US Army Corps
of Engineers
Baltimore District

Maryland Port
Administration

Baltimore Harbor Anchorages and Channels, Maryland

Integrated Feasibility Report and Environmental Impact Statement

Technical Appendices

APPENDIX J - GROUNDWATER INVESTIGATION REPORT

March 1997

US Army Corps
of Engineers
BALTIMORE DISTRICT

GROUNDWATER INVESTIGATION REPORT
COX CREEK/CSX DREDGE MATERIAL PLACEMENT AREA
ANNE ARUNDEL COUNTY, MARYLAND

Prepared as part of

BALTIMORE HARBOR ARCHORAGES AND CHANNELS INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

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Executive Summary

A groundwater investigation was conducted at the former adjacent dredged material placement sites known as Cox Creek and CSX. Currently the Cox Creek and CSX placement sites have dikes at respective elevations of 15 and 20 feet (msl). This site has been targeted for reactivation as a repository for dredged material from the Baltimore Harbor Anchorages and Channels Project. Depending upon the amount of dredged material generated and the final operation plan, the site will probably be used for maintenance dredge disposal. Experience in the Baltimore harbor indicates that dredged material from maintenance operations is primarily composed of clay.

The purpose of the investigation was to determine: 1) the site-specific geologic and hydrogeologic conditions, 2) the current groundwater flow directions on and around the site, 3) the current and potential groundwater use in the area, including human receptors, and 4) the affect of a dredged material placement site on the quality or quantity of groundwater, including any future conditions such as drought which could alter current groundwater flow conditions. Existing wells were identified and located, eleven new wells were installed, groundwater levels were monitored, a pumping test was performed, and a groundwater model was constructed. Results of the investigation are as follows:

1) Published geologic literature describes a surface aquifer, a regional confining layer, and a deeper aquifer, all contained within the Cretaceous Patapsco Formation. Well bores performed for this investigation support this basic conceptual model, however the Upper Patapsco surface aquifer does not appear to exist over most of the Cox Creek/CSX site. Instead, there is a thick clay (with a few sand and silt layers) which extends from the surface to a depth of about 150 ft. This clay would be classified as the upper portion of the Lower Patapsco with the aquifer sands located below this clay. Below the Lower Patapsco lies a thick, dense unit known as the Arundel Clay which forms an effective lower boundary to the shallow aquifer flow system.

2) Based on several rounds of synoptic water level measurements, groundwater at the site is flowing east, toward Sparrows Point. Well clusters located directly on the dike next to the Patapsco River indicate that there is a downward vertical gradient. Water levels in the Lower Patapsco Aquifer are actually below sea level. This surprising observation violates the standard coastal groundwater model where the major waterway represents the effluent point for groundwater flowing through the aquifer. This indicates that there is significant pumping located to the east of the site. Analysis of regional water levels suggests that the industrial pumping by Bethlehem Steel at Sparrows Point may be contributing to the downward vertical gradients. Bethlehem Steel claims to be pumping from a deeper aquifer (the Patuxent), however the USGS observation well located on their property shows the lowest Patapsco Aquifer water level in the region (1.7 ft below msl). Bethlehem Steel reportedly pumps over 103 million gallons per month (3.4 mgd) from the Patuxent Aquifer. Their pumping center is located about 3 miles east of the Cox Creek/CSX placement area. There may be other industrial pumpers contributing to the downward gradients.

3) There is no current or potential groundwater use in the area of the placement area. Anne Arundel County's municipal wells are located in various sites around the city of Glen Burnie, about six miles southwest of Cox Creek/CSX. Based on the 1990 appropriation, Anne Arundel County is allowed to pump 11.8 mgd from the Patapsco Aquifer, though actual pumpage probably does not exceed 9 mgd. Though more water-level data are needed to accurately define the radius of influence for this well field, existing data indicate that its closest point lies three to four miles southwest of the Cox Creek/CSX placement area. Existing wellhead protection investigations and modeling support this conclusion. Based on the master plan of Anne Arundel County, there are no plans to drill any other Lower Patapsco wells in this part of the county.

Interviews with residents indicate that there are only two households still utilizing groundwater in the area. These houses are located roughly at the intersection of Ft. Smallwood and Kembo roads and are located more than a mile upgradient from the Cox Creek/CSX placement area. According to the groundwater model, the small amount of pumpage from these wells is not able to create a measurable reversal in the regional flow direction.

4) Based on groundwater modeling, expansion of the Cox Creek/CSX dredge material placement area will not affect flow direction or quality of groundwater. Several different placement area scenarios were modeled: current conditions, impoundment elevations of 28 and 39 ft., impoundments filled with both water and dredge material (clay), and drought. In all cases, the placement area had no substantial effect. Groundwater flow in the Lower Patapsco Aquifer was never affected. Model results indicate that there will be groundwater flow in the surface clay from the placement area to the wetlands located adjacent to the southwest. The extremely low hydraulic conductivity of the clay, however, makes any contribution from the placement area *de minimis* in quantity. Particle tracking was performed to estimate groundwater travel times out of a filled, 39-foot impoundment. The worst case scenario, with no retardation, indicated that over a 100-year simulation, horizontal travel distance totaled slightly more than a foot; vertical travel distance totaled slightly less than a foot.

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1.0 Project Description and Goals

The purpose of this report was to determine: 1) the site-specific geologic and hydrogeologic conditions, 2) the current groundwater flow directions on and around the site, 3) the current and potential groundwater use in the area, including human receptors, and 4) the affect of a dredged material placement site on the quality or quantity of groundwater, including any future conditions such as drought which could alter current groundwater flow conditions. The goal of the project is to assist in developing the Baltimore Harbor Anchorages and Channels Feasibility Study by providing specific guidance concerning potential impacts to ground water and site wetlands resulting from placement of dredged sediments containing a variety of contaminants from the Inner Harbor.

This report has been written to communicate basic ideas and results to a wide audience. Understanding the details of the investigation, however, requires a working knowledge of basic hydrogeologic principles and groundwater modeling techniques. For more basic information on the subject, the reader is referred to Anderson and Woessner, (1992).

2.0 Geology

2.1 Regional Geology

The CSX/Cox Creek site is located within the Atlantic Coastal Plain Physiographic Province which is characterized by sequences of marine and terrestrial sedimentary deposits. The western limit of the province is referred to as the Fall Line, where the older igneous and metamorphic rocks of the Piedmont Province meet the younger sediments of the Coastal Plain. The Fall Line is located about 8 miles west of the site (Mack, 1962). The location of the study area is shown in Figure 1.

The Coastal Plain in Maryland consists of a southeastward-thickening wedge of unconsolidated and poorly-consolidated clays, silts, sands and gravels that have been deposited by a combination of processes, including: marine transgressions and regressions caused by Pleistocene glaciations, rivers and streams cutting channels thereby leaving channel and floodplain deposits of sands and clays, respectively, and by tectonic (structural movement) of the basement rocks (Glaser, 1976).

The Patuxent Formation is the basal unit of the Potomac Group, and overlies a crystalline bedrock surface. The formation consists principally of complex combinations of sand and gravel with lesser amounts of silt and clay typical of riverine deposits. This formation was too deep to be encountered by the wells for this study, but typically consists of irregularly stratified layers of sand and gravel derived from channel and river bar environments exhibiting relatively thin beds, pods, and ribbons of silt and clay associated with overbank deposits. This

formation is estimated to be approximately 200 feet thick near the site and lies at an approximate depth of 350 feet.

The Arundel Formation overlies the Patuxent Formation and is believed to represent a floodplain overbank deposit. The Arundel was too deep to be encountered by the wells in this field study, but is described as a reddish-brown to dark-gray, tough and massive clay, with minor occurrences of sand beds. This clay unit is estimated to be approximately 100 feet thick at the site and lies at an approximate depth of 250 feet. It is an efficient confining layer and was used as the lower boundary of the flow model discussed in later sections.

The Patapsco Formation overlies the Arundel Formation and was deposited in a riverine environment. Its depositional characteristics are similar to those of the Patuxent Formation. The Maryland Geological Survey subdivides this unit into the Upper and Lower Patapsco. The Upper Patapsco consists primarily of clays and silts. The Lower Patapsco contains a confining clay layer at the top, with the lower layers composed primarily of sands and gravels (Otton and Mandel, 1984).

2.2 Cox Creek/CSX Geology

Available geologic information indicates that the area near the site is underlain by Cretaceous age sediments of the Potomac Group. The eastern portion of the site, adjacent to the Patapsco River shoreline, is identified on the Geologic Map of Anne Arundel County as artificial fill which could contain sand, gravel, slag, construction debris, and/or dredged material. The major geologic units of concern at the site include sediments associated with the Patapsco Formation, Arundel Formation and Patuxent Formation, all members of the Potomac Group (Glaser, 1976; Otton and Mandle, 1984)

The Upper Patapsco consists of a fine to medium, brownish-yellow sand with an average thickness of 100 feet. In the study area, much of the Upper Patapsco has been eroded away leaving the Lower Patapsco which consists of a confining clay overlying a fine to medium-grained, brownish-yellow sand. The thickness of the confining clay is approximately 150 feet at the site. The interbedded sands, silts, and clays below the confining layer are approximately 100 feet thick at the site.

Overlying the Patapsco Formation in the easternmost portion of the site may be Holocene and Pleistocene alluvium associated with the Patapsco River and Chesapeake Bay. The average thickness of these deposits varies from zero to five feet. At the dredge placement site, there may be up to 20 feet of recent dredged fill overlying the Patapsco, Holocene, and Pleistocene alluvium where present (Glaser, 1976).

Two of the wells in this study (C-1 and F-3, shown on Figure 3) are located in the low-lying areas of Cox Creek in the Swan Creek drainage system that extends through the study area. These borings appear to be located along the trend of a former stream channel which may have been cut during a low sea level stand during a Pleistocene glaciation. Based on typical depositional models, the channel was probably filled with sand and organic matter, followed by silts and clays as sea level rose during an interglacial. In well C-1, sands extend from the surface to a depth of at least 150 feet. Well F-3 is composed almost entirely of silt.

