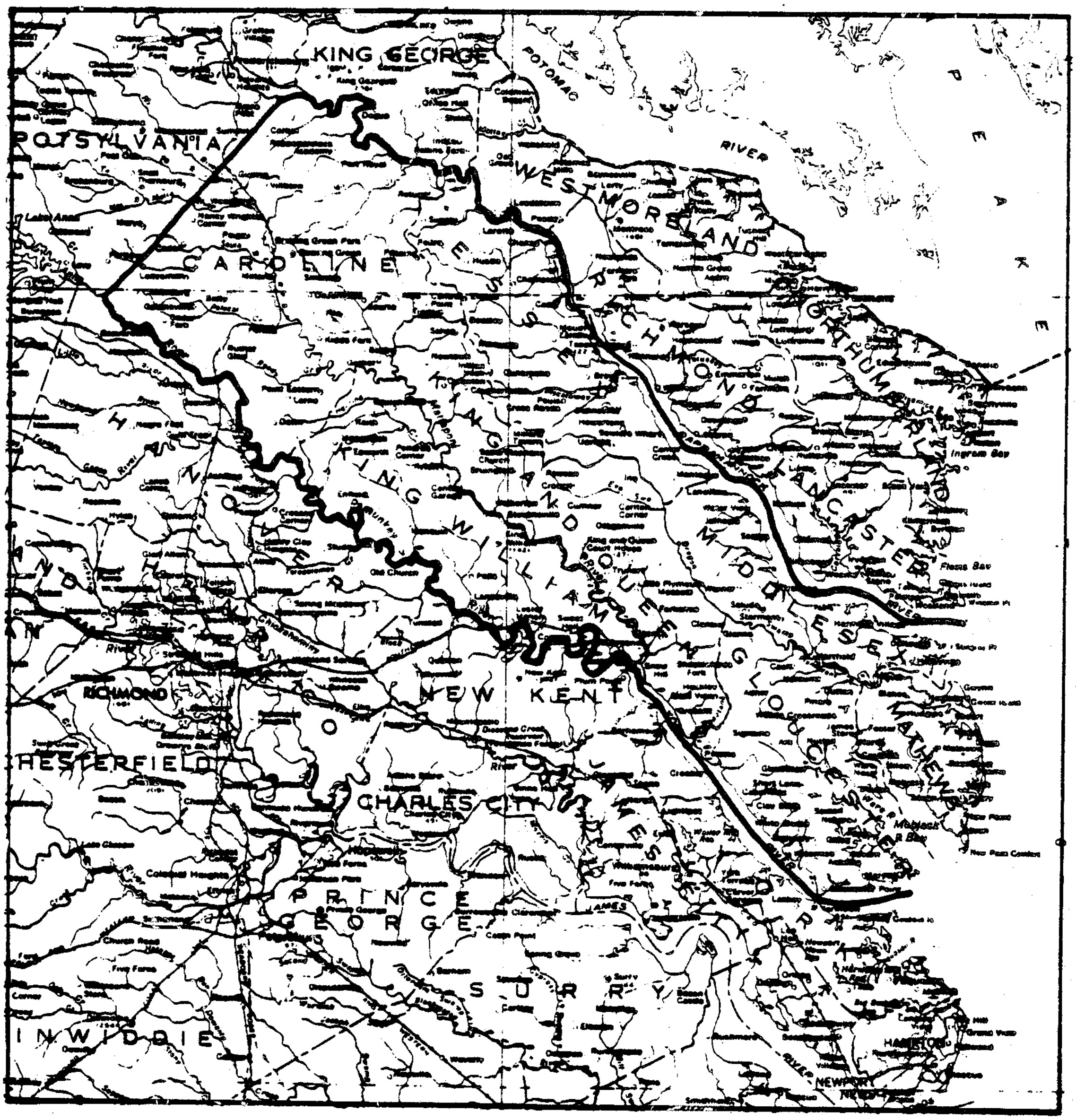
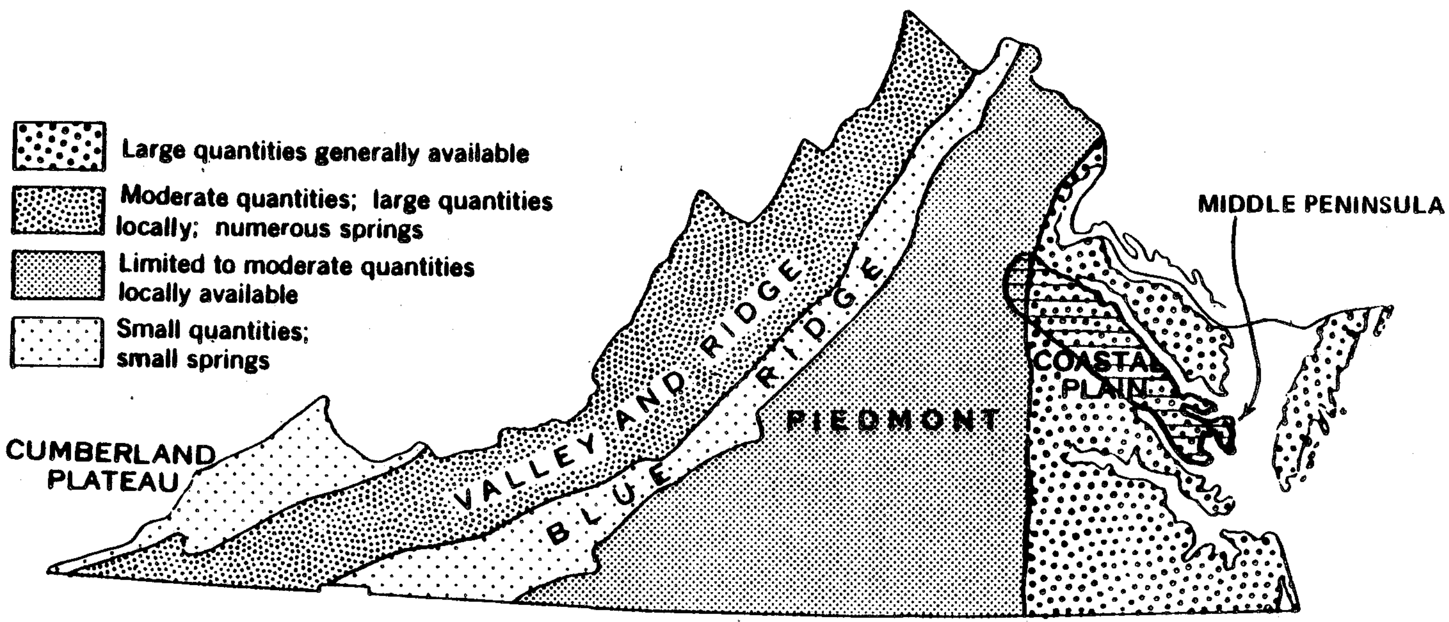
GROUNDWATER OF THE MIDDLE PENINSULA, VIRGINIA



by
E. A. Siudyla, T. D. Berglund, and V. P. Newton
and
Tidewater Regional Office

COMMONWEALTH OF VIRGINIA
STATE WATER CONTROL BOARD
BUREAU OF WATER CONTROL MANAGEMENT

Richmond, Virginia
Planning Bulletin 305
January 1977



GROUNDWATER AVAILABILITY IN VIRGINIA

Source: Virginia State Water Control Board – BWCM

Errata Sheet

Groundwater of the Middle Peninsula, Virginia

Page 19, 20, 63	The vertical scale is incorrectly numbered and should begin with 200 on the top of the scale and end with 1200 at the bottom. Also, the elevation of 157-13 should be 5 ft. MSL.
Page 55, Plate 14b:	The eastern most potentiometric line should be labeled 20 instead of 10.
Page 59, Line 2:	Aquifers.
Page 60, Line 13:	Values are generally less than those of the principal artesian aquifer.
Page 77, Lines 16, 17:	In Chapter VIII.
Page 79, Line 4:	Sites
Page 86, Line 3:	Stations

LIST OF PLATES

LIST OF PLATES (continued)

LIST OF TABLES

ACKNOWLEDGEMENTS

The Tidewater Regional Office of the State Water Control Board would like to express its gratitude to the following agencies and companies which provided data to make this report possible: Fetterholf Brothers; Douglas-Drilling Company; R. L. Magette; Brown's Well Drilling Company; Sydnor Hydrodynamics; Layne-Atlantic Company; Chesapeake Corporation of Virginia; Virginia Division of Mineral Resources; United States Geological Survey; the Division of State Planning and Community Affairs; Middle Peninsula Planning District Commission; Virginia Department of Health; and the many industries, towns, businesses, and private well owners on the Middle Peninsula of Virginia.

This report was prepared by E. A. Siudyla, Senior Geologist of the Tidewater Regional Office, with the assistance of T. D. Berglund, Specialist, Virginia Newton, Geologist, L. S. McBride, Director, Tidewater Regional Office, and J. A. Brown, Director, Division of Water Control Management. This report was a joint effort of the Tidewater Regional Office and the Bureau of Water Control Management, State Water Control Board: D. F. Jones, Director, Bureau of Water Control Management; E. W. Ramsey, Director, Hydrologic Division; T. L. Swearingen, Principal Geologist; and M. A. Saint-Pe', Geologist.

GROUNDWATER OF THE MIDDLE PENINSULA, VIRGINIA

by

Eugene A. Siudyla, Terry D. Berglund, and Virginia P. Newton

ABSTRACT

The Middle Peninsula of Virginia, a portion of the Atlantic Coastal Plain, is situated in the east-central portion of the State, bounded on the north by the Rappahannock River and on the south by the Pamunkey and York Rivers. Land area of the Peninsula includes 1837 square miles and has a population of 61,534. Precipitation in the area averages 43 inches annually.

Groundwater in the Middle Peninsula is found predominately in the unconsolidated sediments of the Middle Mesozoic, Tertiary and Quarternary Age. These sediments have been deposited on a basement rock complex of Pre-Cretaceous Age. Sediments of the Patuxent Formation of Cretaceous Age, which range in thickness from 20 feet in the west to 1700 feet in the east, have been deposited on the basement rock complex by fluvial and deltaic depositional processes.

Overlying the Patuxent Formation from oldest to youngest are the Mattaponi, the Nanjemoy, the Calvert, and the Yorktown Formations, and the Columbia Group. The Mattaponi, Nanjemoy, Calvert, and Yorktown aquifers are composed of marine sediments where as the Columbia Group contains both marine and non-marine sediments.

Groundwater in the Middle Peninsula is found in the water-table aquifers, the upper artesian aquifer system, and the principal aquifer system. The most important water-table aquifer, the Yorktown aquifer,

found in the eastern part of the study area, is a relatively reliable source for domestic, institutional and light municipal use. The upper artesian aquifer system, made up of sands of the Nanjemoy Formation and the basal sands of the Calvert Formation, is a reliable source for domestic, light municipal, agricultural, and institutional use. The principal aquifer system is composed of the Patuxent and basal Mattaponi Formations. Throughout most of its extent, the principal aquifer is capable of supporting high yield wells or well fields, but some locations are more favorable than others.

Historic potentiometric surface maps show that development of the principal aquifer system at West Point and east of Urbanna has caused a lowering of water levels in the area. The maximum decline of about 140 feet is found at West Point. Current water level trends show water levels continuing to decrease in response to increases in pumpage in West Point and Urbanna. However, water levels would probably stabilize if pumpages in the West Point and Urbanna areas were kept relatively constant.

Transmissivities were estimated from specific capacities for the major aquifers. Transmissivities were found to average as follows: 5,000 to 50,000 gpd/ft for the principal aquifer; 3,000 to 10,000 gpd/ft for the upper artesian system and about 1,000 gpd/ft for the Yorktown aquifer.

A high chloride groundwater zone of natural origin was delineated within the eastern part of the Study Area. In the Town of Gloucester area no detectable movement of the high chloride zone toward the major pumping centers has occurred in the last 30 years. Lack of deep well control north and south of Gloucester make it impossible to assess whether the high chloride zone has moved or is moving toward the pumping centers in these areas.

The major variables limiting groundwater supply in the area include the presence and potential movement of the highly mineralized zone in the eastern part of the Study Area, the water-bearing characteristics of the major aquifers, and major water level declines in the principal aquifer associated with the major water withdrawals. Taking the above factors into account, it is estimated that a considerable quantity of groundwater is available for further development in the west central part of the Middle Peninsula with smaller quantities available in other parts.

Eight research stations were recommended in order to determine the best areas for future development in the Yorktown, upper artesian and principal aquifers, to monitor movement of the high chloride zone in the artesian aquifers, and to extend the present water level monitoring network.

CHAPTER I

INTRODUCTION

Purpose and Scope

This report will present an expanded, up-to-date evaluation of current groundwater conditions in the Middle Peninsula Study Area. Since future economic growth in this area depends upon development of an abundant source of inexpensive fresh water, it is anticipated that this report will be used as an effective aid to assist in future planning, development, and maintenance of the area's invaluable groundwater resources.

Study Area Description

The Middle Peninsula of Virginia is situated in the east-central portion of the State, bounded on the north by the Rappahannock River and on the south by the Pamunkey and York Rivers. Western Caroline County, the western limits of the Study Area, is approximately 86 miles from the Chesapeake Bay, which forms the eastern boundary. The width of the Study Area is nearly uniform, grading from 22 miles wide along a line between Gloucester Point and Gwynn Island in the east to about 30 miles wide along Caroline County's eastern border (Plate 1).

There are seven counties included within the Middle Peninsula Study Area. From east to west they are Mathews, Gloucester, Middlesex, King and Queen, King William, Essex and Caroline. Mathews, Gloucester, Urbanna, West Point, Tappahannock, Bowling Green and Port Royal are the major towns in the Study Area. In addition, portions of three major river basins, the Rappahannock, the York and the Small Coastal River Basins, are within the Middle Peninsula Study Area.

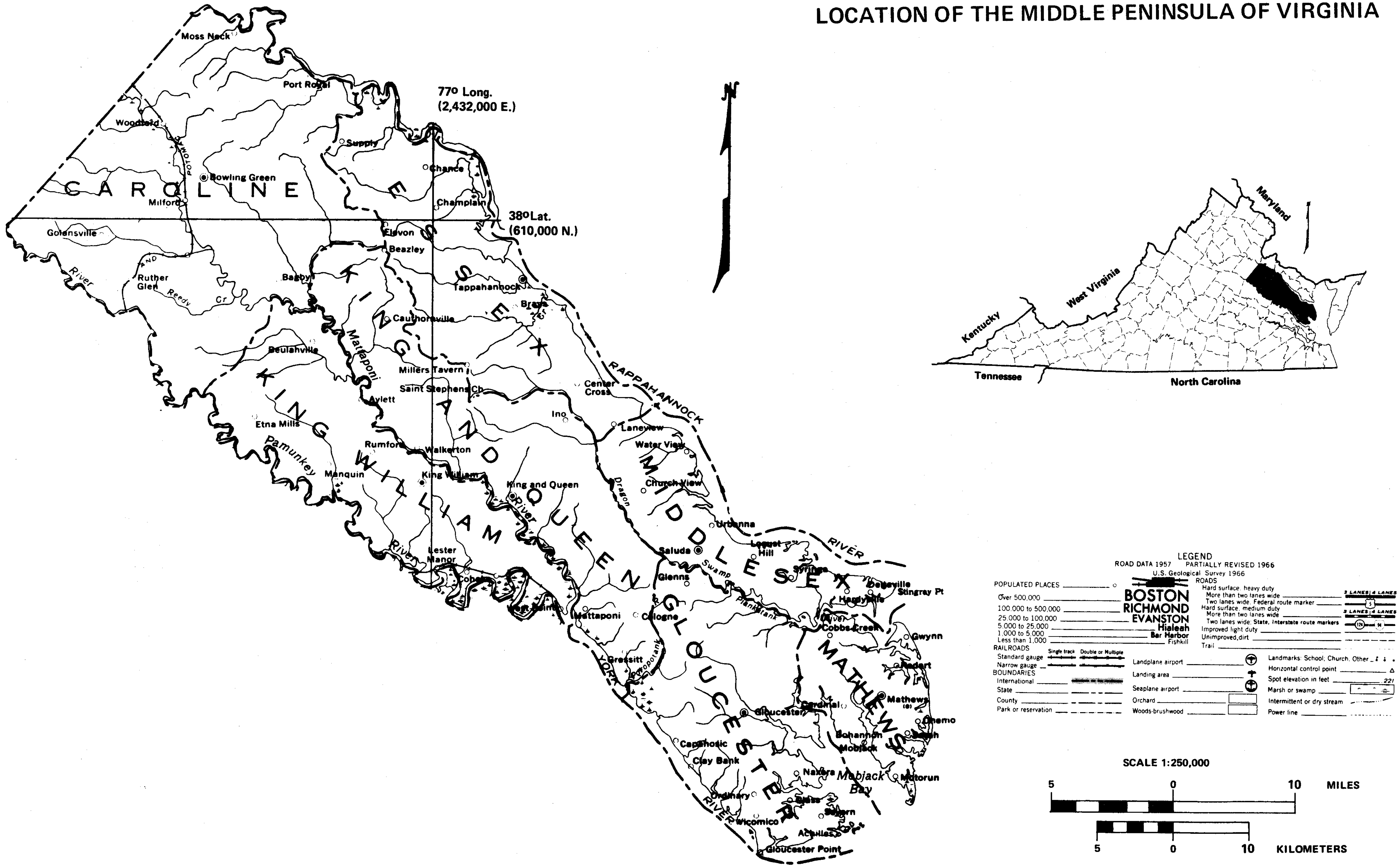
The population figures for the Study Area presented in Table 1 show the breakdown, by county, of the 61,534 total population. According to the 1970 census, population varied by county from a low of 5,491 in King and Queen County to a high of 14,059 in Gloucester County. King and Queen County is the least densely populated county with an average of 17.3 persons per square mile, while Mathews County, although smaller in size and total population than Gloucester, is the most densely populated, with an average of 80.8 persons per square mile (Table 1).

Previous Investigations

Four previously developed investigations deal primarily with the groundwater resources of the Middle Peninsula of Virginia: Sanford (1913) discussed the groundwater resources of the Coastal Plain of Virginia including a county-by-county description of the groundwater resources of the Middle Peninsula; Sinnott (1955) presented an abbreviated sketch of groundwater occurrence in the Tappahannock area; Cederstrom (1968), in an unpublished report, discussed the groundwater resources of the Middle Peninsula; and, the State Water Control Board (1973) covered the groundwater conditions of King William County in Ground Water of the York-James Peninsula.

Other investigations relating to the groundwater conditions of the Middle Peninsula of Virginia include Cederstrom's (1943, 1946) analysis of the groundwater quality distribution in the Virginia Coastal Plain, Back's (1966) determination of saltwater-freshwater

LOCATION OF THE MIDDLE PENINSULA OF VIRGINIA



Source: Virginia State Water Control Board – TRO

PLATE NO. 1

TABLE 1

POPULATION AND LAND AREA OF THE
MIDDLE PENINSULA

County	Total Population (1970 Census)	Area Size (square miles) Land	Water	Total	Population Density (per/sq/mi)
Caroline	13,925	545	4	549	25.6
Essex	7,099	250	13.8	263.8	28.4
Gloucester	14,059	225	32	257	62.5
King and Queen	5,491	318.1	8.9	327	17.3
King William	7,497	278.1	7.9	286	27.0
Mathews	7,168	88.7	13.3	102	80.8
Middlesex	6,295	132	6	138	47.7
Total	61,534	1,836.9	85.9	1922.8	41.3 (avg)

Source: DSPCA Data Summary for each respective county.

boundaries and estimated regional flow patterns for aquifers in the Northern Atlantic Coastal Plain, Teifke's (1973) stratigraphy of the Coastal Plain of Virginia, Brown's et. al. (1973) study of the structural geology, stratigraphy, and relative permeability of strata in the North Atlantic Coastal Plain, and Onuschak's (1973) environmental geologic maps of geomorphic features and general geologic processes in the area.

Method of Investigation

Numerous publications dealing with the groundwater resources of the Middle Peninsula were consulted in order to establish the geologic framework for evaluating the groundwater resources of the Middle Peninsula. Static water level measurements, for example, were obtained from both State Water Control Board observation wells and wells owned by various entities (i.e. private, municipal, industrial, and agricultural). Pump test data, as well as driller's notes and logs were obtained from the files of area drillers. Pumpage records submitted to the State Water Control Board by specific large withdrawers were also examined and subsequently incorporated into the study. Water quality data from wells was used to determine the chemical distribution within the major aquifers and to indicate changes in chemical parameters over a period of time. The most recent quality information presented in this study was obtained from the Virginia State Department of Health and Virginia State Water Control Board.

CHAPTER II

PHYSICAL SETTING

Climate and Meteorology

The Middle Peninsula's climate is determined by latitude, topography, prevailing winds and proximity to the Chesapeake Bay and Atlantic Ocean. The peninsula lies in the temperate climatic zone, situated in or near the mean path of winter storm tracks. The average annual temperature of the Middle Peninsula, based on a U. S. Governmental Survey for the years 1930 to 1960, was 58° F with an average January temperature of 37° F, and an average July temperature of 77° F (Table 2). Evaporation averages 38 to 39 inches from April to October, based upon records for the period 1951 to 1963 for Charlottesville, Virginia.

The long range mean annual precipitation in the Study Area is 44 inches, varying from a low of 42 inches in the northern section of Essex County to a high of 46 inches over the central portion of the Peninsula. However, large year-to-year variations in rainfall occur with annual totals frequently ranging from less than 38 inches to more than 53 inches. Average seasonal snowfall is approximately 13 inches, with January and February, averaging 3.4 to 3.9 inches, respectively.

The Middle Peninsula has experienced several meteorological drought periods, the most notable of which occurred in the years 1930-32. The drought of 1930 was the most severe for the eastern United States

TABLE 2

TEMPERATURE AND RAINFALL
OF THE MIDDLE PENINSULA

County	Average Annual Temperature	Average July Temperature	Average January Temperature	Average Annual Rainfall
Caroline	59	78	81	43"
Essex	56.6	76.7	35.5	40"
Gloucester	58.1	77.6	37.9	41"
King and Queen	56.6	76.7	35.5	42"
King William	56.6	76.7	35.5	43"
Mathews	58.1	77.6	37.9	46"
Middlesex	58.1	77.6	37.9	43"
Total	57.6	77.3	37.3	43"

Source: DSPCA Data Summary for each respective county.

as well as the Peninsula. At that time rainfall in the Middle Peninsula averaged 18 inches below normal, and eight consecutive months were classified as "extreme" by the Palmer Index for the classification of meteorological drought.

Physiography

The Middle Peninsula is located almost entirely within the Coastal Plain Physiographic Province. Only the western third of Caroline County lies west of the Fall Line in the Piedmont Province. The Coastal Plain Province is characterized by the following geomorphic (land form) features:

1) broad, gently dipping terraces formed by ancestral sea level stands;
2) steep ancestral beach ridge escarpments separating the terraces (Two noted Tidewater scarps are the Surry Scarp which passes through Signpine and Woods Crossing (100 feet above M.S.L.) and the Suffolk Scarp which passes through the Gloucester Courthouse Area (50 feet above M.S.L.)):
3) broad flood plains characterized by meander loops and depositional features (This type of stream morphology is characterized by the stream expending most of its energy in lateral erosion rather than vertical down-cutting, i.e. the Pamunkey and Mattaponi Rivers); and
4) the formation of fluvial-estuarine systems (drowned river valleys) as river flood plains and channels engulfed by an increase in sea level (i.e. the York, lower Rappahannock Rivers, and Mobjack Bay areas).

Overall average relief of the Study Area is approximately 300 feet, ranging from the rolling slopes in western Caroline County to sea level in Mathews and Gloucester Counties.

Land Use

Farming and forestry, land practices which exemplify the rural agricultural type economy that has historically dominated this area, are the two major land uses.

Although urban and industrial acreages are a minor fraction of the total land area, there is increasing pressure for industrial development, particularly environmentally clean industry. These industries are primarily for expansion of local economy and community tax base and are, for the most part, light industries which do not place large demands on the water or sewage systems in the towns where they are located.

CHAPTER III

GEOLOGY

Geologic Setting

The Middle Peninsula of Virginia lies within the embayed section of the Atlantic Coastal Plain Province. Crustal movements along the Atlantic continental margin have produced a seaward slope on the crystalline-rock basement surface (Plate 2). Areas west of the Fall Line were uplifted during these movements 430 to 280 million years ago and underwent erosion, whole areas east of the Fall Line were depressed and became centers of deposition. The sediments eroded from uplifted areas filled these depositional basins to the east.

These unconsolidated sediments dip gently seaward and rest upon a basement complex of sedimentary, igneous and metamorphic rocks older than Cretaceous Age. The unconsolidated sediments are of Cretaceous (about 63-135 million years old), Paleocene (about 58-63 million years old), Eocene (about 36-58 million years old), Miocene (about 13-25 million years old), and Post Miocene Age (recent - about 13 million years old), and consist of a series of alternating marine and non-marine clay, silt, sand, and gravel. In west central Caroline County, just east of the Fall Line, unconsolidated sediments are thin and bedrock has been reached in several wells. West of the Fall Line the Coastal Plain sediments have been removed by erosion and bedrock is exposed at the surface. East of the Fall Line the basement rock lies at progressively greater depths. Near the eastern extreme of the

Study Area in Mathews County, the thickness of unconsolidated sediments is approximately 2,600 feet.

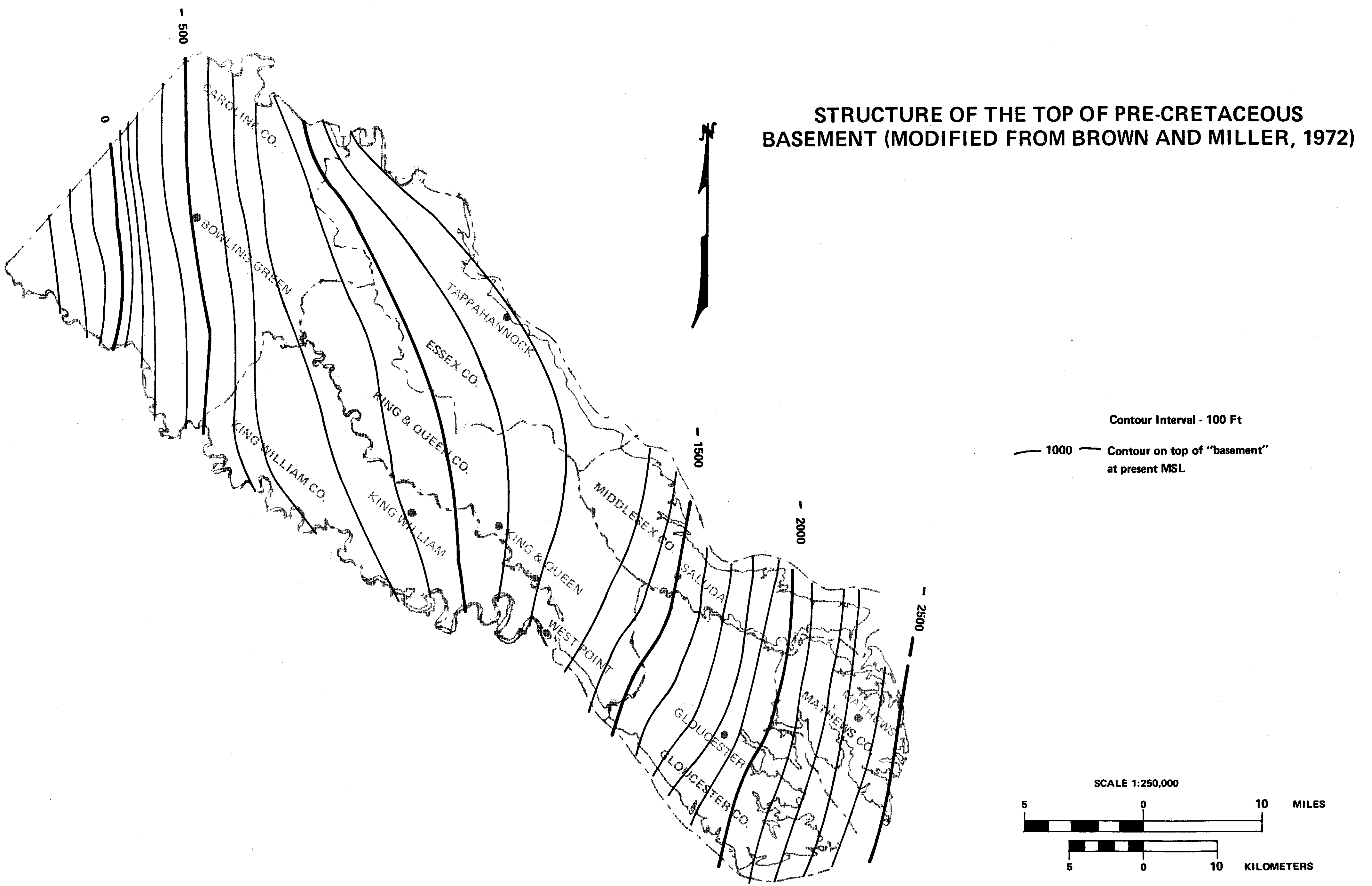
The formational boundaries presented in this report are based mainly on lithostratigraphic correlations and interpretations of geophysical logs, and well cuttings from selected areas with additional information from previous publications. The formation found immediately below the land surface is indicated in Plate 3, and distribution of the formations is found in Plates 4, 5, 7, and 9. Plates 6 and 8 show the probable geologic facies changes within the Cretaceous Age sediment.

Geologic Units

Pre-Cretaceous. The Cretaceous-Recent sedimentary sequence is underlain generally by igneous, metamorphic and consolidated sedimentary rocks. These lithologic types constitute the "basement complex" upon which the Lower Cretaceous Patuxent Formation was non-uniformally deposited. At most places along the Fall Line, Patuxent strata are in contact with granitic rocks at elevations ranging from about 100 feet above mean sea level to 400 feet below mean sea level. For the most part, the "basement" along the Fall Line consists of granite or its weathered component that is readily correlatable with the Petersburg Granite exposed immediately to the west in the Piedmont (Plate 3).

