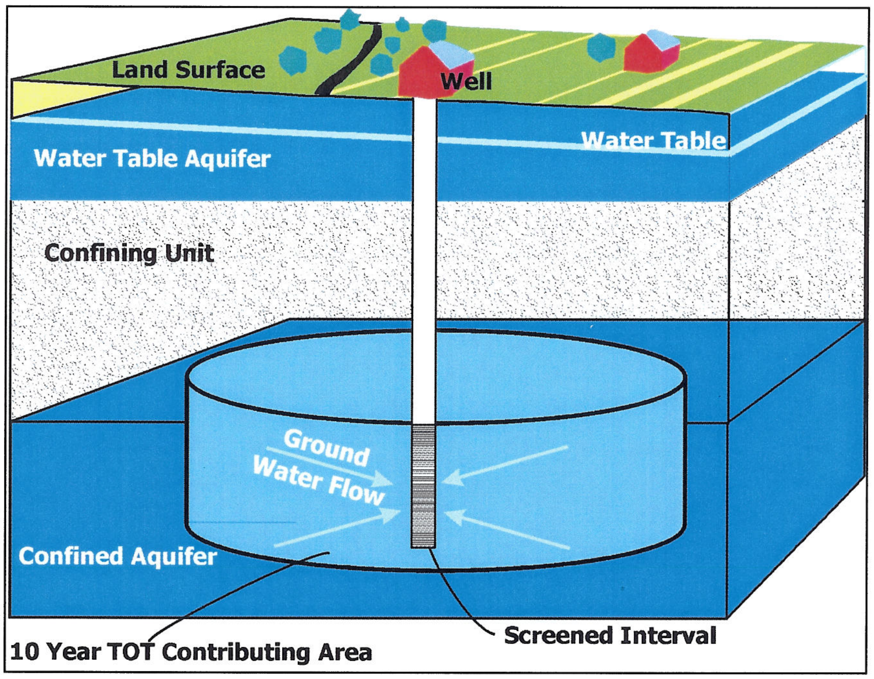
SOURCE WATER ASSESSMENTS

FOR NINE NONTRANSIENT NONCOMMUNITY WATER SYSTEMS IN CAROLINE COUNTY, MD



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SUMMARY

The Maryland Department of the Environment's Water Supply Program (WSP) has conducted Source Water Assessments for nine nontransient noncommunity water systems in Caroline County. The required components of this report as described in Maryland's Source Water Assessment Program (SWAP) are 1) delineation of an area that contributes water to each source, 2) identification of potential sources of contamination within the areas, and 3) determination of the susceptibility of each water supply to contamination. Recommendations for protecting the drinking water supplies conclude this report.

The water supply sources of the nine systems in this report are naturally protected, confined, Coastal Plain aquifers. These water systems are currently using eleven supply wells that draw from the Eocene Series Piney Point Formation, the Chesapeake Group's Cheswold and Federalsburg aquifers of the Calvert Formation, and the Frederica aquifer of the Choptank Formation, respectively. Five additional wells at four of the water systems are designated "other use wells". The Source Water Assessment areas were delineated by the WSP using EPA approved methods specifically designed for confined aquifers in the Coastal Plain.

Potential point sources of contamination were identified within the assessment areas from field inspections, and contaminant inventory databases. In confined aquifer settings, sources of contamination at the land surface near the wells are generally not a threat unless there is a pathway for direct injection into the deeper aquifer such as through unused wells or along well casings that have no grout seal. Well information and water quality data were also reviewed. Figures showing well locations, and potential contaminant sources within and near the wellhead protection areas are enclosed at the end of the report.

The susceptibility analysis is based on a review of the existing water quality data for each water system, the presence of potential sources of contamination in the individual assessment areas, well integrity, and aquifer characteristics. It was determined that the nine confined water systems are not susceptible to contaminants originating at the land surface due to the protected nature of confined aquifers. Based on available sampling data, the systems are also not susceptible to regulated naturally occurring contaminants since these elements have not been detected at levels of concern.

The sanitary integrity of the nine water supply systems may be maintained by following the well improvements recommendations at the end of this report. These recommendations include inspecting the integrity of old well casings, installing insect-proof and flood-proof well caps on wells in need of them, extending the casings of wells that are currently below ground surface that have experienced flooding, properly abandoning and sealing wells with no planned future use, and installing protective bollards around well casings prone to damage from vehicular collisions.

INTRODUCTION

The Water Supply Program has conducted Source Water Assessments for nine nontransient noncommunity water systems in Caroline County. Nontransient noncommunity water systems are defined as public water systems that regularly serve at least 25 of the same individuals over 6 months per year. The nine water systems assessed in this report serve a combined estimated population of 3,892 (Table 8). Caroline County is located on the Delmarva Peninsula along the eastern shore of Maryland. The county is bounded on the north by Queen Anne's County, to the south by Dorchester County, on the east by the State of Delaware, and by Talbot and Queen Anne's Counties to the west. Based on July 2005 data, the total population of Caroline County is 31,100 persons (MD Assoc. of Counties, 2005/2006). The systems include five privately owned and operated facilities, and four public schools. Eight of the facilities are considered "small" systems, defined in Maryland's Source Water Assessment Plan (MDE, 1999) as water systems that have a ground water appropriation permit of less than 10,000 gallons average daily use. North Caroline High School / Career & Tech Center currently does not have a water appropriation and use permit. Therefore, the average daily useage of the two schools was estimated at 7,200 gallons per day (gpd) based on a reported population of 1,028 at 7 gpd per person. Burris Retail Logistics uses an average of greater than 10,000 gpd, and is therefore referred to as a "large" nontransient noncommunity water system (MDE, 1999). The nine systems in this report obtain their water supply from wells completed in confined, unconsolidated Coastal Plain sediments. The locations of the nine water systems are shown on Figure 1.

WELL INFORMATION

Well information for each system was obtained from the Water Supply Program's database, site visits, well completion reports, sanitary survey inspection reports, and published reports. A total of eleven supply wells are used by the nine systems assessed in this report. Five additional wells at Colonel Richardson Middle & High Schools, North Caroline High's Career & Tech. Center, Burris Retail Logistics, and Pillsbury-General Mills respectively are designated "other use wells" (Table 2). Twelve of the wells were drilled in or after 1973 and should comply with Maryland's well construction regulations for grouting and casing. The Choptank Electric, and Pillsbury-General Mills supply wells that were drilled prior to 1973 when current regulations went into effect, have no record of grout seals, and therefore may not meet the current construction standards. New casings with grout seals were installed for the Mulholland Harper Company, and North Caroline High School supply wells respectively, as these wells were also originally drilled prior to 1973 (Appendix A). Single wells currently supply the North Caroline High & Technical Center Schools, and the Colonel Richardson Middle & High Schools respectively (Figures 2b & 2e). Table 2 contains a summary of well information for each of the water systems assessed in this report.

Based on site surveys, the supply wells are generally in good to fair condition. Some of the older wells should have a two-piece well cap installed to prevent contamination from insects through unscreened vents and electrical conduits

(Appendix A). Additionally, the casings of the older wells should be inspected to assess their integrity. A review of the Public Drinking Water Information System (PDWIS) database and field surveys indicate unused wells at the Colonel Richardson Middle & High Schools (Figure 2e), and Tri-Gas and Oil Company. In addition to the supply well, two other well records exist for the Tri-Gas and Oil Company. However, Safety Director, Mr. Eric Kuster is not aware of any additional wells on the property. Unused wells that are not constructed properly or adequately maintained may provide a direct pathway for ground water contamination from the shallow aquifer to the deeper aquifers. These wells should be properly abandoned and sealed by a licensed well driller according to current State regulations.

The supply wells at Greensboro Elementary, and Choptank Electric are located below ground surface in square vaults with lids (Appendix A). In December 2002, the Greensboro Elementary Well 1 pit flooded because its sump pump was not operational. Pump repairs were made, and subsequent well testing was negative for the presence of coliform bacteria. There have been no reported sump pump failures at either well since that time. Additionally, the operator at Choptank Electric reported that its well vault has never been seen with water in it. The casing of the Pillsbury-General Mills Well 1 extends only to about six inches above ground surface (Appendix A). Wells cased at or below ground surface are more likely to be subject to flooding during heavy rains. This may allow contaminated surface water to enter the well through openings at the wellhead and ultimately may reach the aquifers. The Colonel Richardson, Denton, and North Caroline Schools, Mulholland Harper Company, and Pillsbury-General Mills Wells are all located inside pump houses and therefore should be protected from storm water runoff. The Tri-Gas and Oil Company and Burris Retail Logistics wells are located outside with casings extending at least one foot above ground surface (Appendix A).

Daily use averages reported from 2001 - 2005 indicate that the Burris Retail Logistics "large" nontransient noncommunity water system is within its allocated Water Appropriation Permit limit of 14,000 gallons per day (gpd).