Two of the wells (H-2 and I-2) were drilled on the dikes which extend into the original Patapsco River channel. Though mostly comprised of clay, both of these wells contain more sand layers than those drilled on the headland. In H-2, gravely sands containing bivalve shells and peat are found at the bottom of the boring at 145 feet, and strongly indicate a Quaternary age for these channel fill deposits.

3.0 Hydrostratigraphy

3.1 Regional

The Coastal Plain sediments have been subdivided into 11 regional aquifers separated by 9 confining units (Trapp, 1992). These aquifers are as follows:

1. Surficial aquifer
2. Upper Chesapeake aquifer
3. Lower Chesapeake aquifer
4. Castle Hayne-Piney Point aquifer
5. Beaufort-Aquia aquifer
6. Peedee-Severn aquifer
7. Black Creek-Matawan aquifer
8. Magothy aquifer
9. Upper Potomac aquifer
10. Middle Potomac aquifer
11. Lower Potomac aquifer

The basis for the division of the aquifers is continuity of permeability. Adjacent permeable beds or those separated by only minor thicknesses of low permeability materials such as clay or silt, may be considered to be parts of the same aquifer. The framework of the regional aquifer system could be represented by larger or fewer numbers of aquifers than 11. Subsurface data are insufficient to further subdivide the regional sedimentary section, although locally, additional aquifers can be defined, as has been done for the Upper and Lower Patapsco aquifers, in Anne Arundel County, which are part of the Middle Potomac aquifer in the Regional system (Trapp, 1992).

3.2 Anne Arundel County Hydrogeology

The aquifers which overlie bedrock in Anne Arundel County are from oldest to youngest, the Patuxent, Lower Patapsco, Upper Patapsco, Magothy and Aquia aquifers. The Aquia and Magothy aquifers are not present in northern Anne Arundel County near the study area. The Patapsco Aquifer System in Anne Arundel County consists of an upper and lower aquifer separated by a confining unit of variable thickness (Mack, 1962; Achmad 1991).

In the project area, the Patapsco Aquifer System is about 250 feet thick, and is comprised of the confining layer and Lower Patapsco Aquifer. The Upper Patapsco Aquifer appears to be erosionally truncated. The Lower Patapsco Aquifer overlies the Arundel Formation (Arundel Clay) and is a major source of ground water for large public supply wells for Anne Arundel County. County well fields pumping from the Lower Patapsco are located approximately five to six miles to the west of the site, in various locations around the city of Glen Burnie.

Regionally, the groundwater flow pattern is from west to east. Inland, to the west of the project area, water levels are higher in the upper aquifer than in the lower suggesting a downward vertical component of flow (recharge). Published literature indicates that artesian pressures exist in the Lower Patapsco Aquifer on the eastern side of the peninsula reflecting an upward flow of water to the Patapsco River (Achmad, 1991). This, however, was not observed in the wells for this investigation. Instead, water levels in the Lower Patapsco Aquifer are actually below sea level. This surprising observation violates the standard coastal groundwater model where the major waterway represents the effluent point for groundwater and is discussed below.

3.3 Cox Creek/CSX Hydrogeology

The recent ground water investigation at the site shows that the area is underlain by two principal aquifers, one in the Quaternary sediments overlying the confining clay layer in the Lower Patapsco, and the other in the Lower Patapsco sands beneath the confining layer. The shallow water-bearing zone is an unconfined (water table) aquifer and is not present in the area of the Cox Creek/CSX disposal cells. The second, confined aquifer is located in the Lower Patapsco. These aquifers consist primarily of sands and gravels with numerous areas of lower permeability materials (aquitards). The Patapsco Aquifer, as described above, is separated from the deeper Patuxent Aquifer by the confining silts and dense clays of the Arundel Formation.

The local groundwater originates from infiltration in recharge areas located where the formations outcrop (are exposed at the ground surface). The water generally percolates through the more permeable sand and gravel units and in places is segregated from water in other beds by less permeable silts and clays resulting in local confined (artesian) conditions. Local variations in the groundwater flow direction have been found to exist due to elevation, irregularities in sedimentation, and the location of aquitards.

Locally at the study area, ground water elevations are higher in the water table aquifer than in the lower aquifer. In fact, water levels on the eastern side of the site are below sea level in the Lower Patapsco. This suggests that there is significant pumping located to the east of the site. Analysis of regional water levels suggests that the industrial pumping by Bethlehem Steel at Sparrows Point may be contributing to the downward vertical gradients. Their pumping center is located about 3 miles east of the Cox Creek/CSX placement area. Bethlehem Steel claims to be pumping from a deeper aquifer (the Patuxent), however the United States Geological Survey (USGS) observation well located on their property shows the lowest Patapsco Aquifer water level in the region (1.7 ft below msl). In the first six months of 1996, Bethlehem Steel Corp. pumped over 103 million gallons per month (3.4 mgd) for cooling and/or process water. The regional ground water contour map showing ground water elevations in the Lower Patapsco is presented in Figure 2. This map is a composite, showing data from different years, but the same season. It proved to be impossible to acquire regional data from disparate sources for exactly the same time period.

The water table in the surface aquifer was not contoured due to a lack of data. Unlike the deeper confined aquifer, the unconfined surface aquifer is largely controlled by topography. Water level data are shown in Table 1, and well locations are shown in Figure 3.

Different scenarios for groundwater flow based on present and possible future events are discussed in Section 6.3.

3.4 Groundwater Use

Anne Arundel County currently provides approximately 90% of its public water requirements through groundwater withdrawals from three geologic formations which overlie bedrock. The County has 65 production wells including several standby wells and wells currently being repaired, redrilled, abandoned, or under construction. These wells are located at twenty-three locations throughout central and northern Anne Arundel and are grouped into 9 separate service areas. The existing wells have the potential to supply approximately 50 mgd (million gallons per day) if they are all pumped simultaneously at their present capacity. In addition to the pumping capacity, the county can withdrawal up to 30 mgd from Baltimore City via pipeline (personal communication, Richard Dixon, Anne Arundel Co. Engineer, 2 Oct 96). The number of Lower Patapsco wells has been reduced to 12 due to a decrease in the base flow of streams observed in areas near the well fields. The total 1990 appropriation for the Patapsco Aquifer is 11.8 mgd; however, 1992 pumpage totaled only 5.3 mgd (Wilson and Achmad, 1995).

In an effort to increase the capacity of the County water supply system and to more efficiently utilize their groundwater resources, the County has evaluated future sources of groundwater supply. Potential well locations were based on a Water Supply Systems Analysis completed in the 80's which utilized a quasi three-dimensional finite difference ground water flow model (Mack and Achmad, 1986), plus various analytical models to determine the optimum location of potential well fields in the County. The locations of potential wellfields are shown in

Figure 4. Note that no new Lower Patapsco fields are planned in the region of the Cox Creek/CSX placement area. The total capacity of all proposed future well fields is approximately 53 mgd. This brings the county's proposed grand total to 103 mgd.

The closest residential community to the Cox Creek/CSX site is approximately one mile west, at the corner of Fort Smallwood and Kembo roads. The community has been supplied with city water; however, interviews with residents indicate that there are two households still utilizing groundwater in the area. One property, 7014 Ft. Smallwood Rd. (Mike Frank), has two wells. One is for household use with an estimated daily pumpage of 900 gallons from a depth of 165 feet. The other well, completed at a depth of 205 feet, is used to fill up commercial water trucks, and the estimated daily pumpage is 3200 gallons. Located about a block away, the residence of Charlotte Tayman also utilizes groundwater. The depth of this well is unknown. The daily pumpage was estimated to be 900 gallons. Affects from the pumpage from these domestic wells were simulated in the groundwater model discussed in Section 6.

Future land use in this area is zoned for light industrial (personal communication, Bahid Tayebi, Anne Arundel Co. planner, 22 Aug 96). On the other side of the peninsula near Tanyard Cove, however, a large housing development has been approved for 2300 housing units with mixed commercial. Water and sewerage for this development will be supplied by Anne Arundel County.

Because of the availability of city water and proposed land use, no other domestic or commercial wells are expected to tap the Patapsco aquifers in the region of the Cox Creek/CSX placement area site.

4.0 Previous Investigations

Two previous field programs were conducted in the CSX/Cox Creek containment areas. Woodward-Clyde conducted an Environmental and Geotechnical Characterization Study for the CSX portion of the site in 1992, and EA Engineering, Science, and Technology conducted a Phase II Environmental Site assessment for the Cox Creek portion of the site in 1994. Other regional investigations used in this study are listed in the references.

Concurrent with this investigation, the Maryland Environmental Service (MES) conducted a Site Operational Assessment Study for the Maryland Port Administration (MPA) to assess the feasibility and operational plan for the proposed Cox Creek/CSX Dredged Material Placement Site. Results from this study were not conclusive, based on insufficient geotechnical data to assess the strength of the foundation material. Some of the conclusions relevant to this groundwater investigation include:

a) There is enough on-site material to extend the dikes to an elevation of 22 feet (MSL).

b) The dikes must be extended to an elevation of 28 feet to supply a containment capacity of 3.7 million cubic yards (mcy) and an operational life of 7 to 8 years. Current information suggests that the foundation strength is probably sufficient to support 28-foot dike elevations, although more geotechnical data are needed to confirm this.

c) The dikes must be extended to an elevation of 39 feet to supply a containment capacity of 6 mcy and an operational life of 12 years. Current information suggests that there may be insufficient foundation strength to support this. Again, more geotechnical data are required.

There is reportedly an environmental investigation recently completed by Cox Creek Refining Company on their refinery property. This parcel is directly upgradient from the dredge material placement site. Work was reportedly conducted by EA Engineering and was under the regulation of the Maryland Department of the Environment (MDE). No information could be gathered from this investigation; however, the Corps did acquire a copy of a transmittal letter (22 Aug 96) from MDE and the Cox Creek Refining Company's executed Consent Order (2 Aug 91). The letter stated that all outstanding issues with the consent order were brought "to a close".

