc, QTs, Ty

*Formations are: Qn, Norfolk Formation; Qw, Windsor Formation; QTbc, Bacons Castle formation; QTs, Sedley formation; Ty, Yorktown Formation; Ts, St. Marys Formation.

Field work in the Bacons Castle quadrangle and that part of the Hog Island quadrangle south of the James River was carried out intermittently by N. K. Coch from June 1961 to November 1963 under contract NONR 609 (40), Geography Branch, U. S. Office of Naval Research. For a period of 10 weeks during 1967 the Virginia Division of Mineral Resources employed the writer to do detailed mapping and to supervise the drilling of 35 test holes. All the holes were cased and split-spoon samples were taken at 5-foot intervals; some continuous sampling was done across contacts and other critical intervals. Coch accompanied the drillers in order to keep drilling logs and to take penetrometer readings.

The writers gratefully acknowledge the financial and technical aid of the Virginia Division of Mineral Resources. Many local residents provided useful information and help to the writers in the field. Dr. Gerald H. Johnson, of the Geology Department of the College of William and Mary, deserves special thanks for many stimulating discussions and for the aid he provided the writers during the latter part of the study. E. F. Caldwell and the Carpenter Construction Company of Norfolk provided Coch with laboratory and shop facilities and Stephen Brennan assisted him in the field in the summer of 1967.

MORPHOLOGY

The Williamsburg, Hog Island, and Bacons Castle quadrangles are located in the Coastal Plain physiographic province approximately halfway between the Atlantic Ocean and the Fall Zone. The Virginia Coastal Plain, which has a "stair-step" characteristic is composed of a series of plains that are successively lower from west to east and are separated from one another by scarps. The description and history of this "terraced" topography have been the subjects of much study over the past 75 years; Coch (1965) has reviewed the studies pertinent to southeastern Virginia. Because the term "terrace" carries many connotations relating to previous studies of the Coastal Plain, the writers have applied the purely descriptive and noncommittal term "plain" to these morphologic features. Table 2 is a comparison of the terminology used in this report with the "terrace" terminology of other workers.

Four plains are recognized in the area of this report; from highest to lowest they are: 120-foot plain, 90-foot plain, 70-foot plain and 45-foot plain (Figure 2). Each plain is designated on the basis of a characteristic altitude, but this does not imply that the entire surface of a plain is at the same altitude. In addition to

Table 2.—Comparison of the morphologic terminology used in this report with the "terrace" terminology used in previous reports.

This Report	Virginia-Maryland (Clark and Miller, 1912)	Virginia (Wentworth, 1930)	North Carolina (Stephenson, 1912)	South Carolina	
				(Cooke, 1936)	(Colquhoun, 1965)
45-foot plain	Talbot	Princess Anne	Pamlico	Pamlico	Silver Bluff
		Dismal Swamp			Pamlico
		Chowan	Chowan	Talbot	
70-foot plain	Wicomico	Wicomico	Wicomico	Penholoway	
90-foot plain				Wicomico	
120-foot plain	Sunderland	Sunderland	Sunderland	Sunderland	Okefenokee
					Sunderland

the four plains, four major scarps are prominent morphologic features. Three of the scarps, the Chippokes, Kingsmill, and Peary (Figure 2), separate the 45-foot plain from higher plains; the fourth scarp, a continuation of the Surry scarp (Wentworth, 1930), separates the 90-foot plain from the 120-foot plain.

The 120-foot plain occupies approximately the western third of the Williamsburg quadrangle (Figure 2). Altitudes at the eastern margin of the plain are approximately 120 feet, although the plain rises gently westward. An eastward-facing scarp that is a continuation of the Surry scarp (Wentworth, 1930) forms the eastern boundary of the 120-foot plain at some localities on the York-James Peninsula, but is not a continuous feature. The boundary between the 120-foot plain and the 90-foot plain is commonly more in the nature of a slight steepening of slope that is apparent on topographic maps but usually obscure on the ground. Although the 120-foot plain is highly dissected, the original surface is generally preserved along the axial portions of the York-James Peninsula.

The 90-foot plain occupies most of the area of this report (Figure 2). Where the 90-foot plain is separated from the 120-foot plain by a scarp, the altitude at the scarp toe is close to 90

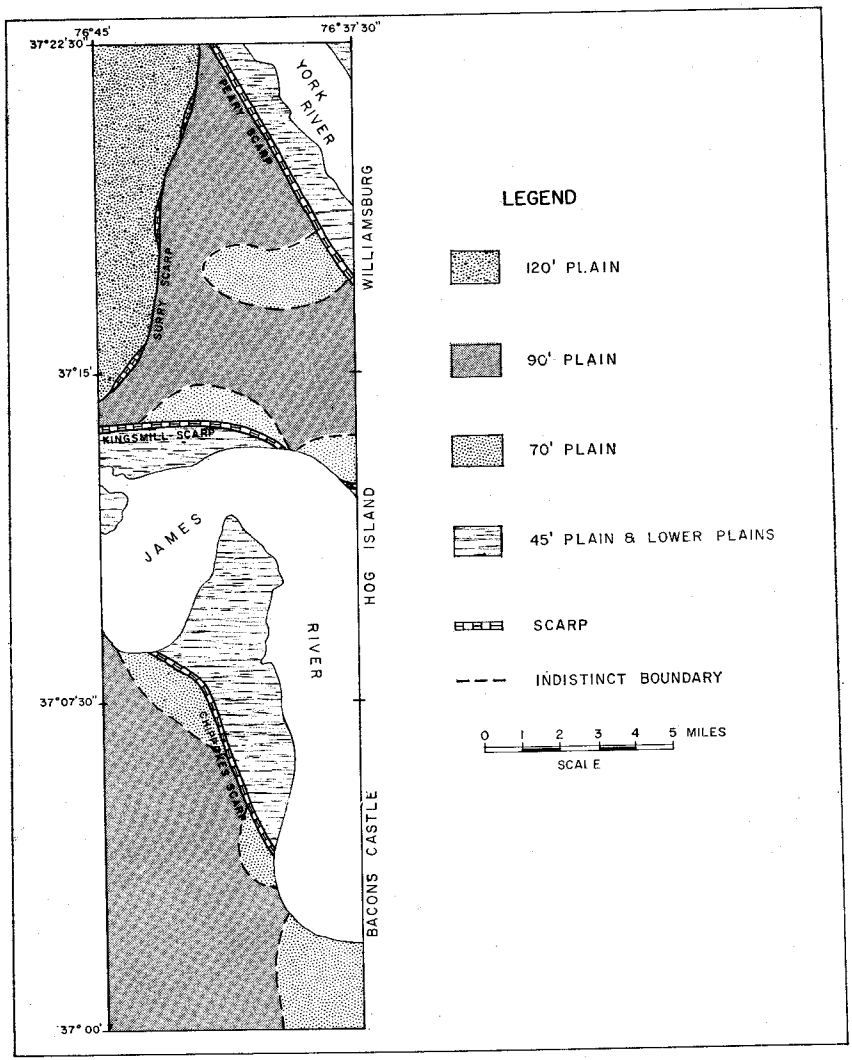

Figure 2. Morphologic features in the Williamsburg, Hog Island, and Bacons Castle quadrangles.

feet. Where the morphologic boundary is less pronounced, the two plains merge rather imperceptibly, and no particular altitude can be cited as the upper limit of the plain. The 90-foot plain slopes away from its boundary with the 120-foot plain to an altitude of about 80 feet. The plain slopes generally southeastward, but it also slopes toward the major drainage lines.

The 70-foot plain, which is somewhat indistinct, occupies relatively small portions of the area (Figure 2). The highest part of the plain is at an altitude of approximately 75 feet. Slopes between altitudes of 83 feet and 73 feet are steeper than slopes above or below these altitudes, but the steeper slopes are not pronounced enough to sharply demarcate the 90-foot and 70-foot plains. The lowest parts of the plain, which is everywhere truncated by scarps (Figure 2), range in altitude from 55 to 65 feet. The plain slopes gently southeastward in the southeast part of the Bacons Castle quadrangle, but elsewhere local slopes toward major drainage lines, such as the James River and Queens Creek (Plate 1), are more obvious than the overall southeasterly slope. The 70-foot plain is dissected to about the same degree as the 90-foot plain, and its surface is well preserved locally.