HYDROGEOLOGY

Ground water flows through pores between gravel, sand, and silt grains in unconsolidated Coastal Plain formations (aquifers) that are used by the nontransient noncommunity water systems in Caroline County. An aquifer is any formation that is capable of yielding a significant amount of water. Transmissivity is a measure of the amount of water that an aquifer is capable of producing, and is the product of hydraulic conductivity and aquifer thickness. Confining layers are composed of fine-grained clay and silt material that have very small pore spaces and therefore transmit very little water. Confined aquifers are those formations that are overlain by one or more confining layers. Ground water is isolated from the atmosphere at the point of discharge by these confining layers, and the aquifer is subject to pressures higher than atmospheric pressure (Driscoll, 1986). The aquifers are recharged very slowly from the water stored in the confining layers above, and from precipitation that infiltrates into the formation where it reaches the ground surface, referred to as the outcrop area.

Caroline County is underlain by unconsolidated sediments of the Coastal Plain Physiographic Province. The sediments were deposited in a southeasterly thickening wedge extending from the Fall Line (roughly the area east of Interstate 95) to the Continental Shelf. They consist of layers of clay, silt, sand, and gravel that form a regular banded sequence of interbedded aquifers, and confining layers that gently dip to the southeast. The unconsolidated sediments overlie a complex assemblage of crystalline bedrock. The age of the deposits (from oldest to youngest), range from Cretaceous, just above the crystalline basement rocks, to Tertiary, to Quaternary near the land surface (Rasmussen & Slaughter, 1957). A generalized description of the hydrogeologic units and lithology of the major aquifers and confining layers of Maryland's Eastern Shore are shown on Table 1. The nine systems in this report utilize confined aquifers for their potable water supply sources. The confined aquifers used by these systems include the Eocene Series Piney Point Formation, the Chesapeake Group's Cheswold and Federalsburg aquifers of the Calvert Formation, and the Frederica aquifer of the Choptank Formation. Confining clay units of low permeability that inhibit the infiltration of contaminants from the land surface overlie confined aquifers. General descriptions of each aquifer as they increase in depth are shown below. The reader may refer to the referenced reports for additional information.

Choptank Formation (Frederica Aquifer)

The Frederica aquifer of the Choptank Formation is used by the Tri-Gas & Oil Company water system, and by the Burris Retail Logistics truck maintenance shop. It consists of gray and brown sand and silt with shell marl. The top of the Choptank Formation ranges from about 50 feet above sea level at Henderson, northern Caroline County to 100 feet below sea level at Federalsburg (Rasmussen & Slaughter, 1957). Its thickness ranges from approximately 50 to 130 feet in Caroline County. The Choptank Formation has a relatively low transmissivity and specific capacity. A transmissivity of 802 ft^2/day was reported from an aquifer test conducted in West Denton (Rasmussen & Slaughter, 1957). It is capable of small to moderate yields over most of its extent. The Saint Mary's Formation overlies the Frederica aquifer. It consists of clayey silt and silty clay which functions as a confining layer to the Frederica aquifer covering most of Caroline County.

Calvert Formation (Federalsburg & Cheswold Aquifers)

Burris Retail Logistics Wells 1 and 2, and Pillsbury-General Mills Well 1 are completed in the Federalsburg aquifer, which is the uppermost aquifer of the Calvert Formation. The underlying Cheswold aquifer supplies the Colonel Richardson Middle and High Schools, Denton Elementary School, and the Mulholland Harper Company respectively. The Calvert formation consists of gray diatomaceous silts and clays with interspersed sand lenses. The sands are fine-to-medium-grained, with shell fragments. The top of the Calvert Formation ranges from about 50 to 200 feet below sea level going from north to south Caroline County (Rasmussen & Slaughter, 1957). Transmissivity values are moderately low. A test conducted at Easton in Talbot County yielded a transmissivity of 468 ft^2/day (Rasmussen & Slaughter, 1957). The thickness of these sediments is highly variable in Caroline County, but they generally thicken to the southeast. The Cheswold aquifer is overlain by a confining layer of silt and clay that separates it from the Federalsburg aquifer above. In areas where this confining bed is absent, the two aquifers may be hydraulically connected (DNR, 1987). The aquifers are a good source for small to medium sized water supplies due to their accessibility and excellent water quality.

However, larger water systems may find them insufficient to meet their demands. The clayey portions of the overlying Choptank Formation function as a leaky confining unit to these aquifers.

Piney Point Formation

The Choptank Electric Corporation, Greensboro Elementary, and North Caroline High School and Tech Center from this report use the Piney Point aquifer as their potable water supply source. The formation consists of medium to course grained olive-green to black slightly glauconitic sand with interbedded clayey layers and shell fragments. Clay content tends to increase near the bottom of the formation. In Caroline County, the thickness of the sandy (permeable) portion of the formation ranges from 50 to 80 feet (Williams III, 1979). The top of the aquifer ranges from 150 feet below sea level near the northern tip of the county to about 525 feet below sea level in the southeastern corner (Figure 3). Transmissivity values, estimated by modeling and aquifer tests, range from approximately 500 to 1800 ft^2/day, and are highest near Denton in the central part of the county (Williams III, 1979). The Piney Point aquifer does not outcrop at the ground surface in Maryland, and therefore is not directly recharged by precipitation. Recharge is derived from lateral and vertical leakage through adjacent beds. It is overlain by the Chesapeake Group Formations whose clayey portions function as multiple confining and leaky confining beds to this aquifer. The thickness of the confining material overlying the Piney Point aquifer in Caroline County ranges from 80 to 150 feet (Figure 4).

SOURCE WATER ASSESSMENT AREA DELINEATION

For ground water systems, a Wellhead Protection Area (WHPA) is considered to be the source water assessment area for each system. The nine nontransient noncommunity systems in this report utilize confined aquifers for their water supplies. The methodologies used to delineate confined aquifer WHPAs for "large" and "small" public water system users as defined in Maryland's Source Water Assessment Plan (MDE, 1999), are as follows:

"Large" Confined Water System Delineations (see Figure 2f)

Wells drilled into confined aquifers in the Coastal Plain pumping an average of 10,000 gallons per day (gpd) or greater are to be delineated using a volumetric equation referred to as "The Florida Method". The method is used to calculate the volume of aquifer needed to store the quantity of water pumped from the well for a ten-year period. The equation is as follows:

$$r = \sqrt{\frac{Qt}{\pi n H}}$$

where: r = calculated fixed radius (ft)
Q = pumping rate of well (ft^3 / yr)
t = time of travel in years (yr)
n = aquifer porosity (dimensionless)
H = length of well screen (ft)

A porosity (n) of 25% was assumed for the aquifer based on published reports (Fetter, 1988). The pumping rate (Q) is generally the permitted daily average from water appropriation permit information. Burris Retail Logistics is the only "large" public water system in this report. Two wells are used to supply water to the main warehouse building. According to Plant Engineer, Mr. Skip Gillespie, Well 2 is the primary well, and provides most of the daily average demands to the plant. Well 1 is considered the secondary well, and is used to supplement Well 2 when necessary to meet peak demands, or to temporarily supply the entire plant if Well 2 were in need of repair. Since either well could be used to supply the entire needs of the plant, the WHPAs were calculated using the total daily average appropriation allocation of 14,000 gpd for each well. The lengths of well screens (H) were obtained from well completion reports. The volumetric equation was solved for each well using the pertinent data as shown on Table 3. The resulting WHPAs are radial zones of transport based on a ten-year time of travel. Since the delineated radius for Well 2 is fully encompassed by the Well 1 radius, the final WHPA for this system is an 800-foot radius surrounding both wells (Figure 2f).

"Small" Confined Water System Delineations (see Figures 2a- 2g)

The Wellhead Protection areas for the eight remaining public water systems using an average of less than 10,000 gpd whose wells are completed in confined Coastal Plain aquifers is a fixed radius of 600 feet around each well (MDE, 1999). This radius is based on the previously discussed volumetric equation assuming a minimum aquifer thickness of 20 feet, a porosity of 25%, and an average daily pumpage of 10,000 gpd. The fixed radius represents a 10-year zone of transport from the supply wells providing the largest protection area for conservative purposes. Greensboro Elementary School uses two wells that share the same aquifer and whose radial areas overlap. Therefore, the two radiuses were combined to form one larger WHPA at this school (Figure 2a).

The WHPAs for each of the nine confined aquifer water systems are shown on Figures 2a-2g. The protection areas for assessment purposes are located within the aquifer below the confining layers at depths below land surface. Diagram 1 is a conceptual illustration of a WHPA in a confined Coastal Plain aquifer setting.