5.0 Site Characterization

5.1 Well Drilling and Installation

Monitoring wells which were installed as part of this project were designed and installed in accordance with EM 1110-1-4000 and Maryland Department of the Environment (MDE) regulations governing well construction (Title 26, Subtitle 04, Chapter 04). The wells were installed by the Field Exploration Unit of the Baltimore District Corps of Engineers.

Eleven new wells were installed in the project area in seven well clusters during the period from 20 May 1996 to 8 August 1996. A map showing the locations of the wells is shown in Figure 3. Drill logs containing lithologic descriptions, and drilling method information is contained in Appendix A.

With the exception of wells F-3 and F-2, all wells installed for this investigation were 4 inches in diameter. Well F-3 was installed as a 2-inch observation well for the pumping test. Well F-2 was a six-inch well intended to be the pumping well for the pumping test. Unfortunately, difficulties were encountered during installation, and the well never showed proper communication with the aquifer, regardless of repeated development attempts. In spite of its larger diameter, relatively small quantities of water could be pumped from F-2, and it exhibited a non-Theisian response to the pumping test. Well F-1 was used as the pumping well for the test. As-built well records which describe drilling methods and materials used are included in Appendix B.

5.2 Well Development

Wells were developed using simultaneous pumping and surging with an air compressor actuated piston/pump assembly and/or with a submersible pump. Measurements of conductivity, temperature, and pH were made before, during, and after development to monitor the progress of purging the well. Details of well development are provided in Development Records provided in Appendix C

5.3 Aquifer testing

The US Army Corps of Engineers, Baltimore District, conducted an aquifer testing program at the Cox Creek Site for the Maryland Port Authority from 19-27 July 1996. All labor and equipment were supplied by the Geology and Investigations Section and the Field Exploration Unit. This testing was conducted to obtain aquifer parameters necessary to conduct a site groundwater flow simulation. These parameters include: hydraulic conductivity (K), transmissivity (T), storage (S or Sy), and vertical leakance. A Static Monitoring test was conducted to observe the response of certain wells to diurnal (2 high tides, 2 low tides, every 24 hours) fluctuations. In addition to the aquifer tests, the water levels in all available wells were regularly measured from 20 May 96 to 4 Oct 96. These data are shown in Table 1.

5.3.1 Static Monitoring Test

A Static Monitoring test of water levels was performed prior to the pumping test in order to evaluate tidal and other potential influences on site groundwater. The long term background test started on 19 July and ended 27 July 1996. Pressure transducers and data loggers were installed in wells E-1, G-1, and H-2 to monitor water levels in the Lower Patapsco Aquifer under static conditions. The water level records for these wells are shown in Figure 5. Well H-2 showed the greatest amplitude of tidal changes since it is the closest to the Bay. The tidal fluctuations in G-1 are attenuated, but present. Observe that the ground water elevations in both of these wells are below MSL for much of the cycle. This is probably due to the large withdrawals (over 200 mgd) from the Patuxent aquifer at Sparrows Point by Bethlehem Steel.

Well E-1 is located the furthest of the three wells from the shoreline. Consequently, tidal fluctuations observed in this well are most attenuated. The graph of the ground water elevations (Figure 5) for this well shows a muted tidal cycle. The downward spike at 6,400 minutes was caused by adjustment of the pump in well F-2 prior to the start of the Constant Rate Pumping Test. The lower water levels in E-1 beginning at 10,000 minutes reflects the beginning of the test. Data from this long term monitoring were also used in the estimation of parameters below.

5.3.2 Constant Rate Pumping Test

A constant rate pumping test was conducted from 1200 hours on 24 July to 1500 26 July 1996. Well F-1 was the test well and was pumped at approximately 62 gallons per minute. The pumping rate did vary slightly during the test, but the discharge was within +-10% of 62 gpm throughout the test. Wells F-2, F-3 and E-1 were used as observation wells during the test. During pumping, drawdown was observed in all of these wells.

Discharge of extracted groundwater was directed to the ground surface approximately 300 feet from the pumping well so as to not present a potential recharge source of water. Because this water is discharged from a drinking water aquifer, no environmental testing was indicated.

As mentioned earlier, drawdown data for well F-2 were not used to estimate aquifer parameters since problems encountered during construction affected the flow response through the screen of the well.

The software used to analyze the test results was AQTESOLVE, v2.2, published by Geraghty and Miller. The data indicate that well F-3 produced reasonable estimates of aquifer parameters. A transmissivity (T) value of 1411 ft^3/day and a storativity (S) value of $1.1x10^{-4}$ were obtained using the Hantush method (as described in the AQTESOLVE manual v2.2). The geologic literature and site information indicate that the Lower Patapsco Aquifer is approximately 100 feet thick. This translates to a hydraulic conductivity (K) of 14 ft^2/day.

Drawdown data were extracted from the long term data collected for E-1 to account for tidal effects. A transmissivity (T) value of 2507 ft^3/day (K = 25 ft^2/day) and a storativity (S) value of $2.2x10^{-4}$ were obtained using the Hantush method. The Cooper-Jacob method provided a transmissivity of 2450 ft^3/day (K = 24.5 ft^2/day) and a storativity value of $2.5x10^{-4}$. The Cooper-Jacob method was used with a stability criteria of u = 0.1. Test data and graphical results are provided in Appendix D.

5.3.3 Recovery Test

At the conclusion of the 72-hour pumping test phase, the recovery of water levels in the observation wells (F-2, F-3, and E-1) was gauged. Each well was allowed to recover to at least 90% of the initial static water level. All of the wells observed recovered 90% or more of the induced drawdown. The Theis recovery method provided a transmissivity of 3555 ft^3/day (K = 35.5 ft^2/day) for E-1, approximately 2350 ft^3/day (K = 23.5 ft^2/day) for well F-3, and 2484 ft^3/day (K = 25 ft^2/day) for F-2.

5.3.4 Aquifer Test Results

The pumping test proved quite successful. A number of different observation points, analyzed with multiple methods, all yielded similar results. Hydraulic conductivities ranged from 14 to 35 ft^2/day with most values clustered around 25 ft^2/day. Storativity values ranged from 1.1×10^{-4} to 2.5×10^{-4}.

6.0 Groundwater Modeling

6.1 Numerical Model

The model chosen for this investigation was FEMWATER (Lin, et al., 1996), published by the US Army Corps of Engineers, Waterways Experiment Station. This is a finite-element model capable of handling density-driven flow (brackish water) and vadose-zone (unsaturated) transport. Both of these conditions were considered a possibility when the modeling investigation was being scoped. The final model, however, did not utilize density-driven flow or vadose-zone transport.

The geological visualizations and modeling interface were performed with the Department of Defense Groundwater Modeling System (GMS). Geological visualizations and model development were conducted in Baltimore. This application of FEMWATER required about 260 Megs of RAM and was executed on a UNIX system at Waterways Experiment Station.

6.2. Conceptual Model

6.2.1. Mesh

The finite element mesh was developed using the Map Module of GMS. This is accomplished by specifying boundary or interior arcs, assigning nodal spacing along these arcs, specifying any other refinement required (around wells, for example), and then letting GMS build the mesh. For this effort, boundary arcs were built directly on an aerial photo which was uploaded to the Map Module. Regional topology was based on digitized 7.5-minute USGS quadrangle maps purchased from American Digital Cartography (Appleton, WI). The final mesh (Figure 6) contains 2156 surface nodes and 4223 surface elements.

6.2.2. Geology and Layering

The geologic conceptualization and discretization was performed using GMS. Because there is so much variation in coastal plain sedimentation, the geologic information sometimes required simplification. This was accomplished by examination of the data and grouping the geologic layers into dominant stratigraphy types. For example, intervals dominated by thick clay

beds with only thin, occasional layers of silt or sand were designated as Clay. This classification scheme led to the development of 8 different material types:

1) Dummy Material - when the material type was unknown or not important,
2) Clay - dominantly clay,
3) Sand - dominantly sand,
4) Silt - dominantly silt,
5) Mixed - layering is highly varied with thinly bedded sand, silts, or clays,
6) Layered - dominantly clay, but contains continuous sand layers,
7) Red Arundel Clay - this formation name was used when available, and
8) Transition - material with aquifer properties that span the difference between Clay and Sand (required for numerical reasons).

Geologic information was gathered from several places. (See the List of References for complete information.) The Maryland Geological Survey (MGS) and USGS have published many documents on the geology and hydrogeology of the area. There are many nonpublished documents for the various industrial sites on the peninsula (Quarantine Road Landfill, Solley Road Landfill, Hawkins Point Landfill, Cox Creek Refinery, CSX property, etc.) Anne Arundel County has conducted several investigations, mostly for water supply and wellhead protection. In addition to the existing information, eleven new wells were installed on the site. Figure 7 shows an isometric view of the well information as viewed from the northeast.

As mentioned earlier, existing literature divides the shallow hydrostratigraphy into 3 units: the Upper Patapsco Aquifer, the Lower Patapsco confining layer, and the Lower Patapsco Aquifer. Three-dimensional examination of the geologic information, however, indicated that the Upper Patapsco Aquifer was limited to the northwest portions of the peninsula. Over the remainder of the peninsula, the Upper Patapsco was composed mostly of clay. Sand was present at the surface over the southern regions of the peninsula, but averaged only 15 feet in thickness. The Lower Patapsco Aquifer appeared to be present over the entire peninsula.

An isometric view of the conceptual model is shown in Figure 8. The refinement in the mesh in the eastern portion of the model domain represents the dredge material disposal areas. The refinement observed in the western portion of the model domain represents the location of the domestic wells. Figure 8a shows the locations of the cross sections used to create the fence diagram in Figure 8b.

The geology was represented by 3 layers. Each layer, however, could be comprised of different materials. Layer 1 (Figure 9) was given a constant thickness of 15 feet, and was composed of "Sand" in the southern portions of the peninsula (K_h = 33 ft/day, K_v = 3.3 ft/day), and "Clay" in the northern portions (K_h = 0.00035 ft/day, K_v = 0.000035 ft/day). Between the sand and the clay, a "Transition" material was used (K_h = 0.035 ft/day, K_v = 0.035 ft/day). This is not intended to represent an actual geologic material, but is required for numerical stability.

