Environmental Impact Assessment

for an

Exploratory Well -- King George County, VA

May 15, 1991

prepared for:

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EXECUTIVE SUMMARY

This Environmental Impact Assessment (EIA) was prepared on behalf of Texaco Inc., who is considering the drilling of a test well in King George County, Virginia. Topical areas that are discussed in this document include: ground water and geology, surface water resources, vegetation and wildlife, wetlands, economic, air quality, waste management, archaeological and historic resources, visual and scenic resources, and noise. Descriptions of the site layout, drilling operations, and a detailed evaluation of potential environmental impacts for each topical area are provided. The EIA also outlines the potential adverse impacts that can result from an accidental event and summarizes the control measures to be put in place should an accidental event occur. Although the primary focus of the EIA is on impacts associated with the test well, potential environmental impacts of longer term production activities are also discussed, in a general sense.

This document also addresses the requirements of Virginia Statute 62.1-195.1 which requires an environmental impact assessment (EIA) to be prepared and submitted as part of any oil and gas permit application for projects proposed in Tidewater Virginia. Because specific guidance has not yet been developed by the Virginia Council of the Environment, this document has been prepared based on best available scientific data and best scientific and engineering judgement.

Major findings of this EIA are summarized below:

- A series of safety measures will be implemented to assure protection of fresh-water aquifers, by not allowing hydrological communication to occur between formations, or between fresh-water formations and the well. These measures will be employed during well construction, the drilling process, and abandonment procedures.

- Alternative methods of disposal of waste drilling cuttings and produced water are described. For any option selected, waste drilling mud will be hauled offsite to a disposal facility.

- Impacts to surface water resources should be minimal as all discharges from the drill site including rainwater, will be collected and hauled offsite to an approved disposal facility. A series of dams, levees and booms should act to reduce the likelihood of aquatic impacts.

- Direct impacts of drill site construction on terrestrial habitat will be limited to an open agricultural field. The area is currently unvegetated, except for grasses. All existing forest areas will remain undisturbed.

- Literature review and field efforts did not reveal any Federal or State endangered or threatened species of vegetation or wildlife on the site.

- No wetlands were observed on the proposed rig site. They do exist along the tributaries which drain the site and along the Upper Machodoc Creek, but are located at sufficient distances (>500 feet) from the rig site and should not be impacted by rig construction or normal operations.

- The exploration project will have virtually no impact on population, public services, or schools.

- Screening procedures indicated that national air quality standards would be met for all pollutants for which such standards exist, including, SO_2, NO_x, and particulates.

- There are no state noise level regulations in Virginia. However, noise impacts are not expected to be significant.

- No archaeological or historic features are known to exist on or in the immediate vicinity of the drill site. Therefore, there are no expected impacts to such resources.

- Only minimal visual impacts will be associated with the proposed exploratory operations, which will result from the drilling rig being visible to motorists on State Route 205, and approximately 6 nearby residences.

I. INTRODUCTION

Texaco Inc. is evaluating the possibility of drilling a well in King George County, Virginia to explore for oil and gas. To that end, Coastal Environmental Services, Inc. was contracted to prepare an Environmental Impact Assessment for an exploratory test well located in the vicinity of Ninde, VA. Such an operation would require approximately 3-4 weeks for site preparation, 12-14 weeks for the actual drilling operation (plus 4-6 weeks of additional completion and testing if warranted), and another 3-4 weeks to restore the site.

The designated site for the test well is located on a tract of land leased from Thorn Hill Farm, Inc. The leased tract borders Route 205 on its southern most edge, and is approximately 4.3 miles east of the intersection of Route 205 and Route 301 (Figure I-1).

The exploratory well site itself is expected to require a maximum area of approximately 3.5 acres. The site will be located in what is presently an unused pastureland. A sample rig layout, expected to be similar to the one proposed at this site is depicted in Figure I-2. The exploratory well site is essentially self-contained. Employees live on-site in trailers. Water is expected to be provided from a well, and there will be on-site sewage treatment facilities.

The drill site will be designed to contain the discharge of all fluids generated within the drill site (except trailer and parking areas). Rainwater and snow melt which fall within the site will be captured and hauled to an appropriate disposal facility, except that volume which may be utilized in the fresh water mud system. This is being done to minimize the potential threat to the drainage basin of the Upper Machodoc Creek and its tributaries, the Potomac River, and the surrounding ground water. The drilling operation will be conducted 24 hours a day, therefore Texaco personnel will be in a position to continually monitor and inspect the erosion and sediment control structures. A daily inspection of these facilities will be implemented.

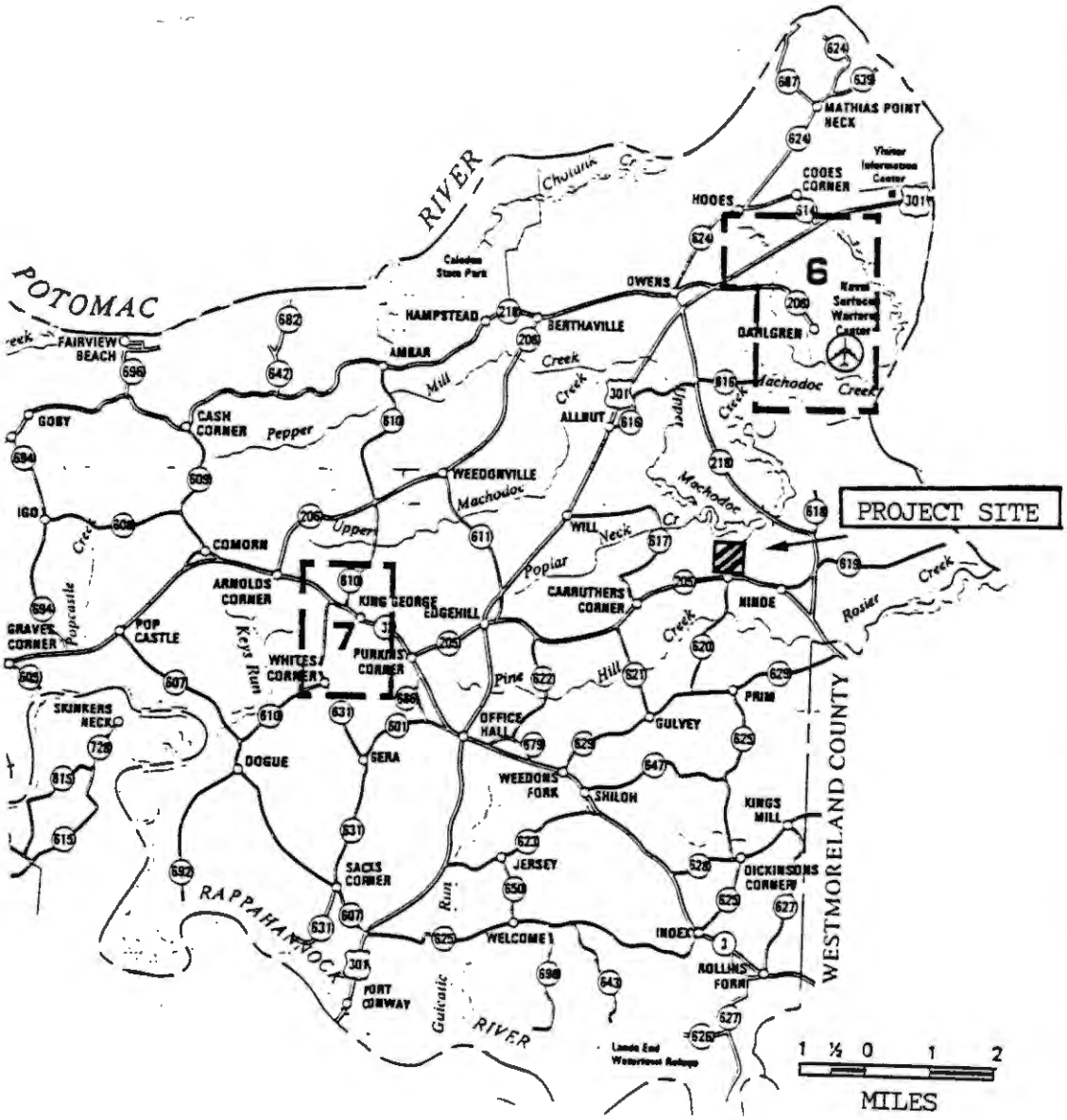
The focus of this document will be to evaluate the potential environmental impacts associated with the proposed exploratory test well, many of which will likely be temporary, given the transitory nature (14-20 weeks) of the drilling activity. The document will also discuss, in a general sense, the potential impacts of a long-term production facility.

This document also addresses the requirements of Virginia Statute 62.1195.1 which requires an environmental impact assessment (EIA) to be prepared and submitted as part of any oil and gas permit application for projects proposed in Tidewater Virginia. Because specific guidance has not yet been developed by the Virginia Council of the Environment, this document has been prepared based on best available scientific data and best scientific and engineering judgement.

Chapter II of this report describes the existing conditions of the test site and nearby vicinity. Topical areas that are discussed include:

- Ground Water and Geology
- Surface Water Resources
- Vegetation and Wildlife
- Wetlands
- Economics
- Air Quality
- Waste Management
- Noise
- Archaeological and Historic Resources
- Visual and Scenic Resources.

Chapter III describes and evaluates the potential environmental impacts that may result should the exploratory well be constructed, for each of the topical areas discussed in Chapter II. Chapter IV assesses the potential environmental effects that may result from an accidental event. It also briefly describes methodologies which would be put in place to minimize the likelihood of such events occurring, and control measures to minimize impacts, should an accidental event occur. Should the test well prove successful, Texaco may consider the well for production purposes. Chapter V discusses the types and magnitude of environmental impacts which may occur as a result of longer-term production activities.



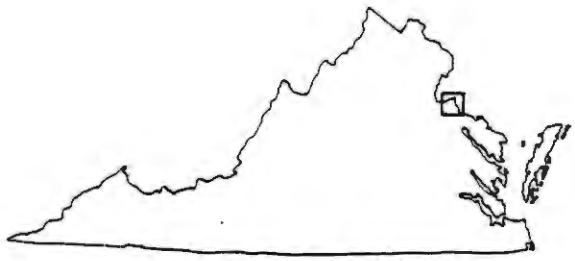


Figure I-1. LOCATION OF PROJECT SITE

Texaco EIA, King George Co., VA

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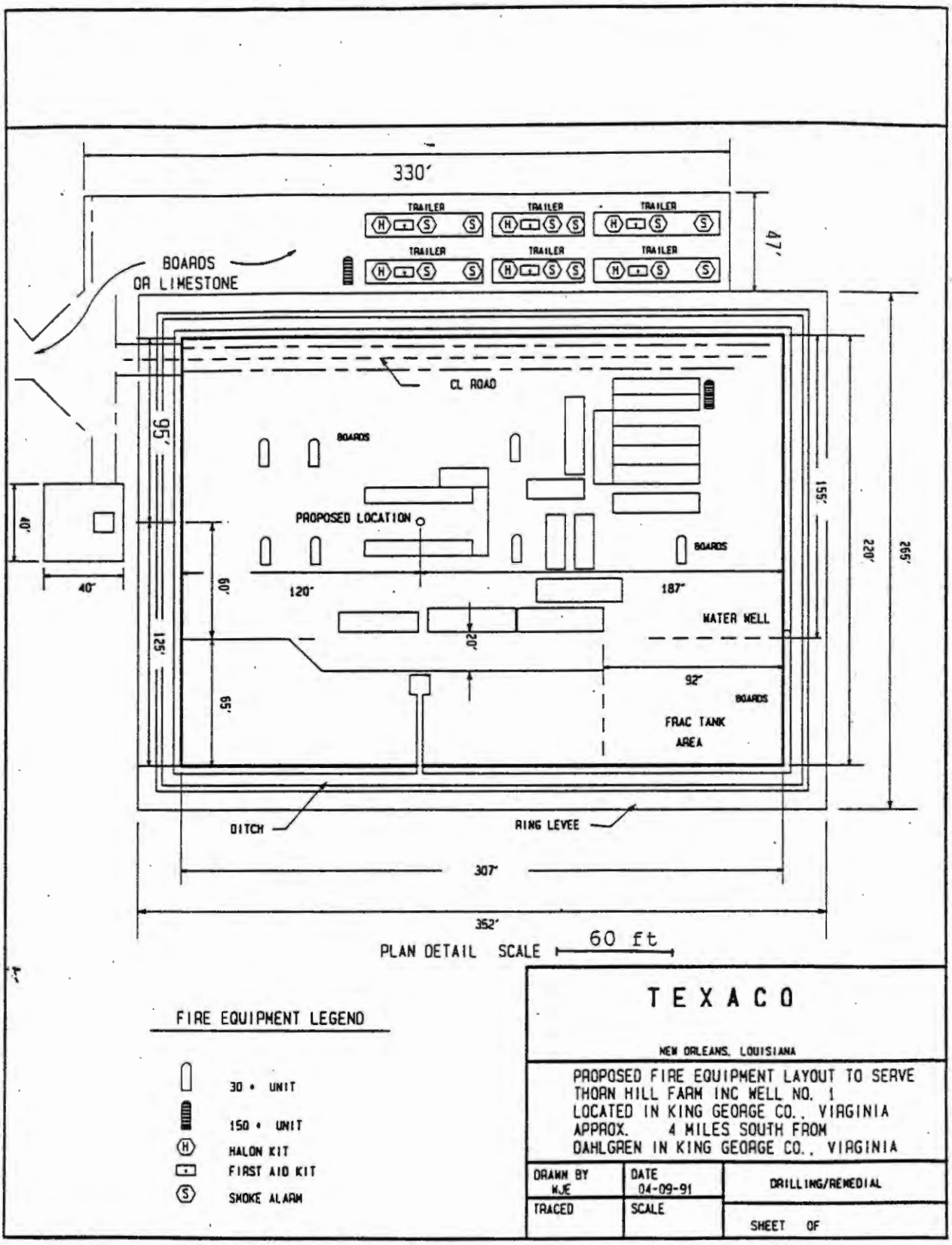

Figure I-2.
DRILL SITE LAYOUT

Texaco EIA, King George Co., VA

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II. EXISTING CONDITIONS

II.A. Ground Water and Geology

1. General Hydrogeological Setting

King George County, Virginia is located within the Virginia Coastal Plain, a local designation for the physiographic province of the Atlantic northern Coastal Plain that extends continuously from North Carolina to Long Island, New York (Figure II-1). The Virginia Coastal Plain consists of an eastward-thickening wedge of generally unconsolidated, interbedded sands and clays, ranging in age from Early Cretaceous to Holocene, and ranging in thickness from more than 6,000 feet beneath the northeastern part of the Eastern Shore Peninsula to 0 feet along the Fall Line (Meng and Harsh, 1988).

Precipitation is the primary source of recharge to the ground-water system within the Virginia Coastal Plain. Average annual precipitation in this area is approximately 43 inches. Thus, each square mile of Coastal Plain area receives an average of 750 million gallons of water per year in precipitation. Of the annual 43 inches of precipitation falling on this area, 10 inches, or 475,000 gallons per day per square mile, effectively recharges the ground-water reservoirs (Meng et al., 1985).

Movement of ground water in the Coastal Plain aquifers is controlled primarily by regional geologic structure, hydraulic gradients, and by differences in permeability. The general direction of ground-water movement is toward the south and east. Where ground water is contained in unconfined aquifers, its movement is controlled by topography and permeability. Ground-water movement is primarily from upland to the low-lying areas along the major stream valleys, and occurs at points of emergence in low areas such as seeps, swamps, and springs, sustaining streamlow during periods of little or no precipitation.

The hydrogeologic framework of the Coastal Plain sediments in Virginia consists of eight confined aquifers, eight confining units, and an uppermost water-table aquifer. The nine regional aquifers, from youngest to oldest, are Columbia, Yorktown-Eastover, St. Mary's-Choptank, Chickahominy-Piney Point, Aquia, Brightseat, upper, middle, and lower Potomac (Figure II-2). A detailed description of each of these hydrogeologic units follows.

a. Columbia Aquifer

The Columbia aquifer consists of the predominantly sand and gravel surficial deposits of Pleistocene and Holocene age. This aquifer correlates with the surficial aquifers in Maryland. The Columbia aquifer is generally unconfined; however, clayey sediments within it may produce local confined or semiconfined conditions (Meng and Harsh, 1988). This aquifer is commonly between 30 and 50 feet thick, but generally thickens eastward to as much as 100 feet.

The Columbia aquifer is most productive in eastern areas of the Coastal Plain and is very thin to missing in western areas (Meng et al., 1985). Well yields commonly range between 5 and 250 gallons per minute (gpm), but may exceed 350 gpm in some areas (Meng et al., 1985). This aquifer is used primarily for domestic water supply, especially throughout the eastern portion of the Virginia Coastal Plain. Wells in these sediments are usually large-diameter shallow wells that are used exclusively for domestic water supplies in older homes. The water in this aquifer is characterized by large concentrations of iron (in excess of 0.3 mg/l) and nitrate (in excess of 10.0 mg/l as nitrogen) (Meng et al., 1988).

b. Yorktown-Eastover Aquifer

The Columbia and Yorktown-Eastover aquifers are separated by the Yorktown confining unit, defined by the predominantly clayey deposits of the upper parts of the Yorktown Formation. These sediments are Pliocene in age and correlate with the upper Chesapeake confining unit in Maryland. This confining unit is wedge-shaped in cross section, dips eastward, and attains maximum thickness (> 100 feet) in the northeastern portion of the Virginia Coastal Plain (Meng and Harsh, 1988).

The Yorktown-Eastover aquifer consists of the predominantly sandy deposits of the Yorktown Formation and the upper part of the Eastover Formation in the Chesapeake Group. These sediments are late Miocene and Pliocene in age and correlate with the upper Chesapeake aquifer in Maryland. This aquifer is overlain by the Yorktown confining unit in the central and eastern parts of the Coastal Plain, and is generally unconfined throughout the western part (Figure II-3). The Yorktown-Eastover crops out in a broad area covering most of the uplands in the western and north-central parts of the Coastal Plain, including all of King George County. This aquifer is commonly between 30 and 200 feet thick, but its thickness may exceed 300 feet in eastern locations.

The Yorktown-Eastover aquifer is primarily used for light industrial and domestic water supply; however, in the eastern portions of the Coastal Plain it supplies most of the water to all users (Meng and Harsh, 1988). Well yields commonly range between 5 and 500 gpm, but may exceed 1,000 gpm in some areas (Meng et al., 1985). The lower part of

this aquifer tends to be characterized by elevated chloride levels in eastern locations (Meng and Harsh, 1988).

c. St. Mary's-Choptank Aquifer

Separating the Yorktown-Eastover and St. Mary's-Choptank aquifers is the St. Mary's confining unit. This confining unit is defined by the clayey facies of the St. Mary's formation. These sediments are middle to late Miocene in age and correlate with the St. Mary's confining unit in Maryland. This confining unit is wedge-shaped in cross section and attains a maximum thickness (>300 feet) in the northeastern portion of the Coastal Plain and thins to nearly zero thickness along its western limit (Meng and Harsh, 1988).

The St. Mary's aquifer is defined by the sandy facies of the St. Mary's and Choptank Formations. These sediments are middle Miocene in age and correlate with the lower Chesapeake aquifer in Maryland. This aquifer is wedge-shaped in cross section, thickens northeastward, and pinches out updip beneath the Chesapeake Bay (Figure II-4). There are no known users of the St. Mary's-Choptank aquifer in Virginia due in part to the availability of water at shallower depths in the Columbia and Yorktown-Eastover aquifers, and due also to the poor quality of water in this aquifer (Meng and Harsh, 1988).

d. Chickahominy-Piney Point Aquifer

The St. Mary's-Choptank and Chickahominy-Piney Point aquifers are separated by the Calvert confining unit, defined by the clayey deposits of the Calvert Formation. These sediments are early to middle Miocene in age and correlate with the lower Chesapeake confining unit in Maryland. In the northeastern and east-central portions of the Coastal Plain this unit is overlain by the St. Mary's-Choptank aquifer, and in the western portion it is overlain by the Yorktown-Eastover aquifer. This confining unit is wedge-shaped in cross section, thickens and dips eastward attaining a maximum thickness (350 feet) in the northeast and minimum thickness (0 feet) along the Fall Line (Meng and Harsh, 1988).

The Chickahominy-Piney Point aquifer is defined by the sandy deposits of the Chickahominy and Piney Point Formations. These sediments are middle to late Eocene in age and correlate with the Piney Point-Nanjemoy aquifer in Maryland. This aquifer is commonly between 100 and 300 feet thick, but generally thickens eastward attaining thicknesses that may exceed 300 feet (Figure II-5).

The Chickahominy-Piney Point aquifer is an important aquifer in central portions of the Coastal Plain. Well yields commonly range between 10 and 350 gpm, but may exceed 700 gpm in some areas (Meng et al., 1985). This aquifer is used primarily for domestic,

small industrial, and municipal wells. The water contained in this aquifer is a soft calcium-sodium bicarbonate type, suitable for most uses (Meng et al., 1985).

e. Aquia Aquifer

The Chickahominy-Piney Point and Aquia aquifers are separated by the Nanjemoy-Marlboro Clay confining unit, defined by the clayey deposits of the Nanjemoy and Marlboro Clay Formations. This confining unit is comprised of two distinctly different formations- the lower Marlboro Clay and the upper Nanjemoy (Meng and Harsh, 1988). These sediments are latest Paleocene to middle Eocene in age and correlate with the Nanjemoy-Marlboro confining unit in Maryland. This confining unit is wedge-shaped in cross section and thickens to the northeast to a maximum depth of approximately 175 feet. The Marlboro Clay is areally limited to the northern half of the Coastal Plain while the Nanjemoy is areally extensive throughout the Coastal Plain and comprises the majority of this confining unit (Meng and Harsh, 1988).

The Aquia aquifer is defined by the predominantly sandy facies of the Aquia Formation. These sediments are late Paleocene in age and correlate to the Aquia aquifer in Maryland. The Aquia overlies three separate hydrogeologic units- the Brightseat confining unit in the north-central area, the upper Potomac confining unit in the central and southern regions; and the middle Potomac confining unit in the western region. The Aquia is a continuous, elongate, lenticular sand body that thins slightly to the west and greatly to the east, pinching out near the western edge of the Chesapeake Bay (Figure II-6). The Aquia aquifer dips eastward and is commonly between 100 and 400 feet thick, but thicknesses may exceed 500 feet in the northwestern region of the Coastal Plain (Meng et al., 1985).

The Aquia is an important aquifer in the northern two-thirds of the Coastal Plain, yielding moderate supplies to domestic, small industrial, and municipal wells (Meng et al., 1985). Well yields commonly range between 20 and 200 gpm, but may exceed 600 gpm in some areas. The water contained in this aquifer is described as a soft sodium bicarbonate type with iron locally exceeding 0.3 mg/l (Meng et al., 1985).

f. Brightseat Aquifer

Separating the Aquia and Brightseat aquifers is the Brightseat confining unit, defined by the uppermost clay bed of the interbedded sand and clay sequence of the Brightseat Formation. These sediments are early Paleocene in age and correlate with the Brightseat confining unit in Maryland. In the northwestern part of the Coastal Plain, the Brightseat Formation comprises the upper part of the middle Potomac confining unit that separates the underlying middle Potomac aquifer from the overlying Aquia aquifer. In contrast, the Brightseat Formation in the north-central and northeastern portion of the Coastal Plain wholly

comprises the Brightseat confining unit that separates the underlying Brightseat aquifer from the overlying Aquia aquifer (Meng and Harsh, 1988). This confining unit attains a maximum thickness of 62 feet in the northern portion of the Coastal Plain and thins to nearly zero thickness along its western and southern limits.

The Brightseat aquifer is defined as all interbedded sands of early Paleocene age in the Coastal Plain and correlates with the Brightseat aquifer in Maryland. This aquifer dips eastward and is lenticular in cross section. It is commonly between 350 and 800 feet thick, but thicknesses may exceed 900 feet in some areas (Figure II-7) (Meng et al., 1985).

The Brightseat aquifer provides water to numerous industrial and municipal users, especially the seafood-processing industries in north-central portion of the Coastal Plain (Meng and Harsh, 1988). Wells generally yield between 50 and 350 gpm, but yields may exceed 700 gpm in some areas (Meng et al., 1985). The water in this aquifer is described as being a soft, sodium bicarbonate type containing less than 200 mg/l dissolved solids (Meng et al., 1985).

g. Upper Potomac Aquifer

The Brightseat and upper Potomac aquifers are separated by the upper Potomac confining unit, defined by the major clayey strata directly above the upper Potomac aquifer. These sediments are Late Cretaceous in age and correlate with the Patapsco confining unit in Maryland. This confining unit is overlain by the Brightseat aquifer in the north-central and northeastern portion of the Coastal Plain, and by the Aquia aquifer throughout the remainder of its extent (Meng and Harsh, 1988). This confining unit thickens and dips to the northeast, attaining a maximum thickness of 126 feet.

The upper Potomac aquifer is defined by the sandy sediments of Late Cretaceous age, correlating with the upper sediments of the Patapsco aquifer in Maryland. This aquifer dips eastward attaining a maximum thickness of 425 feet in the northeastern portion of the Coastal Plain, and pinches out along its western subsurface limit throughout the west-central portion of the Coastal Plain (Figure II-8) (Meng and Harsh, 1988). The upper Potomac aquifer is a multi-zone unit consisting of stratified sands and clays. This aquifer provides water to most light industrial and municipal ground-water users throughout the central portion of the Coastal Plain. The upper Potomac is capable of producing large quantities of generally good water, with well yields commonly ranging between 100 and 2,500 gpm. The water of the aquifer contains large concentrations of iron (in excess of 0.3 mg/l), sodium (in excess of 100 mg/l), and fluoride (in excess of 1.4 mg/l) in some eastern areas (Meng and Harsh, 1988).

h. Middle Potomac Aquifer

Separating the middle and upper Potomac aquifers is the middle Potomac confining unit, defined by the major clayey strata directly above the middle Potomac aquifer. These sediments are late Early Cretaceous in age and correlate with the Patapsco confining unit in Maryland. This confining unit overlies the middle Potomac aquifer and is overlain by the upper Potomac aquifer, except in the western portion of the Coastal Plain where it is transgressed by the Aquia aquifer (Meng and Harsh, 1988). The thickness of this confining unit is variable, but attains a maximum (203 feet) in the northeastern portion of the Eastern Shore Peninsula and thins to nearly zero thickness along its western limit near the Fall Line (Meng and Harsh, 1988). The clays identified as the middle Potomac confining unit are not a single, and areally extensive layer, but rather, are a series of interfingering deposits. Water-level data indicate that these clays act locally as confining units and, when viewed regionally, constitute a single confinement (Meng and Harsh, 1988).

The middle Potomac aquifer is comprised of the sandy sediments of the Potomac Formation. These sediments are late to middle Early Cretaceous in age and correlate with the lower part of the Patapsco aquifer in Maryland. The middle Potomac aquifer consists of interlensing medium sands, silts, and clays of differing thickness. This aquifer generally dips eastward, attaining a maximum thickness (930 feet) in the northeastern portion of the Coastal Plain and thinning to nearly zero thickness along its western limit near the Fall Line (Figure II-9).

The middle Potomac aquifer is capable of producing large quantities of high-quality ground water in the western half of the Coastal Plain, but lies too deep for all but large industrial users in the eastern half (Meng and Harsh, 1988). Well yields commonly range between 100 and 1,500 gpm. The water of this aquifer is characterized by a high chloride concentration (in excess of 250 mg/l) in eastern portions of the Coastal Plain.

i. Lower Potomac Aquifer

The middle and lower Potomac aquifers are separated by the lower Potomac confining unit, defined by the major clayey strata directly above the lower Potomac aquifer. These sediments are middle Early Cretaceous in age and correlate with the Potomac confining unit of Maryland. This confining unit attains a maximum thickness (173 feet) in the northeastern portion of the Coastal Plain and thins to nearly zero thickness along its western limit near the Fall Line.

The lower Potomac aquifer is defined by the sandy sediments of the Potomac Formation. These sediments are early to middle Early Cretaceous in age and correlate with the Patuxent aquifer in Maryland. The lower Potomac aquifer is the lowermost confined aquifer in the hydrogeologic framework of the Virginia Coastal Plain region. It rests entirely

on the basement surface and is overlain throughout its extent by the lower confining unit. This aquifer dips eastward, attaining a maximum thickness (3,010 feet) in the northeastern portion of the Coastal Plain and thinning to nearly zero thickness along its western limit near the Fall Line (Figure II-10) (Meng and Harsh, 1988).

Few wells drilled in the Virginia Coastal Plain penetrate the lower Potomac aquifer. This aquifer is capable of producing large quantities of water, but generally lies too deep for all but large industrial applications. In addition, the lower Potomac aquifer contains higher chloride concentrations (in excess of 250 mg/l) in eastern areas further restricting its usage as a potable source of water (Meng and Harsh, 1988).

The lower Potomac aquifer unconformably overlies the basement crystalline rocks that range in age from Precambrian to Lower Paleozoic. This complex of rocks consists mainly of massive igneous and metamorphic rocks, but also includes unmetamorphosed, consolidated sediments and igneous intrusives of probable Triassic age within isolated grabens and half-grabens (Meng and Harsh, 1988).

2. Local Hydrogeological Setting

Local subsurface geology within the Virginia Coastal Plain will differ from the general regional description as a result of varying depositional and post-depositional processes. A description of the local geology in close proximity to the proposed Texaco drill site is obtained from data contained in the Oak Grove core (Reinhardt et al., 1980) (Figure II-11). Meng and Harsh (1988) present a stratigraphic section of the Coastal Plain sediments from the Oak Grove core (Figure II-12).

The Quaternary deposits in this area are not considered to be an important source for ground water, except for shallow farm and domestic wells. However, these deposits have an important role in the hydrogeology of the area as they extend beneath the Potomac River (Slaughter and Otton, 1968) forming a mantle of mud, silt, sand, and gravel between the brackish river water and the underlying Tertiary and Cretaceous formations. Along the Virginian shore of the river, basal gravel deposits directly overly the Aquia aquifer (Figure II-13). However, any potential vertical movement of brackish river water into the Aquia aquifer, as the result of heavy pumping in the Aquia, would more than likely be restricted by several feet of alluvial river mud that overlies the basal gravel deposits (Slaughter and Otton, 1968).

3. Surface Soils

Nine major soil series are present in the vicinity of the project site (Figure II-14). The two most common series are the Sassafras fine sandy loam (2 to 6% to 6 to 10% slopes) and the Galestown - Sassafras complex (6 to 15% and 15 to 30% slopes). Most of the agricultural areas, including the location of the proposed drill site, occur on the less steeply sloped soils of these two series. Sassafras soils formed in sandy and loamy Coastal Plain sediment and consist of deep well-drained soils. Galestown soils are deep, somewhat excessively drained and occur on sloping or steep slopes in uplands. They formed in sandy Coastal Plain sediments (SCS, 1974).

Four other less common soil types that also support agricultural activities on the site are the Bourne fine sandy loam (2 to 6% slopes), the Tetotum fine sandy loam (0 to 2%, 2 to 6%, and 6 to 10% eroded slopes), the Craven loam (0 to 2% slopes), and the Pooler loam (thin solum variant). The Bourne and Tetotum soils occur on broad, nearly level, upland ridges and are moderately well drained. They formed in loamy sediments on the Coastal Plain. The Pooler series consists of deep, somewhat poorly drained, nearly level soils that formed in loamy and clayey Coastal Plain sediment. The Craven loam is a deep, moderately well drained soil occurring on level or gently sloping land. Unlike the preceding soils, it was formed exclusively in clayey sediments (SCS, 1974).

Forested areas of the site occur on the more steeply sloping soils of all of the aforementioned soil series. In addition, forests occur on the single unit of Caroline - Sassafras complex within the property boundaries and on the wet Alluvial Land adjacent to all intermittent and perennial streams. Caroline soils are deep and well drained, and occur on slopes of gentle to steep pitch. They formed in stratified loamy and clayey sediments of the Coastal Plain. Alluvial Land, Wet is local alluvium deposited in long, narrow drainageways and small streams. These areas are subject to frequent flooding and seepage occurs where this soil adjoins uplands. Understandably, this soil is hydric. It and Tidal marsh, the final soil type on the site and another form of alluvial deposit, are the only hydric soils on the property (SCS, 1974).

II.B. Surface Water Resources

1. Physiography

The proposed test drill site is located within the Upper Machodoc Creek watershed, which is a tributary to the Potomac River estuary (Figure II-15). The watershed is approximately 54,520 acres (85 sq. mi.) in area (MMC, 1979). The Upper Machodoc Creek is located just south of the Dahlgren Naval Surface Weapons Center, and confluences with the Potomac River approximately three miles downstream of the Route 301 bridge. The

watershed is predominantly undeveloped, with primary land uses including open lands, woodlands, and agriculture.

The Creek is approximately 17.5 miles long from the point of its perennial headwaters to its mouth. Major tributaries to the Creek include: Pepper Mill Creek, Poplar Neck Creek, Deep Creek, and Williams Creek. Numerous smaller and intermittent tributaries also drain into the Creek.

The limit of tidal influence along the Upper Machodoc Creek is located approximately 8.1 miles upstream from the mouth of the Creek. This limit is approximately 2.8 miles upstream of the point where tributaries draining the project site confluence with the Creek. The mean tidal range of the Potomac River at the point of confluence with the Upper Machodoc Creek is approximately 1.4 feet (mean low to mean high tide). This reach of the Upper Machodoc is relatively protected from turbulent inflows from the Potomac by its meandering path around Tetotum Flats and Pumpkin Neck. Average depth is about 2.3 m (7.5 feet) (MMC, 1979).

The smaller tributary stream channels in this region are well incised with relatively steep slopes. In its lower (tidal) reach, the Upper Machodoc Creek is characterized as having a relatively flat (approximately 0.6 feet per mile) slope, and meanders through marshes and wetlands as it flows toward its confluence with the Potomac River.

Route 205 borders the south side of the project site and forms the drainage divide between the Upper Machodoc and Rosier Creek drainage basins. Drainage from the proposed project site is via two tributaries that drain directly to the Upper Machodoc Creek (Figure II-15). One tributary is located to the west of the western boundary of the leased property. The second tributary channel begins just east of the drill site, and drains north through the leased property. Each tributary is approximately 0.6 miles in length, with average slopes of 40 to 50 feet per mile. The combined drainage area of the two tributaries is approximately 0.35 square miles.

These tributary headwaters begin approximately 400 to 500 feet north of (and downslope of) the drill site. Flow in these channels is intermittent, based on the USGS Champlain 7.5' quadrangle (USGS, 1983). However, the natural drainage of the western tributary has been altered substantially by the property owner. Cut and fill has been used to create two artificial ponds and vehicle access across the stream. Each pond is contained by an earthen embankment, graded on top for vehicular cross-over. Each embankment has two 12 inch galvanized pipes to provide downstream drainage from the ponds to the tributary channel. The upper-most pond is located approximately 1,500 feet below the beginning of the tributary headwaters. The lower pond is located approximately 2,300 feet below the beginning of the tributary headwaters.

2. Water Quality

The Virginia Water Control Board (VWCB, 1990) operates two water quality monitoring stations within the Upper Machodoc Creek basin: one on Williams Creek (at Route 206); and one on the Upper Machodoc Creek at Route 218, approximately 0.6 mile downstream of the confluence of the center tributary of the project site and the Upper Machodoc (see Figure II-15).

Water quality data are collected by the state at these stations for use in fulfilling their reporting requirements under the Federal Water Pollution Control Act [Section 305 (b)]. Under this Act, states are required to monitor surface waters and report on the progress of attaining fishable/swimmable surface water quality goals set forth in the 1972 Clean Water Act (CWA), and for other uses designated by the state (VWCB, 1990).

Available water quality data were obtained through the VWCB from the STORET database for these two stations for the last five years (VWCB, 1991). The data sets obtained include monthly measurements spanning the five year period from January 1985 to October 1990, but are discontinuous. It is, therefore, difficult to draw definitive conclusions regarding specific chemical parameters. However, some generalizations can be drawn from the data, as described below.

Temperature measurements of the Upper Machodoc Creek range from 0.3 to 33.6 °C (32.5 to 92.5 °F). Averages for each of the twelve months range from 1.9 °C (January) to 29.4 °C (July) (35.4 to 84.9 °F). The pH measurements of the Upper Machodoc Creek range from 5.7 to 8.9, with averages for each of the twelve months ranging from 6.8 to 7.6 (VWCB, 1991).

Total alkalinity (mg/l CaCO3) measurements range from 10 to 5,020 mg/l, but generally range from 18 to 64 mg/l. A range of 24 (February) to 54 (September) was recorded in 1990. Field conductivity measurements range from 45 to 17,160 micromhos/cm, with higher readings generally recorded in the summer and fall months (June through November). Salinity was measured in January 1985, at 4 parts per thousand, with no additional data available. Total chloride measurements ranged from 103 to >5,000 mg/l. Data for 1990 ranged from 103 (May) to 3,590 mg/l (September) (VWCB, 1991).

Dissolved oxygen (DO) measurements over the five-year period ranged from 5.4 to 14.3 mg/l, and 62.9 to 120.2 percent saturation. Measurements for 1990 ranged from 6.8 mg/l (July) to 12.3 mg/l (February), and 73.6 % (May) to 109% (September) (VWCB, 1991). This indicates that the system is well oxygenated, as waters over 5 mg/l (or 5 ppm) are generally considered more than adequate to sustain aquatic biota.

Table II-1 presents a comparison of selected parameters for the Upper Machodoc Creek with measurements of two streams in eastern Virginia sampled during the EPA National Stream Survey (USEPA, 1988). These streams are Marshall Creek (Westmoreland Co., VA) and an unnamed stream in Lancaster Co., VA (southeast of Westmoreland Co., and north of the Rappahannock River). Data were obtained for these streams from two sets of measurements. Based on the temperature ranges it is probable that these samples were taken in early winter or spring. The Upper Machodoc Creek data ranges are reflective of annual variations, as recorded on a monthly basis.

The most recent measurements of metals concentrations in the water column were recorded in October 1989 (Table II-2). Also shown in the table are current EPA drinking water standards for each of the metals measured. A comparison indicates concentrations recorded for Upper Machodoc Creek are below the EPA drinking water standards for all of the listed compounds, except for iron and manganese.

The VWCB "305 (b) Report" characterizes the Upper Machodoc Creek as fully supporting the CWA goals for fishable/swimmable waters, with no violations of state standards for pH, temperature, dissolved oxygen, and fecal coliform levels. Williams Creek was also characterized as fully supporting the CWA fishable/swimmable waters goal. This stream is nutrient enriched, and showed 7% of the samples violated fecal coliform bacteria criteria (any sample in excess of 1,000 fecal coliform cells per 100 ml of water). The Dahlgren "A" sewage treatment plant discharges to Williams Creek. This facility consists of primary sewage lagoons, chlorination, dechlorination and a polishing pond for 0.175 MGD flows to Williams Creek. The facility is to be upgraded and expanded to 0.325 MGD by early 1991 (VWCB, 1990).

3. Aquatic Biota

Only limited information is available regarding fish, plankton, and benthic communities within the Upper Machodoc Creek system. Contacts with numerous state, interstate, and research organizations located no recent studies of biological species in the watershed.

The Virginia Department of Game and Inland Fisheries maintains a warm water stream survey program for Biota of Virginia (BOVA). This program has computerized all available data throughout the state including historic collections (dating as far back as the 1800's) as well as the results of ongoing systematic surveys which began in 1985. However, a search of the computer database revealed no available information for Upper Machodoc Creek, or any of the nearby Virginia streams of similar character (Rosier Creek, Mattox Creek, or Popes Creek) (VDGIF, 1991).

Numerous studies have been conducted for the Potomac River basin. However, these have focused mostly on Maryland tributaries, or upstream reaches of the Potomac estuary. Some generalizations can be drawn, however, from the information presented in the "Environmental Atlas of the Potomac Estuary" (MMC, 1979). Although dated, this document and its folio maps present some data, information, and extrapolations for the tidal reach of the Upper Machodoc Creek. The remainder of this section is drawn largely from the Environmental Atlas.

Two points must be emphasized when evaluating the potential existence of aquatic species for this study. First, the following discussions describe species that may occur in habitats with conditions similar to those of the Upper Machodoc Creek. However, not all species discussed are expected to exist in the Creek. The information provided suggests that the Upper Machodoc Creek is typical of tidal creeks within this region of the Potomac River basin, and is unlikely to harbor any unique species or habitats. Second, the biota described below may occur in the Upper Machodoc Creek, but most would not occur in any of the intermittent tributaries draining the project site.

a. Habitat Conditions

Bottom sediments of the Upper Machodoc Creek can be generally categorized as soft muds and silts of low to moderate compactions, with silt generally increasing with depth. Submerged rooted aquatic vegetation is expected to occur along the shoreline (MMC, 1979).

The downstream portion of the Creek is classified as oligohaline (0.5 to 5 ppt) in the spring, and mesohaline (5 to 18 ppt) in the fall, for both surface and bottom. Typically, the Creek reaches its lowest salinity (2-3 ppt surface, 4-5 ppt bottom) in May, and its highest salinity (9-10 ppt, both surface and bottom) in November (MMC, 1979).

b. Algae

A dominance of estuarine dinoflagellates and diatoms may be expected in the most downstream portion of the Creek (downstream of Deep Creek). A general distribution of seaweeds (Ulva lactuca and Enteromorpha prolifera) may also be expected in this reach, particularly near the shorelines. Blue and red flagellates and golden-brown algae may appear, at times in high numbers in the winter (MMC, 1979).

c. Zooplankton

The zooplankton community in the higher salinity reaches of Upper Machodoc River, near its mouth, is likely to be similar to that observed in this region of the Potomac River.

The calanoid copepods Acartia tonsa and Eurytemora affinis are likely to be dominant forms, in warmer and colder months, respectively. Other taxa such as barnacle nauplii, polychaete larvae, and ichthyoplankton, may at times be observed in considerable abundance. Numerous cladoceran species, including Bosmina longirostris, Diaphanosama leuctenbergianum, Moina micrura, and cyclopoid copepods are more likely to be observed in the fresher, upstream reaches of the Creek (Jacobs et al, 1990).

Based on known salinity tolerances, the lower most reach of the Upper Machodoc may harbor sea nettle polyps over winter, which emerge as medusae in late May and early June. Seasonal distributions of winter jellyfish, moon jellyfish, and ctenophores may extend into this lower reach of the Creek (MMC, 1979).

d. Benthic Invertebrates

Based on salinity, sediment, vegetation and habitat information, a diverse assemblage of benthic macroinvertebrates typical of mid to low salinity tidal creeks is likely to occur in the Upper Machodoc Creek, as shown in Table II-3. Substantial numbers of blue crab may also occur in the summer in the Upper Machodoc, particularly downstream of Williams Creek, but possibly as far upstream as the project site (MMC, 1979).

Occurrences of both soft-shell and brackish-water clams may exist in the lower most reach of the Creek. The area upstream of the confluence with Williams Creek had been closed to general shellfish harvesting as of 1976 by the Virginia Department of Health. The current status of this closure could not be confirmed. As of the 1979 publication, two oyster bars are shown to exist on the shelf of the Potomac River at the mouth of the Upper Machodoc (Tylers Lump and Walkers Bar) (MMC, 1979).

e. Fishes

Given the depth and salinity habitats, several species of estuarine fish may occur in the Creek from the mouth to the project site as shown in Table II-4. Upstream of the project site, banded killifish, mummichog (killifish), and tidewater silverside may occur (MMC, 1979).

Based on the salinity, depth, and vegetative habitats in the Creek, conditions may exist to support spawning of, or a nursery activities for, several common fishes, particularly along the shoreline and shelves of the lower reach of the Creek as shown in Table II-5 (MMC, 1979). Although listed as a potential species for these habitat conditions, the striped bass is not expected to spawn to any significant degree in creeks such as the Upper Machodoc.

Spawning migration of the alewife and blueback herring may occur along the Upper Machodoc to as far as approximately 7 miles upstream of the Potomac River. Movement may also extend up Poplar Neck Creek. Although undocumented, it is also probable that yellow perch (Perca flavescens) spawn in the upstream reach of the Creek between Pepper Mill Creek and Poplar Neck Creek (MMC, 1979).

II.C. Vegetation and Wildlife

1. Vegetation

Floristically, the site is located in the Atlantic Slope Section of the Oak-Pine Forest Region (Braun, 1950). Vegetation consists of the three major cover types, agricultural fields, second growth forests, and tidal marshes. The agricultural lands are almost entirely in pasture and represent roughly 35 percent of the property. Pastures are dominated by a mixture of forage grasses (e.g. Agrostis spp., Poa spp.), goosegrass Eleusine indica, and little bluestem Andropogon scoparium.