The 45-foot plain, which is marginal to the James and York rivers, lies at the toes of the Chippokes, Kingsmill, and Peary scarps that separate it from the higher plains (Figure 2). Minor areas of the 45-foot plain are present along Queens Creek, and some problematical remnants occur along other smaller streams. Although the major part of the plain lies at altitudes near 35 feet, the maximum altitude of the plain is about 45 feet and the minimum is slightly above sea level. Within these altitudes, flats are present at several different levels. Because none of these flats is extensive or morphologically distinct from other portions of the plain, the flats have been included in the 45-foot plain. Earlier workers have subdivided the 45-foot plain into several "terraces" (Table 2), but the subdivisions seem to be quite arbitrary when applied in this area. The 45-foot plain slopes toward the James and York rivers, but, contrary to the higher plains, has no regional slope to the east and southeast within the mapped area.

STRATIGRAPHY

MIOCENE SERIES

The oldest rock unit exposed in the area of this report is the St. Marys Formation (Figure 3). It and the overlying Yorktown Formation are in the upper part of the Chesapeake Group of Miocene age. The Yorktown crops out in all three of the quadrangles (Plates 1, 2, 3), but the St. Marys is exposed only north of the James River (Plates 1, 2).

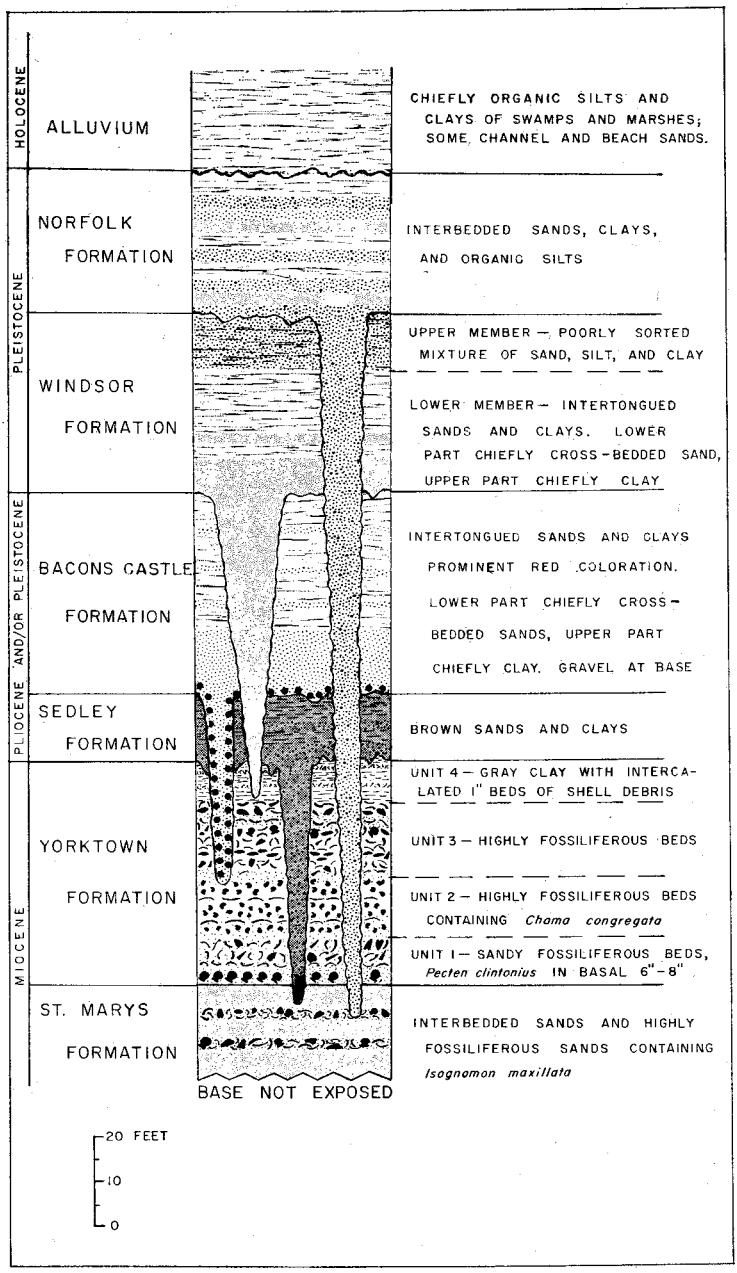

Figure 3. Stratigraphic units in the Williamsburg, Hog Island, and Bacons Castle quadrangles.

McLean (1956) discussed the ecology of fossil forms represented in the Yorktown Formation. In a later report (McLean, 1966), he added to the information on the Yorktown and also discussed the environment represented by microfossils in the St. Marys Formation. Samples taken by Bick across the St. Marys-Yorktown contact were found by McLean (1966) to show a gradational, rather than abrupt, environmental change at the contact. In summary of McLean's findings: the Yorktown appears to represent an open-ocean deposit formed at a maximum depth of about 300 feet; the St. Marys appears to represent a definitely shallower water marine environment with some brackish-water conditions.

The minimum depth at which the Yorktown Formation could have been deposited is not well established by the faunal evidence. The fauna does not preclude minimum depths as shallow as the submerged portion of a beach foreshore. The physical nature of units 1, 2, and 3 of the Yorktown in the Williamsburg quadrangle is consistent with extremely shallow deposition, possibly even storm-caused shell heaps in some beds. Unit 4 has the physical and faunal characteristics of a lagoon deposit. The Yorktown and St. Marys therefore appear to represent near-shore marine environments with occasional periods of deposition in environments in which access to the open ocean was restricted.

St. Marys Formation

The St. Marys Formation was named for exposures in St. Marys County, Maryland (Shattuck, 1902). The name was extended into southeast Virginia by Clark and Miller (1906). In the Hog Island quadrangle (Plate 2) the formation is exposed due east of Birchwood Park on the right bank of College Creek (at the end of the northernmost road intersecting State Road 617 from the east) and immediately below the dam at Lake Powell (adjacent to State Road 618). Less than 8 feet of vertical exposure is present at either locality.

The contact between the St. Marys and the overlying Yorktown Formation has been interpreted as both conformable (Clark and Miller, 1906, 1912) and unconformable (Mansfield, 1943). The evidence in the area of this report suggests a conformable relationship between the formations. The dip of the St. Marys-Yorktown contact is 3 to 4 feet per mile to the southeast, and the regional dip of the St. Marys appears to be the same. The St. Marys-Yorktown contact as used in this report coincides with that used by Mansfield (1943). The criteria used by Mansfield to define the St. Marys-Yorktown contact were fundamentally faunal.

Within the area of this report, the St. Marys Formation consists of alternating sand units and highly fossiliferous units with a sand matrix. *Isognomon maxillata* is an abundant and easily identified form in these beds. The basal part of the overlying Yorktown Formation is a fossiliferous unit with a sand matrix, but the faunal content differs in many respects from that of the underlying beds. In particular, *Pecten clintonius* occurs at, or within a few inches of, the base of the lowermost unit of the Yorktown Formation. The St. Marys-Yorktown contact is therefore taken at the base of the highly fossiliferous unit containing *Pecten clintonius*. There is no well-defined lithologic change at this contact, but it is readily recognized by the distribution of the two fossil forms. Within the mapped area, *Isognomon* is unknown above the *Pecten* horizon and *Pecten clintonius* has been found only within a restricted vertical range of a few inches. At many localities the St. Marys is unconformably overlain by post-Yorktown formations. The thickness of St. Marys Formation exposed in the area studied does not exceed 20 feet, although well data (Cederstrom, 1957) indicate a total thickness on the order of 150 feet.