Numerical models often exhibit instability and long convergence times when the properties of adjacent elements vary by large amounts.

Layer 2 extended from the bottom of Layer 1 to the sands of the Lower Patapsco (Figure 10). In the northwest portion of the peninsula, this material (entitled "Layered") was given the basic properties of a clay containing sand lenses (K_h = 0.0035 ft/day, K_v = 0.000035 ft/day). For the rest of the model, Layer 2 was assigned the properties of "Clay" (K_h = 0.00035 ft/day, K_v = 0.000035 ft/day).

Layer 3, the Lower Patapsco Aquifer, extended from the bottom of the confining layer, to the top of the Arundel Clay. It was assigned a constant K_h of 15 ft/day, and a K_v of 1.5 ft/day.

The Arundel Clay is a thick massive unit, regional in extent. It was chosen as the lower boundary of the flow model. Hydraulic conductivities for all layers were based on the work by Achmad (1991) and the pumping test; however, anisotropy was determined during the calibration process.

The top of each of these geologic units was created as a Triangular Irregular Network (TIN) within GMS. The top of Layer 1 represents the surface topography and is shown in Figure 11. The top of Layer 2 (bottom of Layer 1) is shown in Figure 12. The top of Layer 3 (bottom of Layer 2) is shown in Figure 13. The bottom of Layer 3 (top of the Arundel Clay) is shown in Figure 14. The vertical layering of the model is created by extruding the mesh (described above) through the TINs representing the layer boundaries.

To aid in numerical stability, each geologic layer can be subdivided into any number of element layers. Layer 1 was subdivided into 4 element layers. Layer 2 was subdivided into 6 layers of elements, the top 3 of which were devoted to "Transition" material (K_h = 0.034 ft/day, K_v = 0.034 ft/day) between the highly conductive sands of Layer 1 and the clays of Layer 2. Layer 3 was subdivided into 3 element layers. This yielded 13 layers of elements for a total of 36442 nodes and 66495 elements.

6.2.3. Boundary Conditions

The model domain and boundary conditions were selected based on location of control points and natural boundaries, and available geologic information. Care was taken so that model boundaries were located far enough away from the placement area to avoid numerical artifacts.

Natural boundaries were available for Layer 1. A constant head of 0.0 ft was assigned at the coast line surrounding the peninsula. To avoid boundary problems, the model was extended offshore to the east. The shape of the eastern boundary was based on a potentiometric line for the Lower Patapsco Aquifer (Figure 2). For all the offshore areas, bathymetry was used to specify the top of Layer 1. A constant head (with actual ponding depths) defined the surface condition for the offshore elements. Onshore elements were assigned a recharge of 10 in/year in

sand areas and 4.38×10^{-7} in/year in clay areas. These values are in the range of those developed for other modeling efforts in the area. Achmad (1991) calculated a recharge of 16 in/year using the groundwater-stage method, and 20 in/year using base-flow separation techniques. Considerable sensitivity analyses were performed during calibration to validate the values. Experimentation with GMS indicated that the model converged much faster using constant flux surface boundaries rather than the Rainfall/Evaporation package which alternates between constant flux and constant head depending upon evaporation and ponding .

Because of extremely low permeabilities, the boundaries for Layer 2 (the confining layer) did not appear to be a sensitive parameter. The boundaries within the clay were assigned the same constant heads as those in Layer 1. The nodes at the interface between Layer 2 and Layer 3 were assigned the same constant heads as those in Layer 3.

The boundary conditions for Layer 3 were more problematic to determine, because they did not lie on a natural boundary. Initial constant heads were based on the regional potentiometric map of the Lower Patapsco Aquifer (Figure 2). The location of the southern boundary was chosen because of the Solley Road Landfill. This facility contains many wells at different depths, and allowed us access for water level measurements. The actual water levels observed in the wells were used to set the constant head nodes.

It is important to mention that this region contains many industrial and waste disposal operations which were not incorporated into the groundwater model. There are leachate collection and pump-and-treat systems operating at both the Solley Road Landfill and the Quarantine Road Landfill. SCM Chemicals, located only a few hundred feet north of the Cox Creek / CSX impoundment, operates pump-and-treat systems as remedial action for their process water lagoons. These systems were omitted from the model for several reasons. First, the information was simply not available. Most of these systems are owned and operated by the PRPs (Potentially Responsible Parties). Second, their pumping schedules are variable. Most were happy to supply information on wells, but were hesitant to supply information on the day-to-day operation of their systems. Third, because most of these systems re-injected the treated water from their systems, it could be assumed that the net affect to the aquifer was minimal.

6.2.4. Initial Conditions

The initial condition used for the first simulation (the "cold start") was created by estimating and extrapolating water levels in Layer 1 from the wells to the coast line. A "hot start" (water level results from the previous simulation) was used for all subsequent initial conditions. All simulations were run in steady state, flow-only mode. The moisture content, relative conductivity, and water capacity curves, which are required for unsaturated flow calculations, were generated by GMS for the material types used. No additional materials testing was performed.

Maintenance General Appropriation

6.3. Sensitivity Analyses / Steady State Calibration

Because so many parameters were tested in developing the steady state calibration, there was not a formalized sensitivity analysis performed. Instead, the performance results from each tested parameter are reported below. Results are reported in Root-Mean-Square error (RMS) compared to the 19 Sep 96 sampling. The calibration wells are shown in Figure 3. The best RMS error achieved was 0.51 ft, determined from the following values:

	9/19/96		
WELL	Actual	Modeled	Difference
106	1.25	1.75	-0.5
C-1	4.95	4.6	0.35
D-2	1.89	2.35	-0.46
E-1	1.46	2.2	-0.74
F-1	1.54	2	-0.46
G-1	0.07	0.9	-0.83
H-2	-0.08	-0.16	.0.08
I-2	-0.23	-0.16	-0.07

Ave Difference:	-0.32875
RMS Error	0.51

6.3.1. Hydraulic Conductivity in Lower Patapsco Aquifer (Layer 3)

Field tests and geologic literature (Achmad, 1991) indicated that K for this layer should fall in the range of 14 to 35 ft/day. Values of horizontal hydraulic conductivity (K_h) ranging from 1.5 to 30 ft/day were tested in the model. For all but one of the geological materials, vertical hydraulic conductivity (K_v) was set at one-tenth the value for K_h. The only exception to this was the layered material in the northwest portion of Layer 2 (described in section 6.1.2 above). This material was given an anisotropy of 100 to 1 ($K_v = .01K_h$).

For K_h = 30 ft/day, the best RMS error achieved was 1.87 ft. For K_h =15 ft/day, the best RMS achieved was 0.51 ft. For K_h = 1.5 ft/day, the best RMS achieved was 1.03 ft. For K_h = 0.15 ft/day, the best RMS achieved was 2.95 ft.

For K_h = 0.15 ft/day, the pumping action in the domestic wells west of the placement area caused poor RMS values and created a large cone of depression that is not supported by field observations. The field tested value of K_h = 15 ft/day (K_v = 1.5 ft/day) was most appropriate for the conditions applied to the model.

6.3.2. Hydraulic Conductivity in Layer 1 Clay Materials

Geologic literature (Achmad, 1991) indicated that K for this layer should be about 3.5×10^{-5} ft/day (isotropic). Use of isotropic clay, however, caused a water buildup problem in the areas where sand was surrounded by clay. Anisotropic conditions were tested with $K_h = 3.5 \times 10^{-4}$ ft/day and $K_v = 3.5 \times 10^{-5}$ ft/day. Use of this anisotropy solved the water build-up problem.. In addition, this type of anisotropy is supported by the geological information which indicates that many thin layers of sands and silts can exist in otherwise massive clays. The anisotropic conditions appeared to provide the most appropriate results for the model study.

6.3.3. Hydraulic Conductivity in Layer 1 Sand Materials

Geologic literature (Achmad, 1991) indicated that a value of 33 ft/day should be used for the sands in this layer. Both isotropic and anisotropic conditions were simulated; however, anisotropic conditions were decided to be most appropriate to account for clay lenses interspersed in the sand. In an attempt to relieve head buildup in the surface sand, a K_h of 330 ft/day was applied to the sand without significant result in solving the problem. The field values with anisotropic conditions ($K_v = .1K_h$) were used in the final model runs. This value is consistent with geological site conditions.

6.3.4. Constant Head Boundary Conditions in Lower Patapsco Aquifer

The constant head nodes which corresponded to the regional potentiometric map of the Lower Patapsco (Figure 2) produced modeled water levels that were too high. Many different configurations of model parameters were tested to reduce this problem. In order to match the observed water levels at the site, the constant heads along the eastern boundary were lowered until an acceptable match was found (Figure 15) . Resulting RMS values ranged from 1.80 to 0.51 ft. The constant heads which produced the lowest RMS values (0.51) were used in final model scenarios.

The constant heads required to achieve an acceptable calibration were 3.4 feet below sea level on the eastern boundary of the model (Figure 15). While the regional mapping does not support water levels this low, there is no hard data to refute it. This uncertainty, however, indicates that while groundwater flow vectors are considered correct in the immediate vicinity of the containment area, vectors along the eastern border may be suspect. Fortunately, the flow velocities from the containment area are extremely slow. To prove this, particle tracking was performed around the perimeter of the containment area. The worst case scenario, with no retardation, indicated that over a 100-year simulation, horizontal travel distance totaled slightly more than a foot; vertical travel distance totaled slightly less than a foot. This means that solute transport from the placement area is a localized phenomenon, and the model is considered to give a quite reasonable estimation of localized conditions of flow and transport.

6.3.5. Type of Boundary Condition for Western Face of Model

Because there appeared to be too much water entering the model from the constant head boundary condition, several constant flux simulations were conducted to reduce the amount of water in the system. The initial flux value was calculated from Darcy's law using the calibrated values of hydraulic conductivity and the observed gradient. For the flux boundary condition, the following values and corresponding RMS values were obtained:

Flux (ft/day)	RMS (ft)
6.85×10^{-3}	1.01
6.0×10^{-3}	0.96
5.0×10^{-3}	0.94
2.5×10^{-3}	0.91

It is evident that the best constant flux simulation yielded poorer RMS values than the constant head simulation. (The best RMS value obtained from constant head boundaries was 0.51.) Constant head boundary conditions were used for all subsequent simulations.