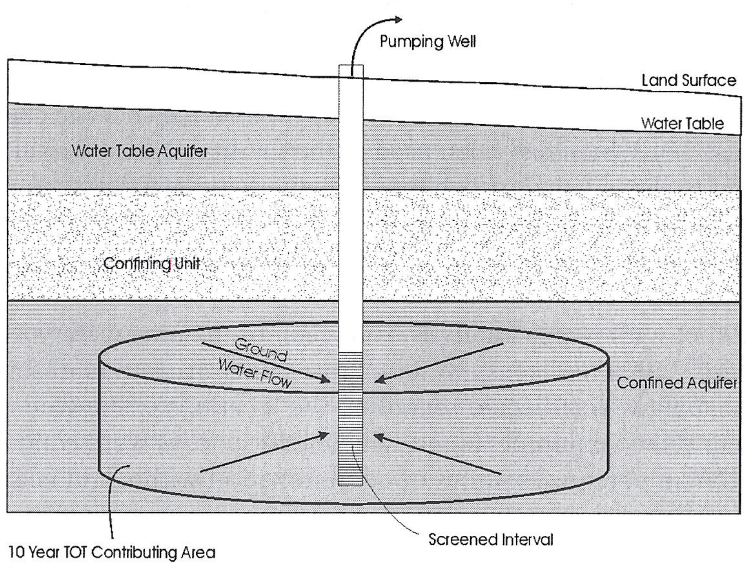

Diagram 1. Conceptual Illustration of a Zone of Transport for a Confined Aquifer

Potential Sources of Contamination

Potential sources of contamination are classified as either point or non-point sources. Examples of point sources of contamination are leaking underground storage tanks, controlled hazardous substance generators, ground water discharge permit sites, old dump sites, and pesticide dealers. These sites are generally associated with commercial or industrial facilities that use chemical substances that may, if inappropriately handled, contaminate ground water via a discrete point location. Non-point sources of contamination are associated with certain types of land use practices such as the use of pesticides, application of fertilizers, sludge or animal wastes, or septic systems all that may lead to ground water contamination over a larger area. All of the nontransient noncommunity water systems in this report draw water from confined aquifers. In confined aquifer settings, sources of contamination at the land surface are generally not a threat unless there is a pathway for direct injection into the deeper aquifers such as through unused wells that have not been properly abandoned, or along well casings that have no grout seal.

Old dump sites (ODS) are areas where municipal or commercial wastes were disposed of in the past, often without proper permitting. Underground storage tank (UST) sites are facilities that store petroleum in underground tanks registered with the MDE Waste Management Administration. Leaking underground storage tanks (LUSTs) are tanks and lines that have had integrity issues that may have resulted in soil and/or ground water contamination. Controlled hazardous substance generators (CHS) are facilities that may use or store any hazardous substance on-site. Ground water discharge permits (GWDP) are issued by the MDE Water Management Administration for discharge of wastewater to ground water. General Permit (GP) sites are facilities that were issued general industrial storm water, oil operations, or other related discharge permits. Pesticide dealers (PD) are facilities that sell or store large quantities of these chemicals on-site. Miscellaneous sites (MISC) such as salvage yards, auto repair shops and dealerships, volunteer fire companies, dry cleaners, and other commercial facilities that use, handle and store chemicals were also identified during the site surveys.

The contaminants associated with the types of facilities are based on generalized categories and often the potential contaminant depends on the specific chemicals and processes being used or which had been used at the facility. The potential contaminants may not be limited to those listed in Table 4. Potential contaminants are grouped as Volatile Organic Compounds (VOC), Synthetic Organic Compounds (SOC), Metals (M), Heavy Metals (HM), Nitrate/Nitrite (NN), and Microbiological Pathogens (MP).

The WSP met with representatives from each of the nine water systems on February 27th & 28th, 2006 to discuss water quality concerns, and to observe the integrity of the wells. Also, data was collected regarding the locations of the wells using Global Positioning System (GPS) equipment, and windshield surveys were conducted using the GPS to locate and map potential sources of contamination within and near the WHPAs.

Potential contaminant sources were identified within and near the WHPAs for awareness purposes and to ensure that the deep aquifers do not become affected by unused wells or poorly constructed wells completed in the aquifers used by the water suppliers. Table 4 lists the facilities identified from MDE databases and site surveys as potential sources of contamination and the locations are shown on Figures 2a-2g.

Facilities located within and near the WHPAs are being inspected by MDE staff to determine the potential for contamination of any unpermitted ground water discharges (e.g. open floor drains), to the aquifers. No violations have been reported to date. The reader may contact the MDE Ground Water Permits Program for information regarding the specific inspections performed. Ground water discharges to the shallow unconfined aquifers should not pose a threat to the deeper confined aquifers. These aquifers are naturally protected from land use activities originating from the ground surface unless there is a pathway for direct injection (e.g. unused wells) into the confined aquifer. The Colonel Richardson Middle & High Schools have a confirmed unused well located within its WHPA (Figure 2e). Tri-Gas & Oil Company may have two unused wells located on their property; however, neither of these has been confirmed. No other unused wells were reported from inspections conducted by MDE staff. However, there may be others (e.g. unused residential wells) that are currently not inventoried, due to limitations in database, and inspection staff resources.

The Caroline Nursing Home, and former Denton Citgo Station located to the north-east of the Denton Elementary School WHPA had heating oil or petroleum product releases from underground storage tank leaks resulting in elevated levels of VOCs in ground water (Figure 2D). These open cases are currently under investigation by the MDE Oil Control Program Remediation Division. The former Coastal/TG&O Station located to the northwest of the Pillsbury-General Mills WHPA in Federalsburg is still active. However, monitoring well VOC results have been decreasing over the past few years, and the Oil Control Program is preparing to close this case. Summaries of these cases can be found in Appendix B. The reader may contact the Oil Control Program for additional information.

The Old West Denton Dump located about a half-mile northeast of the Mulholland Harper Company WHPA was identified as having historical soil and ground water contamination concerns. The site is listed in Table 4, and its location is mapped on Figures 2b & 2c. Appendix C provides a general information fact sheet for this site.

The Mullholland Harper Company water system has an industrial ground water discharge permit to release an average of 2,600 gpd of metal cleaning wastewater to the subsurface (Figure 2c). The company specializes in production signage. The Choptank Electric Corporation water system located across from the Mulholland Harper Company also has an industrial discharge permit for its utility vehicle maintenance facility (Figure 2c). Database summaries of these and other discharge permit sites located within and near the confined WHPAs from this report are found in Appendix D. The reader may contact the specific programs within the MDE Water and Waste Management Administrations for additional information on any of these permits.

None of the sites located within or near these WHPAs should present a water quality threat to the supply wells due to the natural confining clay layers that protect the aquifers from contamination that occurs near the ground surface. Contamination from these sites may threaten the water quality of the shallow unconfined aquifers.

Water Quality Data

Water Quality data was reviewed from the Water Supply Program's database and system files for Safe Drinking Water Act contaminants. The State's SWAP defines a threshold for reporting water quality data as 50% of the Maximum Contaminant Level (MCL). If a monitoring result is at or greater than 50% of a MCL, this assessment will describe the sources of such a contaminant and, if possible, locate the specific sources which are the cause of the elevated contaminant level. Eight of the nine systems currently do not use water treatment. The Pillsbury-General Mills plant recently added pre-chlorination treatment to its raw water at the pump house for disinfection purposes. Cartridge filters are also used to remove particulates from the treated water prior to distribution to the plant.

A review of the monitoring data since 1991 indicates that the water supplies for the nine systems in this report meet the drinking water standards (Table 5).

Inorganic Compounds (IOCs)

A review of the available data shows that regulated IOCs were not detected at levels of concern for the nine nontransient noncommunity water systems.

Volatile Organic Compounds (VOCs)

No VOCs were detected from available sampling results of the nine water systems.

Synthetic Organic Compounds (SOCs)

North Caroline High School & Tech Center, and Pillsbury-General Mills are the only two nontransient noncommunity water systems in Caroline County that currently have SOC data (Table 5). Dalapon was detected at 0.16 parts per billion (ppb) from one set of sampling results in September 1999 at North Caroline High School & Tech Center. The MCL for this compound is 200 ppb. It was not detected again from a subsequent sample collected in November 2005. Di(2-ethylhexyl phthalate) was detected at 0.8 ppb from the same 2005 data set collected at the high school. It was also detected in the laboratory blank sample accompanying this data set, and therefore the result is not believed to represent actual water quality. No other SOCs were detected from available sampling results of the two systems. The seven systems that currently have no SOC data are to be sampled in 2007 and 2008.

Microbiological Contaminants

Ground water under the influence of surface water (GWUDI) testing is not required for the nine systems in this report since their supply wells draw from confined aquifers. However, each of the systems has quarterly or monthly routine bacteriological samples that are collected as required by the Safe Drinking Water Act. The Pillsbury-General Mills plant is the only water system in this report that has disinfection treatment, and therefore the finished water data is not indicative of the quality of raw water directly from the well. The other eight systems currently do not use any type of treatment and therefore the results may be indicative of raw water (Table 6). Total coliform bacteria are not pathogenic, but are used as an indicator organism for other disease-causing microorganisms. Four systems had positive total coliform results in at least one sample, but several repeat samples were found to be free of total coliforms after the issues responsible for these positive hits were resolved. No positive total or fecal coliform results were reported for the remaining five systems in this report from samples collected quarterly or monthly since 1996 (Table 6).