The exposed part of the St. Marys Formation, which is only locally consolidated, is dominated by two lithologies. One lithologic type is quartz sand that is fine to medium grained, rounded to subangular, and light brown on fresh and weathered surfaces. Some bluish sands are present and gray to white sands are common, but these colorations reflect local oxidation states rather than distinctive lithologies. Consolidated sands are yellow-brown to dark brown due to the presence of limonitic cement. The fossil content of the sands is variable. The other lithologic type is composed primarily of whole and fragmental fossil material in a sand matrix. The two lithologies are approximately equally abundant.

The attitude of the interbedded sand and shell units is horizontal on a large scale, but because the thickness of individual units varies markedly, the contacts between units are not horizontal in detail. The units range in thickness from about 6 inches to 3 feet. There is little evidence of bedding within most of the units, although discontinuous cut-and-fill structures are present within some of the fossiliferous units. The bedding indicates that these units were deposited rapidly under agitated conditions; the jumbled aspect of the fossils reinforces this interpretation.

The fossil content of the St. Marys Formation is extensive (Clark and Miller, 1912; Gardner, 1943; McLean, 1956, 1966; Gibson, 1962). *Isognomon maxillata* is the most distinctive form

and serves as a useful indicator to the formation. The age of the St. Marys Formation, based on the abundant marine fauna, is considered to be middle Miocene.

Yorktown Formation

The Yorktown Formation was named by Clark and Miller (1906) from exposures in the York River bluffs near Yorktown, Virginia, about 8 miles east of the Williamsburg quadrangle. The most extensive outcrops of the formation in the area of this study are in the James River bluffs between the Camp Wallace Military Reservation and College Creek (Plate 2); the upper part of the formation is best seen in roadcuts immediately east of where Interstate Highway 64 crosses Kings Creek (Plate 2).

The contact of the Yorktown Formation with the underlying St. Marys Formation, which is taken at the base of a fossiliferous unit containing *Pecten clintonius*, appears conformable in the area of this report and has a dip of 3 to 4 feet per mile to the southeast. The upper contact of the Yorktown is an unconformity that is easily recognized by its irregularity and by the contrasting materials in the Yorktown and the overlying formations. The unconformity truncates the Yorktown at a low angle, causing stratigraphically higher parts of the formation to crop out progressively to the southeast. In many areas the Yorktown has been removed by erosion, and post-Yorktown sediments unconformably overlie the St. Marys. Because there have been several post-Yorktown erosional episodes in the history of the area, any of the post-Yorktown formations may be found in contact with the Miocene formations. The contact between the Yorktown and Sedley formations represents the oldest, and most widespread, of these several erosion surfaces. The unconformity has as much as 15 feet of relief in single outcrops and at least 60 feet of relief within the mapped area.

The regional configuration of the Yorktown-Sedley contact conforms closely to the major elements of the present topography, but in some areas ground-water solution has produced significant differences; locally, the unconformity is a highly irregular karst surface. In most areas where the post-Miocene formations rest on abundantly fossiliferous units of the Yorktown or St. Marys, they are separated by a dark reddish-brown saprolite that ranges from a few inches to 10 feet in thickness. The saprolite is not always easy to distinguish from the Sedley formation, especially in test borings. . The karst features have been forming since

Yorktown deposits were exposed above sea level and cannot be ascribed to any particular episode in the post-Yorktown history of the area.

The thickness of the Yorktown Formation is usually cited as 150 to 200 feet (Clark and Miller, 1912), but no more than the lower 40 to 45 feet is present in the Williamsburg quadrangle where the formation has been most intensively investigated for this report. The lower 35 feet of the formation consists primarily of abundantly fossiliferous material with a sandy, or clayey, matrix. The upper 10 feet of the exposed portion of the formation is predominantly thinly parted clay. The formation is unconsolidated, except locally.

For the purpose of this report, the Yorktown Formation has been subdivided into four informal units. Unit 1, about 10 feet thick, is the lowermost unit of the Yorktown Formation and contains *Pecten clintonius* at the base. The unit is characterized by numerous types of large mollusks crowded together in a quartz-sand matrix that is in some places clayey. Unit 2, about 15 feet thick, is easily recognized by an abundance of *Chama congregata;* the matrix is sandy and contains much finely broken shell debris. Bedding is generally obscure in units 1 and 2, but in some places it is marked by concentrations of large oysters and pectens. The attitude of these concentrations is irregular in detail, but is horizontal on the large scale.

Unit 3 is 10 to 15 feet thick; it is generally abundantly fossiliferous, but some relatively unfossiliferous clays are present. Individual layers of the sandy fossiliferous strata can be distinguished on the basis of prominent fossils, but there are repetitions of these beds. Similar beds are also intercalated with *Chama*-rich beds of unit 2 in some outcrops. The strata of unit 3 have strong ecologic control, and the vertical sequence of unit 3 (and probably including unit 2) has little or no relevance for time correlation. Unit 4, about 10 feet of which is exposed, is gray to brown, thinly parted clay containing several 1-inch-thick layers of comminuted shell debris. The Yorktown Formation is regarded as late Miocene in age on the basis of its fauna.

PLIOCENE AND/OR PLEISTOCENE SERIES

Sedley Formation

The Sedley formation was informally named by Moore (1956) and was retained as a stratigraphic unit by Coch (1968). The type section is near Sedley, Virginia. Outcrops of the Sedley formation

are present in the roadcut immediately south of Tutters Neck Pond along State Road 637 (Plate 1) and in the sides of a small valley 0.2 mile due west of a point on the Colonial National Historical Parkway that is 0.35 mile north of the bridge over Halfway Creek (Plate 2).

The Sedley unconformably overlies either the Yorktown Formation or St. Marys Formation and is unconformably overlain by the Bacons Castle formation or by younger units where the Bacons Castle is not present. The top of the Sedley is marked by some irregularity, which is not prominent in all outcrops; by a change in color from dark brown or dark red-brown to yellow- or red-brown; and by a change of grain size from clay, silt, or fine to medium sand to coarse sand and gravel. Gravelly sands floored by a cobble zone, one cobble thick, are generally present at the upper contact.

At some localities where the Sedley formation has been completely removed by erosion, the Bacons Castle rests directly on the Miocene formations. At other localities, especially south of the James River, the younger Windsor Formation rests on the Sedley (and in some places on Miocene formations). Windsor-Sedley contacts are similar to Bacons Castle-Sedley contacts except that the cobble zone is not well developed and the Windsor lacks the strongly developed red hues characteristic of the Bacons Castle formation. The Norfolk Formation, which is younger than the Windsor, unconformably overlies the Sedley or the Miocene formations in areas below 45 feet altitude in all three quadrangles. Sedley-Windsor contacts are similar to Sedley-Norfolk contacts, but the Norfolk Formation is less weathered than the Windsor.

The Sedley formation appears horizontal in outcrops but has southeasterly dips of about 2 feet per mile, based on the average slope on the surface of the Miocene formations in southeast Virginia which is about 2 feet per mile to the southeast (Coch, 1965). The thickness of the Sedley south of the James River ranges from 0 to 35 feet, averaging about 10 feet; north of the James River, the formation is about one-half as thick. The difference in thickness is believed to be chiefly due to post-Sedley erosion; today the York-James Peninsula is much more dissected than the area south of the James River. The variations in thickness are also due to the configuration of the surface upon which the Sedley was deposited. The thickness of the Sedley increases toward present-day major drainage lines, which occupy the same sites as pre-Sedley drainage, indicating that the Sedley filled depressions on the pre-Sedley land surface.

The Sedley formation is composed of unconsolidated materials ranging in size from clay to medium sand. On a regional scale the grain sizes become finer from west to east (Coch, 1965). In the area of this report the Sedley is predominantly silt and clay beneath interfluves, especially beneath the broad interfluves in the Bacons Castle quadrangle, and is sandy near present major drainage lines. The fine-grained facies commonly consists of intercalated laminae of clay and silt to fine sand. Glauconite, which is present throughout the formation, is concentrated at the base. Ferricrete layers are common, especially at contacts between materials of differing permeability.