6.3.6. Infiltration in Sand Layers

Considerable effort has been applied by other authors toward estimating the infiltration rates in this area (Achmad, 1991). To further calibrate the infiltration for our application, the model results were matched against the perennial streams within the model domain. Too much infiltration would cause the modeled streams courses to flow in areas higher than what is observed in nature. Conversely, too little infiltration would cause the modeled stream courses to be dry. Tested values of infiltration in the surface sand layers ranged from 5×10^{-4} ft/day to 3.65×10^{-3} ft/day (2 in/yr to 16 in/yr). Constant head nodes were used to represent perennial streams in the model. If the nodes ended up supplying water to the model, the corresponding infiltration rate was too low. If the water table was much higher surrounding these nodes, the infiltration value was too high. The rate of 10 in/yr showed the best correlation to the mapped stream courses. The following specific values were simulated:

Infiltration (ft/day)	Water Table Levels at Streams
5×10^{-4}	too low
7×10^{-4}	too low
9×10^{-4} (4 in/yr)	too low
1.83×10^{-3} (8in/yr)	too low
3.65×10^{-3} (16in/yr)	too high
2.75×10^{-3} (12 in/yr)	too high
2.5×10^{-3} (11 in/yr)	too high
$2.28\ 10^{-3}$ (10 in/yr)	best correlation

6.4. Transport Scenarios - Discussion

6.4.1. Scenario 1, Current Conditions

As has been described, the model was calibrated to current conditions at the placement area. Figure 11 shows a view of the topography of the area. The dike elevations for the CSX and Cox Creek cells are 20 and 15 ft respectively. The elevation of ponded water was estimated at 10 ft. Other model parameters have been described above.

Figure 16 shows the model-simulated total head in Layer 1. Due to the extremely high number of nodes, flow vectors are not displayed; however, we know that groundwater flow will be from high potential to low, in a direction perpendicular to lines of equal potential (total-head contour lines). For this and subsequent figures, color fill between potentiometric contours was used to aid in the interpretation.

Note that most of the groundwater flow directions are from topographic highs toward the coast. In the vicinity of the placement area, the 10-foot head of water sitting in the existing cells has reversed the natural easterly flow direction. Examination of Figure 15 shows that flow directions are reversed inland for a distance of approximately 650 ft from the edge of the containment cell. This distance lies well within the current property boundaries of the CSX factory property. Even though flow vectors are directed inland for a short distance, the extremely low conductivities of the clays make travel times exceedingly large, less than one foot in 100 years. Particle tracking was performed for the worst-case scenario and is discussed below.

Figure 17 shows the model simulated total head in Layer 3, the Lower Patapsco Aquifer. It is evident that the current impoundment at Cox Creek has no effect on the regional flow in this aquifer. Regional flow is still dominated by the pumping at Sparrows Point. It is also evident that the pumping from the domestic wells has almost no effect on regional flow. Careful examination will show that the potentiometric contours are refracted very slightly at the well location with no discernible reversal in gradient.

6.4.2. Scenario 2, 28-foot Dikes, Impoundment Filled With Water

The next scenario was based upon one of the operational plans outlined in the Operational Assessment Study (MES, 1996). Because no definite plan was recommended in that report, groundwater simulations were performed on several likely scenarios. For this scenario (and all others), the medial dike separating the two placement areas and the mound in the center of the CSX (southern) cell have been removed. The dikes on the resulting enclosure were raised to an elevation of 28 ft.

This type of placement facility operates by pumping dredge material into the enclosure via a slurry. The impoundment will be filled effectively to the top of the dikes with this liquid

material. The facility is then left alone to allow the clays to settle out of the liquid, and to allow the liquid to evaporate and percolate through the dike material leaving the solid dredge material. This procedure is repeated until the placement area has reached its capacity. This scenario modeled the effects of the containment facility filled with liquid. In other words, there was a head of 28 feet applied to the interior of the impoundment.

Figure 18 shows the model-simulated total head in Layer 1. The head of 28 feet in the impoundment has reversed the natural flow vectors inland about 790 feet. Figure 19 shows the model simulated total head in Layer 3. As before, the impoundment at Cox creek has no effect on the regional flow in this aquifer.

6.4.3. Scenario 3, 28-foot Dikes, Impoundment Filled With Dredge Material

Once the placement area is filled with dredge material (clay), its hydrogeology will logically be different than when it was filled with liquid. This scenario simulates the hydrologic effects of 28 ft of clay in the placement area. This is the configuration which could create an unsaturated zone within the dredged material. This can be of concern because once unsaturated, the metallic contamination in the dredged material can oxidize and become more soluble. Figure 20 shows the model-simulated head in Layer 1. Close examination indicates that groundwater flows eastward through the clay. Comparison of this figure with the topography (Figure 11) indicates a significant unsaturated zone is developed. While there may be some concern about the unsaturated zone which is created, the velocity and quantity of solute flow through the clay will be quite low. Figure 21 shows the total head in Layer 3. Again, the dredge material placement area has no effect on the groundwater flow in Layer 3.

6.4.4. Scenario 4, 39-foot Dikes, Impoundment Filled With Water

This scenario is the same as Scenario 2 (impoundment filled with liquid) except the dikes have now been raised to 39 ft. Figure 22 shows the model-simulated total head in Layer 1. The head of 39 feet in the impoundment has reversed the natural flow vectors inland about 835 feet. Again, flow velocities will be less than a foot in 100 years. Figure 23 shows the model simulated total head in Layer 3. As before, the impoundment at Cox creek has no effect on the regional flow in this aquifer.

6.4.5. Scenario 5, 39-foot Dikes, Impoundment Filled With Dredge Material

This scenario is the same as Scenario 3 (impoundment filled with clay) except the dikes have now been raised to 39 ft. Results are very similar to Scenario 3. Figure 24 shows the model-simulated head in Layer 1. Groundwater flows eastward through the clay and another unsaturated zone is developed. Figure 25 shows the total head in Layer 3. Again, the dredge material placement area has no effect on the groundwater flow in Layer 3, the Lower Patapsco.

6.4.6. Scenario 6, Worst Case / Drought

A scenario was developed to simulate worst-case conditions. For this scenario, the dikes were extended to an elevation of 39 ft, and the impoundment was filled with liquid, as in Scenario 4. To simulate drought, all recharge was eliminated. This represents an extreme condition which probably will never occur. Figure 26 shows the model-simulated total head in Layer 1. For this extreme condition, groundwater flow directions in the surface sand have only been reversed 1000 ft in the western, upgradient direction. This reversal still does not extend off of the Cox Creek refinery property. Figure 27 shows the total head in Layer 3. As with all previous cases, the dredge material placement facility has no affect on groundwater flow in the Lower Patapsco Aquifer.

To estimate potential solute movement, particle tracking was performed for this scenario. Clusters of particles were introduced at different depths into the dike material. These particles were started at elevations of 35, 25, 15, 4, and -1 feet. Ten clusters of points were introduced around the perimeter of the enclosure, and one was introduced in the center. Particle positions were plotted out at ten-year increments for a total of 100 years. There was no retardation, or dispersion applied to the particle movement (pure advective flow). Examination of particle movements showed that the maximum movement occurred on the southwest side of the impoundment, adjacent to the lake and wetland area. At this location, maximum particle movement over a 100-year simulation, totaled slightly more than a foot horizontal travel distance, and slightly less than a foot in the vertical direction.

7.0 Conclusions

Well bores performed for this investigation reveal that the geology in the area of the proposed dredge material placement area is predominantly clay and extends from the surface to a depth of about 150 ft. The aquifer sands of the Lower Patapsco are located below this clay.

Groundwater at the site is flowing east, toward Sparrows Point. Well clusters located directly on the dike next to the Patapsco River indicate that there is a downward vertical gradient. This indicates that there is significant pumping located to the east of the site. Analysis of regional water levels suggests that the industrial pumping by Bethlehem Steel at Sparrows Point may be contributing to the downward vertical gradients. Bethlehem Steel reportedly pumps over 103 million gallons per month (3.4 mgd) from the Patuxent Aquifer. Their pumping center is located about 3 miles east of the Cox Creek/CSX placement area. It seems unlikely, however, that the reported daily pumpage from Bethlehem steel could create the large ground water depression shown in Figure 2. Other industrial pumpers may exist.

There is no current or potential groundwater use in the area of the placement area. The radius of influence for Anne Arundel County's well field lies three to four miles southwest of the

Cox Creek/CSX placement area. Based on the master plan of Anne Arundel County, there are no plans to drill any other Lower Patapsco wells in this area. There are only two households still utilizing groundwater in the area. According to the groundwater model, the small amount of pumpage from these wells is not able to create a measurable reversal in the regional flow direction.

Based on groundwater modeling, expansion of the Cox Creek/CSX dredge material placement area will not affect flow direction or quality of groundwater. Several different scenarios were modeled: current conditions, impoundment elevations of 28 and 39 ft., impoundments filled with both water and dredge material (clay), and drought. In all cases, the placement area had no substantial effect. Groundwater flow in the Lower Patapsco Aquifer was never affected. Model results indicate that there will be groundwater flow in the surface clay from the placement area to the wetlands located adjacent to the southwest. The extremely low conductivity of the clay, however, makes any contribution from the placement area *de minimis* in quantity. Particle tracking was performed to estimate groundwater travel times out of a filled, 39-foot impoundment. The worst case scenario, with no retardation, indicated that over a 100-year simulation, horizontal travel distance totaled slightly more than a foot; vertical travel distance totaled slightly less than a foot.

Because the new dredge material is being placed on a prepared surface of old dredge material from the 1960's, there appears to be no mechanism for the development of preferential leachate pathways. Considering the downward vertical gradients, the extremely slow travel times, and the 150 feet of clay below the site, groundwater impacts will be negligible.