SUSCEPTIBILITY ANALYSIS

The wells serving the nine water systems in this report draw water from confined aquifers. Confined aquifers are naturally protected from land use activities at the ground surface due to the confining layers that provide a barrier for water movement from the surface into the aquifers below. A properly constructed well with the casing extended to the confined aquifer and with sufficient grout should be well protected from contamination at the land surface. A contaminant released in a confined WHPA setting must travel through either the annular space of a poorly grouted well, an unused improperly abandoned well, or an underground injection well drilled into the confined aquifer to potentially contaminate the aquifer. Confined aquifers are recharged very slowly from the water stored in the confining unit above, and from precipitation that infiltrates into the formation where it reaches the ground surface. Generally, water stored in confined aquifers has traveled great distances from its origin at the ground surface. Elements such as fluoride are naturally occurring in the aquifers, and may reach concentrations that pose a risk to the water supply. This is generally more problematic in confined aquifer settings than contaminants at the land surface.

The susceptibility analysis of the individual water supplies to each group of contaminants has been completed based on the following criteria: (1) available water quality data, (2) presence of potential contaminant sources within and near the WHPAs, (3) aquifer characteristics, and (4) well integrity. Table 7 summarizes the susceptibility of each of the nine systems covered in this report to each of the contaminant groups.

Inorganic Compounds

Inorganic compounds are not present at significant levels in the water supplies of the nine systems in this report. The low levels of inorganic constituents detected in the wells likely represent the naturally occurring levels present in the aquifers from dissolving minerals in the unconsolidated sediments. Therefore, the nine water supplies in this report are **not** susceptible to regulated inorganic compounds based on available water quality data, and the naturally protected characteristics of confined aquifers (Table 7).

Volatile Organic Compounds

Volatile Organic Compounds have not been detected from available samples collected for the nine water supplies. Several potential sources of these types of contaminants (e.g. USTs) were identified within and near most of the wellhead protection areas from this report as shown in Table 4 and in the corresponding figures. However, as long as there is no potential for direct injection into the confined aquifers, the nine water supplies in this report should **not** be susceptible to VOC contamination.

Synthetic Organic Compounds

The sources of SOCs to ground water include point and non-point sources. Non-point sources include pesticides, and herbicides applied to agricultural fields, and residential lawns. Potential point sources of these types of contaminants were identified within and near some of the wellhead protection areas as shown in Table 4 and in the corresponding figures. The only contaminants detected in this group from single samples collected at the North Caroline High School & Tech Center were di (2-ethylhexyl) phthalate, and dalapon. The phthalate detect was attributed to its presence in a laboratory blank sample, and therefore does not represent actual water quality. Dalapon was detected at 0.16 ppb from one set of sampling results taken in September 2003 at the school. This compound is an herbicide used on orchards, beans, lawns, and road/railway right of ways. Dalapon was not detected again from a repeat sample collected in November 2005, nor was it detected from a previous round of SOC testing conducted in November 1996. The single detect of this compound is therefore considered anomalous since the school well is completed in a confined aquifer, which is naturally protected from land use activities such as herbicide applications at the ground surface.

A confined aquifer waiver has been issued to eight of the nine systems in this report for synthetic organic compounds. The waiver allows confined systems to reduce the sampling frequency of SOCs to once every 12 years. North Caroline High School & Tech Center currently is sampled once every 6 years for SOCs. Based on the available water quality data, and confined aquifer characteristics, the nine systems in this report were determined **not** susceptible to SOC contamination (Table 7).

Microbiological Contaminants

Raw water monitoring for microbiological contaminants is not required for the nine confined aquifer water systems because they are considered naturally protected from sources of pathogens at the land surface.

Water stored in confined aquifers has traveled great distances through the naturally filtering sands, and is considered "very old". Microbial organisms in ground water generally have a maximum survival time of one year, and therefore they would have long since perished in a confined aquifer setting. Additionally, confined aquifer wells are generally well protected from microbiological contaminants originating at the ground surface due to the overlying protective confining layers. Four of these systems had routine positive total coliform results in at least one sample (Table 6). However, several repeat samples showed no positive coliform detects. Positive coliform results in confined aquifer wells are likely to be the result of well construction or integrity issues, and are unlikely to be representative of the source water quality of the aquifer. In these instances, the wellheads should be inspected, and any deficiencies should be corrected. As an example, new casings with grout seals were installed for the Mulholland Harper Company, and North Caroline High School supply wells respectively, as these wells were originally drilled prior to current construction standards (Appendix A). Sanitary seals around casings, electrical conduits and well caps all help to protect the water supplies from microbiological pathogens. None of the nine systems in this report have had any positive coliform detects from routine samples collected since 2002.

Based on available sampling data, and aquifer characteristics, the source water at each of the nine systems in this report is **not** susceptible to any microbiological contaminant present at the surface including *Giardia & Cryptosporidium* (Table 7).

MANAGEMENT OF THE SOURCE WATER ASSESSMENT AREA

The information contained in this report provides a basis for understanding the risks to contamination of the water supplies for the nine nontransient noncommunity water systems in Caroline County. As all of the systems use confined aquifers, maintaining proper well construction is most critical for future water quality protection. Specific management recommendations for consideration are as follows:

Public Awareness and Outreach

- Conduct educational outreach to businesses and residents within the WHPAs focusing on potential contaminant sources. Important topics include: (a) compliance with MDE and federal guidelines for gasoline and heating oil USTs, (b) proper hazardous material disposal and storage, and (c) well abandonment regulations and procedures.
- Being aware of the WHPA boundaries will assist employees and others at commercial facilities to use "common sense" practices with regard to the handling, placement and proper storage of chemicals, petroleum and other contaminants on facility grounds. Common sense practices can go a long way in protecting the aquifers from contamination.

Cooperative Efforts with Other Agencies

- The nine water systems should work with the Caroline County Health Department to ensure that there are no other unused wells within their respective WHPAs. Improperly abandoned wells may provide a direct route for ground water contamination to an aquifer.

Monitoring

- Systems should continue to monitor for all Safe Drinking Water Act contaminants as required by MDE.
- Annual raw water bacteriological testing is a good check on well integrity for all water systems.

Contaminant Source Inventory Updates/ Inspections

- Water system owners should conduct its own survey of their wellhead protection areas to ensure that there are no additional potential sources of contamination. Updated records of new development within the WHPAs should be maintained.
- Water system operators should have a program for periodic inspections and maintenance of the supply wells to ensure their integrity and to protect the aquifers from contamination.

Changes in Use

- Water system owners are required to notify the MDE Water Supply Program if new wells are to be added or if they wish to increase their water useage. The addition of new wells or an increase in pumpage of the existing wells may require revisions to the WHPAs.

Well Improvements

- Wells drilled prior to 1973 that do not meet current construction standards should be upgraded to protect them from contamination associated with poor or outdated construction. The casings of the Choptank Electric Corp. Well 1, and the Pillsbury-General Mills Well 1 should be inspected to assess their integrity, and repaired or replaced as necessary. Also, these wells should be upgraded with grout seals around their respective casings.
- Two-piece insect-proof well caps should be installed on the Burris Retail Logistics Wells 1 and 2. Wells with split caps (e.g. North Caroline High School & Tech Center, Mulholland Harper Co., & Pillsbury-General Mills Co.) should have screened vents, and be adequately sealed to prevent insects and debris from entering the well casings (Appendix A).
- Greensboro Elementary School, and the Choptank Electric Corporation should consider extending the casings of the wells to above grade. Wells cased below ground surface are more likely to be subject to flooding during heavy rains. This may allow contaminated surface water to enter the well through openings at the wellhead and ultimately may reach the aquifer. Wells susceptible to flooding should have flood-proof well caps installed. According to Public Schools Maintenance Foreman, Mr. Dale Kenton, the Greensboro Elementary School has plans to connect to the Town of Greensboro public water supply in the near future.
- The unused well at Colonel Richardson Middle & High Schools should be properly abandoned and sealed by a certified well driller according to current State well construction standards if there are no plans for future use (Appendix A). A further investigation should be conducted at the Tri-Gas and Oil Company to determine if additional wells still exist on their property. If so, and if there are no future plans for these wells, they should also be properly abandoned and sealed. Unused wells may provide a direct route for ground water contamination to an aquifer.
- Protective bollards should be installed around the Burris Retail Logistics Well 2 since it is located in the facility's parking lot (Appendix A). The well casing is currently prone to damage in the event of a vehicular collision.

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OTHER SOURCES OF DATA

Water Appropriation and Use Permits
Public Water Supply Sanitary Survey Inspection Reports
MDE Water Supply Program Oracle® Database
MDE Waste Management Sites Database
MDE Environmental Permits Database
ADC® Digital Maps for Caroline County
DNR DOQQs: Denton NE, NW, & SW, Hobbs NW & SW, and Federalsburg NE & NW
MD State Highway Administration Digital Road Maps

Tables

Table 1. — Coastal Plain stratigraphic nomenclature and aquifers of the Eastern Shore of Maryland.