On the York-James Peninsula, where the Sedley is thin, the coarse-grained facies is generally oxidized to dark brown with some dark red, and the fine-grained facies is gray-brown to greenish brown. South of the James River, the formation is brown to reddish brown in the upper part, bright blue and greenish blue in the middle part, and very dark reddish brown with black streaks in the basal part.

The available evidence in the area of this report is consistent with a fluvial-estuarine origin for the Sedley formation, although this must be considered a tentative conclusion. The possibility that the upper Yorktown Formation may be post-Miocene (U. S. Geological Survey, 1965, p. A 71) and the evidence of extensive pre-Sedley erosion suggest a post-Miocene age for the Sedley; therefore, this formation is assigned an age of Pliocene and/or Pleistocene.

Bacons Castle Formation

Stratigraphically, the Bacons Castle formation (Coch, 1965) unconformably overlies the Sedley formation, but in some areas it overlies Miocene formations. Exposures of the Bacons Castle are in a roadcut along State Road 637 immediately south of Tutters Neck Pond and in roadcuts along State Road 646 southwest and southeast of Barlows Corner (Plate 1).

The irregular basal contact of the Bacons Castle is roughly parallel to the present topography. The Bacons Castle is unconformably overlain by the Windsor Formation east of the Surry scarp and in many areas west of the scarp where altitudes are less than 110 feet. Because the Windsor was not deposited above altitudes of 110 feet, the Bacons Castle is the surficial, and youngest, deposit above this altitude. The 120-foot plain represents the present-day, dissected depositional surface of the Bacons Castle. In many places a distinct Bacons Castle-Windsor

contact is difficult to discern because the formations are lithologically similar, but the contact is generally marked by a color change and a general change in grain size of sands. The hematite-imparted red colors of the Bacons Castle contrast with the grays and yellow-browns of the Windsor, and the medium to coarse sands, some of which are gravelly, of the Bacons Castle contrast with the fine to medium sands of the Windsor. The silt facies of each formation can be separated only at exposures where the weathering differences are apparent. The surficial formation east of the Surry scarp and above 45 feet altitude is principally the Windsor, and the surficial formation west of the Surry scarp and above 45 feet altitude is principally the Bacons Castle.

The Bacons Castle formation appears horizontal in outcrop, but has a regional dip to the southeast of about 2 feet per mile. Thickness of the Bacons Castle ranges up to 50 feet. East of the Surry scarp, the Bacons Castle is much thicker on the north side of the James River than on the south side where only small unmappable remnants are present. This probably resulted from differing amounts of wave planation that accompanied a rising sea level during Windsor deposition. The formation is also thicker near the present major drainage lines and thinner beneath the interfluves. Stratigraphic relationships, sediment types, and sediment structures indicate that the Bacons Castle formation is of fluvial origin. The formation was spread over the area as an extensive, but thin, apron; this surface is preserved as the 120-foot plain.

The Bacons Castle formation is composed of a sand facies that dominates near the present major drainage lines and in the lower part of the unit; a bedded silt facies that predominates beneath the interfluves and in the upper part of the formation; and a sand and silt facies that consists of the preceding two facies interbedded in about equal proportions. The most distinctive characteristic of the formation is its extensive oxidation. The sandier parts of the Bacons Castle are characteristically red, dark brown, or yellow-brown, and the silt facies and interbedded silt and sand facies generally have intense red coloration. Ferricrete layers ranging from a fraction of an inch to nearly a foot in thickness are common, especially at the contacts between beds of clay and sand.

The sand facies of the Bacons Castle formation ranges in thickness from 3 feet to about 15 feet and is invariably cross bedded. The cross-beds are normally of the trough type, representing the remains of dune-bed forms. Clay balls and flat clay

chips, identical to material in the silt facies, are aligned parallel to many of the cross-beds, emphasizing the cross stratification. The sand facies fills distinct channels cut into the underlying formations but the overall geometry of the facies is that of a sheet-type deposit. The sands above the basal gravelly sand are generally well sorted and account for 70 to 90 percent of the facies by weight; the remaining material consists of about equal amounts of silt- and clay-size particles. The sands range from fine to very coarse; medium and coarse sands are characteristic of the facies. A few pea-size pebbles are scattered through the sands, and local areas of mixed sand and pea gravel are present. The sands and gravels are composed principally of quartz. Zircon, opaque minerals, staurolite, kyanite, epidote, sillimanite, tourmaline, rutile, garnet, and sphene are present in the heavy-mineral fraction, but minerals of lesser stability such as hornblende and pyroxene are rare. All minerals have etched surfaces and solution features indicative of intrastratal solution. Hematite and limonite impart coloration to the sands.

The silt facies occurs in units up to about 8 feet thick. The units are thinly parted, with films of very fine sand commonly present on the parting surfaces, and many individual laminae are cross laminated on an extremely fine scale. The attitude of the laminated silts is generally subhorizontal, but the bedding conforms to whatever irregularities may occur on the tops of underlying sand units. By increase in the thickness and coarseness of the sand partings, with concomitant reduction in the number of silt laminae, the silt facies grades laterally and vertically into the sand facies. Most of the lateral gradation occurs over distances of 10 to 30 feet and vertical gradation is complete within 1 or 2 feet, although many of the contacts between sand and clay units are sharp rather than gradational. The laminae of the silt facies contain up to 75 percent clay-size particles by weight, but grain sizes are generally about equally divided between clay and silt, or slightly more than half silt. Sand content within the silt facies ranges up to about 5 percent by weight. The gray to blue-gray color of the silts is generally obscured by extensive permeation of red colors caused by hematitic staining.

Bedding within the alternating sand and silt facies ranges from 6 inches to about 1 foot in thickness. The silt beds in this facies are identical to those in the silt facies, but the sand beds differ from those of the sand facies in that they are finer grained, are generally devoid of internal sedimentary structures, and are commonly red. Where these sands are cross bedded, the scale

of the bedding indicates that the deposits represent the remains of ripple-bed forms. Flat clay chips are aligned with the cross-beds in places and clay balls are present. The redness of the sands in this facies appears to reflect the intimate association with the characteristically red clays because the sand facies is typically red to dark brown or yellow-brown.

The cobble zone at the base of the Bacons Castle formation is of special interest. The well-rounded cobbles are principally clasts of sedimentary and metamorphic quartzite with some red sandstone and various types of igneous and metamorphic rocks; all except the quartzite cobbles are weathered. The largest cobble observed was 15 inches in longest dimension, a size that apparently far exceeds the competence of modern streams in the area and is beyond the ability of normal oceanic or tidal-channel processes. Boulders as large as 2 feet in diameter have been reported from this general area by Wentworth (1930) who has concluded that cobbles and boulders were transported by river ice during periods of colder climate than at present. A 300-cobble sample, which included all sizes greater than 1 inch in smallest dimension, was measured at an outcrop adjacent to Tutters Neck Pond (Plate 3). The largest cobble in this sample, 13 inches in diameter, was at the upper limit of a continuous size distribution. Generally, observations indicate that cobbles up to at least 15 inches in diameter are merely the extremes of a depositional suite. The cobble zone is probably a lag deposit formed of materials that were carried by infrequent floods of exceptional magnitude; the cobbles could not be moved later by normal stream discharges and eventually became concentrated at the base of the Bacons Castle formation by continued winnowing of finer grained sediments.

The post-Miocene Bacons Castle formation is unfossiliferous except for worn, redeposited Miocene foraminifera and a few enigmatic burrows(?). Therefore, based upon available information, the formation is assigned a Pliocene and/or Pleistocene age.