Triassic sediment "basement" has been encountered at two sites in Caroline County. Sandstone strata found in Bowling Green and Moss Neck appear to be the northern extension of a narrow north-south trending band of apparently infaulted Triassic sediments which are found to the south in Hanover and Henrico Counties (Virginia State

STRUCTURE OF THE TOP OF PRE-CRETACEOUS BASEMENT (MODIFIED FROM BROWN AND MILLER, 1972)



Source: Virginia State Water Control Board — TRO

PLATE NO. 2

GEOLOGIC MAP
MIDDLE PENINSULA
(Modified From Division of Mineral Resources; 1963)

Key

Old Classification	New Classification
Quaternary Sand & Gravel	Columbia Group
Tertiary Yorktown	Yorktown
Tertiary St.Marys	Yorktown
Tertiary Calvert	Calvert
Tertiary Nanjemoy	Nanjemoy
Tertiary Aquia	Mattaponi
Patuxent	Patuxent
Granite Gneiss	Pre-Cretaceous

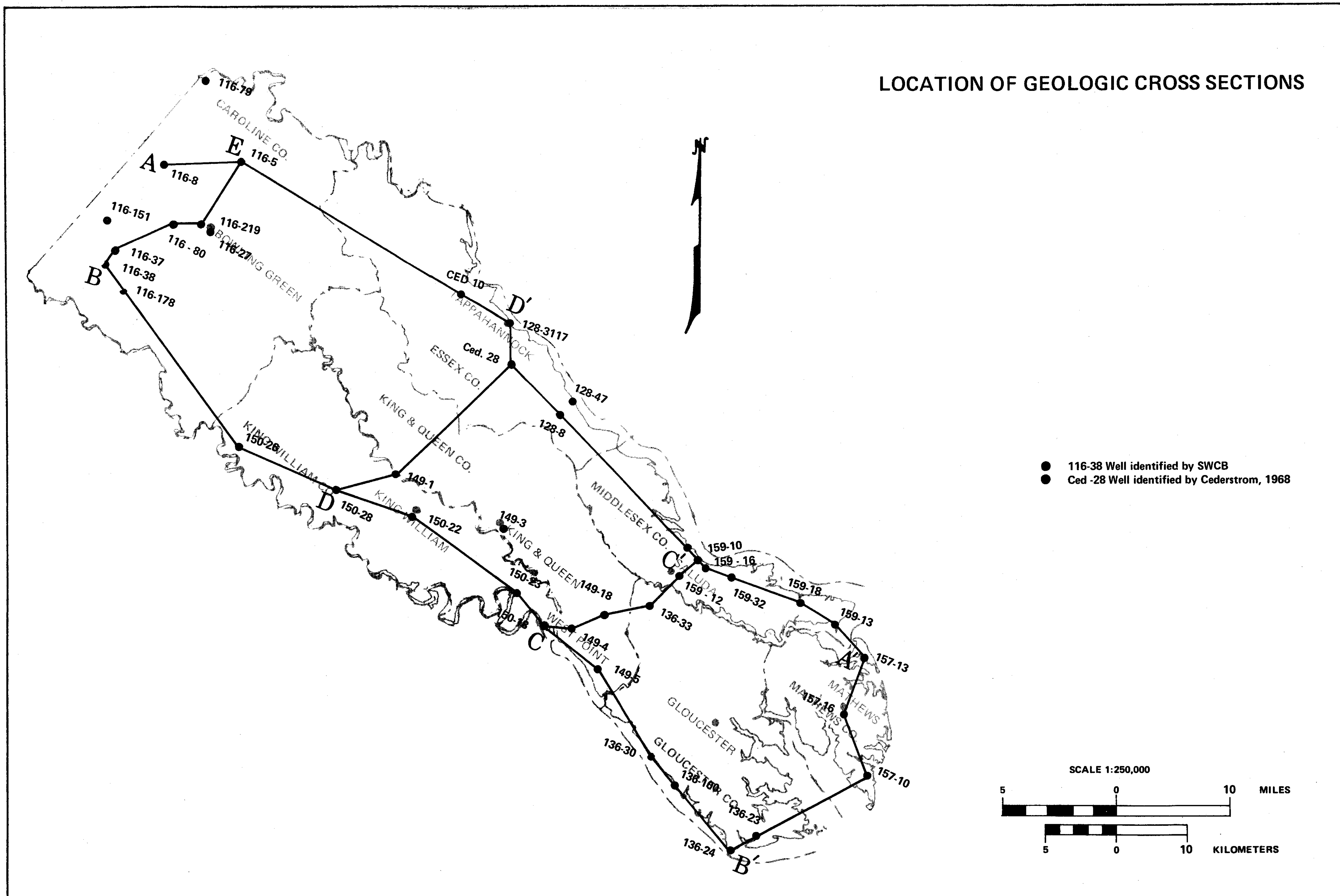
SCALE 1:250,000

5 0 10 MILES

5 0 10 KILOMETERS

Source: Virginia State Water Control Board – TRO

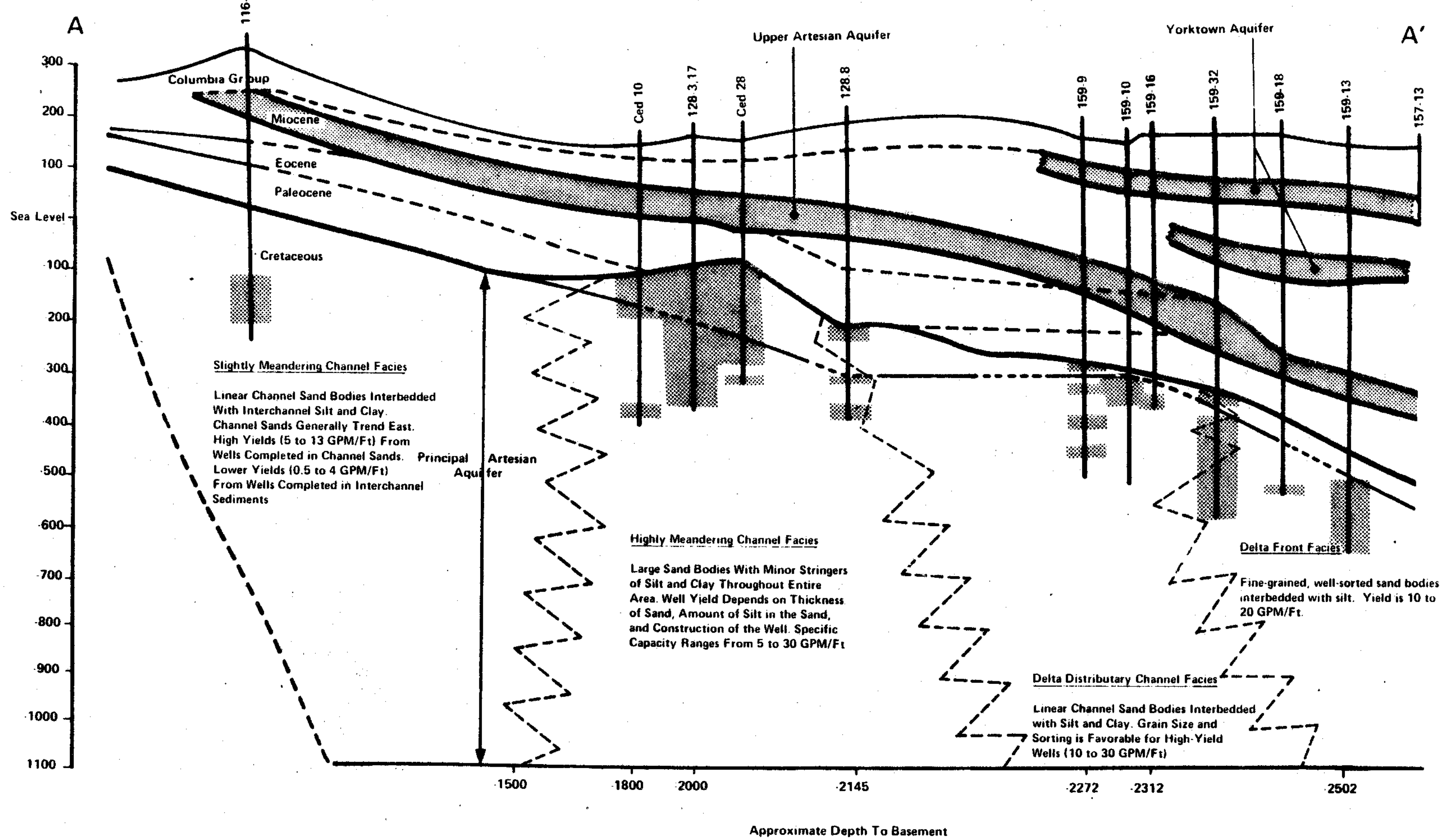
LOCATION OF GEOLOGIC CROSS SECTIONS



Source: Virginia State Water Control Board – TRO

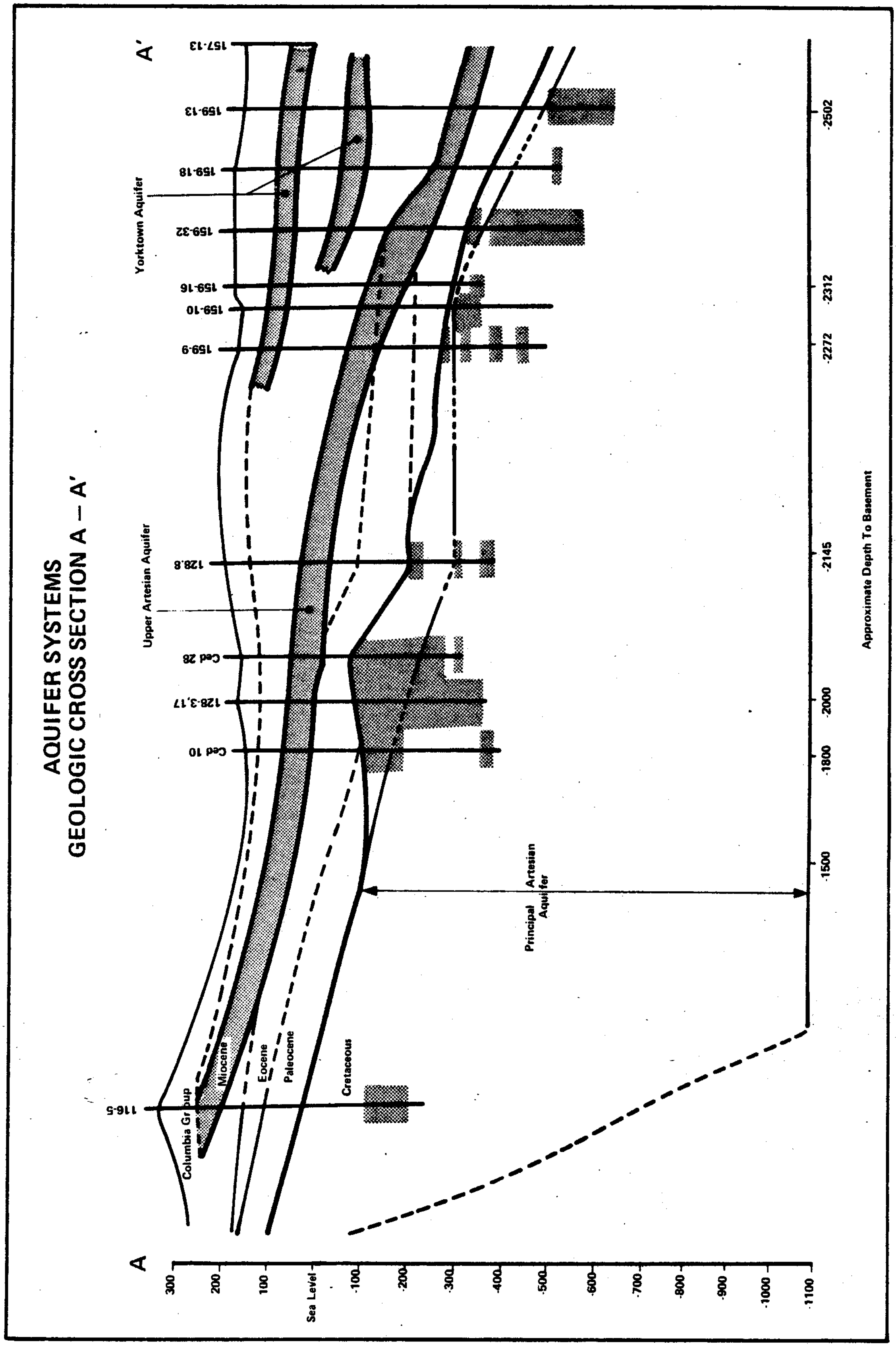
PLATE NO. 4

DEPOSITIONAL ENVIRONMENTS OF THE CRETACEOUS SEDIMENTS AND THEIR EFFECT ON HYDROLOGY CROSS SECTION A – A'



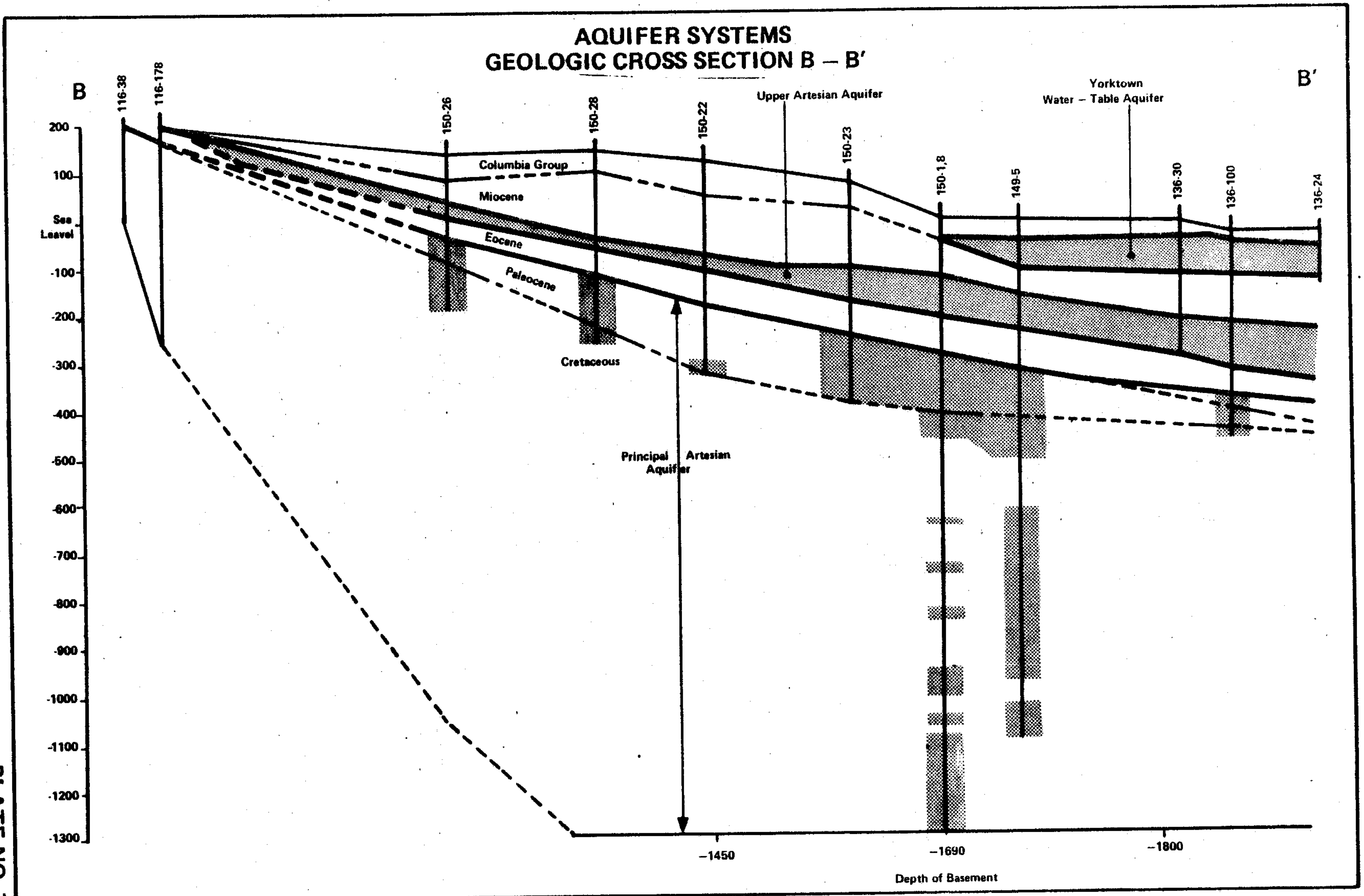
Source: Virginia State Water Control Board

PLATE NO. 6



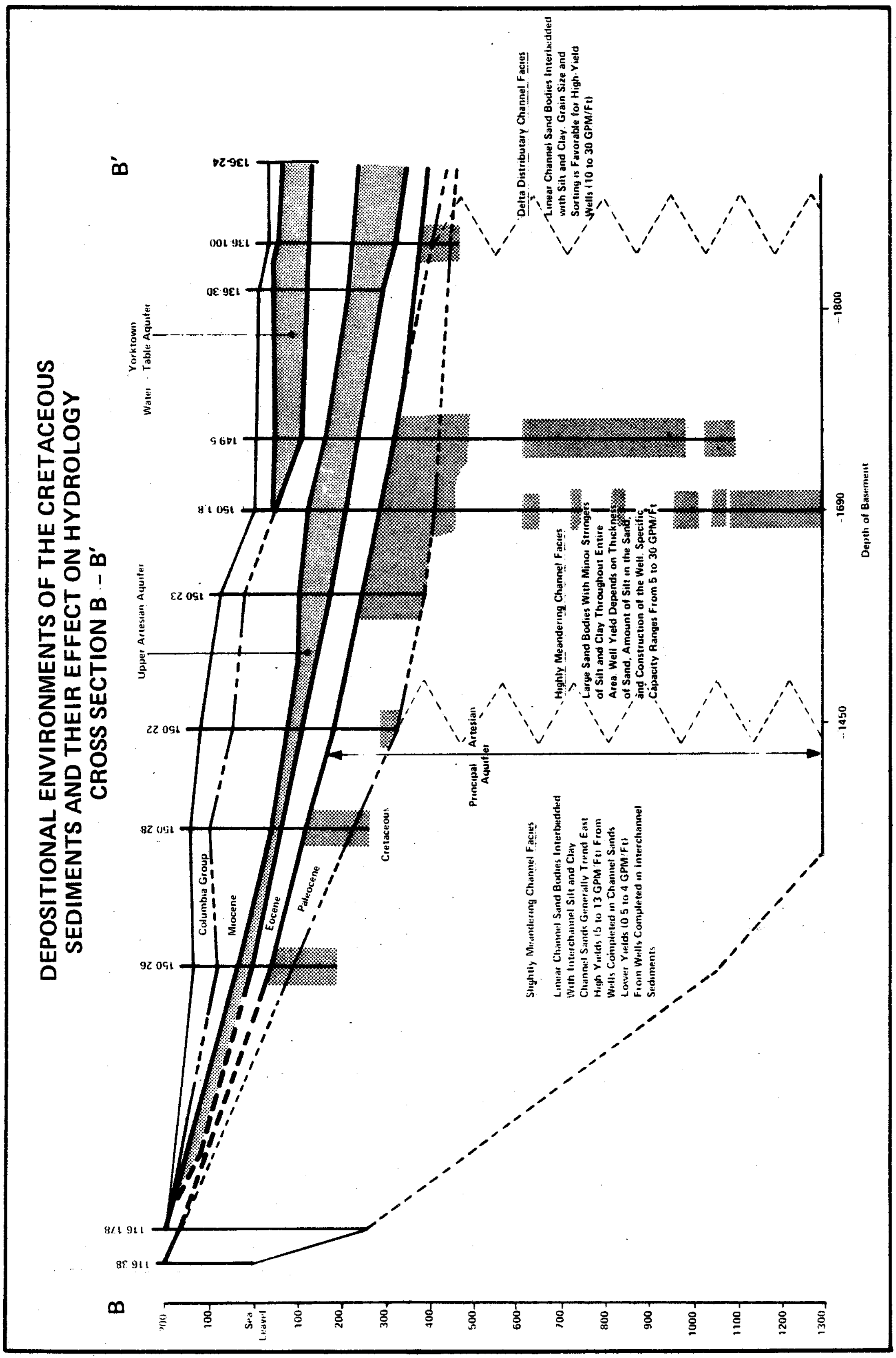
Source: Virginia State Water Control Board

PLATE NO. 5



Source: Virginia State Water Control Board

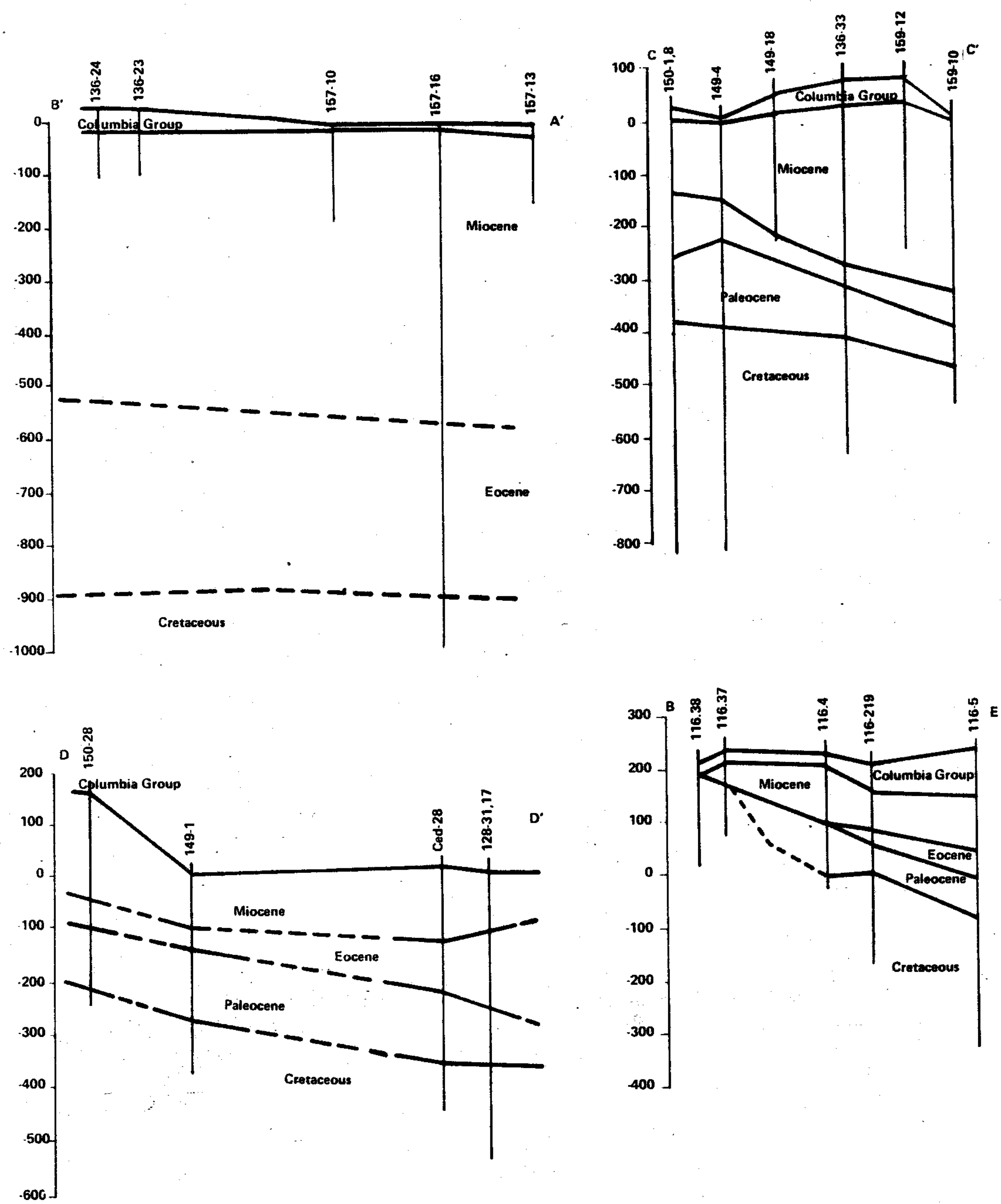
PLATE NO. 7



Source: Virginia State Water Control Board

PLATE NO. 8

GEOLOGIC CROSS SECTIONS
B'—A', C—C', D—D', B—E



Source: Virginia State Water Control Board

PLATE NO. 9

Water Control Board, 1973). Also, further east in West Point, Triassic sandstones were found to form the basement at approximately 1,255 feet below sea level. The Triassic sediment may be part of a trough which extends south into James City County and may be the hingeline of a fault block (Graben) along which active crustal deformation has occurred from Triassic through Miocene Ages (Brown, 1972). The hingeline may have controlled subsequent deposition in the West Point area.

Cretaceous. In older previous reports of the Middle Peninsula, the Cretaceous has been subdivided into the Lower Cretaceous Potomac group and the Upper Cretaceous Mattaponi Formation. However, in a recent report by Teifke (1973), the Lower Cretaceous was defined to include the lower non-marine sequence of the Mattaponi Formation, referred to as the Patuxent Formation. The Patuxent Formation, as defined by Teifke (1973), is analogous to the Cretaceous Units H, G, and F as defined by Brown (1972). Teifke's newer classification of the Patuxent Formation and subsequent younger units will be used in this report (Table 3). Geologic classification and a general description of the formations is given in Table 4.

The Cretaceous sediments of the Middle Peninsula were deposited in a fluvial-deltaic environment (Cederstrom, 1945). The facies which have been preserved are the meandering channel facies of the fluvial environment and the deltaic environment (Plates 6 and 8). Characteristic of all these facies are discontinuous sand bodies interbedded with silts and clays.

The slightly meandering channel facies (Virginia State Water

TABLE 3

COMPARISON OF THE STRATIGRAPHIC UNITS

Age		Richards (1967)	Present Report
Quaternary	Pliocene-Holocene		Columbia Group
Tertiary	Miocene	Yorktown Formation	Yorktown Formation (possibly Pliocene in part)
		St. Marys Formation	
		Choptank Formation	
		Calvert Formation	Calvert Formation
	Eocene	Chickahominy and Piney Point fms.	
		Nanjemoy Formation	Nanjemoy Formation
		Aquia Formation	Mattaponi Formation
	Paleocene	Mattaponi Formation	
?	? ?		
Cretaceous	Upper (?)		
	Lower	Raritan Formation	"transitional beds"
		Patapsco Formation	
		Arundel Formation	
		Patuxent Formation	Patuxent Formation

Source: Teifke, 1973.

Source: Virginia State Water Control Board

TABLE 4

GEOLOGIC UNITS AND THEIR WATERBEARING CHARACTERISTICS

Age	Series	Formation	Aquifer Designation in This Report	Approximate Thickness (feet)	Lithologic Character and Origin	Hydrologic Comments
Quaternary	? ?	Columbia Formation	Water Table System	20-100	Unconsolidated sand, clay, and gravel of fluvial and marine deposition. Surficial terraces and dunes.	Supplies ground water to low yield water table wells throughout the area.
Tertiary	Miocene	Yorktown Formation		0-200	Silts, sand, and shell beds. Clay beds uncommon. Marine deposition.	Supplies ground water to low yield water table and locally artesian wells in the eastern parts of the area.
		Calvert Formation	Confining Units	0-280	Clays and silty clays, plant and shell material locally abundant. Coarse basal sand. Marine deposition.	Acts as a confining unit for the upper artesian system. The basal sand is part of the upper artesian aquifer system.
	Eocene	Nanjemoy Formation	Upper Artesian System	0-160	Quartz-glauconite sands. Shell beds common. Marine deposition.	Yield sufficient water for domestic, subdivision, and light industrial purposes. Highest yields in West Point area. Chlorides increase rapidly east of Capahosic.
? ? ?	Paleocene ? ? ?	Mattaponi Formation	Confining Units	0-160	Highly glauconitic sands, silts, and clays. Often referred to as "greensand" or "blacksand" marine origin.	Generally an aquitard confining layer for principal aquifer system.
Cretaceous ? ? ?	Upper (?)					
Cretaceous	Lower	Patuxent Formation	Principal Artesian System	0-1500	Interbedded sands, silts, and clays of fluvial and deltaic origin. Some thin marginal marine beds.	Capable of high yield with proper development. Chlorides increase rapidly east of Capahosic.
		"basement"			Igneous and metamorphic and partly consolidated shales and sandstones.	Supplies moderate quantities of ground water to wells near Fall Zone.

Source: Teifke, 1973.

Control Board, 1973 and Fisher and McGowen, 1967) found in Caroline, western King William, and Essex Counties, is characterized by channel sand bodies which are coarse-grained at the base and become finer-grained upward. Geologic correlations made for this report indicate that the channel sands are 50 to 70 feet thick. In the York-James Peninsula these sand bodies have been reported to be one to three miles wide, and up to 10 miles long. In addition finer-grained sands resulting from crevasse deposits, overbank spills and tributary stream channels are found. The fluvial sands are generally subordinate to coarse and fine inter-channel silt.

The sands of the highly meandering channel facies (Fisher and McGowen, 1967 and Virginia State Water Control Board, 1973) found in eastern King William, eastern King and Queen, and Middlesex Counties, are medium to coarse grained, moderately well sorted, and have an average thickness of about 100 feet. Sand bodies are discontinuous as shown in the geologic correlation in the West Point area (Plates 5 and 7). Finer sands associated with crevasse deposits and overbank spills are found, with overbank silts and clays subordinate to sands in this facies. The dominant thick sands of this facies form generally good aquifers.

The delta distributary facies and delta front, found in the eastern part of the Study Area, are characterized by medium-grained, moderately well-sorted sands, about 50-200 feet thick, and exhibit somewhat linear trends (Plates 6 and 8, Mathews County). In certain parts of the delta distributary facies, interchannel swamp deposits, consisting of dark-colored silts and clays with sand stringers, are found.

Paleocene. The Mattaponi Formation of Paleocene Age lies directly upon the Patuxent Formation throughout the Middle Peninsula (Plates 5, 7, and 9) and is overlain by the Nanjemoy Formation. Thus defined, the Mattaponi interval of marine origin, including rocks referred to as the Aquia Formation in Cederstrom (1968), is comprised of beds of quartz-glauconite sand, drab-colored glauconite-bearing clay, shell beds, and an occasional bed or beds of indurated calcitic rock (Teifke, 1973). Basal gravel and sandy dolomitic siltstone are subordinate lithologic types of relatively local occurrence. Abundant autochthonous glauconite is the principal lithologic criterion used to identify the unit.

The Mattaponi Formation is found overlying the Patuxent throughout the Middle Peninsula except in those areas near the Fall Zone in western Caroline County where they have been removed by erosion. The thickness of the Mattaponi fluctuates between 20 and 160 feet (Teifke, 1973). In the western part of the Middle Peninsula, the Mattaponi consists of fine to medium sands interbedded with silts and clays (Plates 5, 7, and 9) and the central part consists of fine grained quartz sand with 10 to 75 percent glauconite and numerous clay stringers. The Mattaponi in the eastern Middle Peninsula consists of alternating silts and clays.

Eocene. The Nanjemoy Formation is comprised of sediments generally considered to be of early to late Eocene Age. The Nanjemoy as defined by Teifke is equivalent to sediments of Claiborne Age as described by Brown (1972). The formation is an alternating succession of sands, clays, and calcitic units (Plates, 5, 7, and 9). The sands are mineralogically simple, consisting mainly of varying proportions of quartz and glauconite which range from brown clayey sands in which glauconite is a minor constituent to clean "greensand" in which glauconite may constitute as much as 90 percent of the grains (Teifke, 1973).

The Nanjemoy varies considerably in thickness west to east from 20 feet in Carolina County to over 100 feet in eastern counties. It outcrops in a thin band along the Matta River in Caroline, King William and King and Queen Counties (Plate 3).

Miocene. The Calvert Formation includes all strata between the top of the Eocene Age Nanjemoy Formation and the base of the Yorktown, and the base of the Pliocene-Holocene Age Columbia Group in the absence of the Yorktown Formation (Plates 5 and 7). The Calvert Formation can generally be divided into three parts: the basal sand member, the diatomaceous member, and the upper member. The basal sand member consists predominately of sands with minor clay beds or lenses with traces of glauconite. The diatomaceous beds are pale brown to buff and uniform in texture; they contain very little sand or silt. The upper unit consists mainly of greenish-gray to brownish-gray silty clay and interbedded accumulations of mollusk shells.

The Calvert Formation outcrops in Caroline, western Essex, western King and Queen, and western King William Counties (Plate 3). Thickness varies from approximately 50 feet in the outcrop areas to over 200 feet in Mathews County.

Sediments between the top of the Calvert Formation and the base of the Columbia Group are referred to as the Yorktown Formation (Plates 5, 7, and 9). They are distinguished from the Calvert by their more abundant and markedly coarser sand and gravel units, by more abundant and thicker shell beds, and, to a lesser extent, by the prevalence of gray, light gray, and bluish-gray colors of the Yorktown strata.

The Yorktown Formation constitutes the land surface over a wide part of the Study Area (see Plate 3) and, where present, averages about 60-100 feet thick.

All sediments overlying recognizable Yorktown or Calvert strata are referred to as the Columbia Group (Table 4). These younger deposits, marine and non-marine, Pliocene through Recent in age, cover most of the Yorktown and older rocks in the Study Area and can be as much as 122 feet thick. They consist mainly of oxidized clays, silts, sands, and some gravel. In most places the sediments of the Columbia Group contrast sharply with any marine formation which they overlie.

CHAPTER IV

OCCURRENCE AND USE OF GROUNDWATER

Groundwater of the Middle Peninsula occurs in three major aquifer systems (Table 4). The uppermost aquifer system, the water-table aquifer, is found throughout the Peninsula. It consists of unconsolidated deposits of Tertiary and Quaternary Age (primarily the Columbia Group, the Yorktown Formations and the Calvert Formations) except in southwestern Caroline County where consolidated bedrock of Pre-Cretaceous Age is found. This unconsolidated aquifer is a reliable source of domestic groundwater supply in most of the Study Area, but seasonal fluctuations and lack of sufficient storage make it impractical for major industrial or municipal supplies. The second aquifer system of the Middle Peninsula is the upper artesian aquifer system, formed from sediments of Miocene and Eocene Age (Nanjemoy and the Lower Calvert Formations). The third aquifer system, the principal aquifer system, comprised of Paleocene and Cretaceous Age (Patuxent and Mattaponi Formations) is found throughout the entire Peninsula.

Specific capacity, defined as gallons per minute of discharge per foot of drawdown (gpm/ft) is the most reliable hydrogeologic information available for most of the wells in the Middle Peninsula. Therefore, specific capacity is used in this report as an indicator of aquifer potential. It should be noted that variations in well construction will have pronounced effects on the specific capacity of a well, but in those areas where specific capacities are reported and accurate, well completion information is available and specific capacities can be used as a reasonable comparative parameter of aquifer potential.

For wells on which construction data and geophysical logs are available, specific capacities have been corrected by means of a graph. The graph has been constructed from the Kozeny formula which compensates for well diameter, well construction, and partial penetration of the aquifer (Johnson, 1972 and State Water Control Board, 1973).

Water-Table Aquifers

State Water Control Board data files show that the unconsolidated water-table aquifers are a significant source of domestic groundwater in the Middle Peninsula. In addition, these aquifers supply groundwater to some institutions, farms, and other small users in the area.

The Yorktown aquifer system which occurs generally under water-table conditions but locally under artesian conditions, is an important aquifer found in the eastern part of the Middle Peninsula (Plates 5, 7, and 9, and Table 4). The Yorktown aquifer is especially important in eastern Middlesex, eastern Gloucester, and Mathews Counties where the upper and principal artesian systems are brackish and therefore unsuitable for potable use (see Chapter VI).

The Yorktown aquifer system consists of discontinuous lenses of fine sand and shells which may be as thick as 30 feet in Mathews County. Specific capacities generally range from .3 to 1 gpm/ft (see Table 5 and Plate 10a) and reported yields throughout the system generally range from five to 20 gallons per minute. Clogging of wells

SPECIFIC CAPACITY DISTRIBUTION

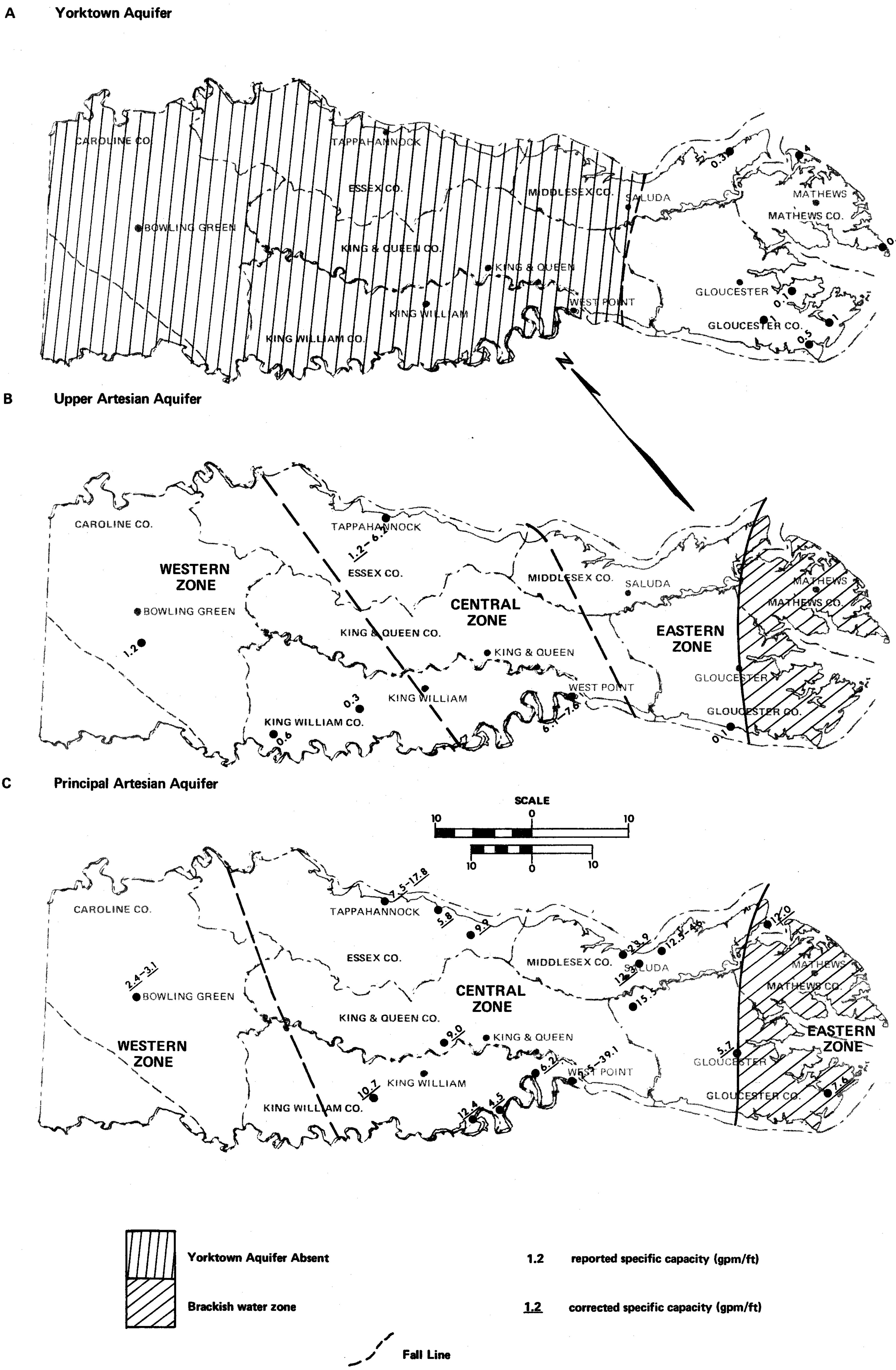


TABLE 5

CHARACTERISTICS OF AQUIFERS IN THE MIDDLE PENINSULA

Aquifer	Approximate Depth to top of Aquifer (ft)	Yields from Wells 4" or Greater in Diameter (gpm)	Specific Capacity Ranges (gpm/ft)	Corrected Specific Capacity** (gpm/ft)
Water Table* (Yorktown Only)				
Eastern Zone (Locally highly mineralized)	50 - 140	5 30	.3 - 1	.3 - 1
Upper Artesian				
Western Zone	20 - 80	20 - 80	.3 - 1.2	.3 - 1.2
Central Zone Tappahannock	150 - 200	20 - 60	1.2 - 6.2	1.2 - 6.2
West Point	150 - 200	275 - 352	6.1 - 7.6	6.1 - 7.6
Eastern Zone (Highly mineralized)	250	15	.1	.1
Principal Artesian				
Western Zone	100 - 200	12 - 76	.8 - 1.8	2.4 - 3.1
Central Zone Tappahannock	300 - 400	50 - 375	2.0 - 7.14	5.9 - 17.8

TABLE 5 (continued)

CHARACTERTISTICS OF AQUIFERS IN THE MIDDLE PENINSULA

Aquifer	Approximate Depth to top of Aquifer (ft)	Yields from Wells 4" or Greater in Diameter (gpm)	Specific Capacity Ranges (gpm/ft)	Corrected Specific Capacity** (gpm/ft)
Principal Artesian continued				
Central Zone West Point to Urbanna	300 - 400	100 - 1800	2.5 - 39.1	2.5 - 39.1
Eastern Zone (Brackish, highly mineralized)	400 - 600	50 - 100	.5 - 1	5.7 - 12.0

* Specific capacity data was unavailable for other aquifers under water table conditions in the Western and Central part of the Middle Peninsula.