System	Series (Group)	Geologic Unit	Thickness (feet)	Hydrogeologic Unit(s)	Dominant Lithologic Character
QUATERNARY & TERTIARY (?)	Holocene	Holocene deposits	0 - 40	---	Soil, alluvial sand and silt, dune sand, and peat. Disconformable base.
	Pleistocene and Pliocene (?) (Columbia Group)	Shoreline complex	0 - 230	Columbia aquifer	Lenticular deposits of sand, silt, clay, and peat. Some beds of coarse sand and fine gravel. Tan; some gray and blue clay.
		Salisbury Formation: Beaverdam Fm. and Pensauken Fm. of Owens and Denny (1979)			Beaverdam Sand: Light gray to light tan, fine to coarse grained, moderately sorted, feldspathic sand. Pensauken Formation: Light tan to orange tan, medium to coarse grained, moderately to poorly sorted, pebbly feldspathic sand.
?	?	?			
TERTIARY	Miocene (Chesapeake Group)	Upper Miocene Aquifer Complex	0 - 50	Upper confining bed	Lenticular silts, clays, and fine sands. Green-blue silt and fine gray sand most common, but occasionally includes blue-green pebbly clay.
			0 - 80	Pocomoke aquifer	Sand, gray or tan-gray; coarse and pebbly generally, but locally fine.
		[Yorktown and Cohansey Formations (?) of Rasmussen and Slaughter (1955)]	0 - 85	Lower confining bed	Blue and gray clayey silt and sand; some peat. Some beds of shell and calcite and/or limestone.
				Ocean City aquifer	Coarse gray sand, fine gravel.
			0 - 240	Manokin aquifer	Fine to very coarse gray sand, and some lignite or peat. Some silty sand and clay. Occasional beds of shell and/or "rock".
		St. Marys Formation	0 - 190	Confining layer	Gray fossiliferous clay, silt, fine sand, and silty and sandy clay.
		Choptank Formation	0 - 240	Frederica aquifer and confining layer	Gray fine sand. Thin beds of shell and calcite. Green or brown clay and fine sand. Thin beds of shell and calcite or limestone.
		Calvert Formation	0 - 680	Cheswold aquifer and confining layers	Gray sand and diatomaceous silt and clay. Shell beds.
	Eocene	Piney Point Formation	0 - 220	Piney Point aquifer	Olive-green to greenish-gray quartz sand, slightly to moderately glauconitic; shell beds.
		Nanjemoy Formation	0 - 294	Confining layer	Gray to dark gray, glauconitic, silt, sand, and clay.
	Paleocene	Aquia and Hornerstown Formations (undivided)	0 - 165	Aquia aquifer	Green to brown, fine to coarse grained, glauconitic sand; interstratified with grayish-green silt and clays; calcite cemented sands and fossil beds.
		Brightseat Formation	0 - <100	Confining layer	Dark gray clay and fine, silty, micaceous sand.
CRETACEOUS	Upper Cretaceous	Matawan and Monmouth Formations (undivided)	0 - 960 ?	Matawan-Monmouth aquifers	Dark greenish-gray to reddish-brown, fine to occasionally coarse quartz sand. Facies may be glauconitic, micaceous, shelly and/or clayey.
		Magothy Formation	<50 - 100	Magothy aquifer	Light gray to white "sugary", medium to coarse grained quartz sand and fine gravel; interbedded dark gray clays in upper part.
	Lower Cretaceous (Potomac Group)	Patapsco Formation	<50 - 1,750	Aquifers and confining layers	Interbedded, variegated (gray, brown, and red) silt and clay, and argillaceous, subrounded, fine to medium quartz sand.
		Arundel and Patuxent Formations (undivided)	<50 - 2,950	Aquifers and confining layers	White to light gray to orange brown, moderately sorted, angular and subrounded quartz sand; also gray to ocherous silt and clay beds, which occur in amounts ranging from less than 25% to greater than 75% of formation.
JURASSIC (?)	---	Unnamed	0 - 135	---	White quartzite conglomerate, dark gray, reddish-green and apple green shales, sandy shales, and arkosic sandstones. Does not outcrop on the Eastern Shore.
PALEOZOIC (?) & PRECAMBRIAN	Basement Complex			---	Believed to be chiefly schist, granite, gabbro, and gneiss.

1/ The nomenclature is that of the Maryland Geological Survey.

2/ Compiled from Rasmussen and Slaughter (1957), Hansen (1972; oral commun., 1982), and Weigle (1974).

FROM MGS R.I. No. 40, 1984

PWSID [1]	SYSTEM NAME	PLANT ID [2]	SRC. ID [3]	USE CODE [4]	SOURCE NAME	WAPID [5]	AVE. AMT. (gpd)	WELL PERMIT NO.	WELL DEPTH (ft.)	CASING DEPTH (ft.)	DATE DRILLED	AQUIFER
1050001	CHOPTANK ELECTRIC CORP.	01	01	P	WELL 1	CO2005G007	2300	n/a	360	n/a	1949	PINEY POINT FORMATION
1050002	COLONEL RICHARDSON MIDDLE SCHOOL	01	01	P	WELL 1	CO1978G004	7000	CO731247	300	n/a	1978	CHESWOLD AQUIFER
		00	90	U	UNUSED WELL	CO1978G004	0	CO040607	328	296	11/15/1960	CHESWOLD AQUIFER
		00	91	H	IRRIGATION WELL 1	n/a	n/a	CO942950	75	55	10/15/2005	QUATERNARY SYSTEM
		00	92	H	IRRIGATION WELL 2	n/a	n/a	CO942951	37	22	10/15/2005	QUATERNARY SYSTEM
1050004	DENTON ELEMENTARY	01	1	P	WELL 1	CO1974G023	3500	CO730310	260	247	9/12/1974	CHESWOLD AQUIFER
1050006	GREENSBORO ELEMENTARY	01	01	P	WELL 2	CO1973G001	6500	CO730124	355	335	10/3/1973	PINEY POINT FORMATION
		01	02	P	WELL 1	CO1973G001	6500	CO730063	360	339	6/5/1973	PINEY POINT FORMATION
1050008	MULHOLLAND HARPER COMPANY	01	01	P	WELL 1	CO1962G004	2800	CO050158	253	113	1/18/1963	CHESWOLD AQUIFER
1050011	TRI-GAS AND OIL CO.	01	01	P	WELL 1	CO1988G013	1900	CO812054	160	145	10/31/1989	FREDERICA AQUIFER
1050013	NORTH CAROLINE HIGH SCHOOL	01	01	P	WELL 1	n/a	7200*	n/a	355	n/a	1958	PINEY POINT FORMATION
		00	90	H	CATTLE WATERING WELL	CO1996G012	600	CO940206	27	22	4/10/1996	QUATERNARY SYSTEM
1050014	BURRIS RETAIL LOGISTICS	01	01	P	WELL 1	CO1983G004	14000	CO810358	260	140	2/20/1984	FEDERALSBURG AQUIFER
		01	02	P	WELL 2	CO1983G004	14000	CO811984	272	252	9/14/1989	FEDERALSBURG AQUIFER
		00	90	H	TRUCK SHOP WELL	CO1980G007	1000	CO731689	130	110	6/12/1980	FREDERICA AQUIFER
1050015	PILLSBURY -GENERAL MILLS	01	01	P	WELL 1	CO1969G003	9500	CO690031	305	256	10/28/1968	FEDERALSBURG AQUIFER
		01	90	H	IRRIGATION WELL	n/a	n/a	CO810830	60	40	4/26/1986	QUATERNARY SYSTEM

Table 2. Well Information

[1] PWSID = Public Water System Identification

[2] PLANT ID = Plant Identification. The water point of entry to a system from each well

[3] SRC. ID = Source Identification. Each well is considered a unique water source

[4] P = Production Well, H = Other Use Wells, U = Unused Wells

[5] WAPID = Water Appropriation Permit Identification   n/a = not available   * estimated pumpage

PWSID	SYSTEM NAME	WELLS INCLUDED IN WHPA	AVE. WELL PUMPAGE (gpd)	AVE. WELL PUMPAGE (ft^3/year)	SCREENED INTERVAL (H) (in feet)	CALCULATED WHPA RADIUS (ft) [1]	DELINEATED WHPA RADIUS (ft) [2]	ACREAGE OF WHPA	COMMENTS
1050014	BURRIS RETAIL LOGISTICS	WELL 1	14000	683064	15	761	800	45.9	
		WELL 2	14000	683064	20	659	700	35.2	Circle fully encompassed by larger Well 1 circle

Table 3. Parameters Used for WHPA Delineations Using an Average Pumpage of Greater Than 10,000 gpd

1 A porosity of 25% was assumed for the aquifer based on lithology and as a conservative estimate (Fetter, 1988)

2 Calculated radiuses were rounded-up for conservative purposes

Note: A fixed radius of 600 ft. was used for wells pumping an average of less than 10,000 gpd (MDE, 1999)