PLEISTOCENE SERIES

Windsor Formation

The Windsor Formation was named by Coch (1968). The type section is a core boring in the vicinity of the town of Windsor, Isle of Wight County, Virginia. In the area of study the best exposure of the Windsor is in a sandpit on the west side of State Road 604, 0.1 mile south of Carter Creek (Plate 1), where approxi-

mately 35 feet of the formation is exposed. The Windsor, which was not deposited above 110 feet altitude, occurs chiefly east of the Surry scarp where the 90-foot and 70-foot plains represent the now-dissected depositional surface of the formation. Stratigraphically, the Windsor unconformably overlies the Bacons Castle formation, but in the absence of the Bacons Castle, may overlie the Miocene formations or the Sedley formation. The Windsor is stratigraphically succeeded by the Norfolk Formation, which underlies the 45-foot plain, but the two formations are seldom in contact except in the immediate vicinity of the scarps bounding the 45-foot plain because planation prior to Norfolk deposition removed the Windsor.

The Windsor Formation appears horizontal in outcrop, but has a regional dip of 1 to 3 feet per mile to the east and southeast. Its depositional surface slopes about the same amount toward present major drainage lines. Thickness of the Windsor, which ranges from 0 to about 40 feet, is more variable north of the James River than south of the river because the formation was deposited over a more irregular topography on the York-James Peninsula. In general, the Windsor is thicker near present major drainage lines and thinner beneath the interfluves.

The Windsor Formation can be subdivided into two informal members. The lower member makes up about three-fourths of the total thickness of the formation where the Windsor is fully developed, but accounts for only one-fourth of the formation or less in areas where it is thin. Local facies within the lower member are controlled chiefly by proximity to major drainage lines. The facies of the upper member are related to proximity to the Surry scarp and also appear to be somewhat different on the York-James Peninsula than in the area south of the James River.

The lithology of the lower member of the Windsor Formation is similar to that of the Bacons Castle formation. The lower Windsor is thickest near present major drainage lines and thinnest beneath interfluves. Where thick, the lower Windsor is chiefly a cross-bedded sand facies, and where thin, it consists of sand in the lower part and a bedded silt facies in the upper part. Locally north of the James River and generally south of the James, the sand facies of the lower member grades vertically into the upper member with little or no development of the bedded silt facies. The main differences between the lower Windsor and the Bacons Castle are: (1) the Windsor seldom contains cobble-size clasts in the basal gravel zone, (2) the sands of the Windsor are in general finer grained than those of the Bacons Castle, and (3)

weathered Windsor is yellow-brown (sand facies) to gray and blue-gray (silt facies) with only minor hematite staining, whereas hematite stains are strongly developed in the Bacons Castle. The mineralogy of the Windsor is similar to that of the Bacons Castle, but hornblende and pyroxene are more common in the heavy-mineral fraction of the Windsor and none of the minerals are as etched and pitted as those of the Bacons Castle (Coch, 1968).

Beneath interfluves, where the sand facies of the Windsor is thinnest, a few of the sand units are undulatory; cross-beds within the sand dip in both directions normal to the axes of these undulations, indicating that the undulatory structures are sand bars of depositional origin. The sand facies is better sorted beneath interfluves than elsewhere and also contains prominent heavy-mineral laminae.

The upper member of the Windsor Formation is gradational with the lower member across a vertical interval of a few inches to 2 feet where it overlies the bedded silt facies of the lower member. Where the bedded silt facies is absent, particularly south of the James River, the upper member is gradational across several feet with the sand facies of the lower member. The upper member is a heterogeneous mixture of sand, silt, clay, and fragments derived from the silt facies of the lower member and/or the Bacons Castle formation. Eastward from the Surry scarp, there is a general gradation from relatively sandy to relatively clayey material, but the facies pattern is highly irregular in detail. The most common lithology consists of 30 to 40 percent sand-size grains by weight; the remaining material is about equally divided between silt and clay. On the York-James Peninsula, the sand fraction increases to 70 to 80 percent within 0.25 mile of the Surry scarp, but, except for this visible change, mechanical analysis is usually required to differentiate facies. The upper member is generally less sandy south of the James River, probably reflecting the increased distance from the Surry scarp. Sorting is very poor and grain sizes range from granules to clay. The mineralogy of the upper member is similar to that of the lower member.

With the exception of the sandy facies near the Surry scarp, the upper member is very cohesive and characteristically forms nearly vertical cliffs, 5 to 10 feet high, in natural and artificial exposures. Another characteristic feature is the lack of sedimentary structures except for horizontal and cross bedding in the basal gradation zone. The cross beds represent the remains of ripple-bed forms.

The color of the upper member, which is primarily due to oxidation associated with present soil-forming processes, is typically a mottled mixture of yellows, grays, browns, and less prominent reds. The shape and position of the mottles indicate that the coloration is associated with chemical activity around root systems. Below the zone of extensive root action, the color is generally more uniform brown, gray-brown, or purplish gray with only minor mottling.

Although most of the Windsor Formation occurs below 100 feet altitude, discontinuous areas of quartz sand belonging to the Windsor are found up to 110 feet altitude. The sands are generally less than 5 feet thick, and their white to tan color contrasts markedly with the red Bacons Castle formation that underlies them.

A few isolated pebbles are found in both members of the Windsor Formation. At the James River bluffs near College Creek (Plate 1) the river is eroding the Norfolk Formation that contains scattered cobbles. The cobbles are set free from the bluffs by the erosion and fall onto the modern sandy river bed; because the river cannot move the cobbles, they are incorporated into the modern deposits. No cobbles are known in deposits older than the Bacons Castle formation, and no formation younger than the Bacons Castle lacks scattered cobbles. This suggests that most, if not all, of the cobbles were originally deposited in the Bacons Castle and were redeposited in younger formations through cliff recession associated with fluvial, estuarine, and marine processes. Some of the larger boulders (up to 2 feet in diameter) reported by Wentworth (1930) may have been the result of ice transport, although boulders of this size are probably rare, and none over 15 inches in diameter were observed by the writers.

The lower member of the Windsor Formation is fluvial estuarine in its lower part and littoral in its upper part. The upper member is of bay origin. Deposition of the Windsor accompanied a marine transgression during which maximum relative sea level reached + 100 to 110 feet.

The age of the Windsor Formation cannot be determined by paleontological evidence, as the foraminifera present range from Miocene to the present. Because the Windsor was deposited during a time when maximum relative sea level stood at + 105 ± 5 feet altitude, the formation is considered to date from a Pleistocene interglacial stage. The "fresh" aspect of the Windsor suggests

one of the younger stages. The Windsor Formation is probably either of Yarmouth or early Sangamon age and is tentatively assigned a Yarmouth age.

Norfolk Formation

The Norfolk Formation was named by Clark and Miller (1906) for exposures in the vicinity of Norfolk, Virginia. Excellent exposures of the Norfolk are present in the James River bluffs and in a borrow pit immediately northeast of the Chippokes scarp on the north side of State Road 628, 0.2 mile east of the bridge over Lawnes Creek (Plate 3). The Norfolk Formation, which underlies the 45-foot plain, unconformably succeeds the Windsor Formation in the stratigraphic section, but locally may overlie any of the older formations. In other parts of southeast Virginia the Norfolk Formation is unconformably overlain by younger formations, but the Norfolk is the youngest Pleistocene formation definitely recognizable in the area of this report.

The surface of the Norfolk Formation slopes toward major drainage lines. It ranges in thickness from a few feet near the Chippokes, Kingsmill, and Peary scarps, which form its chief landward boundaries, to over 45 feet near creeks and rivers. The upper surface of the Norfolk is nearly level, and the lower contact is undulatory; the formation is thin in the vicinity of interfluves and thickens toward major drainage lines.

The Norfolk Formation is composed of cross-bedded medium to coarse sand, sandy pebble gravel, silty sand, and laminated silty clay units that have an orderly facies arrangement. From the scarps bounding the formation toward the rivers, there is an overall decrease in grain size, an increase in the abundance of horizontally bedded silt and clay, and an increase in the abundance of invertebrate fossil remains. The Norfolk Formation is a fluvial-estuarine complex that was deposited during a maximum relative sea level of + 45 to 50 feet. During Norfolk deposition, the morphology of the area of this report was similar to that of today except that the James and York river estuaries were approximately twice as wide.