Six tributary and headwater corridors on the lease property and their adjacent slopes are the principal locations of the second growth forests. Forests in these areas display gradients of vegetation from locally moist ravines with perennial or intermittent streams to drier upland sites. Stream valleys include a variety of canopy dominants such as sycamore Platanus occidentalis, sweet gum Liquidambar styraciflua, chinquapin oak Quercus muhlenbergii, bitternut hickory Carya cordiformis, and American beech Fagus grandifolia. The understory is dominated by spicebush Lindera benzoin, musclewood Carpinus caroliniana, and American holly Ilex opaca. Christmas fern Polystichum achrosticoides, jewelweed Impatiens capensis, and poison ivy Toxicodendron radicans were the only obvious ground covers at the time of the site visit in late October.

On slopes above the streams, tulip Liriodendron tulipifera, white ash Fraxinus americana, pignut hickory Carya glabra, and northern red oak Q. rubrum are the canopy dominants. Red maple Acer rubrum, black cherry Prunus serotina, and mazzard cherry P. avium, also occasionally occur in the canopy. Persimmon Diospyros virginiana appears in the subcanopy along with flowering dogwood Cornus florida and hercules club Aralia spinosa. Wood fern Dryopteris sp., pokeweed Phytolacca americana, sensitive fern Onoclea sensibilis, and japanese honeysuckle Lonicera japonica were the principal ground covers.

At the top of the slopes, black cherry, white oak Q. alba, tulip, and southern red oak Q. falcata become the canopy dominants. Some drier portions of the uplands also include loblolly pine Pinus taeda, pitch pine P. rigida, and Virginia pine P. virginiana as canopy dominants. Catbrier Smilax glauca is prominent in upland understories along with Virginia

creeper Parthenocissus quinquefolia, poison ivy, and wild grape Vitis sp. Black locust Robinia pseudoacacia, tree of heaven Ailanthus altissima, and box elder Acer negundo are common in previously disturbed areas and in forest openings. Black walnut Juglans cinerea occurs at forest edges as do several species of raspberries Rubus spp.

Tidal marshes are dominated by a variety of emergent aquatic species including cattails Typha spp., rushes Juncus spp., bulrushes Scirpus spp., arrowhead Sagittaria sp., and common reed Phragmites australis.

2. Wildlife

Direct observation or sign for 18 species of wildlife were noted during a single afternoon site visit on 26 October 1990 (Table II-6). The site's wildlife are primarily associated with the wooded areas and the ecotone between forested and agricultural lands. The previously described forest communities contain various patches of vegetation within them that are particularly suited to functionally similar groups of wildlife known as guilds. One example of a guild would be species that feed on adult and larval insects in the leaf litter on the forest floor. This guild would include shrews, white-footed mice and several species of birds. Other guilds can be identified that are associated with other sub-sections of the forest such as the leaves and twigs in the canopy, the holes of mature trees, or the edge between forest shrubs and adjacent open areas in the agricultural fields. Overall, the forests and their associated edges contain a diversity of vegetation patches that provide suitable habitat for a variety of guilds and their associated species.

In contrast, the agricultural areas, because they are structurally and compositionally simplistic, offer very few types of patches for use by wildlife, even during the growing season. Pastures provide limited nesting habitat and cover during the summer months and thus serve primarily as foraging areas for species such as whitetail deer, eastern cottontail, and some species of birds such as song sparrows and red-winged blackbirds. Such areas provide year-round habitat primarily only for meadow voles, although resident herbivores such as the eastern cottontail and carnivores such as weasels and foxes will forage there in all seasons.

Upon request, the Virginia Division of Natural Heritage has confirmed that no threatened or endangered species are recorded to exist within the lease boundaries. A letter to this effect is included in Appendix A.

II.D. Wetlands

Surface drainage on the lease property consists of six headwater and intermittent tributary channels that drain northward into the Upper Machodoc Creek, which flows eastward, and forms the northern boundary of the property. The Dahlgren USGS quadrangle National Wetlands Inventory (NWI) map (Figure II-16) depicts four types of wetlands as occurring on the lease property. Three of these are various types of tidal marsh: Estuarine Intertidal Emergent Irregularly-flooded Broad-leaved persistent marsh (E2EMP6), Estuarine Intertidal Regularly-flooded Non-pioneer Vegetated Flat (E2FLN6), and Estuarine Subtidal Intermittently Exposed Open Water marsh (E1OWL6). The fourth wetland type is Palustrine Forested Broad-leaved Deciduous Temporarily-inundated wetland (PF01A). This description is applied to the immediate channels of the unnamed tributaries to Upper Machodoc Creek.

The King George County Tidal Marsh Inventory (KGCTMI) (Figure II-17) indicates virtually the same distribution of tidal marshes on the property as does the NWI map. These marshes are numbered 26, 27, 28, 29, and 30 on the KGCTMI map.

The field inspection of the site concurred with both the NWI and KGCTMI maps of wetlands on the site. In particular it was noted that fresh-water, non-tidal wetlands were limited to within or immediately adjacent to the banks of the unnamed tributaries to Upper Machodoc Creek. Thus, under current regulations, these streams are primarily waters of the United States and of the Commonwealth of Virginia.

II.E. Economics

1. Socio-economic Overview

Socio-economic information for King George County is primarily compiled by the Rappahannock Area Development Commission(RADCO) (Beard, 1990). RADCO is a state agency that provides economic development planning and assistance for Stafford County, Spotsylvania County, Caroline County, the City of Fredericksburg, and King George County. RADCO assisted the King George County Planning Commission in preparing the King George County Comprehensive Plan (KGCPC, 1990). Information presented below is compiled from material received directly from RADCO as well as the Comprehensive Plan. The data provided is based on 1980 Census results, as well as other data collected by various state agencies in recent years (Beard, 1990).

Of the municipalities in the RADCO region, King George County has the smallest population. It is also the only county of the region not impacted or affected by the I-95 corridor, which is responsible for substantial economic growth in the other municipalities (Beard, 1990).

The primary economic focal point of King George County is the Dahlgren Naval Surface Weapons Center, which is responsible for several high-technology and defense contractor employers having established operations in the County. Approximately 3,800 people are employed at the Dahlgren facility, with only a small percentage comprised of military personnel (Beard, 1990).

King George County maintains a reputation for its rich heritage and its natural resources. Caledon State Park (just north of the Upper Machodoc Creek watershed, along the Potomac River) is a wildlife refuge for nesting bald eagles. The county continues to remain a rural county, with relatively little demand for housing development or the associated supporting infrastructure. Many of those who work in King George County live outside of the county (Beard, 1990).

The principle economic centers of the county are the Route 301 corridor at Dahlgren, and King George Courthouse, which is the county seat. General "leakage" areas are to Maryland, across the Route 301 bridge, and Fredericksburg, located just west of King George County (Beard, 1990).

2. Population

Estimates prepared by the Virginia Employment Commission for historic, current and projected population in King George County are (VEC, 1988):

Year	Population
1980	10,543
1988	12,500
1990	13,000
2000	15,100
2010	17,200
2020	19,300
2030	21,400

The population increase between 1980 and 1988 was 18.6% (VEC, 1990). The average annual growth rate for the 1980 to 1988 period was 2.2%. The projected annual growth rate for the 1988 to 2000 period is 1.5%. This compares to projected growth rates in other RADCO municipalities of: Caroline County -- 1.4%; Fredericksburg City - 0.5%; Spotsylvania County -- 2.6%; Stafford County -- 1.9%. Predicted annual growth rate for 1988 to 2000 for the Commonwealth of Virginia is 0.9%, and for the country as a whole is 0.7% (CPS, 1990).

The population density per square mile in 1988 was 69.4 (CPS, 1990). The percentage of population by age bracket is shown below for the 1988 county population (RADCO, 1988):

Age Bracket	Percent of Population
0 - 9	15.8
10-19	16.5
20-29	15.5
30-39	15.1
40-49	14.0
50-59	9.6
60-69	7.6
70-79	4.2
80+	1.5

3. Housing

As of 1980, 3,513 housing units existed within King George County. Owner-occupied units accounted for 74%, and renter occupied units accounted for 26%. Between 1981 and 1989, 1,356 residential building permits were issued in the county. Of this total, 94% were single family unit permits, and 6% were for multifamily units (including duplexes).(RADCO, 1988)

4. Economic Characteristics

a. Employment

According to the Comprehensive Plan, the overall number of jobs in the county has been steadily growing, increasing from 4,830 (1983) to 6,267 (1989), representing an increase of approximately 30% over the seven year period. A breakdown of 1989 employment by sector is provided below (KGCPC, 1990):

Sector	Number of Positions
Agriculture, Forestry Fishery	8
Mining	D
Construction	213
Manufacturing	245
Lumber	34
Trans., Comm., PU	91
Trucking-Warehouse	134
Wholesale Trade	95
Retail Trade	405
Financial, Insurance, Real Estate	91
Services	1,153
State Government	34
Local Government	476
Federal Government	3,287

(D in table indicates disclosure suppression in the source document.)

The Federal government sector offers by far the largest number of positions, accounting for 52% of all reported positions in the county in 1989. This sector has grown by 9.5% since 1983. Major employers in the county include Dalhgren Naval Surface Weapons Center, White Packing Company (meat packing), Vitro Corp., Computer Sciences Corp., EG&G, Heritage Health Care (nursing home), Sperry Corp., and Syscon Corp. Except as noted, these employers are government contractors (KGCPC, 1990).

The private "services" sector accounts for the largest increase in the number of jobs, jumping from 469 (1983) to 1,153 (1989). The construction industry, however, has experienced the highest rate of increase, 157% between 1983 and 1989. The number of positions for manufacturing employment has been declining since 1985, from a high of 476 to 245 (1989), which represents the lowest level for this sector for the entire 1983-89 period.

In general, the labor force and economy of the county are reported adjusting to the changes that are occurring. The primary sector of concern is the level of Federal spending at the Naval Surface Warfare Center and its associated contractors in the county. Fluctuations in Federal spending associated with these operations are expected to have significant impact

on the county because the economy of the county is so greatly connected to these operations (KGCPC, 1990).

The unemployment for King George County was 4.0% in 1989, second lowest of the RADCO communities. This was up from 3.7% in 1988, but down from 8.5% in 1982. For comparison, the average unemployment rate for the Commonwealth of Virginia was 4.1% (1989); the 1989 rate for Westmoreland County was 7.6% (1989) (KGCPC, 1990).

b. Income

In 1987, 33.7% of tax returns for the county showed adjusted gross income of $30,000 or more. For the same year 38.7% showed adjusted gross incomes of $15,000 or less (KGCPC, 1990). The 1989 (actual) median family income was $37,599. The projected median for 1990 is $39,848 (CPS, 1985).

Between 1980 and 1987, Total Personal Income in King George County grew at an average annual rate of 9.8%, from $98,226,000 (1980) to $186,400,000 (1987). This compares to the average growth rate for the RADCO region of 11.3%, and for the state, 9.0% for the same period. In 1987, per capita income in King George County was $15,154 (CPS, 1990), up from $8,553 in 1980 (RADCO, 1988).

Taxable sales in the county for 1988 were $35,150,000 (or $2,812 per capita), comprising 3.6% of the total taxable sales for the RADCO region. This ranks well below the other municipalities of the RADCO region: Caroline County, 4.8%; Stafford County, 20.6%; Fredericksburg City, 27.5%; Spotsylvania County, 43.4%. (CPS, 1990) Taxable sales for King George County increased by 84% between 1980 and 1987 (RADCO, 1988).

5. Utilities

a. Electricity

Electricity for the county is supplied by Virginia Power Co. and Old Dominion Cooperative. The electricity is distributed by Virginia Power, Northern Neck Electric Cooperative, and Rappahannock Electric Cooperative (VPC, 1989).

King George County has been recently selected as the location for a new independently owned coal-fired power plant. Reportedly, the county government is very eager to see this plant developed in the county, and has placed a high priority on facilitating the development of this project (Beard 1990, 1991).

The plant is reportedly planned at 200 MWe, with an estimated cost of $305 million. It will be developed by Southern Electrical International of Atlanta. The proposed King George County site is located on Route 665, south of Route 3 (Fredericksburg Journal, 1990). This location is not within the immediate proximity of the proposed oil and gas exploration project site.

The plant developer has announced that they will initiate rezoning procedures and finalize other site decisions during the first quarter of 1991, and will begin permitting processes as well. Financing arrangements are planned to be completed by November 1991. Site work is expected to begin in 1994, following receipt of the necessary permits (Beard, 1991).

b. Water Supplies

The county relies exclusively on ground-water resources for water supply. The county does not have a centralized public system that serves residents. Water service is provided by the Dahlgren Sanitary District, the Fairview Beach Sanitary District, private companies, and individual wells. The Dahlgren Sanitary District operates four deep water wells, with an average daily use of 187,000 gallons per day (KGCPC, 1990). The water system servicing King George Courthouse draws from 7 deep wells, with an average daily use of 154,000 gpd. This system is privately operated (VPC, 1989).

c. Sewage Treatment

Sewage treatment in the county is provided primarily by individual septic systems. This will be the primary source of disposal for the foreseeable future. Available public sewage treatment systems include the Dahlgren Sanitary District, and the Fairview Beach Sanitary District. Both provide central sewage collection and treatment services for legally defined areas of the county. The average daily use for Dahlgren's System A is 183,000 gpd; and for System B is 36,000 gpd. Planned upgrades, due to be completed in the near future, will expand the capacity of the Dahlgren system to 325,000 gpd (KGCPC, 1990).

d. Solid Waste Management

The county's solid waste disposal is handled by the King George County Sanitary Landfill, which accepts household, commercial, and non-hazardous waste (VPC, 1989).

6. Public Services and Schools

a. Emergency Services

Fire protection services for the county are provided primarily by two volunteer fire departments, operating from three stations located in the Courthouse area, Fairview Beach, and Dahlgren. In addition, mutual cooperative agreements have been established with surrounding counties, and a limited agreement exists with the Naval Surface Warfare Center's paid fire department to provide assistance to the county. The rescue services are provided by Dahlgren Rescue Squad, which operates from two stations at the Courthouse area, and on Route 206 in Dahlgren (KGCPC, 1990).

Law enforcement is provided by the County Sheriff's Department and the Virginia State Police. These services include 21 sworn sheriff's deputies and four State troopers. These State troopers also patrol Caroline County (KGCPC, 1990).

b. Schools

The King George County school system includes two elementary schools, one middle school, and a high school. Estimated total enrollment for 1989-90 is 2,473 students. This is 129 below the combined building capacity of the schools (2,602). Estimated enrollment for 1994-95 is 2,670 students, which will exceed current capacity. However, additions to the Potomac Elementary School are anticipated which will allow accommodation of 3,114 total combined students in the county system (KGCPC, 1990).

II.F. Air Quality

The Commonwealth of Virginia is divided into 7 air quality control regions by the Department of Air Pollution Control. Ambient air quality is monitored at various locations throughout the State, for a variety of pollutants including: total suspended particulates, lead, sulfur dioxide, nitrogen oxides, carbon monoxide, and ozone.

The site for the exploratory well is located in Region IV, also called the Northeastern Virginia Intrastate Air Quality Control Region, which includes King George County. This entire air quality control region is considered to be in compliance with all NAAQS[1]. This

[1]Appendix K (Non attainment Areas) to Regulations for the Control and Abatement of Air Pollution, Department of Air Pollution Control, Commonwealth of Virginia.

implies that the regulatory requirements for sources locating in this area would be less stringent than those for sources located in areas designated as "non-attainment".

II.G. Waste Management

The site of the prospect well is currently used as farmland. An inspection of the site did not reveal the presence of waste materials on the property, and it is not believed that the site has been used for the disposal or storage of wastes. Waste-related issues are important in as much as improper waste management may impact soils, ground water, surface water and other resources. Existing conditions of such resources are described elsewhere in this report, and are not repeated here.

II.H. Noise

The leased tract is located in a predominantly rural area, and occupies what is currently agricultural land. The tract is bounded by woods to the north, the east, and the west, and by Route 205 to the south. The nearest residences are along Route 205.

Existing sources of noise are typical of agricultural rural areas, and would include traffic along Route 205, farm equipment, and household sources (e.g. appliances). Ambient day and night noise levels in rural communities are typically less than 55 dB(A). Higher levels may be expected during periods when agricultural field machinery is in use.

II.I. Archaeological and Historic Resources

1. Historical Setting

The King George County Comprehensive Plan describes the county as beautiful rural county steeped in history (KGCPC, 1990). The county places a high priority on maintaining its historic heritage and resources. The following discussion is an excerpt from the Comprehensive Plan.

King George County was named after King George I of England. The county was created by an Act of Assembly in 1720. During that time the boundaries included parts of the current Richmond, Westmoreland, Stafford, Prince William and Fauquier counties. The county did not obtain its present day boundaries until 1776. Today the county contains 183 square miles and is bounded by Stafford County to the west, Westmoreland and Essex counties to the east, the Potomac River to the north and the Rappahannock River to the south (KGCPC, 1990).

King George county has been home to many prominent old Virginia families and is the birthplace of James Madison, the fourth president of the United States. Settled along the Potomac River in the Chotank area (just north of Upper Machodoc Creek watershed) were large landowners known as the "Barons of the Potomac". These landowners operated large plantations that produced tobacco and various other crops. Many descendants of these original settlers still live in the county today (KGCPC, 1990).

One of the first groups to settle along the Rappahannock River was the Nanzatico or Nantaughtacund Indian tribe. This Indian village was the largest and most important Indian settlement on the Rappahannock from 1650 to 1702 (KGCPC, 1990).

King George County played varied roles in the Civil War. The Potomac and Rappahannock Rivers were utilized by Union and Confederate gunboats. The union army used many of the old homes and churches in the county as shelters, stables, headquarters and hospitals. During the Civil War many homes and plantations, as well as records from the county clerk's office were destroyed by the Union army. There were also many skirmishes fought during the Civil War. One of note was the skirmish fought at Mathias Point on June 27, 1861. It was here that Confederate soldiers successfully repelled an attack by a flotilla led by the Thomas Freeborn (KGCPC, 1990).

Of the many stories and legends of King George County and its residents, is of John Wilkes Booth. Reportedly after the assassination of President Lincoln, John Wilkes Booth sought medical attention and food from Dr. Richard Stuart of Cleydael. Dr. Stuart, suspecting Booth's identity refused to assist him and sent him and the other men who were with him on their way. Booth continued on to Port Royal, located across the Rappahannock River in Caroline County, where he died in the Garret barn (KGCPC, 1990).

2. Archaeological and Historic Resources

The Virginia Department of Historic Resources maintains records and catalogings of sites of archaeological and historic significance. Upon request, these files were reviewed along with the Virginia Landmarks Register and the National Register of Historic Places. No recorded sites of historic or archaeological significance were found for the leased property. Two features are located approximately 3,000 feet east of the proposed drill site, and a third feature is located approximately 3,500 feet northeast of the site, near the southern shore of the Upper Machodoc Creek. The site descriptions for these features are included in Appendix B.

II.J. Visual and Scenic Resources

The drill site is not located in, along, or within view of any known scenic resources. There are no public lands, parks or recreational facilities in the general area (VDCR. 1989). The drill site will be within view of motorists on State Route (SR) 205, and from approximately 5 residences located along SR 205, as well as one residence on the lease property. The site will be lighted for 24-hour drilling operations and security. This lighting will be visible from the road and neighboring residences.

Table II-1. COMPARISON OF UPPER MACHODOC CREEK WATER QUALITY DATA TO MEASUREMENTS OF OTHER NEARBY STREAMS

Parameter (units)	Upper Machodoc (King George Co., VA)[1]	Marshall Creek (Westmoreland Co., VA)[2]	Unnamed Stream (Lancaster Co., VA)[2]
pH	5.7 - 8.9	5.68 - 6.46	5.77 - 7.24
Dissolved Oxygen (mg/l)	5.4 - 14.3	8.8 - 11.3	6.5 - 12.0
Temperature (°C)	0.3 - 33.6	8.5 - 16.5	8.2 - 13.5
Conductivity (umhos/cm)	45 - 17,160	26 - 65	74 - 88

[1] Source: VWCB, 1991.

[2] Source: USEPA, 1988.

Table II-2. UPPER MACHODOC CREEK DATA FOR METALS IN WATER COLUMN (OCTOBER 1989) VERSUS EPA DRINKING WATER STANDARDS

Constituent	Measured Concentration (mg/l) (1)	EPA Drinking Water Standards (mg/l) (2)
cadmium	0.003 *	0.010
chromium	0.050 *	0.05
copper	0.050 *	1
iron	0.660	0.3
lead	0.010 *	0.05
manganese	0.180	0.05
nickel	0.050 *	na
zinc	0.050 *	5
selenium	0.005 *	0.01
mercury	0.0003 *	0.002

* data for which STORET printout indicated that the actual value is known to be less than value given.

na standard not yet promulgated

(1) Source: VWCB, 1991

(2) Source: 40 CFR, Part 141

Table II-3. POTENTIAL BENTHIC MACROINVERTEBRATE SPECIES OF THE UPPER MACHODOC CREEK (MMC, 1979)

Common Name	Scientific Name
Sea anemones	(Diadumene leucolena)
Flat worms	(Stylochus ellipticus)
Proboscis worms	(Micrura leidyi)
Bryozoans	(Membranipora tenuis; Electra crustulena)
Polychaete worms	(Eteone heteropoda; Glycera dibranchiata; Heteromastus filiformis; Polydora ligni; Paraprionospio pinnata; Scolecolepides viridis; Streblospio benedicti; Hypaniola grayi; Peloscolex gabriellae)
Bivalves	(Brachiodontes recurvus; Crassostrea virginica; Rangia cuneata; Macoma balthica; Macoma phenax (mitchilli); Mya arenaria)
Snails	(Littorina irrorata; Crepidula fornicata)
Cumaceans	(Oxyurostylis smithi)
Isopods	(Cyathura polita; Chiridotea almyra; Edotea triloba)
Amphipods	(Leptocheirus plumulosus; Corophium lacustre; Gammarus daiberi; Gammarus palustris; Gammarus mucronatus; Gammarus sp.; Melita nitida; Lepidactulus dytiscus; Neohaustorius schmitzi)
Mysid shrimp	(Neomysis americana)
Grass shrimp	(Palaemonetes pugio)
Crabs	(Callinectes sapidus; Rhithropanopeus harrisii; Pinnotheres ostreum; Uca minax)
Tunicates	(Molgula manhattensis)

Table II-4. COMMON FISHES THAT MAY EXIST IN THE UPPER MACHODOC CREEK HABITAT

Shallow-water fishes

- **Killifishes**

Banded killifish	(Fundulus diaphanus)
Mummichog	(Fundulus heteroclitus)
Sheepshead minnow	(Cyprinodon variegatus)
Striped killifish	(Fundulus majalis)
Rainwater killifish	(Lucania parva)
Spotfin killifish	(Fundulus luciae)
Marsh killifish	(Fundulus confluentus)

- **Sticklebacks**

Fourspine stickleback	(Apeltes quadracus)
Threespine stickleback	(Gasterosteus aculeatus)

- **Pipefishes**

Northern pipefish	(Syngnathus fuscus)

Pelagic fishes

- **Silversides**

Tidewater silverside	(Menidia beryllina)
Atlantic silverside	(Menidia menidia)
Rough silverside	(Membras martinica)

- **Bay anchovy** (Anchoa mitchilli)

Table II-5. COMMON FISHES THAT MAY SPAWN IN THE UPPER MACHODOC CREEK HABITAT (MMC, 1979)

Common Name	Scientific Name
Alewife *	(Alosa psuedoharengus)
American Shad *	(Alosa sapidissima)
Banded Killifish	(Fundulus diaphanus)
Bay Anchovy	(Anchoa mitchilli)
Blueback Herring *	(Alosa aestivalis)
Hogchoker	(Trinectes maculatus)
Mummichog	(Fundulus heteroclitus)
Naked Goby	(Gobiosoma bosci)
Needlefish (Atlantic)	(Strongylura marina)
Pipefish (Northern)	(Syngnathus fuscus)
Puffer (Northern)	(Sphoeroides maculatus)
Rainwater Killifish	(Lucania parva)
Seahorse (Lined)	(Hippocampus erectus)
Sheepshead Minnow	(Cyprinodon variegatus)
Silverside (Atlantic)	(Menidia menidia)
Silverside (Rough)	(Membras martinica)
Silverside (Tidewater)	(Menidia beryllina)
Striped Bass **	(Morone saxatilis)
Striped Killifish	(Fundulus majalis)
Oyster Toadfish	(Opsanus tau)
White Perch **	(Morone americana)

* anadromous

** semianadromous

TABLE II-6. WILDLIFE DIRECTLY OBSERVED OR FOR WHICH SIGN WAS OBSERVED AT THE KING GEORGE COUNTY SITE ON 26 OCTOBER 1990.

	Common Name	Scientific Name
Birds	Black Vulture	Coragyps atratus
	Turkey Vulture	Cathartes aura
	Red-Bellied Woodpecker	Melanerpes carolinus
	Northern Flicker	Colaptes auratus
	Barn Swallow (nest)	Hirundo rustica
	American Crow	Corvus brachyrhynchos
	Carolina Chickadee	Parus carolinensis
	Tuffed Titmouse	Parus bicolor
	Carolina Wren	Thryothorus ludovicianus
	Eastern Bluebird	Sialia sialis
	European Starling	Sturnus vulgaris
	Field Sparrow	Spizella pusilla
	Song Sparrow	Melospiza melodia
	Dark-eyed Junco	Junco hyemalis
	House Finch	Carpodacus mexicanus
Mammals	Whitetail Deer (tracks)	Odocoileus virginiana
	Raccoon (tracks, scat)	Procyon lotor
	Fox (probably red) (scat)	Vulpes fulva

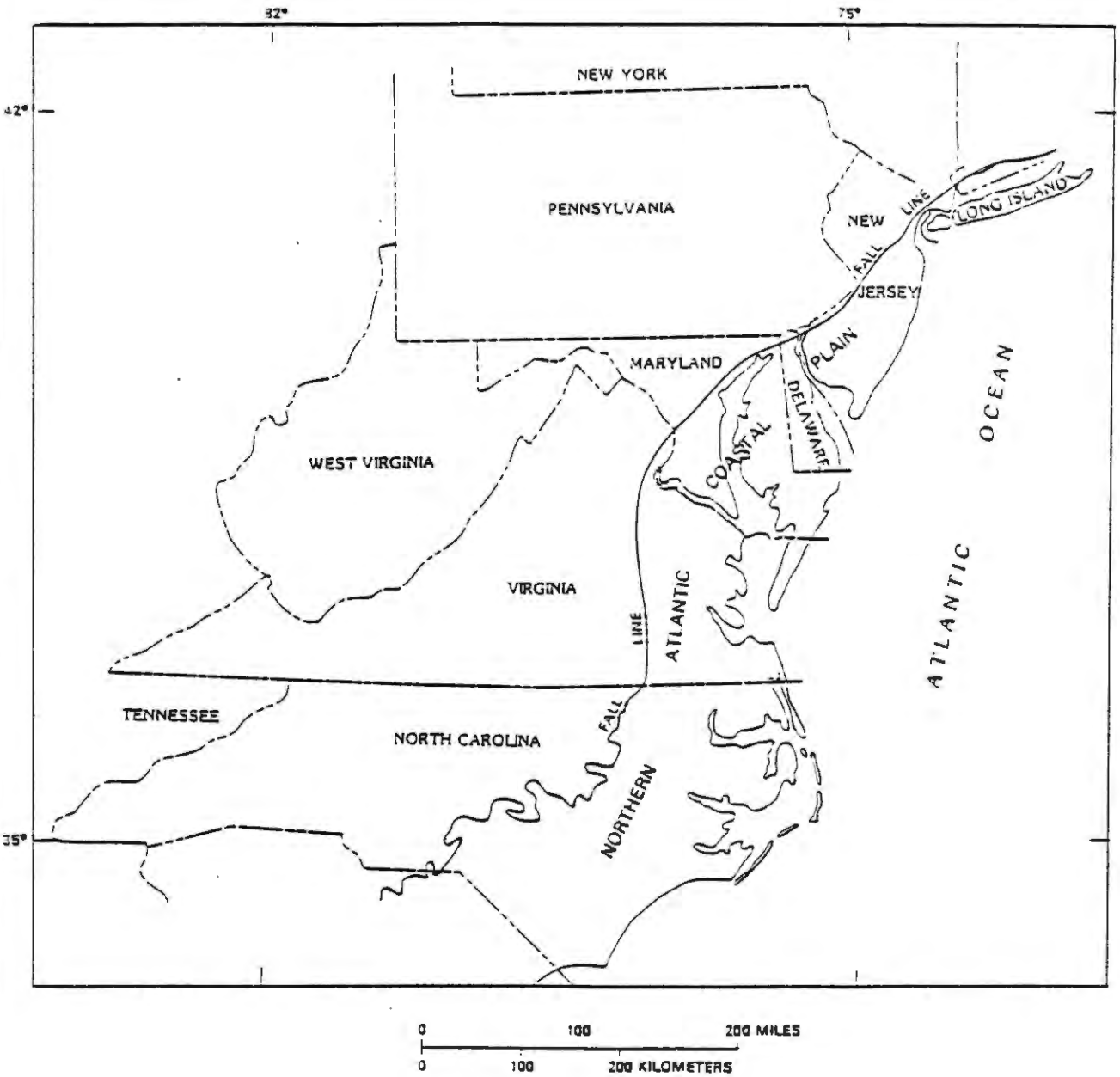

Figure II-1. LOCATION OF NORTHERN ATLANTIC COASTAL PLAIN
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

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COASTAL ENVIRONMENTAL SERVICES INC.

PERIOD	EPOCH	AGE	STRATIGRAPHIC FORMATION	VIRGINIA RASA HYDROGEOLOGIC UNIT
QUATERNARY	HOLOCENE	POST-GLACIAL	Holocene deposits	Columbia aquifer
	PLEISTOCENE	WISCONSIN TO NEBRASKAN	Pleistocene undifferentiated deposits	
TERTIARY	PLIOCENE	PIACENZIAN	Becons Castle Formation (Oaks and Cook, 1973)	Yorktown confining unit
		ZANCLEAN	Yorktown Formation (Chesapeake Group)	Yorktown-Eastover aquifer
	MIOCENE	MESSINIAN	Eastover Formation (Chesapeake Group)	
		TORTONIAN		St. Marys confining unit
		SERRAVALLIAN	St. Marys Formation (Chesapeake Group)	St. Marys-Choptank aquifer
			Choptank Formation (Chesapeake Group)	
		LANGHIAN	Calvert Formation (Chesapeake Group)	Calvert confining unit
		BURDIGALIAN		
		AQUITANIAN	Old Church Formation (Chesapeake Group)	Chickahominy-Piney Point aquifer
	OLIGOCENE	CHICKASAWHAYAN[1]	Not present in study area	
		VICKSBURGIAN[1]		
	EOCENE	JACKSONIAN[1]	Chickahominy Formation (Pamunkey Group)	Chickahominy-Piney Point aquifer
		CLAIBORNIAN[1]	Piney Point Formation (Pamunkey Group)	
		SABINIAN[1]	Nanjemoy Formation (Pamunkey Group)	Nanjemoy-Marlboro clay confining unit
	PALEOCENE		Marlboro clay (Pamunkey Group)	
		MIDWAYAN[1]	Aquia Formation (Pamunkey Group)	Aquia aquifer
			Brightseat Formation (Pamunkey Group)	Brightseat confining unit
				Brightseat aquifer
CRETACEOUS	LATE CRETACEOUS	MAASTRICHTIAN	Unconsolidated sediments	Upper Potomac confining unit
		CAMPANIAN		
		SANTONIAN		
		CONIACIAN		
		TURONIAN		
		CENOMANIAN	Potomac Formation	Upper Potomac aquifer
	EARLY CRETACEOUS	ALBIAN		Middle Potomac confining unit
				Middle Potomac aquifer
		APTIAN		Lower Potomac confining unit
		BARREMIAN		
		HAUTERIVIAN		Lower Potomac aquifer
		VALANGINIAN		
		BERRIASIAN		

[1] Commonly used ages in Atlantic Coastal Plain province

Figure II-2. HYDROGEOLOGIC FRAMEWORK OF THE VIRGINIA COASTAL PLAIN (after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

COASTAL ENVIRONMENTAL SERVICES INC.

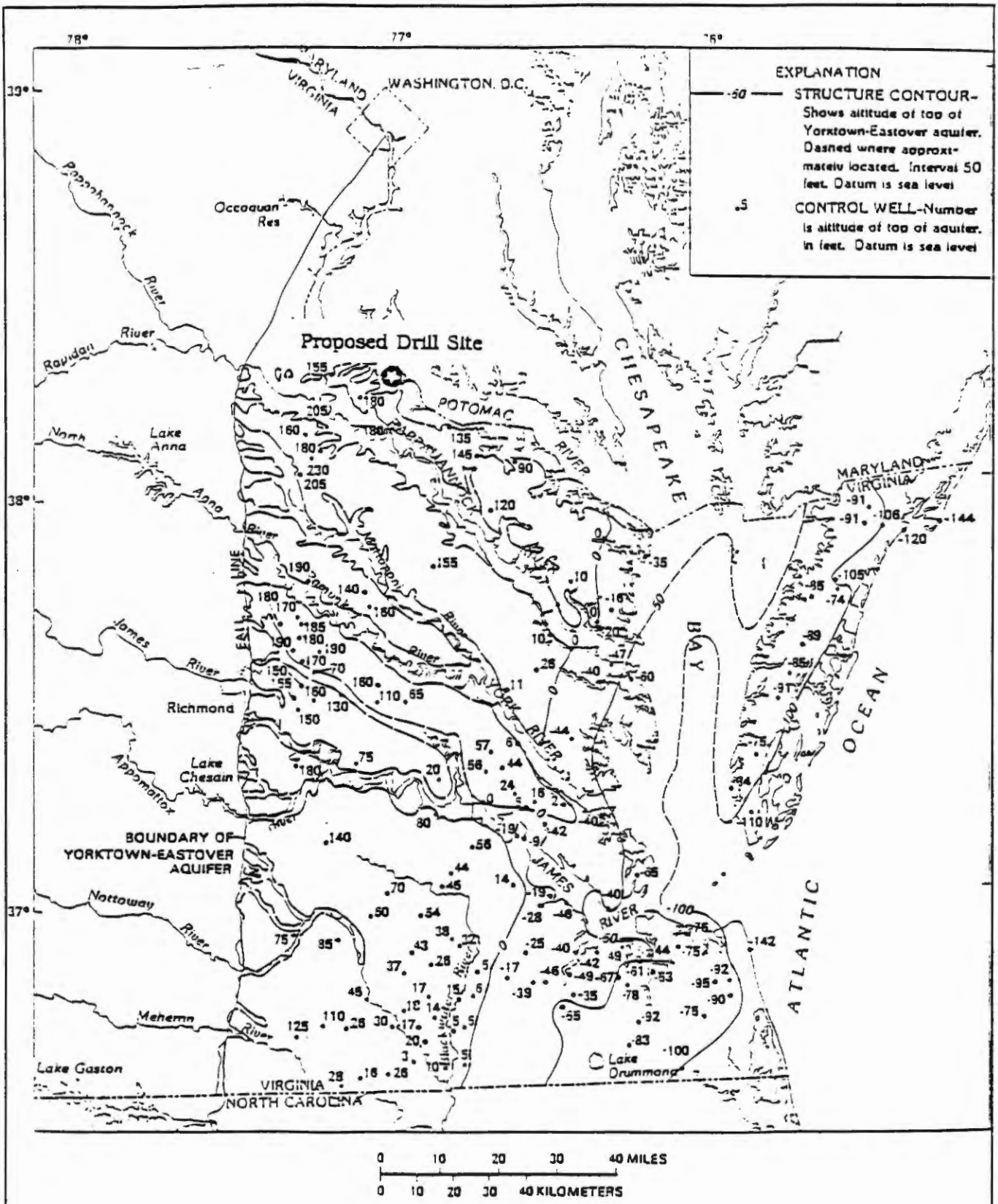

Figure II-3. ALTITUDE OF TOP OF YORKTOWN-EASTOVER AQUIFER
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

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ENVIRONMENTAL SERVICES INC.

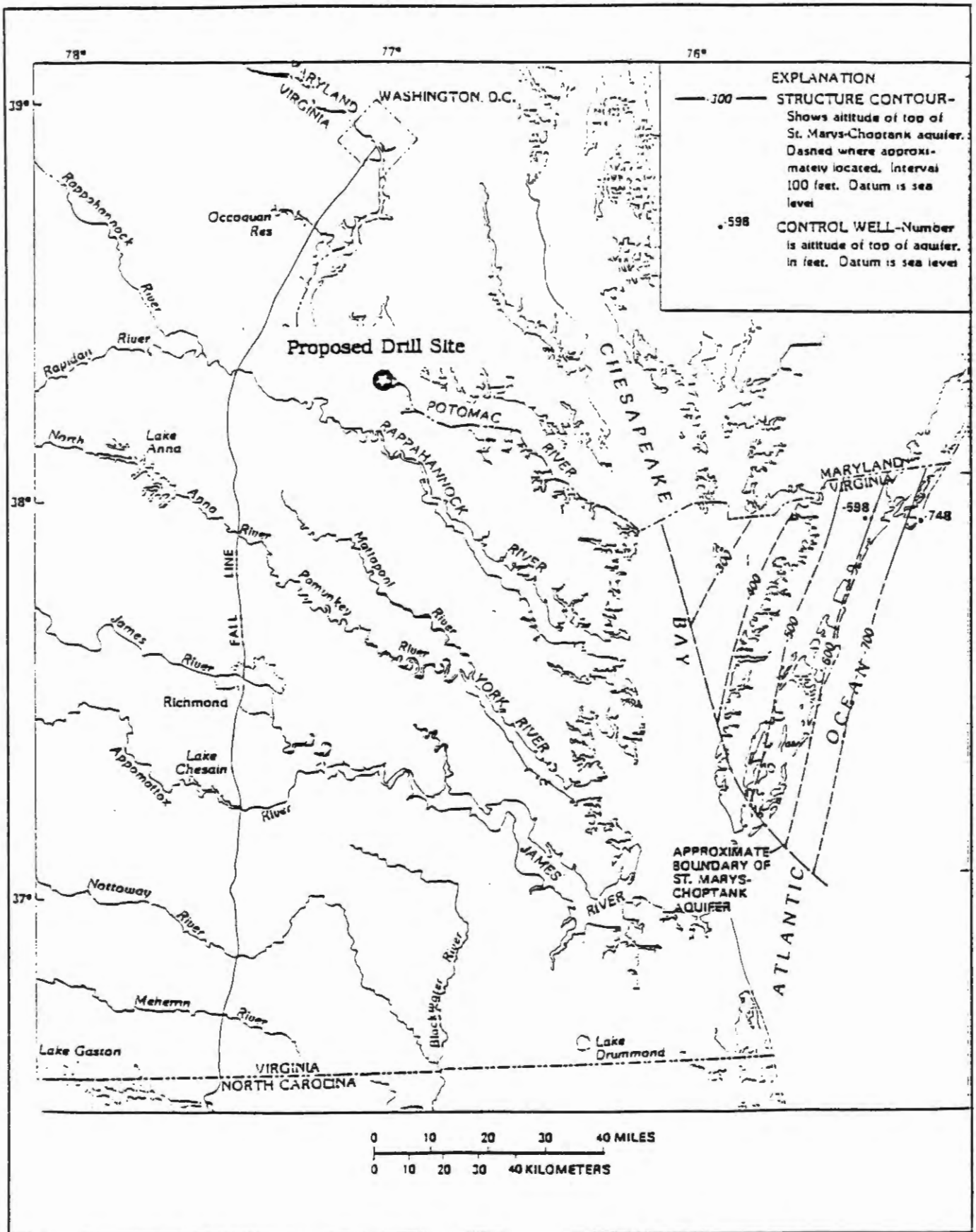

Figure II-4. ALTITUDE OF TOP OF ST. MARY'S-CHOPTANK AQUIFER
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

COASTAL
ENVIRONMENTAL SERVICES INC.

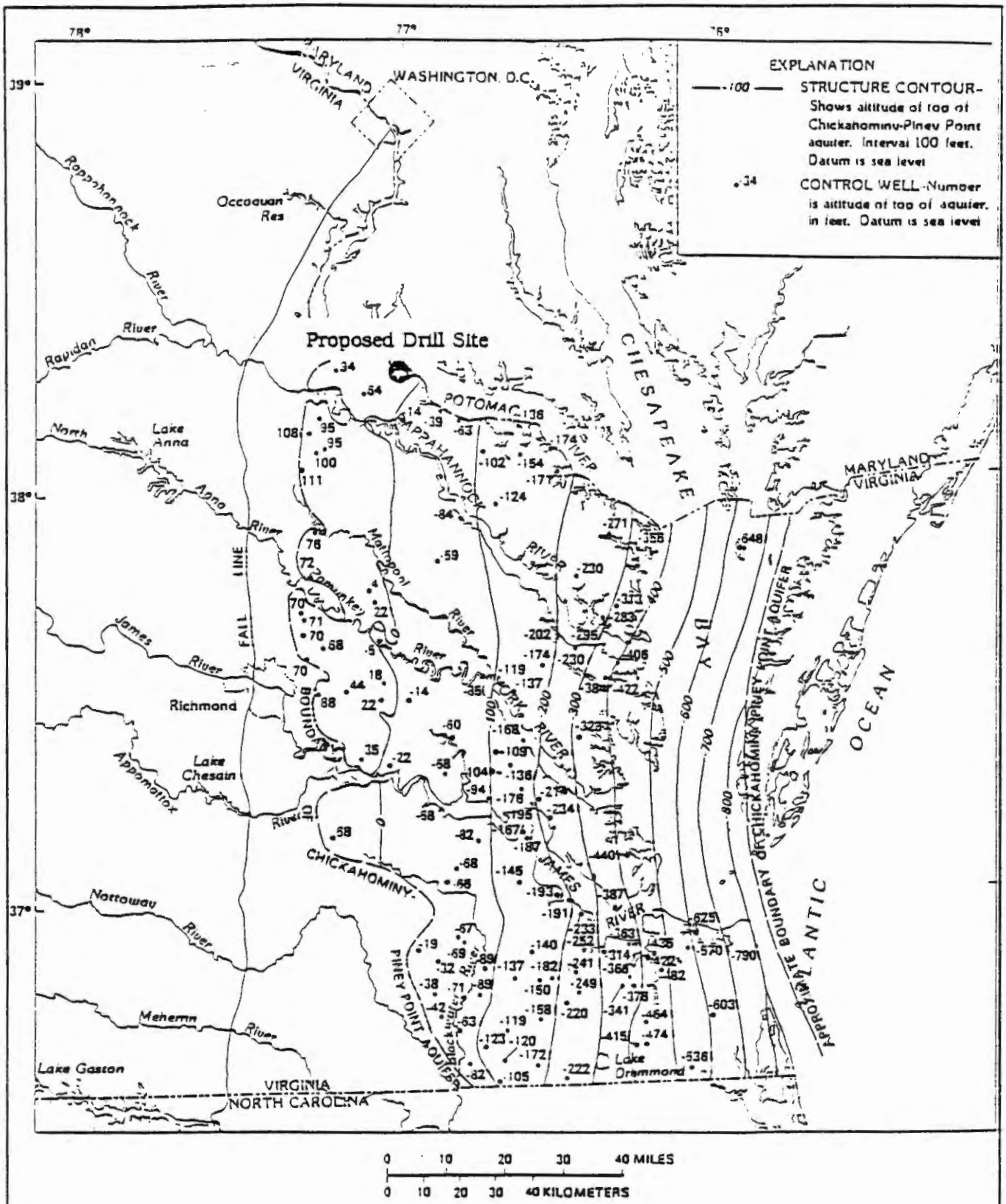

Figure II-5. ALTITUDE OF TOP OF CHICKAHOMINY-PINEY POINT AQUIFER
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

COASTAL
ENVIRONMENTAL SERVICES INC.