** Specific capacities were corrected using the Kozeny Formula (Johnson, 1966).

Source: Virginia State Water Control Board - TRO because of the fine sand has been reported in many small diameter wells which tap the Yorktown aquifer. Clogging generally can be avoided by gravel packing, but only modest yields of 30 gpm may be safely obtained even after gravel packing (Cederstrom, 1968). The largest reported yield was obtained on Gwynn Island in Mathews County, where 200 gpm were pumped. Cederstrom (1968) attributed the high yield to coarse sand but this strata has not been found in other areas.

The Gloucester Point Sanitary District which taps the Yorktown aquifer is currently looking for an additional water supply source. The current well system is not supplying an adequate quantity of water. This is attributed to the poor aquifer characteristics of the Yorktown aquifer in the Gloucester Point area. The two Gloucester Point Sanitary District wells for which there is adequate hydrologic information show test yields of only 6 gpm each and specific capacities of .12 and .17 gpm/ft. Wells with slightly higher specific capacities in the Yorktown aquifer have been found outside the Gloucester Point area in Eastern Gloucester, Mathews, and eastern Middlesex Counties. Currently an area north of Gloucester Point is being evaluated for the Sanitary District's supply (John McNair and Associates, 1975 and the Ranney Company, 1976).

Because of the possibility of local scarcity of suitable sand strata and the presence of brackish water, test drilling and hydrogeologic testing is recommended prior to any building or development where a large supply of water is desired from the Yorktown aquifer. Otherwise, initial development may take place in an area without a satisfactory water system to support the development. The inadequacy of the current Gloucester Point well system demonstrates what may happen when hydrogeologic testing is not conducted.

Upper Artesian Aquifer

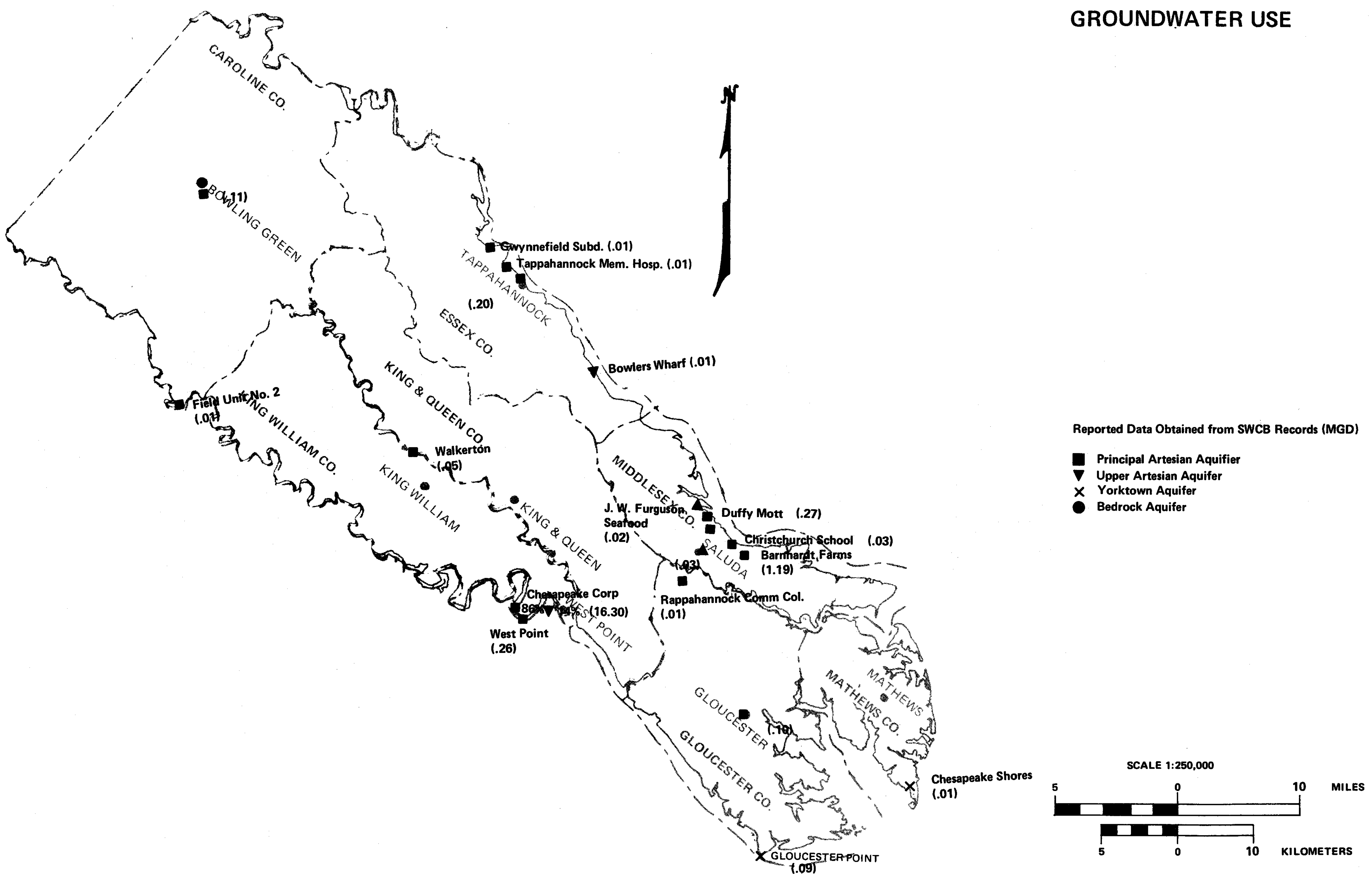
Geologic and hydrologic information indicate that the upper artesian aquifer system becomes regionally artesian east of West Point. This system is also found to be locally artesian in high elevation areas in the western portions of Essex, King and Queen, and King William Counties.

This system has a fairly consistent thickness of about 50 feet and a lithology of fine to medium grain sand, moderately to poorly, sorted with glauconite, and usually referred to as greensand or blacksand. The consistency of this system makes it a reliable source of individual domestic and subdivision groundwater supply.

Based on geologic logs and specific capacity data, the artesian aquifer is divided into three zones (Plates 10b and Table 5). The central zone shows the best potential, especially in the West Point area, where yields as high as 350 gpm and specific capacities between 6.1 and 7.6 have been recorded. The sands are generally coarser and better sorted in the West Point area. Based on limited data, the western and eastern zone appears to have lower yields and specific capacities and the eastern zone yields highly mineralized water in some areas, especially near the Bay (Chapter V and Plate 10b).

In Essex, King William and King and Queen Counties, and to a lesser extent in Caroline County, this system provides groundwater for many moderate to light water users, including water for individual domestic, subdivision, institutional, and agricultural purposes (Plate 11).

GROUNDWATER USE



Source: Virginia State Water Control Board – TRO

PLATE NO. 11

Principal Artesian Aquifer

The principal artesian aquifer system in the Middle Peninsula contains a very large potential groundwater supply. The system is composed of many sands that have a high potential yield with depths which vary from 50 feet above sea level in Caroline County to 600 feet below sea level in Mathews County.

Near the Fall Zone, the principal aquifer system is somewhat erratic. The topography of the basement rock complex, the presence of faults in the basement, the percentage of sand in the aquifer, and the thickness of the aquifer control the hydrology of the aquifer (State Water Control Board, 1973).

When the thickness of the system exceeds 250 feet, sand percentage of the aquifer system, the thickness of the aquifer system, and the construction of the well affect well yield. Aquifer sand percentage is higher in the areas where sands were deposited by meandering river channels than in areas where sands were deposited by tributary stream channels (see Chapter III). The thickness of the aquifer system increases to the east and northeast of the Study Area. The installation of multiple short screens in the various sands rather than a single long screen is the most efficient method of well construction for this area.

In the central and eastern portions of the Middle Peninsula, the principal aquifer system is very thick and has a large groundwater yield potential, although this potential has not been developed in most of the area (Table 5). Geohydrologic information indicates that the only areas in which poor aquifer characteristics exist is the

Gloucester and West Point area. In the Gloucester area, a considerable portion of the principal aquifer system consists of silts and clays with a low percentage of sand. At West Point, the sands of the principal artesian aquifer system are poorly sorted and extremely discontinuous. The principal aquifer is generally brackish and unsuitable for potable use in the eastern portion of the Study Area.

Specific capacities of wells completed in the principal aquifer system vary greatly (Plate 10c and Table 5). In the western part of the Study Area, specific capacities range from 0.8 to 1.8 gpm/ft and are generally larger in the central and eastern zones. In the Tappahannock area corrected specific capacities range from 2 to 7 gpm/ft while in West Point, an industrial well completed within the principal aquifer has a specific capacity of 39.1 gpm/ft. Other completed wells in West Point in both the upper and principal aquifers have specific capacities as high as 30 gpm/ft. The highest uncorrected specific capacities in the Study Area are found near Urbanna at Barnhardt Farms where they range from 8 to 46 gpm/ft. In Urbanna, a coarse sand with sand and gravel streaks may explain the high specific capacities.

Groundwater Use

The most extensive groundwater development in the Middle Peninsula has been in the principal aquifer system in the vicinity of West Point and Urbanna (Plate 11). This aquifer system has been under development for some time in the West Point area while development around Urbanna is relatively recent.

Barnhardt Farms near Urbanna, began groundwater withdrawals in

1962. The Farms currently withdraws over 1.2 mgd.

During the period 1890-1930, total withdrawals from the artesian aquifers in the West Point area have been estimated at approximately 0.39 mgd from free-flowing wells of small diameter. In the 1930's the first high capacity industrial wells were drilled and developed in the upper and principal artesian aquifer systems by the Chesapeake Corporation. From 1931 to 1940 groundwater withdrawals increased to about 1.25 mgd and from 1941 to 1950 Cederstrom estimated the pumpage increased to about 6.91 mgd. With additional industrial well construction, groundwater withdrawals averaged approximately 10.2 mgd from 1951-1960, further development of the well field raised the total pumpage to an average of 15.5 mgd in 1972 and during 1975, Chesapeake Corporation reported withdrawals of 16.3 mgd, approximately 14.3 mgd of which is from the principal artesian system.

Municipal and subdivision pumpage from the principal artesian system was an estimated 1.2 mgd for 1975. This pumpage includes the Towns of West Point, Urbanna, Tappahannock and Gloucester. There are no exact records prior to 1970 relating to municipal and domestic withdrawal rates.

In summary, industrial withdrawals account for 16.3 mgd of the approximately 17.8 mgd withdrawals from the principal aquifer in the Middle Peninsula. Withdrawals from the upper artesian and water-table aquifers account for about 2.2 mgd.

Current groundwater withdrawal data is presented in Appendix C. Most of the wells in this tabulation are screened in the principal artesian aquifer system. In addition to this listing, there are scattered domestic, agricultural and institutional supply wells throughout the Middle Peninsula.

CHAPTER V

GROUNDWATER HYDROLOGY

First, the general hydrology of the major aquifers is presented. Then, water level declines and flow conditions in the principal aquifer are discussed.

Yorktown Aquifer

The Yorktown aquifer located only in the eastern portion of the Middle Peninsula (see Plate 10a), is made up of one or more fine-grained discontinuous sand bodies which may be as thick as 20 feet. In the absence of a confining layer, this system is recharged directly from the overlying Post-Miocene water-table aquifer. However, much of the recharge to the system is probably derived from vertical leakage through the confining silts and clays. This system in turn supplies recharge to the upper artesian aquifer system by vertical leakage through the confining bed separating the two systems when a sufficient pressure differential exists.

Estimates of the transmissivity of various portions of the major aquifer have been made from available specific capacity data using the graphical method of Walton (1970) (Appendix A). Specific capacity values were corrected for partial penetration using the graphical method based on the Kozeny formula (Johnson, 1972).

Based on specific capacity data, estimated transmissivities of only 500-1,000 gpd/ft can be expected for the Yorktown aquifer in the area. The low transmissivities may be accounted for by the fine-grained particle size and discontinuous nature of the aquifer (Appendix A). Only one area, Gwynn Island in Mathews County, shows a higher transmissivity, 5,000 gpd/ft. Coarser grained sands encountered on the Island account for the higher transmissivity.

Upper Artesian Aquifer

The upper artesian aquifer system is made up of fairly homogenous areally extensive sands. The sands are fine to medium grained, moderately to poorly sorted with an average thickness of about 50 feet. The overlying confining layer consists of silts and clays which increase somewhat in thickness to the east. Although there are some areas, especially in the western one-third of the Study Area, where this system is directly recharged from the overlying water-table aquifers, much of the recharge to the system probably derived from vertical leakage through the confining silts and clays. This system in turn supplies recharge to the principal aquifer system by vertical leakage through the confining bed separating the two systems where a sufficient pressure differential exists.

Since there is little available hydrogeologic information, the estimates of transmissivities in the upper aquifer systems were based only on limited geologic logs and specific capacities (Appendix A). The highest estimated transmissivities were found in the central part of the area; 3,000-12,000 gpd/ft in the Tappahannock area and 15,000 gpd/ft in the West Point Area (Appendix A). Estimated transmissivities range from 1,000-5,000 gpd/ft in the western part to 1,000 gpd/ft in the eastern part of the area. The lower transmissivities in the western and eastern zones may be due to the finer particle size and more discontinuous nature of the upper artesian aquifer in these areas.

Principal Aquifer

The principal aquifer system of the Middle Peninsula consists of Cretaceous fluvial and deltaic deposits and lower Paleocene marine sands. Individual aquifers in the Cretaceous strata are thick, discontinuous sand bodies interbedded with silt and clay, while the Paleocene sands are thinner but more continuous. The confining beds overlying the principal aquifer system consist of clay, silt and poorly sorted sand of the Mattaponi Formation.

In Caroline County and the western parts of the King William, King and Queen, and Essex Counties, recharge to artesian aquifers occurs near the outcrop area along the western edge of the Coastal Plain. For the remainder of the area substantial recharge occurs from vertical leakage between adjacent aquifers through aquitards. The rate of vertical flow is proportional to the difference in water levels in adjacent aquifers and effective vertical permeability.

With heavy pumpage and increasing pressure differentials, leakage can yield substantial quantities of water to pumped aquifers. In the West Point and Urbanna areas water derived from vertical leakage may be greater than that derived from lateral migration and the small amounts released from artesian storage.

A minimum value for leakage through the confining layer of the principal aquifer system can be estimated by using Darcy's Law, Q - PIA, where Q = recharge in gallons per day; P - permeability of the confining layer; I - hydraulic gradient, which in this case, is the ratio of the head differential to the thickness of the confining layer; and A - areal extent of confining layer.

Laboratory permeameter tests of a core of a very low permeability clay taken from Well 118-49 (Charles City County) show an average permeability of 0.0025 inches per day, which is equal to 0.0015 gallons per day per square foot. In the West Point area, head differentials between two aquifers separated by a 70-foot thick confining layer is 50 ft/70 ft or 0.71. For an area of one square mile, the recharge derived from leakage through the confining bed would be:

$$Q = 0.0015 \text{ gpd/ft}^2 \times 0.71 \times (5.28 \times 10^3 \text{ ft})^2$$

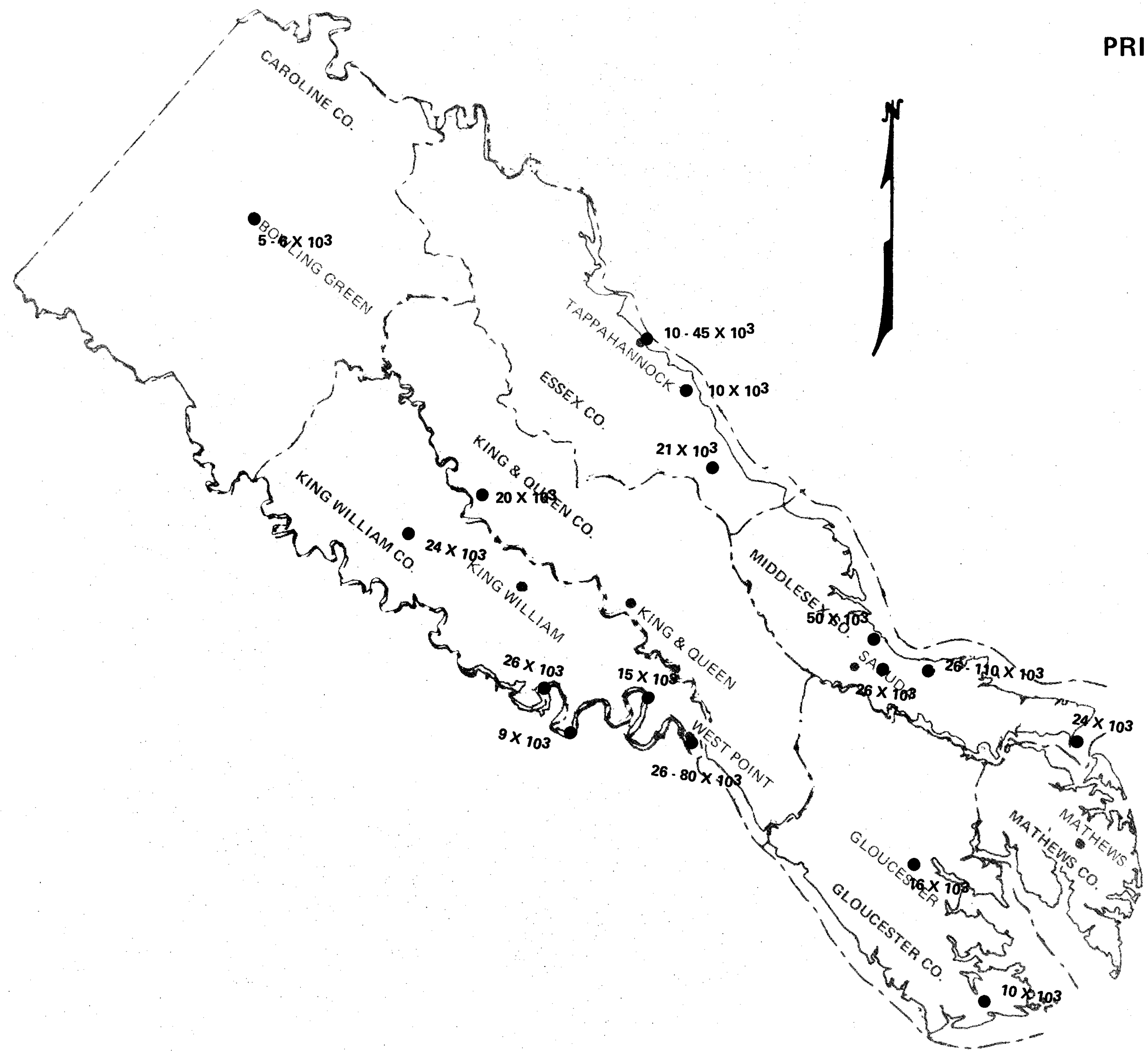
$$Q = 0.0305 \times 10^6 \text{ gpd} = 30{,}500 \text{ gpd}$$

As previously stated, this estimate of leakage is a minimum value. Clay as impermeable as that in the core sample from Well 118-49 is not often found. The confining layer is usually made up of more silty material in which a permeability increase of one order of magnitude can be expected. The head differential in the West Point area is lower than normal because of heavy pumpage in both of the aquifers separated by the confining bed.

In the western part of the Middle Peninsula, transmissivities of the principal aquifer system vary from 5,000 gallons per day per foot (gpd/ft) to 6,000 gpd/ft and the central and eastern parts, transmissivities range from 10,000 gpd/ft to 110,000 gpd/ft (Plate 12). The highest transmissivitie were found in the Urbanna area where 26,000, 80,000, 48,000, 110,000 and 50,000 gpd/ft were observed. The high degree of lateral variability in the principal aquifer makes it difficult to use one transmissivity value for an area (Brown and Cosner, 1974) as demonstrated by the variability of transmissivities.

TRANSMISSIVITY VALUES

PRINCIPAL ARTESIAN AQUIFER SYSTEM



26×10^3 – Transmissivity as expressed in terms of gallons/day/feet

SCALE 1:250,000

5 0 10 MILES

5 0 10 KILOMETERS

Source: Virginia State Water Control Board – TRO

PLATE NO. 12

The transmissivities of the Middle Peninsula agree with those transmissivities determined on the York-James Peninsula (State Water Control Board, 1973). Transmissivities determined from a pumping test at Cape Peary in northern York County ranged from 22,000 to 85,000 gpd/ft. Transmissivities ranging from 3,000-40,000 gpd/ft were estimated for the York-James Peninsula from specific capacity and geologic data. These transmissivities are similar in range to those found on the Middle Peninsula; 3,000 - 85,000 gpd/ft for the York-James Peninsula and 6,000 - 110,000 gpd/ft in the Middle Peninsula. Because of the similarity in transmissivities, the storage coefficient ranges determined from the above pump test in York County of between 1.0×10^{-4} and 1.9×10^{-4} may be used as an approximation of storage coefficients for the Middle Peninsula.

Water Levels in the Prinicipal Aquifer

Selected data from groundwater resource studies by Sanford (1913) and Cederstrom (1968) and subsequent investigation and study by the State Water Control Board, were used to prepare historical potentiometric-surface maps of the Middle Peninsula (Plates 13 and 14). These surfaces are, of course, approximations of the conditions for the time period indicated.

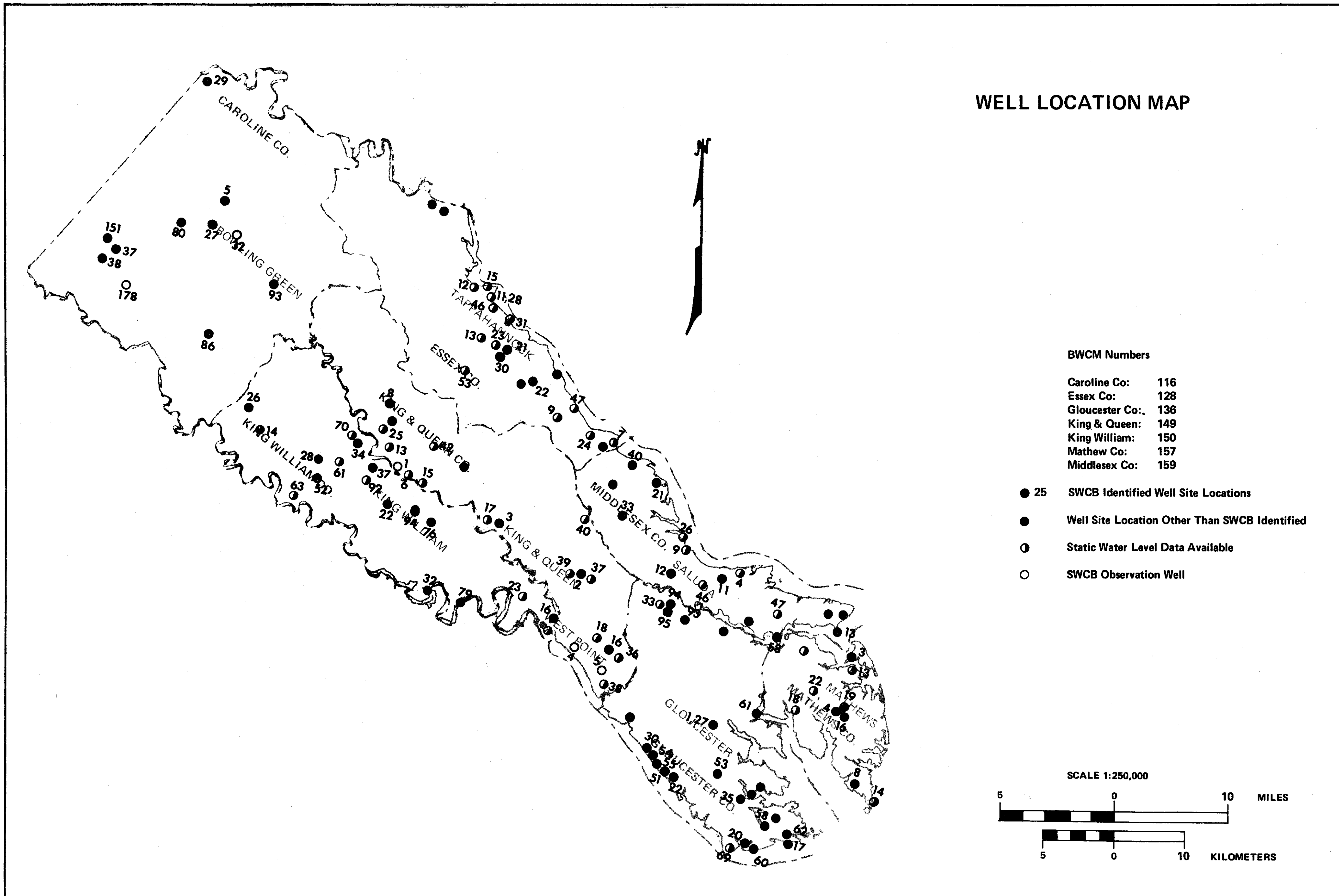
The potentiometric surface of the Principal Aquifer System for the year 1900 shows water levels and flow conditions prior to any subsequential groundwater withdrawals in the Middle Peninsula (Plate 14a). Flow was generally from west to east. An anomalous depression found between West Point and Saluda may be a result of thinning and/or permeability changes along the postulated hingeline zone near West Point (Brown, 1972).

Between 1900 and 1950, industrial pumpage lowered water levels and modified flow patterns in the principal aquifer system (Plate 14b). In the 1940's the 6 mgd withdrawals by Chesapeake Corporation in West Point caused an elliptical shaped cone of depression approximately 10 miles in radius to develop. Flow in the Middle Peninsula was generally directed toward the center of this cone of depression.

Increased pumpage by Chesapeake Corporation from 1950 to 1975 and the pumpage from Barnhardt Farms beginning in 1962, caused further water level declines and modification of flow patterns in the Study Area (Plate 14c). Chesapeake Corporation which increased its withdrawals from about 6 mgd in 1950 to over 14 mgd in 1975, caused a further expansion of the cone of depression. Currently, the cone extends approximately 29 miles from the center which is 120 feet below mean sea level (MSL). A secondary cone of depression in the Urbanna area attributed to the seasonal pumpage of Barnhardt Farms of over 1.2 mgd can be readily observed. Both cones of depression extend outside the Study Area boundaries. Thus, since about 1900, water levels in the principal aquifer system have declined 70 to 100 feet in the West Point area and 60-90 feet in the Urbanna area.

Well hydrographs from four observation wells show recent water level trends in the area (Plates 14c and 15). The Chesapeake Corporation observation well in the center of the cone of depression at West Point shows a water level decline of 30 feet from 1967 to 1972 which is attributed to the increase in pumpage during the time period. From 1972-1975, water level declines were less which is probably due to a smaller

WELL LOCATION MAP

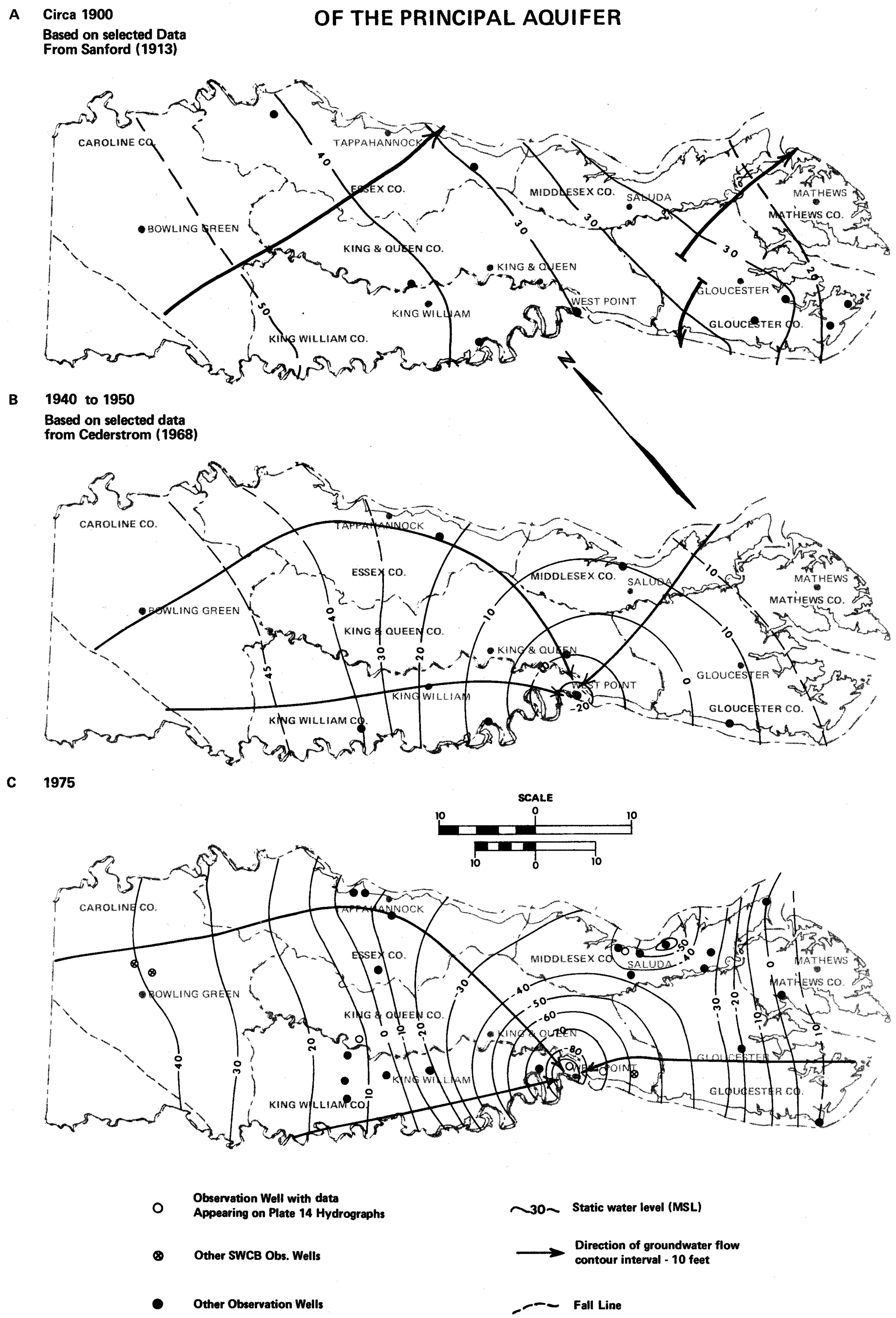


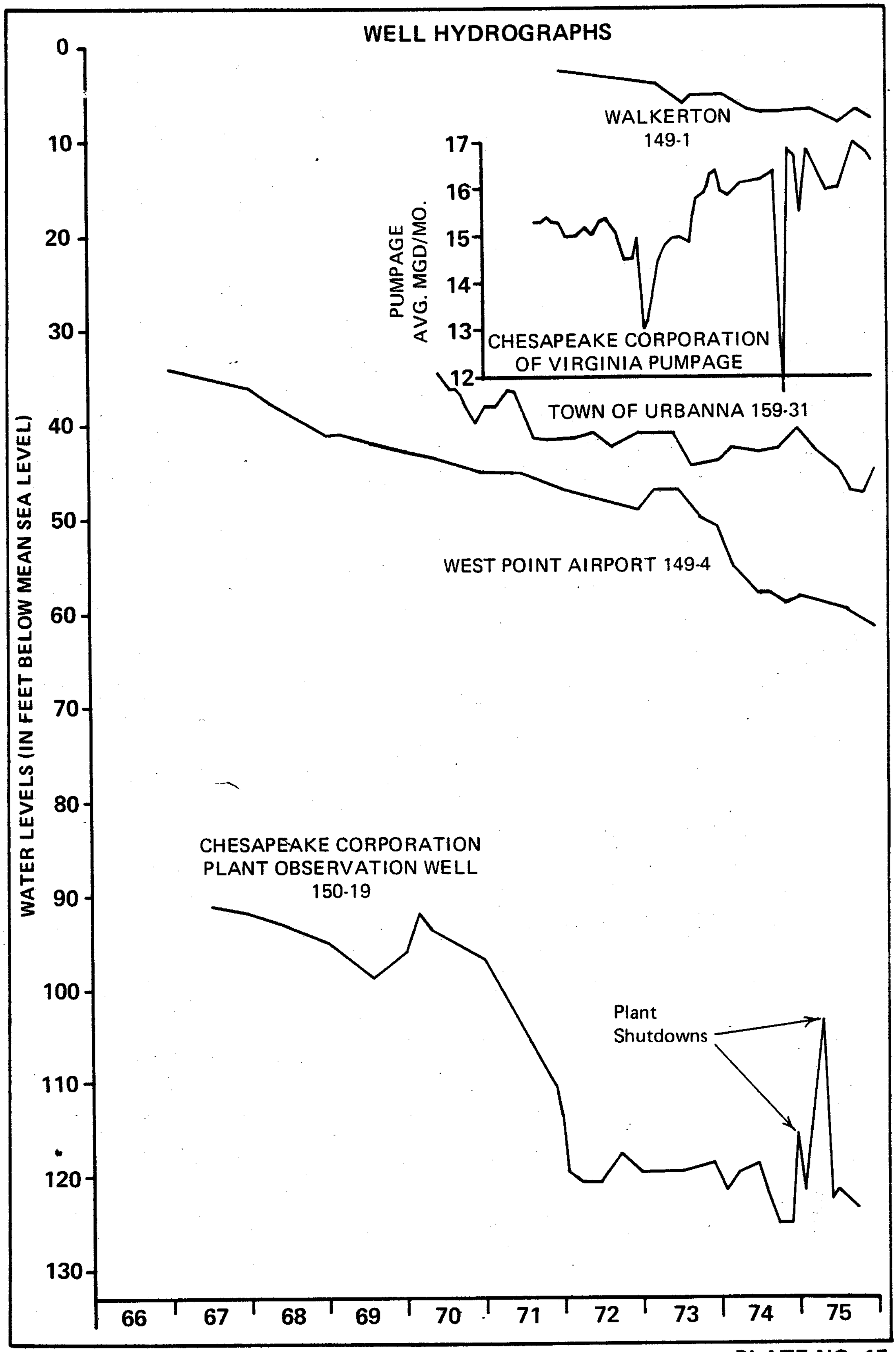
Source: Virginia State Water Control Board – TRO

PLATE 13

Source: Virginia State Water Control Board – TRO

POTENTIOMETRIC SURFACE OF THE PRINCIPAL AQUIFER





SOURCE: STATE WATER CONTROL BOARD

PLATE NO. 15

increase in pumpage by Chesapeake Corporation.