At the time of this writing, discussions are underway to possibly close the Bethlehem Steel shipbuilding plant at Sparrow's Point. Bethlehem Steel's daily groundwater pumpage of 3.4 mgd appears to affect the regional groundwater flow system in the Patapsco (and probably Patuxent) Aquifer. A change in pumping at Sparrow's Point may change the ultimate flow directions of solute determined in this investigation. While the future of Sparrows Point may represent water supply and/or environmental concerns to other parties, it should not change the basic conclusions of this investigation: 1) Because of the thick clay unit under the facility, the water-supply aquifer of the Lower Patapsco will not be affected by dredge material placement activities, and 2) The velocity of solute from the facility will be less than a foot per 100 years.

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Table 1. Ground water elevations in new and existing wells in the study area.

Well	20-May-96	21-May-96	22-May-96	23-May-96	24-May-96	30-May-96	1-Jun-96	3-Jun-96	4-Jun-96	5-Jun-96	6-Jun-96	7-Jun-96	8-Jun-96
F-1	7.22	5.21	4.17	4.62	3.02	1.14	1.35	1.46	1.57	1.62	1.25	1.52	1.63
E-1						7.46	3.78	2.23	2.09	2.11	1.41	1.62	1.58
G-1												1.24	1.82

Well	11-Jun-96	12-Jun-96	13-Jun-96	14-Jun-96	15-Jun-96	17-Jun-96	18-Jun-96	19-Jun-96	20-Jun-96	21-Jun-96	24-Jun-96	25-Jun-96	26-Jun-96
F-1	1.67	1.62	1.62	1.52	1.45	1.47	1.71	1.79	4.77			1.77	1.42
E-1	1.70	1.63	1.82	1.70	1.63	1.67	1.79					2.01	1.51
G-1	1.35	1.97	0.24	0.34	0.36	1.52	-7.36	0.79	0.84			0.81	0.02
I-2						3.04	2.93	1.36	-0.44	18.96	-1.39	-1.02	-1.55
I-1								8.37	2.09	18.99	18.99	1.51	0.41
H-2													2.94

Well	27-Jun-96	28-Jun-96	29-Jun-96	1-Jul-96	2-Jul-96	3-Jul-96	8-Jul-96	9-Jul-96	10-Jul-96	11-Jul-96	12-Jul-96	13-Jul-96	14-Jul-96
F-1	1.50			1.98	1.64	1.75	1.57	1.65	1.49	1.25	1.22	1.72	1.44
E-1	1.58			1.96	1.82	1.96	1.75	1.74	1.59	1.31	1.42	1.96	1.60
G-1	0.36			0.80	0.73	0.64	0.36	0.26	0.07	-0.16	-0.01	0.79	0.22
I-2	-1.35	18.96	18.96	0.26	0.50	0.39	-0.19	-0.22	-0.66	-0.72	-0.36	18.96	-0.34
I-1	-0.22	1.28	18.99	2.09	2.41	1.62	1.59	1.72	1.29	1.20	1.65	18.99	1.38
H-2	0.75	18.24	0.50	2.20	-2.67	0.50	0.82	0.12	-0.06	-0.19	-0.18	18.24	-0.27
H-1				3.02	2.18	2.31	2.20	2.47	2.03	1.71	1.38	18.83	1.55
F-3								9.44	0.49	22.57	22.57	22.57	22.57

Well	15-Jul-96	17-Jul-96	18-Jul-96	31-Jul-96	2-Aug-96	4-Aug-96	5-Aug-96	6-Aug-96	7-Aug-96	8-Aug-96	17-Sep-96	19-Sep-96	4-Oct-96
F-1		0.80	0.72	1.31	1.30	1.58	1.37	0.22	1.27	1.17	1.62	1.54	1.68
E-1		1.44	1.41	1.64	1.39	1.63	1.58	1.50	1.41		1.71	1.46	1.10
G-1		0.27		0.41	-0.01	0.36	0.19	0.06	-0.08	0.04	0.94	0.07	-0.44
I-2	18.96	-0.20	-0.34	-0.89	-0.42	-0.07	-0.26	-0.39	-0.64	-0.32	0.22	-0.23	-1.06
I-1	18.99	2.99	1.40	2.04	2.01	2.02	1.85	1.64	1.29	1.69	2.44	1.82	0.95
H-2	18.24	-0.01	-0.16	0.38	-0.18	0.25	0.00	-0.12	-0.46	-0.10	0.38	-0.08	-0.79
H-1	18.83	1.96	1.69	2.15	1.54	2.11	2.08	1.78	1.55	1.88	2.58	1.90	1.06
F-3	1.19	1.32	1.29	1.58	1.40	1.65	1.57	1.55	1.47	1.47	-1.88	22.57	1.14
F-2		0.70	1.47	2.03	2.03	1.28	1.26	1.05	1.14	1.14	5.10	1.33	2.16
D-2									1.68	1.73	2.05	1.89	1.41
C-1											4.95	4.95	4.47
106												1.25	1.81
Ba Gf 168													-1.65
B-1													38.86
B-2													21.74
B-3													4.59
R-8-3													13.69
R-10-3													10.51
R-22-3												9.12	8.68
Franks													45.00