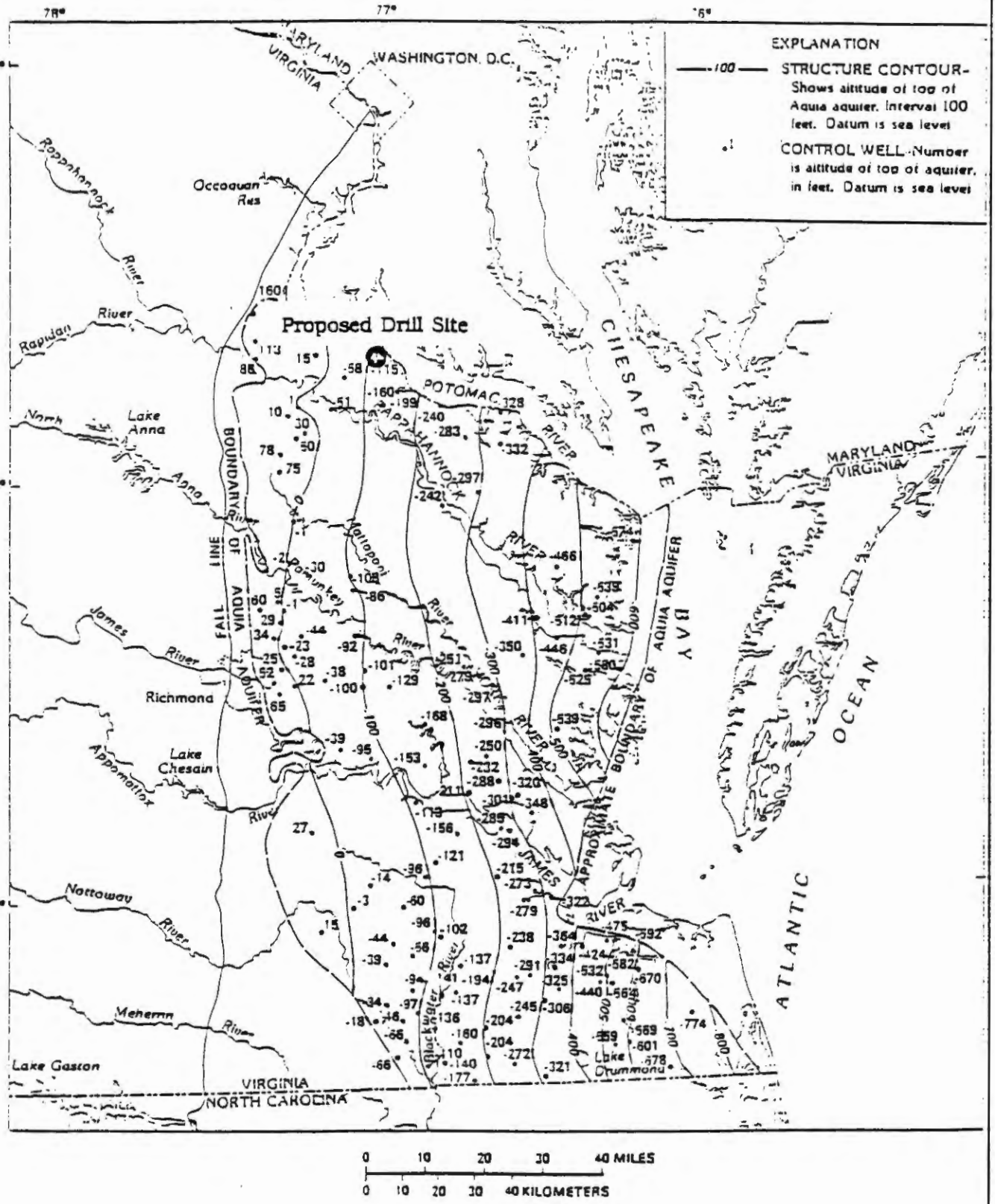

Figure II-6. ALTITUDE OF TOP OF AQUIA AQUIFER
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

COASTAL
ENVIRONMENTAL SERVICES INC.

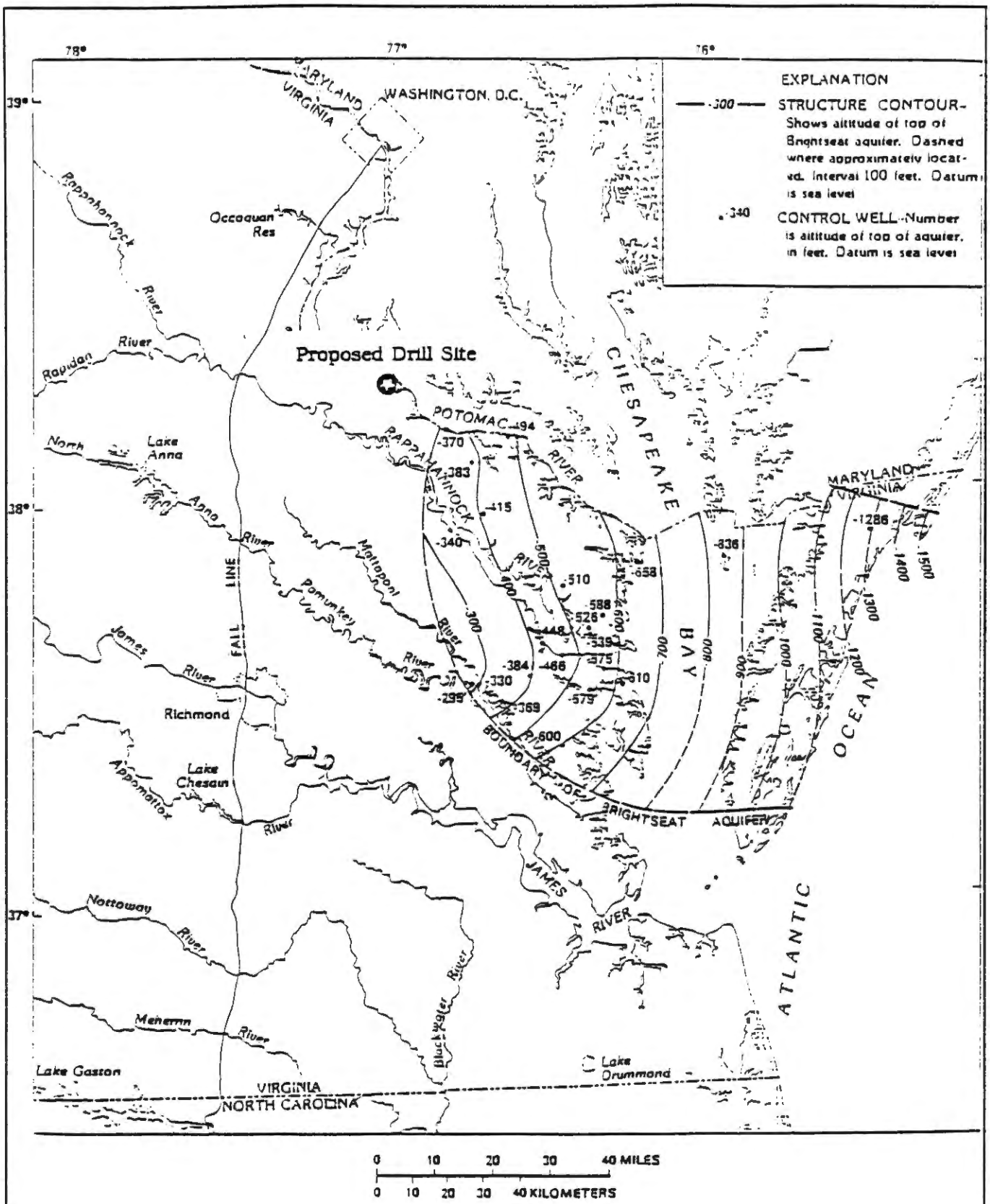

Figure II-7. ALTITUDE OF TOP OF BRIGHTSEAT AQUIFER
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

COASTAL ENVIRONMENTAL SERVICES INC.

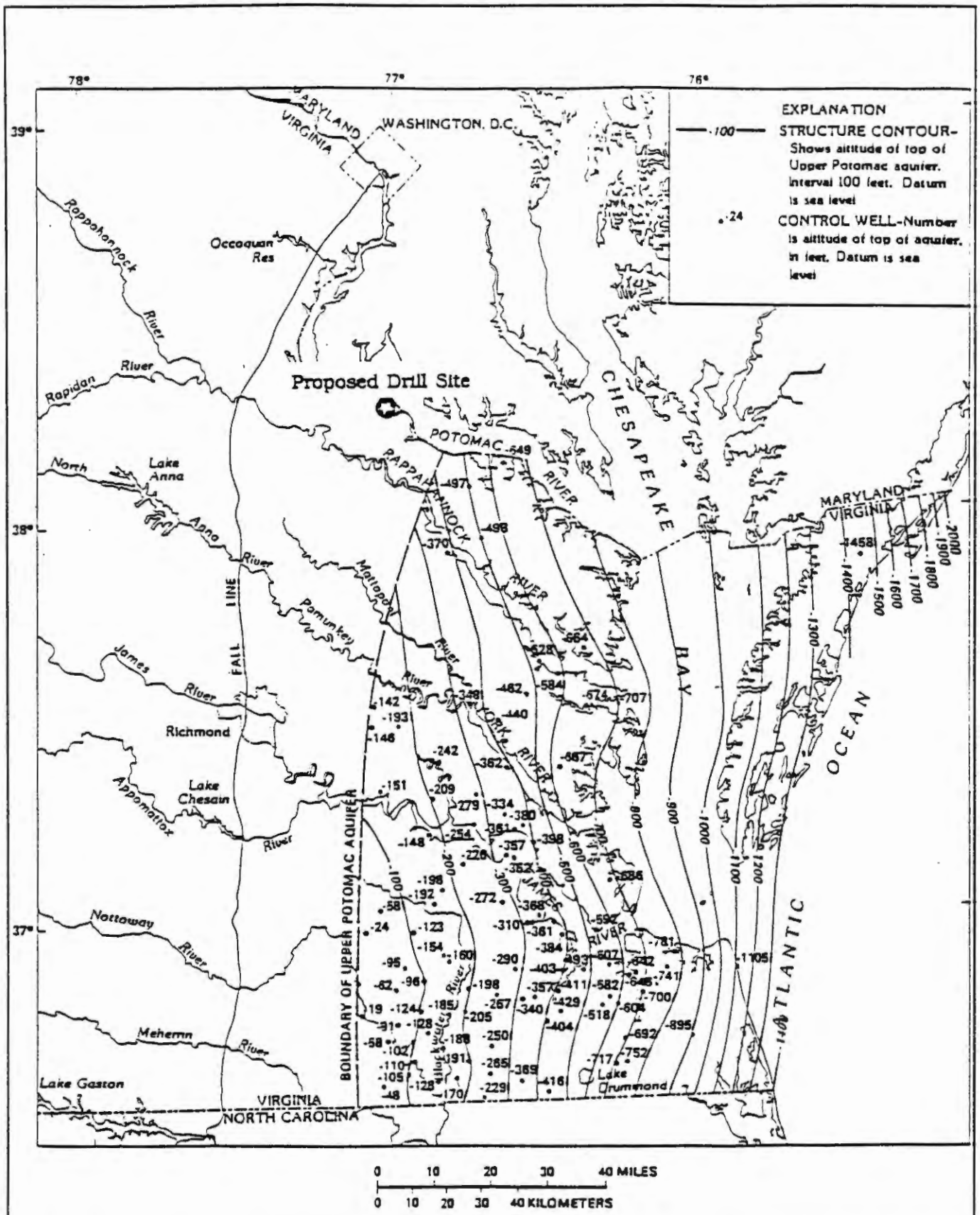

Figure II-8. ALTITUDE OF TOP OF UPPER POTOMAC AQUIFER
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

COASTAL
ENVIRONMENTAL SERVICES INC.

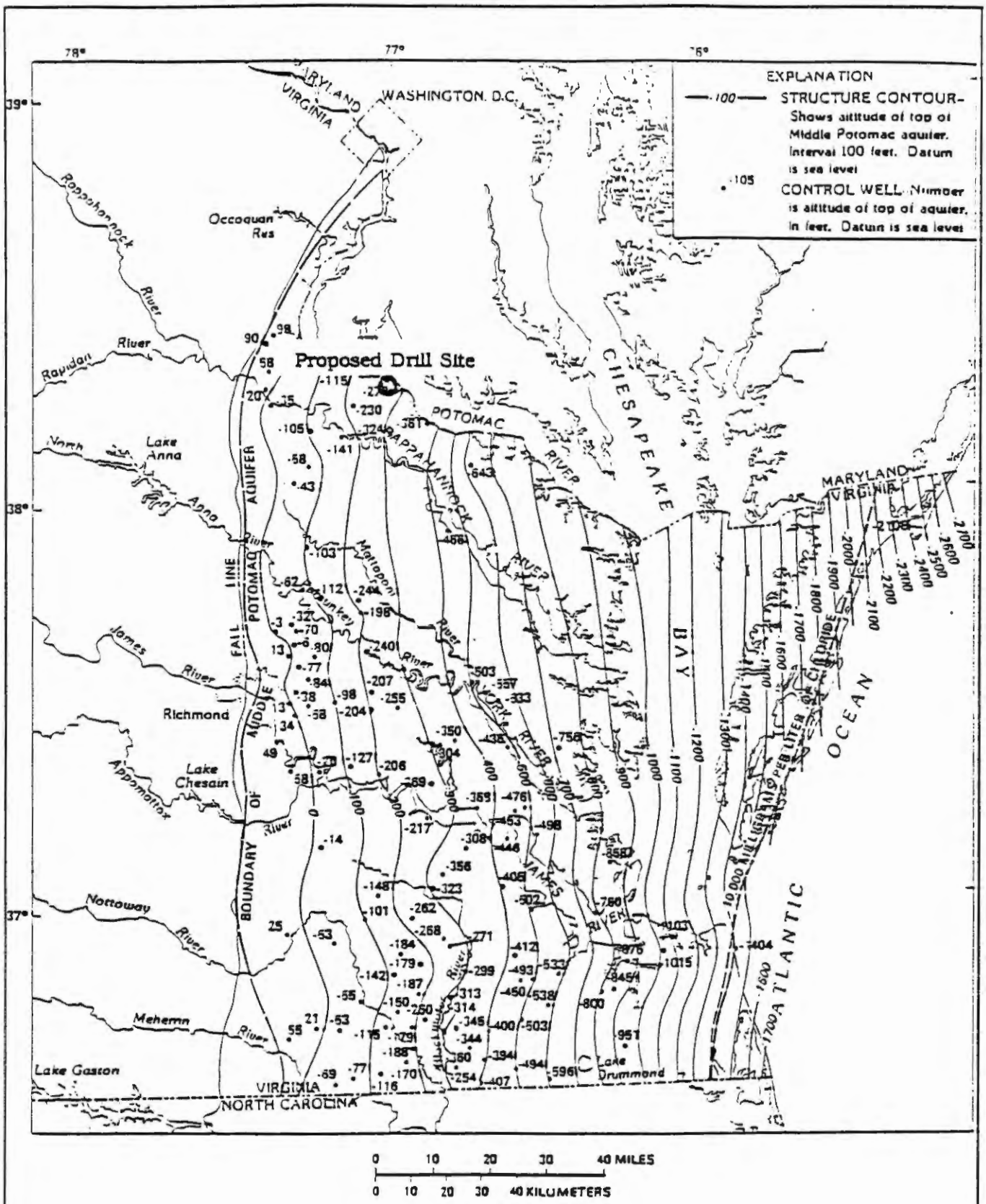

Figure II-9. ALTITUDE OF TOP OF MIDDLE POTOMAC AQUIFER
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

COASTAL ENVIRONMENTAL SERVICES INC.

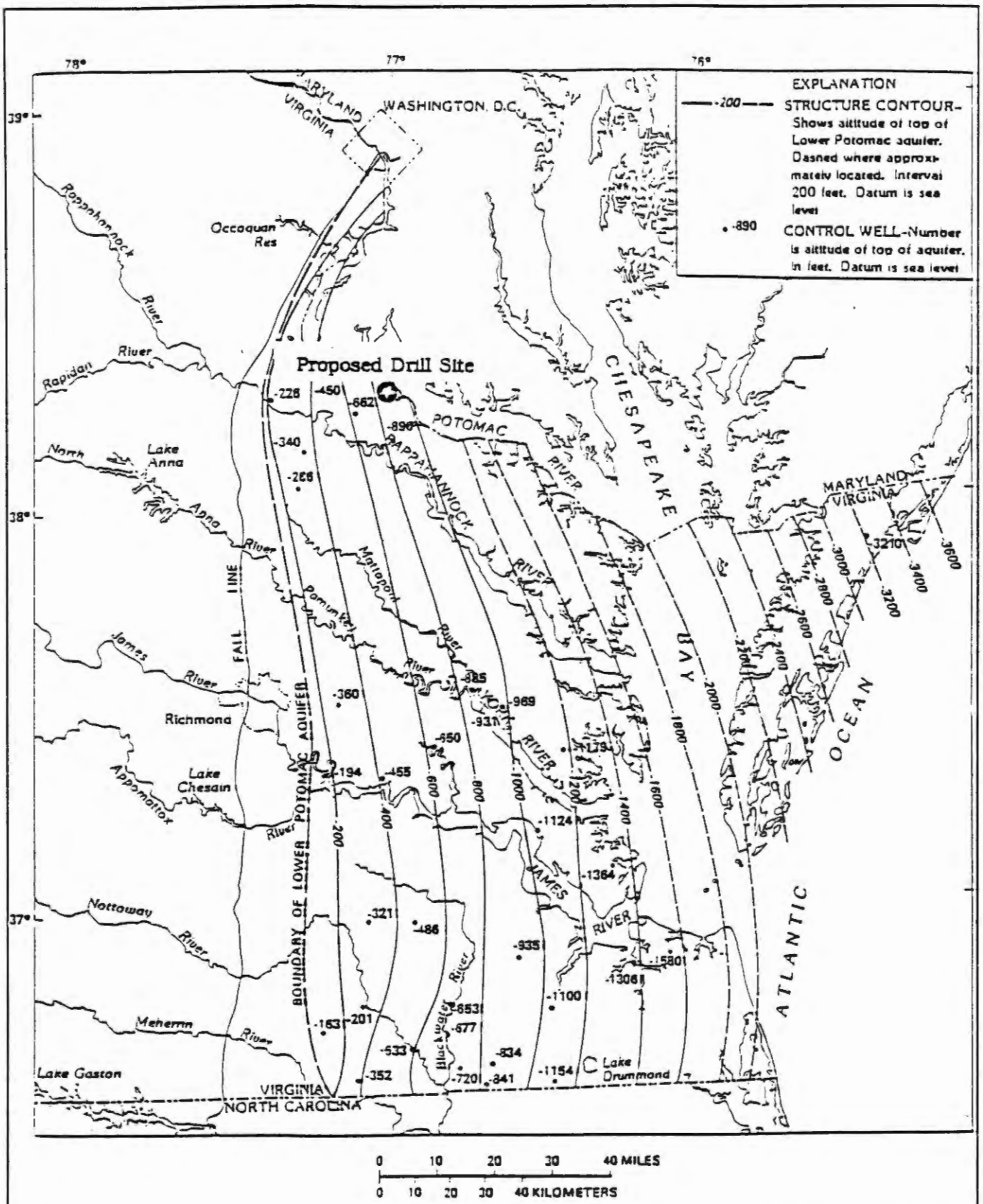

Figure II-10. ALTITUDE OF TOP OF LOWER POTOMAC AQUIFER
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

COASTAL
ENVIRONMENTAL SERVICES INC.

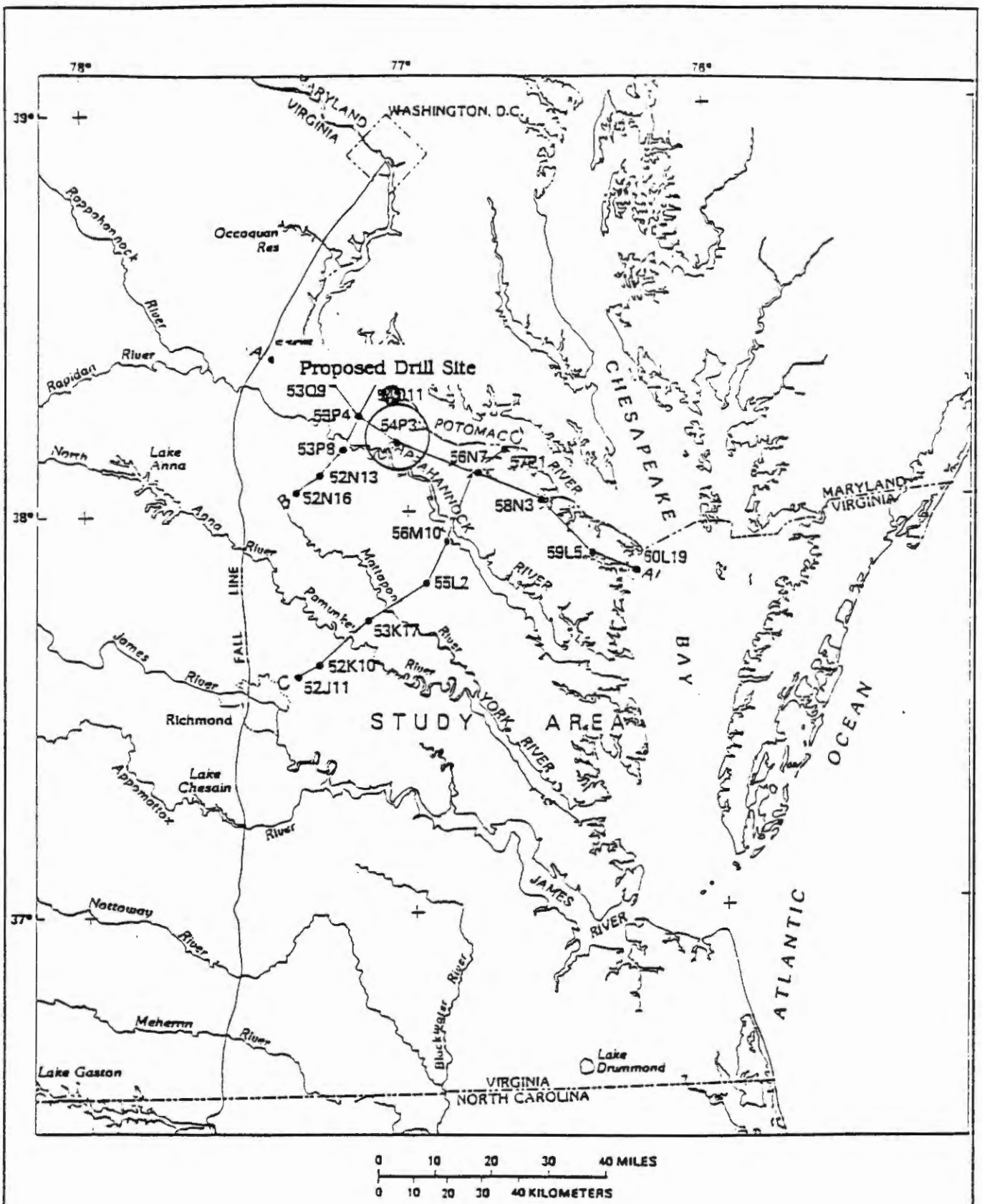

Figure II-11. LOCATION OF OAK GROVE CORE (54P3), KING GEORGE CO.,VA
(after Meng and Harsh, 1988)

Texaco EIA, King George Co., VA

COASTAL ENVIRONMENTAL SERVICES INC.

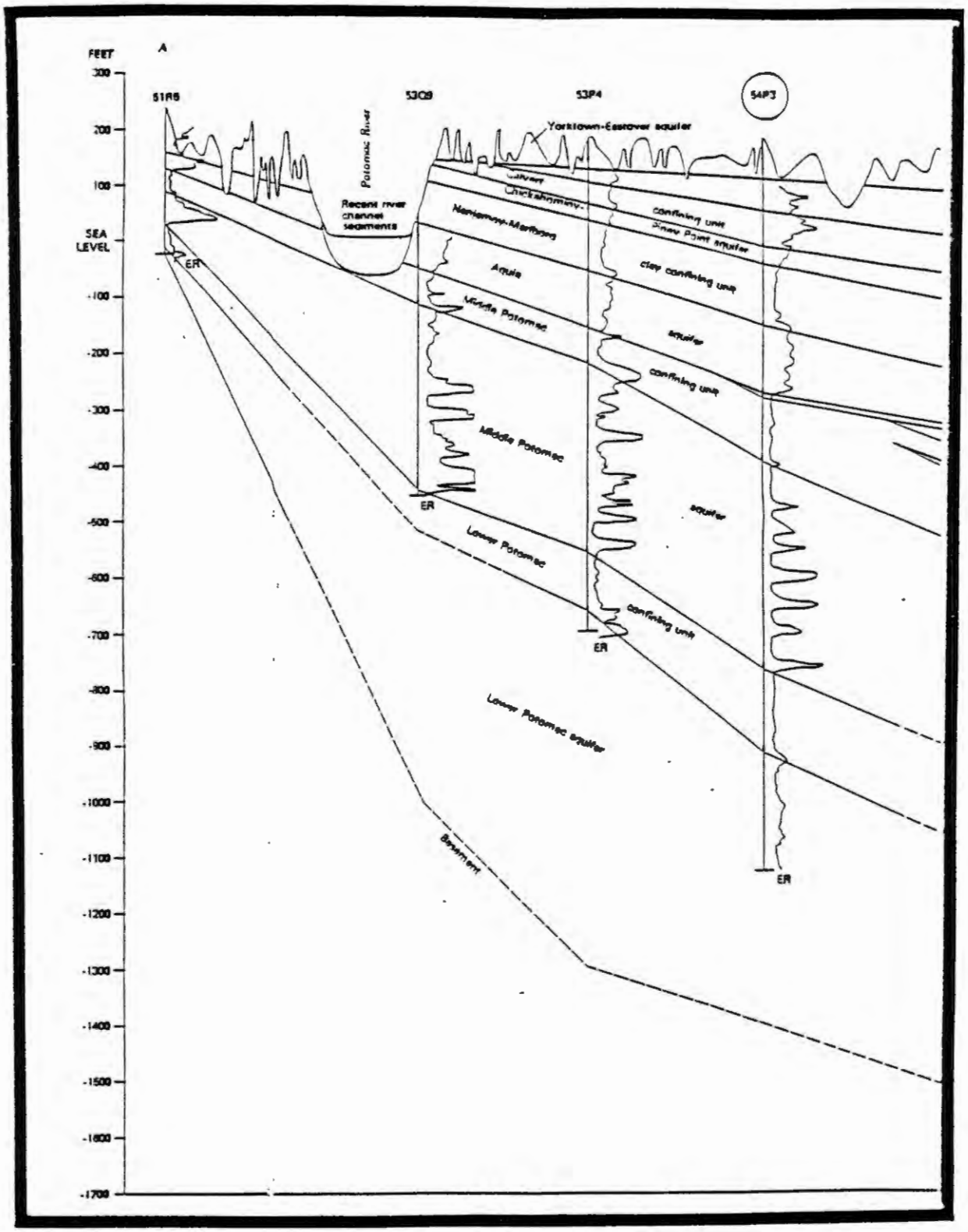

Figure II-12. STRATIGRAPHIC SECTION OF OAK GROVE CORE (54P3), KING GEORGE CO.

Texaco EIA, King George Co., VA

COASTAL ENVIRONMENTAL SERVICES INC.

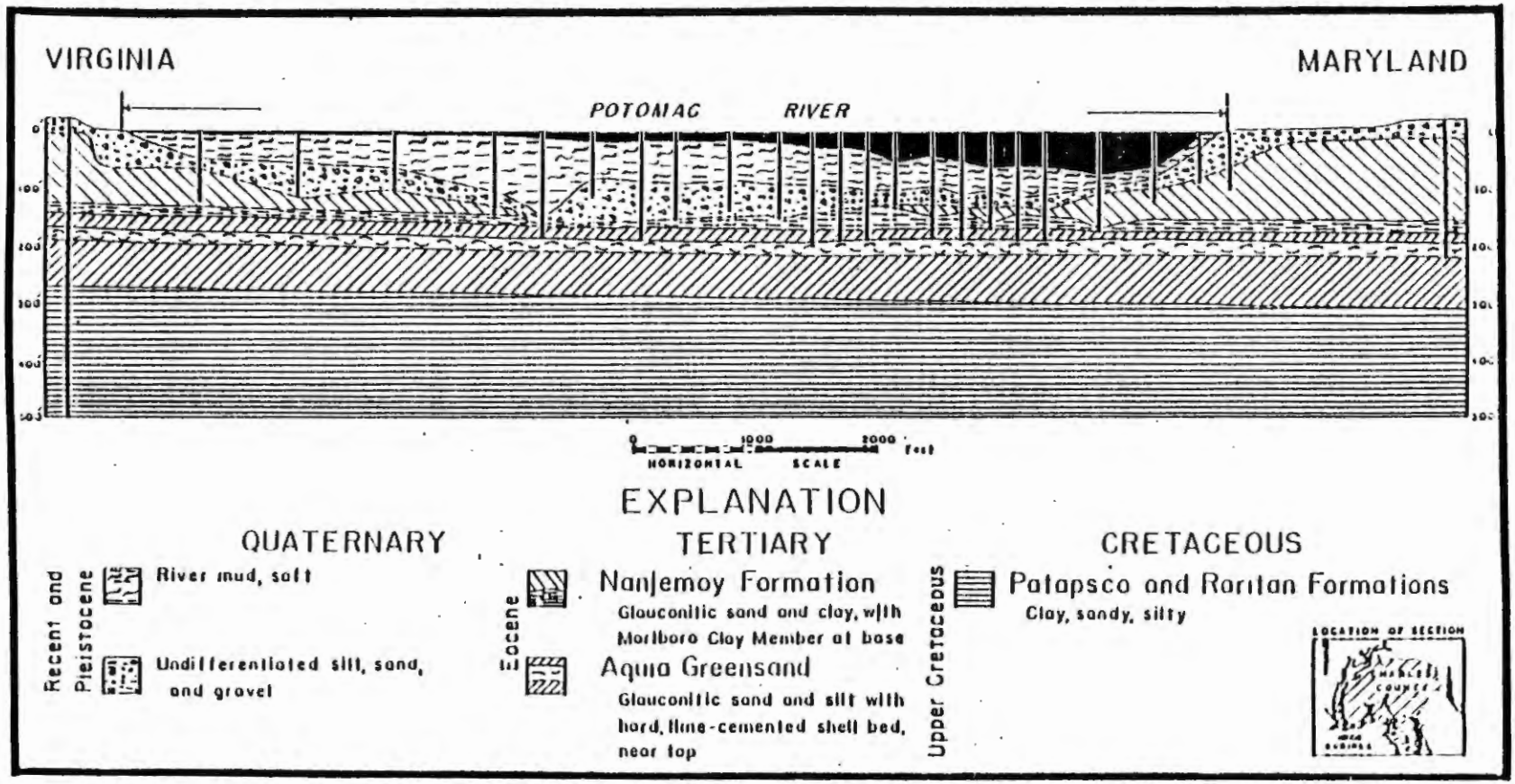

Figure II-13. GEOLOGICAL SECTION AT THE POTOMAC BRIDGE ON U.S. ROUTE 301, NEAR MORGANTOWN
(after Slaughter and Otton, 1968)

Texaco EIA, King George Co., VA

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Figure II-14. SOILS MAP OF THE PROJECT SITE (SCS, 1974)

Texaco EIA, King George Co., VA

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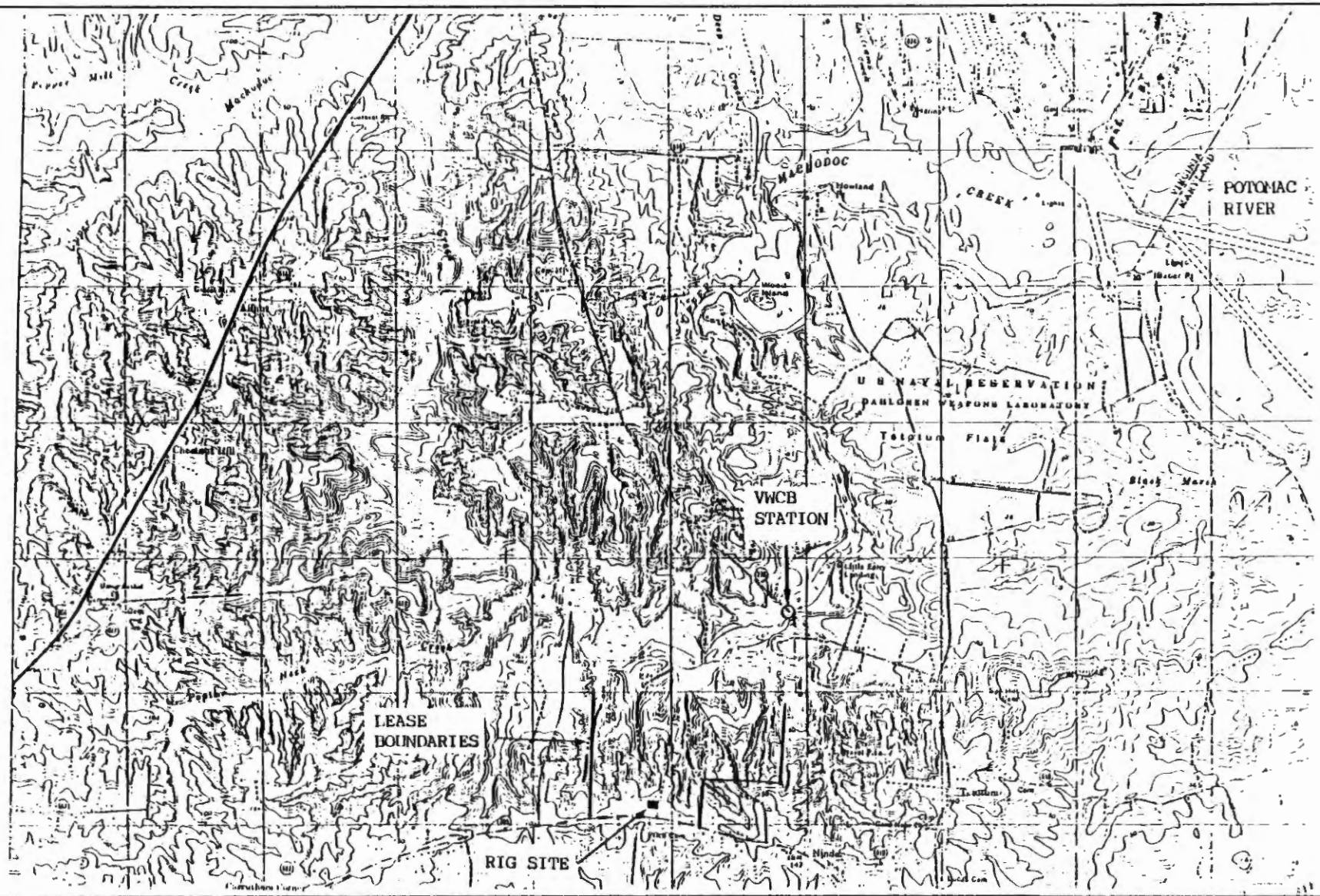

Figure II-15.
EASTERN PORTION OF UPPER MACHODOC CREEK WATERSHED, WITH PROJECT SITE LOCATION
(USGS, 1968)

Texaco EIA, King George Co., VA

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Figure II-16. NATIONAL WETLANDS INVENTORY OF THE IMMEDIATE PROJECT SITE AREA
(USFWS, 1977)(Scale 1":2000')
Texaco EIA, King George Co., Va

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COASTAL
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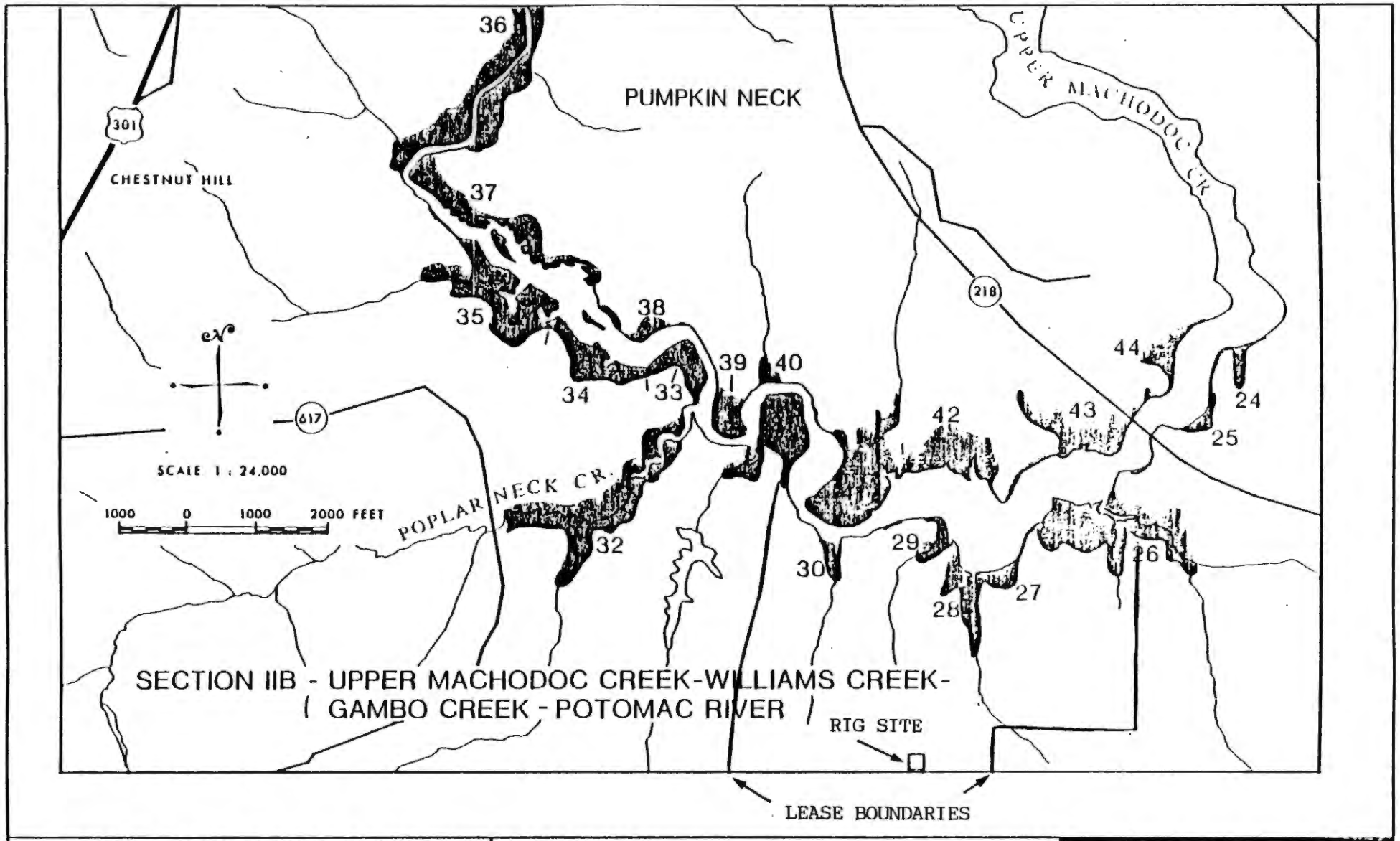

Figure II-17. KING GEORGE COUNTY TIDAL MARSH INVENTORY MAP OF IMMEDIATE PROJECT SITE AREA (VIMS, 1981)(Scale 1":2000')

Texaco EIA, King George Co., VA

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III. PROPOSED CHANGES AND POTENTIAL IMPACTS

III.A. Ground Water and Geology

1. Well Construction

Normally, potential contaminants present in deeper formations are prevented from mixing with fresh waters of shallower formations by confining layers characterized by very low permeabilities. Because the drilling process disrupts the natural protection of fresh waters provided by the confining layers, measures must be taken to artificially isolate the fresh-water zones to insure that no hydrological communication occurs between these zones and deeper formations that may contain contaminants. The hydrostatic weight of the drilling mud prevents hydrological communication during normal drilling operations. Casing and grouting are also used to eliminate the likelihood of any hydrological communication with the fresh-water aquifers. In the Coastal Plain areas of Virginia, where the majority of the population is dependent on ground water, protection of fresh-water aquifers is an issue of extreme concern.

Construction of the King George County prospect well will be similar in design to the exploration well drilled by Texaco in Westmoreland County, Virginia. Steel conductor pipe (O.D. 16 inch) will be installed to an approximate depth of 100 feet.

Once the conductor casing is in place, the well will be drilled downward through the formations containing fresh-water supplies to a depth of about 2,500 feet. It is estimated that this depth will be approximately 1,100 to 1,200 feet below the deepest fresh-water aquifer, and well into the competent rock. Steel surface casing (O.D. 9 5/8 or 10 3/4 inch) will then be set along the entire length of the hole for the prime purpose of fresh-water protection. The entire length of annular space between this casing and the walls of the well will also be grouted with portland cement.

After the surface casing is in place, the drilling of the well will continue through the rock to total planned depth. Should a producible reserve be discovered, steel production casing (O.D. 7 inch) would be set for the entire length (approximately 10,000 feet) of the hole, or to the depth of the hydrocarbon deposit. The annular space between this casing and the surrounding geological formations will be grouted along enough (usually about the bottom portion) of the production casing to isolate any potential hydrocarbon-producing zone(s). Within the production casing, production tubing will be placed, and secured by means of a packer just above the hydrocarbon zone. A schematic of the proposed well is presented in Figure III-1.

The protection of fresh-water aquifers will be accomplished by not allowing any hydrological communication to occur between formations, or between fresh-water formations and the well. The proposed well-construction practices will isolate deeper geological units containing brine or petroleum products from the important fresh-water zones found at shallower depths.

Considerable care will be taken by Texaco to prevent the use of cracked or otherwise ruptured casing, and in the injection and curing of the cement grouts. After placement of the grout, a sonic log will be performed to test the bond between the casing and cement for the production casing, and the well will be pressure tested to ensure that satisfactory sealing has occurred.

2. Drilling Processes

Waste fluids are generated during the drilling process, consisting of drilling lubricants, drilling muds containing chemical additives, and brines originating from deeper formations. Though not toxic or harmful in nature, proper handling and disposal of these wastes is necessary to protect shallow fresh-water zones and surface waters from possible contamination. Texaco proposes to divert all drilling-waste fluids to above-ground settling tanks. In-ground waste pits will be constructed and used only in the event that a tank failure occurs, or when the flow temporarily exceeds the design capacity of the tanks.

Several precautionary steps will be taken to prevent seepage of the waste liquids from the pits into the ground in the event the pits are used. The pits will be lined with an impermeable geomembrane liner (30-50 millimeters thick), which will be underlain by a six-inch layer of poorly permeable clay soil. The geomembrane liner will be firmly anchored to the rim of the pit to prevent slippage during injection of drilling wastes. Also, drilling wastes will be frequently removed from the pits and carried offsite to an approved disposal facility.

Geological formations containing hydrocarbon reserves also commonly contain saline formation waters. If the formation water has a total dissolved solids (TDS) content in excess of 100,000 milligrams per liter (mg/l), it is defined as a brine. In the event the well goes to a production phase, this formation water becomes a waste stream referred to as "produced water." The salinities of such waters, whether formally defined as brine or not, necessitate their disposal in a manner that protects fresh-water supplies.

Subsurface disposal of produced water is a common practice in most oil producing states. This means of produced water disposal, while less expensive and more convenient than hauling the produced water to a disposal site, is only feasible if geological conditions permit this type of disposal without adversely affecting fresh-water aquifers. Formations

considered for deep-well injection of drilling wastes must have sufficient porosity, permeability, thickness, and areal extent to function as storage reservoirs at safe injection pressures.

The Maryland Geological Survey (Otton, 1970) concluded that Maryland's Inner Coastal Plain, similar to the Virginia Coastal Plain, is unsuitable for deep-well injection of wastes, presenting a "very significant hazard to ground-water supplies." This conclusion was based on the relatively shallow depths of formations examined, the resulting uncertainty of confining conditions, and the presence of fresh or only slightly saline water in the majority of aquifers in this area.

While the disposal of produced water will not be an issue during the exploration phase of this project, it will become an important concern should the well go into a production mode. Alternative disposal methods are discussed in Section V.A.

3. Abandonment Procedures

If the drilling of the exploration well is unsuccessful, abandonment procedures will be undertaken. The abandonment will consist of placing cement plugs and non-porous materials throughout the length of the well. A cement plug will be placed at any hydrocarbon-bearing formation. The plug will cover the thickness of the formation, and will also cover overlying and underlying formations.

Cement plugs will also be placed at the base of the surface casing and at the fresh and brackish-water interface. Again, this plug will cover the entire interface, and will extend 100 feet above and below the interface. Although the fresh-water zone will be protected from contamination by the casing and grouting installed during construction of the well, this additional cement plug will provide a secondary means of protecting fresh-water supplies should a casing failure occur.