The West Point Airport well, east of the center of the cone of depression at West Point, shows a fairly steady decline of about 30 feet during 1967 to 1975 because the cone of depression has not yet stabilized to the current pumpage. A similar trend of declining water levels is attributed to the Chesapeake Corporation cone of depression which has not yet reached equilibrium in the Walkerton well 25 miles northwest of West Point; a steady decline of about 1.5 feet/year was observed from 1972 to 1975.

The water level decline observed at the Urbanna well is a result of the effects of the Chesapeake Corporation and Barnhardt Farms cones of depression (Plate 15). From 1972 to 1975 water level declines of seven feet were observed and attributed to these unstabilized cones of depression.

CHAPTER VI

GROUNDWATER QUALITY

Water Quality by Aquifer

Chemical quality data for groundwater of the major Middle Peninsula aquifer has been compiled in Appendix B. This data consists of water quality surveys conducted by both the State Water Control Board and other outside additional researchers. The chemical characteristics of groundwater by aquifer is discussed in this chapter. A more thorough and regional discussion of the chemical character of groundwater in the Coastal Plain of Virginia can be found in Cederstrom (1946).

Water-Table Aquifer. Groundwater from the Yorktown aquifer, occurring in the eastern part of the Study Area, is of a moderately hard calcium-bicarbonate type (Cederstrom, 1946). Hardness ranges from 80-250 ppm with an average of 166 ppm. In many places it is satisfactory for domestic use in spite of its hardness, but elsewhere the presence of high iron makes it unsatisfactory. Complete softening and iron removal are practiced where the water is used by commercial laundries. Average values for major chemical parameters may be found in Table 6 (see Appendix B for basic data).

Chloride content has a relationship to the proximity of brackish surface water bodies. The Yorktown aquifer was divided into eastern and western zones according to chloride concentrations (Plate 16a). In the western zone chlorides tend to be less than 25 ppm while chlorides in the eastern zone are generally in the potable range (less than 250 ppm) except in localized areas immediately adjacent to brackish surface water bodies. In such areas the groundwater is influenced by or is in hydrologic connection with the saline surface water bodies.

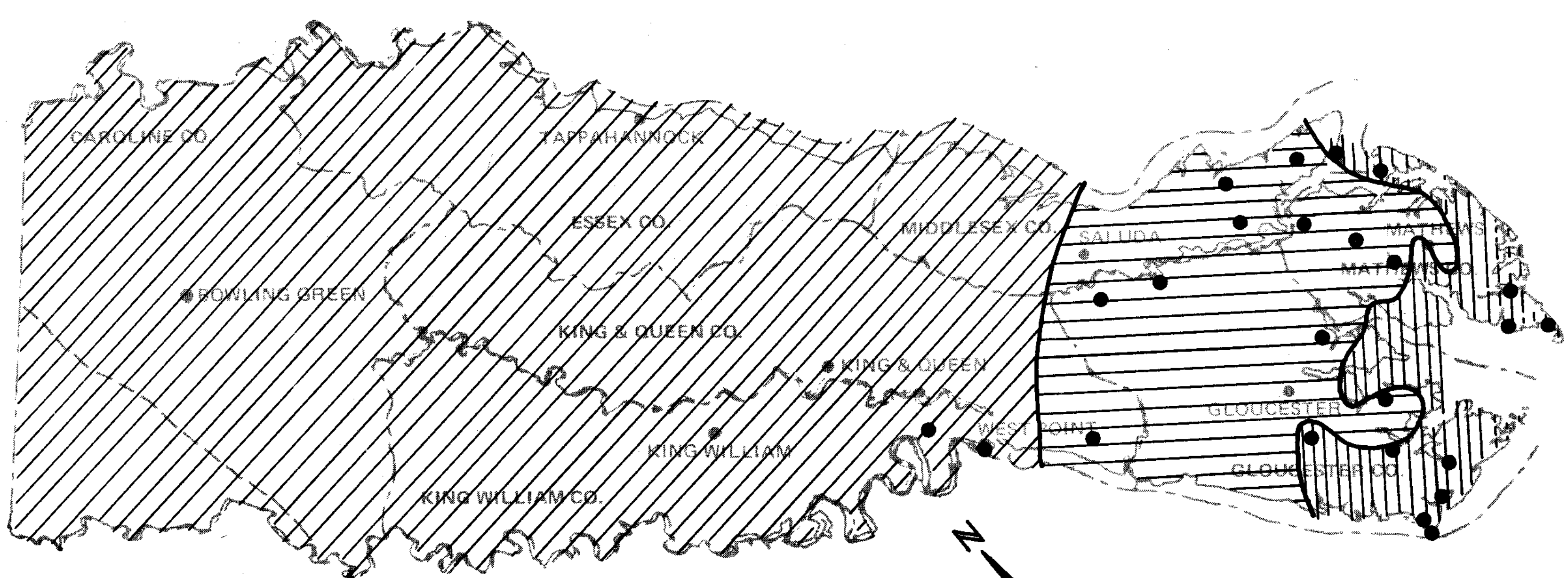
The water-table aquifer in the central zone, a combination of Miocene and Post-Miocene sediments, exhibits lower values in all chemical parameters than does the Yorktown aquifer (Table 6) which are accounted for by the lack of influence of brackish water bodies, the decrease in shell material responsible for hardness, and a decrease in travel time through the aquifer.

Upper Artesian Aquifer. The upper artesian aquifer produces water of a moderately hard-bicarbonate type, and all major chemical parameter values are less than those of the water table aquifer (Table 6). The upper artesian aquifer is suitable for potable use in the major portion of the Study Area but as one moves into eastern Gloucester, Middlesex, and Mathews Counties, highly brackish groundwater is encountered (Plates 4, 17, and 18). The water of the upper artesian aquifer, as well as that of the principal artesian aquifer, becomes quite high in chlorides and total dissolved solids east of the 300 ppm chloride isoconcentration line shown in Plate 16 and is generally not suitable for potable use.

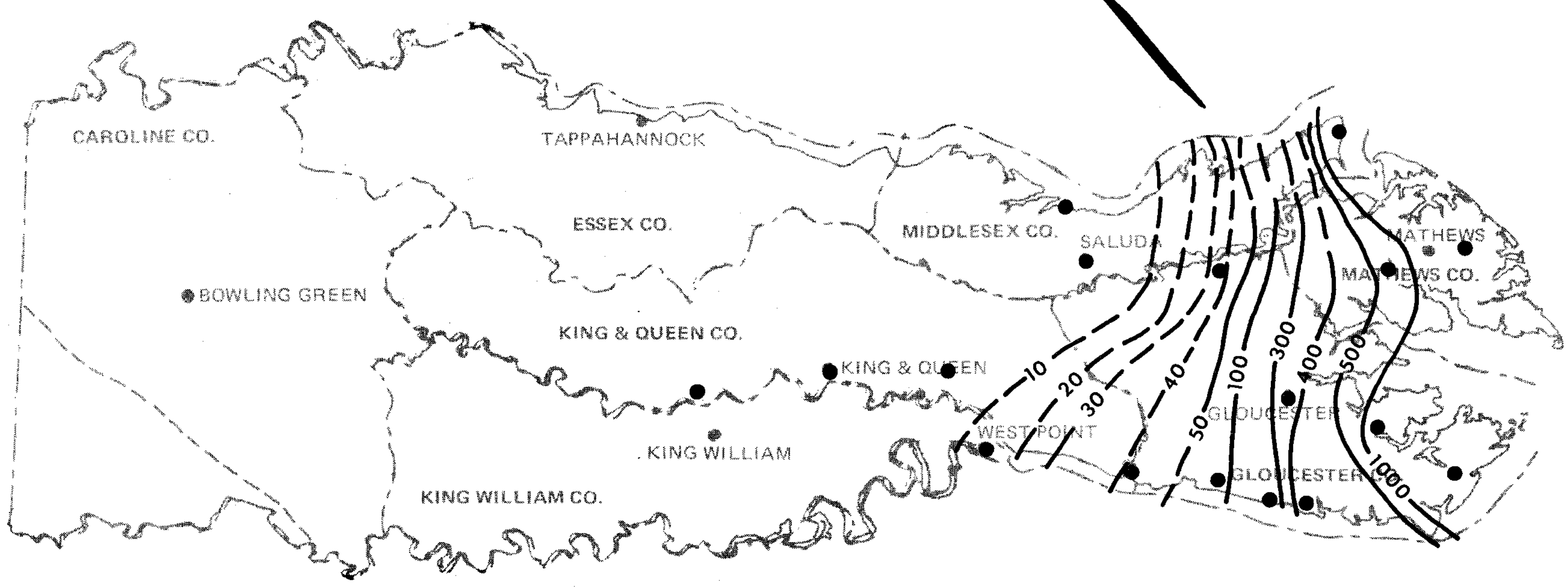
Principal Aquifer System. The principal aquifer system contains soft sodium-bicarbonate type groundwater which has very low hardness and moderate to high amounts of dissolved solids (Table 6). A high ratio of total dissolved solids to hardness in this aquifer is in contrast to a lower ratio for the same parameters in the upper

CHLORIDE DISTRIBUTION

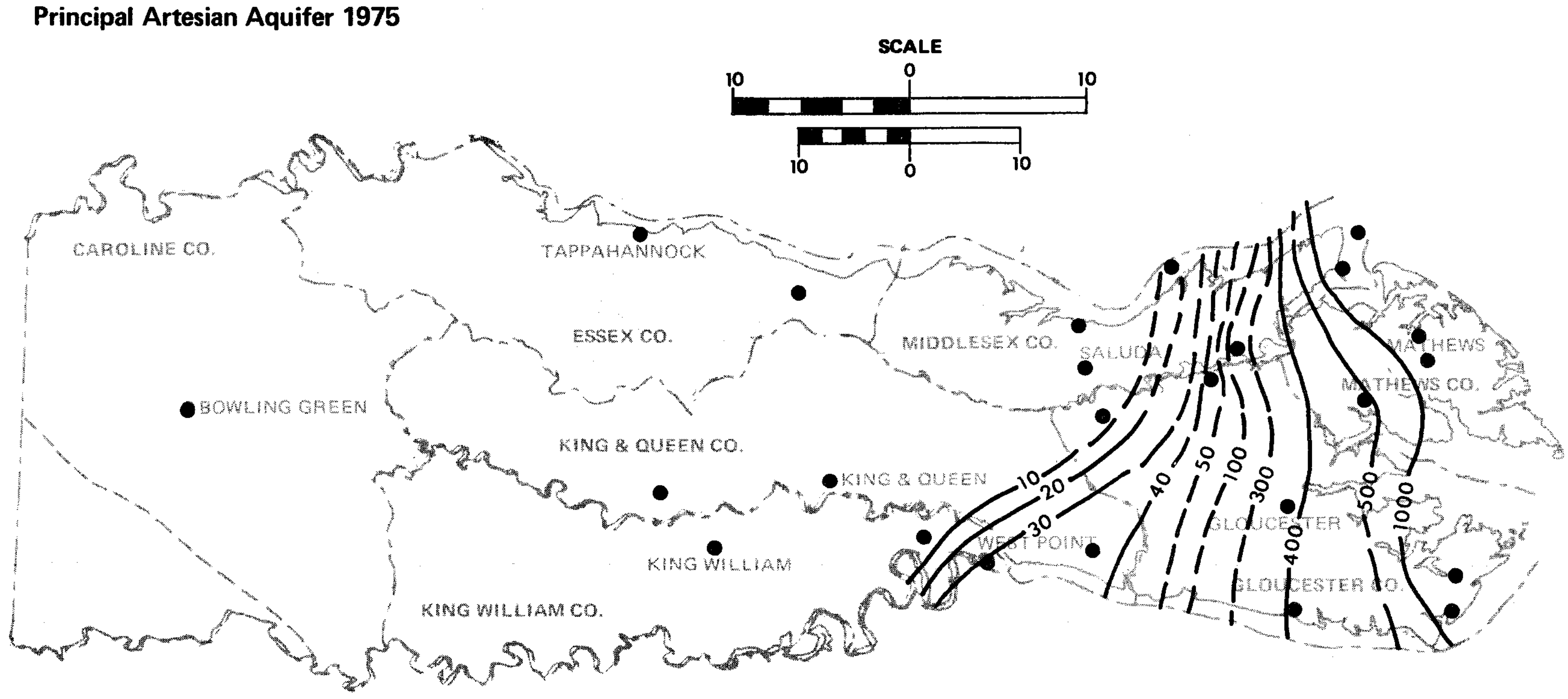
A **Yorktown Aquifer 1975**

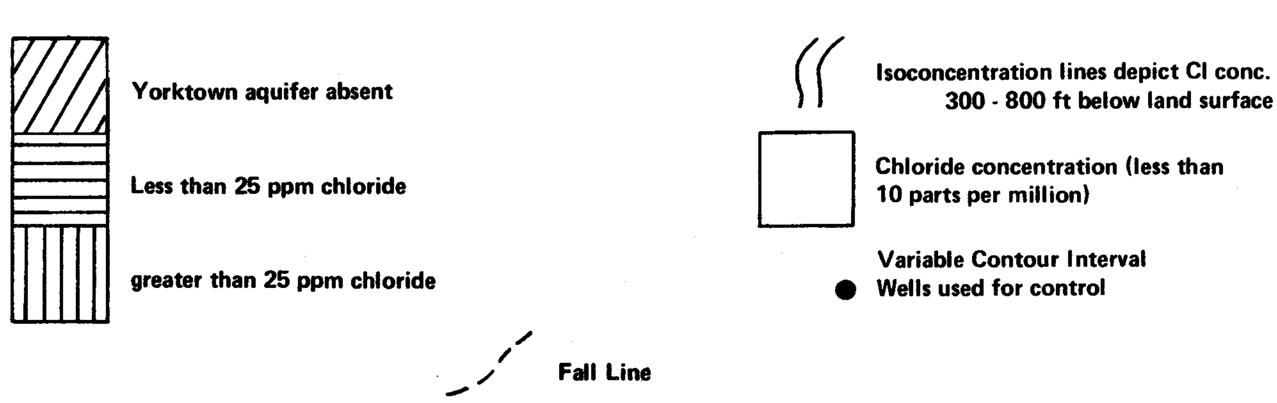


B **Principal Artesian Aquifer**
1945-1950
Based on Selected data from Cederstrom (1946)



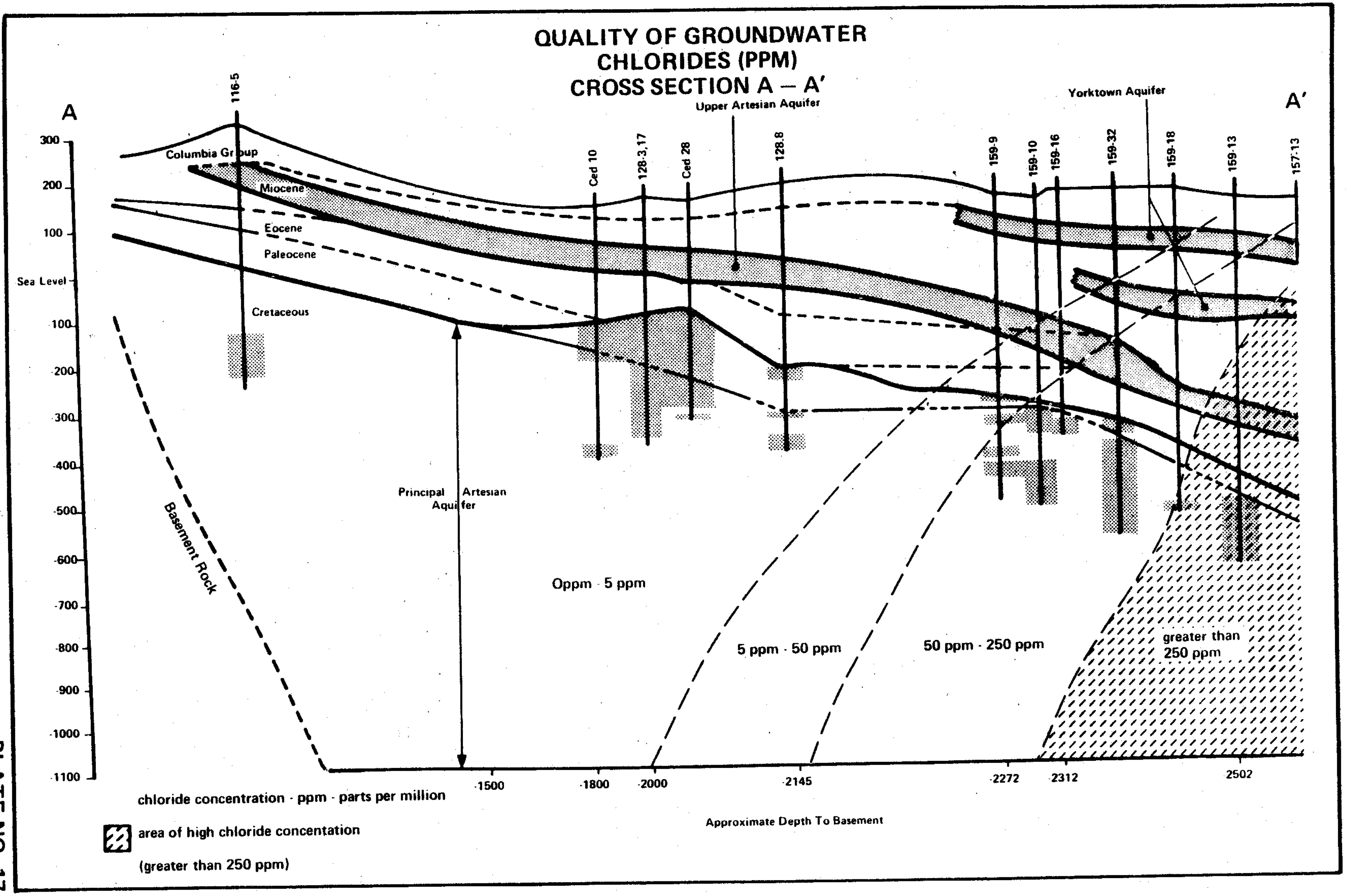
C **Principal Artesian Aquifer 1975**





Source: Virginia State Water Control Board – TRO

PLATE NO. 16



Source: Virginia State Water Control Board

PLATE NO. 17

Source: Virginia State Water Control Board

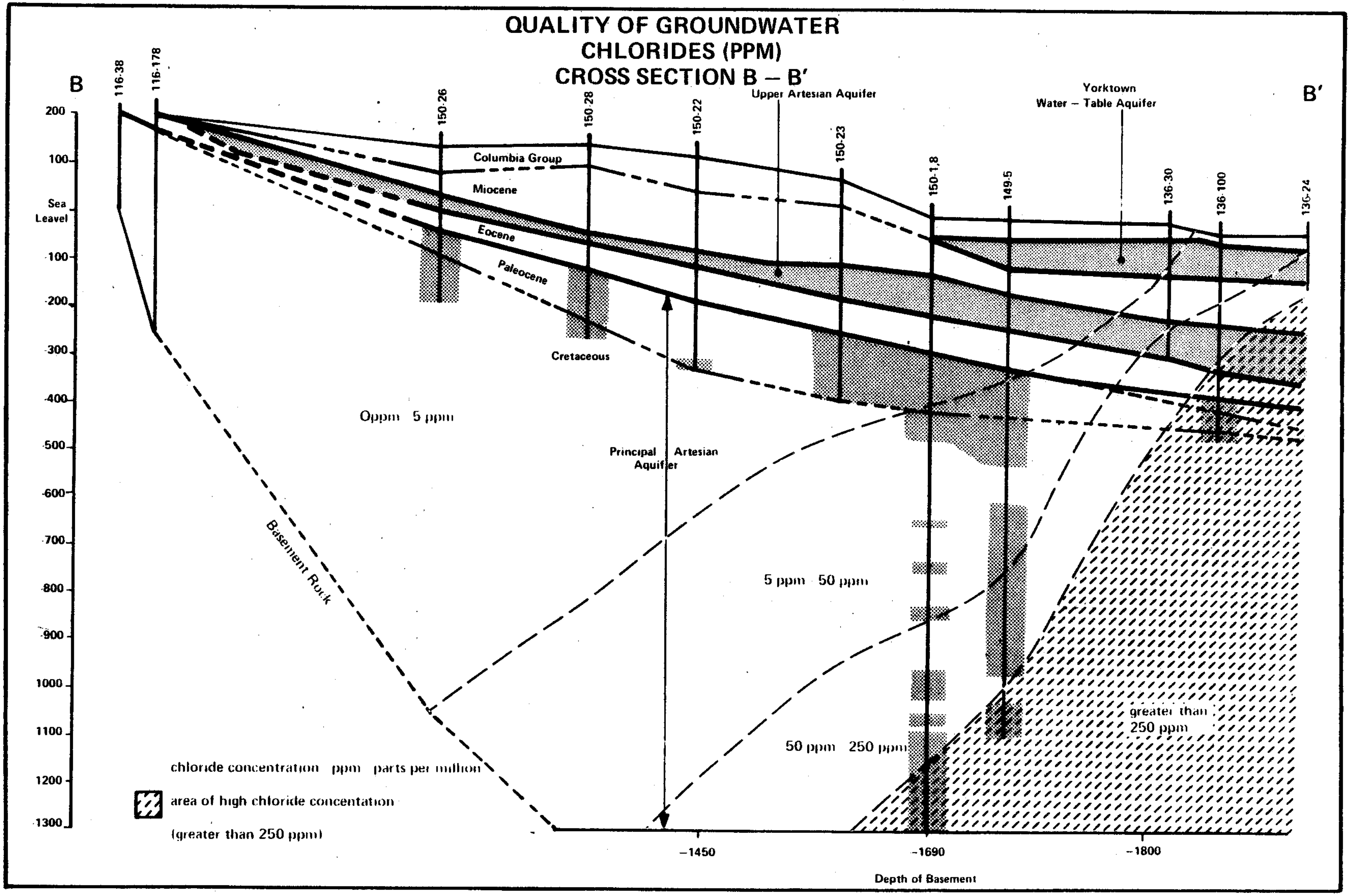


PLATE NO. 18

TABLE 6

MEAN GROUNDWATER QUALITY DATA FOR THE MAJOR AQUIFERS

Aquifer	Depth	Cl	Hrd	TDS	NO_3	F	Fe	Mg	Na	TDS/H
Eastern Zone										
Water Table	78	93	166	473	1.1	.13	1.7	15.3	79	2.8
Upper Artesian	238	129	121	721	0.05	.17	0.15	6.3	110	6.0
Principal Artesian	546	670	114	1950	1.5	1.7	.23	5.0	590	17.1
Central Zone										
Water Table	55	10	100	142	-	0.1	.3	1.8	2	1.4
Upper Artesian	214	3	79	230	.4	0.4	.06	6.9	39	2.9
Principal Artesian	538	4	5.2	378	.21	1.9	.11	.4	126	72.7
Western Zone (1)										
Principal Artesian	323	7	31	215	.13	.42	.13	2.0	50	7.0

Mean quality values for each aquifer in the East, Central, and Western sections of the Study Area in parts-per-million.

(1) Limited chemical data was available for the water table and upper artesian aquifers in the Western Zones.

Source: State Water Control Board

artesian aquifer (State Water Control Board, 1973). Fluoride concentrations are higher for the principal aquifer in the eastern and central areas than they are in the water-table and upper artesian aquifers; values range from about 1 to 2.6 with an average of 1.7 (Health Department Interim Standards are approximately 1.4 ppm, based on temperature correction). Fluoride concentrations may increase with depth as indicated by a deep well in West Point which showed 4.1 ppm fluoride at a depth of 1,275 feet.

Chloride concentration, negligible in the western and central part of the Study Area, increases steadily southeastward from Saluda and West Point (Plate 16c). Concentrations greater than 400 ppm chloride, found east of Gloucester, are generally too high for most potable use. The high chloride zone is found at about -1200 MSL in West Point and increases in elevation steadily eastward (Plate 18). The top of the high chloride zone has not been determined in the Urbanna area by test drilling but has been estimated as approximately -1200 feet MSL (Plate 17).

Nature of High Chloride Zone

The high chloride zone in the artesian aquifers found in the eastern portion of the Study Area was identified by Cederstrom (1946). This high chloride zone is not confined to the Middle Peninsula but extends to the south on the York-James Peninsula and Southeastern Virginia, and to the east on the Virginia Eastern Shore. It is believed that the salinity or high chlorides of the artesian aquifer of the Virginia Coastal Plain is due to the incomplete flushing of these aquifers since they were last saturated with sea water.

The historic chloride data further illustrates that the high chloride zone is a naturally occurring phenomena. The phenomena has been recorded since only 1906, but has probably existed as such before recorded history in the geologic past. Chloride records for a particular town or area have been relatively consistent from 1900 to 1975, considering that the high chloride zone is variable, and that not all samples compared were from the same well or even the same town (Table 7). Areas exhibiting high concentrations of chlorides (areas A, B, and H in Table 7). as well as those less concentrated in chloride (areas C, D, E, F, and G), show fairly consistent chloride observations for the period of record.

It is important to determine whether there has been or will be lateral or vertical migration of the high chloride zone in response to pumping. The two major groundwater withdrawals on the Middle Peninsula are located within the low chloride zone near West Point and Urbanna. The major withdrawer is Chesapeake Corporation in West Point about 12 miles from the lateral 250 ppm chloride interface in the upper part of the principal aquifer (Figures 16c and 18). Vertically the 250 ppm chloride interface at West Point has been encountered at about -1200 feet MSL. The other major groundwater withdrawer is Barnhdardt Farms, in the Urbanna area, about six miles from the lateral 250 ppm chloride interface, the exact depth to the vertical 250 ppm interface in the Barnhardt well field has not been exactly determined, but an approximation based on adjacent wells is -1200 feet MSL.

The heaviest withdrawals began in recent years: over 16 mgd for Chesapeake Corporation annually and over 1.2 mgd for Barnhardt Farms.

TABLE 7

HISTORIC TRENDS OF CHLORIDES IN THE EASTERN ZONE
OF THE ARTESIAN AQUIFERS

Location	Date	Total Depth (ft-LSD)	Chloride (ppm)
Gloucester County			
A. Achilles Area			
1. Union Baptist Church*	1906	450	1500
	1918		1540
2. Bena-Theodore Pratt	1969	440	1110
#136-50	1972		1100
	1975		870
B. Naxera and Secern			
1. A. M. Withers*	1941	716	1700
2. J. M. Shakelford*	1906	575	2500
	1941		2600
C. Gloucester Point Hotel*	1906	694	410
	1918		424
	1941		432
D. Gloucester Courthouse			
1. Town 136-1	1958	701	303
	1975		272
2. Town 136-27	1941	810	345
	1975		333
E. Clay Bank			
1. #36**	1950	460	476
2. #34**	1950	610	412
3. N. C. Israel	1975	440	420
F. Allmondsville-Capahosic Area			
1. W. R. Seward*	1906	270	106
	1941	270	69
2. Gloucester A&I School	1918	395	54
Capahosic	1941		53
Mathews County			
G. North*	1918	460	550
	1941		552
Middlesex County			
H. Deltaville-Amburg			
1. Amburg*	1918	822	1820
2. Stove Point Test Well	1964	650	1848

*From Cederstrom, 1943.
**From Cederstrom, 1968.

Source: State Water Control Board

Changes in chloride concentrations from the 1940's to 1975 have been investigated in order to determine chloride movement due to recent heavy pumping by Chesapeake Corporation and Barnhardt Farms. Isoconcentration maps depicting the chloride concentrations at depths 300-800 feet below the land surface were constructed for the periods 1945-1950 and 1975 (Plates 16b and c). No substantial changes were observed. An important deep well control point of the 250 ppm chloride lines was the Town of Gloucester, which has shown relatively constant chloride concentrations from 1945-1975; probably no substantial movement of the 250 ppm chloride lines has occurred since 1945 in the vicinity of the Town of Gloucester.

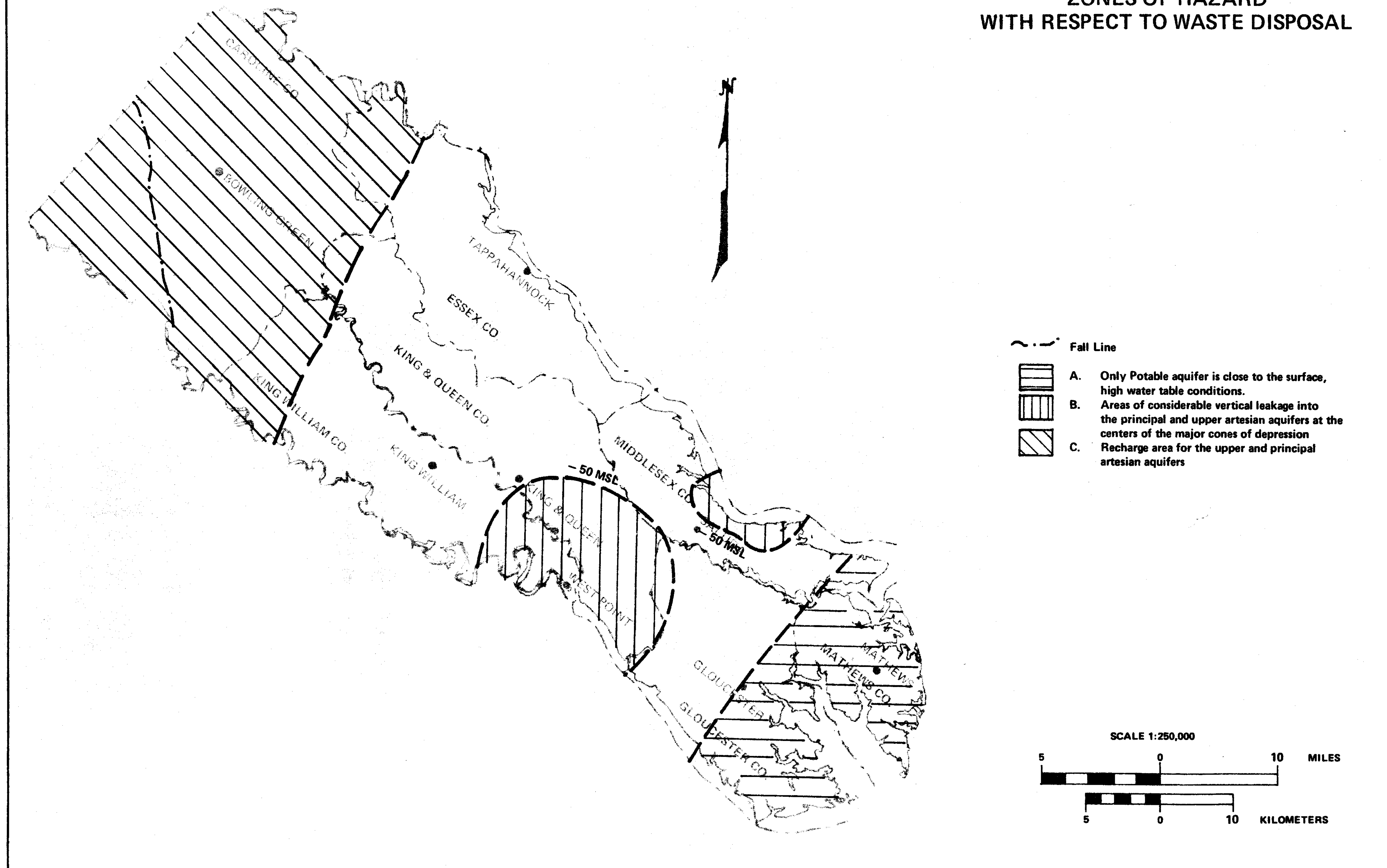
Lack of deep well control southwest of Gloucester in 1975 and northwest of Gloucester in 1945-1950 make it impossible to determine whether or not the 10-300 ppm chloride lines have moved closer from 1945-1975 to the pumping centers into these areas. No vertical saltwater movement has been observed in the well fields, which would be detected by increases in chlorides in the well fields. Recommendations to monitor the freshwater-saltwater interface in order to detect future chloride movement are made in Chapter VIII.

Groundwater Contamination

The majority of the groundwater parameters sampled are useful for determining natural groundwater quality problems such as hardness, high iron and manganese, total dissolved solids, and chlorides, and for making various hydrologic analysis. Nitrate, total organic carbon and chloride in the absence of naturally occurring high chloride concentrations in the groundwater are the most useful parameters for indicating certain types of groundwater contamination. Based on limited data, no groundwater contamination was indicated by the above parameters (Appendix B).

To accurately analyze the groundwater contamination or contamination potential, chemical monitoring of the most hazardous wastes should be initiated first. This would mean constructing monitoring wells and analyzing the groundwater for the hazardous waste to determine boundaries of contaminant movement. Priority of the study should be given to the hydrologically most susceptible areas (Plate 19). After a substantial number of disposal areas are monitored, the contamination potential and disposal criteria for the area may be derived.

ZONES OF HAZARD
WITH RESPECT TO WASTE DISPOSAL



Source: Virginia State Water Control Board – TRO

PLATE NO. 19

CHAPTER VII

GROUNDWATER AVAILABILITY

The availability of groundwater in the Middle Peninsula and hydrogeologic or hydrologic variables which limit or potentially limit groundwater availability in the area will be discussed in this chapter. Variables include highly mineralized groundwater zones, poor aquifer characteristics, water level declines, interference between groundwater users, potential movement of the mineralized zone, and groundwater contamination.