ID[1]	Type[2]	Facility Name	Address	[1]Reference Location	WHPA System Name(s)	[3]Potential Contaminants
1	UST	Greensboro Mobil	13760 Greensboro Rd.	Figure 2a	Greensboro E.S.	VOC, M
2	CHS	Technitrol, Inc.	Church St. & Cedar La.	Figure 2a	Greensboro E.S.	VOC, SOC, HM
3	PD	Growmark F.S., Inc.	702 W. Sunset Ave.	Figure 2a	Greensboro E.S.	SOC, NN
4	UST	St. Paul's United Methodist Church	300 W. Sunset Ave.	Figure 2a	Greensboro E.S.	VOC
5	UST	Bodie's Dairy Market (gas station)	100 N. Main St.	Figure 2a	Greensboro E.S.	VOC
6	UST	North Caroline High School	10990 River Rd.	Figure 2b	North Caroline H.S.	VOC
7	UST	North Caroline Career & Tech. Center	10855 Central Ave.	Figure 2b	North Caroline H.S.	VOC
8	ODS	Old West Denton Dump	River Rd.	Figures 2b, 2c	North Caroline H.S., Mulholland Harper, Choptank Electric	VOC, SOC, HM, NN, MP, M
9	GP	Delmarva Industries - Fil (US), Inc.	24562 - 24600 Meeting House Rd.	Figure 2c	Mulholland Harper, Choptank Electric	VOC, SOC, HM
10	CHS, GWDP	Mulholland Harper Company	24778 Meeting House Rd.	Figure 2c	Mulholland Harper, Choptank Electric	VOC, SOC, HM
11	MISC	Schultz & Sons Salvage	24769 Meeting House Rd.	Figure 2c	Mulholland Harper, Choptank Electric	VOC, HM, M
12	CHS, GWDP	Choptank Electric Corp.	24820 Meeting House Rd.	Figure 2c	Mulholland Harper, Choptank Electric	VOC, SOC, HM, M
13	MISC	The Hotrod Garage	24848 Meeting House Rd.	Figure 2c	Mulholland Harper, Choptank Electric	VOC, HM, M
14	MISC	Countryside Motors	River Rd.	Figure 2c	Mulholland Harper, Choptank Electric	VOC, HM, M
15	PD	Royster Clark	10413 River Landing Rd.	Figure 2c	Mulholland Harper, Choptank Electric	SOC, NN
16	LUST	Denton Citgo (now closed)	405 S. 5th St.	Figure 2d	Denton E.S.	VOC, M
17	MISC	Denton Volunteer Fire Co.	400 S. 5th St.	Figure 2d	Denton E.S.	VOC, HM
18	LUST	Caroline Nursing Home	520 Kerr Ave.	Figure 2d	Denton E.S.	VOC
19	MISC	Dry Cleaners @ Food Lion Shopping Center	840 S. 5th St.	Figure 2d	Denton E.S.	VOC
20	UST	High's Citgo	Shore Highway	Figure 2d	Denton E.S.	VOC
21	MISC	Hertrich Chevrolet / Admiral Tire	1123 Shore Highway	Figure 2d	Denton E.S.	VOC, HM, M
22	MISC	Dodge Truck Dealership	Shore Highway	Figure 2d	Denton E.S.	VOC, HM, M
23	GWDP	Midatlantic Farm Credit	379 Deep Shore Rd.	Figure 2d	Denton E.S.	HM, M
24	MISC	Preston Ford of Denton	1207 Shore Highway	Figure 2d	Denton E.S.	VOC, HM, M

Table 4. Potential Contaminant Point Sources within or near Wellhead Protection Areas

ID[1]	Type[2]	Facility Name	Address	[1]Reference Location	WHPA System Name	[3]Potential Contaminants
25	MISC	Giant GMC Trucks	3945 Federalsburg Highway	Figure 2f	Tri-Gas & Oil, Burris Retail Logistics	VOC, HM, M
26	MISC	Burris Retail Logistics	3946 Federalsburg Highway	Figure 2f	Tri-Gas & Oil, Burris Retail Logistics	VOC, HM, M
27	CHS	Tri-Gas & Oil Co., Inc.	3941 Federalsburg Highway	Figure 2f	Tri-Gas & Oil, Burris Retail Logistics	VOC, SOC, HM
28	MISC	Commercial Truck & Trailer	3922 Old Denton Rd.	Figure 2f	Tri-Gas & Oil, Burris Retail Logistics	VOC, HM, M
29	UST	Union United Methodist Church	301 N. Main St.	Figure 2g	Pillsbury-Gen. Mills	VOC
30	UST	A Sewing Outlet	121 N. Main St.	Figure 2g	Pillsbury-Gen. Mills	VOC
31	UST	Super Soda Center	102 W. Central Ave.	Figure 2g	Pillsbury-Gen. Mills	VOC
32	LUST, UST	Federalsburg Coastal / TG&O	105 E. Central Ave.	Figure 2g	Pillsbury-Gen. Mills	VOC, M
33	UST	Lucky Corner, Inc. (gas station)	301 Libery Rd.	Figure 2g	Pillsbury-Gen. Mills	VOC
34	CHS, GP	Maryland Plastics, Inc.	251 E. Central Ave.	Figure 2g	Pillsbury-Gen. Mills	VOC, SOC, HM
35	MISC	Brownie's Tires	220 S. Main St.	Figure 2g	Pillsbury-Gen. Mills	VOC, HM, M
36	GP	Federalsburg Wastewater Treatment Plant	125 Kerney St.	Figure 2g	Pillsbury-Gen. Mills	MP, NN, VOC, SOC, M
37	CHS, GP	Solo Cup Co.	1000 Industrial Park Rd.	Figure 2g	Pillsbury-Gen. Mills	VOC, SOC, HM
38	UST	S & S Market	521 S. Main St.	Figure 2g	Pillsbury-Gen. Mills	VOC

Table 4 (continued). Potential Contaminant Point Sources within or near Wellhead Protection Areas

[1] See referenced figure for location

[2] UST = Underground Storage Tanks, GWDP = Ground Water Discharge Permit Sites, CHS = Controlled Hazardous Substance Generators, PD = Pesticide Dealers

LUST = Leaking Underground Storage Tanks, ODS = Old Dump Sites, GP = General Permit Sites, MISC = Miscellaneous Sites

[3] VOC = volatile organic compounds, SOC = synthetic organic compounds

M = Metals, HM = Heavy Metals, NN = nitrate / nitrite, MP = Microbiological Pathogens

PWSID	SYSTEM NAME	PLANT ID	IOCs (except nitrate)		NITRATE		VOCs		SOCs	
			No. of Samples	No. of samples > 50% MCL	No. of Samples	No. of samples > 50% MCL	No. of Samples	No. of samples > 50% MCL	No. of Samples	No. of samples > 50% MCL
1050001	CHOPTANK ELECTRIC CORP.	01	5	0	15	0	4	0	0	
1050002	COL. RICHARDSON MIDDLE SCHOOL	01	6	0	16	0	7	0	0	
1050004	DENTON ELEMENTARY	01	6	0	15	0	7	0	0	
1050006	GREENSBORO ELEMENTARY	01	6	0	15	0	7	0	0	
1050008	MULHOLLAND HARPER COMPANY	01	5	0	17	0	7	0	0	
1050011	TRI-GAS AND OIL CO., INC.	01	4	0	13	0	7	0	0	
1050013	NORTH CAROLINE HIGH SCHOOL	01	6	0	15	0	12	0	3	0
1050014	BURRIS RETAIL LOGISTICS	01	4	0	20	0	6	0	0	
1050015	PILLSBURY -GENERAL MILLS	01	11	0	13	0	10	0	1	0

Table 5. Summary of Water Quality Results

PWSID	SYSTEM NAME	No. of Samples	No. of Positive Samples	Disinfection Treatment?
1050001	CHOPTANK ELECTRIC CORP.	39	0	NO
1050002	COL. RICHARDSON MIDDLE SCHOOL	59	2	NO
1050004	DENTON ELEMENTARY	37	0	NO
1050006	GREENSBORO ELEMENTARY	38	0	NO
1050008	MULHOLLAND HARPER COMPANY	39	1	NO
1050011	TRI-GAS AND OIL CO., INC.	40	3	NO
1050013	NORTH CAROLINE HIGH SCHOOL	57	0	NO
1050014	BURRIS RETAIL LOGISTICS	37	1	NO
1050015	PILLSBURY -GENERAL MILLS	88	0	YES

Table 6. Routine Bacteriological Monitoring Results from System Distributions Since 1996

PWSID	SYSTEM NAME	Is the Water System Susceptible to….			
		Regulated Inorganic Compounds (including arsenic & nitrate)	Volatile Organic Compounds	Synthetic Organic Compounds	Microbiological Contaminants
1050001	CHOPTANK ELECTRIC CORP.	NO	NO	NO	NO
1050002	COLONEL RICHARDSON MIDDLE SCHOOL	NO	NO	NO	NO
1050004	DENTON ELEMENTARY	NO	NO	NO	NO
1050006	GREENSBORO ELEMENTARY	NO	NO	NO	NO
1050008	MULHOLLAND HARPER COMPANY	NO	NO	NO	NO
1050011	TRI-GAS AND OIL CO., INC.	NO	NO	NO	NO
1050013	NORTH CAROLINE HIGH SCHOOL	NO	NO	NO	NO
1050014	BURRIS RETAIL LOGISTICS	NO	NO	NO	NO
1050015	PILLSBURY -GENERAL MILLS	NO	NO	NO	NO