Fossil imprints collected from the Norfolk Formation 0.3 mile north of Baileys Beach (Plate 3) have been identified as *Mercenaria mercenaria* Linne, *Rangia* sp., *Yoldia* sp., and *Mulina lateralis* Say (Horace G. Richards, written communication to Coch). *Rangia* sp. has also been collected from the bluffs on the

north side of the James River. *Mulina lateralis* is indicative of a brackish-water environment, and the other forms include brackish water within their environmental limits.

The Norfolk Formation cannot be accurately dated from the fauna found in the area of this report but, based on the relative lack of weathering, is geologically young. Fossils from other facies of the formation outside this area are indicative of Pleistocene age and a warm-water environment (Horace G. Richards, written communication to Coch). The Norfolk Formation is tentatively assigned a Sangamon age.

HOLOCENE SERIES

Holocene sediments unconformably overlie the older stratigraphic units adjacent to the James and York rivers and along all stream valleys subject to tidal influence; Holocene alluvium occupies the non-tidal parts of some stream valleys. The bulk of exposed Holocene sediments consists of tidal-marsh deposits. These sediments are organic-rich, dark-gray, silty clays. Well-developed beach deposits of fine to coarse sand occur along the James and York rivers and locally along their tributaries. The beach sands and the sands immediately offshore, contain scattered pebbles and cobbles derived from the bluffs bordering the streams. A small proportion of the exposed Holocene sediments consists of stream and tidal-channel deposits. Shell fragments, derived from the Miocene formations and from indigenous fauna, are generally a prominent constituent of channel deposits.

GEOLOGIC HISTORY

Prior to late Miocene time, the area of study was part of the Continental Shelf. The region was the site of extensive sedimentation, which aggregated between 700 and 1200 feet of terrigenous clastic and bioclastic debris, from Early Cretaceous to Miocene (Cederstrom, 1957). The middle Miocene St. Marys and upper Miocene Yorktown formations, which accumulated in near-shore marine and littoral environments, represent the closing stages of this long-continued depositional history. As the area of the quadrangles became emergent, drainage networks were established and dissection commenced. During this period of erosion, saprolite was developed on the calcareous Miocene sediments.

A relative change in sea level led to the deposition of the fluvial-estuarine Sedley formation. Following another period of extensive erosion in which the Sedley was partially removed, the fluvial Bacons Castle formation was spread over the area. The Bacons Castle is preserved on interfluves as remnants of a gently southeastward-sloping surface designated the 120-foot plain. A period of extensive erosion followed deposition of the Bacons Castle. This degradational episode possibly began in Pliocene time, and continued into the Pleistocene.

In the Pleistocene Epoch, a glacially controlled eustatic rise of sea level caused the inundation of most of the area. Maximum relative sea level attained during this transgression was + 100 to 110 feet. Wave planation partially or completely removed the Bacons Castle formation and some of the older units below an altitude of 100 feet and formed the Surry scarp, which is the present boundary of the 120-foot plain. The Windsor Formation, an estuarine-littoral complex, was deposited on the planed surface. The Windsor is exposed east of the Surry scarp as the surface of the 90-foot and 70-foot plains. This transgression and its accompanying deposits are tentatively assigned to the Yarmouth interglacial stage.

The next transgression occurred during the Sangamon interglacial stage; maximum relative sea level reached + 45 to 50 feet, insufficient to inundate the area completely. Planation and the consequent deposition of the Norfolk Formation were confined to areas marginal to the James and York river estuaries, and, except for the approximately doubled width of the rivers, the morphology at the time of maximum sea level was similar to that of today. Wave-cut cliffs bordered the estuaries, and a gently sloping subaqueous plain led from the foot of the cliffs to the edges of the main river channels. The surface of this plain, the depositional surface of the Norfolk, is preserved as the 45-foot plain, and the wave-cut cliffs are the Chippokes, Kingsmill, and Peary scarps. In general the more recent history of the Williamsburg, Hog Island, and Bacons Castle quadrangles encompasses an erosional period during the low sea levels of the Wisconsin glacial stage followed by a rise of sea level to its present position. The Holocene sediments principally represent a complex of estuarine channel and littoral environments that accompanied this eustatic rise of sea level following the Wisconsin glacial stage.

ECONOMIC GEOLOGY

Sand for general construction and road fill is being obtained from the Norfolk Formation at two sites in the Bacons Castle quadrangle (Plate 3). C. E. Hunter of Zuni operates a pit, located on the north side of State Road 628, 0.25 mile west of State Road 676 on the right bank of Lawnes Creek, from which sand and gravelly sand are obtained. The Virginia Department of Highways extracts similar materials from a pit located 0.6 mile to the north. Access to this pit is by a dirt road extending eastward from State Road 628 about 0.5 mile northwest of the intersection of State Roads 628 and 627.

There are numerous inactive pits, especially on the York-James Peninsula. Materials have been extracted from each of the formations in the area except the Yorktown, but most borrow pits are in the Windsor and Norfolk formations. The Bacons Castle and the lower member of the Windsor Formation have been utilized as sources of sand and gravelly sand. Some of the pits in these formations are of substantial size. Both members of the Windsor, especially the upper, were used extensively for roadbed construction at the time Interstate Highway 64 was built in the Williamsburg quadrangle, but the pits were abandoned at the close of construction.

Laboratory testing of four samples of clay material from the Williamsburg and Bacons Castle quadrangles indicated that they were potentially suitable for use in brick, drain tile, and, possibly, lightweight aggregate (Johnson and Tyrrell, 1967). A sample of clay and clayey sand (R-2714) from the Windsor Formation, 3.2 miles north of Williamsburg (Plate 1), was determined to be potentially suitable for the manufacture of face brick. Testing indicated that a pink-gray clay (R-2892) from the Windsor Formation 2.8 miles southeast of Bacons Castle (Plate 3) had potential use for the production of face brick. Gray and yellow-orange clay (R-2961) from the Windsor Formation 3.5 miles southwest of Rushmere (Plate 3) was found to be potentially suitable for the manufacture of face brick and drain tile. Sandy clay (R-1992) from the Yorktown Formation 0.4 mile east of Rushmere (Plate 3) may represent a possible source of raw material for the production of lightweight aggregate.