Limitations

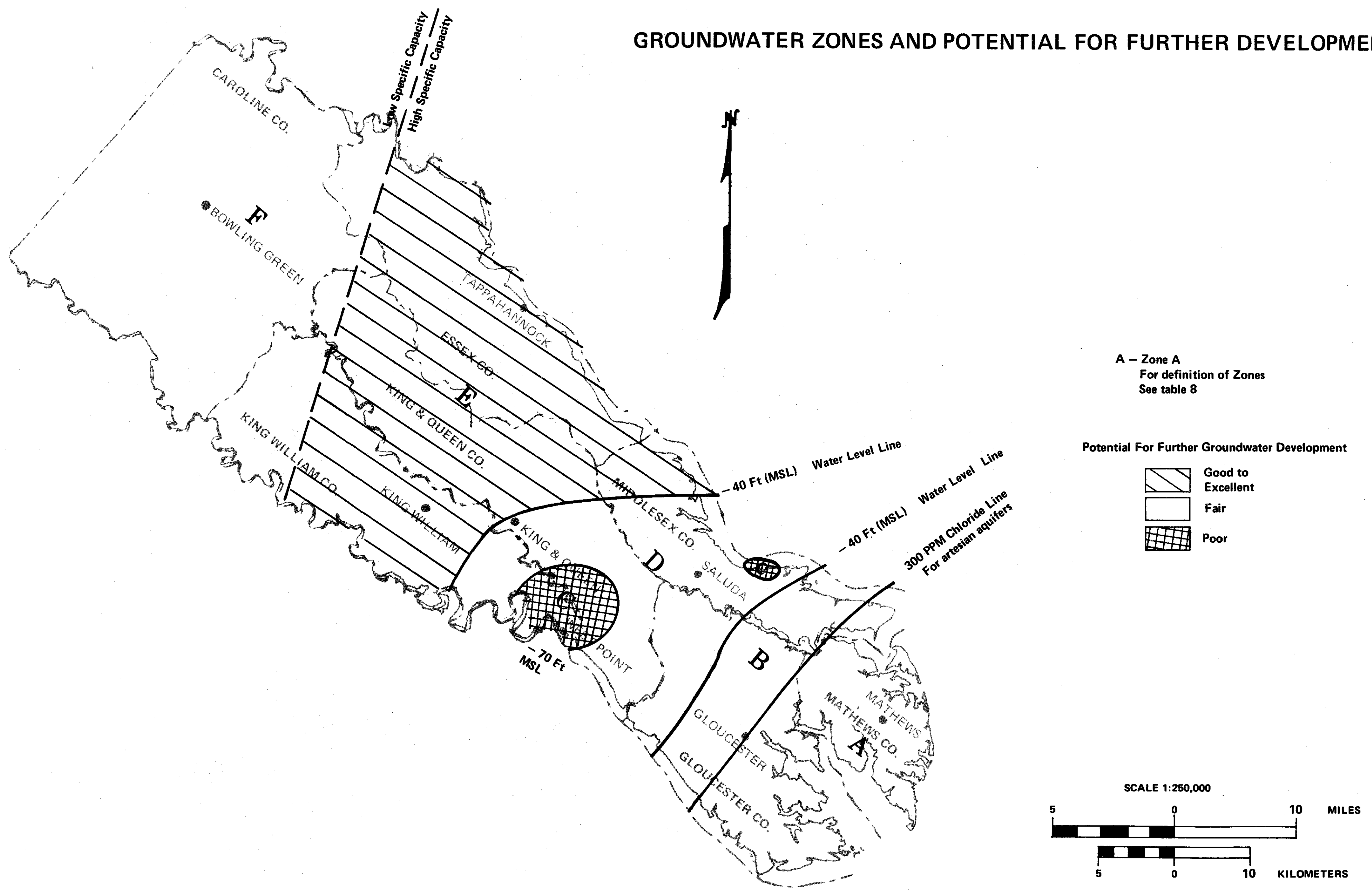
Highly Mineralized Zone. The high mineral content of groundwater in the eastern part of the Middle Peninsula limits the use of this groundwater (see Chapter VI). East of the Town of Gloucester the principal and upper artesian aquifers contain greater than 250-300 ppm chloride which is generally unsuitable for most potable use (Plate 20). Mineralized groundwater in large quantities may be used for non-potable functions such as cooling and industrial use; Colonial Williamsburg and Dow Badische to the south on the York-James Peninsula use mineralized groundwater for such purposes. This water may be corrosive when hot, as observed in Yorktown by Cederstrom (1957).

The Yorktown aquifer, the most important aquifer in the mineralized zone, is generally suitable for potable use. However, highly brackish groundwater has been found adjacent to brackish surface water bodies, especially on narrow peninsulas (Plate 16a).

Poor Aquifer Characteristics. The portion of the Yorktown aquifer found in the eastern part of the Peninsula, is considered rather poor (see Chapter IV). In other areas such as the City of Virginia Beach and the Virginia Eastern Shore (State Water Control Board, 1975), the Yorktown aquifer is a productive aquifer with yields of 100 gpm common. On the Middle Peninsula, however, yields of only 25-30 gpm can be expected from large diameter wells and specific capacities are low, usually one or less (Plate 10a). As a result of the low yield capabilities of the Yorktown, a moderate size well field can be expected to yield only 200 gpm. As an example, the Town of Gloucester Point needs an additional 700 gpm water supply by the year 2000. A detailed water supply study on Gloucester Point recently concluded that the demand can be met with multiple well systems at a number of sites rather than one well system or well field (the Ranney Company, 1976). For larger systems, those comparable Gloucester Point, or smaller systems, test drilling is recommended prior to well development to guarantee an adequate water supply.

Water Level Declines. Significant cones of depression associated with major water withdrawals have been observed in the central and eastern part of the Study Area. The two major cones of depression have not yet stabilized, but probably will when water withdrawals from the industries involved stabilize (Plates 14 and 15). Water levels in the principal aquifer system at the center of the Chesapeake Corporation cone of depression are currently about -120 MSL or about 180 feet above the top of the principal aquifer. The water level at the center of the Barnhardt Farms cone is about -70 MSL, or about

GROUNDWATER ZONES AND POTENTIAL FOR FURTHER DEVELOPMENT



Source: Virginia State Water Control Board – TRO

PLATE NO. 20

300 feet above the top of the principal aquifer (Plate 20). Water levels should be prevented from dropping below the top of the aquifer to prevent serious damage to the aquifer from dewatering.

Water Well Interference. No significant interference between groundwater users has been reported in the Middle Peninsula. It is probable, however, that some interference problems have been encountered by smaller groundwater users in the centers of the cones of depression of Chesapeake Corporation and Barnhardt Farms.

Movement of the Highly Mineralized Zone. Chloride data in the eastern part of the Study Area shows that chloride movement from the Town of Gloucester westward to the pumping centers in West Point and Urbanna has not taken place (Plates 16b, c). Lack of deep well control north or south of the Town of Gloucester makes it impossible to determine at the present time whether chloride movement is occurring from these areas toward the pumping centers. Observation well locations to adequately detect future chloride movement are discussed later in the chapter.

Cederstrom (1946) recommended that large well installations in the low chloride zone intended to continuously withdraw a million gallons or more of water should be located at least five or more miles from the leading edge of the high cloride zone. The author recommends that a buffer zone be maintained in the Study Area to prevent migration of the high chloride waters. Smaller pumpages in the neighborhood of .2 to .5 mgd are safe in the buffer zone as long as these withdrawals are not congregated in a small area to cause a significant cone of depression to develop.

TABLE 8

ESTIMATED GROUNDWATER AVAILABILITY

Zone (see Plate 20)	Characteristics of Zone	Estimated Availability Per Well or Well Field Site (mgd)	Estimated Ground Water Availability in Zone (mgd)
A	Yorktown aquifer has a low yield potential. Principal and upper artesian aqufers not suitable for potable use.	.2 mgd from a well field in the Yorktown aquifer and Columbia Group.	2-5 mgd
B	Buffer zone between pumping centers and high chloride zone.	.2 mgd from principal and upper artesian aquifers.	2-5 mgd
C	High water level declines. Currently pumpage is 16.3 mgd in West Point and 2 mgd in Urbanna	Limited availability from upper artesian and principal aquifers due to risk of dewatering aquifers.	19-22 mgd (includes current groundwater use of 18.3 mgd)
D	Moderate water level declines.	.2 in upper or principal aquifer.	2-5 mgd
E	Slight to no water level declines.	Variable depending on local capabilities of principal artesian aquifer, no more than 2 mgd per well field in the principal aquifer. Cones of depression should not overlap. .2 per well field in the upper artesian.	5-15 mgd
F	Moderate yield characteristics in principal and upper artesian aquifers.	.2 mgd in the principal aquifer.	2-5 mgd (bedrock aquifers not considered).
		TOTAL AVAILABILITY-	32-57 mgd

Source: State Water Control Board

Groundwater Contamination. No detectable groundwater contamination was observed for the limited number of wells which were randomly sampled. Chemical monitoring wells at the major waste disposal site are needed, however, to determine the extent of possible groundwater contamination and to recommend preventive measures. After a number of sites have been sampled, adequate criteria for waste disposal in the area may be established and hydrologically susceptible areas should be given priority (Plate 19).

Availability

Groundwater availability on the Middle Peninsula was estimated on current knowledge of aquifer capabilities (Chapter III) and limitations characteristic of each zone (Plate 20 and Table 8) as discussed in the previous section of this chapter. Based on those characteristics, the Study Area was then divided into six zones of groundwater availability (Plate 20 and Table 8). More refined estimates of groundwater availability will be possible as further groundwater research is conducted and groundwater models are developed as discussed in Chapter VIII.

Estimates of groundwater availability in zones B, D, E, and F were made by evenly distributing theoretical pumpages with the associated cone of depression in each zone so that little or no overlap of the cones occurs. Availability in Zone A was projected from the aquifer characteristics and estimated availability from a recent water supply study in Gloucester Point area, a segment of Zone A. For Zone C, availability was estimated as approximately equal to current pumpage. In regard to availability in Zones B, C, and D, it was assumed that movement of the high chloride zone will not be detected or associated with the current pumpage in Zone C. It was also assumed in estimating availability in Zones, B, C, and D that current water level declines associated with pumpage in Zone C will stabilize when the pumpage is held constant.

Zone A. This zone is characterized by the unsuitability of the principal and upper artesian aquifers for potable use and poor aquifer characteristics in the Yorktown aquifer, as described earlier in the chapter. Because of the low available yields from the Yorktown aquifer, a moderately sized well field can be expected to yield 200 gpm. Currently, small systems including domestic, institutional and small subdivisional systems, are most common. The only larger system currently considered is located in the Gloucester Point Sanitary District.

Since the specific capacities and yields from the Yorktown, Zone A, are fairly uniform, the availability of about .4-1 mgd (The Ranney Company, 1976) in the Gloucester Point area was multiplied by five to get an approximate figure of 2-5 mgd for groundwater availability in Zone A. It is assumed that pumpage will be distributed throughout the zone and there will not be concentrated withdrawals in any one area.

Zone B. This is the buffer zone adjacent to the high chloride Zone A. In order to prevent movement of high chloride waters from Zone A into Zone B, only limited withdrawals with small cones of depression are considered safe in this buffer zone. Withdrawals of about .2 mgd from the principal or upper artesian aquifer are considered safe as long as these withdrawals are distributed throughout the zone so that the cones of depression associated with these withdrawals do not overlap. If these cones of depression from .2 mgd pumpage are distributed evenly in Zone B, without overlapping, it is estimated that about 2-5 mgd is available from the zone. The chlorides in this zone will range from 50 to 200 ppm.

Zone C. Zone C, the area of high water level declines in the principal aquifer, is associated with the central portions of the two major cones of depression in the area (Plate 20 and Table 8). Water levels in this zone are -70 feet MSL or less, with water levels of -120 feet MSL reported at the center of the cone associated with Chesapeake Corporation in West Point. Essentially only a small increase in groundwater withdrawals, currently 18.3 mgd, is recommended in order to prevent the dewatering of the principal artesian aquifer. Dewatering would occur if the water level falls below the top of the principal aquifer. Allowing for a slight .7-3.7 mgd increase to satisfy industrial and municipal needs, groundwater availability of 19-22 mgd was estimated.

Zone D. This zone is an area of relatively moderate water level decline in the principal artesian aquifer associated with pumpages of Chesapeake Corporation in West Point and Barnhardt Farms in Urbanna. Water levels range from -40 to -70 feet MSL in Zone D. Smaller withdrawals of approximately .2 mgd would not cause major water level declines provided these withdrawals are not concentrated in any area. It is estimated that about 2-5 mgd is available safely from these properly spaced small withdrawals with the principal or upper artesian aquifers (Plate 20 and Table 8).

Zone E. In Zone E, principal artesian aquifer water level declines associated with Chesapeake Corporation or Barnhardt Farms pumpages are either insignificant or non-existent. The groundwater resources in this zone have been virtually untapped. No more than 2 mgd withdrawals per well field is recommended from the principal aquifer with adequate spacing between well fields to prevent the respective cones of depression from overlapping (Plate 20). In the upper artesian aquifer approximately .2 mgd per well field is available if wells are adequately spaced from other withdrawals. The total availability for Zone E is approximately 5-15 mgd.

Zone F. The principal and upper artesian aquifers of Zone F, located along the western margin of the coastal plain, are not as productive as the zones to the east. Bedrock aquifers are productive in Zone F but these aquifers were not studied extensively enough to make estimates of availability. Approximately .2 mgd is available per well field in the principal aquifer. Approximate groundwater availability from the coastal plain aquifers in Zone F is 2-5 mgd.

It is estimated that approximately 32-57 mgd of groundwater is available in the Middle Peninsula from the coastal plain aquifers. About 20 mgd of groundwater is currently being used in the Middle Peninsula which means that 35 percent to 62 percent of the estimated available groundwater is currently being utilized.

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The Yorktown aquifer system, which occurs in the eastern portion of the Middle Peninsula, is a relatively reliable source of potable water although local problems of high chlorides, hardness and iron may affect usefulness. Aquifer thickness, permeability and lateral variability preclude development of high-yield or moderate-yield wells or well fields in this aquifer, but this system has a potential to be developed for domestic, institutional, and light municipal use. The Yorktown aquifer is important in eastern Gloucester, eastern Middlesex, and Mathews Counties where it is virtually the only potable aquifer available. To secure an adequate supply, test drilling is essential prior to aquifer development because of variability in aquifer characteristics and water quality in the Yorktown aquifer.

The upper artesian aquifer system, found throughout much of the Middle Peninsula, is a reliable source of good quality groundwater. Aquifer thickness and hydraulic conductivity of the aquifer preclude development of high-yield wells or well fields in most places but the fairly shallow occurrence of the aquifer and the good quality of its groundwater make the upper aquifer system an excellent source of domestic groundwater supply. In eastern Gloucester, eastern Middlesex and Mathews Counties, however, it is unsuitable for potable use because of high chloride content. This system has sufficient aquifer potential for institutional, agricultural, light municipal and possibly light industrial uses. Groundwater from this system can be used as a supplement to a groundwater supply in the principal aquifer system, especially if the water from the principal aquifer is of undesirable quality.

The principal aquifer system is found throughout the entire Middle Peninsula and has a high yield potential. As was previously discussed, a high chloride wedge is found within the principal artesian aquifer in the eastern portion of the Study Area. The depth of the high chloride wedge increases westward with the wedge depth about -1200 feet MSL in West Point. Throughout most of its extent, the principal aquifer is capable of supplying high-yield wells or well fields, though some locations are more favorable than others.

Development of the principal aquifer system at West Point and east of Urbanna has caused a lowering of water level in the system, with a maximum decline of about 140 feet at West Point. Current water level trends show a continuing water level decline as a result of increased pumpage in West Point and Urbanna. Water levels will probably stabilize, however, when pumpages in the West Point and Urbanna areas are kept relatively constant.

The high chloride groundwater zone within the artesian aquifers in the eastern part of the Study Area is of natural origin. Adequate deep well control in the Town of Gloucester area indicates that movement of the high chloride zone western boundary toward the major pumping centers has not occurred in this area during the last 30 years. Lack of deep well control north and south of Gloucester at the present time make it impossible to assess whether the high chloride zone has moved toward the pumping centers in these areas.

The major variables limiting groundwater supply in the area include the presence and potential movement of the highly mineralized zone in the eastern part of the Study Area, the water bearing characteristics of the major aquifers, and major water level declines in the principal aquifer aasociated with major water withdrawals. The most promising area for future groundwater development is the west-central part of the Study Area (Zone E) where the principal and upper artesian aquifers have been only slightly developed.

Recommendations

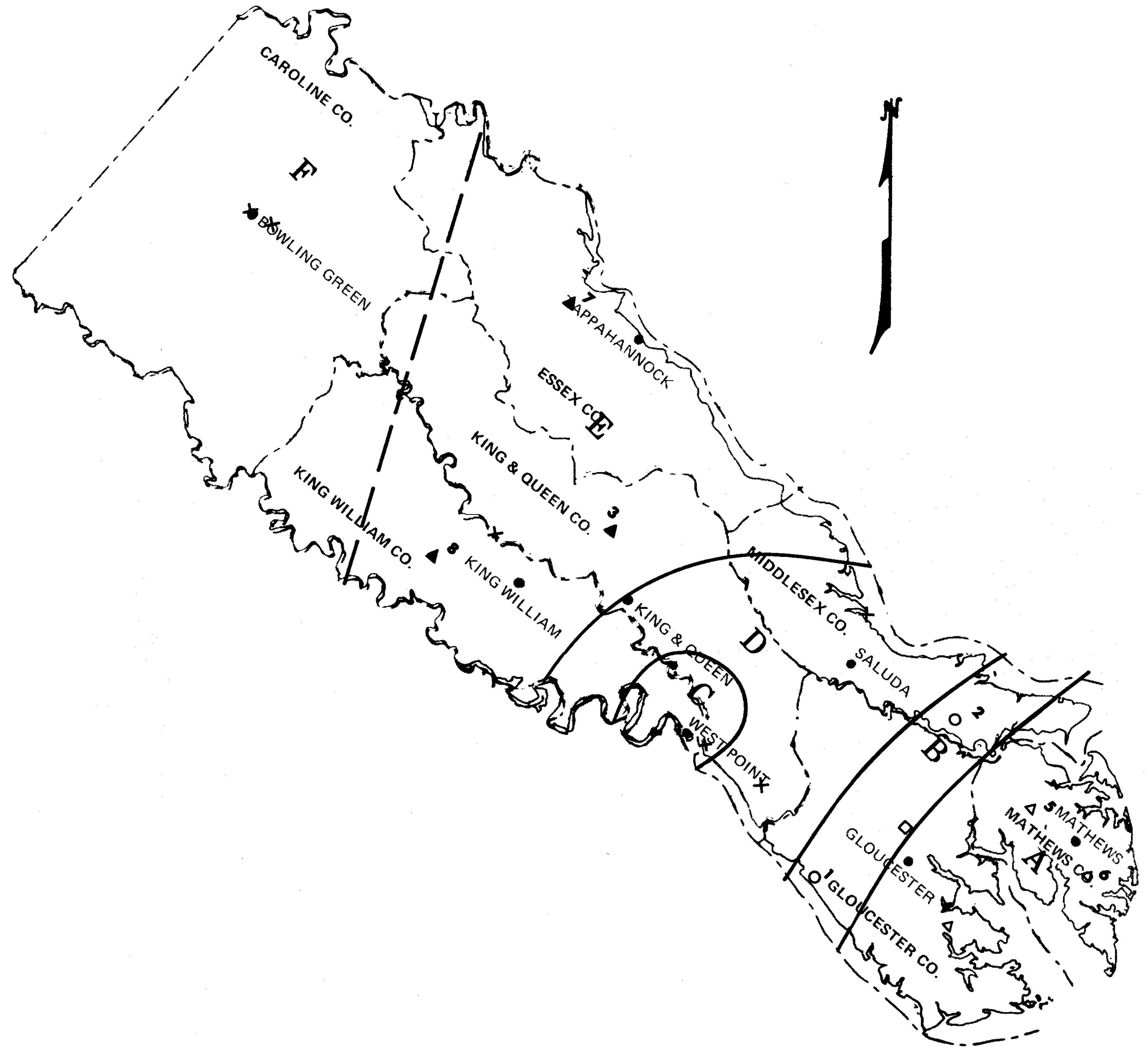
During this study, various groundwater resources of the Middle Peninsula were examined using existing wells as sampling or geologic control points. In the process of analyzing available data, it was discovered that several data control points, which could not be obtained from existing wells, were lacking. The need for groundwater research stations is outlined below for the three groundwater availability zones.

Zone A. The general capabilities of the Yorktown aquifer in Zone A are known but shallow research drilling is needed to determine the best areas within Zone A for further development. Currently, test drilling in the Gloucester Point area, in connection with a water supply study for the Gloucester Point Sanitary District is being conducted (The Ranney Company, 1976). Research stations further north in Zone A are needed to determine the most promising areas for further development. Three possible areas for research stations are shown by hole numbers 4, 5, and 6 in Plate 21. Exact station sites can be selected by conference with local drillers based on coarsest strata. Pump tests should be conducted at the most promising research station. Auger drilling should supplement research station data. A map delineating the most promising areas for groundwater development should be drawn as a result of this study.

Zone B. In Zone B, the boundary between high chloride groundwater (>250 ppm chloride), and lower chloride groundwater in the principal and upper artesian aquifers is encountered. Currently there is lack of historic chloride data from deep wells along the outer boundary of the chloride zone (see Chapter VI). Since there are no existing deep wells located north or south of Gloucester, two deep research stations to monitor chloride movement are recommended north and south of Gloucester (wells 1 and 2 in Plate 21). These two stations, the Town of Gloucester deep well and other deep or intermediate wells should be sampled on a quarterly basis in order to detect any movement of the high chloride zone toward the pumping centers. Continuous monitoring of chlorides in these areas will facilitate early detection of the high chloride zone.

Zone E. Since there is a lack of data on the capabilities of the lower part of the principal aquifer in Zone E (Plates 5 and 7), construction of three groundwater research stations down to the basement complex is recommended to establish the capabilities of the principal aquifer (Plate 21). The most favorable sites for further development in Zone E may be determined from the results of these stations.

MONITORING SYSTEM



Present Monitoring System

- X Existing Observation Wells
- □ Potable Water Supply Wells

Recommended Monitoring System

- ○ Chloride Monitoring in Principal Artesian Aquifer
- △ To Determine Capability of Yorktown Aquifer
- ▲ To Determine Capability of Principal Artesian Aquifer

SCALE 1:250,000

5 0 10 MILES

5 0 10 KILOMETERS

Source: Virginia State Water Control Board – TRO

PLATE NO. 21

Water Level Monitoring

More extensive areawide coverage is needed in the current water level monitoring network of the Middle Peninsula principal aquifer system to assess future water level decline problems. The recommended research stations, numbers 1, 2, 3, 7, and 8, can be used as part of the water level monitoring system for the principal aquifer in addition to their primary function (Plate 21). These stations will be located in control areas to determine water level declines associated with the current major water withdrawals at West Point and Urbanna.

In addition, the stations completed in the Yorktown aquifer, Zone A, may be used as an initial water level monitoring network for the Yorktown aquifer. Station number 4 may be located close to the planned groundwater withdrawal of Gloucester Point to monitor water level declines associated with this withdrawal. The other two stations may be located close to areas of projected growth so that water level declines may be observed from these areas of development.

Water Quality Monitoring

Collection of water quality background data should continue so that changes in quality may be detected. Although disposal site monitoring data in the Study Area is currently non-existent, future disposal site monitoring data is needed to protect the major aquifer and to provide a scientific criteria for disposal of wastes. Priority of study should be given to disposal sites containing the most hazardous wastes located in the hydrologically most susceptible areas (Plate 19).

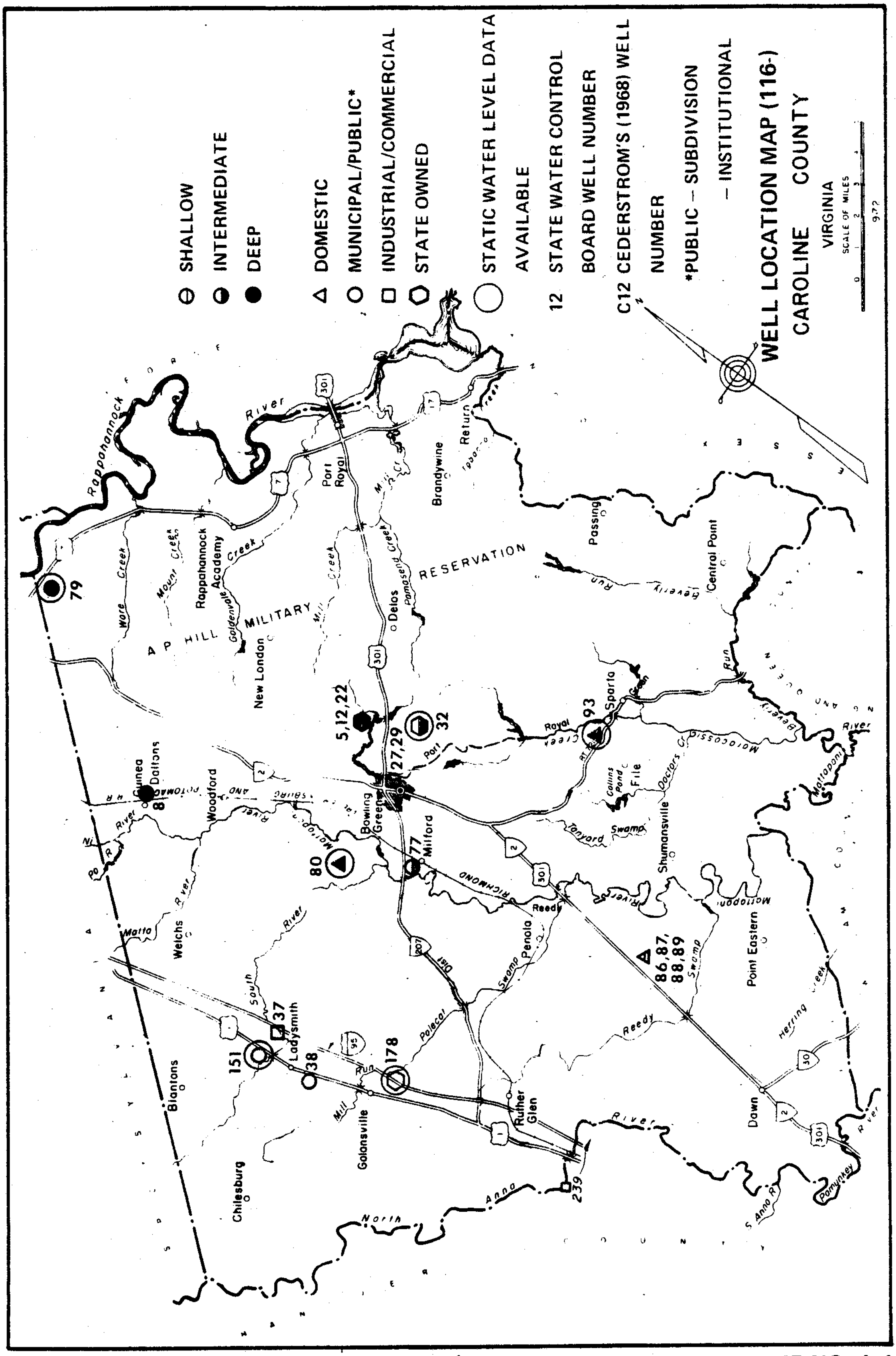
Existing data and data obtained from the proposed groundwater research stations may be used to construct a computer model to predict water level declines and to assess groundwater availability. A comprehensive and continuous program of data collection and research is necessary for model verification and update.

APPENDIX A

WELL AND AQUIFER CHARACTERISTICS

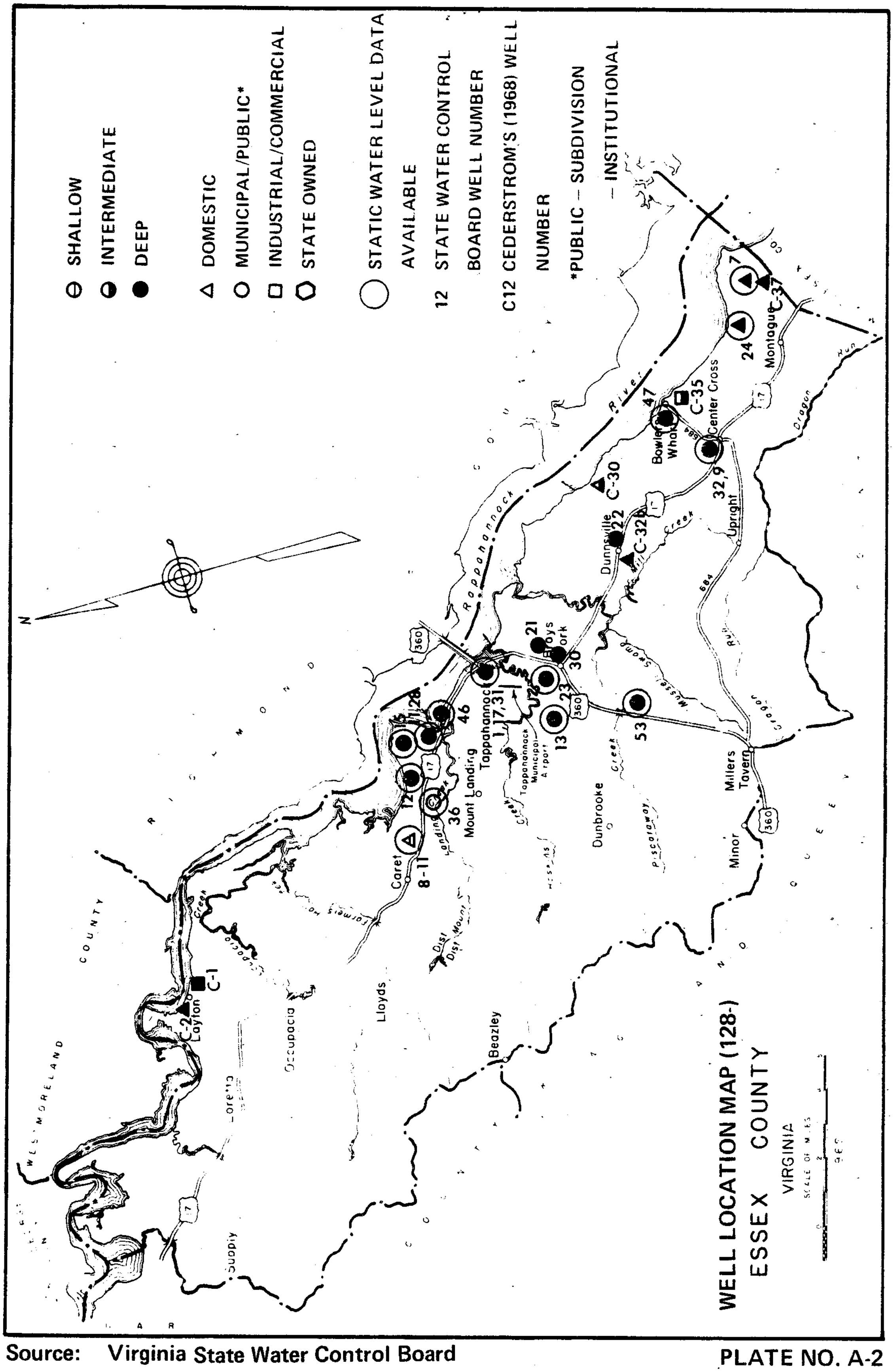
Well data was obtained from State Water Control Board files, Well Completion Reports, and personal communication with drillers. Corrected specific capacities were found, when possible, using the graphical approximation method in Johnson (1972). Transmissivities were estimated from specific capacity or corrected specific capacity data using the graphical method in Walton (1970).

Also included in Appendix A are county well location maps for wells used in this report. Numbers used are State Water Control Board numbers except where indicated otherwise. Well symbols indicates relative depth, well ownership, and whether static water level data is available as described in the legend.