A cement plug will then be placed in the well from just below (about 8 feet) the ground surface to a depth of 50 feet. The surface and conductor casings will be cut off about 8 feet below the ground surface. A 1/2 inch steel plate will be placed on top of the cut. Where cement is not set in the well, non-porous material (muds) will be used to fill the length of the hole.

This abandonment procedure will restore hydrological isolation of fresh-water zones, thus protecting them from possible contamination. Naturally, any abandonment procedures will be conducted in accordance with Commonwealth of Virginia regulations.

III.B. Surface Water Resources

Several measures will be taken to protect the surface waters of the Upper Machodoc Creek and its tributaries from any discharges associated with the exploratory drilling. Because the project site is drained by two intermittent tributaries, it is possible that preventative measures may be required on both tributaries simultaneously. The proposed project will include the following preventative measures:

- a dirt containment levee that encompasses the entire drill site (except trailer and parking area) to collect all surface runoff from the site and allow transport of this water off-site.

- an earthen dam to be constructed (if any spilled materials escape the dirt containment levee) across the local intermittent stream channel(s) draining the rig site, in a location that will allow collection of these materials without impeding the permanent flow of water in the tributary(ies), and allowing for collection before the materials enter the wetlands and marshes along the Upper Machodoc Creek.

- a series of booms to be deployed in the event of a spill at a site on the tributary channel(s) upstream of the wetlands and marshes along the Upper Machodoc Creek, should any spilled materials escape the dirt containment levee and earthen dam.

The dirt containment levee will be seeded immediately after its construction to reduce the probability of any erosion from the berm surface. Also, the two existing earthen embankments (previously installed by the property owner for other reasons) on the western tributary draining the site, may provide additional containment of any released materials. These embankments are located just upstream of the confluence with the Upper Machodoc Creek and the associated wetlands, and may provide another level of protection, provided that the outlet pipes are adequately blocked following the accident to prevent flow through the pipes.

This array of protective measures should localize any spill or stormwater runoff, thus minimizing the spatial extent of any potential impact on the stream and its biota. These measures also allow for rapid response and cleanup of any materials that are spilled or escape any of the above containment structures.

Any post-drilling impacts on the Upper Machodoc Creek and its biota should also be minimal. The proposed plan for closure of the drill site entails regrading and replanting to return the site to its pre-construction condition. These activities should result in little if any

disturbance of the Upper Machodoc Creek during the post-drilling period. Appropriate erosion control measures, as defined by the State and King George County, will also minimize any effects of stormwater runoff, until such a time as the site is revegetated.

In total, the proposed site configuration, spill containment, and cleanup measures will provide more than adequate protection of the Upper Machodoc Creek and its tributaries, and the associated biota. The impact, if any, on the surface water resources will be minimal.

III.C. Vegetation and Wildlife

1. Vegetation

All existing forested areas will be maintained undisturbed under the proposed project. Direct impacts of construction and operation of the drilling project will be limited to the open agricultural field on the southwestern portion of the property. This area is currently in pasture. Indirect impacts of construction runoff to natural vegetation down slope from the site will be minimized by the implementation of an approved sedimentation and erosion control plan. Construction at the site will establish a levee that will surround the drilling rig and operations. This levee is designed to allow no fluid, including rainwater, to escape the site.

2. Wildlife

There appear to be two direct potential impacts to wildlife associated with construction and operation of the project. The first will be the loss of the limited drill site area itself and of the immediately adjacent portions of the agricultural field as habitat for grassland species such as the meadow vole and as foraging habitat for granivorous/insectivorous species such as blackbirds, and herbivores such as whitetail deer. The second anticipated impact to wildlife will be the potential disruption of movement patterns for mammals with large home ranges such as whitetail deer and red fox. Because these species are more sensitive to human activity than the avian species mentioned above, the "impact area" of the project site may extend several hundred meters from the site itself with regard to their behavioral patterns. However, it should be noted that if the exploratory drilling is unsuccessful, even the relatively minor impacts described will represent only a temporary condition. These impacts, should they occur, would nevertheless be considered extremely minor as well as temporary.

III.D. Wetlands

The proposed project site is located approximately 500 feet from the nearest intermittent stream channel and more than 800 feet south of any non-tidal wetland associated with this stream channel. The nearest of the extensive tidal marshes along Upper Machodoc Creek is approximately 0.4 miles from the proposed rig site. No direct impacts to these areas are anticipated from the construction or operation of the drilling project. As noted previously, indirect impacts of construction to downgradient communities will be minimized by the implementation of an approved sedimentation and erosion control plan. Indirect impacts of the actual drilling operation will be substantially controlled by construction of the proposed levee around the drill site.

III.E. Economics

It is very unlikely that the population increase from this proposed exploratory well, or possible production scenarios, would result in any socioeconomic dislocations. Twenty to 25 people will be housed on-site during the 14-20 week drilling and abandonment period for the test well. During the site preparation and cleanup phases, far fewer people would be involved. These people would live offsite for approximately 4 weeks prior to and following drilling.

1. Population

The estimated workforce for the project is 20 to 25 persons for the drilling phase of the project. The skill categories required for exploratory well drilling would not be found locally. In fact, Texaco will utilize a crew of individuals that travel around the country, to work on these projects.

The types of labor usually required for an exploratory test well include: tool pusher, driller, engineer, crane operator, mechanic, electrician, common laborer, welder, logging crew, casing crew, formation testing crew, geologist, and supervisor. To the extent that any common laborers or contractors were hired locally, this would represent an economic plus to the County residents.

The in-migrant labor will not be accompanied by families. Previous studies (Centaur Associates, 1985) have noted that most of this labor is from outside the area and do not move their families for the temporary assignment. Many oil and gas development companies rotate their drilling crews on and off the project, where a crew may work 7 or 14 days of twelve hour shifts, followed by transit home, and 7 to 14 days off.

As indicated above, 20 to 25 people would be living on-site during the 14-20 week drilling and abandonment phase, with far fewer individuals involved in the four week site preparation and cleanup phases. Hence, there will be no significant population impact associated with the exploratory phase of the project.

2. Housing

During the exploratory phase, individuals will be housed on-site in temporary housing (e.g. trailers), which will be removed after the 14-20 week test period. Drinking water will be obtained from a shallow water well, while on-site sewage treatment/disposal will be handle by an on-site septic system.

3. Economic Impacts

A complete economic impact analysis of a development project would include an itemization of all local purchases of goods and services associated with the exploration phase, and an analysis of the effects of these purchases throughout the County's economy. Such an effort is unnecessary in this case, because a limited amount of the goods and services used would be purchased locally. The exceptions, however, might include site preparation, waste disposal, communications, warehouse, food and miscellaneous tool rentals. In general, most of the items used for well drilling such as drill bits and mud, well services, the drilling rig, well control equipment, safety services, and well-heads would be provided from vendors outside the immediate area. Some utilization of local restaurant, groceries, and shops could be expected. To the extent that some items were purchased locally, this would represent a positive economic contribution to the local economy and local household income.

4. Public Services

No impacts are expected on local public services associated with the project, given the lack of any expected population impacts, and the self-contained nature of the project.

III.F. Air Quality

The proposed operations will involve site preparation, transportation of equipment and materials to the site, set-up, and the drilling itself. Emissions of air pollutants will result from the following:

- The diesel-fueled drilling generators. It is expected that 3 units, each of approximately 950 HP, will be used. At any given time, 2 units will be in operation, with the third as backup.

- Vehicular traffic exhaust, including trucks used to bring the drilling rig in and out, to haul wastes off-site, and automobiles used by site workers.

- Fugitive emissions from paved and unpaved roads because of vehicular traffic.

- Fugitive emissions from construction activities including land clearing, site grading, site restoration.

- Fugitive emissions of volatile organic compounds in cleaning formulations and paints.

Of these, most emission sources are expected to be short-term and minor in nature. The diesel generators are expected to be the only significant sources of atmospheric emissions. Information from a vendor of diesel engines was used to estimate emissions from these generators. The estimates are presented in Table III-1.

The potential impact of emissions from the diesel engines was investigated further by the use of USEPA's ISC-ST model run in the screening mode. This method estimates hourly downwind concentrations under 24 different combinations of wind speed and stability class.

It was assumed that two diesel generators would operate at any given time, 24 hours/day for a maximum period of 3 months. Parameters used in the screening procedure include:

- Discharge height 15 feet

- Exhaust gas flow rate 5,043 acfm at 874° F at 100% load, 1980 CFM at 597° F at 30% load

- Two stacks of 12 in. diameter, 15 ft. apart

The referenced screening procedure estimates maximum 1-hour concentrations. To estimate concentrations for longer averaging periods, scaling factors were used to convert maximum hourly concentrations to maximum 8 and 24 hour and annual average concentrations. The following factors were used:

Averaging Time	**Scaling 10 Factor**
8 hours	0.7
24 hours	0.4
Annual	0.06

Maximum predicted ambient air quality concentrations were estimated using this screening procedure, and are shown in Table III-2. It is seen that the maximum predicted concentrations are well below the National Ambient Air Quality Standards.

III.G. Waste Management

Typical well construction operations involve rotary drilling employing the recirculation of a drilling fluid (mud). The mud is pumped down the hollow drill pipe and across the face of the bit to provide lubrication, cooling, and to remove cuttings. The mud and cuttings are then pumped back up through the annular space between the drill pipe and the walls of the hole or casing. The mud also helps to stabilize the well-bore, and counter-balances the pressure of oil, gas, or water in the formations being drilled.

A fresh water based mud system will be used at this site. Constituents of mud include:

- Bentonite for viscosity
- Chrome-free Desco for thinning
- Hematite or barite for weighting
- Drispac (polyanionic cellulose) (for dewatering)
- Potassium hydroxide (for pH control).

At the surface, cuttings will be removed using a solid control system including following equipment:

- Shale shakers (2)
- De-sander
- De-silter
- Centrifuges (2)
- Manifold for adding polymer flocculants.

The reclaimed drilling mud will then be recirculated back to the well. All drill cuttings from the solids control equipment will be stored on site, prior to further disposition.

Potential producing zones will be tested to determine if commercial quantities of oil and/or gas are present. If a decision is made to go to the production phase, the well will be "prepared" or completed. Typically, this involves running production casing into the hole and cementing it in place. Then one or more strings of production tubing are set in the hole, productive intervals are isolated with packers, and surface equipment is installed. Perforation in the producing zone completes the well and starts the flow of petroleum products into the well.

Frequently, some stimulation techniques are necessary to aid or increase the flow of oil or gas. Such techniques include acidizing (use of acids to enlarge channels in rock) and fracturing (use of fluids containing sand or glass beads under high pressure to create fractures in the rock). Other specialized fluids may be used for corrosion inhibition, cleanup, and to reduce friction. The formation retains some of these fluids; a portion is returned to the surface during production and must be separated and disposed of.

Other wastes may be generated from activities such as painting, maintenance of on-site machinery (e.g. lubricating oil), washing and cleaning of the rig. Rigwash compounds are mostly detergents but can include some organic solvents such as degreasers. Another type of waste is pipe dope, which is used to lubricate connections in pipes.

It should be noted that not all such wastes will be generated in this instance. The use of acidizing or fracturing fluids, for example, is not anticipated. In the event any such wastes are generated, they will be transported off-site to an approved disposal facility.

A final determination regarding the method of disposal of waste drilling cuttings has not yet been made. The liquid component of the waste drilling mud will be hauled offsite for any disposal option selected. Some of the options being considered for solids disposal at this time are:

1. Mixing the cuttings into the native soil at the completion of drilling.

   The major potential environmental impact of this option is associated with the relatively high levels of barium in waste drilling fluids, if barite is used as the weighting agent. The barium is present in the form of barium sulfate, which has a relatively low solubility in water (1.3 mg/l at 18 C, expressed as barium). The current MCL (i.e. maximum contaminant level) for barium in drinking water is 1.0 mg/l. There are currently no numerical water quality criteria for barium for the protection of aquatic life. Given the low solubility of barium sulfate, and the likely dilution associated with migration to either

surface or ground water, it is likely that the resulting concentrations in either surface or ground water will be far less than 1.0 mg/liter.

Studies conducted for the American Petroleum Institute (1983) indicate that the chief environmental problems associated with land disposal of drilling fluids are related to the mobile ions in these fluids, namely sodium and chloride. Such ions migrate to ground water, are available for plant uptake, and can cause plant yield reductions. Barium, being less soluble and mobile, is generally not available for plant uptake. Barium concentrations in ground water were lower than the drinking water standard at most sites studied. These studies also indicate the adverse environmental impacts can be minimized by low application rates (one volume of waste to four or more volumes of soil) and by the use of fresh water based muds (which have a lower salt content). In some instances land spreading of drilling wastes may benefit vegetative production by increasing the soil's water holding capacity.

2. Offsite disposal of cuttings and muds.

This option would involve transportation of waste drilling fluids by trucks to an offsite permitted disposal facility. While this would be a more expensive option, it would ensure that, no adverse site-specific impacts would occur. However, selection of this option would have to consider the potential for an accident during transport to the disposal facility.

Under Section 3001 (b)(2)(A) of the 1980 Amendments to the Resource Recovery and Conservation Act, Congress temporarily exempted several types of solid wastes from regulation as hazardous wastes, pending further study by the EPA. Among the categories of waste exempted were "drilling fluids, produced water, and other wastes associated with the exploration, development, or production of crude oil or natural gas..." On December 31, 1987, the EPA completed its study, as part of which it defined exempt wastes (USEPA, 1987). Table III-3 presents a partial list of exempt and non-exempt wastes. Exempt wastes, though not regulated under RCRA, are regulated as solid wastes under existing Federal and State requirements.

Consequently, all the wastes discussed in this section are exempt from regulation under RCRA, although they must still be managed as solid wastes in accordance with other, generally less stringent Federal and State requirements.

III.H. Noise

The proposed changes at the site may be differentiated into two groups - those related to the construction phase, and those related to the drilling operation itself.

During the construction phase, an access road to the drill site will be built, the site cleared and graded, and the drilling rig and associated equipment brought on-site and assembled. Noise sources during construction include: construction machinery, trucks used to bring material to the site, and vehicles used by site workers. It is expected that construction machinery to be used for site preparation will probably include a dozer, backhoe, and crane. Noise levels from these sources are shown in Table III-4. All these noise sources will be temporary in nature, since the construction phase is expected to last no more than 30 days.

During the construction phase, it is expected that about 45 truck trips will be necessary for the transportation of equipment and supplies, spanning several days. An increase in automobile traffic may also be expected during the construction phase. This increased construction-related traffic will result in temporary increases in noise levels along Route 205. Noise levels from trucks are expected to be below 90 dB(A) (at 15 meters), and those from automobiles to be below 70 dB(A) (at 15 meters).

At the conclusion of the construction phase, the drilling operation will commence. While the drill rig itself may be considered as a noise source, it is in reality composed of several individual sources including the diesel engines, the rotary drive, circulating water pumps and mud pumps, the shale shaker and assorted equipment. Noise from each such source is transmitted by both structural and airborne means to form the combined noise from the rig.

Noise levels were measured by Texaco Inc. at various distances from a rig located in the Hatters Pond field in Alabama. The results of those measurements are summarized in Table III-5. As may be expected, noise levels decrease as the distance from the rig increases. The Hatters Pond rig is similar in size and equipment to the one proposed for this project. However, the diesel engines (one of the major individual noise sources on a rig) at the King George County site will be equipped with mufflers, unlike those at the Hatters Pond site. Consequently, the overall noise levels from the proposed rig are expected to be lower than the values shown in Table III-5.

III.I. Archaeological and Historic Resources

Based on information from the Virginia Department of Historic Resources, the archaeological/historic features known to exist on the adjacent property are sufficiently far from the drill site and will not be impacted by the exploratory operations.

III.J. Visual and Scenic Resources

As previously described, the drill site is not located in, along, or within view of any known scenic resources. There are no public parks or recreational facilities within the general area. The drill site will be within view of motorists driving by on SR 205, and from approximately 5 nearby residences, and possibly one residence on the lease property (depending on foliage). Because the exploration operations are only temporary, they will cause only minimal impact to the immediate viewing area. Night lighting will be maintained at the sight for security and 24-hour operation of the rig. This lighting may be visible from these homes and the road. Efforts will be made to direct such lighting to the immediate area of operations, and away from homes and surrounding areas.

Table III-2. MAXIMUM ESTIMATES OF AIR QUALITY IMPACTS

(Concentrations in micrograms/cubic meter)

Pollutant	NAAQS	Maximum Prediction 100% load(a)	30% load(b)
Nitrogen oxides			
Annual avg.[c]	100	33.2	22.4
Sulfur dioxide			
24 hr avg.	365	55.0	46.6
Annual avg.[c]	80	2.1	1.7
Carbon monoxide			
1-hr avg.	40,075	507.5	185.0
8-hr avg.	10,030	355.2	129.5
Particulate			
24-hr avg.	150	8.7	9.3
Annual Avg.[c]	50	0.3	0.4
Hydrocarbons			
1-hr avg.	--	129.0	92.5
Annual avg.[c]	--	1.9	1.4

(a) Both engines at 100% load

(b) Both engines at 30% load

(c) Annualized average concentration resulting from operation over 3 months.

Table III-3. PARTIAL LIST OF EXEMPT AND NONEXEMPT WASTES (USEPA, 1987)

Exempt Wastes

Drill cuttings

Drilling fluids

Well completion, treatment, and stimulation fluids

Packing fluids

Sand, hydrocarbon solids, and other deposits removed from production wells

Pipe scale, hydrocarbon solids, hydrates, and other deposits removed from piping and equipment

Hydrocarbon-bearing soil

Pigging wastes from gathering lines

Wastes from subsurface gas storage and retrieval

Basic sediment and water and other tank bottoms from storage facilities and separators

Produced water

Constituents removed from produced water before it is injected or otherwise disposed of

Accumulated materials (such as hydrocarbons, solids, sand, and emulsion) from production separators, fluid-treating vessels, and production impoundments that are not mixed with separation or treatment media

Appropriate fluids injected downhole for secondary and tertiary recovery operations

Liquid hydrocarbons removed from the production stream but not from oil refining

Gases removed from the production stream, such as hydrogen sulfide, carbon dioxide, and volatilized hydrocarbons

Materials ejected from a production well during the process known as blowing down a well

Waste crude oil from primary field operations

Light organics volatilized from recovered hydrocarbons or from solvents or other chemicals used for cleaning, fracturing, or well completion

Table III-3. (CONTINUED)

Nonexempt Wastes

Waste lubricants, hydraulic fluids, motor oil, and paint

Waste solvents from clean-up operations

Off-specification and unused materials intended for disposal

Incinerator ash

Pigging wastes from transportation pipelines

Sanitary wastes, trash, and gray water

Gases, such as SOx, NOx, and particulates from gas turbines or other machinery

Drums (filled, partially filled, or cleaned) whose contents are not intended for use

Waste iron sponge, glycol, and other separation media

Filters

Spent catalysts

Wastes from truck- and drum-cleaning operations

Waste solvents from equipment maintenance

Spills from pipelines or other transport methods

Table III-4. PEAK NOISE LEVELS FROM CONSTRUCTION EQUIPMENT

Equipment	Peak Noise Level Within 15m dBA
Cranes	70 - 94
Backhoes	74 - 92
Dozers	65 - 95

Table III-5. MEASURED NOISE LEVELS AT A TEXACO DRILLING RIG, HATTERS POND, ALABAMA

(Sound Levels in dBA)

	Distance From Rig (ft)		
Location	5	1000	2000
South side	83-97	56-62	53-61
West side	83-97	58-64	53-61
North side	84-97	57-63	54-62
East side	73-86	56-62	53-60

Note: The baseline sound level 1 mile from the rig site was 50 dBA.

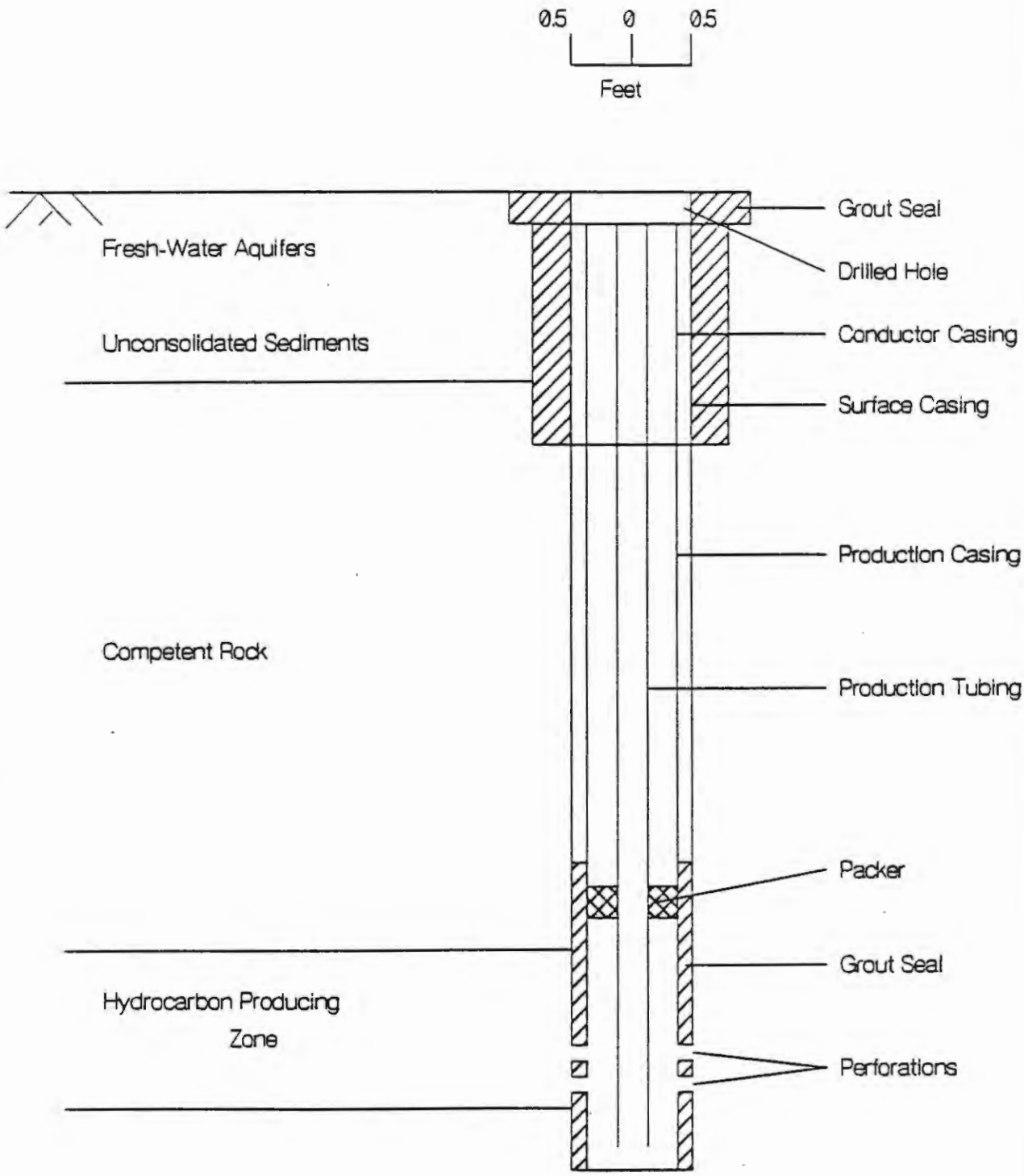

Figure III-1. SCHEMATIC OF KING GEORGE COUNTY PROSPECT WELL

Texaco EIA, King George Co., VA

COASTAL
ENVIRONMENTAL SERVICES INC.

IV. ASSESSMENT OF POTENTIAL IMPACTS FROM ACCIDENTAL EVENTS

IV.A. Ground Water and Geology

Potential contamination of fresh-water aquifers can occur during the initial stages of well drilling and construction, and during the later stages of production. Because the emphasis of this EIA is on potential environmental impacts associated with the drilling and construction of an exploration well, this section will address those potential impacts in a detailed manner, and the impacts associated with production procedures in a more general manner.

1. Drilling and Construction Procedures

a. Leakage from Waste Impoundments

The potential contamination of fresh-water aquifers by leakage from waste impoundments was addressed previously in the Drilling Processes section of Chapter III, and so will not be repeated here.

b. Well Control

A rare occurrence commonly known as a blow-out can occur when a formation containing fluids under extreme pressure, such as natural gas or oil, is penetrated during the drilling process. An unlikely combination of failures in the mud system and casing or mechanical blow-out prevention (BOP) systems must occur for a blow-out to happen. This sudden release of pressure from the formation results in the release of the gas or liquid. The force of the expulsion of gas or oil will be a direct result of the pressure that naturally exists within the formation. The volume of liquid or gas expelled will be variable and dependent on numerous factors such as the formational pressure and the volume of hydrocarbon present in the formation.

The environmental impacts of a well blow-out would depend on the nature of the hydrocarbon (i.e., natural gas or oil), the volume of hydrocarbon released, and the force of the expulsion. The environmental impacts resulting from an oil-well blow-out would likely be significantly more extensive than a blow-out of a gas well because the former concerns the expulsion of a dense liquid, and the latter concerns expulsion of a gas. This discussion will therefore be limited to an oil well blow-out, although a gas discovery is more likely, should the test well prove to be successful.

Normally, blow-outs are prevented by carefully monitoring pressures in the drill pipe and well annulus during drilling. Should elevated pressures be discovered during drilling, certain precautionary measures will be taken to prevent a blow-out from occurring.

There will be three lines of defense taken to minimize the adverse environmental effects associated with a well blow-out. The first two (mud weight and BOP equipment) are procedures which are aimed at preventing the occurrence of a blow-out during the drilling of the exploration well. The third line of defense is aimed at limiting the damages that would result in the unlikely event that a well blow-out occurs.

Pressures will be carefully monitored in the drill pipe and well annulus, and if elevated pressures are encountered, mud weight will be increased to control such pressures. If the use of heavier muds under higher pumping pressures does not adequately reduce the elevated pressure, a pipe ram (BOP) will be used to shut the well in. This procedure will prevent explosive escape of petroleum products from the well.

In the unlikely event that the precautionary measures fail to prevent a blow-out from occurring, procedures will be enacted to catch the petroleum products at the ground surface. The design of the surface catchment program will include earthen levees surrounding the drill site to prevent movement of the oil off-site. Impoundment structures (secondary containment) will be constructed on drainage ways, and surface water booms will be used to trap the released oil in the event that the secondary levees fail.

i. Environmental Impacts to Soils

The volume of soil adversely affected by the blow-out will be dependent on the volume of oil expelled from the well, and the force of the expulsion. Thus, the first procedure performed after a blow-out will be the delineation of the areal extent of the contamination using appropriate methods such as conduction of a soil-gas survey and collection of soil-water and soil samples. Subsequent to analysis of the samples, soil will be removed from affected areas and transported to an appropriate waste disposal facility.

ii. Environmental Impacts to Ground Water

The results of the soil-gas survey, and analysis of soil and soil-water samples will indicate the extent to which the blow-out may have affected ground water. The Yorktown-Eastover deposits provide the shallowest aquifer in the area and are underlain by the poorly permeable Calvert Formation. The Calvert Formation would greatly impede vertical movement of oil to the deeper confined aquifers, thus limiting contamination of ground water by oil to the aquifer contained in the Yorktown-Eastover deposits. The number of domestic wells affected by such a contamination would be minimal, as there are few domestic wells surrounding the well-site that derive water from this aquifer.

Because ground-water flow in the Yorktown-Eastover aquifer is toward local discharge points, and because it also discharges along exposures of the geological contact between these sediments and the Calvert Formation, surface waters may also be affected by oil-contamination of the shallow ground water, should this occur. An accidental event of sufficient magnitude to contaminate shallow ground water is unlikely. However, if necessary, the containment procedures for surface water resources, as described in Chapters III.B and IV.B, will be used to contain and collect contaminated water that migrates into the tributaries.

2. Production Procedures

a. Casing Failure

Although failure of surface casing in a properly constructed well is unlikely, its result could be contamination of important fresh-water aquifers. Whether or not fresh-water aquifers would be contaminated, and the extent of the contamination would depend on the nature of the casing failure, and how soon after the failure the incident is discovered and corrective action taken.

To prevent such incidents from going unobserved, certain precautionary measures will be taken to monitor the well if it reaches the production stage. Pressure gauges will be installed on the well and the pressures monitored frequently. Pressures between the various casings should be zero under normal circumstances. Failure of the production tubing or casing would be evident in positive pressure readings between casings strings. In this case, fluid samples can be collected from bleeder valves, and analyzed to help ascertain the nature of the problem. While this process cannot prevent failures in the well, it can minimize adverse effects to fresh-water zones by discovering any problem in its early stages.

Should a leak be discovered in the well by pressure monitoring, well production will be stopped immediately. Subsequently, a sampling scheme will be devised to delineate the extent of the contamination. After determination of what formations are affected, and determination of the associated human health risk, a remedial action plan, if required, will be prepared and implemented.

b. Subsidence

Surface subsidence in the area of the proposed well is extremely improbable due to the depth and nature of the formations from which gas/oil reserves will be potentially withdrawn. The anticipated depth of the proposed well extends into competent bedrock, far beyond the lowest extent of the unconsolidated Coastal Plain sediments. Removal of hydrocarbons or formational waters from producing zones should not result in subsidence unless these formations are characterized by large solution cavities or fault zones.

Although land subsidence associated with oil and gas operations has rarely occurred elsewhere, such as in the Wilmington oil field near Long Beach, CA, it is generally associated with oil production activities. In the Wilmington oil field, subsidence was attributed to a number of unique local geologic conditions. The area is tectonically active, and the near-surface strata are comprised of generally unconsolidated sediments forming incompetent strata. Thse incompetent formations form a relatively low, flexible arch that cannot sufficiently support their weight when the fluid is removed. The withdrawal of oil resulted in compaction in the oil-bearing formations which was followed by downwarping and subsidence of the overlying arched formations. Regional tectonics and the compaction of these unconsolidated sediments contributed to subsidence in this area even before significant oil operations began (City of Huntington Beach, 1982; Underground Injection Practices Council, 1989).

c. Earthquakes

While the occurrence of earthquakes is difficult to predict on the East Coast, the Maryland Geological Survey has reported that "Maryland has a very low chance of experiencing a damaging earthquake in a 50-year period" (Reger, 1987). In the next 475 years Virginia can expect to experience a quake with horizontal ground acceleration equivalent to only 8 percent of the acceleration due to gravity (Figure IV-1).

In the event of casing failure due to an earthquake, the same procedures would be followed that are outlined earlier in this document.

IV.B Surface Water Resources

The major catastrophic accidental event that could impact the surface water resources of the Upper Machodoc Creek, its tributaries, and the associated biota is a blow-out. As described in Chapter III, the proposed containment structures should provide adequate protection of the Creek and tributaries from such an occurrence by localizing the blow-out materials thus allowing for rapid cleanup. In particular, the tidal wetlands located along the Creek at the lower reaches of the tributaries, and non-tidal wetlands along the tributary channels, are the major aquatic habitats that will require protection from any harm due to an accidental event.

IV.C. Vegetation and Wildlife

1. Vegetation

It is difficult to predict potential impacts for hypothetical accident scenarios. However, impacts can be generalized for the two most likely accident scenarios. If drilling muds were to escape the primary containment area, some downslope areas of natural vegetation could be buried. This could result in the destruction of some herbaceous and shrub vegetation; and depending on the depth and duration of the fill, some trees could be lost.

If oil were to escape the primary containment area, potential impacts would be more severe. Presumably, cleanup would involve the removal of contaminated soils. Any vegetation on those soils would likely be destroyed in the cleanup operation. These areas would then have to be regraded, have topsoil applied, and be replanted.

2. Wildlife

The escape of drilling muds from the primary containment area would have the greatest effect on those animals associated with the ground and herbaceous layer; such as leaf litter invertebrates, small mammals (e.g., mice, shrews, voles), salamanders, toads, snakes, and if the accident occurred during the breeding season, the nests of some species of birds.

An oil spill would affect all wildlife in the area of the spill and potentially beyond, either directly through contact, or indirectly through habitat loss or food contamination.

IV.D. Wetlands

Presumably, the quantity of drilling muds that could escape the drill site is not sufficient to reach downstream areas in amounts great enough to have significant immediate or long term impacts. However, the potential exists under a worst case oil spill scenario for wetlands down stream of the drill site to be adversely affected. Tidal action could exacerbate this impact by spreading contamination more rapidly.

IV.E. Air Quality

Potential air quality impacts can occur as a result of certain accidental events during the initial stages of well drilling and construction, and during the later stages of production.

a. Drilling and Construction Procedures

Both crude oil and natural gas may contain the toxic gas hydrogen sulfide. When dissolved in crude oil, it is not expected to have an air quality impact, but when produced at the wellhead in gaseous form, it may have an air quality impact in the event of a well blow-out. Measures that are taken to prevent well blow-outs are described elsewhere. Texaco's experience at W.B. Wilkins No. 1 well in Westmoreland County, Virginia, indicates that the likelihood of encountering hydrogen sulfide in these operations is extremely low. In the unlikely event that a blow-out does occur and hydrogen sulfide is released, any air quality impacts will be transient, and atmospheric dispersion processes will dilute air quality concentrations. The Texaco crew on site should be well-prepared to enact emergency response procedures to be followed to ensure the safety of personnel and the general public in the surrounding area.

b. Production Procedures

As stated earlier, hydrogen sulfide is not expected to be found in this formation. If natural gas containing hydrogen sulfide is found, it will be separated out in a gas "sweetening" process. Processes employed for the removal of H_2S from natural gas include the amine, iron sponge, and selexol processes. These result in the emission of sulfur dioxide. Hydrogen sulfide will only be emitted in the event of a malfunction in the sweetening process. Bypass stacks or vents are typically used to ensure that any releases during the period of malfunction are diluted to safe levels.

Releases of volatile organic compounds can occur during malfunctions of process equipment used for the separation of petroleum products from produced water. Again, bypass stacks or vents are used to ensure that any releases during the period of malfunction are diluted to safe levels.

IV.F. Waste Management

Accidental events involving the storage, handling and disposal of each of the waste streams discussed earlier can have an environmental impact.

a. Drilling and Construction Procedures

Drilling mud and cuttings are to be managed in above ground tanks and solids control equipment. In the event of a failure in this system, wastes will be diverted to a lined mud pit. The mud pit, in turn, will be located within a levee, to ensure all wastes will be contained on-site and that there will be no off-site discharge.

If the option of off-site disposal of drill cuttings is selected, a transportation related accident can result in a release of contaminants to the environment. An emergency response team should be available to aid in spill containment and cleanup measures, to ensure that environmental impacts are minimized.

In the event of a well blow-out or uncontrolled flow of fluids, there may be some impacts to soils. Contaminated soils may have to be removed and transported to an approved waste disposal facility.

b. Production Procedures

Accidental events related to the handling of produced water could occur through:

- A failure in the storage and treatment system
- A failure in the deep well injection system (if this disposal option is chosen)
- A transportation related incident (if produced water is sent offsite)

In the event of a leak or rupture in the storage and treatment system, produced water will be diverted to a lined pit. This will ensure that there is no discharge to surface or ground water. The lined pit, in turn, will be surrounded by a levee, to ensure that there is no discharge to surface waters in the event of an overflow of the lined pit.

Problems related to the deep well injection system can be prevented by conducting periodic mechanical integrity tests. If leaks are detected, such disposal will be suspended until repairs can be made. Produced water will be sent off-site to a permitted disposal facility in the interim.

In the event of spills or releases from a transportation- related accident, measures will be followed to ensure that environmental impacts are minimized.

IV.G. Noise

Potential accidental events are described in the preceding sections. The noise levels associated with accidental events are difficult to predict. Events such as blow-outs or explosions, while considered to be unlikely, may result in high sound pressure levels for very brief durations of time. Depending on the intensity of the blast, the noise impulse may travel considerable distances. Beyond measures taken to reduce the likelihood of such events, there is little that can be done to reduce the noise impact. The fact that the well site is located in a predominantly rural area should serve to minimize the adverse impacts of such events.

IV.H. Archaeological and Historic Resources

The archaeological/historic sites known to exist on the adjacent property are sufficiently far from the drill site and will not be impacted by the exploratory drilling operations.

IV.I. Visual and Scenic Resources

The visual impacts of a potential accidental event may include those associated with emergency response equipment and activities at the site. If such an event occurred, these would be visible to motorists along SR 205 as well as the nearby residences, and would be temporary.

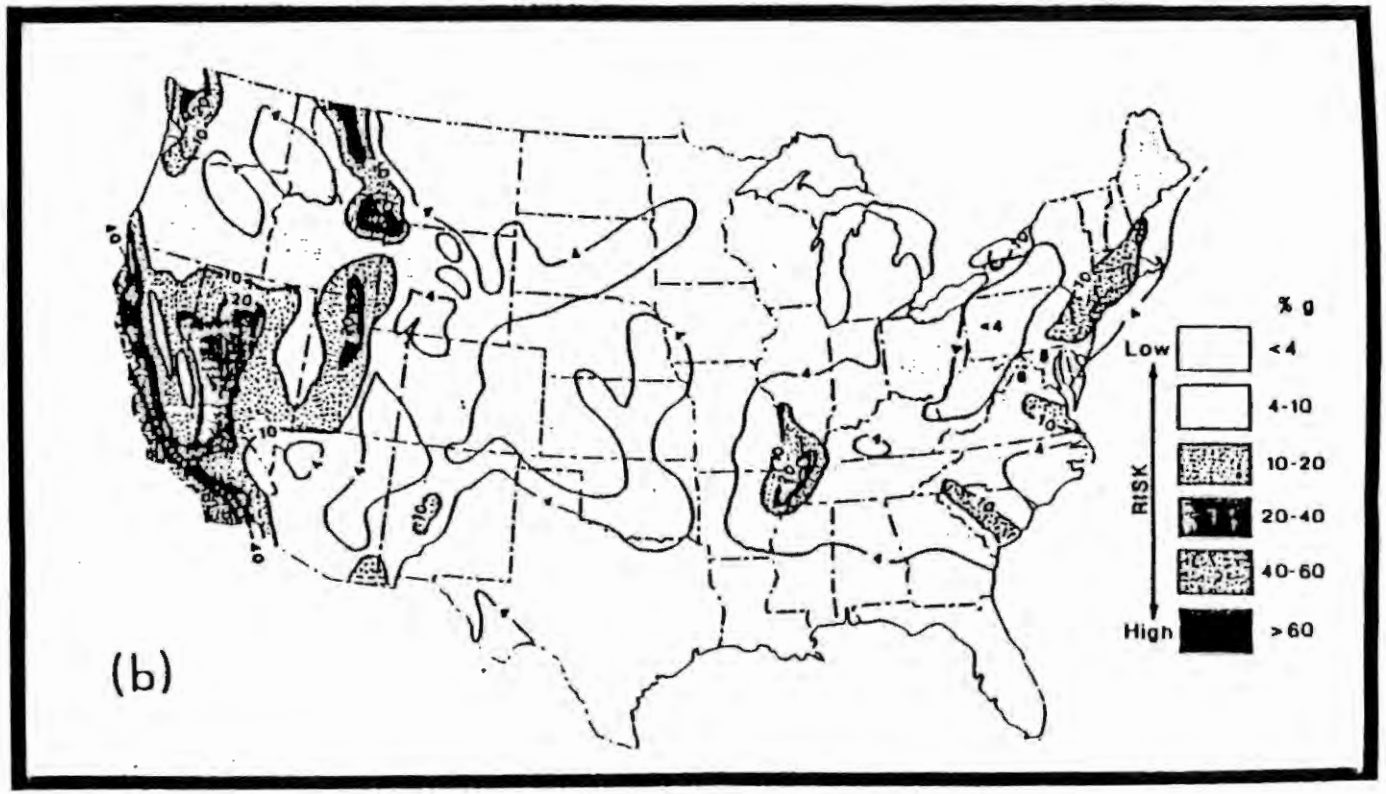

Figure IV-1. PROBABILISTIC RISK MAP SHOWING MAXIMUM HORIZONTAL GROUND ACCELERATION WITH A 90% PROBABILITY OF NOT BEING EXCEEDED IN 50 YEARS
(after Reger, 1987)

Texaco EIA, King George Co., VA

COASTAL
ENVIRONMENTAL SERVICES INC.

V. POTENTIAL IMPACTS RELATED TO LONG-TERM PRODUCTION

The focus of this EIA is the environmental impacts that would be associated with the construction and drilling of an exploratory well. Should the test well prove successful, Texaco may consider the well for production purposes. Potential impacts associated with a production phase of this project (for the specific well, or a well field), are discussed below only in a general manner. Obviously, further environmental investigations would be warranted if additional well sites were being considered. Potential accidental scenarios and resulting impacts of a production well were discussed in Chapter IV.

V.A. Ground Water and Geology

Long-term production related impacts to ground-water resources are similar to the possible ground-water impacts discussed previously in the EIA. Long-term production related impacts would differ only in that there may be a higher probability of an accident occurring since production of a profitable petroleum reserve would continue for some length of time, and would more than likely consist of a well field, rather than a single well.

Brine generated during production from a single well or a well field will require adequate disposal. Permission from the state may be sought for deep-well injection, provided that a suitable and safe repository for the brine is discovered. While Otton (1970) concluded that shallow disposal of injected wastes may pose a hazard to ground water resources in the Coastal Plain, injection at much greater depths may be acceptable. The produced brine represents only a percentage of the total fluid withdrawn from the producing formation and would be injected to approximately the depth from which it was extracted. Due to the substantially deeper location of the injection zone relative to the depth of freshwater aquifers, it is highly unlikely that contamination would occur. Further, the confining conditions that must exist for oil or gas accumulations to occur may also serve to confine injected brines from overlying aquifers. Another alternative would be to collect and transport brine to an appropriate disposal facility.

As described in Chapter IV (section A.2.b.) surface subsidence in the area due to oil drilling or production is extremely improbable due to the depth and nature of the formations from which the gas/oil reserves will be potentially withdrawn.

V.B. Surface Water Resources

If the proposed test well proves successful, production activities may proceed at the site. If so, these activities will pose similar potential impacts as did the exploratory drilling operations. The precautionary measures specified to be employed to contain any spills or

blow-out should provide adequate protection of the surface water resources in the area. If more wells are put into production, further assessment of the potential long-term impacts may be necessary.

V.C. Vegetation and Wildlife

1. Vegetation

If a production well were to be located in the existing agricultural field, impacts would be minimal and similar to those described for vegetation under Chapter III.

2. Wildlife

If the drill site is limited to the agricultural field, impacts would be minimized. However, if more than one production well is being proposed, it can be expected that expanding the area and intensity of human activities on the site will increase the impacts to wildlife.

V.D. Wetlands

Impacts of a production well on this site would be similar to those described for wetlands under Chapter III. Potential offsite impacts such as sediment runoff would require more information on the extent of the proposed well field.

V.E. Economics

Should the well prove successful, the magnitude of population increase associated with a production facility will need to be considered. The actual production crew would probably include 5 to 10 persons. These individuals would move into the area with families, if they have them, since their assignment would be long-term. A reasonable expectation is that the total number of in-migrant population associated with a production well would be 20 to 30 persons. Given the size of the County population, and the presently expected growth rate of this population in the absence of oil and gas development, it does not appear that there will be significant population impact associated with either the exploratory or production phases of the project.

Another positive economic contribution could be an increase in the local tax base. If the site were successful, the County would tax the site, most likely as a commercial

property, thereby increasing the tax base in the County. A severence tax of up to 3% of the full well stream revenue would also result in a positive economic contribution to the county.

Possible impact on public schools is expected to be minimal also. Information from the County on the local public schools suggests that capacity in these schools is being reached, and new facilities will be needed shortly. The County has plans to expand the elementary school capacity by September of 1991 to accommodate anticipated growth. Therefore, the possible increase of school-age children due to permanent population increases associated with this project should have minimal impact on school facilities.

V.F. Air Quality

Once the well is completed and production operations commence, emissions of air pollutants will result from processes employed to separate hydrocarbon fluids and produced water, and to remove hydrogen sulfide (if present) from natural gas. There will also be emissions related to the transportation of petroleum products and production wastes. Specific emission sources include the following:

- Process vents and fugitive emissions from oil/water separators, gas/liquid separators, gas dryers and gas sweetening units
- Natural gas flare(s)
- Pipeline compressor engines for transporting natural gas offsite
- Vehicular exhaust from trucks used for hauling produced waters (if this option is selected; see discussion in section on waste management) and other wastes off-site
- Fugitive emissions from unpaved and paved roads because of vehicular traffic.