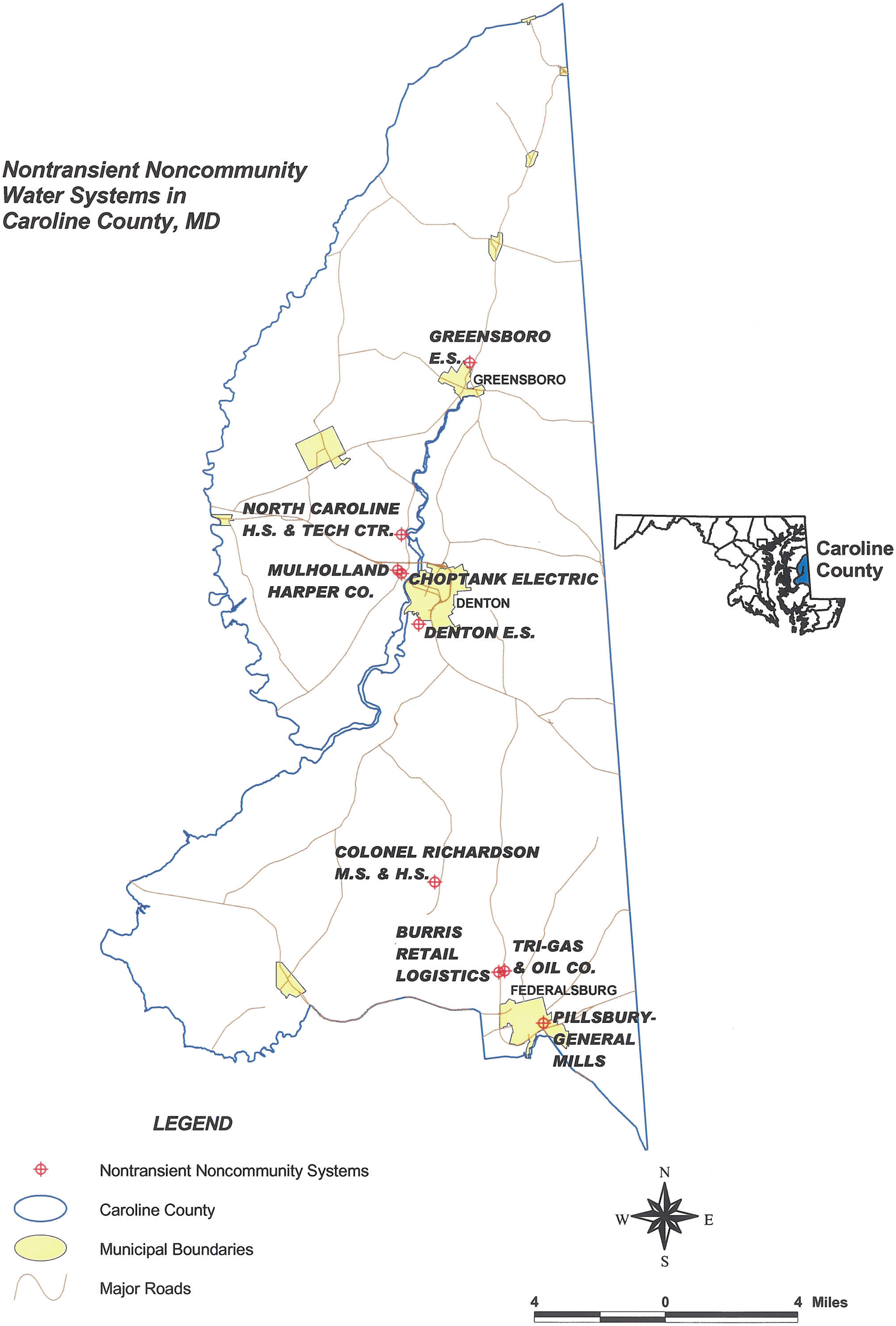
Table 7. Susceptibility Analysis Summary

PWSID	SYSTEM NAME	POPULATION
1050001	CHOPTANK ELECTRIC CORP.	80
1050002	COLONEL RICHARDSON MIDDLE SCHOOL	1022
1050004	DENTON ELEMENTARY	752
1050006	GREENSBORO ELEMENTARY	737
1050008	MULHOLLAND HARPER COMPANY	25
1050011	TRI-GAS AND OIL CO., INC.	90
1050013	NORTH CAROLINE HIGH SCHOOL	1028
1050014	BURRIS RETAIL LOGISTICS	75
1050015	PILLSBURY -GENERAL MILLS	83
	TOTALS	3892

Table 8. System Population Estimates

Figures

Figure 1. Nontransient Noncommunity Water Systems in Caroline County, MD



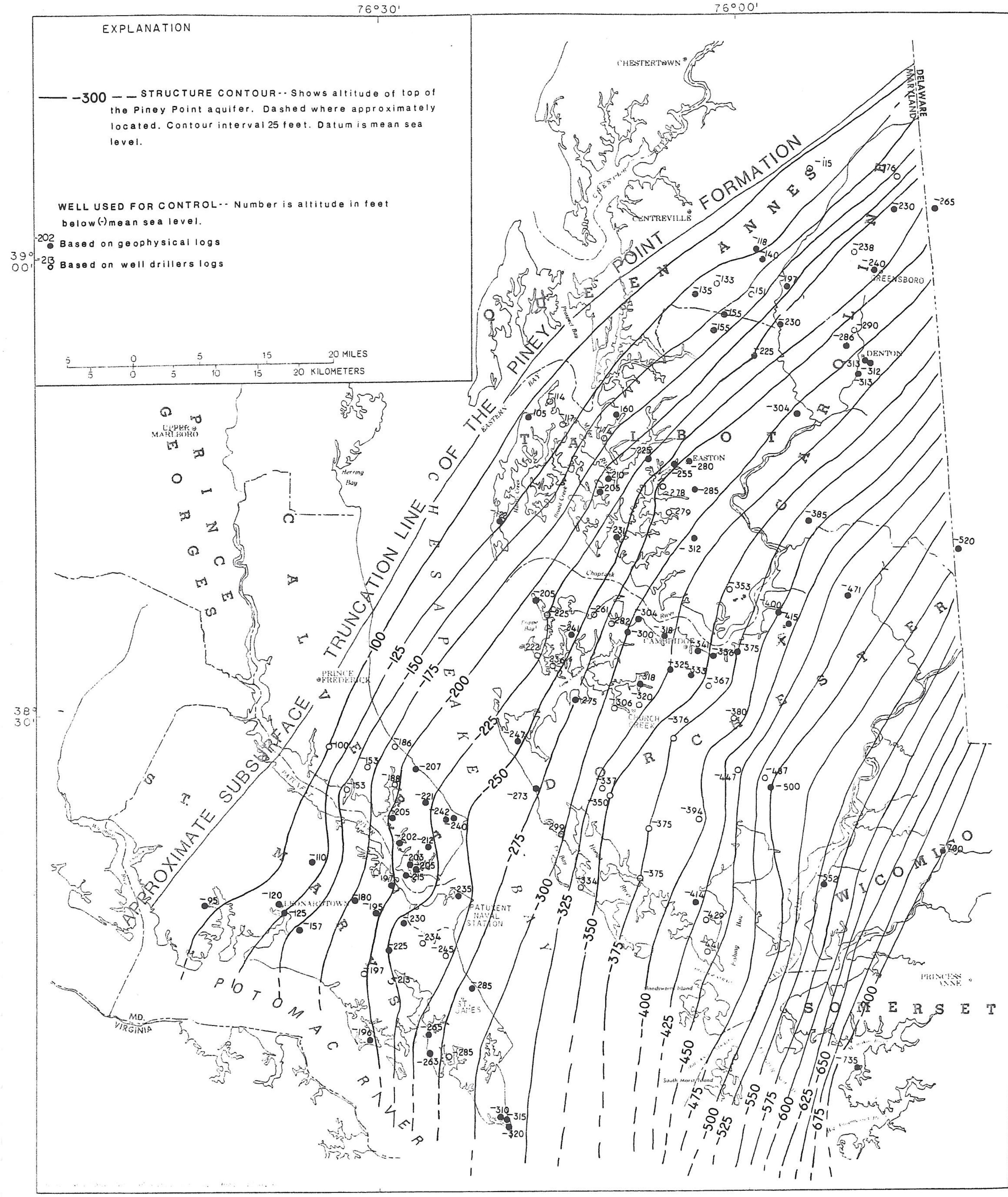


Figure 3.—Altitude of the top of the Piney Point aquifer.