Source: Virginia State Water Control Board

PLATE NO. A-1



Source: Virginia State Water Control Board

PLATE NO. A-2

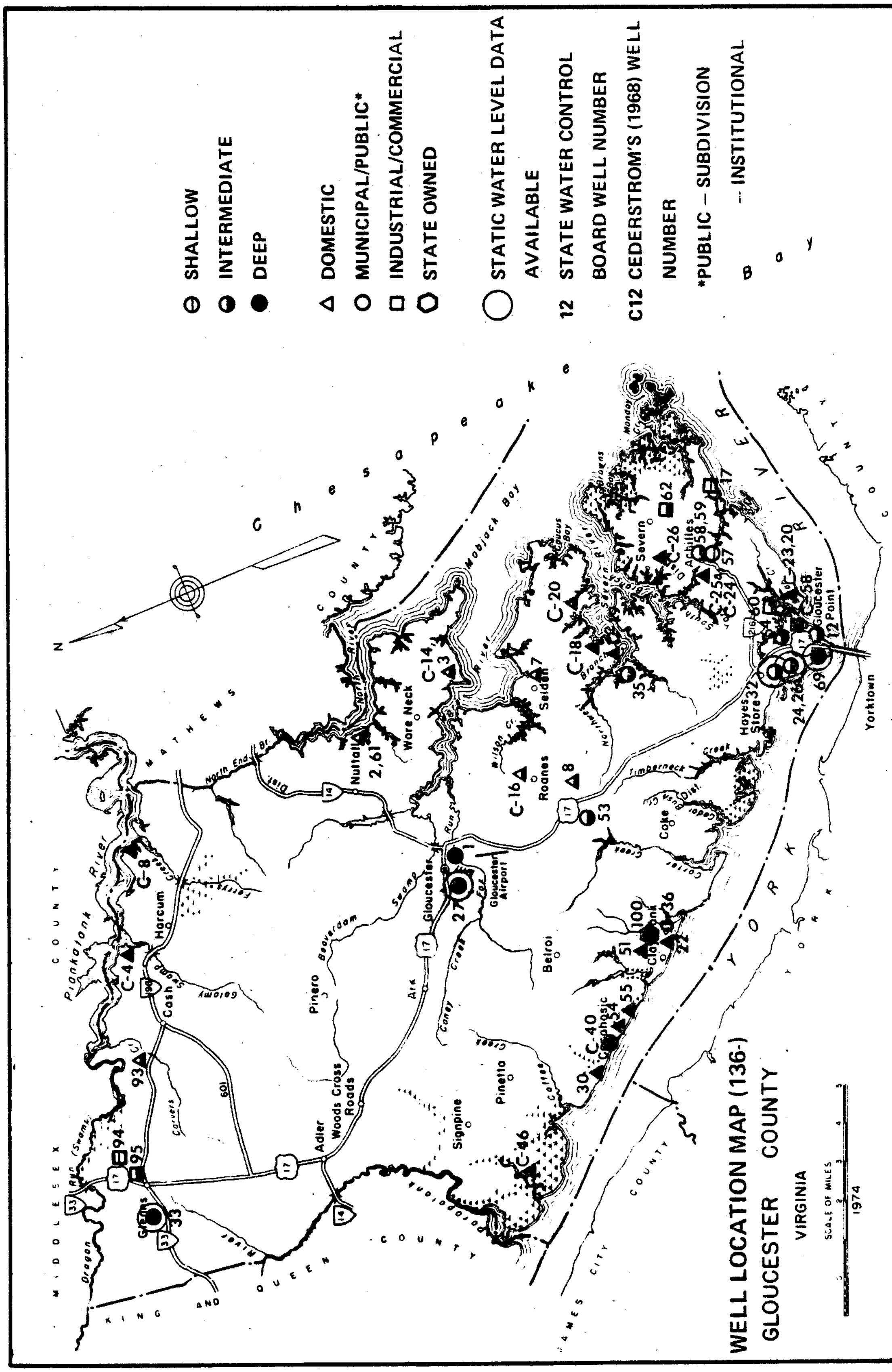
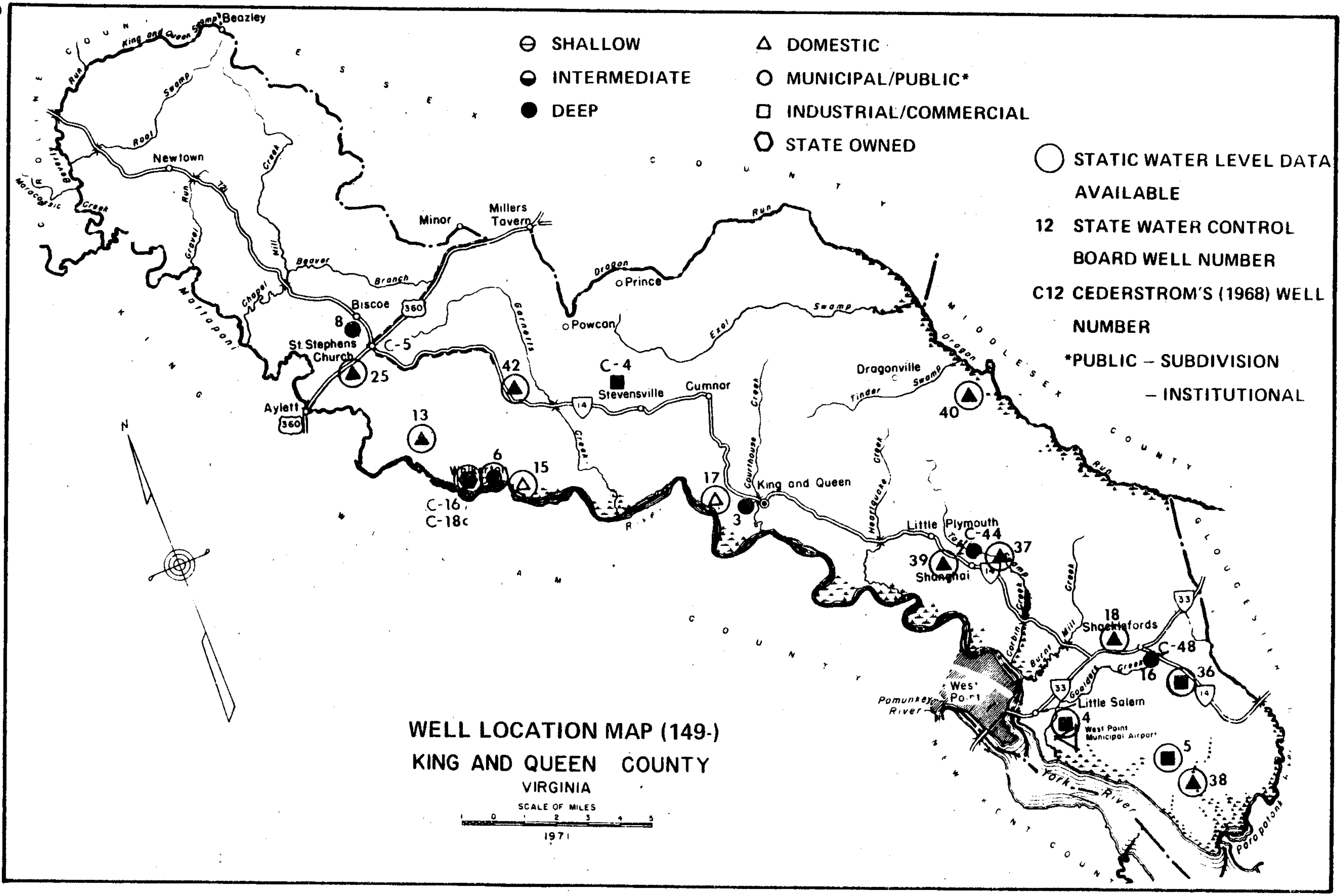

WELL LOCATION MAP (136-)
GLOUCESTER COUNTY
VIRGINIA
SCALE OF MILES
1974
SHALLOW
INTERMEDIATE
DEEP
DOMESTIC
MUNICIPAL/PUBLIC*
INDUSTRIAL/COMMERCIAL
STATE OWNED
STATIC WATER LEVEL DATA AVAILABLE
12 STATE WATER CONTROL BOARD WELL NUMBER
C12 CEDERSTROM'S (1968) WELL NUMBER
*PUBLIC – SUBDIVISION
– INSTITUTIONAL
Chesapeake Bay
MIDDLESEX COUNTY
MATHEWS COUNTY
KING AND QUEEN COUNTY
JAMES CITY COUNTY
YORK COUNTY
YORK RIVER
Piankatank River
Mobjack Bay
Gloucester
Gloucester Airport
Gloucester Point
Yorktown
Hayes Store
Adler
Woods Cross Roads
Signpine
Pinetta
Pinero
Belroi
Coke
Roanes
Seldon
Ware Neck
Nuttall
Harcum
Cash
Severn
Achilles
Ark

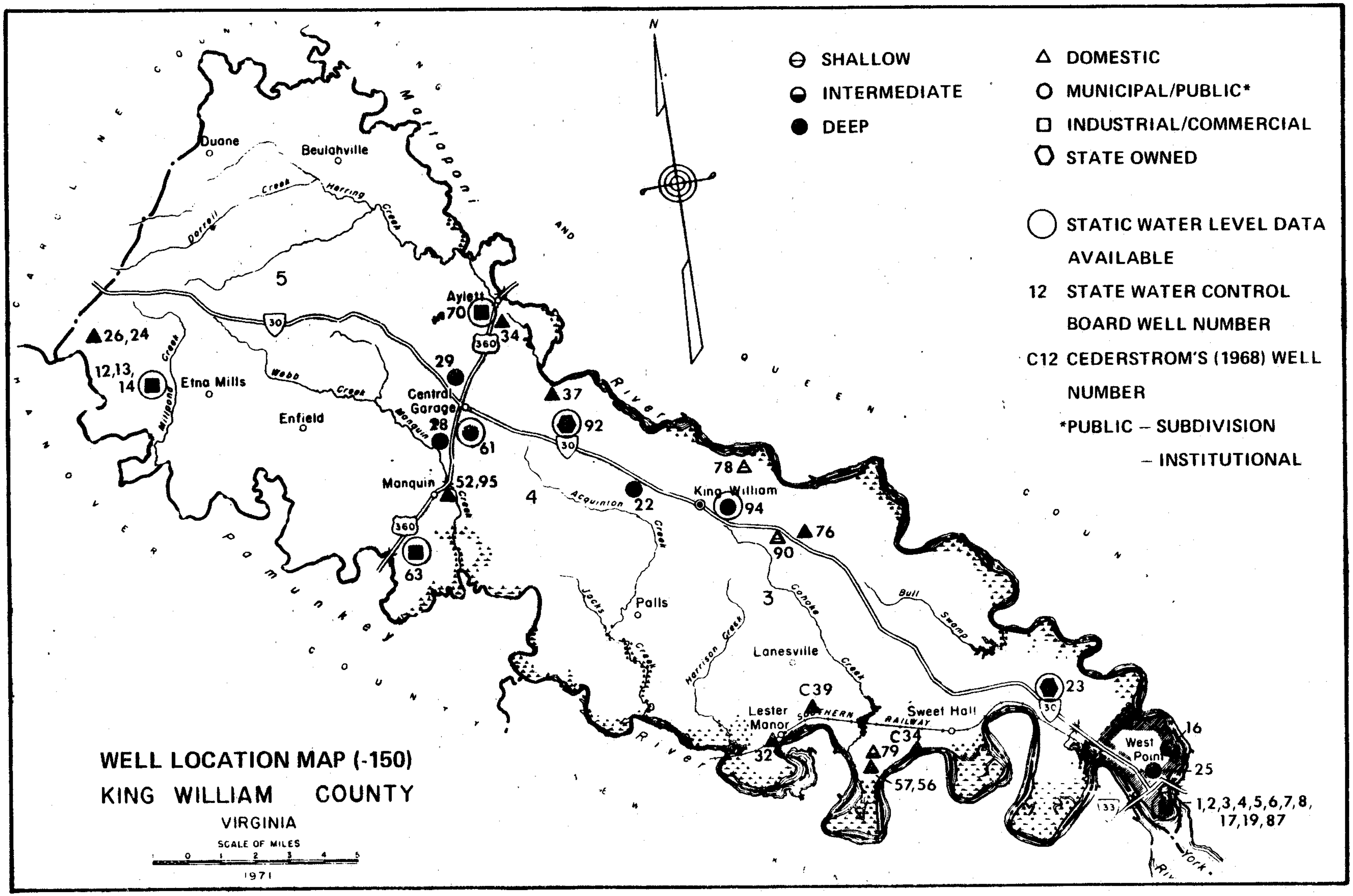
PLATE NO. A-3



WELL LOCATION MAP (149-)
KING AND QUEEN COUNTY
VIRGINIA

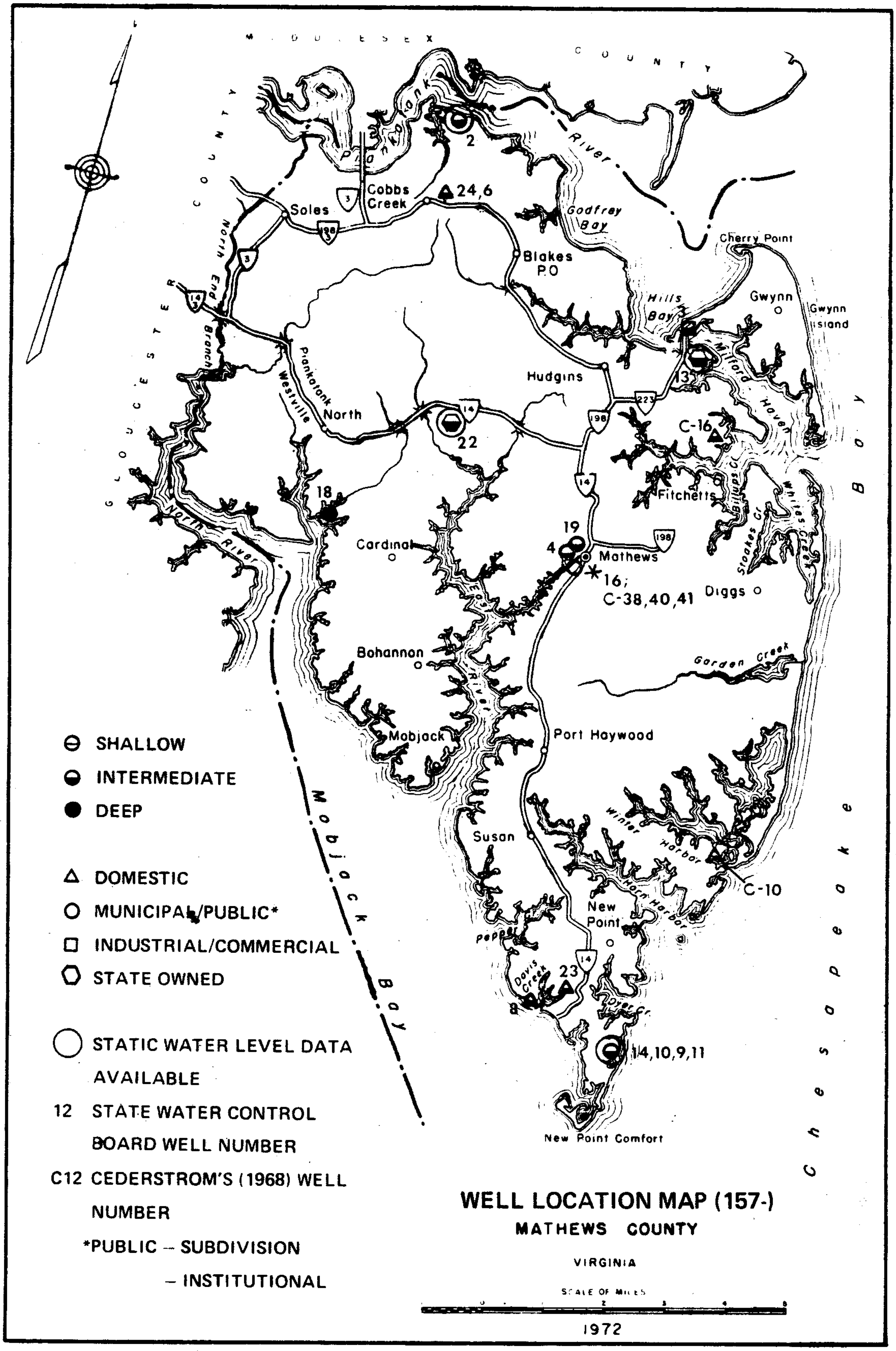
Source: Virginia State Water Control Board

PLATE NO. A-4



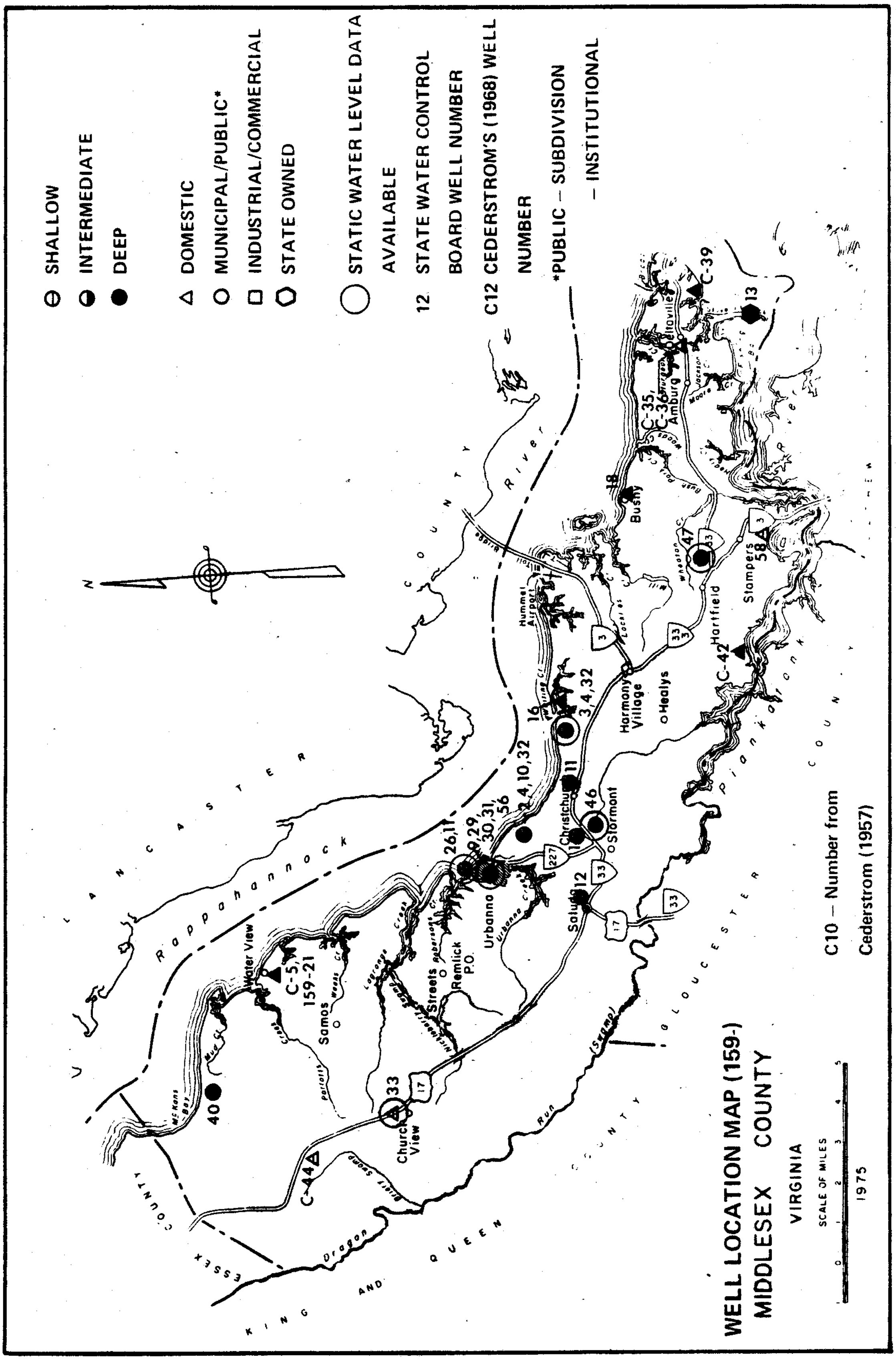
Source: Virginia State Water Control Board

PLATE NO. A-5



Source: Virginia State Water Control Board

PLATE NO. A-6



Source: Virginia State Water Control Board

PLATE NO. A-7

TABLE A-1

CAROLINE COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
12	Camp A. P. Hill Building 1501	492-507	Principal	6	76	50	1.54	3.08	120	6000
22	Camp A. P. Hill Ammunitions Storage Area	460-470 480-490	Principal	6	33	18	1.83	2.66	48	5500
29	Bowling Green Jail	376-396	Principal	4	25	30	.80	2.40	6	5000
77	Milford Sanitary District 2	267-292	Upper Artesian	3	80	67	1.19		24	5000

TABLE A-2

ESSEX COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
1	Town of Tappahannock	513-528	Principal	10	200	28	7.14 (10 hr)	17.8	10	45,000
3	Daw Theatre Cooperation Tappahannock	383-403	Principal	6	60	25	2.40 (4 hr)	7.2	41	15,000
5	William Ware Tappahannock	195-215	Upper Artesian	3	20	11	1.81 (24 hr)		24	3,000
6	W. C. Brooks Tappahannock	250-270	Upper Artesian	2	6	10	.60 (15 hr)		15	900
18	Riverdale Sub. Tappahannock	215-230 265-275	Upper Artesian	4	50	8	6.25		10	12,000
19	Riverdale Sub. Tappahannock	185-215	Upper Artesian	3	30	6	5.00		11	8,000
20	Wilson Acres Tappahannock	412-433	Principal	2	50	20	2.50	7.5	6	15,500
21	Marvin Clark Tappahannock	413-433	Principal	2	50	20	2.50	7.5	6	15,500
30	Clopton Brays Fork	417-437	Principal	6	100	51	1.96	5.88	2	10,500
32	Person Wells Project Centercross	480 +	Principal	4	10	3	3.33	9.99	25	21,000

TABLE A-3

GLOUCESTER COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
7	Chandler Bates Selden	129-140	Yorktown	4	5	107	.09		12	500
8	H. W. Baruch	115-125	Yorktown	5	21	22	.95		5	1000
10	Virginia Institute of Marine Science	64-74	Yorktown	6	2	31	.07		8	500
12	Virginia Institute of Marine Science	54-64	Yorktown	6	10	16	.53		17	600
20	Theodore Pratt Bena	395-420	Principal	5	48	107	.76	7.6	11	16,000
24	Gloucester Sanitary District #2, Gloucester Point	60-84	Pleistocene, Yorktown	6	6.4	64	.12		8	500
26	Gloucester Sanitary District #2, Gloucester Point	52-58 71-77 82-90	Pleistocene Yorktown	6	6	60	.17		24	500
27	Town of Gloucester	776-806	Principal	4	85	149	.57	5.7	4	10,000

TABLE A-3 (Continued)

GLOUCESTER COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
29	H. A. Gray Gloucester Point	46-56 89-99	Pleistocene Yorktown	5	6	64	.09		4	500
30	M. D. Nannally Capahosic	255-266	Upper Artesian	5	15	104	.14		8	500
32	Maurice Motley Gloucester Point	95-116 116-122	Yorktown	4	8	52	.15		4	500
33	Rappahannock College South of Saluda	496-506 538-548 582-592	Principal	4	140	9	15.55		9	37,000

TABLE A-4

KING AND QUEEN COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
4	Chesapeake Corp. Obs.	1233-1248	Principal	4	100	129	.95		24	1000
18-D	(Cederstrom) Taylor and Caldwell Cannery Walkerton	390 TD	Principal	10	253	129	1.8	9.0	unknown	20,000

TABLE A-5

KING WILLIAM COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
1	Chesapeake Corp.	zones within 1051-1277	Principal	8	708	155	6.00	18	24	29,000
2	Chesapeake Corp.	zones within 340-705	Principal	10	1800	71	25.35		24	45,000
4	Chesapeake Corp.	zones from 350-750	Principal	8	1496	247	8.08		10	19,000
5	Chespeake Corp.	zones within 316-701	Principal	10	1800	46	39.13		24	80,000
6	Chesapeake Corp. 23rd Street	zones from 204-628	Upper Artesian Principal	8	600	160	4.61		8	7,500
11	Chesapeake Corp.	141-163	Upper Artesian	8	275	57	7.63		unknown	15,000
12	Bleak Hill Farms Etna Mills	288-305	Upper Artesian	6	12	190	.18		6	500
13	Bleak Hill Farms Etna Mills	183-200	Upper Artesian	6	34	156	.35		16	500

TABLE A-5 (Continued)

KING WILLIAM COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
17	Chesapeake Corp.	139-164	Upper Artesian	8	352	69	6.14		unknown	15,000
19	Chesapeake Corp. Plant Observation Well	within 400-851	Principal	4	82	112	2.48	4.88	6	
23	Virginia State Police West Point	417-437	Principal	4	25	40	.62	6.2	7	15,000
24	W. T. Smithdeal Hanover Courthouse	106-116	Upper Artesian	6	25	80	.62		12	500
28	Marle Hill Sub.	246-266 358-378	Upper Artesian Principal	6	100	24	4.16	12.48	24	26,000
29	Venter Heights Subdivision Central Garage	250-260 388-408	Upper Artesian Principal	6	150	42	3.57	10.71	24	24,000
34	(Cederstrom, 1957) Cahoke	575 + D	Principal	6	18	7	2.5	4.5	unknown	9,000
38	(Cederstrom, 1975) Lester Manor	538	Principal	3	40	7	5.8	12.4	unknown	26,000

TABLE A-6

MATHEWS COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
6	Joseph G. Mullin Cobbs Creek	106-115	Yorktown	4	22	104	.29		unknown	900
9	U.S. Army New Point Comfort	142-158	Yorktown	6	25	85	.30		9	900
10	U.S. Army New Point Comfort	148-169	Yorktown	6	30	72	.48		20	900
11	U.S. Army New Point Comfort	149-159	Yorktown	6	26	81	.33		15	900
13	U.S. Coast Guard	105-125	Yorktown	6	200	49	4.08		2	5,000

TABLE A-7

MIDDLESEX COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
2	Barnhardt Farms Ins. #1	472-494 508-515 584-594	Principal	10	857	112	7.65	12.4	7	26,000
4	Barnhardt Farms #2A	514-529 533-543 549-559 592-603 678-693 703-708	Principal	8	1100	50	22	36.0	18	80,000
10	Barnhardt Farms #3	460-480 572-582 606-616 623-648	Principal	8	752	60	12.5	20.80	8	48,000
32	Barnhardt Farms #4	screen in 507-725	Principal	8	1200	26	46.15	76.9	24	110,000
9	Town of Urbanna	470-485 562-567 575-595	Principal	6	430	70	14.33	23.9	24	50,000
11	Christchurch School	562-567 619-624 683-733	Principal	4	162	22	7.37	12.3	24	26,000

TABLE A-7 (Continued)

MIDDLESEX COUNTY

SWCB Number	Owner	Screen Depth	Aquifer	Diameter (in.)	Test Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft)	Corrected Specific Capacity (gpm/ft)	Duration of Pump Tests (hr.)	Approximate Transmissivity (gpm/ft)
18	Ed Anderson Bushy Park Farm	79-99	Yorktown	4	9	28	32		6	900
13	Stove Point	432-452 628-650	Principal	20	10	17	1.2	12.0	9	24,000

APPENDIX B

GROUNDWATER QUALITY DATA

Table B-1 contains chemical quality data on the groundwater in the Middle Peninsula. Well numbers in Table B-1 can be cross-referenced to Appendix A and Plate 13 to determine the location from which quality samples were taken. The data listed in Appendix B include:

State Water Control Board Number
Owner and/or Location of the Well
Date Sampled
Depth of Well
Screen Depths in well
Number (DWR No.)
The date the water sample was taken
The following chemical constituents in milligrams per liter (mg/l):

- Iron (Fe)
- Calcium (Ca)
- Magnesium (Mg)
- Copper (Cu)
- Lead (Pb)
- Manganese (Mn)
- Sodium (Na)
- Potasium (K)
- Bicarbonate (HCO_3)
- Alkalinity
- Sulfate (SO_4)
- Fluoride (F)
- Chloride (Cl)
- Nitrate (NO_3)
- Total Hardness
- Ca, Mg Hardness
- Total Solids
- Volatile/Fixed Solids
- Dissolved Solids
- Specific Conductivity
- pH
- TOC
- Silica (SiO_2)

The data in Appendix B is a composite listing of water samples taken by the State Water Control Board and by other governmental agencies.

TABLE B-1

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Cu	SiO_2	Fe	Metals							Specific Conductance
																								Pb	Mg	Mn	Hg	Zn	Na	K	
ESSEX COUNTY																															
128 - 1	Town of Tappahannock	2/9/76	1030	8.4	-	573	513-528	-	202	285	2	8	-	285	147/138	14.7	-	.05	1.38	5	-	-	-	-	-	-	-	-	-	-	-
1		11/68	-	-	-	573	513-528	244	-	255	1.7	1	-	-	-	15	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-
1		6/30/50	-	8.3	-	573	513-528	221	-	-	1.9	18	-	277	-	12.8	-	.2	1.8	-	5.9	-	20	-	9	-	-	-	-	-	-
7	John Evans	11/24/75	1530	7.7	-	252	-	-	142	225	4	80	-	225	172/53	8.5	-	.07	.52	4	22	-	3	-	8.9	.01-	-	-	19	10.6	-
9	Centercross School	11/24/75	1400	7.6	-	340	280-340	-	138	225	2	62	-	225	170/55	7.8	-	.05	.5	5	15	-	.1	-	6.3	.01-	-	-	25	9.8	-
12	J. C. Hayden (Rappahannock Beach)	11/24/75	1400	7.6	-	460	420-435	-	194	280	2	4	-	280	196/84	13.4	-	.05-	1.5	4	1	-	.1-	-	.3	.01-	-	-	96	2.7	-
17	Town of Tappahannock	9/16/75	1440	7.5	-	542	522-537	-	191	250	1	8	-	260	175/85	10.8	.01	.05-	1.3	5	1	-	.1	-	.4	.01-	-	-	98	2.7	-
17		10/10/74	-	8.6	-	542	522-537	-	187	148	2	1	-	252	186/66	12.9	.01-	.03	1.4	-	.15	-	.1	-	.11	.04	-	-	95	3.2	-
17		3/7/72	-	8.5	-	542	522-537	-	187	312	.5-	1	-	-	-	13.5	-	.22	1.35	-	-	-	.01-	-	.2-	.01-	-	-	105	3.75	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCE Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals Pb	Metals Mg	Metals Mn	Metals Hg	Metals Zn	Metals Na	Metals K	Specific Conductance
ESSEX COUNTY continued																															
[illegible]8- 18	Riverdale Subdivision	6/6/63	-	8.3	-	385	no screens water zones 215-230 265-275	248	-	-	4	[illegible]	-	299	-	7.4	-	-	1.0	-	8.9	-	0.0	-	1.7	-	-	-	92.9		-
19		1/11/75	-	7.9	-	215	no screens water zone 185-215	-	67	348	1.0	13	-	354	247/107	10.5	.01-	.35	1.7	-	1.0	-	.01-	-	.39	.02	-	-	220	4.[illegible]	-
21	Whispering Pines	1/4/73	-	8.6	-	433	413-433	-	228	-	.5	4	-	-	-	-	.02	.22	1.5	-	.45	-	.11	-	.23	.01	-	-	103	5.25	410
21		3/23/72	-	8.7	-	433	413-433	-	229		-	8	-	-	-	-	-	-	-	-	-	-	.55	-	-	.025	-	-	-	-	-
[illegible]1		1/19/[illegible]	-	8.5	8.4	433	413-433	-	230	443	1.5	3	-	-	-	15.5	-	.04	1.45	-	-	-	2.04	-	.10	.03	-	-	105	4.20	-
[illegible]2	Point Breeze Subdivision	10/[illegible]/74	-	8.7	-	580	-	-	335	390	1.5	8.7	-	392	310/82	6.6	.01-	.27	2.4	-	2.1	-	.14	-	.69	.04	-	-	148	7.0	-
23	Tidewater Memorial Hospital (Tappahannock)	11/24/75	1130	7.9	-	672	550-580	-	211	297	4	2	-	297	224/73	16.6	-	.07	1.5	5	1	-	.1-	-	[illegible]	.01-	-	-	97	2.4	-
23		3/19/64	-	8.7	-	672	550-580	290	-	-	1.5	11	-	309	-	8.9	-	0.0	1.4	-	3.8	-	.75	-	.2	-	-	-	119.7		

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Mg	Mn	Hg	Zn	Na	K	Specific Conductance
ESSEX COUNTY continued																															
128-24	Mark Haven Beach Supply	11/24/75	1500	8.1	-	350	-	-	322	404	3	4	-	404	348/56	7.2	.05	.04	2.6	5	2	-	.6	-	.5	.01	-	-	145	3.8	-
25	Mark Haven Beach Supply	7/1/65	-	8.4	-	450	-	418	-	-	1	-	-	-	-	2.8	-	.5	2.7	-	-	-	.8	-	-	-	-	-	-	-	-
26	Gwynnfield Subdivision #2	1/4/74	-	8.4	-	554	528-548	-	218	288	.75	3	-	295	158/137	7.0	.03	.13	2.1	-	.25	-	.1	-	.18	.01	-	-	100	-	-
26		1/20/66	-	7.8	-	554	528-548	249	-	-	0.0	12	-	258	-	1.2	-	.2	-	-	3.8	20.6	.34	-	.5	-	-	-	-	-	-
28	Maryfield Subdivision	3/21/69	-	8.8	9	422	395-415	-	305	-	10.0	7	-	-	-	-	-	.9	1.3	-	.8	-	.48	-	-	.03	-	-	-	-	-
46	Danger Field Subdivision	11/24/75	1330	7.8	-	438	379-389, 410-430	-	268	354	2	6	-	354	264/90	12.0	-	.10	1.75	6	2	-	.1-	-	.5	.01-	-	-	125	4.1	-
47	Bowlers Wharf	10/10/74	-	8.2	-	250	210-250	-	138	206	2.5	57.8	-	208	163/45	8.3	.03-	.35	.57	-	14.4	-	.07	-	5.2	.03	-	-	39.5	10.7	-
53	Arch Liles (Shadyside Trailer Park)	11/24/75	-	7.7	-	400	390-400	-	253	317	2	10	-	317	230/87	6.2	-	.05-	1.8	5	5	-	.1-	-	1.3	.01-	-	-	107	7.1	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Mg	Mn	Hg	Zn	Na	K	Specific Conductance
ESSEX COUNTY continued																															
128-C-1	Chesapeake Corp. (Layton)	11/68	-	-	-	250	-	428	-	412	2.7	18	-	-	-	16	-	-	1.5	-	-	-	.03	-	-	-	-	-	-	-	-
C-2	J. H. Allen (Layton)	11/68	-	-	-	375	-	362	-	364	2.1	5	-	-	-	13	-	-	1.6	-	-	-	-	-	-	-	-	-	93		-
C-30	Wares Wharf	7/18	-	-	-	180	-	302	-	319	3.3	67	-	-	-	11	-	.48	-	-	25	38	.07	-	-	1.1	-	-	-	-	-
C-32b	Dunnsville	2/41	-	-	-	390	-	198	-	-	2	32	-	-	-	8	-	.6	.6	-	-	-	-	-	-	-	-	-	-	-	-
C-35	Claybrook and Neal Packing Co.	2/41	-	-	-	165	-	186	-	-	2	72	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-37	Butylo	11/68	-	-	-	330	-	172	-	188	3.6	92	-	-	-	11	-	-	.7	-	-	-	-	-	-	-	-	-	-	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolived Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals							Specific Conductance
																								Pb	Mg	Mn	Hg	Zn	Na	K	
GLOUCESTER COUNTY																															
136-1	Gloucester, Town of	2/19/75	1100	7.9	-	702	-	-	690	1374	272	18	-	1374	1276 / 98	65	-	-	1.8	10	5	-	.1-	-	1.8	.01	-	-	510	9.9	334
1		9/15/58	-	7.9	-	702	-	872	-	-	303.7	-	-	1336	-	-	-		2.2	-	-	-	2.0	-	-	-	-	-	-	-	
2	Webster Rhoades, Sr.	7/28/69	-	7.6	-	120	97-104	136	-	-	13	169	-	191	-	27	-	8.8	-	-	51.0	7.1	.1	-	3.3	-	-	-	6.0	2.0	
61	Webster Rhoades, III	2/25/75	-	-	-	100	80-95	-	-	-	8	146	-	238	216 / 22	-	-	-	-	-		-	-	-	-	-	-	-	-	-	360
3	Schley	7/8/69	-	7.9	-	150	83-87	266	-	-	109	-	-	448	-	15	-	-	-	-	0.0	-	-	-	0.2	-	-	-	166	0.4	781
C-14	Schley	9/50	-	-	-	85	-	236	-	435	18	206	-	-		6	-	.1	.1	-	-	-		-	-	-	-	-	-	-	
7	Chandler Bates	6/27/69	-	7.6	-	150	130-140	422	-	-	20	-	-	-	-	48	-	-	.1	-	145	-	-	-	5.5	-	-	-	21	2.0	819
8	White Marsh	7/8/69	-	7.5	-	130	115-125	240	-	-	4.4	-	-	258	*	8.6	-	-	-		62	-	-	-	4.1	-	-	-	20	6.2	390
10	VIMS	2/25/75	-	-	-	90	64-74	-	-	-	29	268	-	450	374 / 78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	580
10		6/27/69	-	7.8	-	90	64-74	120	-	-	13	-	-	158	-	12	-	-	.1		37	-	-	-	1.2	-	-	-	15	0.4	279

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
GLOUCESTER COUNTY continued																															
136-11	VIMS	2/25/75	-	-	-	112	81-110	-	-	-	15	144	-	174	72/102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	240
11		1/27/69	-	7.7	-	112	81-110	115	-	-	16	-	-	155	-	13		-	.1	-	35	-	-	-	1.0	-	-	-	17	1.2	285
12	VIMS	2/25/75	1025	-	-	90	54-64	-	-	-	50	148	-	276	145/131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	440
12		7/8/69	-	7.4	-	-	-	140	-	-	13	-	-	201	-	35	-	-	-	-	59	-	-		2.2	-	-	-	6.9	2.3	201
16/17	York River Seafood*	2/25/75	-	-	-	550/80	?	-	-	-	1810	520	-	3045	2570/475	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,000
19	Theodore Pratt	7/17/75	-	7.5	-	76	60-72	-	118	259	44	84	-	261	209/52	11.9	.01-	.08	.14	4	44	-	1.5	-	3.2	.2	-	-	33	2.0	-
19		2/19/75	-	-	-	76	60-72	-	-	-	47	118	-	239	197/42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	480
19		7/28/69	-	7.8	-	76	60-72	137	-	-	45	132	-	236	-	13	-	.1	.1	-	44	-	-		3.0	-	-	-	32	2.8	396
20	Theodore Pratt	2/19/75	-	-	-	440	395-420	-	-	-	870	116	-	2823	2696/127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,700

*York River Seafood owned two wells; one well was 550 and the other 80 feet (I was told the one sampled was 80 feet and yet the data seems to indicate otherwise that the 550 feet well was abandoned.)