All these emission sources are expected to be minor in nature and no significant air quality impacts are expected. Process descriptions, estimates of emissions of toxic air pollutants, and an assessment of ambient air quality impact will also be required. Much of this information will be available only after it is known whether oil and/or gas are present in commercial quantities, and a decision is made to go to the production phase.

V.G. Waste Management

Typical production operations involve separation of the fluids produced from a well field e.g. crude oil, natural gas, and produced water, and treatment of these fluids. Figure V.1 shows a schematic of typical production operations. New wells may produce little if any water. As reservoirs are depleted the ratios of produced water to hydrocarbon product fluids may increase steeply, particularly if waterflooding is employed to enhance product recovery.

Before the product can be transported by pipeline, the water must be removed. While some oil/water mixtures may separate easily by settling/flotation processes, the use of emulsion-breaking processes is often necessary. About 500 different types of de-emulsifiers, or mixtures thereof, may be used. Heat may also be applied, in "heater treaters". Separated oil and water streams are stored in tanks prior to further transportation and/or disposal.

The largest volume of production-related wastes is that of produced water. The quantity of such water generated often varies widely from well to well, and cannot be estimated reliably at this time. Typically, most produced water is injected down disposal wells or enhanced recovery wells, or may be discharged to tidal areas, surface streams, storage/evaporation ponds, or put to agricultural or other beneficial use.

Produced water has high level of total dissolved solids (as much as 100mg/liter or more), and in particular, chlorides. It may also contain low levels of hydrocarbons, metals, and radionuclides. Hydrocarbons found in produced water include volatile organics (e.g. benzene), base/neutrals (e.g. phenol), and acid extractables (e.g. phenanthrene). Metals include barium, lead, arsenic, cadmium and zinc. If underground injection is used, these materials pose no problem to the environment.

The production of natural gas involves dehydration processes, often using glycol, or various solid desiccants. A typical glycol dehydrating system contains approximately 150 gallons of glycol, which is replaced every 3 to 6 months.

Apart from produced water, other wastes that may be generated from oil and gas production operations include:

- Tank bottoms, sludges and sediments from product and waste storage tanks and process vessels.
- Gas plant dehydration wastes (including glycol compounds, filter media, backwash, and molecular sieves).
- Wastes from sweetening processes, including waste reactants and reaction media.

A final determination regarding the method of disposal of produced waters has not yet been made. Some of the options being considered at this time are:

- Deep well injection of produced waters. This option is discussed further in the section on ground-water impacts.

- Offsite disposal at a permitted facility. This option would involve transportation of produced waters by tanker trucks to an offsite permitted disposal facility. While this would quite likely be the most expensive option, it would ensure that no site-specific environmental impact would occur. However, this option would have to consider the potential for an off-site accident during the transport to the disposal facility.

All other wastes will be transported offsite to approved treatment or disposal facilities. All the wastes generated from production operations (see Table III-4) are exempt from regulation under RCRA, although they must still be managed as solid wastes in accordance with Federal and State requirements.

V.H. Noise

Noise sources from producing wells depend on whether oil or gas is produced, since that dictates the type of equipment used. Typical noise sources from producing wells include compressors and pumps. Noise levels are expected to be roughly the same as from exploration operations, (and lower if compressors are not used) and are not expected to result in a significant impact.

Because of the longer term of operation of producing wells, Texaco may consider the use of noise controls such as line-of-sight barrier walls and site grading to minimize the environmental noise impact. All production operations will comply with applicable noise regulations.

V.I. Archaeological and Historic Resources

Based on information from the Virginia Department of Historic Resources, the archaeological and historic features that are known to exist on the adjacent property are sufficiently far from the drill site and would not be impacted by long-term production operations.

V.J. Visual and Scenic Resources

If operations moved into long-term production, the visual impacts would remain unchanged, except for their duration. The operations would be visible to motorists on SR 205 and nearby residences in the immediate area. Efforts would be made to direct night lighting to the immediate project site and away from the road and residences.

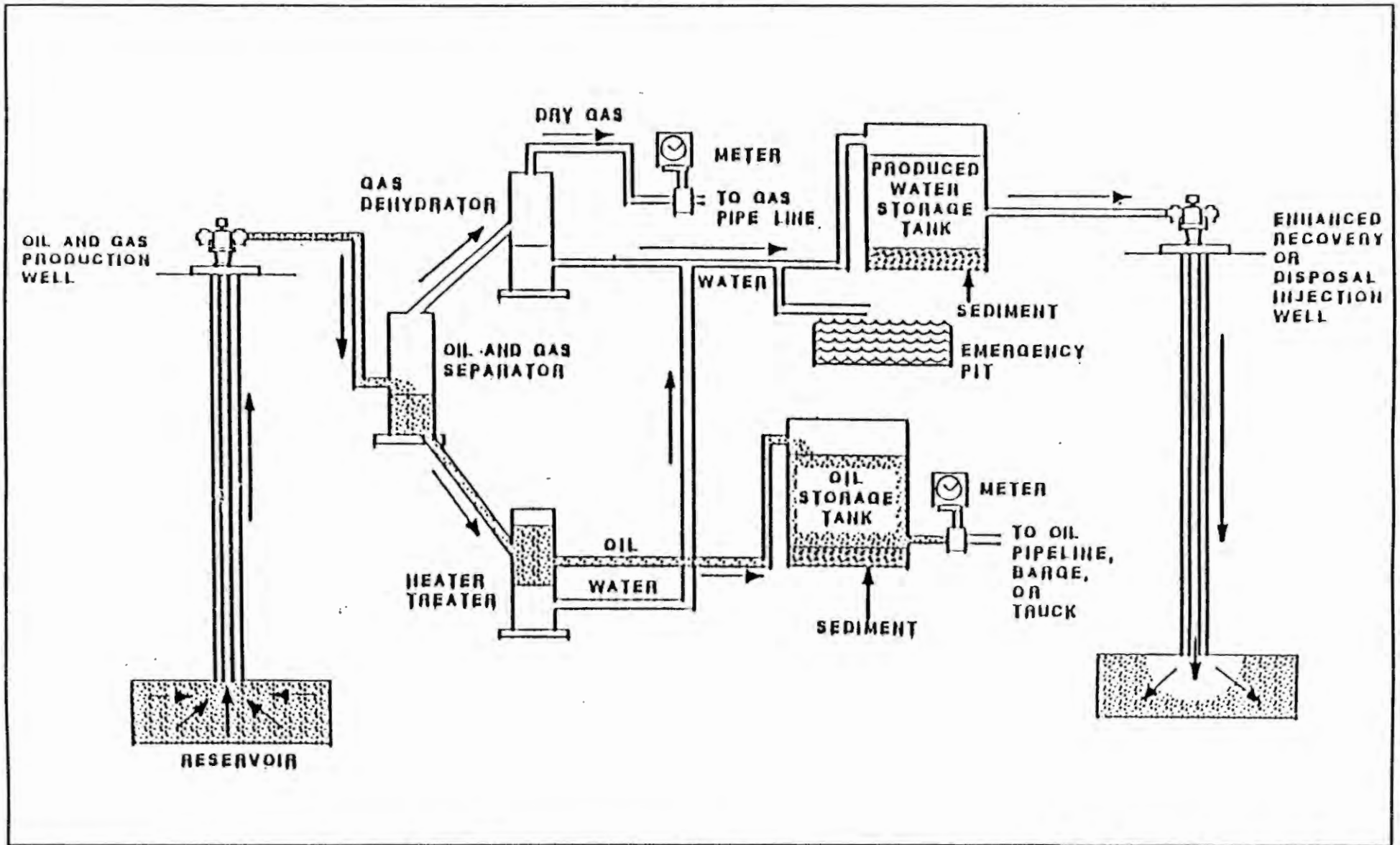

Figure V-1.
TYPICAL PRODUCTION OPERATION, SHOWING SEPARATION OF OIL, GAS AND WATER

Texaco EIA, King George Co., VA

COASTAL ENVIRONMENTAL SERVICES INC.

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Appendix A

LETTER FROM VIRGINIA DIVISION OF NATURAL HERITAGE

B. C. LEYNES, JR.
Director

ADMINISTRATION
NATURAL HERITAGE
PLANNING AND RECREATION RESOURCES
SOIL AND WATER CONSERVATION
STATE PARKS

COMMONWEALTH of VIRGINIA

DEPARTMENT OF CONSERVATION AND RECREATION

DIVISION OF NATURAL HERITAGE

203 Governor Street, Suite 402

TDD (804) 786-2121 Richmond, Virginia 23219 (804) 786-7951 FAX: (804) 786-6141

January 24, 1991

Janet L. Bowers
Coastal Environmental Services, Inc.
1099 Winterson Road, Suite 130
Linthicum, MD 21090

re: Natural heritage resources at site in King George County

Dear Ms. Bowers:

In response to your recent request for information, the Virginia Department of Conservation and Recreation's Division of Natural Heritage has searched its databases for occurrences of natural heritage resources (rare, threatened, or endangered species, unique or exemplary natural communities, and significant geologic features) reported from the area indicated on the submitted map.

According to the information presently in our files, there are no natural heritage resources in the project area. The absence of data does not necessarily mean that rare, threatened, or endangered species or other significant habitats do not exist on or adjacent to the proposed project site, but rather that our files currently do not contain information documenting the presence of them.

Thank you for the opportunity to comment on this area.

Sincerely,

Kennedy H. Clark
Environmental Review Coordinator

Appendix B

LETTER FROM VIRGINIA DEPARTMENT OF HISTORIC RESOURCES

COMMONWEALTH of VIRGINIA

Hugh C. Miller, Director

Department of Historic Resources
221 Governor Street
Richmond, Virginia 23219

TDD: (804) 786-1934
Telephone (804) 786-3143
FAX: (804) 225-4261

January 30, 1991

Ms. Janet L. Bowers
Senior Scientist
Coastal Environmental Services, Inc.
1099 Winterson Road, Suite 130
Linthicum, Maryland 21090

Re: Cultural Resource Request - King George County
DHR File No. 91-133-F

Dear Ms. Bowers:

Please accept my apologies for not responding to your request for cultural resource information earlier. I have examined our maps of architectural and archaeological sites for the area under study. We do not have any archaeological sites recorded in the study area. This does not mean that the area does not have archaeological potential, just that no sites have been recorded. However, there are three archaeological sites nearby. I have enclosed copies of the site survey forms for these sites.

I have also examined our architectural maps for the study area and we do not have any standing structures recorded in the study area. Again, this does not mean that there is no architectural potential in the area, just that no standing structures have been recorded with this office. There are no sites on the Virginia Landmarks Register or the National Register of Historic Places within the study area.

Thank you for inquiring about state or federal regulations protecting historic resources. Protection to cultural resources is provided through a review process required when state or federal funding and/or permitting is involved in an undertaking. The project will then be reviewed by this office. It is the responsibility of the agency providing the funding or permits to request a determination of effect to cultural resources from this office.

This letter does not give you clearance from cultural resource

effect determination should your client receive state or federal funds or permits. I have enclosed a few publications which might be applicable to your client's project. Should you have other questions please contact this office.

Sincerely,

Lauren E. Batte

Lauren E. Batte
Preservation Program Technician

cc: Joe White
Enc.

VIRGINIA RESEARCH CENTER FOR ARCHAEOLOGY
SITE SURVEY FORM

Name of site: Site number: 44KG47

Type of site: House site ruins Cultural affiliation: Post 1820

Map reference: Dahlgren 7.5

Latitude ° ' " north. Longitude ° ' " west.
U.T.M. Zone 18 Easting 319710 Northing 4238130.
(or distance from printed edge of map: bottom edge ___: right edge ___)

Owner/address: Elmer Morris, King George
Tenant/address:
Attitude toward investigation:
Informant/address: Harry Swain, Colonial Beach, VA
Surveyed by: Mark Wittkofski & Harry Swain Date: 4/27/83

General surroundings: Site is located about 300 meters north of Route 205, about 1/2 km. northwest of Ninde, Va. On the east side of a dirt farm road, there remains a small patch of woods with this ruinous structure in it.

Nearest water: nature, direction and distance:
Spring in ravine to west 200 meters

Dimension of site:
1-2 acres
Description: depth, soil, collecting conditions:
Mr. Swain had earlier located the site and upon our return visit, a surface collection was made. Two brick chimneys were still standing on the east end of the house. There was evidence that each chimney had two fireplaces, (two per floor of the house). The house was wood framed. The sills had been hand-hewn. The brick bond of the chimneys was five course American with sand and shell combined mortar. Cut nails were evident throughout the remaining wood structural ruins. Artifact scatter continues into the field behind the structure and down the hill which slopes to the northeast. A 1934 U.S.G.S. survey marker was located on a concrete slab on top of the well.
Specimens collected: kinds, quantities, materials:
Whitewares, pressed glass, milk glass, cut nails

Specimens reported, owners, address:

Other documentation: reports, historical data:

Condition: erosion, cultivation, excavation, construction:
Wooded around ruins, cultivated around wooded area.

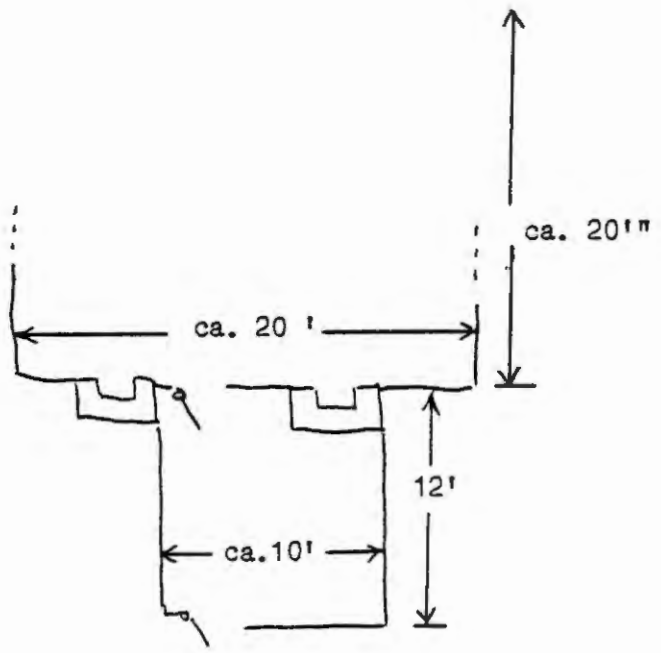
Recommendations:

Photo: B & W, Color slide
Recorded by: Map:
Mark Wittkofski Date: 9/23/83

(Use reverse side of sheet and additional pages for sketches of site and artifacts)

County King George Map Sheet Dahlgren Site Number 44KG47

Sketch of ruinous structure at 44 KG 47



VIRGINIA RESEARCH CENTER FOR ARCHAEOLOGY
SITE SURVEY FORM

Name of site: Site number: 44KG48

Type of site: Historic (unmarked cemetery) Cultural affiliation: Unknown, probably 18th c.

Map reference: Dahlgren 7.5

Latitude o ' " north. Longitude o ' " west.
U.T.M. Zone 18 Easting 319680 Northing 4238240.
(or distance from printed edge of map: bottom edge ___: right edge ___)

Owner/address: Elmer Morris, King George, VA
Tenant/address:
Attitude toward investigation:
Informant/address:
Surveyed by: Mark Wittkofski & Harry Swain Date: 4/27/83

General surroundings: Located about 75 meters due north of 44KG47. This site although not confirmed by testing appears to be an unmarked cemetery.

Nearest water: nature, direction and distance:
None nearby

Dimension of site:
About 100 feet square

Description: depth, soil, collecting conditions:
Site is surrounded by wooden fence posts. It is covered with lillies and periwinkle. No markers were seen.

Specimens collected: kinds, quantities, materials:

None collected

Specimens reported, owners, address:

Other documentation: reports, historical data:

Condition: erosion, cultivation, excavation, construction:

Wooded, no immediate threat known

Recommendations:

Photo:
Recorded by: Mark Wittkofski Map:
Date: 9/23/83

(Use reverse side of sheet and additional pages for sketches of site and artifacts)

County King George
Map Sheet Dahlgren 7.5
Site Number 44KG48

VIRGINIA RESEARCH CENTER FOR ARCHAEOLOGY
SITE SURVEY FORM

Name of site:

Site number: 44 Kg 32

Type of site: Prehistoric

Cultural affiliation: Prehistoric: Early & Late Woodland

Map reference: Dahlgren

Latitude ° ' " north. Longitude ° ' " west.
U.T.M. Zone 18 Easting 319,350 Northing 4,239,120.
(or distance from printed edge of map: bottom edge ____ : right edge ____)

Owner/address: unknown
Tenant/address:
Attitude toward investigation:
Informant/address: Harry Swain, Colonial Beach, VA
Surveyed by:

Date:

General surroundings:

Nearest water: nature, direction and distance:

Upper Machodoc Creek, North directly

Dimension of site:
less than one acre
Description: depth, soil, collecting conditions:

Specimens collected: kinds, quantities, materials:

none

Specimens reported, owners, address:
Harry Swain: Large portion of a sand temper, net impressed Popes Creek vessel; numerous Rappahannock Fabric Impressed sherds found belong below bluff on beach
Other documentation: reports, historical data:

Condition: erosion, cultivation, excavation, construction:
Wooded

Recommendations:

Photo:
Recorded by: J. Mark Wittkofski
Keith Egloff

Map:
Date: 6/26/79

(Use reverse side of sheet and additional pages for sketches of site and artifacts)

County: King George
Map Sheet: Dahlgren
Site Number: 44 KE 32

COASTAL
ENVIRONMENTAL SERVICES INC.

3 September 1991

Mr. B. T. Fulmer
Department of Mines, Minerals and Energy
Division of Oil and Gas
230 Charwood Drive
Abingdon, VA 24210

Dear Mr. B. T. Fulmer:

Enclosed please find 1 copy of Submittal entitled "Addendum to the Environmental Impact Assessment for an Exploratory Well - King George County, VA." Please note that Appendix A of the enclosed Addendum is a cross reference between VA-COE Guidelines, and the EIA, the Drill Permit Application Package (DPAP) and this Addendum. This was added at the Council's request in order to facilitate review of the information presented in the three submittals.

Also, please be advised that Texaco has asked me to request on their behalf, a one week delay for the Council to make their recommendations to the Department of Mines, Minerals and Energy. Texaco is requesting this extension (from September 10 to the 17) to allow Council staff adequate time to review the newly submitted material.

Please do not hesitate to contact me if you have any questions, or would like additional clarifications.

Respectfully,

Fred Jacobs, Ph.D.
President

FJ:mrb

1099 WINTERSON ROAD, SUITE 130, LINTHICUM, MD 21090 • TEL (301) 684-3324 • FAX (301) 684-3326
2 RESEARCH WAY, PRINCETON, NJ 08540 • TEL (609) 987-0966 • FAX (609) 987-2443

ADDENDUM TO THE ENVIRONMENTAL IMPACT ASSESSMENT

for an

EXPLORATORY WELL - KING GEORGE COUNTY, VA

Prepared for:

TEXACO, INC.
400 Poydras Street
New Orleans, LA 70130

Prepared by:

Coastal Environmental Services, Inc.
1099 Winterson Road, Suite 130
Linthicum, MD 21090

September 3, 1991

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Appendix C Deep Boring Soils Profiles

Appendix D Louisiana Land Treatment Requirements for Metal Concentrations in Cuttings

Appendix E Laboratory Analysis of Water Well Data Collected in the Vicinity of the Proposed Project

Appendix F Written Comments Received from the Council on the Environment

I. BACKGROUND

On June 6, 1991, Texaco Inc. submitted a Drill Permit Application Package (DPAP) to the Virginia Department of Mines, Minerals and Energy for an exploratory well to be located in King George County, VA. Subsequently, the Virginia Council on the Environment enacted emergency guidelines for the preparation of environmental impact assessments to be prepared as part of any drill application permit for projects located in Tidewater Virginia. As a result, the Environmental Impact Assessment (EIA) prepared and submitted by Texaco with the application package was reviewed by the Council within the context of these emergency guidelines.

The purpose of this Addendum is to respond to comments resulting from the Council's review of the EIA that have been received by Texaco and its contractors. Mr. Jay Roberts of the Council on the Environment provided several comments verbally to Coastal Environmental Services, Inc. (August 13, 1991). Written comments were also received from the Council on August 20, 1991. Other concerns that were also raised during an on-site visit (August 20, 1991) by the Council and members of other State agencies are addressed in this Addendum.

II. FORMAT

This Addendum is formatted to follow the Council's written comments (received August 20, 1991). These responses are followed by responses to any remaining comments from Mr. Robert's August 13 conversation with Coastal. Finally, a summary of the current status of an archaeological investigation for the site is described.

Appendix A presents a cross-reference between the VA-COE Guidelines, the EIA, the Drill Permit Application Package (DPAP), and this Addendum. Appendices B-E provide supporting data to the information presented in this Addendum. Appendix F is a copy of the Council's written comments that were received on August 20, 1991.

III. RESPONSES TO WRITTEN COMMENTS FROM THE VIRGINIA COUNCIL ON THE ENVIRONMENT (August 20, 1991)

5.C. Cross-Reference Between EIA/Drill Permit Application and Guidelines

Attached as Appendix A is a listing of topics addressed in the VA-COE Guidelines cross-referenced to the document(s) in which the topic is addressed. This is provided to allow reviewers easier access to the information presented in the various submittals.

6.A. Description of Proposed Operations and Facilities

As indicated in the Cross-Reference, an Operations Plan is presented in the DPAP. This Operations Plan provides additional information regarding the drilling operations and facilities.

6.B.2. Maps and Site Plans for Environmental Review

The Cross-Reference indicates which site plan maps present information required in the EIA Guidelines. These site plans are presented in the DPAP.

6.C.3. Fluid Circulation System and Fluids

Discussed in 6.C.7

6.C.4. Blow-Out Prevention and Containment

Additional discussion regarding the blow-out prevention system can be found in the DPAP, Spill Prevention Control and Countermeasures Plan, and sections ER.7 and ER.10 of this addendum.

6.C.7. Solid Wastes

Information regarding management of wastes was presented in Section III.G of the Environmental Impact Assessment document (page 61). The types of

wastes to be generated as well as disposal options for solids disposal were also discussed. Supplemental information is provided in the following sections.

Wastes generated

The mixture of drilling muds and cuttings brought to the surface is sent to the solids control system where cuttings are seperated from the drilling mud. Solids removal occurs in vibrating screens, hydroclones, and centrifuges. It is estimated that approximately 7800 cubic feet of cuttings (and associated muds retained on the cuttings) will be generated. The cuttings will first be stored in a lined tank of 240 barrel capacity, then moved to a segregated storage area within the levee.

Waste Characteristics and Disposal

The environmental concerns related to disposal of cuttings and muds center around the presence of barium. Land farming is the most likely disposal option for cuttings. The cuttings are likely to contain some barium, on account of the associated muds. Because of the extreme insolubility of barium sulfate, it is extremely unlikely that there will be any ground water contamination problems on account of leaching of barium from land farmed cuttings. It should be noted that levels of barium in soil after land farming will be lower than 3000 ppm, the Louisiana limit for land farming applications of cuttings (used as a guideline in this case).

The other waste stream from the drilling operation is the drilling mud. At the conclusion of drilling, approximately 1500 barrels (63,000 gallons) of mud will require disposal. Texaco proposes to transport this liquid waste to an approved waste disposal facility. If, however, another well is drilled at the conclusion of this one, the muds can be re-used at that location.

6.C.7.1 Potential impact of land farmed cuttings on groundwater

The prediction of the potential of hazardous constituents present in wastes to impact underlying aquifers is a complex process, subject to a great deal of uncertainty. A very rough estimate may be obtained by the use of the VHS Model, developed by the USEPA (as part of its hazardous waste delisting program). The model predicts the concentration of constituents of concern at a hypothetical well hydraulically downgradient from hypothesized waste disposal site, assumed to be an unlined municipal landfill.

The VHS model approximates the transport process likely to occur in an aquifer below a waste disposal site. The model predicts the dilution of the contaminants in a drinking water aquifer due to dispersion in the vertical and horizontal directions. This dispersion generates a compliance point concentration, defined as the concentration of the contaminant of concern at a hypothetical well site 500 feet from the landfill, which is compared with the regulatory standard for that contaminant. A compliance point concentration that is greater than the regulatory standard would indicate a contamination potential. The version of the model adopted by the USEPA's delisting program is given by the following equation (50 FR 48896, November 27, 1985):

(1) $$C_y = C_o \, erf(Z/[2(a_z y)^{0.5}]) erf(X/[4(a_t y)^{0.5}])$$

where

C_y	=	compliance point concentration of constituent (mg/l),
C_o	=	constituent leachate concentration (mg/l),
erf	=	error function,
Z	=	penetration depth of leachate into the aquifer (m),
Y	=	distance from disposal site to compliance point (m),
X	=	length of disposal site measured in the direction perpendicular to the direction of groundwater flow (m),
a_t	=	lateral transverse (horizontal) dispersivity (m),
a_z	=	vertical dispersivity (m),

The error function is defined as

(2) $$efr\ A = 2/_{\pi} 0.5 \int_{O}^{A} \exp(-t^2) dt$$

The Agency assigns values to each of the variables in Equation 1 (except for waste generation rate and length of the disposal site). The leachate concentration (C_o) and the waste generation rate (WA) are the only independent input parameters used in the VHS model. The length of the disposal site is calculated from the waste generation rate; the leachate concentration is determined by laboratory analysis or modeling. The other parameters in Equation 1 have been assigned values consistent with the Agency's concept of a reasonable worst-case scenario. A detailed discussion of the parameters chosen by the Agency is provided in 50 FR 7896, February, 1985 and 50 FR 48896, November 27, 1985.

In practice, a simplified version of the VHS equation is used. In the simplified version, the error function terms are replaced by a single conversion

factor (C_f), a computer-generated number equal to the error function terms. Table 1 of the Agency document (not reproduced here) provides calculated conversion factor values for incremental waste generation rates. The dilution factor (DF) is the reciprocal of the conversion factor and is also listed. After substitution of the appropriate input parameters, Equation 1 becomes

(3) $$C_y = C_o * C_f$$

where C_f = $erf(Z/[(a_z y)^{0.5}])erf(X[4(a_x y)^{0.5}])$ obtained from Table 1 corresponding to a given waste generation rate (WA).

Table 1 of the Agency document presents conversion and dilution factors for waste generation rates ranging from 475 to 8,000 cubic yards. Where waste generation rates are less than the minimum value, the conversion factor for the minimum (475 cubic yards) value is used. For any waste generation rate greater than 8,000 cubic yards, the conversion factor for the maximum (8,000 cubic yards) value is used.

In this case quantity of cuttings = 7800 ft^3 or 289 yd^3

C_f = 0.030950

If one assumes that the concentration in the leachate equals the solubility of barium sulfate (1.3 mg/l at 18°C),

Co = 1.3 mg/l

Compliance point concentration

Cy = 0.030950 x 1.3 = 0.04 mg/l

This is considerably below the drinking water MCL (maximum contaminant level) for barium, 1.0 mg/l.

Under extreme conditions, leachate concentrations of barium may be higher. However, even a ten-fold increase in leachable concentrations would not result in an exceedance of the MCL. Therefore, the potential for groundwater contamination appears to be extremely unlikely.

6.C.8. Solid and Liquid Waste Management Procedures

Discussed in 6.C.7

6.C.11. Water Consumption and Use

Texaco will require the use of fresh water for both mud make-up and personal use. A fresh water well will be drilled on site for that specific purpose. It is expected that maximum water usage will average less than 6,000 gal/day over the three month drilling operation. This total is divided about evenly between mud requirements and personal use for the 25 man crew.

The 6,000 gal/day for 90 day figure amounts to the usage of over 600,000 gal of water for the duration of operations. However, Texaco plans to use rainwater captured in the levee for the mud system to the extent possible. In 1989, when drilling the W.B. Wilkins No. 1 well in Westmoreland County, only 60,000 gal of freshwater were pumped from the freshwater well because of the efficient use of rainwater. It should be mentioned though, that all water for the crew was trucked to the Westmoreland drill site.

6.C.12. E&S and Stormwater Management Plans

A meeting was held between Gordon Linkous, Tri-County Conservation Specialist, and Torben Agesen, Texaco site engineering consultant concerning the 13 items questioned by Tri-County/City Soil and Water Conservation District. A plan of action was agreed upon at this meeting to address each item in detail in order to obtain final approval. All the necessary items have been addressed, which include: meeting the minimum standards of the erosion and sediment control regulations of Virginia, pre & post stormwater calculations, implementation of protective check dam measures, outlet protection, sediment basin construction, best management practices as outlined in the Chesapeake Bay Preservation Act, soil map, and finally a cost estimate.

The revised package will be submitted to the King George County Director of Code Compliance on September 4, 1991.

6.D.1. Vegetation Clearing

A description of the vegetation of the area is described in Section II.C of the EIA. This section presents a more detailed description of the flora contained in the immediate vicinity of the drill site. The majority of the proposed drill site is covered by various grasses and forbs typical of pastureland throughout the Mid-Atlantic region. Common species in this area were as follows: red top (*Agrostis alba*), foxtail (*Setaria italica*), goose grass (*Eleusine indica*), horse nettle (*Solanum carolinense*), ivy leaved bindweed (*Ipomoea hederacea*), white clover (*Trifolium repens*), globose sedge (*Cyperus ovularis*), and lovegrass (*Erogrostis sp.*). The majority of these species are introduced species that possess a high tolerance to disturbance related to grazing.

In addition, three small patches of trees were present in the northwest portion of the site. Two of the areas consisted primarily of black cherry (*Prunus serotina*). In the largest and southernmost patch of trees were 17 black cherry and one tulip poplar (*Lirodendron tulipifera*). All of these trees were multistemmed and approximately 30-40 feet tall. The largest tree had a diameter at breast height (dbh) of seven inches. A pair of 15-20 foot high eastern red cedar (*Juniperus virginana*) were growing just to the west of this clump. The second area was comprised of four multistemmed black cherry with dbh's of 6-7 inches, and a single sassafras (*Sassafras albidum*). The third area was dominated by tulip poplar. This clump possessed seven multistemmed tulip poplar approximately 40 feet high, one sweet gum (*Liquidambar styraciflua*) and one red cedar. The largest tulip poplar had a dbh of 8 inches.

The northernmost extent of grading will encroach into the edge of a successional woodland. The trees in this area consisted primarily of tree of heaven (*Ailanthus altissima*). This opportunistic introduced species is an aggressive colonizer of disturbed sites. Although several red maple (*Acer rubrum*) and black walnut (*Juglans nigra*) trees were also present in this area they were deeper in the woods than the tree of heaven.

6.D.5. Associated Facilities

All facilities associated with the proposed exploratory operation have been described in the EIA and DPAP. There will be no additional Texaco facilities off-site. The site plans presented in the DPAP indicate all facilities and structures to be constructed for this project.

7.A.1.c. Stream Water Quality and Quantity Impacts

Because the drill site has been designed as a zero discharge site, there will be no flow from the site into any tributaries. An analysis is currently underway by Lorenzi, Dodd, Gunnels to determine potential nutrient loadings resulting from the land disturbance, as required under the Chesapeake Bay Protection Overlay for King George County.

7.A.1.f. Site-Specific Groundwater Characterization and Protection

Groundwater Characterization

In effort to characterize the local groundwater resources, further literature searches and reviews as well as a field investigation were conducted. The literature searches focused on locating and obtaining additional data describing the groundwater resources for King George County. This included communications with and material provided by the King George Planning Department, a private contractor for the Planning Department, RADCO, the Virginia Department of Health (King George office).

Maps were obtained from RADCO which present depth to the shallow and deep aquifers used within the county for domestic supplies. (These maps were prepared by GKY and Associates for the county, have an indicated accuracy of $\pm$ 20%, and are undated.) In the vicinity of the lease tract, depth to the deep ground water, found in the Potomac aquifer, ranges from approximately 480 feet (in areas of lower topographic elevation) to 520 feet (in areas of higher elevations, such as near Route 205). At the drill site, depth to the deep aquifer is shown as approximately 520 feet. A report provided by the county entitled "Water Resources Planning Study for King George County" (prepared by Systems Design Team CE 576, Catholic University of America, April 16, 1991) provides information indicating that the direction of groundwater flow in this aquifer is generally to the east.

Depths to the shallow unconfined watertable (found in the Yorktown-Eastover aquifer) are shown as ranging from 40 feet (along Route 205) to 20 feet and lower, to the north of 205 and approaching the Upper Machodoc Creek. At the drill site, estimated depth to the unconfined water table would be approximately 30 feet. The Planning Study indicates that the direction of groundwater flow in this aquifer is generally to the northeast, toward the Potomac River, in the area of the Texaco site.

A second set of maps, entitled "Water Quality Atlas" (also prepared by GKY and Associates, undated) presents limited water quality data for one well in the area of the drill site. This well is located on the south side of Route 205,

approximately 2,000 feet south west of the drill site. This well (labeled Well No. 86 on the Atlas) has a recorded groundwater elevation of 8 feet MSL. Surface elevations in the area of this well range from 60 to 100 feet. Because the well location is not precisely given, the actual depth to water cannot be determined, but can be assumed to be probably 50 to 90 feet below the surface. Water quality data provided for this well indicates the following:

- Total Nitrogen 0.2 mg/l
- Total Phosphorous 0.1 mg/l
- Iron 100 μg/l

Groundwater withdrawals in the county, as presented in the Planning Study, include:

• Private wells	Potomac Aquifer	0.136 MGD*
	Yorktown Eastover	0.005 MGD
• Dahlgren Sanitary Districts A and B		0.193 MGD
• Municipal/public		3.09 MGD
• Industrial		0.28 MGD
	Total	3.8 MGD

In an effort to ascertain more specific data regarding the character of groundwater resources in the immediate vicinity of the site, a field study was conducted to document the source and nature of water supplies for all homes on or adjacent to the lease tract. This involved a door-to-door survey to obtain details of well age, depth, construction, and use from property owners. In addition, water samples were collected and have undergone chemical analysis. Results of these analysis are presented in Appendix E. It is anticipated that certain wells will also be tested upon completion of the drilling project.

Based on the obtained information, the homes located along Route 205 to the south and east of the lease tract, as well as the home located just north

*Million gallons per day

of the drill site are served by a private water supply installed by Sydnor Hydrodynamics, Inc. in 1966. The source well (known as the Ninde's Store Well) is located 0.4 miles east of the drill site at a depth of 596 feet. Specific data has been received from Sydnor regarding this well (recent water quality analysis results, listing of homes served, productivity, etc...).

A dug well was located on the property at the southwest corner of the lease tract. This property is reportedly not inhabited at this time. The well was sampled, but is not expected to provide representative results as it is exposed to atmospheric and near surface influences, as the water level is within 15.5 feet of the surface. The Hilliard home (located northeast of the drill site) is served by one artesian well, at a depth of 750 feet. Based on information from the interviews, neither the Hilliard well nor the Sydnor well require any water treatment prior to consumption. Information indicated that well productivity is extremely high.

Groundwater Protection

The probability of a casing leak, especially into a freshwater aquifer is quite remote. Two strings of steel casing and a string of steel tubing will be installed in productive wells in order to protect all freshwater supplies. The outermost casing will be cemented well below the aquifers to insure a proper seal. Further, the drilling mud "cakes" along much of the bore hole providing a secondary seal. Therefore, during production there are five levels of freshwater protection

During the drilling process itself, a freshwater based mud is used to prevent groundwater (and potentially surface water) contamination. The casing, cement and mudcake protect the freshwater during drilling in the event hydrocarbons are encountered. In the case of a dry hole, the well is plugged to ensure that the aquifers are protected from salt water intrusion. Casing pressures are monitored on producing wells to determine if leaks have occurred. If a leak is encountered, the well is shut-in until appropriate responses can be enacted. If contamination should occur, the cleanup process would involve the drilling of additional shallow wells to identify the extent of the contamination, and to essentially "produce" the contaminant from the affected formulation. This is admittedly a difficult and costly process. However, as with any problem which is attributable to the drilling operation, Texaco has pledged to make every effort to clean up and rectify the situation.

During the well construction phase each type of casing is pressure tested to assure integrity. This test basically involves pressuring the casing internally and monitoring, over a time interval, the casings ability to retain the pressure.

Logging devices can be run to evaluate the correct placement of cement behind the casing.

Once the well is in the producing phase, the tubing-casing annulus is measured monthly (usually) to determine if pressure, therefore fluid, has leaked into or out of the well. Though a pressure change does not always indicate a leak has occurred, various production logging devices can be lowered into the well to indicate an exact determination of the cause of the pressure change, and location of the nature of a potential leak. If a leak is present, remedial action is taken to rectify the situation.

7.A.1.g. Soils Information and Geotechnical Information

The exploratory well site is expected to require an area of approximately 2.0 acres. The total disturbed area will be about 4.7 acres. The site will be located in what is presently an idle agricultural pasture that is bounded to the south by Route 205 and to the east by an existing driveway access. On August 22 and 23, 1991, a field investigation was conducted to characterize the soils. In addition, deep borings were taking for site engineering purposes. Appendix B presents exhibits associated with the following discussion (profiles of shallow soils, and soils map). Appendix C presents the results of the deep borings.

Soils Study

The primary objectives of the field soils study was to verify the accuracy of the Soil Conservation Service Mapping in the vicinity of the proposed drill rig and to provide documented site specific soils information. A detailed site investigation was therefore preformed on 22 and 23 August 1991. Prior to the initiation of field work a thorough review of existing resources such as the County Soil Survey report, site plans depicting topography, and the USGS quadrangle map was conducted. The soils investigation involved a number of soil auger borings across the site with a four inch bucket auger. A series of detailed soil borings were taken in representative portions of the site. At each detailed boring location the soil horizons within the profile were examined and the morphological characteristics of the soil were recorded so that the soil could be classified and estimates about the permeability and erosiveness of the soil could be made. A Munsell soil color book was used to determine soil color. Each boring was taken to a depth of four feet or until auger refusal was encountered.

The erosion hazard of a soil is the potential inherent within the soil to erode if the forces that cause erosion are applied to an area that is not adequately

protected. Erosion hazard does not describe past erosion but rather the possibility of future erosion. The principal soil characteristics affecting erosion are texture, organic matter content, structure, and hydraulic conductivity.

The permeability of a soil is the property of a soil that is concerned with the ease in which water moves downward through the soil. The permeability of a soil depends on the physical properties of the soil including texture, structure, and organic matter content.

According to the soil survey of Stafford and King George Counties three soil mapping units are present within the area proposed for the development of the exploratory well site (Appendix B, Figure 1). The soil mapping units indicated are (BmB) Bourne fine sandy loam, 2 to 6 percent slopes; (GsD) Galestown-Sassafras complex, 6 to 15 percent slopes; and (SfB) Sassafras fine sandy loam, 2 to 6 percent slopes. The description of each soil mapping unit on this portion of the site is provided below.

(BmB) Bourne fine sandy loam, 2 to 6 percent slopes

The Bourne soils are moderately well drained, nearly level to sloping soils formed in loamy Coastal Plain sediments. Bourne soils are characterized by the presence of a moderate to strong fragipan at a depth of approximately 18 to 24 inches. A fragipan is a loamy, brittle subsurface pan or layer in the soil that is extremely hard due to extreme density or compactness rather than due to high clay content or cementation. When dry, the fragipan is hard or very hard and has a high bulk density in comparison to the overlying horizons. The fragipan layer is generally mottled and is slowly permeable to water.

In a typical profile the surface layer of the Bourne soil is a dark brown fine sandy loam. The subsoil is generally about 55 inches thick. The upper subsoil is firm, yellowish brown heavy sandy clay loam. The middle portion of the subsoil is a fragipan layer consisting of pale brown fine sandy loam that is mottled with yellowish brown and yellowish red. The lower subsoil is a yellowish brown heavy sandy clay loam that is mottled with yellowish red and red.

Runoff from this soil is slow to medium, and erosion provides a severe hazard only if the soil surface is left exposed for extended periods. The subsoil of the Bourne soil above the fragipan layer is moderately permeable, but the fragipan layer is slowly to very slowly permeable. A perched water table occurs above the fragipan layer during wet periods. However, the soil is droughty during the growing season, because the fragipan is near the surface.

(GsD) Galestown-Sassafras complex, 6 to 15 percent slopes

This mapping unit consists of areas of two soils so intermingled that they cannot be separated on the soil map. Galestown soils make up about 45 percent of this complex and Sassafras soils about 30 percent. Other associated soils comprise the remaining 25 percent.

The Galestown soils are deep, somewhat excessively drained, sloping to steep soils formed in sandy Coastal Plain sediments. The Galestown soils in King George County are mapped only in complex with Aura and Sassafras soils. Typically, the surface layer of the Galestown soil consists of loamy fine sand. The subsoil is a strong brown and yellowish brown, very friable loamy fine sand.

The Sassafras soils are deep, well-drained nearly level to steep soils formed in sandy and loamy Coastal Plain sediment. Typically the surface layer of the Sassafras soil is a dark brown fine sandy loam. The upper portion of the subsoil is a brown, friable fine sandy loam. The middle portion is brown, friable sandy clay loam. The lower subsoil is a strong brown, very friable loamy fine sand.

Runoff from the Galestown and Sassafras soils within this complex is medium, and erosion presents a moderate hazard only if the soils are left exposed. The permeability of the subsoil within the Galestown soils is rapid, while the Sassafras subsoil has a moderate permeability.

(SfB) Sassafras fine sandy loam, 2 to 6 percent slopes

This Sassafras soil is located on broad ridges. It has the characteristics described in the Sassafras soil within the Galestown-Sassafras complex. Included with this soil in mapping are small areas of Bourne, Caroline, and Kempsville soils.

The investigation revealed the SCS mapping of this portion of the site to be rather accurate. The morphological characteristics of the soils encountered fell within the established range of characteristics for the soils indicated to be present on the site. This is not unexpected given the relatively small site area, uniform landform, and obvious topographic breaks encountered. Therefore the properties and characteristics of the soils on site are anticipated to follow those for the soil series identified within the soil survey for King George County.

Soil borings taken within the southern portion of the site revealed the majority of the area to consist of Bourne soils. This would include the area of

the proposed trailers, gravel, and the southernmost levee wall. The area of Bourne soil appears to extend just to the south of the proposed well. The depth to the fragipan in this portion of the site ranged from 22 to 26 inches. The fragipan appeared to be weakly to moderately developed with a soil texture ranging from a heavy sandy loam to a sandy clay loam. The thickness of the fragipan layer was generally 20 or more inches thick across this portion of the site. As a result the anticipated permeability within the fragipan layer would be slow. The subsoil above the fragipan layer was predominantly sandy loam with granular to subangular blocky structure, thus the anticipated permeability would be moderate. The erosion hazard of the soils within this area of the site would be severe only if the surface of the soil was exposed for extended periods of time.

Soil borings taken within the vicinity of the proposed lined cuttings area and the proposed well site were identified to be similar to the Sassafras soil series. The subsoil within this portion of the site ranged from a heavy sandy loam to a sandy clay loam. The soil structure within the subsoil in this area was dominantly subangular blocky. The permeability of the subsoil within this area of the site is anticipated to have a moderate permeability. The erosion hazard in this portion of the site would be moderate only if the soil was left in an exposed condition for extended periods of time.

Soil borings taken within the northwestern portion of the area, which is mapped as containing the Galestown-Sassafras complex by the SCS, were indicative of the Sassafras series rather than the Galestown series. The soils in this area were characterized by weakly developed subangular blocky structure with sandy loam to sandy clay loam textures. Therefore, the soils within this area of the site would have a moderate permeability and erosion hazard.

Geotechnical Information

Geo-Technology Associates was contracted to conduct a geotechnical investigation which included soil borings at the drill site. The scope of the exploration included two Standard Penetration Test borings, limited laboratory analysis, and bearing capacity analysis of the subsoil. The test borings were drilled on August 20, 1991 using an all-terrain-vehicle mounted drill. The borings were advanced to a depth of 20 feet below the surface grade using hollow stem augers. Standard Penetration Tests were conducted at 2.5 foot intervals to a depth of 10 feet, and 5 foot intervals to the bottom of the boring. The drilling logs are included as Appendix C.

The subsurface conditions consisted of Coastal Plain alluvial sediments containing alternating strata of clay, silt, and sand. The density/consistency of

the material was generally dense or stiff to hard, based on Standard Penetration Test N-values of 11 to 88-blows per foot.

Groundwater was not encountered in boring B-1. Groundwater was encountered in boring B-A at a depth of 19 feet below the ground surface. Long term water readings were not made, as the borings were backfilled before leaving the site for safety considerations.