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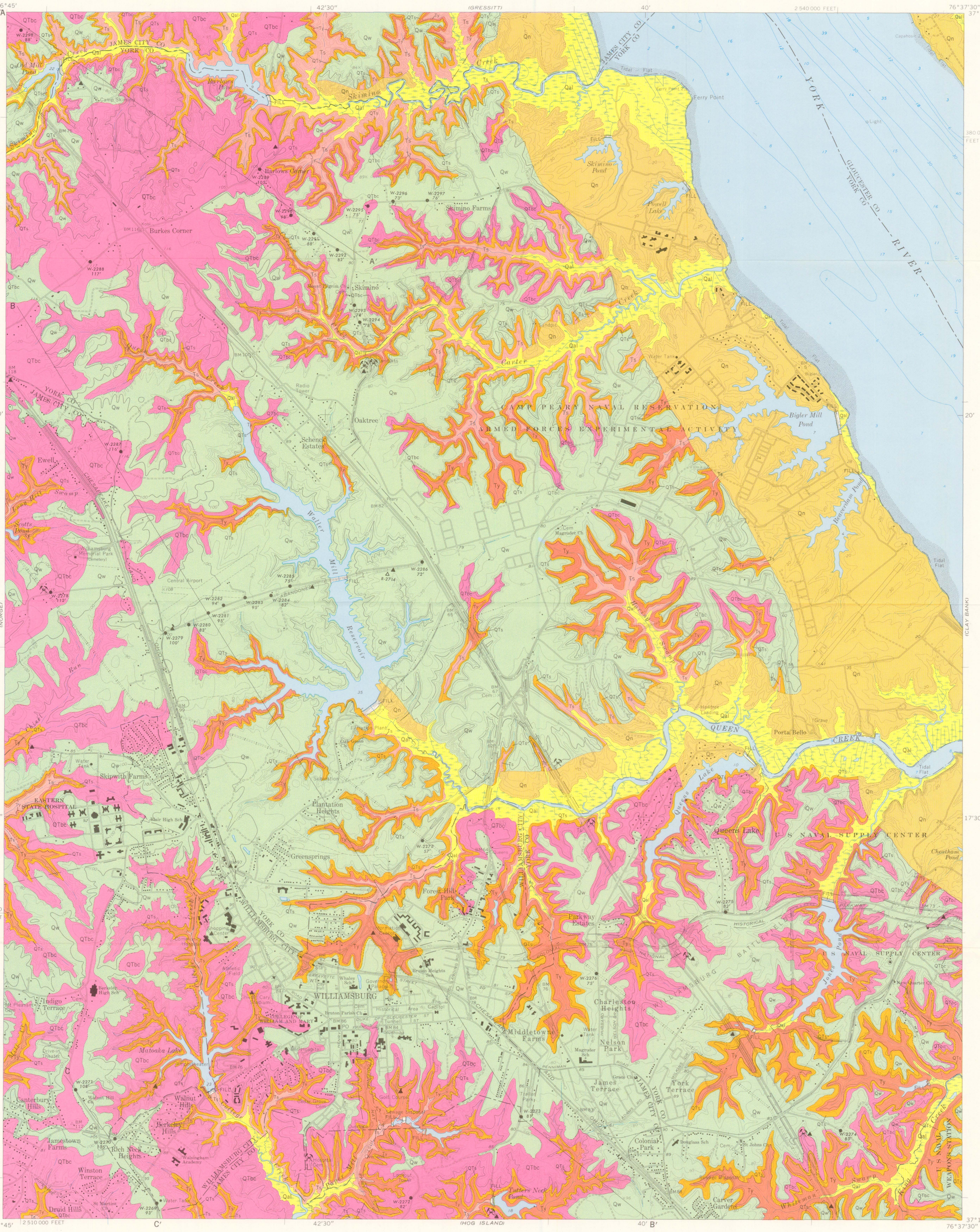
COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist



Base from U. S. Geological Survey, 1965
Williamsburg Quadrangle 7½ Minute Series

Williams & Heintz Map Corporation

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GEOLOGIC MAP OF THE WILLIAMSBURG QUADRANGLE, VIRGINIA

Geology by Kenneth F. Bick

EXPLANATION

QUATERNARY

HOLOCENE

Qal — Alluvium
Organic silt and clay; some sand.

PLEISTOCENE

Qn — Norfolk Formation
Interbedded sand, clay, and organic silt.

Unconformity

Qw — Windsor Formation
Upper part, poorly sorted mixture of sand, silt, and clay; lower part, chiefly cross-bedded sand.

Unconformity

(PLIOCENE?)

QTbc — Bacons Castle formation
Intertongued red sand and clay; gravel at base.

Unconformity

TERTIARY

MIOCENE

QTs — Sedley formation
Brown sand and clay.

Unconformity

Ty — Yorktown Formation
Gray clay and sand; many beds abundantly fossiliferous.

Ts — St. Marys Formation
Sand with interbedded fossiliferous sand.

CONTACTS

exposed

approximate

covered or inferred

STRATIGRAPHIC CONTROL

W-2285 75′ — Location of test boring with altitude of top of hole indicated.

Location where a representative stratigraphic section was examined.

QUARRIES

Abandoned

6½°
Magnetic North
True North

1965 MAGNETIC DECLINATION

SCALE 1:24 000

1 ½ 0 1 MILE

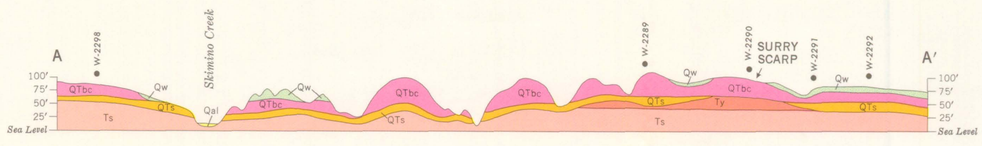
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

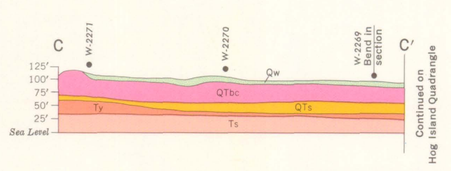
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 2.8 FEET

VIRGINIA

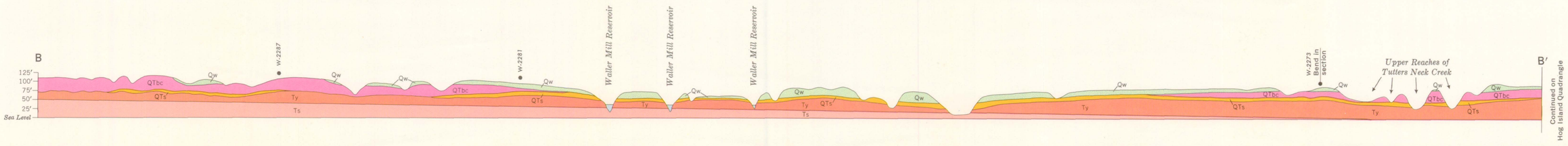
QUADRANGLE LOCATION

1969





Vertical Exaggeration 10X



COMMONWEALTH OF VIRGINIA
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Base from U. S. Geological Survey, 1965
Hog Island Quadrangle 7½ Minute Series

Williams & Heintz Map Corporation

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GEOLOGIC MAP OF THE HOG ISLAND QUADRANGLE, VIRGINIA

Geology by Kenneth F. Bick and Nicholas K. Coch

EXPLANATION

QUATERNARY — HOLOCENE

Qal — Alluvium
Organic silt and clay; some sand.

QUATERNARY — PLEISTOCENE

Qn — Norfolk Formation
Interbedded sand, clay, and organic silt.

Unconformity

Qw — Windsor Formation
Upper part, poorly sorted mixture of sand, silt, and clay; lower part, chiefly cross-bedded sand.

Unconformity

QUATERNARY — (PLIOCENE?)

QTbc — Bacons Castle formation
Intertongued red sand and clay; gravel at base.

Unconformity

QTs — Sedley formation
Brown sand and clay.

Unconformity

TERTIARY — MIOCENE

Ty — Yorktown Formation
Gray clay and sand; many beds abundantly fossiliferous.

Ts — St. Marys Formation
Sand with interbedded fossiliferous sand.

CONTACTS

exposed
approximate
covered or inferred

STRATIGRAPHIC CONTROL

W-2265 77' — Location of test boring with altitude of top of hole indicated.

▲ Location where a representative stratigraphic section was examined.

X Locations at which samples were collected to determine subsurface formation and facies contacts.