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

GLOUCESTER COUNTY
continued

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Mg	Mn	Hg	Zn	[illegible]		Specific Conductance
136-20	Theodore Pratt	12/21/72	-	8.2	-	440	395-420	786	-	-	1100	100	-	2900	-	105	-	4.2	1.2	-	17	20	.12	-	15	-	-	-	1000	41	4,780
20		7/8/69	-	7.7	-	440	395-420	786	-	-	1100	113	-	2876	-	179	-	-	-	-	41	-	-	-	2.7	-	-	-	1060	68	5,050
22		2/19/75	-	-	-	440	410-440	-	-	-	420	26	-	1282	1178/104	-	-	-	-	-	-	-	-	-		-	-	-	-	-	2,200
24	Gloucester Point Sanitary District #1	7/14/75	1120	7.8	-	130	60-84	-	191	290	54	74	-	300	242/58	2.6	.02	.09	.14	6	35		.1	-	6.5	.01	-	-	52	5.2	-
24		6/25/75	1120	7.4	-	130	60-84	-	85	184	15	58	-	200	153/47	7.9	-	-	.15	2	25	-	.1-	-	3.7	.01-	-	-	24	2.5	-
24		2/19/75	1030	7.0	-	130	60-84	-	83	121	10	82	-	121	72/49	9.9	-	-	.1-	3	35	-	.1-	-	3.4	.01-	-	-	12.7	-	-
24		8/31/71	-	8.0	-	130	60-84	-	84	-	-	-	-	-	-	-	-	-	-	-	-	-	.1-	-	-	.01-	-	-	-	-	-
24		1/18/68	-	7.7	-	130	60-84	137	-	-	15	100	-	154	-	3.3		.3	.1	-	32	2.0	.05	-	3.9	-	-	-	18.7		-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: [illegible]	Metals:	Specific Conductance
GLOUCESTER COUNTY continued																															
136-26	Gloucester Point Sanitary Dist. #2	8/20/75	1010	7.4	-	140	52-58 71-77 82-90 99-105	-	85	160	11	74	-	160	124/36	17.4	-	-	.15	3	28	-	.1-	-	3.2	.01-	-	-	15	2.3	-
26		4/4/72	-	8.2	-	140	52-58 71-77 82-90 99-105	-	105	-	12	129	-	-	--	-	-	-	.1-	-	-	-	.2	-	.24	.06	-	-	9	-	-
26		8/31/71	-	8.1	-	140	52-58 71-77 82-90 99-105	-	111	-	-	-		-	-	-	-	-	-	-	-	-	.06	-	-	.01	-	-	-	-	-
26		2/12/68	-	7.9	-	140	52-58 71-77 82-90 99-105	110	-	-	15	86	-	137	-	4.1	-	.3	.1	-	27	1.5	.05	-	3.1	-	-	-	16.1		-
27		11/18/75	-	8.1	9.0	807	776-804	-	648	1368	325	24	-	1390	1254/136	61.8	-	.05-	2.2	18	5	-	.1-	-	1.8	.01	-	-	390	9.7	-
27		8/20/75	-	8.3	-	807	776-804	-	563	1339	329	20	-	1351	1261/90	79.4		-	.1-	10	5	-	.1	-	1.6	.01-	-	-	450	10.4	-

TABLE C-1 (Continued)

Ground Water Quality Data Printout for Middle Peninsula Report - Appendix

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
GLOUCESTER COUNTY continued																															
136-27		6/26/75	-	8.1	-	807	776-804	-	561	1309	350	52	-	1323	1229/94	53.6	-	-	2.1	15	4	-	.1-	-	1.6	.01	-	-	440	10.8	-
27		2/19/75	-	8.1	-	807	776-804	-	563	1339	335	18	-	1339	1252/87	57.0	-	-	1.9	8	5	-	.1-	-	1.9	.01	-	-	310	-	-
33	Rappahannock Community College	12/13/74	-	8.4	-	708	500-630	-	393	490	7.5	5.3	-	490	386/104	24.2	.03-	.27	2.2	-	2.4	-	-	-	.30	.02	-	-	193	6.25	759
33		11/30/70	-	8.6	-	708	500-630	-	410	637	-	7.0	-	-	-	26.0	-	.04	2.6	-	1.6	-	1.62	-	-	.01	-	-	-	-	-
35	Sea Breeze Mobile Home Park (Clay Bank)	2/25/75	-	-	-	90	80-90	-	323	-	26	130	-	323	218/105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	490
51	Walter Norfolk	2/19/75	-	-	-	450	-	-	-	-	320	20	-	1297	1216/81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,200
53	Gloucester High School	2/19/75	-	-	-	90	-	-	-	-	40	230	-	317	267/50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	570
54	Moton Conference Center	11/18/85	1040	8.3	-	250*	-	-	320	1063	395	18	-	1087	972/115	44	-	.05-	2	11	3	-	.5	-	1.0	.02	-	-	250	8.5	-

*This well appears to be deeper than claimed depth.

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals:	Specific Conductance
GLOUCESTER COUNTY continued																															
136-54	Moton Conference Center	9/19/75	1000	7.6	8.5	250	-	-	317	808	400	72	-	810	786/24	31.6	.01-	.05-	2.1	7	3	-	.6	-	1.4	.01	-	-	460	10.9	-
54		7/17/75	1200	8.3	8.7	250	-	-	333	1107	370	1-	-	1190	892/217	45.8	.01-	.15	2.2	6	4	-	1.1	-	1.4	.2	-	-	490	9.0	-
54		2/19/75	1130	8.0	-	250	-	-	337	1056	365	22	-	1056	979/77	42.4	-	-	1.8	8	4	-	.5	-	1.5	.02	-	-	310	8.7	-
55	B. M. Bunting Oyster House	2/19/75	-	-	-	258	-	-	-		59	36	-	790	719/71		-	-	-	-	-	-		-	-	-	-	-	-	-	1,300
56	VIMS	2/25/75	1030	-	-	11	-	-	-	-	40	154	-	320	184/136	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	460
57	Achilles Elementary School	2/25/75	1310	-	-	45	-	-	-	-	159	126	-	818	683/135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,290
58	Achilles Elementary School	2/25/75	1300	-	-	85	-	-	-	-	240	264	-	1079	906/173	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,750
59	Achilles Elementary School	2/25/75	1305	-	-	58	-	-	-	-	141	228	-	773	616/157	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,300

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
GLOUCESTER COUNTY continued																															
136-60	Cook's Oyster House	6/19/75	1030	7.4	-	90	-	-	384	748	161	200	-	768	622 / 146	3.5	.01-	.05-	.17	21	55	-	6.8	-	20	.27	-	-	200	17.4	-
60		2/15/75	1120	-	-	90	-	-	-	-	167	210	-	707	511 / 196	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,300
62	V. A. Haywood Seafood	6/19/75	1140	7.4	-	96	-	-	373	745	175	312	-	755	571 / 184	3.7	.01-	.05-	.1	19	62	-	.9	-	35	29	-	-	150	30.0	-
62		2/25/75	1150	-	-	96	-	-	-	-	184	304	-	782	601 / 181	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,300
63	W. C. Haywood Seafood	6/19/75	1150	7.4	-	96	-	-	371	822	250	280		830	717 / 113	3.4	.01-	.05-	.1-	17	73	-	2.4	-	27	.23	-	-	160	18.7	-
63		2/25/75	1200	-	-	-	-	-	-	-	229	286	-	793	594 / 199	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,500
64	Gloucester Point Sanitary District #3	7/14/75	1105	7.7	-	88	78-88	-	349	655	144	120	-	667	584 / 83	.5-	.01-	.05-	.19	7	33	-	1.0	-	25	.06	-	-	140	21.0	-
64		8/31/71	-	7.8	-	-	-	-	294	-	-	-	-	-	-	-	-	-	-	-	-	-	.06	-	-	.01	-	-	-	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolived Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: [illegible]	Metals: [illegible]	Metals:	Specific Conductance
GLOUCESTER COUNTY continued																															
136-65	Gloucester Point Sanitation District #4	7/14/75	1045	7.7	-	99	89-99	-	314	508	74	150	-	512	364/148	.5-	.01-	.05-	.1	10	25	..	.5	-	14	.04	-	-	100	15.0	780
65		2/19/75	-	-	-	99	89-99	.-	-	-	69	226	-	521	419/102		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66	Gloucester Point Sanitation District #5	7/14/75	1050	7.8	-	95	84-92	-	237	388	71	82	-	396	295/101	.5-	.01-	.05-	.17	8	40	-	1.4	-	21	.27	-	-	100	26	-
66		5/2/74	-	7.9	-	95	84-92	-	223	370	62	110	-	376	327/49	4.3	.01	.04	.21	-	20.2	-	.40	-	14.5	.05	-	-	90	18.8	591
66		3/19/74	-	7.9	-	95	84-92	-	155	248	25	110	-	250	210/40	2.3	.01-	.04	.13	-	23.8		.23	-	12.0	.15	-	-	26	13.	
67	Gloucester Point Sanitation District #6	7/14/75	1130	7.9	-	80	55-60	-	95	132	10	56		133	119/14	2.9	.01-	.05-	.12	4	28.0	-	.1-	-	3.4	.01-	-	-	13.6	2.3	-
67		8/74	-	8.4	-	80	55-60	-	87	131	10	78	-	131	91/40	-	.01-	.04	.13	-	26.8		.2	-	2.5	.01-	-	-	112	2.95	170
67		6/74	-	9.1	-	80	55-60	-	102	155	8	89	-	163	135/28	-	.01	.04	.15	-	36.2	-	.83	-	2.13	.02	-	-	11.3	2.6	185

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
GLOUCESTER COUNTY continued																															
136-67	Gloucester Point Sanitation District #6 (Test Well)	3/18/74	-	7.9	-	80	55-60	-	233	301	62	113	-	413	348/65	3.2	.01-	.04	.23	-	26.5	-	.80	-	13.6	.06	-	-	70	19.7	617
76	Cook's Cold Storage	6/19/75	1040	7.4	-	90	-	-	331	886	300	300	-	890	765/125	2.8	.01-	.05	.11	11	150	-	7.0	-	48.0	.44	-	-	160	18.0	-
76		2/25/75	1125	-	-	90	-	-	-	-	270	278	-	871	709/162	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,500
77	V. A. Haywood Ice Machin[illegible]	6/19/75	1200	7.6	-	96	-	-	431	823	240	230	-	899	775/124	4.3	.01-	.05-	.14	8	51	-	2.9	-	29.0	.13	-	-	180	23.0	-
93	H. M. Mason	12/16/75	1200	5.6	-	55	-	-	5	67	12	32	-	71	-	17.6	-	4.1	.1-	4	6	-	.1	-	2.9	.2	-	-	7	3.3	-
94	Rappahannock Lumber Company	12/16/75	1110	6.9	-	20	-	-	95	124	4	104	-	130	-	14.6	-	.17	.13	6	40	-	.2	-	1.6	.4	-	-	4	3.0	-
95	Glenns Amoco	12/16/75	1145	7.2	-	112	-	-	129	213	7	166	-	221	-	30.6	-	.05-	.1-	4	65	-	.2	-	1.6	.1	-	-	3	.9	-
C-4	Freeport	2/41	-	-	-	330	-	717	-	-	36	21	-	-	-	1.0	-	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Mg	Mn	Hg	Zn	Na	K	Specific Conductance
GLOUCESTER COUNTY continued																															
136-C-4	Freeport	11/68	-	-	-	330	-	708	-	733	29	13	-	-	-	8.2	-	-	3.9	-		-	-	-	-	-	-	-	-	-	-
C-16	Roanes	8/50	-	-	-	120	-	244	-	399	3	166	-	-		1.0	-	.6	.7	-	-	-	-	-	-	-	-	-	-	-	-
C-18	Naxera	1906	-	-	-	981	-	682	-	-	1090	33	-	-	-	100	-	-	-	-	-	-	2.5	-	-	-	-	-	-	-	-
C-19	Naxera	1906	-	-	-	716	-	586	-	3417	1630	-	-	-	-	155		-	-	-	23	20	1.0	-	14	-	-	-	1188		-
C-19		1/41	-	-	-	716	-	588	-	-	1700	105	-	-	-	135	-	-	.9	-	-		-	-	-	-	-	-	-	-	-
C-20	Naxera	8/50	-	-	-	85	-	284	-	1500	316	400	-	-	-	15	-	.1	.2	-	-	-	-		-	-	-	-	-	-	-
C-25a	Achilles	1906	-	-	-	615	-	850	-	-	1400	47	-	-	-	160	-		-	-	-	-	2.5	-	-	-	-	-	-	-	-
C-25a		5/48	-	-	-	615	-	861	-	-	1350	120	-	-	-	60	-	3.5	.6	-	-	-	-	-	-	-	-	-	-	-	-
C-24	Achilles	6/18	-	-	-	450	-	934	-	3777	1540	107	-		-	207	-	-	-	-	10	-	-	-	20	-	-	-	1404		-
C-26	Severn	1906	-	-	-	610	-	628	-	-	2500	222	-	-		216	-	.7		-	46	-	4.9		26	-	-	-	1826		-
C-26		2/41	-	-	-	610	-	635	-	-	2675	375	-	-	-	230	-	-	.7	-		-	-	-	-	-	-	-	-	-	-
C-36	Clay Bank	8/50	-	-	-	460	-	432	-	2250	476	32	-	-	-	58		-	2.0	-	-	-	-	-	-	-	-	-	-	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals:	Specific Conductance
GLOUCESTER COUNTY continued																															
136-C-40	Capahosic	6/18	-	-	-	395	-	690	-	775	54	8	-	-	-	18	-	1.2	-	-	1.2	33	0.0	-	1.1	-	-	-	302		-
C-40		6/41	-	-	.	395	-	611	-	-	53	10		-	-	12	-	-	4.3	-	-	-	-	-	-	-	-	-	-	-	•
C-58	Gloucester Point	6/18	-	-	-	694	-	881	-	1618	424	29	-	-	-	48	-	1	··	-	1.2	30	0.0	-	6.4	-	-	-	619	- -	-
C-58		6/41	-	-	-	694	-	780	-	-	432	30	-	-	-	30	-	-	1.2	-	-	-	-	-	-	-	-	-	-	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

SWCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Mg	Mn	Hg	Zn	Na	K	Specific Conductance
KING AND QUEEN COUNTY																															
149-																															
1	Observation Well #64, Walkerton	8/25/72	-	8.0	-	352	-	236	-	-	.8	6		278	-	13	-	.5	2.0	-	1.4	-	.02	-	.6	-	-	-	99	5.[illegible]	[illegible]
2	King and Queen Elementary School	10/6/75	-	7.9	-	265	235-265	-	155	218	1	52	-	218	149/69	5.9	-	-	.49	6	14	-	.01-	-	6.4	.01-	-	-	41	11.8	
7*	King and Queen Elementary School	12/20/72	-	8.2	-	265	235-265	190	-	-	3.7	57	-	224	-	7.3	-	1.0	.5	-	13	40	.02	-	6.0	-	-	-	48	14	-
7*		8/12/71	-	7.9	-	265	235-265	188	-	-	3:1	63	-	210	-	7.2	-	1.1	.6	-	14	37	.04	-	6.8	-	-	-	43	10	-
3	Central High School	10/6/75	-	7.7	-	225	205-225	-	165	234	3	56	-	238	166/72	10.6	-	-	.43	6	12	-	.1	-	5.5	.01-	-	-	55	10.7	-
4	Airport Well	6/19/75	-	8.3	-	1278	1233-1248		350	2056	1050	46	-	2056	1997/59	68	-	-	1.8	10	14	-	.2		3.3	.06	-	-	890	8.4	-
5	Gressitt Well	7/16/75	-	8.4	-	1050	741-756	-	360	91	38	2-	-	99	54/45	-	01-	.05-	1.8	7	3	-	.01	-	.3	.1-	-	-	140	3.8	-
5	8 hours	5/28/70	-	8.2	-	1050	741-756	457	-	-	42	8	-	552	-	23	-	.1	1.8	-	1.8	33	0.0-		.8	-	-	-	200	8.4	839

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

KING AND QUEEN COUNTY
continued

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: [illegible]	Metals:	Specific Conductance
140- 6	Walkerton Water Works	11/24/75	-	7.7	-	390	342-387	-	180	267	3	6		267	217/50	10.4	-	.07	1.5	5	2	-	.1-	-	.40	.01-	-	-	91	2.5	-
6		12/13/74	-	8.0	-	390	342-387	-	177	255	1.5	6	-	256	168/88	11.4	.01-	.09	1.6	-	.5	-	.1	-	.18	.01	-	-	83	4.5	350
6		8/12/71	-	8.0	-	390	342-387	220	-	-	1.5	2	-	242	-	11.0	-	.10	1.5	-	.6	30.0	.02		.20	-	-	-	84	4.9	390
6		6/14/66	-	7.6	-	390	342-387	232	-	-	3.0	6	-	267	-	11.5	-	.0	1.7	-	2.4	29.5	.06	-	.20	-	-	-	-	-	
8	Lawson School	8/25/75	-	8.4	-	400	-	-	208	265	1.0	48	-	265	240/25	24.0	-	-	1.2	3	1		.20		.50	.01	-	-	93	7.0	-
8		12/20/72	-	8.4	-	400	-	253	-	-	1.5	4	-	266	-	13 0	-	.30	1.2	-	1.1	16.0	.08	-	.50	-	-	-	100	8.6	435
16	York Academy	12/8/72	-	8.2	-	-	-	256	-	-	3.2	17	-	280		10.0	-	1.2	0.9		4.6	24	[illegible]	-	1.30	-	-	-	92	12.0	420
18	Westmoreland Subdivision	3/14/74	-	8.7	-	305	285-305	-	270	329	0.5	15	-	329	270/59	.50-	.01	.04-	1.1	-	3.7	20.[illegible]	[illegible]	-	1.50	.03	-	-	102	11.0	483
18		3/8/74	-	8.4	-	305	285-305	302	264	-	5.0	17.9	-	319	259/60	1.6	-	-	.52	-		19.[illegible]	[illegible]1	-	1.84	4.14	-	-	117.3		-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Mg	Mn	Hg	Zn	Na	K	Specific Conductance
KING AND QUEEN COUNTY continued																															
149-25	Nick Stofi	4/2/574	-	8.4	-	546	515 546	-	163	225	2	52	-	225	179/46	26.6	-	-	.65	1	3	-	.1-	-	.9	.01	-	-	70	7.7	-
36	R. D. Hart	10/6/75	-	7.6	-	340	330-340	-	216	381	4	20		285	199/86	6.5		-	1.0	7	4	-	.1-		1.6	.01-	-	-	88	10.0	-
38	Thomas Haynes	10/6/75	-	8.2	-	285	275-285		291	376	3	10	-	378	271/107	4.6	-	-	1.8	7	5	-	.1	-	1.7	.01-	-	-	149	8.8	-
42	Griggs Dairy Farm	11/29/75	-	7.8	-	460	-	-	185	259	3	4	-	259	201/58	14.6		.05-	1.0	5	1	-	.1-		0.3	.01-	-	-	89	3.3	-
-4	Stevensville	-	-	-	-	465	-	224	-	268	1.7	6	-	-	-	17.0	-	-	1.5	-	-	-	.18		-	-	-	-	-	-	-
-	St. Stephens Church	2/54	-	-	-	517.	-	163	-	-	1.6	10	-	-		-		-	-	-		-	-	-	-	-	-	-	-	-	-
-16	Near Walkerton	12/43	-	-	-	214	-	413		404	4.0	16		-	-	14.0	-	0.0	2.2	-	3.8	17	.02	-	1.6	-	-	-	160 (Na + K)		-
-18c	Walkerton	12/43	-	-	-	365	-	215	-	242	2.2	3.6	-	-	-	11.0	-	0.0	1.7	-	0.6	32	.01	-	0.5	-	-	-	88 (Na + K)		-
-44	Shanghai	7/51	-	-	-	285	-	190	-	-	2.8	56	-	-	-	-	-	1.0	0.8	-	-	-	-	-	-	-	-	-	-	-	-
-48	Shacklefords Fork	5/48	-	-	-	320	-	251	-	267	2.5	18	-	-	-	7.6	-	1.0	1.0	-	4.8	23	.14	-	1.4	-	-	-	94 (Na + K)		-
-48		11/68	-	-	-	320	-	248	-	251	2 3	18	-		-	6.2	-	-	1.1		-	-	.10	-	-	-	-	-	-	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

KING WILLIAM COUNTY

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Pb	Mg	Mn	Hg	Zn	Na		Specific Conductance
150-1	Chesapeake Corp.	6/17/75	-	8.3	-	1228	1050-1277	-	42	51	198	42	-	57	27/30	53.2	-	-	3.4	2	3	-	1-	-	7	-	-	-	330	3.7	-
1·		12/9/68	-	8.1	-	1228	1050-1277	661	-		209		-		-	45.0	-	-		-	-	-	-	-	-	-	-	-	-	-	-
1		9/25/62	-	8.1	-	1228	1050-1277	659		-	240	-	-	-		86.0			-		-	10	-	-	-		-	-	-	-	-
2	Chesapeake Corp.	6/26/75		8.0	-	811	340-704	-	340	513	17	0	-	527	410/117	10 6	.01-	05-	2.3	3	2	-	.2	-	.4	.01	-	-	210	3.6	-
2		10/23/72	-	8.0	-	811	340-704	426	-	-	17	3	-	459	-	14.0	-	0	2.5	-	8	25	.02		2	-	-	-	180	5.2	78[illegible]
2		5/25/64	-	8.1	-	811	340-704	422	-	-	12	-	-	365	-	12.0		-	-	-		25	-	-	-	-	-	-	-	-	-
3	Chesapeake Corp.	6/26/75	-	8.0	-	709	360-379	-	373	526	36	54	-	538	449/89	15 8	.01-	05-	2 7	5	1	-	.1-	-	.4	.01-	-	-	100	3.8	-
3		12/9/68	-	7.9	-	709	360-379	438	-	-	38	-	-	450	-	14	-		-		-	38	-	-	-	-	-	-	-	-	-
3		6/13/59	-	8.1	-	709	360-379	473	-	-	36	-	-	460	-	4	-				-	29	-	-	-		-	-	-	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals Pb	Metals Mg	Metals Mn	Metals Hg	Metals Zn	Metals Na	Metals K	Specific Conductance
KING WILLIAM COUNTY																															
150-4	Chesapeake Corp.	6/26/75	-	8.1	-	750	-	-	376	542	29	0	-	554	468/96	13.3	.01	.05-	2 6	7	1	-	1-	-	.4	.01-	-	-	180	3.6	-
4		12/9/68	-	7.9		750	-	453		-	30	-	-	416	-	14.0	-	-	-	-	-	34		-	-	-	-	-	-	-	-
4		6/13/59	-	8.2	-	750	-	439	-	-	26	-	-	500	-	4.0	-		-	-	-	43	-	-	-	-	-	-	-	-	-
5	Chesapeake Corp.	6/26/75	-	8.2	-	812	316-691	-	343	485	13	28	-	498	368/130	9.3	.01-	.05-	2.4	4	2	-	1-	-	.4	.01	-	-	220	3.8	-
5		5/11/65	-	8.2	-	812	316-391	447	-	-	20	-	-	458	-	9.0		-	-			19	-	-	-	-	-	-	-	-	-
6	Chesapeake Corp.	12/9/68	-	8.0	-	640	204-638	434	-		28	-	-	390	-	14.0	-	-	-	-	-	34	-	-	-	-	-	-	-	-	-
6		4/30/46	-	8.0	-	640	204-638	-	-	-	30	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-
7	Chesapeake Corp.	6/26/75	-	7.9	-	667	390-400 550-570 580-600		316	435	17	0	-	448	307/141	10.7	.01-	.05	-	1.7	5	2	-	.2	-	.5	.01-	-	200	5.0	-
14	Bleak Hill Farm	9/1/75	-	7.3	-	340	284 301	-	143	225	3	22		227	83/144	12.8	.01	.08	.33	5.0	1-	-	.02	-	6	.01-	-	-	58	5.5	-
16	Town of West Point	8/5/74	-	8.6	-	526	-	-	348	434	.5	6.0	-	437	326/111	10.0	.01	.04-	2.65	-	1	2	.02	-	.41	.01-	-	-	165	7.9	650

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Ni	Mn	Hg	Zn	?		Specific Conductance
KING WILLIAM COUNTY continued																															
150-16	Town of West Point	2/28/69	-	8.6	8.3	526	-	-	336	400	20	7	-	-	-	11.7	.01	.22	1.65	-	1.6	27.6	.04	-	.8	.01	-	-	186	23.8	-
23	Virginia State Police	12/7/72	-	8.4	-	437	417-437	292	-	-	2.6	4	-	310	-	8.1	-	.0	1.8		1.3	33.0	.01	-	.3		-	-	110	4.8	480
25	Town of West Point #1	8/10/71	-	8.3	-	375	-	451	-	-	8.2	6	-	454	-	13	-	.1	2.6	-	1.4	17.0	.01	-	.5	-	-	-	180	10.0	750
25		2/25/69	-	8.5	-	375		-	368	476	9.0	6	-	-	-	9.0	01	.2	.32		.4	16.0	.04	-	.4	.01	-	-	188	18.2	
26	Kiwanna's Outdoor	6/16/70	-	6.9	-	320	-	104	-	-	3.3	78	-	149		10.0	-	.1	.2	-	23	30.0	.03	-	5.2	-	-	-	7.9	6.[illegible]	192
26		6/13/68	-	7.2	-	320	-	-	70	116	2.5	67		-	-	9.0		.13	.3	-	-	18.4	.07		1.2	.41	-	-	6.8	-	
28	Marle Hill Subdivision	12/11/72	-	8.3	-	400	246-266 358-378	190	156	-	3.0	2.3		226	192/34	11.5	- 0	0	.5	-	.67	24.8	.08	-	.15	-	-	-	78.1		
29	Venter Heights Division	12/13/74	-	8.3	-	430	250-260 388-408	-	153	.5	25.4	-	-	183	113/70	15.4	.01-	04	.7	-	5.4	21.2	.42	-	2.23	.03	-	-	65	11.0	320
29		3/1/73	-	7.8	-	430	250-260 388-408	168	138	-	4.0	3.3	-	205	149/56	13.2	-	-	.15		1.11	24.2	.01		.11	0.0-	-	-	71.0		

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
	KING WILLIAM COUNTY continued																														
150-32	Lester Manor	8/3/71	-	8.0	-	535	-	226	-	-	2.6	1	-	260	-	9.2	-	.2	1.7	-	.2	34	.17		.1	-	-	-	90	4.7	370
34	Aylett	8/2/71	-	8.0	-	385	-	268	-	-	1 4	2	-	197	-	14.0		.2	.5	-	.4	28	.13	-	.1	-	-	-	70	4.6	285
37	Roanes Wharf	8/2/71	-	8.0	-	340	-	174	-	-	2.4	2	-	208		13.0	-	.0	.9	-	.2	31	.01	-	.2	-	-	-	70	3.6	300
51	Hamilton Holmes School	8/25/75	-	8.4	-	800	-	-	230	280	1.0	50	-	284	226/58	18.6	-		1.2	2	1		.1	-	.6	.01-	-	-	102	6.4	-
51		8/11/71	-	8.3	-	800	-	286	-	-	2.3	6	-	286	-	11.0	-	.1	1.2	-	1.5	16	.02	-	.5	-	-	-	100	11.0	460
52	Manquin	8/11/71	-	8.0	-	365	-	188	-	-	1.8	3		215	-	13.0	-	.0	.6	-	.8	29	.05	-	.3	-	-	-	72	5.7	330
56	Cohoke	8/4/71	-	7.6	-	215	-	198	-	-	3.0	100	-	214	-	7.0	-	.0	5	-	24	45	.02	-	10	-	-	-	30	10.0	320
57	Cohoke	8/4/71	-	8.0	-	260*	-	295	-	-	2.6	9	-	312	-	7.8	-	.1	2.6		2.3	29	.20	-	.8	-	-	-	110	8.7	490
61	King William High School	8/25/75	-	7.8	-	585	-	-	136	185	1	3.6	-	189	142/47	24.5	-	-	.56	1	5		.1	-	1.3	.01	-	-	61	4.5	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
KING WILLIAM COUNTY continued																															
150-61	King William High School	12/21/72	-	8.0	-	585	-	165	-	-	1.2	4	-	204	-	14	-	.4	.6	-	1	32	.07	-	.4	-	-	-	67	5.4	300
61		8/7/71	-	8.2	-	585	-	156	-	-	1.9	4	-	179	-	16	-	.0	.7	-	1	16	.07	-	.3	-	-	-	62	4.7	280
63	Prestley Farm	9/17/75	-	7.3	-	290	-	-	144	225	1.0	8	-	225	90/135	16.2	.01-	.05-	.44	4	1-	-	.10	-	.3	.01-	-	--	70	4.0	-
63		12/8/72	-	8.3	-	290	-	173	-	-	1.0	2	-	229	-	17	-	.1	.5	-	.6	37	.14	-	.2	-	-	-	70	5.2	310
63		8/13/71	-	8.1	-	290	-	176	-	-	1.8	2	-	206	-	16	-	.0	.5	-	.5	30	.04	-	.2	-	-	-	69	5.3	300
70	Lumber Company Aylett	9/16/75	-	7.6	-	340	-	-	119	183	1.0	4	-	189	114/75	9.8 9.8	.01- .01-	.08 .08	.52 .52	4 4	1- 1-	- -	.4 .4	- -	.3 .3	.01 .01	- -	- -	61 61	3.0 3.0	-
70		12/8/72	-	8.2	-	340	-	151	-	-	1.2	2	-	184	-	14	-	.3	.5	-	.4	38	.24	-	.2	-	-	-	60	3.6	270
76	Seth Paul	8/25/75	-	7.4	-	365	-	-	166	250	2.0	160	-	250	221/29	17.2	-	-	.22	4	56	-	1.1	-	4.2	.01	-	-	7	5.1	-
78	Horse Landing	12/8/72	-	8.2	-	115*	-	222	-	-	2.5	130.	-	256	-	6.9	-	.1	.3	-	42	71	.06	-	6.4	-	-	-	19	12.0	340

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolived Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals							Specific Conductance
																								Pb	Mg	Mn	Hg	Zn	Na	K	
KING WILLIAM COUNTY continued																															
150-87	Chesapeake Corp.	6/17/75	-	8.3	-	1280	940-1275	-	42	922	142	44	-	926	853/73	38.2	-	-	4.1	2	4		.1-	-	.8	-	-	-	550	4.3	
89	Chesapeake Corp.	6/8/75	-	8.3	-	744	388-711	431	366	-	33	3.1	-	510	456/54	14.2	-	-	1.88	-	1.01	25.1	.01	-	.14	-	.01	-	195		
90	Floyd Paul	8/25/75	-	6.5	-	30	-	-	47	85	4	94	-	85	64/21	18.3		-	.1-	3	28	-	.3	-	3.6	.01	-	-	3	1.2	
92	Virginia Highway Garage	8/25/75	-	8.1	-	420	400-410	-	208	262	1	52	-	270	196/74	21.5	-	-	.84	4	4	-	.1	-	1.1	.01	-	-	88	7.8	
94	King William Courthouse	8/25/75	-	8.2	-	455	445-455	-	215	280	2	38	-	280	200/80	21.4	-	-	1.3	3	3	-	.1	-	1.3	.02	-	-	89	6.5	