An analysis was undertaken to determine estimated bearing capacity for drilling-platform foundations. Meyerhof equations were used to estimate bearing capacity of the underlying soils. The following are the preliminary recommended allowable soil bearing pressures;

Depth Below Existing Grade	Allowable Soil Bearing Capacity (pounds per square foot)
1.0	2000
2.5	3000

7.A.1.h. Public and Private Water Supplies

No publicly owned and operated water supplies exist in this area. As described above (response to 7.A.1.f), a private supplier furnishes water to several of the homes along Route 205 south and east of the drill site, as well as the home located just north of the drill site. The homes located immediately northeast of the site, southwest corner of the site, and due west of the site are apparently all served by private wells. Chemical analyses of the water quality of these wells are included in Appendix E. Should any problems occur as a result of the Texaco operations, Texaco will take actions necessary to replace or remediate the impacted water supply.

7.A.1.i. Chesapeake Bay Preservation Areas

The King George County Board of Supervisors has amended the zoning ordinance by adding Article 8, "The Chesapeake Bay Preservation Area Overlay District of King George County." The intent of the ordinance is to assure protection of the quality of water in the Chesapeake Bay. To that end, Resource Protection areas (RPA's) and Resource Management Areas (RMA's) have been established. Resource Protection Areas (RPA's) are:

a. tidal wetlands;
b. nontidal wetlands connected by surface flow and contiguous to tidal wetlands or tributary streams.
c. tidal shores;
d. a 100-foot vegetated buffer area located adjacent to and landward of the components listed in subsections a~~s~~ through c. above, and along both sides of any tributary stream.

At the request of King George County, Texaco has mapped all RPA's located throughout the lease tract. The boundaries of these areas were marked by a series of alphanumerically numbered survey flags and are being surveyed as of this date. The Resource Protection Area's (RPA's) were identified and delineated in accordance with the Federal Manual for Identifying and Delineating Wetlands. In accordance with this manual, a thorough investigation of vegetation, soil and hydrology of the entire lease tract was conducted. Based on this approach, an area is defined as a wetland if it, under normal circumstances, has all of the following characteristics.

1. The land supports a dominance of hydrophytic vegetation.

2. The substrate is hydric soil.

3. The soil/substrate is at least periodically saturated of inundated during a significant portion of the growing season.

The areas to be disturbed for construction and operation of the exploratory well are completely out of and removed from any Resource Protection Areas, as established by King George County. The nearest RPA boundary along the tributary draining the drill site is situated approximately 1,200 feet from the closest border of the drill site. The RPA boundary from the tributary located to the east of the site will be situated approximately 900 feet from the drill site. However, this eastern tributary does not normally receive any drainage from the site.

7.A.2.b and c. Terrestrial and Aquatic Habitat and Species

The EIA document presented all available information describing aquatic species and habitats within the vicinity of the proposed drill site at the time of the submittal. These data were collected from an extensive data and literature search and review process which included contacting numerous state, regional and local agencies as well as several research organizations. All existing aquatic data were then reviewed, interpreted, and used as the basis of

developing the impact assessment. Only by conducting in-field seasonal surveys and inventories of aquatic species, could the information in the EIA be augmented. Such efforts are considered beyond the scope of an environmental assessment, given the nature of the proposed activity.

Additional site specific information on terrestrial habitats and species is provided in Section G.D.1. Furthermore, comprehensive information on wetlands and other habitats contained within the Resource Protection Area (RPA) of the lease tract is being submitted to the County as part of a Resource Protection Area (RPA) delineation report.

7.B. Noise

The impact of noise was described in Section III.H of the EIA. Additional information is presented below. Noise levels during site preparation and reclamation will be analogous to those encountered with any moderate to small construction project. Bulldozer and crane operations will be required to construct the site. Traffic will increase over a two to three day period wherein materials are delivered to and removed from the site.

During drilling, noise levels at 1,000 feet from a rig of this type are expected to be comparable to that encountered with standing three feet from a home washing machine. This comparison was based on noise reading from rigs along the Gulf Coast (see EIA, page 71).

Texaco will reduce noise on the King George site as compared to the Gulf Coast rigs by:

- Adding mufflers to the on-site power plants
- Aiming the exhaust from the power plants away from dwellings
- Constructing a topsoil pile 60 feet x 420 feet x 8 feet to act as a noise barrier between the site and Route 205
- Placing the trailers between the site and the topsoil pile to aid in blocking noise.

7.C. Lighting

During site construction and reclamation, all activity will occur during daylight hours. Therefore, lighting will not be necessary. During drilling operations, the site and derrick will be lighted, but not in a manner that will disturb residents in the area. No light intentionally shines directly away from the site. Furthermore, directional lighting will be used and will be focused on areas where workers are operating.

ER.7 Discharge Probability

The Virginia Council on the Environment's emergency guidelines require an assessment of the

"probability of a discharge of oil, condensate, natural gas, and waste and other liquids during drilling, production, and transportation due to well blowout, equipment failure, transportation accidents and other reasons."

In addition, the spill probability should be estimated for three different sizes of discharge event: minor, moderate, and major. For the purposes of this analysis, the definitions of these discharge classes as published in 40 CFR Ch. I (7-1-87 Edition) § 300.6 were employed. These are:

- Minor - a discharge less than 1,000 gallons to inland waters or less than 10,000 gallons to coastal waters;
- Moderate - a discharge of 1,000 to 10,000 gallons to inland waters or between 10,000 and 100,000 gallons to coastal waters;
- Major - a discharge of more than 10,000 gallons to inland waters or more than 100,000 to coastal waters.

This analysis entailed defining the potential accidental discharges, the probability of occurrence of such discharges, and assessment of the extent of the potential environmental impact resulting from such a discharge. A discharge or spill is defined as an uncontrolled release of a substance outside of the drill site area (outside of the area surrounded by the ring levee).

As discussed by Danenberger (1980), because of local and regional differences in geology, differences in operating procedures and conditions, differences in human factors, and continual technological improvements in both operations and safety measures, realistic forecasts of oil or gas well blowouts

would be subject a great deal of uncertainty using the analysis of historical records. The general lack of actuarial data for oil and gas wells with similar operating procedures and conditions and geology to those for the King George County well makes this analysis even more tenuous. However, given the extremely low probability of occurrences and the safety measures to be employed at this well site, even order-of-magnitude differences in probability for those that would be estimated are not significant.

ASSUMPTIONS

There were several assumptions employed in developing this analysis.

Assumption 1. It is most likely that the proposed exploratory well in King George County will discover natural gas rather than oil. This assumption is important since the effects of a blowout for a gas producing well are significantly less than that for an oil producing well.

Assumption 2. Given that discovery and production of natural gas in King George County are more likely than discovery and production of oil, most issues regarding the transportation of the products of the well via tankers or trucks are inappropriate or not significant. Any natural gas produced by the well would be conveyed via a pipeline from the site.

Assumption 3. Application of spill probability statistics developed from the operating records for outer continental shelf (OCS) oil and gas wells to this analysis is valid. The drilling techniques to be employed at the King George County well are similar to those employed at OCS wells (La Belle, 1991).

Assumption 4. The probability of H_2S occurring in the geologic formations to be encountered during the drilling of the King George County well is extremely low.

SPILLS

The most recent analysis of historical data for oil spills from OCS oil and gas wells was conducted by Anderson and La Belle (1990). They employed data from OCS platforms, pipelines, and tankers. They estimated an occurrence rate of 0.60 spills per 10^9 barrels of oil produced on platforms and 0.67 spills per 10^9 barrels of oil transported by pipeline. These estimates are lower than the previous estimates generated in 1983. Tanker spill occurrence rates have not changed significantly since 1983, being 0.90 and 0.40 per 10^9 barrels for at-sea and in-port spills, respectively. These data show that spill occurrence rates are extremely low and are directly related to oil production/handling rates.

Since the King George County well is not likely to produce oil, the probability of an oil spill occurring is even lower. Only 1 in 25 wells drilled produce either oil or gas. Furthermore, should the exploratory well prove successful, the probability of encountering gas rather than oil is 80-90%. If the well does produce oil, the probable size of a spill would range from minor for on-site (within the ring levee) occurrences to moderate for spills that may occur in-transit or due to a pipeline rupture. The probability of an on-site spill escaping the drill site is very unlikely since the ring levee provides the ability to capture any on-site spill. An on-site spill could possibly escape the drill site if:

1) a sufficient amount of precipitation fell with sufficient intensity to cause runoff of stormwater from the site;

2) the oil spill occurs at or near the same time as the precipitation event, precluding the on-site crew from following the Oil Spill Contingency Plan.

The volume of precipitation required to top the ring levee is approximately 176,000 ft^3. This is approximately equal to over 30 inches of rain falling on an area equal to that within the ring levee. This volume of rain exceeds the probable maximum storm of 28 inches as defined by the National Weather Service for this area. The recurrence interval of a storm of at least 30 inches is greater than 100 years. Of additional consideration, is the pump used to collect stormwater and any spills from within the ring levee. While it is only a small capacity pump, it does serve to reduce the probability of stormwater and any spilled material from escaping the drill site. Given these conditions, it can be concluded that the overall probability of occurrence is very unlikely, i.e., on the order of once in 100 - 10,000 years.

Even if the spilled oil and the exceedingly large rainfall do co-occur, there are additional safety measures proposed for the King George County well. These include an earthen dam to be constructed in the receiving stream to preclude downstream movement of any spilled oil to tidal waters. If this earthen dam is breached, then booms will be put in place to further localize any spilled oil. Given these additional safety measures, any spilled oil has little opportunity to cause any serious environmental damage.

BLOWOUTS

Blowouts typically occur at transition points in the operation of an oil or gas well (MMS, 1991). Of the 46 blowouts that occurred on the OCS from 1971-1978, thirty occurred during drilling operations, however these blowouts were of short duration and had minimal effect (Danenberger, 1980). The remaining blowouts occurred during completion, production, or closure of the well.

Danenberger has also pointed to the fact that over the eight-year study period, only one blowout occurred for every 250 wells drilled in the OCS.

From 1979 to 1982 only 16 out of 4449 (0.36%) of the wells started were involved in a blowout incident during drilling operations on the OCS (Fleury, 1983). Defined in the context, a blowout is considered a complete loss of well control. The calculated spillage of oil and oil condensate for all 16 blowouts totaled 64 barrels. Furthermore, 91 wells were spudded in OCS frontier areas, from 1979 to 1982, without a reported blowout incident.

MMS (1991) has also concluded that blowouts are an uncommon result of OCS oil and gas wells. Historically, most blowouts have lasted one day or less. Eighty percent of the blowouts studied by Fleury were shut-in within 3 days, 61% within the first day. Over the last 10 years only about 20% of the gas blowouts have had fires associated with them. Gas blowouts without fires can release gas, gas condensates (typically these releases are less than 1 barrel according to Danenberger), and H_2S. OCS oil blowouts during the period 1978-1982 have resulted in oil spillage equivalent to only 0.0000056% of the oil produced from the OCS (Fleury, 1983).

It is apparent that gas blowouts on the OCS are rare occurrences. Their occurrence during drilling operations is due in large part to the presence of shallow gas in unconsolidated sediments. The probability of a gas blowout is very low in the King George County area due to the low probability of encountering very shallow gas in the local geological formations, as conclusively demonstrated by waterwell drilling in the Tidewater region. As stated in Section ER.10 of this Addendum, the geological structure is not conducive for H_2S accumulation, and H_2S was not encountered in previous drilling.

In view of the uncertainties involved, a precise numerical probability for a blowout in the Taylorsville Basin during exploratory drilling cannot be determined. As stated, shallow gas in the unconsolidated Coastal Plain sediments is very unlikely to be present. Also, the subsurface rocks in the Taylorsville Basin are normally pressured, as conclusively demonstrated by the 1989 Westmoreland well. Because of these and other factors, Texaco believes the risk of a blowout in exploratory drilling operations is far less than 1 in 1,000, perhaps as low as 1 in 100,000.

In order to measure H_2S at any drill site, two basic strategies are used. First, the drilling mud, as it returns to the surface, is monitored for H_2S. Second, a number of detectors are located around the drill site to measure atmospheric concentrations of H_2S.

The mud detection system serves as a pre-warning device in order to determine if there is any H_2S in the subsurface and if present, to keep track of any potentially hazardous quantities of H_2S coming out of the well. The mud sensor detects H_2S at concentrations of much less than one ppm. The sensors located around the rig can detect atmospheric H_2S concentrations as low as two to three (2-3) ppm.

Any oil or condensate that may be spilled during a blowout and that falls within the ring levee will be handled as any spilled oil or liquid wastes would be handled. The escape of this oil or condensate from the area within the levee will depend on the co-occurrence of the blowout and subsequent spill with extremely high precipitation amounts (as discussed above).

Any oil or condensate which escapes the area within the levee either due to excessively high rainfall or to actual blowout from the perimeter of the drill site will be localized by the earthen dam and booms, as described above. Therefore, the potential environmental damage due to an oil or gas blowout will be very unlikely.

ANALYSIS

Table 1 summarizes the potential discharges from the King George County exploratory well, their likely size, and relative probability of occurrence.

Table 1. Summary of the potential discharges, probable size of discharge, and probability of occurrence, of discharges outside the ring levee.

DISCHARGE	PROBABLE SIZE	PROBABILITY OF OCCURRENCE
Blowout		
Oil	Minor	Very Unlikely
Gas	NA	Very Unlikely
Oil Spill		
On-site	Minor	Virtually Impossible
In-transit	Moderate	Virtually Impossible
Pipeline	Moderate	Virtually Impossible
Diesel Fuel		
Tank rupture	Minor	Virtually Impossible
Spill during filling	Minor	Virtually Impossible
Drilling Muds Spill	Minor	Virtually Impossible

OTHER SPILLS

Other spills include diesel fuel and drilling mud spills. Diesel fuel spills can result from either a tank rupture or a spill during filling of the tank. These spills can only occur within the ring levee. The amount of diesel fuel on site will vary with time. A storage tank with a 20,000-gallon capacity will be used at the King George County well site. The amount of drilling muds on-site will also vary but should be approximately 63,000 gallons at any one time.

As described above, any spilled diesel fuel or drilling muds would remain within the levee unless the spill co-occurred with a rainfall amounting to over 30 inches. Also as described above, the probability of such a co-occurrenceis very low (once in 100-10,000 years). Of further consideration is the dilution of the diesel fuel and/or drilling mud that would occur under the high water conditions that would be necessary if the spilled materials were to escape from the area surrounded by the levee. A maximum theoretical spill of 20,000 gallons of diesel fuel would be diluted by a factor of 20 or greater before leaving the drill site. Likewise, a theoretical maximum spill of 63,000 gallons of drilling muds would be diluted by a factor of greater than 6 before leaving the drill site. This dilution effect would act to further reduce the environmental impact outside of the drill site.

ER 9 Discharge Consequences

Because a well blowout is extremely unlikely (due to the quadruple redundant blowout control system being employed), and because H_2S is not expected to be encountered (based on the data retrieved from the Westmoreland exploratory well), the anticipated impacts to be assessed are minimal. However, the EIA does address the potential impact to each of the resources inventoried in Chapter 2 for the site. Due to the equipment and containment systems designed into the project, the EIA concludes minimal impacts. A more detailed assessment would only be warranted had the likelihood of significant impacts been found.

ER.10 Contingency Planning

The likelihood of encountering H_2S is extremely remote. However, as a matter of standard planning in sparsely drilled areas and to fulfill the permit application requirements, Texaco has prepared a Hydrogen Sulfide Contingency Plan which is included in the DPAP. This plan, in conjunction with the Spill Control and Contingency Plan (SPCC), and the other contingency plans presented in the DPAP address procedures to be followed in case of accidental events. The lack of signature on the SPCC was an administrative oversight.

Although the release of hydrogen sulfide (H_2S) is certainly a concern in drilling and producing operations, it should not pose a problem in King George County or anywhere within the Taylorsville Basin. First of all, the geologic structure present here, a rift basin, is not conducive to H_2S accumulation. This has been confirmed by six core holes and the exploratory well drilled in Westmoreland County - none of which encountered H_2S.

Regardless of this, Texaco will equip all rigs in the Basin, at least on the next several wells, with instruments to detect the presence of H_2S (see previous Section ER.7 of this Addendum). Texaco has presented a contingency plan outlining safety measures to be taken if H_2S is encountered, to the State of Virginia, and King George County, up to and including the evacuation of all residences within a one-mile radius of the drillsite. The residents have already been contacted to ensure Texaco knows of everyone within the area.

Finally, it should be noted that the industry drills and produces formations containing H_2S on a regular basis. In some areas where the H_2S content is high enough, the sulfur can be commercially extracted. Because of design and safety precautions, these operations are conducted with very little potential risk to human health or the environment.

12.B.4. Land Use/Zoning

The drill site is located on agricultural land that is currently unfarmed. The Draft King George County Comprehensive Plan (April 1990) designates this area of the county as "rural area." This designation signifies areas that are "largely undeveloped... contain a mix of agricultural, forest, and dispersed low-density residential uses." The area surrounding the proposed drill site is agricultural and low density housing. The proposed operations will have no impact on surrounding land uses. The drilling operations will be temporary in nature (4 to 6 months) and therefore will not pose only temporary change to the existing use of the field.

King George County has recently enacted ordinances allowing for exploratory drilling operations. Texaco has been working closely with the County for several months to address the required changes necessary to be put in place in order to grant a permit to Texaco. A special exception has been requested from the County. The Board of Supervisors is currently investigating certain final legal technicalities before taking its final vote on granting the special exception. Texaco expects to have all necessary County permits in place within the next 2 to 3 weeks.

13.A. Local Fiscal Characteristics

A general discussion of several aspects of local economic conditions are presented in the EIA. Because the proposed operations will be temporary in nature, and will employ labor and goods brought from outside of the county, there will be no anticipated impacts to the local fiscal characteristics of the county.

13.B.1. Transportation Impacts

Texaco estimates about fifty (50) truckloads will be required to bring in the drilling rig. Texaco further expects that an average of one service truck per day will provide for such items as food, fuel, water pickup, etc. and minimal car traffic during drilling. In that the site is along Route 205, there should be no significant traffic impacts.

13.B.2. Infrastructure and Capital Facility Systems

It is not anticipated that the proposed operations will have more than minimal requirements, if any, for local infrastructural or capital facility support services. A well and septic system will be utilized by persons living on-site. As described elsewhere, liquid wastes (e.g. muds, rainwater) will be trucked from the site to an appropriate facility, possibly outside of the county. Solid waste that would be disposed in the local landfill would consist primarily of general waste from the persons living on-site. Solid wastes generated from the drilling process will be cuttings which are expected to be land farmed at the completion of the operations.

13.B.3. Public Safety and Health Services

Plans and information regarding public safety and emergency requirements are presented in the various Contingency Plans included in the DPAP.

IV. RESPONSES TO ADDITIONAL VERBAL COMMENTS FROM MR. ROBERTS (August 13, 1991)

Cuttings Description

At the conclusion of the operation, the remaining mud and ground cuttings require disposal. If another site should follow the King George well, the liquid mud will be utilized at the follow-up location, then transported to an appropriate disposal site when operations in the Taylorsville Basin are concluded.

The rock cuttings recovered will be stored while drilling occurs, then land farmed at the conclusion of activities on the King George site. Land farming refers to the technique of mixing the cuttings with the soil stockpiled during site construction, then using the mixture to re-contour the area to its original condition. The cuttings will be tested to assure that no contaminants change the soil condition. This procedure was discussed in Section 6.C.7 of this Addendum and in the operations plan of the drilling permit.

Texaco's decision criteria and parameters for cuttings disposal are based on Louisiana Statewide Order 29-B. Since it appears that Virginia has no documented criteria for land farming, Texaco will use the limits on metals concentrations in the Louisiana regulations as a guideline for this project (See Appendix D).

Brine Description

"Brine" refers to the water which commonly accompanies oil and gas production. The amounts of brine which flow with the hydrocarbons varies considerably, and Texaco could not predict the characteristics or volumes which could be present in the Taylorsville Basin. As stated in the EIA, brine will not be an issue in the exploration phase of the project; but would become a concern should the well go into a production mode.

Normally, brine associated with natural gas production (which we expect in Virginia if hydrocarbons are encountered) comprise a smaller volume of water than comparable oil production. This is not necessarily a reservoir characteristic, but simply, as gas is lighter than oil, a comparable volume of water could stop the flow in a gas well whereas an oil well would continue to produce. In other words, water can "snuff-out" a gas well.

If production begins, the preferred method for brine disposal, should brine be present, is underground injection. An underground injection well is constructed in the same manner as a producing well except that brine is injected into the well and into a subsurface formation for disposal. Usually the disposal zone is similar in water profile, therefore usually about the same depth as the production zone. Similar water profiles decrease the possibility of precipitates forming which hinder injection performance. In certain situations, the water is reinjected into the production zone to enhance oil recovery, supplementing natural drive mechanisms.

Underground injection is the "preferred" industry solution to brine disposal in onshore operations. Brine often is characterized by salinities higher than those of surrounding ground and surface water. Therefore, disposal procedures should be designed to alleviate contact. Underground injection accomplishes this goal. Another alternative would be to collect and transport brine to an appropriate disposal facility.

Emergency Evacuation Notification System

Emergency response procedures are described in the various contingency plans included in the DPAP.

V. STATUS OF ARCHAEOLOGICAL STUDY

An archaeological field study is presently being conducted on behalf of Texaco on the King George County site. The selected consultant appears on the Department of Historic Resources Review and Compliance Consultants list, and has conducted numerous archaeological and cultural resources investigations in the Virginia Coastal Plain. The investigation focuses on the area of the enclosed drill site. Areas subject to only temporary fill are not being investigated as they will not be disturbed to any extent more than during farming operations that have previously occurred on the site.

VI. LITERATURE CITED

Anderson, C.M. and R.P. La Belle. 1990. Estimated Occurrence Rates for Analysis of Accidental Oil Spills on the U.S. Outer Continental Shelf: Oil & Chem. Poll. G:21-35.

Danenberger, E.P., 1980. Outer Continental Shelf Oil and Gas Blowouts 1971-78, U.S. Geological Survey Open-File Report 80-101, 15p.

Fleury, M.G. 1983. Outer Continental Shelf Oil and Gas Blowouts 1979 -1982. U.S. Geological Survey Open File Report 83-562, 27p.

LaBelle, R.P. 1991. Personal Communication Robert La Belle and Anthony Janicki.

Minerals Management Service. 1991. Comprehensive Program 1992-1997. Draft Environmental Impact Statement. OCS - EIS/FA MMS 91-0044.

APPENDIX A

CROSS-REFERENCE BETWEEN
VIRGINIA COUNCIL ON THE ENVIRONMENT GUIDELINES
AND
TEXACO, INC. PERMIT APPLICATION, EIA, AND EIA ADDENDUM

The attached list is intended to assist reviewers in locating discussions of various topics included in the VA-COE Guidelines. For each topic, the section number (VA-COE Guidelines) is given, as well as the document, section, and/or page number where that topic is addressed in the Texaco Inc. application package. The following abbreviations are used for each indicated document:

EIA - King George Environmental Impact Assessment, (May 15, 1991)

DPAP - Texaco Inc. Drilling Permit Application Package for King George Co, VA, (June 6, 1991)

- **A** - Registration Form
- **B** - Notice and Application for a Permit
- **C** - Operations Plan
- **D** - Site Plans
  - Cover Sheet (Sheet 1)
  - Grading and Erosion Control (Sheet 2)
  - Sediment and Erosion Control (Sheet 3)
- **E** - Contingency Plan
  - **I** - Purpose
  - **II** - General Instruction
  - **III** - Authority and Chain of Command
  - **IV** - Well Control
  - **V** - Fire Control
  - **VI** - SPCC Plan
  - **VII** - Spill Containment
  - **VIII** - H_2S Contingency Plan
  - **IX** - Emergency Incident Reporting
  - **X** - Emergency Evacuation Plan
  - **XI** - Emergency Phone Numbers

Addendum - Addendum to King George Co. EIA (August 30, 1991)

NA - Item Not Applicable to Exploratory Project.

CROSS REFERENCE OF VA-COE GUIDELINES
TO
TEXACO INC. PERMIT APPLICATION DOCUMENTS

Section Number/Data Required		Texaco Inc. Document
5.	**GENERAL INFORMATION REQUIREMENTS**	
5.B.	Title Page	*EIA, title page.*
	Executive Summary	*EIA, pg.vi*
	Table of Contents	*EIA, pg.i.*
	List of Figures	*EIA, pg.iv.*
	List of Tables	*EIA, pg.iii.*
	List of Maps and Plates	*EIA, (presented as Figures, pg.iv)*
	Main Body of Report	*EIA.*
	List of Preparers	*(see Cover, title pg)*
	Topical Index	*(see Table of Contents)*
	Annex of Permits	
5.C.	Cross-Reference	*Addendum, Appendix A*
6.	**DESCRIPTION OF OIL AND GAS OPERATIONS**	
6.A	Location	*EIA, pg.1;DPAP/C, pg.1;DPAP/D, sheet 1.*
	Size	*EIA, pg.1;DPAP/C, pg.1.*
	Number of Facilities	*EIA, pg.1;DPAP/C, pg.1.*
	Related Land Requirements	*EIA, pg.1:DPAP/C, pg.1;DPAP/D, sheet 2.*
	Timetable for Drilling Operations	*EIA, pg.1;DPAP/C, pg.1.*
	Timetable for Production Facilities	*NA*
6.B.1	General Location Map	*EIA, pg.3 and 50;DPAP/D, sheet 1.*
6.B.2	Detailed Site Plats	*DPAP/D, sheets 1-3.*
6.B.2.a	Proposed land-disturbing activities	*EIA, pg.4;DPAP/D, sheets 1-3.*
6.B.2.b	Facilities, equipment, pipelines	*EIA, pg.4;DPAP/D, sheet 2.*
	-Natural resource features that could be affected	*DPAP/D, sheet 2.*
6.B.2.c	Existing man-made features	*DPAP/D, sheet 1.*
6.C.1	Type of Drilling Operation	*DPAP/B. pg.5 (Appendix A).*
6.C.2	Power Systems, fuel sources, associated equipment	*EIA, pg.59.*
6.C.3	Fluid Circulation Systems	
	- List of drilling fluids, components	*EIA, pg.61; DPAP/C, pg 2.*
	-Toxicity classification	*Addendum, pg.2-6*
	- Projected amount and rate of fluid Production	*Addendum, pg.2-6*

6.C.4	Well control and BOP devices	*EIA, pg.73;DPAP/F, pg.7*
	- proposed containment of releases	*EIA, pg. 56,77;DPAP/F, pg. 5,6; Addendum, pg.18-22,23.*
6.C.5	Utility Connections (water, sewer)	*EIA, pg.1;DPAP/C, pg. 1,2.*
6.C.6	Types, Quantities, Chemical Characteristics of Waste Fluids	*EIA, pg. 61,79,85;DPAP/C, pg.2.*
	- Planned surface or ground water emissions	*EIA, pg. 1; DPAP/C, pg. 1.*
6.C.7	Types, Quantities, Chemical Characteristics of Solid Wastes	*EIA, pg. 62; DPAP/C, pg.2, Addendum, pg.2-6,25.*
6.C.8	On-site/Off-site Solid/Liquid Waste Management Procedures	*EIA, pg. 61; DPAP/C, pg.2; Addendum, pg.2-6,25,26.*
	- Waste transfer areas/procedures	
	- Disposal areas/facilities	
	- Handling facilities/equipment	
	- Storage areas/related equipment	
	- Methods of disposal	
6.C.9	Public Safety and Environmental Protection Features and Devices	*(various features/devices addressed throughout EIA,DPAP.)*
6.C.10	Air Emissions	
	- Type	*EIA, pg. 59.*
	- Quantity	*EIA, pg. 59.*
	- Duration	*EIA, pg. 59.*
6.C.11	Methods to Acquire Necessary Water Supply:	*Addendum, pg.6*
	- Withdrawals	
	- Effects on Stream Flow	
	- How supplies will be used	
6.C.12	Erosion and Sediment Control/Stormwater Management Practices	*DPAP/D, sheets 2 and 3.*
6.C.13	Site Restoration Plans	*DPAP/C, pg. 3.*
6.D.	Land-Disturbing Activities (including size/location):	
6.D.1	Clearing of Vegetation	*Addendum, pg.6-7*
6.D.2	Land grading and filling	*DPAP/C, pg.1; DPAP/D, sheets 2 and 3.*
6.D.3	Access Roads	*DPAP/D, sheets 2 and 3.*
6.D.4	Fluid reserve pits, sumps, dikes, tanks	*DPAP/D, sheets 2 and 3.*
6.D.5	Associated facilities inside or outside of the operations area	*DPAP/D, sheets 2 and 3; Addendum, pg.7*

7. DESCRIPTION OF ENVIRONMENT/NATURAL RESOURCES POTENTIALLY AFFECTED

7.A.	Existing resources/environment within 1320 feet of proposed well;	*EIA, Chpt.2*
	- Resources/environment that may be affected outside of that area	*EIA, Chpt.2*
	- Plats of resources/environment at scale of 1:1000 to 1:4000	*Site Plans, Sheet 4*
7.A.1	Physical site conditions:	*EIA, pg. 12.*

7.A.1.a	Topographic features	
7.A.1.b	Surface water hydrology	
	-drainage patterns	*EIA, pg. 12.*
	-subaqueous beds	*EIA, pg. 12.*
	-wetlands	*EIA, pg. 20.*
	-100-year floodplain	
7.A.1.c	Surface water quality characteristics	*EIA, pg. 14.*
	-impacts of emissions	*EIA, pg. 56,77,82.*
7.A.1.d	Existing air quality	*EIA, pg. 26.*
	-impacts of emissions,	*EIA, pg. 59, 78, 84.*
7.A.1.e	Geological conditions	
	-Groundwater/hydrogeology	*EIA, pg. 5; Addendum, pg.8-11,14-15.*
	-Top/bottom of aquifers	*DPAP/B, pg.6;EIA, pg.5.*
	-Geologic strata	*EIA, pg. 5.*
	-Potential for subsidence	*EIA, pg. 76.*
7.A.1.f	Existing groundwater quality that may be impacted	*Addendum pg.8-11.*
	-potable aquifers	*EIA, pg. 5-11.*
	-domestic/communitywatersupply	*EIA, pg. 5-11; Addendum, pg.8-11.*
7.A.1.g	Soil types	*EIA, pg. 12.*
	-Prime agricultural lands	*Addendum, pg.11-15.*
	-Highly permeable soils	*Addendum, pg.11-15.*
	-Highly erodable soil	*Addendum, pg.11-15.*
	-Soil profile to 72"	*Addendum, pg.11-15.*
7.A.1.l	Location of public water intakes within watershed, and 10 miles downstream	
	-Location of public/private water wells within 1 mile radius	*Addendum, pg.8-11.*
7.A.1.i	CBPA's (RPA's; RMA's) within 1320 feet	*Addendum, pg.15-16.*
7.A.2	Biological Conditions and Resources	*EIA, Chpt.2.*
7.A.2.a	Terrestrial and aquatic habitat types	*EIA, pg. 15, 18.*
	-Flora and fauna	*EIA, pg. 18.*
	-Natural heritage survey and documentation	*EIA, pg. 18, Appendix A.*
	Rare, threatened, endangered species	*EIA, pg. 18-19, Appendix A.*
7.A.2.b	Terrestrial wildlife habitat use patterns	*EIA, pg. 18.*
7.A.2.c	Freshwater, estuarine and marine habitat use patterns	*EIA, pg. 15.*
	-aquatic vegetation	*EIA, pg. 15.*
	-fish spawning areas	*EIA, pg. 15.*
	-shellfish beds	*EIA, pg. 15.*
	-anadromous fish/finfish	*EIA, pg. 15.*
	-benthic organisms	*EIA, pg. 15.*
7.A.2.d	State Wildlife Management Areas	*EIA, pg. 29.*
	-State Natural Area Preserves	*EIA, pg. 29.*
	-National Wildlife Refugees	*EIA, pg. 29.*
	-VA National Estuarine Research Reserve System	

7.A.3	Cultural, Historic, Recreational Resources	
7.A.3.a	Historic Properties	*EIA, pg. 28, Appendix B.*
7.A.3.b	Public beaches	*EIA, pg. 29.*
7.A.3.c	Scenic Resources	*EIA, pg. 29.*
7.A.3.d	Public water access sites	
7.A.3.e	Local, state, national parks, recreational areas, forests	*EIA, pg. 29.*
7.A.3.f	State-owned/managed lands	*EIA, pg. 29.*
7.A.3.g	Federally owned/managed lands	*EIA, pg. 29.*
7.A.3.h	Easements held for agricultural, forestal, open space, horticultural, or other conservation purposes	
7.A.3.i	Prime agricultural or important farm lands	*Addendum, pg.6-7.*
7.B.	Existing Noise Levels	*EIA, pg. 27; Addendum, pg.17.*
	- Activities that will produce over 65 dbs	*EIA, pg. 64.*
	-Source	*EIA, pg. 64.*
	-Daily duration	
	-Noise level at nearest receptor	*Addendum, pg.17.*
	- Measures to be taken to reduce noise to below 65 dbs at receptor	*Addendum, pg.17.*
7.C	Activities that will produce light/glare at night	
	- Hours lighting will exist	*EIA, pg. 29,65; Addendum, pg.18.*
	- Intensity	*Addendum, pg.18.*
	- Aesthetic, nuisance, safety, environmental hazards outside of operations area	*NA*
	- Steps taken to minimize light/glare	*EIA, pg. 65; Addendum, pg.18.*
7.D	Measures to avoid impacts on identified natural, scenic, historic recreational resources	*EIA, Chpt.III, IV and V;DPAP/E/VII.*
	- Irrevocable or irreversible losses	*None.*

8. ESTIMATED PROBABILITY OF DISCHARGE

8.A Analysis of Probabilities of accidental discharges - Drilling, Production, Transportation, Blowout *Addendum, pg.18-23.*

- Spill Probability Analysis for:
  - -Minor Discharge
  - -Moderate Discharge
  - -Major Discharge

9. CONSEQUENCES OF DISCHARGE

- Spill Analysis for potential minor, moderate and major accidental discharges
- Effects on:

	-Finfish	*EIA, pg. 77.*
	-Shellfish	*EIA, pg. 77.*
	-Other marine/freshwater organisms	*EIA, pg. 77.*
	-Birds	*EIA, pg. 77.*
	-Wildlife	*EIA, pg. 77, 78.*
	-Air quality	*EIA, pg. 78.*
	-Water quality	*EIA, pg. 77.*
	-Land/water resources	*EIA, pg. 73-76.*

10. SPILL RELEASE AND CONTINGENCY PLANNING

10.A	Procedures/Equipment to Detect and Respond to	
	- Minor, Moderate, Major Discharges	*DPAP/E/IV, VI, VII.*
	- Fires	*DPAP/E/V.*
	- Other Hazards	*DPAP/E.*
10.B.1	Safety Devices for early detection	
	- Timetable for inspection and maintainence of detection/response equipment, pipeline systems, other equipment	*DPAP/E/VI.*
10.B.2.a	-Response Equipment	
	-Supplies and Materials	
	-Private Contractors Local/Regional Emergency Response Sources	
10.B.2.b	Response Times	
10.B.2.c	Discharge Notification System	*DPAP/E/IX.*
	-Individuals/Alternates	
	-Agencies to be notified	*DPAP/E/IX.*
10.B.2.d	Emergency Response Personnel	
	-Hazardous Materials Information Needs	
10.B.2.e	Discharge Response Strategy	*DPAP/E/VI/VII.*
10.B.3	Actions to be Taken if Discharge Discovered	*DPAP/E.*
10.B.3.a	Designated Response Coordinator	*DPAP/E/III.*
10.B.3.b	Location of response operations center	*DPAP/E/II.*
	-communications system	
10.B.3.c	Employees' Responsibilities	*DPAP/E/III.*
	-Employees' Training	*DPAP/E/VI.*
10.B.3.d	Provisions for clean-up, abatement/disposal	*EIA, pg. 56,73.*

11. HYDROGEN SULFIDE CONTINGENCY PLANNING

11.A	Potential for encountering H2S	*EIA, pg. 78.*
	- Steps to be taken to respond to release	*DPAP/E/VIII.*
11.B	H2S Release Contingency Plan	*DPAP/E/VIII.*
11.B.1	Detection and prevention methods and devices	
	- Equipment to be used	*DPAP/E/VIII.*
	- Equipment testing and calibration procedures	*DPAP/E/VIII.*
11.B.2	Operating procedures if atmospheric concentrations reach 5 ppm; 10 ppm; 25 ppm	
11.B.2.a	Emergency notification procedures	*DPAP/E/VIII.*
11.B.2.b	Regulatory agencies notification procedures	*DPAP/E/XII.*
11.B.2.c	Visual/Audible warning systems for concentrations above 5 ppm	*DPAP/E/VIII.*
11.B.3	Potential for Low-Level Emissions in Public Areas	*Addendum, pg.21-22,23.*
	- Air Quality Screening Anal.	*Addendum, pg.21-22,23.*

12. ECONOMIC IMPACTS

12.A	Affects on economic characteristics during	
	-drilling and construction	*EIA, pg. 20, 58.*
	-production	*EIA, pg. 83.*
	- Methodology, assumptions, calculations	*EIA, pg. 20,58,83.*
12.B.1	Effects on:	
	- current population,	*EIA, pg. 58.*
	- demographic structure (age, income, employment characteristics)	*EIA, pg. 58.*
12.B.2	Projected employment levels, estimates of variation over time for:	
	- drilling and construction	*EIA, pg. 58.*
	- production	*EIA, pg. 83.*
	Positions to be filled by local labor pool	*EIA, pg. 58.*
12.B.3	Local support services	
	- Amount of contract awards for local service providers	*NA*
	- Projected term and duration of service contracts	*NA*
12.B.4	Existing land uses that will be affected	*Addendum, pg.24.*
	- Plat of land uses within 1320 feet of well	*Addendum, pg.24.*
12.B.5	Local industrial and commercial bases and economic conditions	*EIA, pg. 23.*
	- tourism/recreation impacts	

-	affect on natural resource-based commercial activities	*EIA, pg. 58-59.*
12.C.	Actions to avoid, minimize, mitigate impacts	*EIA, pg. 59.*
-	Irreversible impacts	*NA*

13. FISCAL IMPACTS

13.A.	Existing Fiscal/Infrastructure Characteristics	*EIA, pg. 20, 58.*
-	Physical Infrastructure	
-	Potential Effects on Infrastructure and Related Fiscal Impacts	
-	Methodologies, Assumptions, Calculations	
13.B.1	Availability and affects on transportation systems	*Addendum, pg.25*
	-Number of vehicle trips	
	-Size of operational support vehicles	
	-Design capacity of affected roads relative to projected size, weight, volume of vehicle traffic	
13.B.2	Facility Support Services	
	-Utility services	*EIA, pg. 24.*
	-Water services	*EIA, pg. 25; PA,pg.11.*
	-Sewer services	*EIA, pg. 25; PA,pg.11.*
	-Solid waste disposal services	*EIA, pg. 25.*
	-Demands proposed project will place on these systems	*EIA, pg. 1; DPAP/C, pg. 1,2.*
	-Capacity to respond to project demands	*NA*
	-Need for upgrades of systems, cost, applicant's participation in upgrades	*NA*
13.B.3	Public Safety and Health Services	
	-Hospitals, emergency rescue services, police, fire, related services	*EIA, pg. 26.*
	-Capacity to respond to accidents or incidents	
	-Needed upgrades, costs, applicant's participation in upgrades	
13.B.4	Existing Temporary and Permanent Housing Units	*EIA, pg. 22.*
	-Ability to accommodate influx of project workers	*EIA, pg. 59.*
	-Affects of temporary housing on existing land uses	*Addendum, pg.25.*
	-How projected housing needs will be met	*EIA, pg. 1,59.*

13.B.5	Educational Recreational, Social Services Needs -Capacity of existing services, ability to handle projected population increase	*EIA, pg. 26,59.*
13.C.	Actions and Measures to Avoid, Minimize, Mitigate Impacts on Fiscal Characteristics	*NA*

APPENDIX B

SHALLOW SOILS PROFILES AND SURFACE SOILS MAPS

SOIL PROFILE NOTES

COASTAL
ENVIRONMENTAL SERVICES INC.

Profile #: 1
Date of Test: 8/23/91 *Soil Boring* ✓ *or Test Pit* _____
Property Owner:
Property Location: King George Co., VA
Site Evaluator: *License No.:* 3165 (ARCPACS)

Slope: 2-5 % *Relief:* Gently sloping
Estimated Permeability:
Depth to Limiting Zone:
Soil Series Identified: Bourne Fine SANDY LOAM

Horizon	Depth	Colors Matrix	Colors Mottles	Mottles Desc. Ab. S. Con	Texture	Structure	Consistence
0-11	0-11	10YR 4/3	/	/	FSL	Gr	Fr
Bt	11-22	10yr 5/6	/	/	Heavy SL	SAB	Fr
Bx	22-34	10yr 5/6	10YR 7/3	CMD	FSL	PL/Pr	Fi
Bt2	34-43	10YR 5/6	/	/	Heavy CSL	WSAB/Gr	Fr

Comments: - Fragipan moderately developed
- Some quartz fragments encountered in Bt2 horizon

William J. Gardner
Site Evaluator's Signature

SOIL PROFILE NOTES

COASTAL
ENVIRONMENTAL SERVICES INC.

Profile #: 2
Date of Test: 8/23/91 *Soil Boring* ✓ *or Test Pit* _____
Property Owner:
Property Location: King George Co., VA
Site Evaluator: *License No.:* 3165 (ARCPACS)

Slope: 2-5% *Relief:* Gently sloping
Estimated Permeability:
Depth to Limiting Zone:
Soil Series Identified: Bourne Fine SANDY LOAM

Horizon	Depth	Colors Matrix	Colors Mottles	Mottles Desc. Ab. S. Con	Texture	Structure	Consistence
Ap	0-9	10YR 5/3	/	/	FSL	Gr	Fr
Bt	9-26	10YR 5/6	/	/	SL	WSAB	Fr
Bx1	26-39	10YR 6/3	10YR 6/8	CMD	SCL	PR	Fi
Bx2	39-46	10YR 7/3	10YR 5/8	CMD	FSL	PR/PL	Fi/brittle

Comments: - Fragipan is weakly to moderately developed
- Soil was droughty, surface horizon was moistened for color determination

William J. Banka
Site Evaluator's Signature

SOIL PROFILE NOTES

COASTAL
ENVIRONMENTAL SERVICES INC.

Profile #: 3
Date of Test: 8/23/91 *Soil Boring* ✓ *or Test Pit* _____
Property Owner:
Property Location: King George County, VA
Site Evaluator: *License No.:* (3165) ARCPACS

Slope: 2-5 % *Relief:* Gently sloping
Estimated Permeability:
Depth to Limiting Zone:
Soil Series Identified: BOURNE FINE SANDY LOAM

Horizon	Depth	Colors Matrix	Colors Mottles	Mottles Desc. Ab. S. Con	Texture	Structure	Consistence
Ap	0-10	10YR 5/3	/	/	FSL	Gr	Fr
Bt	10-28	10YR 5/6	/	/	SL/SCL	WSAB	Fr
Bx	28-35	10YR 7/3	10YR 5/8	CMD	Heavy SL	PL/SAB	Fi

Comments: Fragipan is moderately developed
Auger Refusal at 35 inches

Site Evaluator's Signature

SOIL PROFILE NOTES

COASTAL
ENVIRONMENTAL SERVICES INC.

Profile #: 4
Date of Test: 8/23/91 *Soil Boring* ✓ *or Test Pit* _____
Property Owner:
Property Location: King George Co., VA.
Site Evaluator: *License No.:* (3165) ARCPACS

Slope: 2-5% *Relief:* Gently sloping
Estimated Permeability:
Depth to Limiting Zone:
Soil Series Identified: Sassafras Fine Sandy loam

Horizon	Depth	Colors Matrix	Colors Mottles	Mottles Desc. Ab. S. Con	Texture	Structure	Consistence
Ap	0-10	10YR 4/4	—	—	FSL	Gr	Fr
Bt	10-24	10YR 5/6	/	/	SCL	WSAB	Fr
Bt2	24-33	7.5YR 5/6	/	/	Heavy SL	SAB	Fr
B	33+	7.5YR 5/4	—	—	LFS	WSAB	Fr

Comments: Soil was very droughty, required wetting for soil color determination

Site Evaluator's Signature

SOIL PROFILE NOTES

COASTAL
ENVIRONMENTAL SERVICES INC.