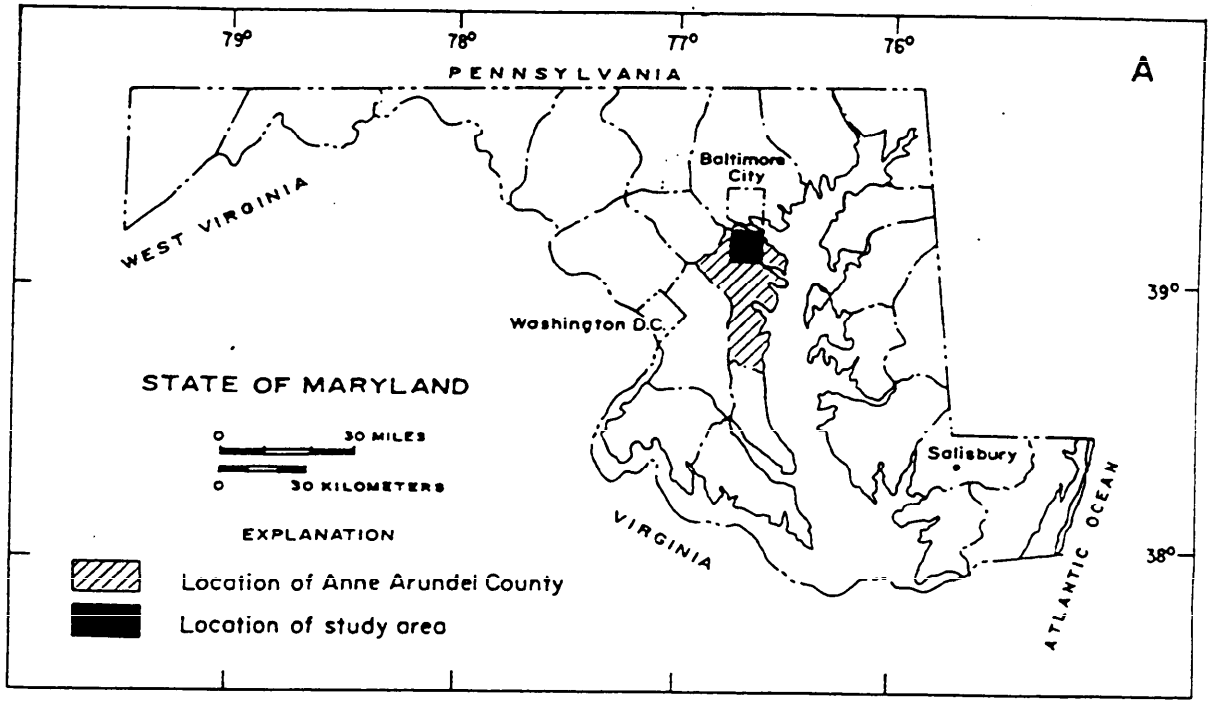
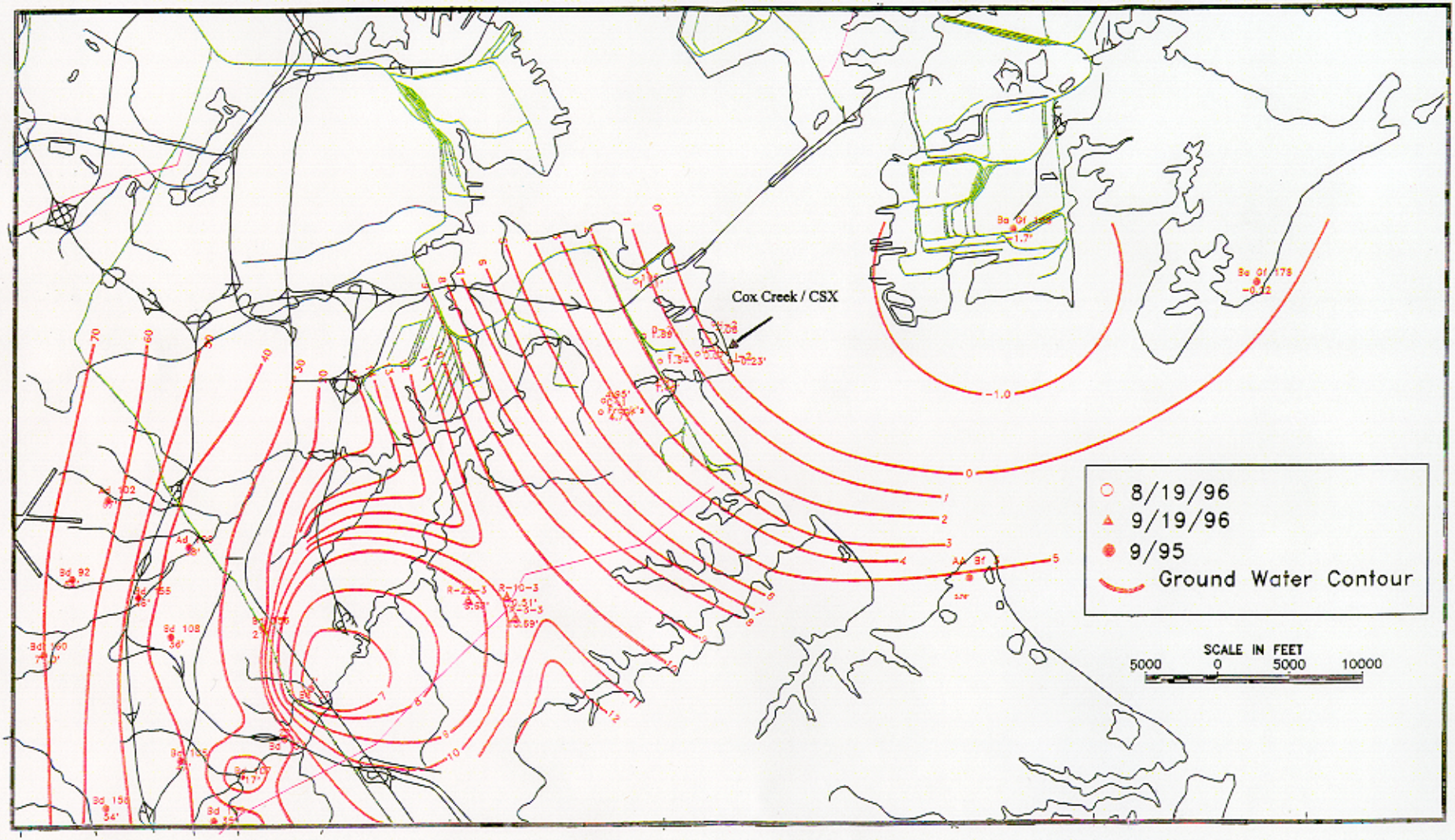
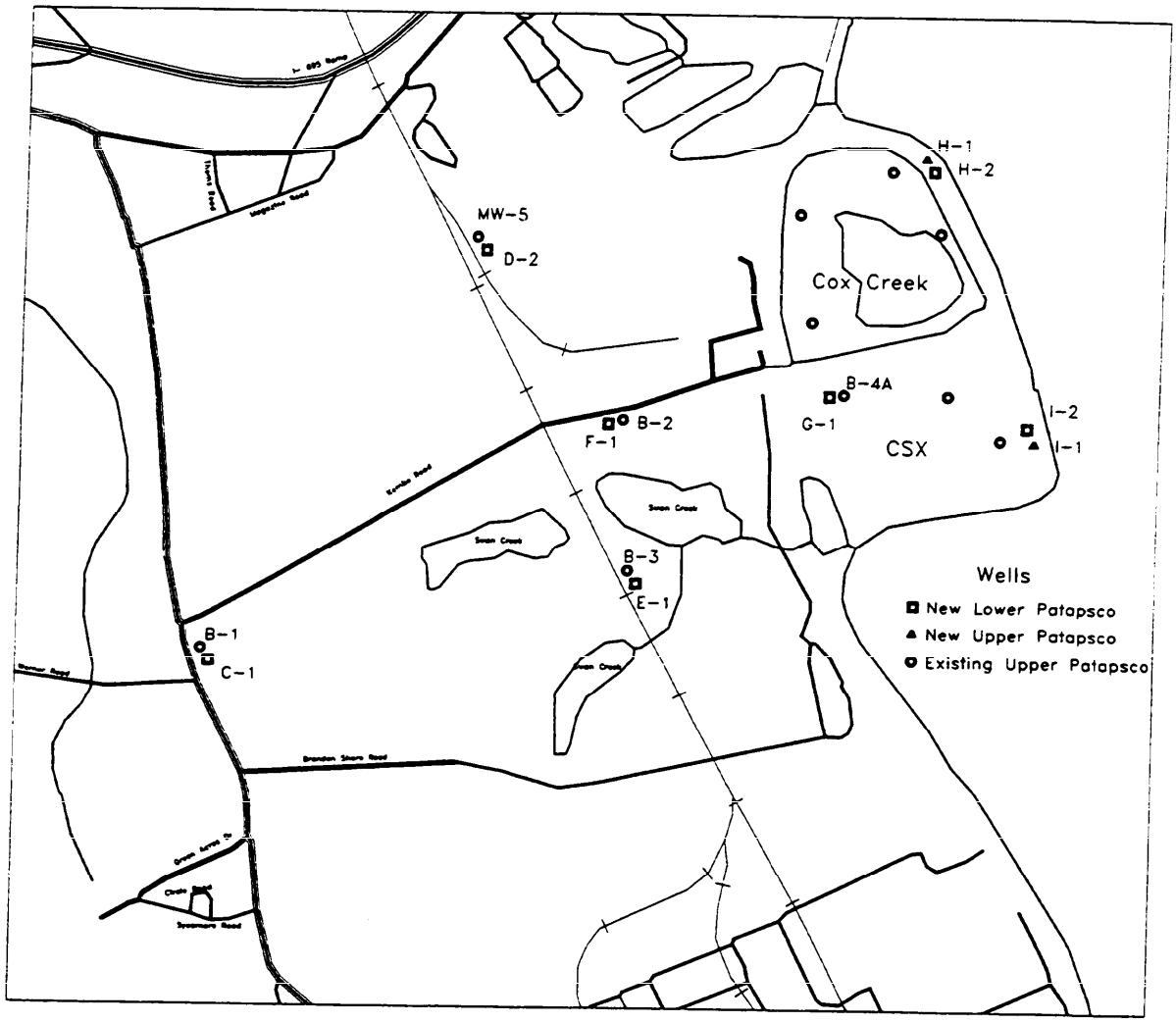


Figure 1. Location of Study Area.

Figure 2. Map showing ground water contours in the Lower Patapsco aquifer.





1 Inch = 1500 ft.

Figure 3. Cox Creek/CSX Site Map

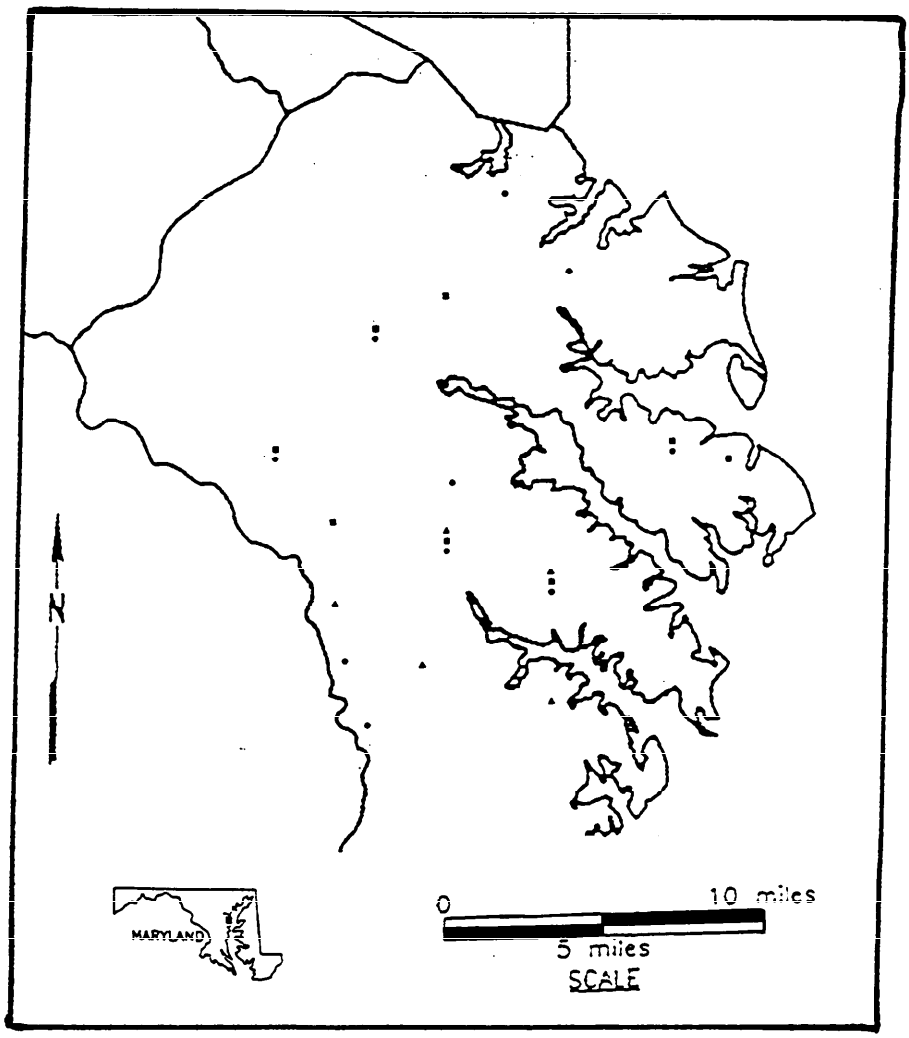


Figure 4.

Location of Potential Well Fields, Anne Arundel County
(from PSC, 1989) modified

Figure 5. Tidal Effects in E-1, G-1, and H-2.