FROM MGS R.I. No. 31, 1979

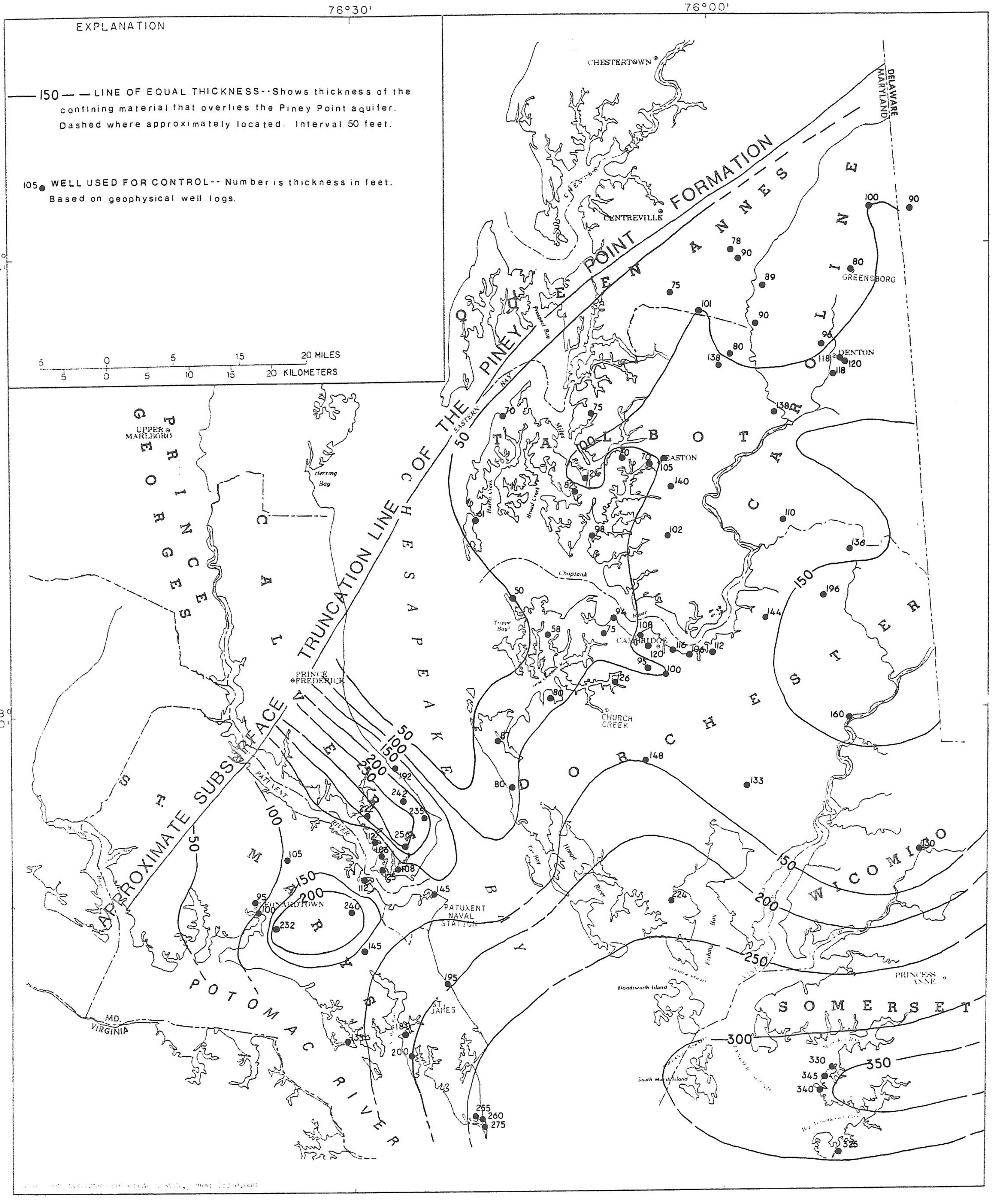


Figure 4. —Thickness of the confining material overlying the Piney Point aquifer.

FROM MGS R.I. No. 31, 1979

APPENDICES

Appendix B

Summaries of open cases near the Caroline County Nontransient Noncommunity WHPAs from the MDE Oil Control Program

CASE NO.	NAME	LOCATION	STATUS AS OF MARCH 2006
00-1376CO	COASTAL / TG&O	105 E. Central Ave., Federalsburg	Old underground tanks were removed. Low-levels of dissolved volatile organic compounds were detected in soils and shallow ground water on the property. Inspector also observed oil sheen in Marshyhope Creek located just to the east of the gas station. Monitoring wells were installed. Samples were collected and tested for VOCs from these monitoring wells, and levels have been decreasing over the past couple of years. The station appears out-of-business based on a recent site survey conducted on 2/27/06. The Oil Control Program is awaiting the monitoring well abandonment and sealing records prior to closing the case.
01-1344CO	CAROLINE NURSING HOME	520 Kerr Ave., Denton	There was a heating oil release from an underground storage tank on this property. The Oil Control Program Remediation Division is actively investigating this site for possible contamination issues. Please contact Fred Keer of the Oil Control Program for additional information.
04-0910CO	DENTON CITGO	405 S. 5th St., Denton	Old USTs were removed. Moderate levels of VOCs were detected in shallow ground water during the excavation. Contamination is believed to be limited to the tank field area on the property. The gas station is now closed and there are no active pumps on the property. The Oil Control Program Remediation Division is currently investigating this site.

MDE Oil Control Program Open Cases near Caroline County NTNC Wellhead Protection Areas

Appendix C

General information of sites with historical soil, and shallow aquifer ground water contamination concerns near the Caroline Co. Nontransient Noncommunity WHPAs from MDE Waste Management Administration

MD-438 Caroline County	
1944-1948	Site was a small sand and gravel operation.
1948-1960	Site was used as a municipal dump.
1992	HSWMA prepared a *Preliminary Assessment* report, concluded the potential for release of hazardous waste was significant.
1994	EPA prepared a *Screening Site Inspection* Report.
1999	WMA prepared a Site Suvey, concluded MDE had further requirements for investigation of site. EPA concurred.

OLD WEST DENTON DUMP
Denton, Maryland

Site Location

The 10-acre Old West Denton Dump site is located in a rural area of Caroline County outside the town of Denton, on the eastern shore of Maryland. The property does not have a street address. No buildings or active operations are on site. The site is located in the Coastal Plain Physiographic Province. The site coordinates are 38° 54′ 2.57″ North and 75° 50′ 15″ West.

The area of the dump site is used for residential, recreational, commercial and agricultural purposes. The Choptank River and wetlands are to the east of the site. River Road and a wooded area are directly to the west. Residences and wetlands are to the north. Wetlands, residences, a small engine repair shop and chicken barns are immediately south and southwest of the site. Individuals may transverse the site while hunting or walking pets. In addition, children may trespass onto the site while playing.

The rectangular site is entirely overgrown with trees and thick underbrush. The terrain is flat. The only topography consists of a foot-high man-made berm along the eastern side of the property that may have been made from dumped material. Wetlands and the Choptank River are adjacent to the east. Approximately three acres of the site are classified as palustrine, forested, broad-leafed-deciduous wetlands. Residences are north and south of the site. The nearest home well is located 150 feet north of the site.

Site History

The Old West Denton Dump was originally a small sand and gravel mining operation from 1944 to 1948. Excavation within the 10-acre site was performed manually to an approximate depth of three feet or less. The site became a municipal dump circa 1948 and continued operations until 1960. The town of Denton disposed of its municipal waste at the site but the arrangements made by the town are unknown. Individuals disposed of household or business wastes such as lumber scraps and wood shavings. The disposed material was burned on site and then leveled with a bulldozer, as needed. Material was also buried. The landfill, which was not lined, had not been capped as of 1994.

No permits are known to have been held by past or present owners. Although the Maryland Board of Health has required disposal permits since 1914, no permit was issued for this site during its operation. Inspection reports from 1957 indicate that the Nuttle Lumber and Coal Company owned the site and that complaints were received from nearby residents about windblown debris.

Environmental Investigations

The Maryland Department of the Environment, Hazardous and Solid Waste Management Administration (HSWMA) prepared a *Preliminary Assessment* report of the Old West Denton Dump in July 1992. The report concluded that the potential for release of hazardous waste from the site to the environment was significant.

The U.S. Environmental Protection Agency (EPA) prepared a *Screening Site Inspection* report of the Old West Denton Dump in March 1994. For the report, on-site soil, surface water and sediment samples were collected and a home well located 250 feet north of the site was sampled. No organic or inorganic chemicals were detected in the home well samples above the detection limit, except iron. Low levels of 1,2-dichloroethene and trichloroethene were also detected. Pesticides were detected in on-site soils and off-site sediments. Low concentrations of pesticides are common in environmental samples taken from agricultural areas. Low levels of tetrachloroethene were also detected in on-site soils. Concentrations of 4,4'-DDE, 4,4'-DDT, and methoxychlor were detected in on-site soil samples at concentrations significantly higher (e.g., three times greater) than in the off-site soil sample. Inorganic soil constituents (arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury and zinc) were detected in soil samples at maximum concentrations greater than those detected in the background soil sample. Iron, lead, and manganese were detected in the one surface water sample at concentrations that have a potential to adversely affect aquatic life. No organic contaminants were detected in this sample.

In 1999, MDE's Waste Management Administration prepared a *Site Survey* for the Old West Denton Dump. The report concluded, on the basis of the available information, that MDE had further requirements related to the investigation of hazardous waste at this site and recommended that the EPA consider the site for further investigation. EPA concurred with the recommendation.

Current Status

This site is on the State Master List that identified potential hazardous waste sites in Maryland. The Master List includes sites currently identified by the EPA's Comprehensive Environmental Response Compensation and Liability Information System. EPA has given the site a designation of No Further Remedial Action Planned (NFRAP). The designation of NFRAP by EPA does not mean that MDE has reached the same conclusion concerning further investigation at the site. The information contained in the fact sheet presents a summary of past investigations and site conditions currently known to MDE.

Facility Contact

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