Profile #: 5
Date of Test: 8/23/91 *Soil Boring* ✓ *or Test Pit* _____
Property Owner:
Property Location: King George Co., VA
Site Evaluator: *License No.:* 3165 (ARCPACS)

Slope: *Relief:*
Estimated Permeability:
Depth to Limiting Zone:
Soil Series Identified: Sassafras Fine Sandy loam

Horizon	Depth	Colors Matrix	Colors Mottles	Mottles Desc. Ab. S. Con	Texture	Structure	Consistence
Ap	0-8	10YR 4/4	—	—	FSL	Gr	Fr
BA	8-12	10YR 5/6	—	—	FSL	Gr/SAB	Fr
Bt	12-24	10YR 5/6	—	—	Heavy SL	SAB	Fr
Bt	24-35	10YR 5/8	—	—	Heavy SL	WSAB	Fr
B	35-43	10YR 5/8	—	—	CSL	Gr	Fr

Comments: Some of the surface horizon particles were present within BA

Site Evaluator's Signature

LEGEND:

Ae Alluvial Land, Wet
BmB Bourne Fine Sandy Loam
GsD, GsE Galestown-Sassafras
Po Pooler Loam
SfB, SfC2 Sassafras Fine Sandy Loam
TeC2 Tetotum Fine Sandy Loam
Tm Tidal Marsh

SOURCE: USDA Soil Survey of Stafford and King George Counties

N

FIGURE 1
SCS SOILS MAP
Texaco, Inc., Exploratory Well
King George County, VA

SCALE 1" = 1320'

COASTAL
ENVIRONMENTAL SERVICES INC.

APPENDIX C

DEEP BORINGS SOILS PROFILE

DRAFT

Harford Drilling and Testing, Inc.
Annapolis Junction, Maryland

Project Name: Texaco Site King George County GTA Job No. 91218.C

Date Started: 8-20-91 Date Completed: 8-20-91 Boring #: B-1

Boring Location: _____ Ground Water @ Completion: Dry, caved 16.7'

Elevation: _____ Total Depth: 20.5' Ground Water @ 0.5 Hrs.: Dry, caved 16.6'

Drilled by: Scott Lyons Equipment: CME 45

Strata Depth	Sample Depth	SAMPLE No.	Blows/6"		Rec/Att	DESCRIPTION (Color, Moisture, Proportions, etc.)
	0.0-1.5	1	6	10	8/18"	Light brown, moist, medium dense, silt with little sand and trace roots (ML)
2.0			16			
	2.5-4.0	2		9	12/18"	Brown, moist, very stiff to hard, silty clay, trace fine sand (CL)
			12	15		
	5.0-6.5	3	12	15	15/18"	
7.0			18			
	7.5-9.0	4		8	16/18"	Brownish orange, moist, medium dense, silty fine sand with little clay (SM)
			12	14		
	10.0-11.5	5	9	11	14/18"	
			14			
	14.0-15.5	6	4	7	10/18"	
			8			
18.0						
	19.0-20.5	7	10	12	12/18"	Orange-yellow, moist, medium dense, fine sand with little silt (SM-SP)
20.5			13			
						B.O.H. - 20.5' Topsoil - 1" No water encountered

Standard Penetration Test: Driving 2-inch O.D. Sampler with 140-pound hammer freely falling 30 inches.

DRAFT

Harford Drilling and Testing, Inc.
Annapolis Junction, Maryland

Project Name: Texaco Site King George County GTA Job No. 91218.C

Date Started: 8-20-91 Date Completed: 8-20-91 Boring #: B-1A

Boring Location: Ground Water @ Completion: Dry, caved 16.9'

Elevation: Total Depth: 20.5' Ground Water @ 0.5 Hrs.: Dry, caved 16.7'

Drilled by: Scott Lyons Equipment: CME 45

Strata Depth	Sample Depth	SAMPLE No.	Blows/6"		Rec/Att	DESCRIPTION (Color, Moisture, Proportions, etc.)
	0.0-1.5	1	8	9	5/18"	Light brown, moist, medium dense, silt with little sand and trace roots (ML)
2.0			13			
	2.5-4.0	2		11	8/18"	
4.0			15	20		Orange-brown, moist, dense, silty fine sand, trace gravel and clay (SM)
	5.0-6.5	3	28	36	8/18"	
7.0			52			Brown and white, moist, very dense, silty fine sand and gravel, trace clay (SM-GM)
	7.5-9.0	4		5	15/18"	
9.0			6	7		Red, moist, medium dense, silty fine sand with little clay (SM)
	10.0-11.5	5	7	8	12/18"	
			12			Orange, brown, moist, medium dense, silty fine sand (SM)
13.0						
	14.0-15.5	6	7	9	14/18"	Yellow and orange, moist, medium dense, fine to medium sand with little gravel and trace silt (SP-SM)
			15			
18.0						
	19.0-20.5	7	4	5	6/18"	Yellowish-light brown, wet, medium dense, sand and gravel with trace silt (SM-GM)
20.5			6			
						B.O.H. - 20.5' Topsoil - 1" Water encountered - 19.0'

Standard Penetration Test: Driving 2-inch O.D. Sampler with 140-pound hammer freely falling 30 inches.

APPENDIX D

LOUISIANA LAND TREATMENT REQUIREMENTS FOR METALS CONCENTRATIONS IN CUTTINGS

Louisiana Land Treatment Requirements for Cuttings.
Maximum Allowable Concentrations of Metals in the Treatment Zone.

Parameter	Limitation (ppm)
Arsenic	40
Barium	3000
Cadmium	10
Chromium	1000
Lead	1000
Mercury	10
Selenium	10
Silver	200
Zinc	500

APPENDIX E

LABORATORY ANALYSIS OF WATER WELL DATA COLLECTED IN THE VICINITY OF THE PROPOSED PROJECT

KEY TO SITE IDENTIFIERS FOR WATER WELL LABORATORY ANALYSIS

KG1	John Thomas Redman Property,
KG2	J. Richmond Low Jr., Property,
KG3	Ninde's Store Well, Sydnor Hydrodynamics
KG4	Thorn Hill Farm, Hilliard Property.

Gascoyne Laboratories, Inc.

Baltimore, MD 21224-6697

BALTIMORE, MD.
(301) 285-8510
FAX #
(301) 285-0815

REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 1 of 12

Sample I.D. Submitted Drinking Water: KG 1 dated 08/23/91 (12:00)

	Results	Detection Limits	MCL	Method	Analyst	Date Test Completed
Arsenic (As)	0.060	0.005	0.050	206.2	GPC	08/24/91
Barium (Ba)	0.016	0.010	1.0	200.7	FAK	08/27/91
Cadmium (Cd)	ND	0.0005	0.010	213.2	GPC	08/24/91
Chromium (Cr)	0.016	0.0010	0.050	218.2	GPC	08/24/91
Lead (Pb)	ND	0.005	0.015	239.2	GPC	08/24/91
Mercury (Hg)	ND	0.0005	0.002	245.1	SCN	08/28/91
Selenium (Se)	ND	0.005	0.010	270.2	GPC	08/24/91
Silver (Ag)	ND	0.0010	0.050	272.2	GPC	08/24/91

Notes: (1) Results expressed as mg/liter (ppm).

(2) ND-Not Detected.

(3) MCL-Maximum Contaminant Level.

Irving M. Kipnis

Laboratory Director
Irving M. Kipnis, Ph.D.

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REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 2 of 12

Sample I.D. Submitted Drinking Water: KG 1 dated 08/23/91 (12:00)

	Results	Detection Limits	MCL	Method	Analyst	Date Test Completed
Specific Conductance	105	NA	-	120.1	RAH	08/23/91
Chloride (Cl)	3	1	250	325.3	RJG	08/26/91
Color (Units)	ND	1	15	110.2	RJG	08/23/91
Hardiness	35	1	-	130.2	RJG	08/26/91
Iron (Fe)	0.04	0.01	0.3	236.1	DLB	08/27/91
Odor (T.O.N.)	ND	1	3	140.1	RJG	08/23/91
pH	5.9	NA	6.5-8.5	150.1	RJG	08/23/91
Sulfate (SO_4)	31	1	250	375.4	RJG	08/23/91
Potassium (K)	5.5	0.1	NA	258.1	BAO	08/27/91
TDS	70	1	500	160.1	DJP	08/27/91
Zinc (Zn)	0.17	0.01	5	289.1	DLB	08/27/91

Notes:
(1) Results expressed as mg/liter (ppm).
(2) ND-Not Detected.
(3) NA-Not Applicable.
(4) MCL-Maximum Contaminant Level.
(5) Specific Conductance reported as micromhos/cm.

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REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 3 of 12

Sample I.D. Submitted Drinking Water: KG 1 dated 08/23/91 (12:00)

	Results	Percent Recovery
Arsenic (As)	< 0.005	98
Barium (Ba)	0.016	92
Cadmium (Cd)	< 0.0005	100
Chromium (Cr)	< 0.0010	100
Lead (Pb)	< 0.005	100
Mercury (Hg)	< 0.0005	110
Selenium (Se)	< 0.005	92
Silver (Ag)	< 0.0010	93

Note: Results expressed as mg/liter (ppm).

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REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 4 of 12

Sample I.D. Submitted Drinking Water: KG 2 dated 08/23/91 (12:00)

	Results	Detection Limits	MCL	Method	Analyst	Date Test Completed
Arsenic (As)	ND	0.005	0.050	206.2	GPC	08/24/91
Barium (Ba)	0.021	0.010	1.0	200.7	FAK	08/27/91
Cadmium (Cd)	ND	0.0005	0.010	213.2	GPC	08/24/91
Chromium (Cr)	ND	0.0010	0.050	218.2	GPC	08/24/91
Lead (Pb)	ND	0.005	0.015	239.2	GPC	08/24/91
Mercury (Hg)	ND	0.0005	0.002	245.1	SCN	08/28/91
Selenium (Se)	ND	0.005	0.010	270.2	GPC	08/24/91
Silver (Ag)	ND	0.0010	0.050	272.2	GPC	08/24/91

Notes: (1) Results expressed as mg/liter (ppm).

(2) ND-Not Detected.

(3) MCL-Maximum Contaminant Level.

Irving M. Kipnis

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REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 5 of 12

Sample I.D. Submitted Drinking Water: KG 2 dated 08/23/91 (12:00)

	Results	Detection Limits	MCL	Method	Analyst	Date Test Completed
Specific Conductance	473	NA	-	120.1	RAH	08/23/91
Chloride (Cl)	1	1	250	325.3	RJG	08/26/91
Color (Units)	ND	1	15	110.2	RJG	08/23/91
Hardiness	9	1	-	130.2	RJG	08/26/91
Iron (Fe)	0.02	0.01	0.3	236.1	DLB	08/27/91
Odor (T.O.N.)	ND	1	3	140.1	RJG	08/23/91
pH	8.7	NA	6.5-8.5	150.1	RJG	08/23/91
Sulfate (SO_4)	16	1	250	375.4	RJG	08/23/91
Potassium (K)	6.2	0.1	NA	258.1	BAO	08/27/91
TDS	290	1	500	160.1	DJP	08/28/91
Zinc (Zn)	0.03	0.01	5	289.1	DLB	08/27/91

Notes:
(1) Results expressed as mg/liter (ppm).
(2) ND-Not Detected.
(3) NA-Not Applicable.
(4) MCL-Maximum Contaminant Level.
(5) Specific Conductance reported as micromhos/cm.

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REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 6 of 12

Sample I.D. Submitted Drinking Water: KG 2 dated 08/23/91 (12:00)

	Results	Percent Recovery
Arsenic (As)	< 0.005	104
Barium (Ba)	0.021	95
Cadmium (Cd)	< 0.0005	98
Chromium (Cr)	< 0.0010	106
Lead (Pb)	< 0.005	101
Mercury (Hg)	< 0.0005	107
Selenium (Se)	< 0.005	90
Silver (Ag)	< 0.0010	95

Note: Results expressed as mg/liter (ppm).

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REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 7 of 12

Sample I.D. Submitted Drinking Water: KG 3 dated 08/23/91 (12:00)

	Results	Detection Limits	MCL	Method	Analyst	Date Test Completed
Arsenic (As)	ND	0.005	0.050	206.2	GPC	08/24/91
Barium (Ba)	ND	0.010	1.0	200.7	FAK	08/27/91
Cadmium (Cd)	ND	0.0005	0.010	213.2	GPC	08/24/91
Chromium (Cr)	ND	0.0010	0.050	218.2	GPC	08/24/91
Lead (Pb)	ND	0.005	0.015	239.2	GPC	08/24/91
Mercury (Hg)	ND	0.0005	0.002	245.1	SCN	08/28/91
Selenium (Se)	ND	0.005	0.010	270.2	GPC	08/24/91
Silver (Ag)	ND	0.0010	0.050	272.2	GPC	08/24/91
Total Radium	ND	1	5 pCi/L	*		
Gross Alpha	ND	2	15 pCi/L	*		
Gross Beta	ND	3	50 pCi/L	*		
Tritium	ND	500	NA	*		

Notes:
(1) Results expressed as mg/liter (ppm).
(2) ND-Not Detected.
(3) NA-Not Applicable.
(4) MCL-Maximum Contaminant Level.
(5) *-Analysis Sub-contracted.

Irving W. Kipnis

Laboratory Director
Irving W. Kipnis, Ph.D.

Please see reverse side for explanations and other information.

Gascoyne Laboratories, Inc.

Baltimore, MD 21224-6697

BALTIMORE, MD.
(301) 285-8510

FAX #
(301) 285-0815

REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 8 of 12

Sample I.D. Submitted Drinking Water: KG 3 dated 08/23/91 (12:00)

	Results	Detection Limits	MCL	Method	Analyst	Date Test Completed
Specific Conductance	329	NA	-	120.1	RAH	08/23/91
Chloride (Cl)	1	1	250	325.3	RJG	08/26/91
Color (Units)	ND	1	15	110.2	RJG	08/23/91
Hardiness	4	1	-	130.2	RJG	08/26/91
Iron (Fe)	0.32	0.01	0.3	236.1	DLB	08/27/91
Odor (T.O.N.)	ND	1	3	140.1	RJG	08/23/91
pH	7.8	NA	6.5-8.5	150.1	RJG	08/23/91
Sulfate (SO_4)	17	1	250	375.4	RJG	08/23/91
Potassium (K)	3.1	0.1	NA	258.1	BAO	08/27/91
TDS	200	1	500	160.1	DJP	08/28/91
Zinc (Zn)	0.02	0.01	5	289.1	DLB	08/27/91

Notes: (1) Results expressed as mg/liter (ppm).

(2) ND-Not Detected.

(3) NA-Not Applicable.

(4) MCL-Maximum Contaminant Level.

(5) Specific Conductance reported as micromhos/cm.

Irving M. Kipnis

Laboratory Director
Irving M. Kipnis, Ph.D.

Gascoyne Laboratories, Inc.

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REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 9 of 12

Sample I.D. Submitted Drinking Water: KG 3 dated 08/23/91 (12:00)

	Results	Percent Recovery
Arsenic (As)	< 0.005	101
Barium (Ba)	< 0.010	95
Cadmium (Cd)	< 0.0005	104
Chromium (Cr)	< 0.0010	109
Lead (Pb)	< 0.005	98
Mercury (Hg)	< 0.0005	110
Selenium (Se)	< 0.005	90
Silver (Ag)	< 0.0010	98

Note: Results expressed as mg/liter (ppm).

Laboratory Director
Irving M. Kipnis, Ph.D.

Gascoyne Laboratories, Inc.

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(301) 285-8510

FAX #
(301) 285-0815

REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 10 of 12

Sample I.D. Submitted Drinking Water: KG 4 dated 08/23/91 (12:00)

	Results	Detection Limits	MCL	Method	Analyst	Date Test Completed
Arsenic (As)	ND	0.005	0.050	206.2	GPC	08/24/91
Barium (Ba)	ND	0.010	1.0	200.7	FAK	08/27/91
Cadmium (Cd)	ND	0.0005	0.010	213.2	GPC	08/24/91
Chromium (Cr)	ND	0.0010	0.050	218.2	GPC	08/24/91
Lead (Pb)	ND	0.005	0.015	239.2	GPC	08/24/91
Mercury (Hg)	ND	0.0005	0.002	245.1	SCN	08/28/91
Selenium (Se)	ND	0.005	0.010	270.2	GPC	08/24/91
Silver (Ag)	ND	0.0010	0.050	272.2	GPC	08/24/91

Notes: (1) Results expressed as mg/liter (ppm).

(2) ND-Not Detected.

(3) MCL-Maximum Contaminant Level.

Irving M. Kipnis

Laboratory Director
Irving M. Kipnis, Ph.D.

Gascoyne Laboratories, Inc.

Baltimore, MD 21224-6697

BALTIMORE, MD.
(301) 285-8510

FAX #
(301) 285-0815

REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 11 of 12

Sample I.D. Submitted Drinking Water: KG 4 dated 08/23/91 (12:00)

	Results	Detection Limits	MCL	Method	Analyst	Date Test Completed
Specific Conductance	297	NA	-	120.1	RAH	08/23/91
Chloride (Cl)	1	1	250	325.3	RJG	08/26/91
Color (Units)	ND	1	15	110.2	RJG	08/23/91
Hardiness	2	1	-	130.2	RJG	08/26/91
Iron (Fe)	ND	0.01	0.3	236.1	DLB	08/27/91
Odor (T.O.N.)	ND	1	3	140.1	RJG	08/23/91
pH	7.7	NA	6.5-8.5	150.1	RJG	08/23/91
Sulfate (SO_4)	14	1	250	375.4	RJG	08/23/91
Potassium (K)	2.4	0.1	NA	258.1	BAO	08/27/91
TDS	210	1	500	160.1	DJP	08/28/91
Zinc (Zn)	0.11	0.01	5	289.1	DLB	08/27/91

Notes: (1) Results expressed as mg/liter (ppm).

(2) ND-Not Detected.

(3) NA-Not Applicable.

(4) MCL-Maximum Contaminant Level.

(5) Specific Conductance reported as micromhos/cm.

Irving M. Kipnis

Laboratory Director
Irving M. Kipnis, Ph.D.

Gascoyne Laboratories, Inc.

Baltimore, MD 21224-6697

BALTIMORE, MD.
(301) 285-8510

FAX #
(301) 285-0815

REPORT OF ANALYSIS

Report No. 91-08-661 Report Date: August 30, 1991

Report To: Coastal Environmental Service Page: 12 of 12

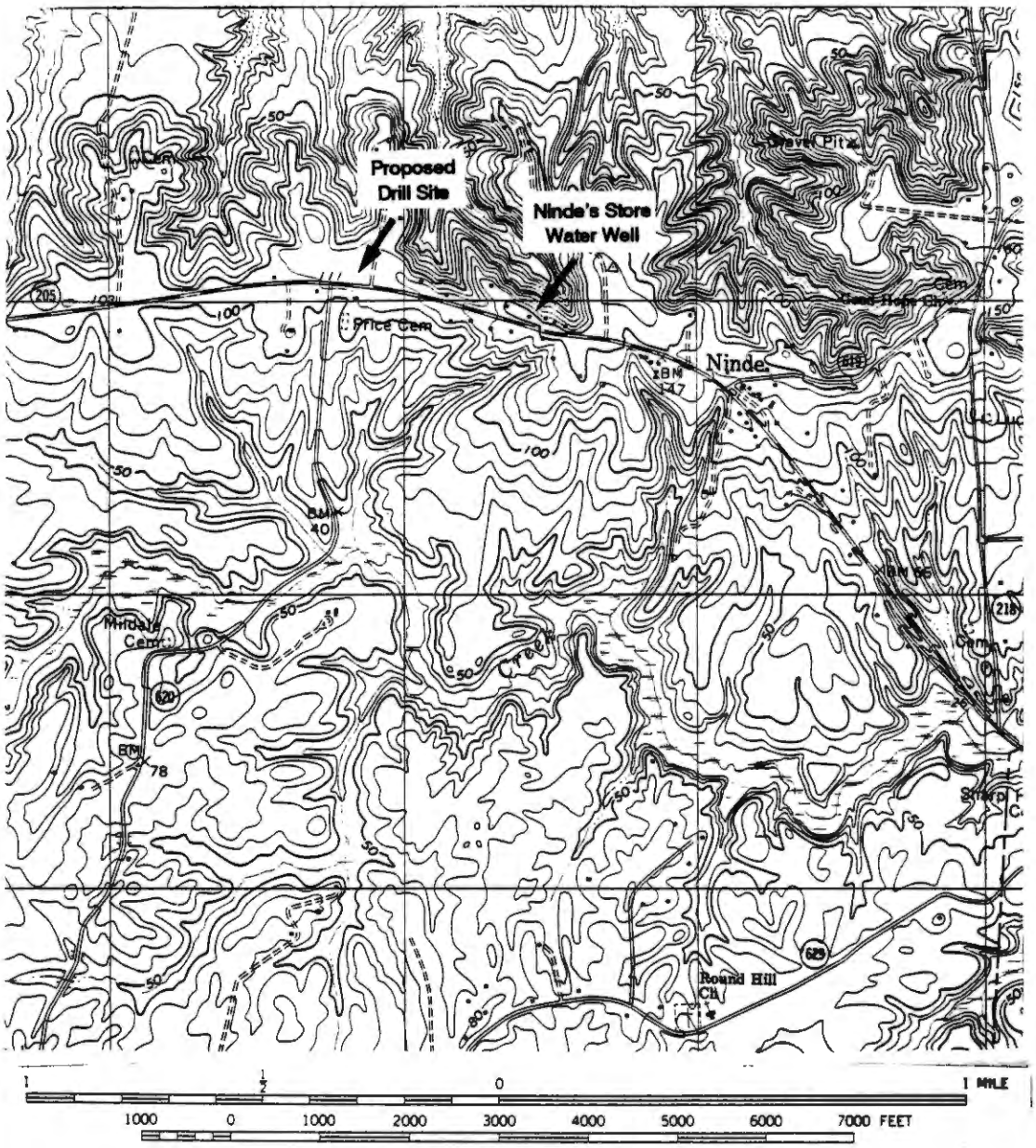
Sample I.D. Submitted Drinking Water: KG 4 dated 08/23/91 (12:00)

	Results	Percent Recovery
Arsenic (As)	< 0.005	103
Barium (Ba)	< 0.010	95
Cadmium (Cd)	< 0.0005	96
Chromium (Cr)	< 0.0010	109
Lead (Pb)	< 0.005	101
Mercury (Hg)	< 0.0005	110
Selenium (Se)	< 0.005	92
Silver (Ag)	< 0.0010	97

Note: Results expressed as mg/liter (ppm).

Irving M. Kipnis
Laboratory Director
Irving M. Kipnis, Ph.D.

Historic Information Pertaining to Ninde's Store Well



CONTOUR INTERVAL 10 FEET
SUPPLEMENTARY CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BATHYMETRIC CONTOUR INTERVAL 1 METER WITH SUPPLEMENTARY
0.5 METER CONTOURS—DATUM IS MEAN LOW WATER
THE RELATIONSHIP BETWEEN THE TWO DATUMS IS VARIABLE
THE MEAN RANGE OF TIDE IS 0.5 METER

Location of Ninde's Store Well and proposed drill site.
(Shown on USGS 1983, scale 1:24,000

N

COASTAL

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT

DIVISION OF MINERAL RESOURCES

JAMES L. CALVER, COMMISSIONER

WATER WELL COMPLETION REPORT

MAILING ADDRESS: Box 3667, University Sta. Charlottesville, Virginia

OFFICE ADDRESS: McCormick Road Charlottesville, Virginia

OWNER: Douglas & Dickinson Inc. Mailing Address: March 29, 1967

TENANT: Ninde Store Mailing Address:

DRILLER: Same As Above (B. Taylor) Mailing Address. Same As Above

WELL LOCATION: County King George (Ninde Store) Approx. 2000 ~~miles~~ feet East 619 (direction) of

200' Off of 619 North and ____ ~~miles~~ feet ____ (direction) of ____

(GIVE DIRECTION AND DISTANCE IN FEET OR MILES FROM TWO REFERENCE POINTS - ROADS, TOWNS, RIVERS, ETC. - ON COUNTY HIGHWAY OR OTHER MAP.)

DATE STARTED: August 14, 1966 DATE COMPLETED: August 17, 1966

TYPE OF DRILL RIG USED: Rotary TOTAL DEPTH 596' feet

WATER LEVEL: Stands 147 feet below surface OR

has NATURAL flow of None gallons per minute.

YIELD TEST: Method Air Lift

Drawdown 33 feet

Rate 30 gal. per min.

Duration 2 hrs., 0 min.

WATER ZONES: from 555 to 575 feet

from ____ to ____ feet

from ____ to ____ feet

WATER: Color None Taste None

Odor None Temp. ____ °F

WELL TO SUPPLY: (check one) Home ____

Farm ____ Town X School ____

Industry ____ Other ____

WATER ANALYSIS AVAILABLE: Yes ____ No X

DRILL CUTTINGS SAVED: Yes X No ____

(DRILL CUTTINGS SHOULD BE COLLECTED AT 10 FOOT INTERVALS. THESE SAMPLES MAY BE SHIPPED TO THIS OFFICE EXPRESS COLLECT. SAMPLE BAGS ARE FURNISHED FREE OF CHARGE UPON REQUEST.)

HOLE SIZE: 6 inches from 0 to 315 feet

3 7/8 inches from 315 to 596 feet

____ inches from ____ to ____ feet

SCREEN SIZE: 2" inches from 555 to 575 feet

____ inches from ____ to ____ feet

____ inches from ____ to ____ feet

CASE SIZE: 4 inches from 0 to 315 feet

2 inches from 315 to ~~596~~ 555 feet

____ inches from ____ to ____ feet

GROUTING: Method ____

Material ____ Depth ____ feet

PUMP: Type ~~Submersible~~ Submersible

Capacity 1000 gal. per min

Depth of intake 210 feet

REMARKS: ____

LOG

FURNISHED BY: Douglas & Dickinson Inc, DATE: March 29, 1967

DEPTH (feet) FROM	TO	TYPE OF ROCK OR SOIL PENETRATED (gravel, clay, etc., hardness, color, etc.)	REMARKS (water, caving, shot, screen, sample, etc.)
0	10	Brown Sand	
10	21	" "	
21	31	" " ,Gravel	
31	42	" "	
42	52	" " , Blue Clay	
52	63	Blue Clay	
63	73	" "	
73	84	" "	
84	94	" "	
94	105	" "	
105	115	" " , Shell	
115	126	" " "	
126	137	" " "	
137	147	" " "	
147	157	" " "	
157	168	" " "	
168	178	" , Red Clay	
178	189	" " " , Shell	
189	199	" " " "	
199	210	" Clay, Shell	
210	220	" " "	
220	231	" " "	
231	241	" " "	
241	252	" " "	
252	263	" " "	
263	273	" " "	
273	284	Sand, Clay and Shell	
284	294	Red and Grayish Clay	
294	305	" " " "	
305	315	" " " "	
315	326	" " " "	
326	336	" " " "	
336	346	" " " "	
347	357	Gray and Redish Clay	
357	368	" " " "	
368	378	Sanded Grayish Clay	
378	389	Shell, " "	
389	399	" " "	
399	410	Sanded Grayish Clay	
410	420	" " "	
420	431	" " "	
431	441	"M " "	
441	452	" Redish Clay	
452	462	" " "	
462	473	" White Clay	
473	483	" " "	
483	495	Redish and Gray Clay	
495	505	" " " "	
505	516	White, Gray Sanded Clay	
516	527	" " " "	
527	538	" " " "	
538	548	" Sand Ball	
548	555	White Sand Ball	
555	565	" "	
565	575	" "	
575	585	Sanded Clay	
585	596	" "	

LAB #: 9609? NOV 30 89

NAME OF WATER SYSTEM: NINDE STORE

SOURCE: Well

OTHER INFORMATION:

REPORT RESULTS TO HEALTH OFFICIAL AT:

Name Sydnor Hydrodynamics Inc.

Address 2111 Magnolia St.

City Rich. Zip Code 23261

Water Quality Report

VOLATILE ORGANICS

WSE 50

Commonwealth of Virginia
Department of Health
Division of Water Programs
Bureau of Water Supply Engineering

REGION: ☐ Abingdon ☐ Culpeper ☐ Danville ☐ Lexington ☐ Richmond ☐ Virginia Beach ☐ Local Health Dept. ☐

PLANNING DISTRICT#

COUNTY: King George

INDEPENDENT CITY:

SAMPLING LOCATION: Pumphouse spigot

CODE: 0 0 1

SOURCE TYPE: ☑ Public-Community ☐ Public-Noncommunity

FIELD TESTS: Temp: Cl_2: mg/L CO_2 mg/L
pH: Alk: mg/L Hard.: mg/L

P.W.S.I.D. #: 6 0 9 3 0 0 TRANSACTION CODE Ø 3

DATE COLLECTED: Mo 11 Day 08 Yr 89

TIME: 1235

COLLECTED BY: E.H.

CONTAINER TYPE: ☑ Glass ☐ Plastic

PRESERVATIVE USED: ☐ None ☐ Ice ☐ Other ☐ Nitric Acid

SAMPLE TYPE: D ☐ Reg. Dist. P ☐ Plant Tap R ☑ Raw Water C ☐ Check M ☐ MCL Check S ☐ Other

CONT. I.D.	CONTAMINANT NAME (Maximum Allowable Level)	MTO.	S	ANALYSIS RESULTS	PRECISION	ANALYSIS DATE Mo Day Yr	A*
2900	Regulated VOCs	524		0 0 00	±		
2990	Benzene 0.005	524		0 0 00	±		
2976	Vinyl Chloride 0.002	524		0 0 00	±		
2982	Carbon Tetrachloride 0.005	524		0 0 00	±		
2980	1,2-Dichloroethane 0.005	524		0 0 00	±		
2984	Trichloroethylene 0.005	524		0 0 00	±		
2977	1,1-Dichloroethylene 0.007	524		0 0 00	±		
2981	1,1,1-Trichloroethane 0.20	524		0 0 00	±		
2969	p-Dichlorobenzene 0.075	524		0 0 00	±		
					±		
2200	UNREGULATED VOCs	524		0 0 00	±		
					±		
					±		
	FIELD BLANK CONTAMINATED				±	11 29 89	(initials)
	WITH TOLUENE, XYLENES, M-DICHLOROBENZENE				±	↓	

DATE REC:

DATE REP:

LAB I.D.

PREPARED BY: R. Tracy Hensley

The results on this report are expressed in mg/L unless otherwise indicated. *A = analyst's initials

LAB #: 9 6 7 0 5 6 JUL 12 89

437655

NAME OF WATER SYSTEM: Wade Store

SOURCE: Well

OTHER INFORMATION:

REPORT RESULTS TO INFORM OF:

Name: Alpha Water Corporation

Address: P.O. Box 26943

City: Richmond Zip Code: 23261

Water Quality Report

RADIOLOGICAL

WSE 50

Commonwealth of Virginia
Department of Health
Division of Water Programs
Bureau of Water Supply Engineering

REGION: ☐ Abingdon ☐ Danville ☐ Richmond ☐ Local Health Dept.
☐ [redacted] ☐ Lexington ☐ Virginia Beach ☐

PLANNING DISTRICT#

SAMPLING LOCATION: R. Coates

COUNTY: King George

CODE: 0 0 4

INDEPENDENT CITY:

SOURCE TYPE: ☒ Public Community ☐ Public Noncommunity

FIELD TESTS: Temp: Cl2: mg/L CO2 mg/L

pH: Alk: mg/L Hard.: mg/L

P.W.S.I.D. #: 6 0 9 9 3 0 0

TRANSACTION CODE: 0 3

SEP 1989 RECEIVED Office of Water Supply Richmond

DATE COLLECTED: Mo 0 7 Day 1 0 Yr 8 9

TIME: 1 2 0 9

COLLECTED BY: C. Fox

CONTAINER TYPE: ☐ Glass ☒ Plastic

PRESERVATIVE USED: ☒ None ☐ Ice ☐ Other ☐ Nitric Acid

SAMPLE TYPE: D ☒ Reg Dist. P ☐ Plant Tap R ☐ Raw Water C ☐ Check M ☐ MCL Check S ☐ Other

CONT. I.D.	CONTAMINANT NAME (Maximum Allowable Level)	MTD.	S	ANALYSIS RESULTS	PRECISION	ANALYSIS DATE Mo Day Yr	A*
4000	Gross Alpha 15 pCi/L	419		ø ø 12 ø ø	± ø 12	7 17 89	SAD
4010	Combined Radium 5pCi/L	420		ø ø ø ø	± ø		
4020	Radium-226	421		ø ø ø ø	± ø		
4030	Radium-228	422		ø ø ø ø	± ø		
4100	Gross Beta 50 pCi/L	419		ø ø 27 ø ø	± ø 09	7 17 89	SAD
4006	Uranium			ø ø ø ø	± ø		
4102	Tritium				±		

LAB I.D. 0 0 0 9 5

DATE REC JUL 12 1989

DATE REP JUL 17 1989

PREPARED BY: S. Dugas KK

The results on this report are expressed in pCi/L unless otherwise indicated. *A = analyst's initials

LAB # 937057 JUL 12 89
1-6

NAME OF WATER SYSTEM: Ninde Store
SOURCE: Well
OTHER INFORMATION:

REPORT RESULTS TO HEALTH OFFICIAL
Name: Alpha Water Corporation
Address: P.O. Box 26943
City: Richmond, VA Zip Code: 23261

Water Quality Report

METALS

WSE 50

Commonwealth of Virginia
Department of Health
Division of Water Programs
Bureau of Water Supply Engineering

REGION: ☐ Abingdon ☐ Danville ☐ Richmond ☐ Local Health Dept.
☒ Culpeper ☐ Lexington ☐ Virginia Beach ☐

PLANNING DISTRICT#
COUNTY: King George
INDEPENDENT CITY:
SAMPLING LOCATION: R. Coates
CODE: 004 7-9
SOURCE TYPE: ☒ Public-Community ☐ Public-Noncommunity

FIELD TESTS: Temp: pH: Cl_2: mg/L Alk: mg/L CO_2: mg/L Hard.: mg/L

P.W.S.I.D. #: 609930 0 10-16
TRANSACTION CODE: 03 17-18

DATE COLLECTED: Mo 07 Day 10 Yr 89 19-24
TIME: 1210 25-28
COLLECTED BY: C. Fox
CONTAINER TYPE: ☐ Glass ☒ Plastic
PRESERVATIVE USED: ☐ None ☐ Ice ☐ Other ☒ Nitric Acid
SAMPLE TYPE: D ☒ Reg. Dist. P ☐ Plant Tap R ☐ Raw Water C ☐ Check M ☐ MCL Check S ☐ Other 29

CONT. I.D.	CONTAMINANT NAME (Maximum Allowable Level)		MTD.	S	ANALYSIS RESULTS	PRECISION ±	ANALYSIS DATE Mo Day Yr	A*
1005	Arsenic	0.05	125	<	0000.005	±		
1010	Barium	1.0	108		000.01	±		
1015	Cadmium	0.010	125	<	0000.002	±		
1020	Chromium	0.05	125		000.01	±		
1030	Lead	0.05	125	<	000.010	±		
1035	Mercury	0.002	106	<	000.0003	±		
1045	Selenium	0.01	125	<	000.005	±		
1050	Silver	0.05	125	<	000.002	±		
1002	Aluminum		108	<	0.01 00	±		
1016	Calcium		108		1.1 00	±		
1028	Iron	0.30	108		00.04 00	±		
1031	Magnesium		108		0.7 00	±		
1032	Manganese	0.05	108		00.01 00	±		
1051	Strontium		108		00.01 00	±		
1095	Zinc	5.0	108		0.14 00	±		
1022	Copper	1.0	108	<	00.01 00	±		
1042	Potassium		108		4.2 00	±		
1052	Sodium	20.	108		0.75.1 00	±		
1036	Nickel		108		000.01 00	±		
1007	Boron		108		000 00	±		
1919	Calcium Hardness		136		26 00 00	±		
1918	Magnesium Hardness		136		29 00 00	±		
1913	Ca & Mg Hardness		136		50 00 00			
1915	Total Hardness ***		136		60 00 00	±		
1004	Antimony		125	<	0.005	±		
						±		
	*** (Al, Ca, Fe, Mg, Mn, Sr, & Zn)					±		
30-33	LAB I.D. 00080 34-38		39-41	42	43-50	51-53	54-59	

DATE REC:
DATE REP: JUL 21 1989

PREPARED BY: Jim Anderson

The results on this report are expressed in mg/L unless otherwise indicated. *A = analyst's initials

LAB #: P 3 7 0 5 6 JUL 2 89
937056 1-6

Water Quality Report

NAME OF WATER SYSTEM: NINDE STORE
SOURCE: WELL
OTHER INFORMATION:

REPORT RESULTS TO HEALTH OFFICIAL:
Name: ALPHA WATER CORPORATION
Address: P.O. BOX 26943
City: RICHMOND, VA Zip Code: 23261

INORGANIC

WSE 50

Commonwealth of Virginia
Department of Health
Division of Water Programs
Bureau of Water Supply Engineering

REGION: ☐ Abingdon ☐ Danville ☐ Richmond ☐ Local Health Dept.
☒ Culpeper ☐ Lexington ☐ Virginia Beach ☐

PLANNING DISTRICT#
SAMPLING LOCATION: R. COATES
SOURCE TYPE: ☒ Public-Community ☐ Public-Noncommunity
COUNTY: KING GEORGE
CODE: 0 0 9 7-9
INDEPENDENT CITY:
FIELD TESTS: Temp: Cl_2: mg/L CO_2 mg/L
pH: Alk: mg/L Hard.: mg/L
P.W.S.I.D. #: 6 0 9 9 3 0 0 10-16
TRANSACTION CODE: 0 3 17-18

DATE COLLECTED: Mo 07 Day 10 Yr 89 19-24
TIME: 1208 25-28
COLLECTED BY: C. FOY
CONTAINER TYPE: ☐ Glass ☒ Plastic
PRESERVATIVE USED: ☒ None ☐ Ice ☐ Other ☐ Nitric Acid
SAMPLE TYPE: D ☒ Reg. Dist. P ☐ Plant Tap R ☐ Raw Water C ☐ Check M ☐ MCL Check S ☐ Other 29

CONT. I.D.	CONTAMINANT NAME (Maximum Allowable Level)	MTD.	S	ANALYSIS RESULTS	PRECISION	ANALYSIS DATE Mo Day Yr	A*
1925	pH (6.5-8.5)	135		0008140000	±	07 12 89	RTR
1927	Alkalinity Total	157		0015300000	±	.. .. ..	..
1928	Alkalinity Bicarbonate	157		0013240000	±	.. .. ..	..
1929	Alkalinity Carbonate	157		0002140000	±	.. .. ..	..
1915	Hardness EDTA	141		0040000000	±	07 13 89	JBM
1932	Acidity	157		0000000000	±		
1910	Corrosion Index	136		0001093000	±		
1025	Fluoride 1.8	107		0000062000	±	07 12 89	JRG
1017	Chloride 250.	107		0000160000	±	07 16 89	RDP
1905	Color (APHA) 15 CU	129		0000500000	±	07 14 89	LR
0100	Turbidity (FTU) 1.0	001		0000020000	±	07 12 89	DJI
1027	Hydrogen Sulfide 0.05	155	<	0000000200	±	07 12 89	DJI
1055	Sulfate 250.	137		0000138000	±	07 16 89	RDP
1040	Nitrogen-Nitrate 10.0	163	<	0000000100	±	07 16 89	RDP
1039	Nitrogen-Ammonia	147		0000000300	±	07 12 89	RTR
1038	Nitrogen-Nitrite	163	<	0000000100	±	07 13 89	JRG
1041	Nitrogen-Total Kjeldahl	175		0000000000	±		
1043	Phosphate-Total (As P)	162		0000059000	±	07 16 89	RDP
1044	Phosphate-Ortho (As P)	162		0000059000	±	07 16 89	RDP
1926	Specific Conductance (umhos/cm)	145		0003201000	±	07 13 89	RTR
1930	Total Dissolved Solids (185°C)	139		0002810000	±	07 13 89	SMZ
1058	Volatile (550°C)	139		0000390000	±	/ / /	/
1059	Fixed (550°C)	139		0002420000	±	/ / /	/
1049	Silica (as SiO_2)	143		0003224000	±	07 13 89	LR
1997	Langlier Index @ 20°C	136	—	0000100202	±		
	Ca Hardness			0040	±	07 14 89	JBM
	Bromide		<	0001	±	07 16 89	RDP
30-33	LAB I.D. 0 0 0 8 0 34-38	39-41	42	43-50	51-53	54-59	

DATE REC: JUL 12 1989
DATE REP: AUG 25 1989

PREPARED BY: Robert D. Potts

The results on this report are expressed in mg/L unless otherwise indicated. *A = analyst's initials

APPENDIX F

WRITTEN COMMENTS RECEIVED FROM THE COUNCIL ON THE ENVIRONMENT (AUGUST 20, 1991).

COMMONWEALTH of VIRGINIA

Council on the Environment

KEITH J. BUTTLEMAN
ADMINISTRATOR

903 NINTH STREET OFFICE BUILDING
RICHMOND 23219
804-786-4500

GENERAL COMMENTS ON THE KING GEORGE EXPLORATORY WELL DRILLING PROPOSAL (Generally applicable to Westmoreland Well)

Cross-referencing (ER § 5)*

5.C - Some of the information required by the EIA regulation is contained in either the project EIA or the permit application; however, the information is inadequately cross-referenced.

Description of Operations (ER § 6)

Lack of Detail in following areas:

6.A* - description of proposed operations and facilities.

6.B.2 - site plats of the proposed operations area were in the permit application but not the EIA; maps were generally not of the quality necessary to promote effective environmental review.

6.C.3* - fluid circulation systems including fluid toxicity; amount and rate of fluid production.

6.C.4 - blow-out prevention and containment; a single ram-annular system. Why was this system chosen over other, more conservative BOP systems?

6.C.6* - waste fluids; projected types, quantities, and chemical characteristics.

6.C.7* - solid wastes; projected types, quantities, and chemical characteristics.

6.C.8* - proposed solid and liquid waste management procedures including proposed disposal areas and methods are much too general.

6.C.11* - volume of water needed and how it will be used in operations.

6.C.12* - local soil and water conservation district staff have identified problems with the proposed E & S and stormwater management plans.

6.D.1* - vegetation clearing, area and type.

6.D.5 - location of associated facilities.

Description of the Environment (ER § 7)

7.A.1.c - There was inadequate discussion of the impact of disturbance on intermittent streams both in terms of the quality and quantity of water flow into the intermittent streams.

7.A.1.f* - There was insufficient detail related to site specific aspects of groundwater including how it may be affected by operations (especially in regard to on-site waste management options or casing failure), how it is used as private or public water supply, and existing on-site water quality.

7.A.1.g* - Inadequate soils information such as profile descriptions, permeability, erodibility, prime agricultural lands.

7.A.1.h* - No discussion of public water supplies in the vicinity of the proposed operation or of private or public water wells within one-mile of the operation.

7.A.1.i* - No discussion of Chesapeake Bay Preservation Areas.

7.A.2.b and c - Concern over the general nature of the information provided on terrestrial and aquatic habitat and the lack of site-specific information on habitat and species.

7.B* - Noise; inadequate discussion on noise levels at receptors and mitigation measures proposed.

7.C* - Lighting; inadequate discussion of lighting levels, sources, impacts, mitigation.

Discharge probability (ER § 8)*

There is no analysis of the probability for an accidental discharge of oil, condensate, natural gas or waste fluids to occur. There is no analysis of the probability of a small, moderate or major spill event. The EIA and permit application assert in the most general narrative language that primary and secondary containment systems will be adequate and more will be done if needed if there is a spill.

Discharge Consequences (ER § 9)

The EIA addresses the potential consequences of an oil, gas, condensate, or waste releases to the environment in only the most general sense.

Contingency Planning (ER § 10)*

The EIA includes only the most general discussion on contingency planning. The permit application contains a more detailed contingency plan. Neither the EIA or permit application address concerns related to accidental gas or condensate releases. Why was the SPCC plan unsigned?

Economic Impacts (ER § 12)

12.B.4 - No discussion of the existing land use or what modifications in local zoning ordinances will have to occur in order to permit the proposed land use.

Fiscal Impacts (ER § 13)

13.A - No discussion of local fiscal characteristics and how they may be affected by the proposed operations.

13.B.1* - No discussion of the potential transportation impacts of the proposed operations such as the number of vehicle trips, size of support vehicles, design capacity of roads relative to equipment weight, etc.

13.B.2 - No discussion of infrastructure and capital facility support systems such as solid or liquid waste disposal services.

13.B.3 - Better discussion of public safety and health services, necessary to respond to an emergency situation.