QUARRIES

Abandoned

Magnetic North — True North
1965 MAGNETIC DECLINATION

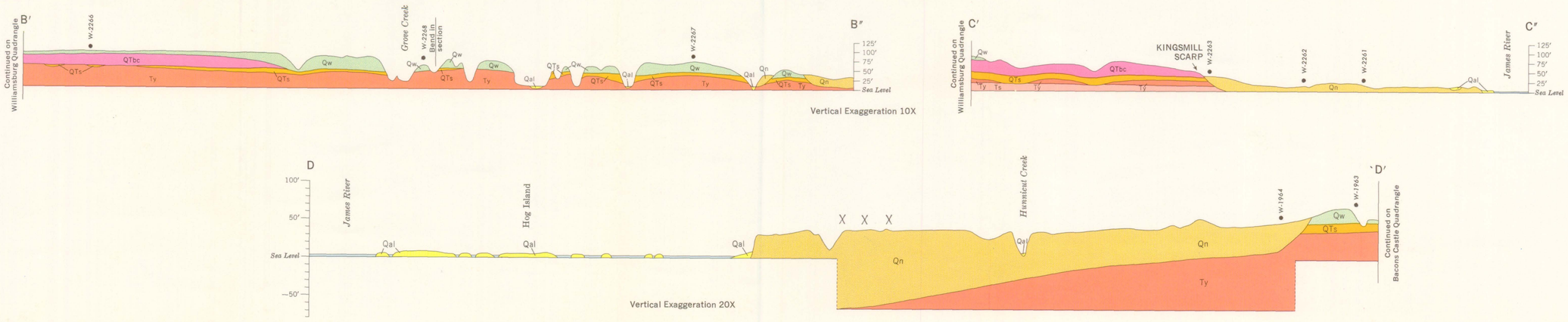
SCALE 1:24 000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 2.2 FEET

VIRGINIA
QUADRANGLE LOCATION

Bick
Coch

1969



COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
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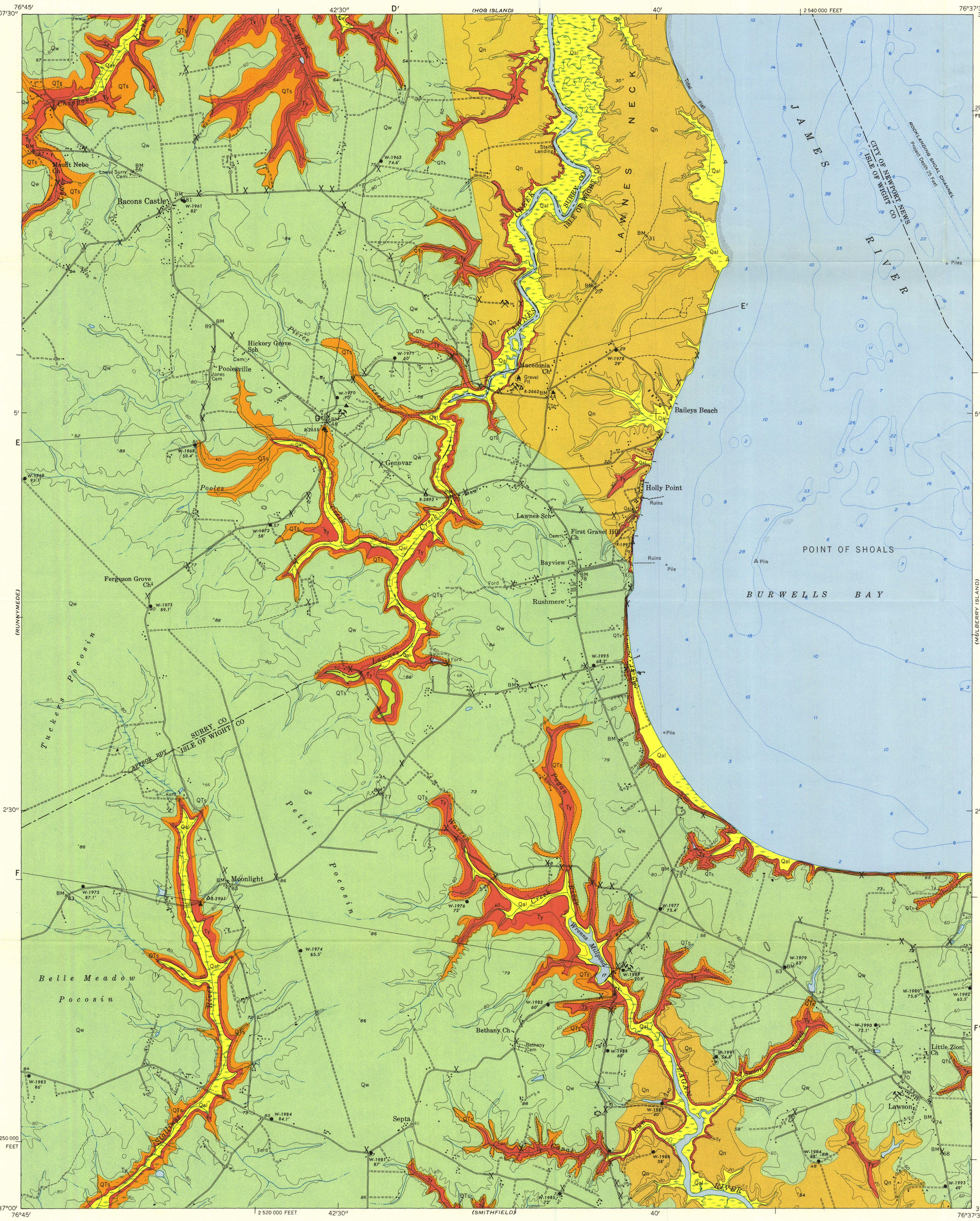
Commissioner of Mineral Resources and State Geologist



EXPLANATION

QUATERNARY	Qal — Alluvium. *Organic silt and clay; some sand.*	HOLOCENE
	Qn — Norfolk Formation. *Interbedded sand, clay, and organic silt.*	PLEISTOCENE
	Unconformity	
	Qw — Windsor Formation. *Upper part, poorly sorted mixture of sand, silt, and clay; lower part, chiefly cross-bedded sand.*	
	Unconformity	
	QTs — Sedley formation. *Brown sand and clay.*	(PLIOCENE?)
	Unconformity	
TERTIARY	Ty — Yorktown Formation. *Gray clay and sand; many beds abundantly fossiliferous.*	MIOCENE

CONTACTS

- exposed
- approximate
- covered or inferred

STRATIGRAPHIC CONTROL

- ● W-1962 74.6′ — Location of test boring with altitude of top of hole indicated.
- ▲ — Location where a representative stratigraphic section was examined.
- △ R-2655 — Location and repository number of sampled lithology.
- X — Locations at which samples were collected to determine subsurface formation and facies contacts.

QUARRIES

- Active
- Abandoned

Base from U. S. Geological Survey, 1957
Bacons Castle Quadrangle 7½ Minute Series

GEOLOGIC MAP OF THE BACONS CASTLE QUADRANGLE, VIRGINIA

Geology by Nicholas K. Coch

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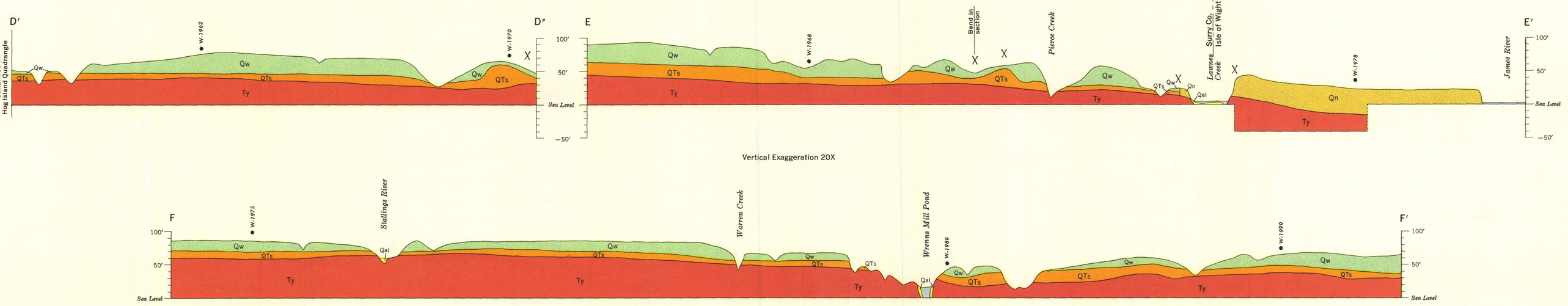
6° Magnetic North — True North
1957 MAGNETIC DECLINATION

SCALE 1:24 000
1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 2 FEET

VIRGINIA
QUADRANGLE LOCATION

1969