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolived Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Mg	Mn	Hg	Zn	Na	K	Specific Conductance
MATHEWS COUNTY																															
157 - 2	Cobbs Creek Sub.	10/20/75	1600	7.6	-	128	92-113	-	165	255	13	164	-	261	72/189	3.5	.01-	.19	.15	4	55	-	.1-	-	7.3	.01-	-	-	1-	4.6	-
3	Jenkins Hotel and Marina	10/20/75	1445	7.5	-	157	110-130	-	215	485	82	212	-	485	106/379	9.2	.01-	.07	.22	7	70	-	1.4	-	7.7	.06	-	-	57	5.0	-
4	Mathews Court House	8/19/75	1130	7.7	-	153	126-136	-	529	933	170	262	-	937	240/697	17	.01-	.05-	.1-	22	55	-	1.1	-	38	.09	-	-	163	31	-
8	Dr. Sherer	10/20/75	1300	7.3	-	180	160-174	-	240	437	49	260	-	439	108/331	2.4	.01-	.17	.21	9	83	-	1.6	-	10.9	.38	-	-	16	7.7	-
10	U.S. Army	6/43	-	-	-	175	148-169	270	-	-	93	279	-	-	-	10	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
13	Gwynn Island USCG	10/12/67	-	7.6	-	125	105-125	238	-	-	43.7	-	-	340	-	7.2	-	0	.3	-	-	-	.30	-	-	-	-	-	-	-	-
14	Chesapeake Shores	10/20/75	1200	7.3	-	153	130-145	-	220	1179	300	440	-	1180	349/832	33.3	.04	.23	.25	6	137	-	.9	-	12.1	.06	-	-	113	8.3	-
14		10/8/74	-	8.2	-	153	130-145	-	177	848	63	360	-	870	160/710	19.2	.03-	.04	.26	-	106	-	.56	-	11.7	.09	-	-	25	12	-
14		8/28/74	-	8.4	-	153	130-145	-	157	759	325	314	-	776	129/647	35.2	.05	.38	.22	-	126	-	1.84	-	-	.08	-	-	103	10.6	-
14		10/5/74	-	7.1		153	130-145	-	-	-	26	-	-	487	-	21.9	-	1.2	.4	-	125.1	-	.67	-	8.7	-	-	-	41.6	-	-
14		5/11/55	1400	7.5	-	153	130-145	-	240	-	102	307	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
MATHEWS COUNTY - continued																															
157 - 15	Chesapeake Bay Estates	7/15/65	-	8.6	-	-	-	430	-	-	10.5	-	-	-	-	-	-	.1	2	-	-	-	.03	-	-	-	-	-	-	-	
16	Mathews (Elkins Well)	8/31/72	-	11.4	-	2328	-	0	-	-	1700	600	-	3330	-	130	-	.1	.4	-	240	6.8	0	-	.03	-	-	-	1000	39	
18	Green Mansions (Billups)	2/41	-	-	-	568	-	824	-	-	552	39	-	-	-	50	-	-	1.0	-	-	-	-	-	-	-	-	-			
18		6/18	-	-	-	568	-	917	-	1881	550	55	-	-	-	65	-	1.2	-	-	8.4	-	-	-	8.3	-	-	-	711		
19	Mathews Fire Department	8/19/75	1145	8.1	-	115	-	-	533	894	180	236	-	918	154/764	22.8	.01-	.05-	.1-	20	57	-	5.5	-	40	.11	-	-	185	31	
22	Mathews County Highway Shop	8/19/75	1100	7.9	-	116	-	-	293	383	13	124	-	395	64/331	1.6	.01-	.05-	.13	11	61	-	.7	-	15.3	.03	-	-	16	15.4	
23	H. B. Armistead	10/20/75	1215	7.6	-	175	-	-	279	1167	425	312	-	1171	185/968	5.2	.01-	.05-	.16	11	83	-	.2	-	31	.01	-	-	220	16	
24	Ebeneezer Church	10/20/75	1530	7.4	-	189	-	-	134	197	3	122	-	197	78/119	1.5	.01-	.05	.17	4	32	-	.1-	-	9.6	.01-	-	-	1-	8.2	
C-10	B. Hudgins	6/18	-	-	-	120	-	183	-	255	10	27	-	-	-	6.1	-	.41	-	-	5.2	48	tr.	-	3.5	-	-	-	75		

C - Cederstrom Wells (taken from his unpublished report, 1968)

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
MATHEWS COUNTY - continued																															
157 - C-16	R. Tabor	6/18	-	-	-	115	-	193	-	266	28	136	-	-	-	13	-	1	-	-	28	-	-	-	16	-	-	-	35 (Na + K)		-
C-38	Mathews County	6/18	-	-	-	817	-	800	-	1090	156	124	-	-	-	9.5	-	tr.	-	-	17	-	-	-	20	-	-	-	351 (Na + K)		-
C-40	C. T. Richardson	2/49	drug store	-	-	120	-	640	-	-	136	255	-	-	-	1	-	-	.2	-	-	-	-	-	-	-	-	-	-		-
C-41	R. Pierce	8/50	-	-	-	127	-	388	-	-	36	268	-	-	-	1	-	.4	.1	-	-	-	-	-	-	-	-	-	-		-

B-30

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

Well Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals Pb	Mg	Mn	Hg	Zn	Na	K	Specific Conductance
MIDDLESEX COUNTY																															
1 9-																															
1	St. Clare Walker School	2/25/76	-	8.4	9.5	700	-	-	344	431	5	8	-	431	332/99	3.7	-	.05-	2.6	8	-	-	-	-	-	-	-	-	-	-	-
1		10/28/75	-	8.4	9.0	700	-	-	377	491	13	10	-	495	448/47	24.1	-	-	2.0	6	2	-	.1-	-	.4	.01-	-	-	200	4.0	-
1		8/26/75	-	8.4	-	700	-	-	339	420	1	48	-	428	389/39	17.9	.01-	.05-	2.7	4	2	-	.1-	-	.6	.01-	-	-	145	6.8	-
1		6/26/75	-	8.6	-	700	-	-	335	438	3	216	-	460	346/114	.1-	-	-	2.6	7	2	-	.1-	-	.7	.01-	-	-	170	7.0	-
2	Barnhardt Duck Farm	1/70	-	8.7	-	675	471-640	468	-	-	11	3	-	503	-	27	-	.1	2.2	-	.5	12	.02	-	.5	-	-	-	200	9.0	880
3	Barnhardt Duck Farm	1/70	-	8.5	-	727	-	474	-	-	11	4	-	501	-	31	-	.7	2.2	-	.8	12	.03	-	.5	-	-	-	199	9.0	870
4	Barnhardt Duck Farm	11/5/75	-	-	-	715	514-560 590-603 678-708	-	-	532	11	6	-	536	386/150	24.7	-	-	2.1	5	5	-	.1-	-	1.0	.01-	-	-	150	3.9	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Mg	Mn	Hg	Zn	Na	K	Specific Conductance
MIDDLESEX COUNTY continued																															
159-4	Barnhardt Duck Farm	1/70	-	8.5	-	715	514-560 590-603 678-708	482	-	-	8.9	4	-	504	-	23	-	.8	2.2	-	.6	12	.01	-	.5	-	-	-	198	9.5	88[illegible]
4		1/26/62	-	7.9	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	.10	-	-	-	-	-	-	-	-
9	Town of Urbanna #3	8/5/74	-	8.4	8.6	662	470-485 562-620	-	374	497	.5-	5	-	497	376/121	15.9	.01	.17	2.15	-	.67	-	-	-	.25	.01-	-	-	183	6.0	700
9		2/19/72	-	8.5	-	662	470-485 562-620	-	381	841	.5-	2	-	-	-	17.2	-	1.02	2.18	-	.4	-	1.0	-	.24	.32	-	-	195	6.4	-
9		1/70	-	8.3	-	662	470-485 562-620	472	-	-	7.7	3	-	476	-	19	-	.7	2.1	-	.6	12	-	-	.4	-	-	-	182	9.0	830
9		12/17/63	-	8.4	-	662	470-485 562-620	454	-	-	6.4	10	-	453	-	13.7	-	1.5	2.1	-	3.2	-	.22	-	.5	-	-	-	184.9	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolived Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
MIDDLESEX COUNTY continued																															
159-10	Barnhardt Duck Farm #3	11/5/75	-	-	-	654	460-648	-	-	514	5	4	-	524	407/117	20.8	-	-	1.95	7	4	-	.1-	-	.9	.02	-	-	170	3.8	-
10		3/13/68	-	8.4	-	654	460-648	454	-	-	16.5	10	-	501	-	12.0	-	.1	1.8	-	3.5	4	.10	-	.3	-	-	-	193.2	-	-
11	Christchurch School	2/25/69	-	8.9	8.4	740	562-567 619-624 683-733	-	381	-	9.0	3	-	-	-	-	-	-	-	-	.8	-	.05	-	.6	.03	-	-	208	-	-
11		12/26/63	-	8.5	9.0	740	562-567 619-624 683-733	473	387	492	8.6	4	-	-	-	21	-	.23	1.98	-	5.2	17.8	.15	-	.6	0.0-	-	-	197	-	-
11		11/9/62	-	8.4	-	940	562-567 619-624 683-733	427	-	493	12	6	-	-	-	22.4	-	-	-	-	1.6	35.0	.10	-	.4	-	-	-	185	-	-
12	Town of Saluda	11/8/74	-	8.5	-	330	298-320	-	255	311	1.0	20	-	312	250/62	3.8	.01-	1.4	1.7	-	3.3	-	.01-	-	1.6	.01	-	-	107	12.1	290
12		2/17/72	-	8.5	-	330	298-320	-	256	410	.5	15	-	-	-	4.5	-	-	1.8	-	3.2	-	.01-	-	1.7	.01	-	-	110	9.5	-
12		2/24/67	-	8.3	-	330	298-320	312	-	-	.5	14	-	372	-	4	-	1.1	-	-	3.2	42.4	-	-	1.4	-	-	-	126	-	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
MIDDLESEX COUNTY continued																															
159-12	Town of Saluda	9/7/42	-	-	-	330	298-320	-	-	-	-	126	-	630	-	12.6	-	-	-	-	33.8	-	-	-	-	10.0	-	-	-	-	-
13A	Stove Point, Test Well	5/64	-	7.4	-	13	-	61	-	-	87	79.4	-	237	152/85	21.4	-	-	-	-	28.0	2	.6	-	2.3	-	-	-	49.9		-
13B		5/64	-	6.8	-	51	-	14.5	-	-	710	720	-	1679	1421/258	34.6	-	-	-	-	251	-	18	-	22.9	-	-	-	115.0		-
13C		5/64	-	6.6	-	-	80-120	209	-	-	3905	2635	-	8255	7399/856	244	-	-	-	-	887	-	46	-	103	-	-	-	1448.9		-
13D		5/64	-	8.4	-	-	432-452	483	-	-	1395	155	-	2965	-	57.6	-	-	.6	-	36	-	.2	-	16	-	-	-	1052		-
13E		5/64	-	8.5	-	-	628-650	-	-	-	1848	119	-	4099	-	169.9	-	-	.7	-	40.5	-	.1	-	4.4	-	-	-	1359		-
21	Waterview	5/48	-	-	-	311	284-306	323	-	319	2.5	33	-	-	-	5.5	-	.5	.9	-	7.2	20	.r.	-	3.7	-	-	-	113		-
26	Remlik	11/68	-	-	-	535	510-532	487	-	465	6.3	3	-	-	-	19	-	-	2.6	-	-	-	-	-	-	-	-	-	-	-	-
29	Town of Urbanna	4/29/43	-	-	-	-	-	483	-	-	6.6	-	-	-	-	-	-	-	2.2	-	6.2	-	-	-	-	-	-	-	-	-	-
30	Town of Urbanna	4/29/43	-	-	-	451	-	508	-	-	6.3	-	-	-	-	-	-	-	2.2	-	6.4	-	-	-	-	-	-	-	-	-	-
31	Town of Urbanna	4/4/72	-	7.8	-	552	-	361	-	-	23	30	-	442	-	6.8	-	.5	2.0	-	8.0	35	.04	-	2.6	-	-	-	130	13	650

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
MIDDLESEX COUNTY Continued																															
17?-?2	Barnhardt Duck Farm	11/5/75	-	-	-	730	507-725	-	-	507	9	8	-	517	389/128	25	-	-	2.1	11	2	-	.1-	-	.4	.01-	-	-	199	4.1	-
32		6/10/74	-	8.3	-	730	507-725	451	402	-	11	3.2	-	506	478/28	25.7	-	.01-	1.85	-	1.2	-	.01-	-	.05	.01-	-	-	202		-
	Hermitage Baptist Church	11/5/75	-	-	-		shallow	-	-	122	19	42	-	124	41/83	.5	-	-	.1-	3	16	-	.1	-	1.6	.02	-	-	1	.9	-
4	Dub-L-Fun Campgrounds	11/5/75	-	-	-	360	-	-	-	231	5	74	-	245	151/94	6.6	-	-	.54	7	19	-	.3	-	8.3	.01	-	-	38	11.2	-
47	Wilton Elementary School .	2/25/76	-	5.8	6	707	-	-	37	144	35	53	-	146	98/48	12.0	-	.45	.1-	5	-	-	-	-	-	-	-	-	-	-	-
47		10/27/75	-	6.1	5.5	707	-	-	29	103	25	56	-	111	100/11	13.9	-	-	.1-	7	15	-	1.7	-	3.7	.09	-	-	4	1.1	-
:		6/26/75	-	6.1	5.2	707	664-684	-	40	139	39	58	-	191	119/72	8.7	-	-	.1-	5	18	-	2.7	-	5.8	.08	-	-	88	1.9	-
[illegible]		3/19/75	-	-	-	707	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	2.2	-	3.9	.03	-	-	15.2	1.2	-

TABLE B-1 (Continued)

GROUNDWATER QUALITY DATA PRINTOUT FOR MIDDLE PENINSULA REPORT

WCB Number	Owner and/or Place	Date	Time	pH (Lab)	pH (Field)	Total Depth	Screen Depth	HCO_3 (Bicarbonate)	Alkalinity	Dissolved Solids (Total)	Chloride	Hardness	TKN	Total Solids	Volatile/Fixed	SO_4	NO_2	NO_3	Fluoride	TOC	Ca	SiO_2	Fe	Metals: Pb	Metals: Mg	Metals: Mn	Metals: Hg	Metals: Zn	Metals: Na	Metals: K	Specific Conductance
MIDDLESEX COUNTY continued																															
159-58	J. H. Collier	11/5/75	-	-	-	82	-	-	-	218	7	160	-	220	137/83	10.1	-	-	.1-	4	68	-	.4	-	1.3	.07	-	-	1	.2	-
C-5	Waterview	5/15	-	-	-	275	-	325	-	-	2	15	-	-	-	5	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-
C-11	Remlik	5/48	-	-	-	471	-	474	-	-	6	9	-	-	-	15	-	.6	2.0	-	-	-	-	-	-	-	-	-	-	-	-
C-35	Deltaville	5/48	-	-	-	121	-	161	-	-	7	114	-	-	-	2	-	.3	-	-	-	-	.31	-	-	-	-	-	-	-	-
C-36	Deltaville	8/50	-	-	-	126	-	316	-	-	56	264	-	-	-	1	-	.2	.1	-	-	-	-	-	-	-	-	-	-	-	-
C-39	Amburg	6/18	-	-	-	822	-	1051	-	4308	1820	104	-	-	-	234	-	5.0	-	-	9	57	8.0	-	20	-	-	-	1646		-
C-42	Fairfield Landing	11/68	-	-	-	500	-	496	-	1067	294	12	-	-	-	5.9	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-
C-44	Jamaica	5/51	-	-	-	54	-	80	-	-	85	36	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX C

GROUNDWATER USE

The data shown in Table C-1 is from one of the following sources: State Health Department Public Water Supplies List, 1976, State Water Control Board Groundwater Pumpage and Use Reports or *Ground Water in Virginia: Quality and Withdrawals* of the State Water Control Board.

TABLE C-1

GROUNDWATER WITHDRAWALS IN MILLION GALLONS PER DAY

System and/or Location	No of Wells	No of Spr	1965 MGD	1966 MGD	1967 MGD	1968 MGD	1969 MGD	1970 MGD	1971 MGD	1972 MGD	1973 MGD	1974 MGD	1975 MGD
CAROLINE COUNTY													
PUBLIC SYSTEMS													
Bowling Green	2		0.109			0.120			0.080	0.1080*			
Camp A. P. Hill	23				0.002	0.011	0.012		0.053				
Caroline Pines									0.003	0.0032*			
Field Unit #2	1					0.007			0.008	0.0120*			
Fredricksburg Magnetic Obs.	1			0.015						0.0035*			
Port Royal	1		0.014			0.015							
Townfield Sub.	X					0.007							
INDUSTRIAL SYSTEMS													
Caroline Packing Corp.	2					0.010							

PUBLIC USE--0.209 MGD** INDUSTRIAL USE--0.010 MGD** TOTAL USE--0.219 MGD**

System and/or Location	No of Wells	No of Spr	1965 MGD	1966 MGD	1967 MGD	1968 MGD	1969 MGD	1970 MGD	1971 MGD	1972 MGD	1973 MGD	1974 MGD	1975 MGD
ESSEX COUNTY													
PUBLIC SYSTEMS													
Bowlers Wharf	1		0.004		0.007					0.012			
Essex Acres	1					0.001			0.001	0.001*			
Gynnefield	1					0.001			0.001	0.013*			
Laurel Park	1					0.001			0.001	0.001*			
Loubern Acres	1			0.001									
Mark Haven Beach	2		0.004		0.004					0.007*			
Maryfield Sub.	1								0.001				

*Estimated from State Department of Health Public Water Supplies List, 1972.
**Estimated from latest available data.

TABLE C-1 (Continued)

GROUNDWATER WITHDRAWALS IN MILLION GALLONS PER DAY

System and/or Location	No of Wells	No of Spr	1965 MGD	1966 MGD	1967 MGD	1968 MGD	1969 MGD	1970 MGD	1971 MGD	1972 MGD	1973 MGD	1974 MGD	1975 MGD
ESSEX COUNTY continued													
PUBLIC SYSTEMS													
Point Breeze	1		0.0004		0.0004				0.002	0.008*			
Rappahannock Beach	1				0.007				0.008	0.008*			
Riverdale Sub	1		0.006			0.015			0.018	0.018*			
South Hill Banks	1		0.004						0.009	0.009*			
Tappahannock	2		0.260			0.260			0.200	0.002		0.199	0.196
Tappahannock Memorial Hospital	1					0.030				0.030		0.015	0.012
Dangerfield Sub.	X									0.001			
The Island	X								0.003				
Whispering Pines Estates	X									0.001			
Wilson Acres	X								0.001				
INDUSTRIAL SYSTEMS													
Essex Concrete Corp	X					0.001							

PUBLIC USE--0.280 MGD** INDUSTRIAL USE--0.001 MGD** TOTAL USE--0.281 MGD**

System and/or Location	No of Wells	No of Spr	1965 MGD	1966 MGD	1967 MGD	1968 MGD	1969 MGD	1970 MGD	1971 MGD	1972 MGD	1973 MGD	1974 MGD	1975 MGD
GLOUCESTER COUNTY													
PUBLIC SYSTEMS													
Gloucester Banks	3					0.007				0.008			
Gloucester Point San. Dist.	4							0.059	0.071	0.056			0.090
Gloucester San Dist.	2		0.090			0.100			0.130	0.063			0.095
Rappahannock C. C.										0.003*			0.011
Sea Breeze Mobile Home Estates	X								0.003			0.008	0.004

TABLE C-1 (Continued)

GROUNDWATER WITHDRAWALS IN MILLION GALLONS PER DAY

System and/or Location	No of Wells	No of Spr	1965 MGD	1966 MGD	1967 MGD	1968 MGD	1969 MGD	1970 MGD	1971 MGD	1972 MGD	1973 MGD	1974 MGD	1975 MGD
GLOUCESTER COUNTY continued													
INDUSTRIAL SYSTEMS													
Buntings Oyster House	1					0.010							
Cooks Oyster Co.	4					0.001			0.002				
York River Seafood Co.	2					0.002			0.001				
PUBLIC USE--0.210 MGD** INDUSTRIAL USE--0.013 MGD** TOTAL USE--0.223 MGD**													
KING AND QUEEN COUNTY													
PUBLIC SYSTEMS													
Walkerton	1					0.010			0.002		0.018*	0.013	0.052
PUBLIC USE--0.052 MGD** INDUSTRIAL USE--0.000 MGD TOTAL USE--0.052 MGD**													
KING WILLIAM COUNTY													
PUBLIC SYSTEMS													
West Point	2		0.236	0.258	0.274	0.276	0.297	0.306	0.288	0.280			0.246
INDUSTRIAL SYSTEMS													
Chesapeake Corp.	13					14.250			15.324	15.075			16.434
PUBLIC USE--0.246 MGD** INDUSTRIAL USE -16.434 MGD** TOTAL USE--16.670 MGD**													

TABLE C-1 (Continued)

GROUNDWATER WITHDRAWALS IN MILLION GALLONS PER DAY

System and/or Location	No of Wells	No of Spr	1965 MGD	1966 MGD	1967 MGD	1968 MGD	1969 MGD	1970 MGD	1971 MGD	1972 MGD	1973 MGD	1974 MGD	1975 MGD
MATHEWS COUNTY													
PUBLIC SYSTEMS													
Chesapeake Shores	1					0.007			0.004	0.010*			
Cobb Shores	1					0.002			0 001	0.002*			
Gwynns Island	1									0.006			
PUBLIC USE--0.018 MGD**				INDUSTRIAL USE--0.000 MGD						TOTAL USE--0.018 MGD**			
MIDDLESEX COUNTY													
PUBLIC SYSTEMS													
Christchurch School	2					0.030				0.030			
Saluda	1					0.050				0.030			
Urbanna	2		0.100			0.100		0.100	0.120	0 116*			
INDUSTRIAL SYSTEMS													
Barnhardt Farms	3		2.000						3.888				1.186
Duffy-Mott, Urbanna	1								0.266				
J. W. Furguson Seafood, Remlik	2					0.012		0.017	0.024				
PUBLIC USE--0.166 MGD**				INDUSTRIAL USE -2.150 MGD**						TOTAL USE--2.316 MGD**			
ENTIRE STUDY AREA													
PUBLIC USE--1.121 MGD**				INDUSTRIAL USE--18.6 MGD**						TOTAL USE--19.8 MGD**			

Source: Virginia State Water Control Board - BWCM

BIBLIOGRAPHY

Back, W., 1966. Hydrochemical facies and groundwater flow patterns in northern part of Atlantic Coastal Plain: U. S. Geological Survey Professional Paper 498-A.

Brown, G. A., Coster, O. J., 1974. Groundwater conditions in the Franklin area, southeastern Virginia: U. S. Geological Survey Hydrologic Investigations Atlas, HA 538.

Brown, P. B., Miller, J. A., and Swain, F. M., 1972. Structural and stratigraphic framework and spacial distribution of permeability of the Atlantic Coastal Plain, North Carolina to New York: U. S. Geological Survey Professional Paper 796.

Cederstrom, D. J., 1943. Chloride in groundwater in the Coastal Plain of Virginia: Virginia Geological Survey Bulletin 58.

Cederstrom, D. J., 1945. Geology and Ground-Water Resources of the Coastal Plain in Southeastern Virginia. Virginia Geological Survey Bulletin 63.

Cederstrom, D. J., 1946. Chemical character of groundwater in the Coastal Plain of Virginia: Virginia Geological Survey Bulletin 68.

Cederstrom, D. J., 1957. Geology and ground-water resources of the York-James Peninsula, Virginia: U. S. Geological Survey Water-Supply Paper 1361.

Cederstrom, D. J., 1968. Geology and ground water of the Middle Peninsula, Virginia: Unpublished Bulletin, Virginia Division of Mineral Resources.

Cosner, O. J., 1975. A predictive computer model of the Lower Cretaceous Aquifer, Franklin area, southeastern Virginia: U. S. Geological Survey Water-Resources Investigations 51-74.

Division of State Planning and Community Affairs. Data summaries:
Caroline County. April, 1972.
Essex County. February, 1972.
Gloucester County. July, 1974.
King and Queen County. January, 1972.
King William County. October, 1968.
Mathews County. September, 1972.
Middlesex County. March, 1975.

Environmental Protection Agency, 1973. Identification and control of pollution from salt water intrusion; U. S. Governmental Printing Office, Washington, D. C.

Fisher, W. L. and McGowen, J. H. Depositional systems in the Wilcox Group of Texas and their relationship to occurrence of oil and gas. Bureau of Economic Geology. The University of Tecas at Austin, 1967.

John McNair and Associates, 1976. Water supply study for Gloucester Point Sanitary District; preliminary report: John McNair and Associates, Gloucester Point, Virginia.

Johnson, Edward E., Inc., 1972. Ground water and wells: Edward E. Johnson, Inc.

Onuschak, E., Jr., 1973. Pleistocene-Holocene environmental geology, in geologic studies, Coastal Plain of Virginia: Virginia Division of Mineral Resources Bulletin 83, Part 3.

Otton, E. G., 1970. Solid-waste disposal in the geohydrologic environment of Maryland: Maryland Geological Survey Report of Investigation No. 18.

The Ranney Company, 1976. Geophysical Investigation for Gloucester Point Sanitary District, Gloucester Point, Virginia: completed for John McNair and Associates, Gloucester Point, Virginia.

Sanford, Samuel, 1913. The underground-water resources of the Coastal Plain province of Virginia: Virginia Geological Survey Bulletin 5.

Sinnott, A., 1955. Summary of geology and ground-water conditions in the vicinity of Tappahannock, Essex County, Virginia: U. S. Geological Survey, Open File Report.

Sinnott, A., and Whetstone, G. W., 1962. Fluoride in well waters of the Virginia Coastal Plain: Virginia Mineral, Volume 8, No. 1, (February).

Teifke, R. H., 1973. Stratigraphic units of the Lower Cretaceous through Miocene series, in geologic studies, Coastal Plain of Virginia: Virginia Division of Mineral Resources Bulletin 83, Parts 1 and 2.

Virginia State Water Control Board, 1973. Groundwater in Virginia: quality and withdrawals: Bulletin 58.

Walton, W. C., 1970. Groundwater resource evaluation: McGraw-Hill, Inc.

GLOSSARY OF TERMS

	Definitions
AQUICLUDE:	A formation of relatively low permeability that overlies or underlies an artesian aquifer and confines water in the aquifer under pressure.
AQUIFER:	A water-bearing formation, group of formations, or part of a formation that will yield groundwater in useful quantities.
AQUITARD:	A formation that partially restricts groundwater flow.
ARTESIAN AQUIFER:	A confined aquifer in which groundwater rises in a well above the point at which it is found in the aquifer.
BICARBONATES (Metal + HCO_3 e.g. $Na\ HCO_3$):	Can raise the pH to a high concentration which may be corrosive.
CAPILLARY FRINGE:	The zone of partial or complete saturation directly above the water table in which water is held in the pore spaces by capillarity.
CHLORIDES (Cl^-):	Are indicative of concentrations of salt water concentrations above 250 milligrams per liter (mg/l) are detectable by taste.
CONE OF DEPRESSION:	A conelike depression of water table or of the piezometric surface that is found in the vicinity of a well by pumping. The surface area included in the cone is known as the areas of influence of the well.
CONFINED WATER:	Water under artesian pressure. Water that is not confined is said to be under water table conditions.
CONFINING BED:	A bed which overlies or underlies an aquifer and which, because of low permeability relative to the aquifer, prevents or impedes upward or downward loss of water and pressure. An aquiclude.

DISSOLVED SOLIDS:	Generally noticeable in concentrations greater than 500 mg/l.
DRAWDOWN:	The depression or decline of water level in a pumped well or in nearby wells caused by pumping. It is the vertical distance between the static and the pumping levels of the well.
EVAPOTRANSPIRATION:	The combined discharge of water to the air by direct evaporation and plant transpiration.
FLOWING WELL:	A well having sufficient artesian pressure head to discharge water above the land surface.
GROUNDWATER:	Water beneath land surface in the zone of saturation and below the water table.
HARDNESS:	Quality of water that prevents lathering because of calcium and magnesium salts which form insoluble soaps.
HYDRAULIC GRADIENT:	The gradient or slope of the water table of piezometric surface, in the direction of the greatest slope generally expressed in feet per mile.
HYDROGEOLOGY:	The science of the natural laws that control occurrence and movement of groundwater. Geology as affected by hydrology.
HYDROLOGY:	The science that relates to water movements and physical characteristics.
IGNEOUS ROCKS: (Basement Rock)	Rocks formed by the cooling and crystallization of molten or partly molten material.
INFILTRATION:	The flow or movement of water into the surface soil and rocks.
INTERSTICES:	The openings or pore spaces in a soil or rock formation. In an aquifer, they are filled with water.
LITHOLOGY:	The large scale physical characteristics of rocks/sediments.
LOSING STREAM:	A stream losing water to groundwater storage (formerly termed "influent stream").

METAMORPHIC ROCKS:	Rocks altered from pre-existing rocks by changes in temperature, pressure, and chemical environment.
NITRATES (NO_3):	A salt or ester of nitrous acid (concentrations greater than 45 parts per million (ppm) can be toxic.
NONFLOWING ARTESIAN WELL:	An artesian well in which the head is not sufficient to raise water to the land surface at the well site.
pH:	The negative logarithm of the Hydrogen Ion activity--measured 1 through 14 with 7 being neutral, 1 being most indicative of acidity and 14 most indicative of alkalinity.
PALEONTOLOGY:	The study of fossil animal and plant remains to determine past environments.
PERCOLATION:	Movement under hydrostatic pressure of water through the interstices of rocks or soils, except movement through large openings such as solution channels.
PERMEABILITY:	The ability of a rock to transmit water per unit of cross-section.
PIEZOMETRIC SURFACE:	An imaginary surface that everywhere coincides with the hydrostatic head of water in an artesian aquifer.
POROSITY:	The ratio of the volume of the openings in a rock to the total volume of the rock.
PUMPING LEVEL:	The relative elevation of the water surface in a well during pumping.
RECHARGE:	The addition of water to an aquifer by natural infiltration or artificial means. Injection of water into an aquifer through wells is one form of artificial recharge.
RECOVERY:	The residual drawdown after pumping has stopped.
SALTWATER INTRUSION:	The phenomenon occurring when a body of saltwater, because of its greater density, invades a body of freshwater. This may be caused by a loss of pressure in the freshwater.

SEDIMENTARY ROCKS:	Usually stratified formations consisting of products of weathering by action of water, wind, ice, etc.
STATIC WATER LEVEL:	The level of water in a non-pumping or non-flowing well.
STRATIGRAPHY:	The relationship of the formation composition, sequence and correlation of layered rocks on sediments.
STORAGE COEFFICIENT:	Volume of water contained in an aquifer which is related to porosity. Expressed as an absolute value normally from 0.00001 to 0.002 for artesian aquifers and from 0.01 to 0.35 for water table conditions.
TRANSMISSIVITY:	The capacity of an aquifer to transmit water in gallons per unit of time per section 1 foot wide by aquifer thickness. Expressed as gallons per day per foot (gpd/ft) normally ranging from 1000 to 1,000,000 gpd/ft.
UNCONFINED AQUIFER:	Water not under artesian pressure. Generally applied to denote water below the water table.
WATER TABLE:	The surface of unconfined groundwater which is determined by gravity.
WATER-TABLE AQUIFER:	An aquifer which is not confined above, in which the water level in a well indicates the water table.
ZONE OF AERATION:	The zone in which the open spaces in soil or in a rock formation contain air and water.
ZONE OF SATURATION:	The zone in which the open spaces in the rocks are completed filled with water.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (Continued)

VIRGINIA STATE WATER CONTROL BOARD
P. O. Box 11143, 2111 North Hamilton Street
Richmond, Virginia 23230
(804) 786-1411

1 **Southwestern Regional Office**
408 East Main Street
P. O. Box 976
Abingdon, VA 23210
(703) 628-5183

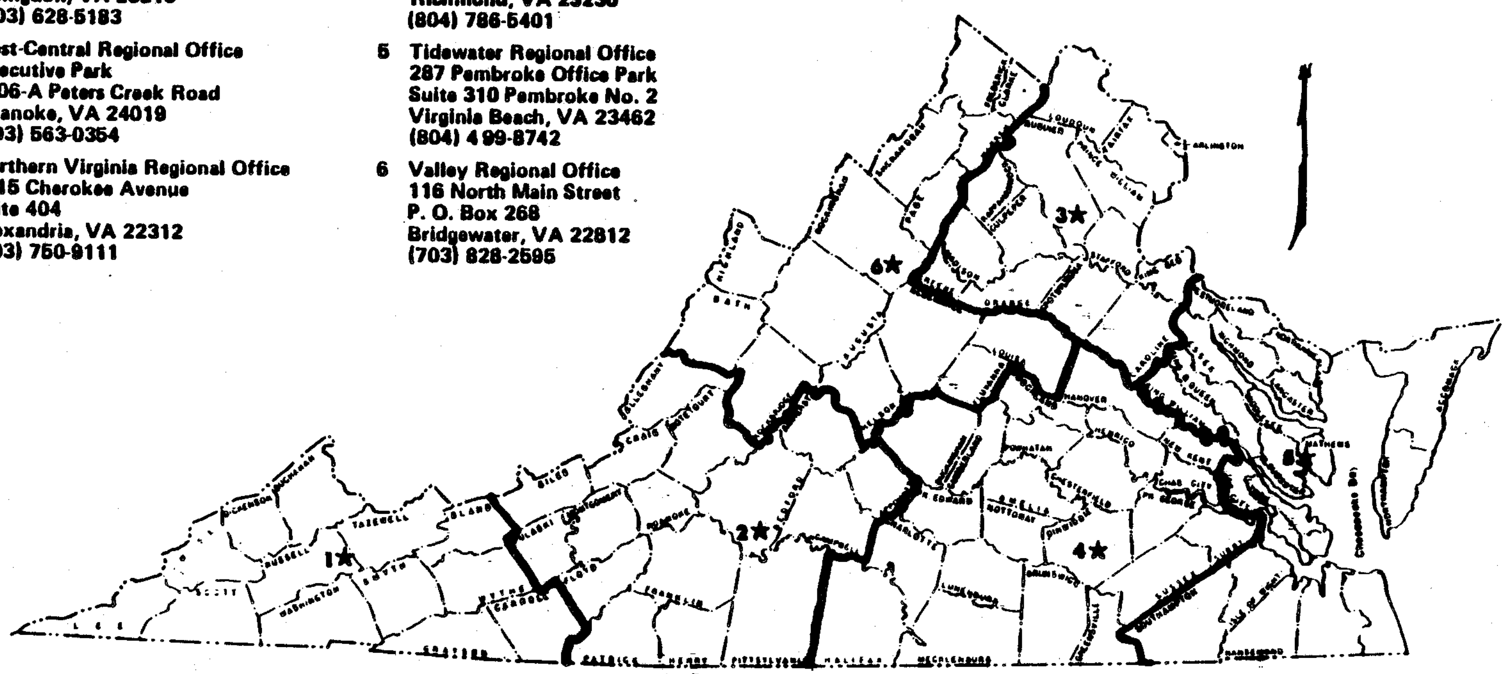
2 **West-Central Regional Office**
Executive Park
5306-A Peters Creek Road
Roanoke, VA 24019
(703) 563-0354

3 **Northern Virginia Regional Office**
5515 Cherokee Avenue
Suite 404
Alexandria, VA 22312
(703) 750-9111

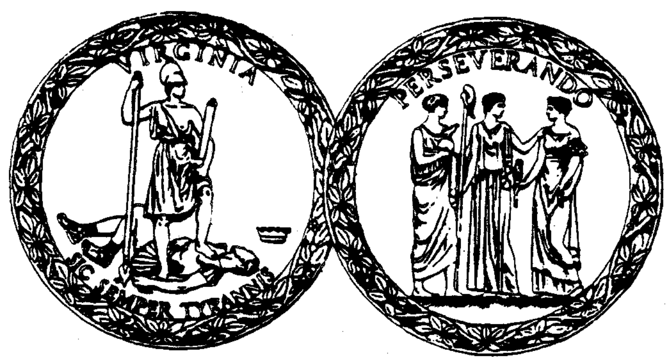
4 **Piedmont Regional Office**
4010 West Broad Street
P. O. Box 6616
Richmond, VA 23230
(804) 786-5401

5 **Tidewater Regional Office**
287 Pembroke Office Park
Suite 310 Pembroke No. 2
Virginia Beach, VA 23462
(804) 499-8742

6 **Valley Regional Office**
116 North Main Street
P. O. Box 268
Bridgewater, VA 22812
(703) 828-2595



Source: Virginia State Water Control Board — BWCM


VIRGINIA
SIC SEMPER TYRANNIS
PERSEVERANDO