RESOURCE PROTECTION AREA DELINEATION REPORT

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Lease Tract

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1. INTRODUCTION

1.1 Purpose of Study

The King George County Board of Supervisors has amended the zoning ordinance by adding Article 8, "The Chesapeake Bay Preservation Area Overlay District of King George County." The intent of the ordinance is to assure protection of the quality of water in the Chesapeake Bay. To that end, Resource Protection Areas (RPAs) and Resource Management Areas (RMAs) have been established. Resource Protection Areas (RPAs) are defined as:

a. Tidal wetlands

b. Nontidal wetlands connected by surface flow and contiguous to tidal wetlands or tributary streams

c. Tidal shores

d. A 100-foot vegetated buffer area located adjacent to and landward of the components listed in subsections a. through c. above, and along both sides of and tributary stream (any perennial stream).

In the Commonwealth of Virginia, wetlands are also regulated by the federal government. At the Federal level, the U.S. Army Corps of Engineers (COE), in accordance with Section 404 of the Clean Water Act, regulates the filling of "Waters of the United States"; this includes streams, lakes, impoundments, intermittent drainageways and associated wetlands.

The COE defines wetlands as :

> " Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."

At the request of King George County, Texaco agreed to map all RPAs located throughout a 134 acre tract located in the vicinity of Ninde, Virginia. The parcel is currently under lease to Texaco and is being considered for exploratory drilling. The boundaries of these areas were marked by a series of alphanumerically numbered survey flags and were subsequently surveyed. The Resource Protection Areas (RPAs) were identified and delineated in accordance with the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (FICWD, 1989). In

accordance with this manual, a thorough investigation of vegetation, soil, and hydrology of the entire lease tract was initiated. The study, conducted on August 22-23, 1991, described and delineated RPAs under County jurisdiction as well as those under COE jurisdiction.

1.2 Site Description

The 134 acre lease tract is located in the vicinity of Ninde, Virginia. The tract is bordered to the south by Route 205, and is approximately 4.3 miles east of the intersection of Route 205 and Route 301. The northern portion of the site is bordered by the Upper Machodoc Creek (Figure 1). Surface drainage on the site consists of six headwater and intermittent channels that flow northward to the Upper Machodoc Creek. The Upper Machodoc Creek then flows eastward to the Potomac River (Figure 2).

The tract consisted of five major plant assemblages, namely: agricultural field, successional field, second growth forest, and tidal marshes. Also present on the site were a residence, outbuildings, a small marina, and several gravel roads.

2. METHODS

The delineation procedure presented in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (FICWD, 1989), involves a thorough investigation of vegetation, soil and hydrology. Based on this approach, an area is defined as a wetland if it exhibits, under normal circumstances, all of the following characteristics:

1. The land supports a dominance of hydrophytic vegetation.
2. The substrate is hydric soil.
3. The soil/substrate is at least periodically saturated or inundated during a significant portion of growing season.

A hydrophyte is any plant that has the ability to grow in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content and depleted soil oxygen levels. The U.S. Fish and Wildlife Service (USFWS) has prepared a list of wetland plant species for the Northeast Region, Region I (USFWS, 1988). The plant species listed in this publication are classified based on their affinity for wetlands. The wetland indicator classification assigned to each species is listed as follows:

Plant Affinity for Water Condition

Classification	Percent Occurrence in Wetlands
Obligate (OBL)	>99
Facultative Wetland (FACW)	67-99
Facultative (FAC)	34-66
Facultative Upland (FACU)	1-33
Non-wetland (UPL)	<1

A positive (+) or negative (-) symbol used in conjunction with one of the facultative indicator classes relates to a species preference to either the drier or wetter end of its indicator class. The positive sign indicates a preference to the wetter end. This wetland indicator classification was used for plant species found at the site. A designation of NI (no indicator) was indicated in the regional list for those species for those species for which insufficient information was available to assign an indicator class. A designation of NL was assigned if a species was not present in the list. Plants not listed are presumed to be upland species (FICWD, 1989).

Hydric soils are very poorly drained, poorly drained, or somewhat poorly drained soils that have the seasonal high water table within 6 inches of the surface (FICWD, 1989). Typically these soils are predominantly gray and mottled immediately below the "A" horizon and have thick, dark colored surface layers.

Prior to initiation of field work, a thorough review of existing resources such as the USFWS National Wetland Inventory (NWI), the county soil survey report, King George County Tidal Marsh Inventory and site plans depicting topography was conducted. The wetland investigation conducted involved the establishment of representative sampling points along the wetland line and at representative locations within each plant assemblage on the site. At each sampling point, data regarding the vegetation, soil and hydrology of the area were collected. The data collected provided the information required to determine whether the area met the definition of a wetland. To accurately describe the vegetation at each sampling point, data on each horizontal strata or layer, i.e., canopy, shrub and herb was collected. The dominant canopy species were determined by measuring the diameter at breast height (dbh) of each tree with a dbh greater than 4 inches within a 20-30 foot radius of the sampling point. The basal area of each individual was then determined. The dominant species were expressed as a percentage of total basal area. The number of saplings and small trees within a 20 foot radius of the sampling point was tallied. The dominant shrub species were determined along a belt transect. The transect consisted of a series of 3 foot by 6 foot quadrats with the sampling point being the center of the transect.

The cover of the shrubs within each quadrat was visually determined and assigned one of the following cover classes: T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0). The midpoints of each cover class are in parenthesis. Vines, when present, were evaluated in a similar manner. The midpoints of each species were averaged by quadrat and ranked. Those species of the herb layer were identified by visually determining the cover class of all herb species and seedlings (tree species less than 3 feet high) in two foot by six foot quadrats. The dominant species were determined as described for the shrub layer. A USFWS wetland indicator was assigned to each species recorded. The affinity of the dominant species to wetlands was used in the determination of the wetland status of each sample point.

At each sampling point, a detailed soil description was obtained from an auger boring. A Munsell soil color book was used to determine soil color. Each boring was taken to a depth of at least two feet. Areas that were not RPAs but under COE jurisdiction (i.e., impoundments and intermittent drainageways), were also delineated.

3. RESULTS AND DISCUSSION

3.1 VEGETATION

3.1.1 USFWS National Wetland Inventory Review

According to the USFWS National Wetland Inventory (NWI) Map, Dahlgren Quadrangle, four wetland types are present on the site (Figure 3). Three types of tidal marsh are present in the northern portion of the site and are associated with the Upper Machodoc Creek. The tidal marsh types indicated are (E2EMP6) Estuarine Intertidal Emergent Irregularly flooded Broad leaved persistent marsh; (E2FLN6) Estuarine Intertidal Regularly flooded non-pioneer vegetated flat; and (E1OWL6) Estuarine Subtidal Intermittently exposed Open Water Marsh. The remaining wetlands are (PFO1A) Palustrine Forested Broad leaved Deciduous Temporarily inundated wetlands. These wetlands are associated with the intermittent tributaries on the lease tract.

3.1.2 King George County Tidal Marsh Inventory Review

Review of the King George County Tidal Marsh Inventory (KGCTMI) (Figure 4) indicates tidal marsh areas in the northern portion of the site associated with the Upper Machodoc Creek. The KGCTMI map concurs with the USFWS NWI map with regard to tidal marsh location. The marshes are numbered 26, 27, 28, 29, and 30 on the KGCTMI map.

3.1.3 Results of Field Investigation: Vegetation

The vegetation of the lease tract can be grouped into 5 distinct classes, pasture, upland forest, riparian forest, scrub/shrub wetland and emergent wetland. Of these classes, pasture occupies approximately 35% of the site.

The northern portion of the lease tract possessed extensive areas of wetland. The northernmost wetlands were characteristic of tidally influenced emergent wetlands in the region. These areas were dominated by narrow leaved cattail (*Typha angustifolia,* OBL) and wild rice (*Zizania aquatica*, OBL). Other species frequently encountered were swamp rose mallow (*Hibiscus moscheutus,* OBL), rice cut grass (*Leersia oryzoides,* OBL), halberd leaved tearthumb (*Polygonum arifolium*, OBL) and arrowhead (*Sagitaria latifolia,* OBL). The portion of this emergent wetland system that

apparently has less tidal influence was marked by a distinct change in species composition. These areas possessed a rich flora composed of rice cut grass, wild rice, OBL, lizard tail (*Saururus cernuus,* OBL), climbing hempweed (*Mikania scandens,* FACW+), boneset (*Eupatorium perfoliatum,* FACW+), New York ironweed (*Veronia novaberacensis,* FACW+), jewelweed (Impatiens capensis, FACW), cardinal flower *Lobelia cardinalis,* FACW+), false nettle (*Boehmeria cylindrica,* FACW+). Common reed (*Phragmites australis,* FACW) was also present in the emergent wetland downgradient of the pond in the watercourse traversing the central portion of the site.

The watercourse draining the central portion of the lease tract possessed two recently created man-made ponds. The vegetation in the upper pond was dead or dying due to the creation of an environment of permanent inundation. A forested wetland with an open understory was located between the two ponds. The canopy of this wetland was dominated by red maple (*Acer rubrum,* FAC). Black-gum *Nyssa sylvatica,* FAC) was also present in the canopy. The herb layer was composed of monkey flower (*Mimulus ringens,* OBL), boneset, soft rush (*Juncusteffusus,* FACW), seedbox (*Ludwigia alternifolia,* FACW+) and water pepper (*Polygonum hydropiper,* OBL).

The area delineated above the southernmost pond was an intermittent stream and was delineated as being "waters of the United States" and not a RPA. The channel of the stream was deeply incised, often 5-6 feet from channel bottom to top of bank. Although the channel was moist, due to seepage, no flow was observed in the channel. The upper portion of the drainage proximate to the eastern property boundary was also delineated as an intermittent stream.

The composition of the riparian vegetation associated with these intermittant drainage channels depended on the steepness of the slope bordering the stream. Common canopy species included sycamore (*Platanus occidentalis,* FACW-), American beech (*Fagus grandifolia,* FACU), black walnut (*Juglans nigra,* FACU), sweet gum (*Liqunidambar styraciflua,* FAC) and American holly (*Ilex opaca,* FACU). The shrub layer was typically dominated by Mountain laurel (*Kalmia latifolia,* FACU). The herb layer was usually sparse, however, marginal wood fern (*Dyropteris marginalis,* FACU-), ebony spleenwort (*Asplenium platyneuron,* FACU), Japanese honeysuckle (*Lonicera japonica,* FAC), Virginia creeper (*Pathenocissus quinquefolia,* FACU), and Christmas fern (*Polystichium acrostichoides,* FACU-) were frequently encountered.

Upland forests on site were, for the most part, dominated by oaks, including white oak (*Quercus alba,* FACU), scarlet oak (*Quercus coccinea,* NL) and turkey oak (*Quercus falcata,* FACU-). Other oaks identified on site were red oak (*Quercus rubra,* FACU-), black oak (*Quercus velutina,* NL), and post oak (*Quercus stellata,* NL). Other tree species found in the oak dominated forests were pitch pine (*Pinus rigida,* FACU), Virginia pine (*Pinus virginiana,* NL), sassafras, tulip poplar and American beech. The understory was dominated by Mountain Laurel (*Kalmia latifolia,* FACU). Other species identified in the shrub layer were lowbush blueberry (*Vaccinium vacillans,* NL), huckleberry (*Gaylusaccia sp.*) and Eastern chinquinpin *(Castanea pumila,* NL). The transition between upland forest and wetlands was often marked by the presence of greenbriar (*Similax rotundifolia,* FAC). The ecotone between upland forest and pasture typically contained a variety of ruderal species such as blackberry *(Rubus allegheniensis,* FACU), pokeweed (*Phytolacca americana,* FACU) and winged sumac (*Rhus copallinum,* NL).

3.2 Soils

3.2.1 Stafford and King Counties Soil Survey Descriptions

The soil survey of Stafford and King George Counties indicate ten different mapping units for the site. The site is covered by atlas sheets No. 47 and 53 in the soil survey, a portion of which is reproduced in this report (Figure 4). The soil mapping units indicated for the site are (Ae) Alluvial land, wet; (BmB) Bourne Fine sandy loam, 2 to 6 percent slopes; (GsD) Galestown-Sassafras Complex, 6 to 15 percent slopes; (GsE) Galestown-Sassafras Complex, 15 to 30 percent slopes; (Po) Pooler loam, thin solum variant; (SFB) Sassafras Fine Sandy loam, 2 to 6 percent slopes; (SFC2) Sassafras Fine Sandy loam, 6 to 10 percent slopes; (TeC2) Tetotum Fine Sandy loam, 6 to 10 percent slopes, eroded; and (Tm) Tidal Marsh. The description of each soil mapping unit on site is provided below.

(Ae) Alluvial land, wet

This mapping unit consists of nearly level to gently sloping, long and narrow areas of local alluvium deposited along drainageways. The characteristics of this soil are quite variable. Typically, the surface ranges from loamy sand to sandy loam and loam. The color of the surface layer is variable. The subsurface soil is gray and gleyed with mottles of strong brown, yellowish-brown, pale brown, and yellowish-red. These areas are subject to frequent flooding from adjacent drainageways and streams.

(BmB) Bourne Fine Sandy loam, 2 to 6 percent slopes

Bourne soils are moderately well drained soils formed in loamy coastal plain sediments. These soils have a moderate to strong fragipan at a depth of about 18 to 24 inches. The surface layer of the Bourne soils are dark brown fine sandy loam. The upper subsoil is a yellowish-brown heavy sand clay loam. The middle portion of the subsoil contains a fragipan layer of pale-brown fine sandy loam that is mottled with yellowish-brown and yellowish red. The fragipan layer is firm, brittle, and compact. The lower subsoil is a yellowish-brown heavy sandy clay loam that is mottled with yellowish red and red.

(GsD) Galestown-Sassafras Complex, 6 to 15 percent slopes

This mapping unit consists of about 45 percent Galestown soils, 30 percent Sassafras soils, and the remaining 25 percent of associated soils. Galestown and Sassafras soils have the profiles representative of their respective series. The Galestown soils are deep, somewhat excessively drained, sloping to steep soils formed in sandy coastal plain sediments. The surface layer consists of loamy fine sand that is very dark grayish grown and brown. The subsoil consists of strong brown and yellowish-brown loamy fine sand. The Sassafras soils are deep, well drained, level to steep soils, formed in sandy and loamy coastal plain sediment. the surface layer of the Sassafras soils is a dark brown, fine sandy loam. the upper subsoil is a brown, fine sandy loam, the middle portion of the subsoil is a brown sandy clay loam, the lower subsoil is strong-brown loamy fine sand.

(GSE) Galestown-Sassafras Complex, 15 to 30 percent slopes

The soils in this complex are located along drainageways. Galestown soils compose 40 percent of the complex, Sassafras about 30 percent, and the remaining portion consists of other associated soils. The Galestown and Sassafras soils are the same as those described previously.

(Po) Pooler loam, thin solum variant

The Pooler soils consist of deep, somewhat poorly drained soils formed in loamy and clayey coastal plain sediments. The soil surface layer is dark grayish-brown loam. The upper subsoil consists of light olive-brown, heavy clay loam, the middle subsoil is grayish-brown , heavy clay loam that

is mottled with gray and yellowish brown. The lower subsoil if dark gray clay that is mottled with strong brown.

(SFB) Sassafras Fine Sandy loam, 6 to 10 percent slope

Sassafras soils are deep, well drained, nearly level to steep soils formed in sandy and loamy coastal plain sediment. The surface layer is dark brown fine sandy loam. The upper subsoil is brown, fine sandy loam. The middle portion of the subsoil is brown, sandy clay loam. The lower subsoil is strong-brown loamy fine sand.

(SFC2) Sassafras Fine Sandy loam, 6 to 10 percent slopes, eroded

This soil is located on the sides of narrow ridges. The surface layer is commonly 5 to 7 inches thick, compared to the 9 inch thick layer in the non-eroded Sassafras soils. The characteristics of this Sassafras soil are similar to those described previously.

(TeB) Tetotum fine sandy loam, 2 to 6 percent slopes

The Tetotum soils consist of deep, moderately well drained soils formed in loamy, coastal plain sediments. The surface layer is dark grayish-brown fine sandy loam. The upper sub-soil is dark yellowish-brown sandy clay loam, below this is yellowish-brown clay loam followed by yellowish-brown clay loam that is mottled with yellowish-brown, gray, and red. The lower portion of the sub-soil consists of a gray sandy lay loam that is mottled with yellowish-brown and strong brown.

(TeC2) Tetotum Fine sandy loam, 6 to 10 percent eroded slopes

This Tetotum soil is similar to the one described previously with the exception of the surface layer thickness. The surface of the eroded phase is commonly 5 to 7 inches, rather than the 9 inches of the non-eroded phase.

(Tm) Tidal marsh

Tidal marsh consists of broad, low areas of mixed alluvium that are covered periodically by tidal waters. Tidal marsh is commonly moderately coarse to medium textured, and composed of various combinations and layers of sandy,

loamy, clayey, and mucky materials. The surface layer is commonly gray or dark-gray muck. The subsurface layers are strongly gleyed and are grey, greenish gray, or bluish gray.

3.2.2 Results of Field Investigation: Soils

The site investigation revealed the upland portions of the property to be characterized by sandy soils derived from coastal plain sediments. The upland portions of the lease tract were typically characterized by brown to grayish brown sandy loam surface soils overlying yellowish brown sandy loam to sandy clay loam textured subsoils. In many areas these soils had an overlying root mat usually an inch or so thick.

The poorly drained soils within the wetland areas generally consisted of a thick dark gray to black silty loam textured surface soil. The subsoil within these areas was generally a heavy textured sandy loam to sandy clay loam soil. The soil color in these areas ranged from black to gray. In many portions of this area, the soils were saturated to the surface and possessed the hydrogen sulfide odor typical of anaerobic conditions.

The transition form the wetland soils to the upland soils occurred over a rather short distance. The width of the transition zone ranged from one to six feet across the site. Typically, the transition was abrupt and dictated by the rapid changes in site topography. The subsoil within the transition zone area was marked by a yellowish brown color with varying degrees of mottling.

The occurrence of hydric soils across the site correspond rather closely with the mapping of tidal marsh and the intermittent drainageways on site by the soils conservation service. For detailed soils information for the site, refer to Appendix II, sampling location results.

3.3 Hydrology

The site is located within the Upper Machodoc Creek watershed. The Upper Machodoc Creek which forms the northern property boundary is a tributary to the Potomac River. The site is drained by two intermittent tributaries that drain directly to the Upper Machodoc Creek. One tributary is located in the central portion of the property. This tributary begins north of the proposed drill site. This tributary has two branches which are perpendicular to the tributary that flow in a westerly direction. The second tributary begins east of the drill site and drains in a northward direction. Several intermittent branches to this tributary existed in its

upper reaches. The upper reaches of these tributaries are characterized by well incised banks with steep slopes.

The natural drainage of the central tributary has been subject to alteration as the result of grading associated with preliminary development activities. The outflow from this tributary has been slowed by earthen embankments and culverts which have resulted in the creation of two artificial ponds. Although these streams were delineated, since they are not perennial or wetlands, they are not RPA. The areas are, however, regulated by the COE.

The incised channels of these tributaries gradually broaden to the north and the drainage is spread through broad flats. These areas possessed soils that were saturated to near the surface. The distinct odor of hydrogen sulfide indicates that these soils were saturated for long durations. The wetlands bordering the creek were tidally influenced. During the site visits tidal amplitude appeared to be approximately 14 inches.

4. CONCLUSIONS

The field investigation revealed that Resource Protection Areas were limited to the northern half of the site. These areas were, however, more extensive than indicated on the Chesapeake Bay map. Most of the northernmost wetlands were tidally influenced emergent wetlands. Except for a relatively small stretch of shoreline cleared for water access uplands bordering the tidal wetlands consisted of upland forest.

Non-tidal emergent wetlands were located in the southern portion of each of the two streams that drain the sites. Scattered pockets of scrub/shrub and forested wetland also existed in the lower half of each drainage. The upper reaches of both drainages were intermittent streams. Although delineated as part of this study, they were delineated as being under the jurisdiction of the COE and not RPAs. The westernmost of the two drainages had two recently created ponds.

The drill site is located approximately 1200 feet upgradient of the nearest RPA to which this portion of the site drains.

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APPENDIX I

PLANT SPECIES LIST

APPENDIX I

LIST OF PLANT SPECIES

The following is a list of species and habitats in which they characteristically occur at the Texaco-King George County, Virginia Site. The USFWS wetland indicator classification of each species is provided. Nomenclature follows USFWS 1986).

Species Name	Scientific	Common	USFWS Classification	Habitat
Osmundaceae	Osmunda cinnamonea	Cinnamon fern	FAC	Wetland
	Osmunda regalis	Royal fern	OBL	Wetland
Polypodiaceae	Pteridium aquilinum	Bracken fern	FACU	Upland
	Onoclea sensiblis	Sensitive fern	FACW	Wetland
	Polystichium acrostichoides	Chritmas fern	FACU-	Upland
	Woodwardia areolata	Netted chain fern	FACW+	Wetland
	Dryopteris marginalis	Woodfern	FACU-	Upland
	Asplenium platyneuron	Ebony spleenwort	FACU	Upland
Pinaceae	Pinus rigida	Pitch pine	FACU	Upland/Wetland
	Pinus virginiana	Virginia pine	NL	Upland
Cupressaceae	Juniperus virginiana	Red cedar	FACU	Upland
Typhaceae	Typha angustifolia	N.lvd. cattail	OBL	Wetland
Alismataceae	Alisma plantago-aquatica	Water plantain	OBL	Wetland
	Sagittaria latifolia	Arrowhead	OBL	Wetland
Graminae	Agrostis alba	Red-top	FACW	Upland
	Avena sativa	Oats	NL	Upland
	Digitaria sanguinalis	Crabgrass	FACU-	Upland
	Echinochloa crusgalli	Barnyard grass	FACU	Wetland
	Leersia oryzoides	Rice cut grass	OBL	Wetland
	Phragmites australis	Common reed	FACW	Upland/Wetland
	Setaria italica	Foxtail	FACU	Upland
	Andropogon scoparius	Little bluestem	FACU	Upland
	Panicum sp.	Panic grass	---	Upland
	Panicum virgatum	Switch grass	FAC	Upland
	Zizania aquatica	Wild rice	OBL	Wetland
	Eleusine indica	Goose grass	FACU	Upland
	Eragrostis sp.	Love grass	___	Upland
	Spartina cynosuroides	Cordgrass	OBL	Wetland

Species Name	Scientific	Common	USFWS Classification	Habitat
Cyperaceae	Cyperus ovularis	Globose sedge	FACU	Upland
	Cyperus esculentus	Yellow nutsedge	FACW	Upland/Wetland
	Carex sp.	Sedge	----	Wetland
	Scirpus cyperinus	Wool grass	FACW+	Wetland
	Scirpus americanus	Three square	OBL	Wetland
	Scirpus validus	Bulrush	OBL	Wetland
Araceae	Arisaema triphyllum	Jack-in-the-pulpit	FACW-	Wetland/Upland
	Symplocarpus foetidus	Skunk cabbage	OBL	Wetland
Commelinaceae	Commelina communis	Asiatic dayflower	FAC	Wetland
Pontedariaceae	Pontedaria cordata	Pickerel weed	OBL	Wetland
Juncaceae	Juncus effusus	Soft rush	FACW+	Wetland
	Juncus tennis	Pathrush	FAC-	Upland
Liliaceae	Smilax glauca	Catbriar	FACU	Wetland/Upland
	Smilax rotundifolia	Greenbriar	FAC	Wetland/Upland
Sauruaraceae	Saururus cernuus	Lizard's Tail	OBL	Wetland
Salicaceae	Salix nigra	Black willow	FACW+	Wetland
Myricaceae	Myrica pensylvanica	Bayberry	FAC	Upland
Juglanaceae	Juglans nigra	Black walnut	FACU	Upland
	Carya glabra	Pignut hickory	FACU	Upland
	Carya cordiformis	Bitternut hickory	FACU+	Upland
Betulaceae	Betula populifolia	Gray birch	FAC	Upland
	Betula nigra	River birch	FACW	Wetland
	Alnus sp.	Alder	—	Wetland
Fagaceae	Castanea pumila	E. Chinquipin	NL	Upland
	Fagus grandifolia	Am. Beech	FACU	Upland
	Quercus alba	White oak	FACU	Upland
	Quercus falcata	Turkey oak	FACU-	Upland
	Quercus prinus	Chestnut oak	NL	Upland
	Quercus coccinea	Scarlet oak	NL	Upland
	Quercus stellata	Post oak	NL	Upland
	Quercus velutina	Black oak	NL	Upland
	Quercus rubra	Red oak	FACU-	Upland
	Quercus phellos	Willow oak	FAC+	Upland/wetland

Species Name	Scientific	Common	USFWS Classification	Habitat
Ulmaceae	Celtis occidentalis	Hackberry	FACU	Upland
Moraceae	Morus rubra	Mulberry	FACU	Upland
Urticaceae	Plea pumila	Clearweed	FACW	Wetland
	Boehmeria cylindrica	False nettle	FACW+	Wetland
Polygonaceae	Polygonum arifolium	Tearthumb	OBL	Wetland
	Polygonum hydropiper	Marsh pepper	OBL	Wetland
	Polygonum pensylvanicum	PA Smartweed	FACW	Wetland
	Polygonum scandens	Tearthumb	OBL	Wetland
	Rumex crispus	Curled dock	FACU	Upland
Phytolaccaceae	Phytolacca americana	Pokeweed	FACU+	Upland
Magnoliaceae	Liriodendron tulipifera	Tulip poplar	FACU	Upland
Lauraceae	Sassafras albidum	Sassafras	FACU-	Upland
	Lindera benzoin	Spicebush	FACW-	Wetland
Rosaceae	Prunus serotina	Black cherry	FACU	Upland
	Rosa multiflora	Multiflora rose	FACU	Upland
	Rosa palustris	Swamp rose	OBL	Wetland
	Fragaria virginiana	Strawberry	FACU	Upland
	Potentilla sp.	Cinquefoil	---	Upland
	Rubus flagellaris	Dewberry	NL	Upland
	Rubus allegheniensis	Blackberry	FACU	Upland
Hamamelidaceae	Liquidambar Styraciflua	Sweet gum	FAC	Upland/Wetland
Platanaceae	Platanus occidentalis	Sycamore	FACW-	Upland
Fabaceae	Trifolium pratense	Red clover	FACU-	Upland
	Trifolium repens	White clover	FACU-	Upland
	Lespedeza sp.	Bush clover	---	---
	Lotus corniculatus	Bird's foot trefoil	FACU-	Upland
Simarubaceae	Ailanthus altissima	Tree-of-heaven	NI	Upland

Species Name	Scientific	Common	USFWS Classification	Habitat
Anacardiaceae	Toxicodendron radicans	Poison ivy	FAC	Upland
	Rhus typhina	Staghorn sumac	NL	Upland
	Rhus copallinum	Winged sumac	NL	Upland
Aquifoliaceae	Ilex opaca	American holly	FACU+	Wetland
	Iler verticillata	Winterberry	FACW+	Wetland
Aceraceae	Acer rubrum	Red maple	FAC	Wetland
	Acer saccharinum	Silver maple		
Balsaminaceae	Impatiens capensis	Jewelweed	FACW	Wetland
Vitaceae	Vitis sp.	Grape	---	Upland
	Parthenocissus quinquefolia	VA creeper	FACU	Upland
Malvaceae	Hibiscus mascheutos	Rose mallow	OBL	Wetland
	Kosteletzkya virginica	Seashore mallow	OBL	Wetland
Melastomaceae	Rhexia virginica	VA Meadow beauty	OBL	Wetland
Onagraceae	Circaea quadrisulata	Enchanters nightshade	NL	Upland
	Oenothera biennis	Evening Primrose	FACU-	Upland
Araliaceae	Aralia spinosa	Hercules club	FAC	Upland
Umbelliferae	Daucus carota	Wild carrot	NL	Upland
Cornaceae	Nyssa sylvatica	Black gum	FAC	Wetland
	Cornus florida	Flwring dogwood	FACU-	Upland
Ericaceae	Vaccinium corymbosum	Highbush blueberry	FACW	Wetland
	Vaccinium vacillans	Lowbush blueberry	NL	Upland
	Gaylussacia baccata	Huckleberry	FACU	Upland
	Kalmia latifolia	Mt. Laurel	FACU	Upland
	Chimaphila maculata	Spotted wintergreen	NL	Upland
Ebenaceae	Diospyros virginiana	Persimmon	FAC-	Upland

Species Name	Scientific	Common	USFWS Classification	Habitat
Apocynanaceae	Apocynum sp.	Dogbane	---	Upland
Convolvulaceae	Ipomoea hederacea	Morning glory	NI	Upland
Verbenaceae	Verbena hastata	Common vervain	FACU+	Wetland
Labiatae	Monarda punctuta	Horse mint	NL	Upland
Solanaceae	Solanum carolinensis	Horse nettle	NL	Upland
	Datura stramonium	Jimsonweed	NL	Upland
Scrophulariaceae	Mimulus ringens	Monkey flower	OBL	Wetland
	Paulownia tomentosa	Princess tree	NL	Upland
	Verbascum blattaria	Moth mullein	NL	Upland
Plantaginaceae	Plantago lanceolata	English plantain	NL	Upland
	Plantago major	Common plantain	FACU	Upland
Rubiaceae	Mitchella repens	Partridgeberry	FACU	Upland
Caprifoliaceae	Viburnum dentatum	Arrowwood	FAC	Wetland
	Lonicera japonica	Honeysuckle	FAC-	Upland
Cucurbitaceae	Cuscuta sp.	Dodder	---	Wetland
Lobeliaceae	Lobelia cardinalis	Cardinal flower	FACW+	
Asteraceae	Eupatorium rotundifolium	Thoroughwort	FAC-	Upland
	Eupatorium hyssopifolium	Thoroughwort	NL	Upland
	Eupatorium perfoliatum	Boneset	FACW+	Wetland
	Eupatorium coelestinum	Mistflower	NL	Upland
	Taraxacum officineale	Dandelion	FACU-	Upland
	Hieracium sp.	Hawkweed	---	Upland
	Achillea millefolium	Yarrow	FACU	Upland
	Ambrosia artemisifolia	Ragweed	FACU	Upland
	Veronia novaboracensis	NY ironweed	FACW+	Wetland
	Solidago sp.	Goldenrod	---	Upland
	Mikania scandens	Climbing hempweed	FACW+	Wetland

APPENDIX II

SAMPLING LOCATION RESULTS

Sample Point 1

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

Sampling Point Location: Upslope of wetland point A-48
Landscape Position: Top of narrow divide

1.0 VEGETATION

1.1 Plant Assemblage: Upland forest
1.2 Dominant Plant Species:

	SPECIES	INDICATOR STATUS
CANOPY LAYER	Scarlet Oak Chestnut oak	NL NL
SAPLINGS (total # in parentheses)	Black Gum Scarlet oak Turkey oak	FAC NL FACU-
SHRUB LAYER Shrubs/vines	Mountain laurel Eastern chinquapin	FACU NL
HERB LAYER	Open	

1.3 Upland _____ Wetland _____ Inconclusive x

1.4 Rationale: All species faculative indicator classes, however, favor non-wetland end of range.

Sample Point __1__

Project Name: Texaco-King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

2.0 SOILS

2.1 Soil Borings

Depth (inches)	Description
1-0	Leaf litter
0-1	Dark grayish brown (10 yr 1/2) sandy loam, very friable, not sticky
1-9	Yellowish brown (10 yr 5/4) sandy loam, very fiable, not sticky
9-20	Yellowish brown (10 yr 5/6) sandy loam, friable, not sticky

2.2 Is the soil hydric?

Yes ____ No __x__ Inconclusive ____

2.3 Rationale: Absence of hydric characteristics such as low matrix chromas and mottling.

2.4 Notes:

Sample Point ___1___

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

3.0 HYDROLOGY

3.1 Is the ground surface inundated?

Yes ____ No _x_ Inconclusive ____

3.2 Is the soil saturated?

Yes ____ No _x_ Depth to free standing water _____

3.3 Other positive indicators of wetland hydrology: none

3.4 Does the area have wetland hydrology?

Yes ____ No _x_ Inconclusive _____

3.5 Rationale: No positive indicators of wetland hydrology were observed.

3.6 Notes:

4.0 WETLAND DETERMINATION

Is the area a wetland?

Yes ____ No _x_ Inconclusive _____

4.1 Comments:

Prepared by: Mark Gallagher

Sample Point 2

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

Sampling Point Location: Fifteen feet upslope of wetland point C-29
Landscape Position: Moderately steep slope, approximately 8-10%

1.0 VEGETATION

1.1 Plant Assemblage: Forested upland
1.2 Dominant Plant Species:

	SPECIES	INDICATOR STATUS
CANOPY LAYER	Princess tree Tulip poplar	NL FACU
SAPLINGS (total # in parentheses)	Tulip poplar	FACU
SHRUB LAYER Shrubs/vines	Spice bush	FACW-
HERB LAYER	Christmas fern Clearweed	FACU- FACW

1.3 Upland _____ Wetland _____ Inconclusive x

1.4 Rationale: The dominant species are all faculative. Indicator status of the dominants indicates a preference to the upland end of range.

Sample Point 2

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

2.0 SOILS

2.1 Soil Borings

Depth (inches)	Description
0-4	Sand, very friable, (10 yr 3/2) loamy, not sticky
4-13	Sand, very friable (10 yr 4/3) loamy
13-20	Loamy sand, very friable, (10 yr 5/4) common medium faint (10 yr 6/4) mottles, not sticky

2.2 Is the soil hydric?

Yes ____ No x Inconclusive ____

2.3 Rationale: Matrix chroma of subsoil greater than 2.

2.4 Notes:

Sample Point 2

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

3.0 HYDROLOGY

3.1 Is the ground surface inundated?

Yes ____ No x Inconclusive ____

3.2 Is the soil saturated?

Yes ____ No x Depth to free standing water _____

3.3 Other positive indicators of wetland hydrology: none

3.4 Does the area have wetland hydrology?

Yes ____ No x Inconclusive _____

3.5 Rationale: No positive indicators of wetland hydrology were observed.

3.6 Notes:

4.0 WETLAND DETERMINATION

Is the area a wetland?

Yes ____ No x Inconclusive _____

4.1 Comments:

Prepared by: Mark Gallagher

Sample Point 3

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

Sampling Point Location: Fifteen feet from wetland survey point X-7.
Landscape Position: Broad flat.

1.0 VEGETATION

1.1 Plant Assemblage: Emergent wetland
1.2 Dominant Plant Species:

	SPECIES	INDICATOR STATUS
CANOPY LAYER		
SAPLINGS (total # in parentheses)		
SHRUB LAYER Shrubs/vines		
HERB LAYER	Climbing hemp weed Jewelweed Arrow leaved-tearthumb	FACW+ FACW OBL

1.3 Upland _____ Wetland _____ Inconclusive _____

1.4 Rationale:

Sample Point 3

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

2.0 SOILS

2.1 Soil Borings

Depth (inches)	Description
0-15	Dark gray (10 yr 4/1) silt loam, common medium fine Sticky when wet, dark grayish brown (10 yr 4/2) mottles, iron staining, H_2S odor.

2.2 Is the soil hydric?

Yes x No _____ Inconclusive _____

2.3 Rationale: Gleyed soil to surface.

2.4 Notes:

Sample Point ___3___

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

3.0 HYDROLOGY

3.1 Is the ground surface inundated?

Yes ____ No __x__ Inconclusive ____

3.2 Is the soil saturated?

Yes __x__ No ____ Depth to free standing water 12 inches

3.3 Other positive indicators of wetland hydrology: Hydrogen sulfide odor within 12 in.

3.4 Does the area have wetland hydrology?

Yes __x__ No ____ Inconclusive ____

3.5 Rationale: Positive indicators of wetland hydrology were observed.

3.6 Notes:

4.0 WETLAND DETERMINATION

Is the area a wetland?

Yes __x__ No ____ Inconclusive ____

4.1 Comments:

Prepared by: Mark Gallagher

Sample Point 4

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

Sampling Point Location: Proximate to wetland flag X-7
Landscape Position: Broad flat

1.0 VEGETATION

1.1 Plant Assemblage: Emergent wetland
1.2 Dominant Plant Species:

	SPECIES	INDICATOR STATUS
CANOPY LAYER		
SAPLINGS (total # in parentheses)		
SHRUB LAYER Shrubs/vines		
HERB LAYER	Water Pepper Yellow nut sedge Boneset	OBL FACW FACW+

1.3 Upland _____ Wetland x Inconclusive _____

1.4 Rationale: Dominant species are all hydrophytes.

Sample Point 4

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

2.0 SOILS

2.1 Soil Borings

Depth (inches)	Description
0-4	Brown (10 yr 4/3) sandy clay loam, common medium distinct strong brown (7.5 yr 4/6) mottles and common medium, prominent dark gray (5 y 4/1) mottles
4-8	Dark gray (5 yr 4/1) sandy clay loam, sticky, common medium distinct strong brown (7.5 yr 4/6) mottles
8-17+	Dark grayish brown (2.5 yr 4/2) loamy sand, friable, not sticky

2.2 Is the soil hydric?

Yes x No _____ Inconclusive ____

2.3 Rationale: Matrix chroma os subsoil less than 2 and presence of low chroma mottles to soil surface.

2.4 Notes:

Sample Point ___4___

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

3.0 HYDROLOGY

3.1 Is the ground surface inundated?

Yes ____ No __x__ Inconclusive ____

3.2 Is the soil saturated?

Yes __x__ No ____ Depth to free standing water seepage at 6 in.

3.3 Other positive indicators of wetland hydrology: Hydrogen sulfide odor

3.4 Does the area have wetland hydrology?

Yes __x__ No ____ Inconclusive ____

3.5 Rationale: Positive indicators of wetland hydrology were observed.

3.6 Notes:

4.0 WETLAND DETERMINATION

Is the area a wetland?

Yes __x__ No ____ Inconclusive ____

4.1 Comments:

Prepared by: Mark Gallagher

Sample Point 5

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

Sampling Point Location: Five feet from X-6
Landscape Position: Gentle slope

1.0 VEGETATION

1.1 Plant Assemblage: Recently disturbed upland forest
1.2 Dominant Plant Species:

	SPECIES	INDICATOR STATUS
CANOPY LAYER	Sweet gum River birch	FAC FACW
SAPLINGS (total # in parentheses)	American holly	FACU
SHRUB LAYER Shrubs/vines	None	
HERB LAYER	Marginal wood fern Crabgrass	FACU- FACU-

1.3 Upland _____ Wetland _____ Inconclusive x

1.4 Rationale: All species faculative

1.5 Notes: Area recently cleared

Sample Point 5

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

2.0 SOILS

2.1 Soil Borings

Depth (inches)	Description
0-4	Dark grayish brown (10 yr 4/2) fine sandy loam, very friable slightly sticky
4-9	Brown (10 yr 5/3) fine sandy loam, very friable slightly sticky
9-18	Light yellowish brown (2.5 yr 6/4) fine sandy loam, very friable, slightly sticky
18-21+	Light yellowish brown (2.5 yr 6/4) fine sandy loam, very friable, common medium distinct, light brownish gray (2.5 y 6/2) mottles

2.2 Is the soil hydric?

Yes ____ No x Inconclusive ____

2.3 Rationale: Matrix chroma of subsoil not gleyed.

2.4 Notes:

Sample Point 5

Project Name: Texaco - King George County Site Project No. 91-191-05
Project Location: King George County, VA
Date: 8-22-91

3.0 HYDROLOGY

3.1 Is the ground surface inundated?

Yes ____ No x Inconclusive ____

3.2 Is the soil saturated?

Yes ____ No x Depth to free standing water _____

3.3 Other positive indicators of wetland hydrology: none

3.4 Does the area have wetland hydrology?

Yes ____ No x Inconclusive _____

3.5 Rationale:

3.6 Notes:

4.0 WETLAND DETERMINATION

Is the area a wetland?

Yes ____ No x Inconclusive _____

4.1 Comments:

Prepared by: Mark Gallagher

APPENDIX III

PHOTOGRAPHS

Photographs of the Site

1. Alder thicket in north central portion of eastern intermittent tributary.
2. Head of intermittent branch of eastern tributary.
3. Transition area between wetland on left of photograph and upland on right.
4. Intermittent branch of eastern drainage.
5. Transition between upland and wetland. Note abrupt break in topography.
6. Emergent wetland in central part of eastern drainage.
7. Emergent wetland to north of driveway crossing of eastern drainage.
8. Upper portion of eastern drainage.
9. Upper portion of eastern drainage as it exits property.
10. Emergent wetland.
11. Upper portion of tidally influenced emergent wetland.
12. Tidal emergent wetland.
13. Area of site proximate to marina.
14. View of site showing forested area bordering creek.
15. Upland forest on drainage divide in northern part of site.
16. Edge of project site.
17. Intermittent drainage traversing center of site.
18. Man-made pond created near center of drainage traversing the central portion of the site.
19. Narrow wetland downgradient of larger and southernmost of the two man-made ponds.
20. Smaller or northernmost of the two man-made ponds.
21. Transition area along central drainage.

22. Emergent wetland at northern end of central drainage.

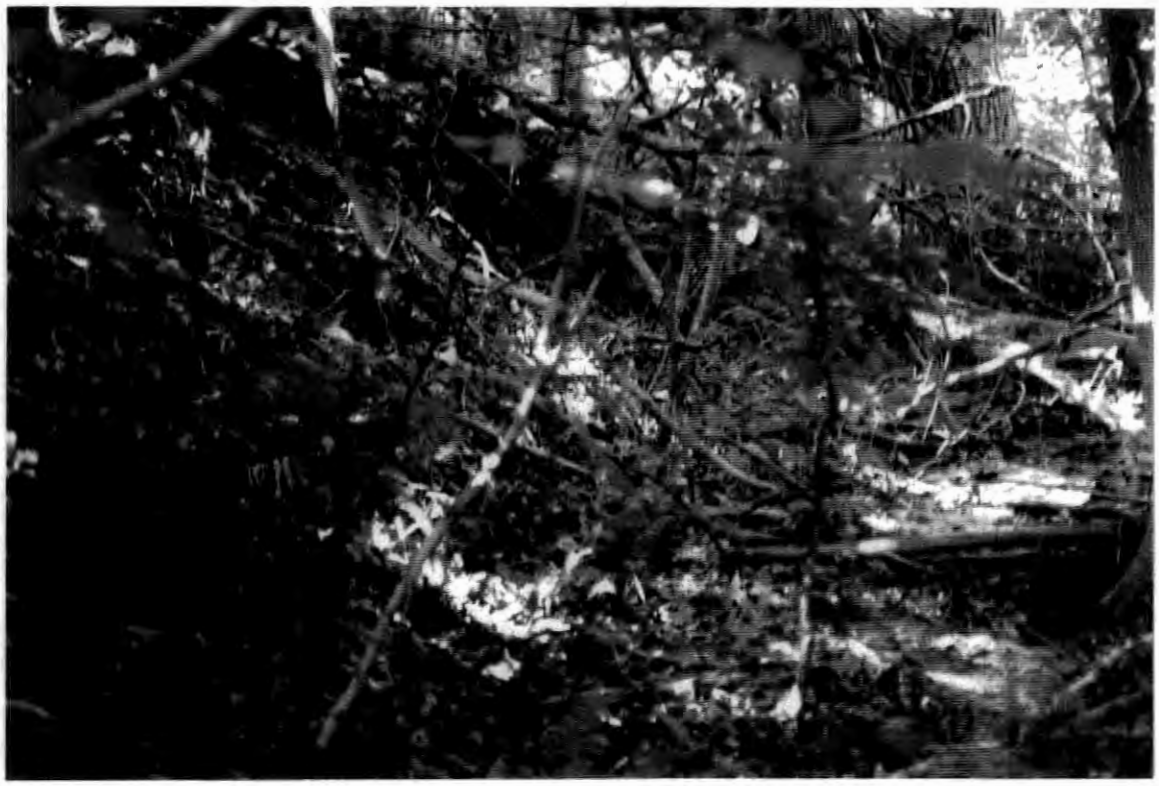
23. View of southwestern portion of the site. The central drainage lies within wooded area of left side of the photograph.

Photograph 1.

Photograph 2.

Photograph 3.

Photograph 4.



Photograph 5.

Photograph 6

Photograph 7.

Photograph 8.

Photograph 9.

Photograph 10.

Photograph 11.

Photograph 12.

Photograph 13.

Photograph 14.

Photograph 15.

Photograph 16.

Photograph 17.

Photograph 18.

Photograph 19.

Photograph 20.

Photograph 21.

Photograph 22.

Photograph 23.