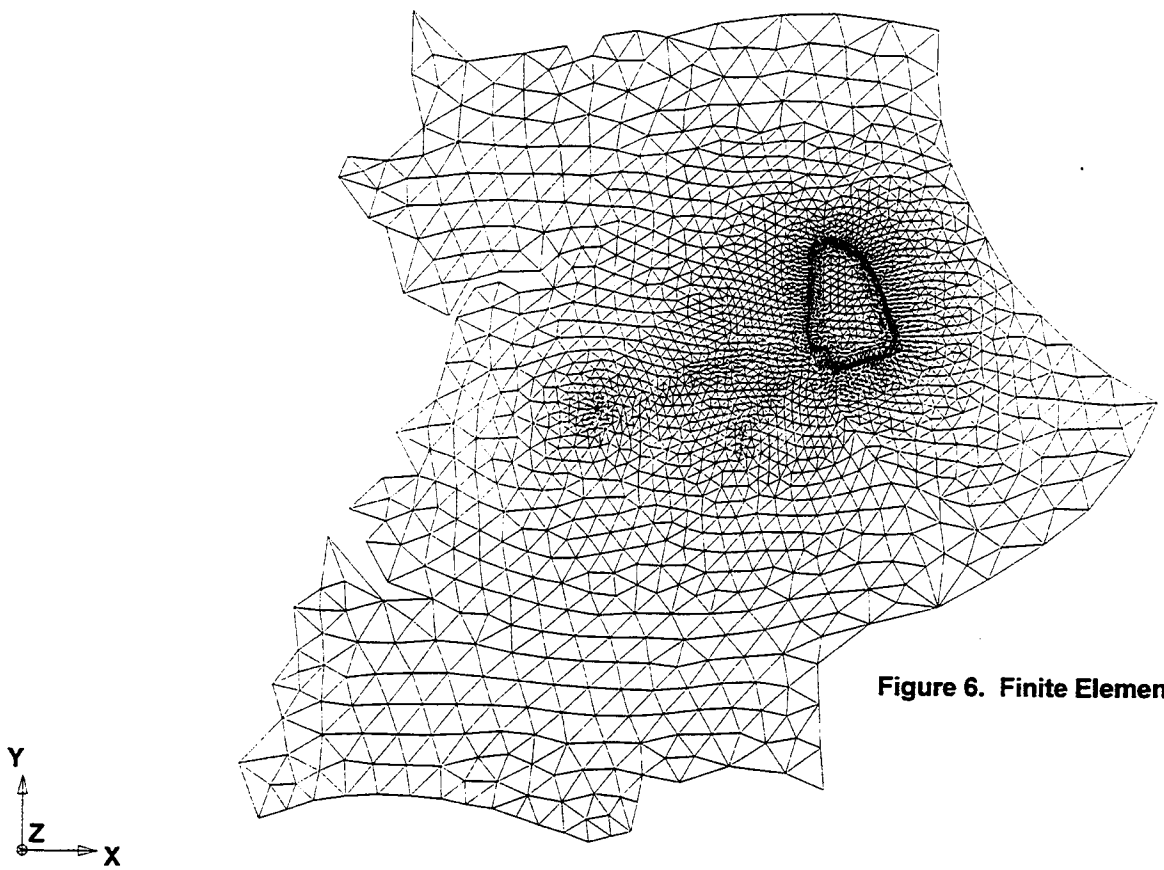


Figure 6. Finite Element Mesh

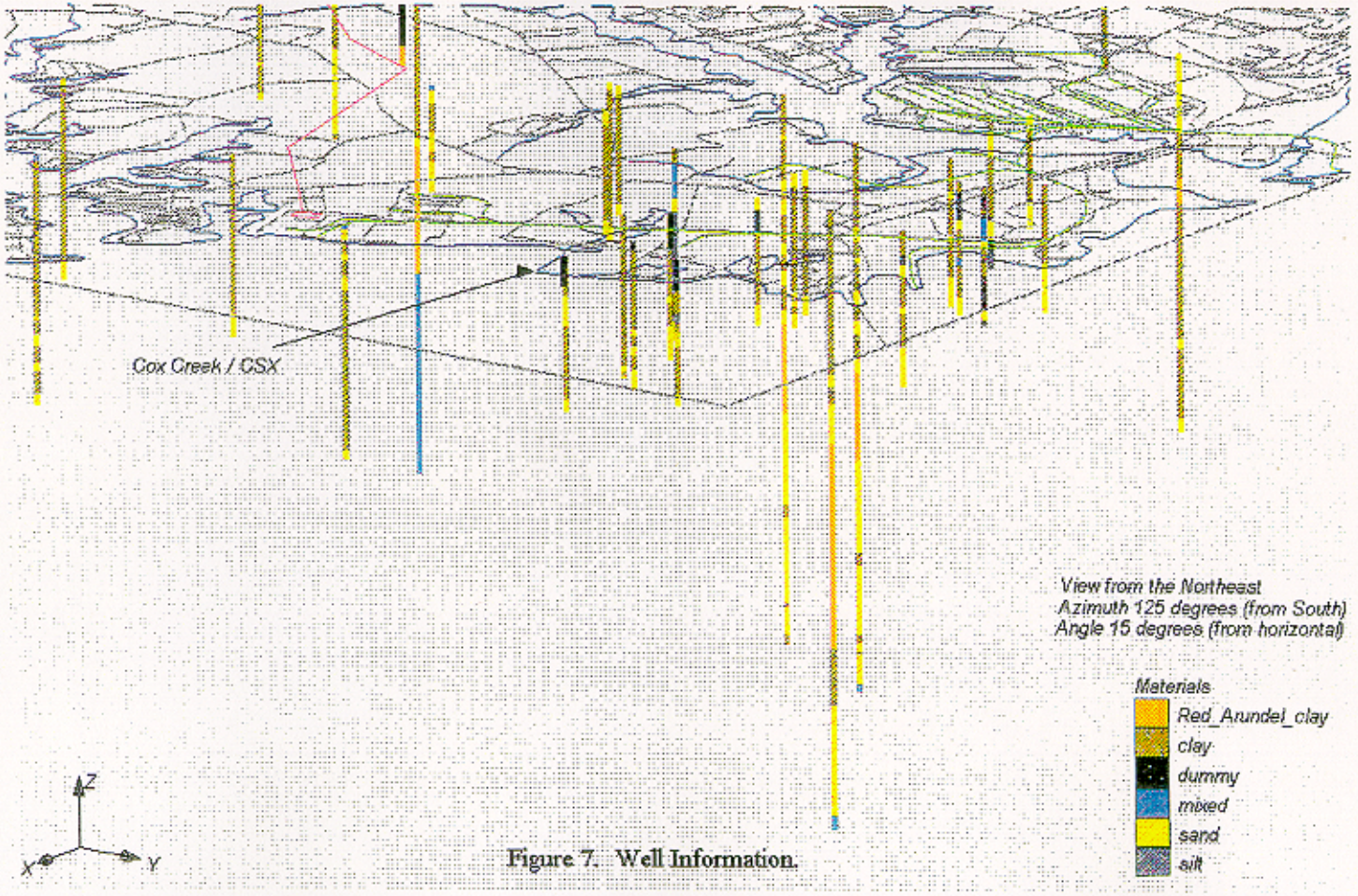


Figure 7. Well Information.

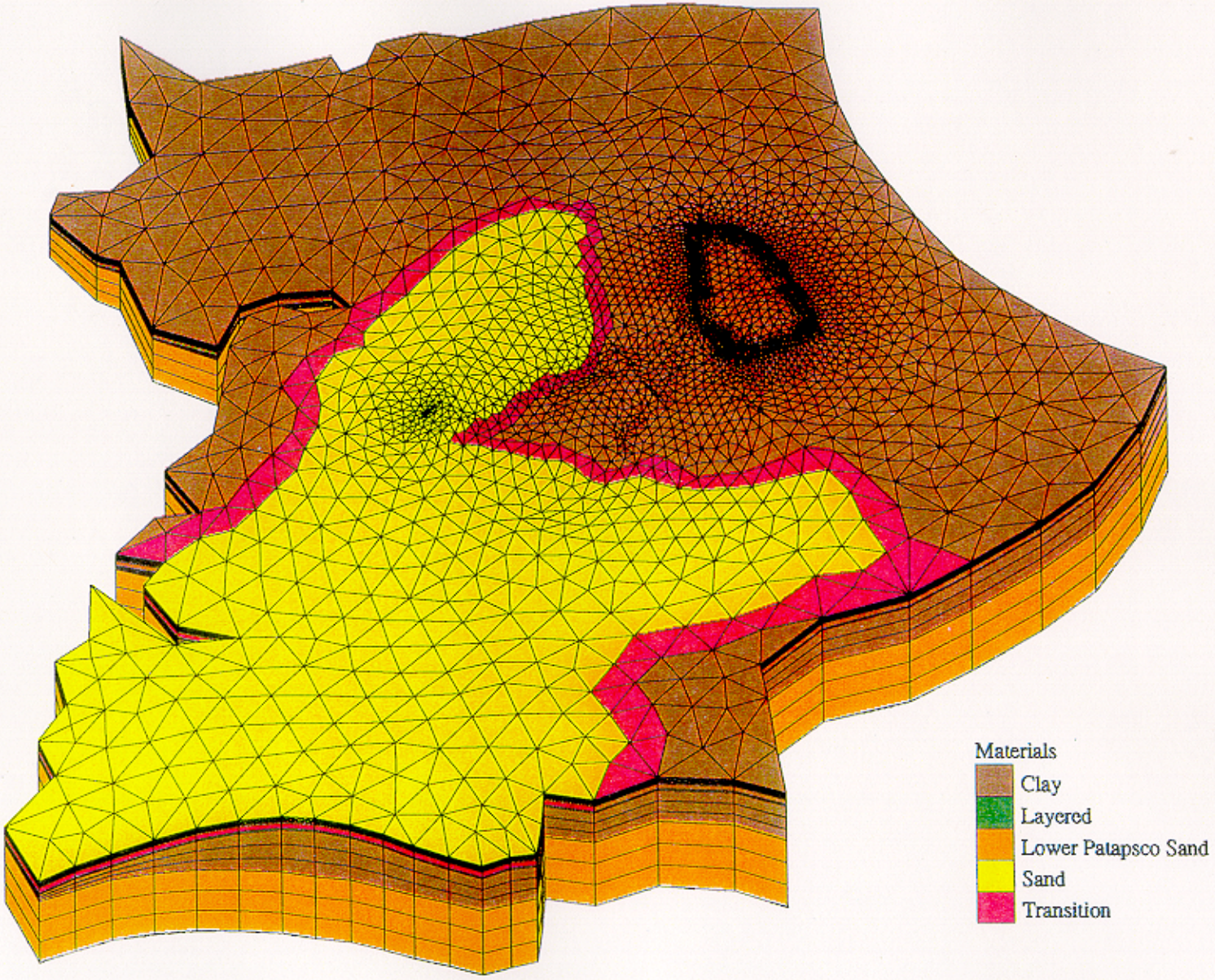


Figure 8. Hydrogeologic Conceptual Model

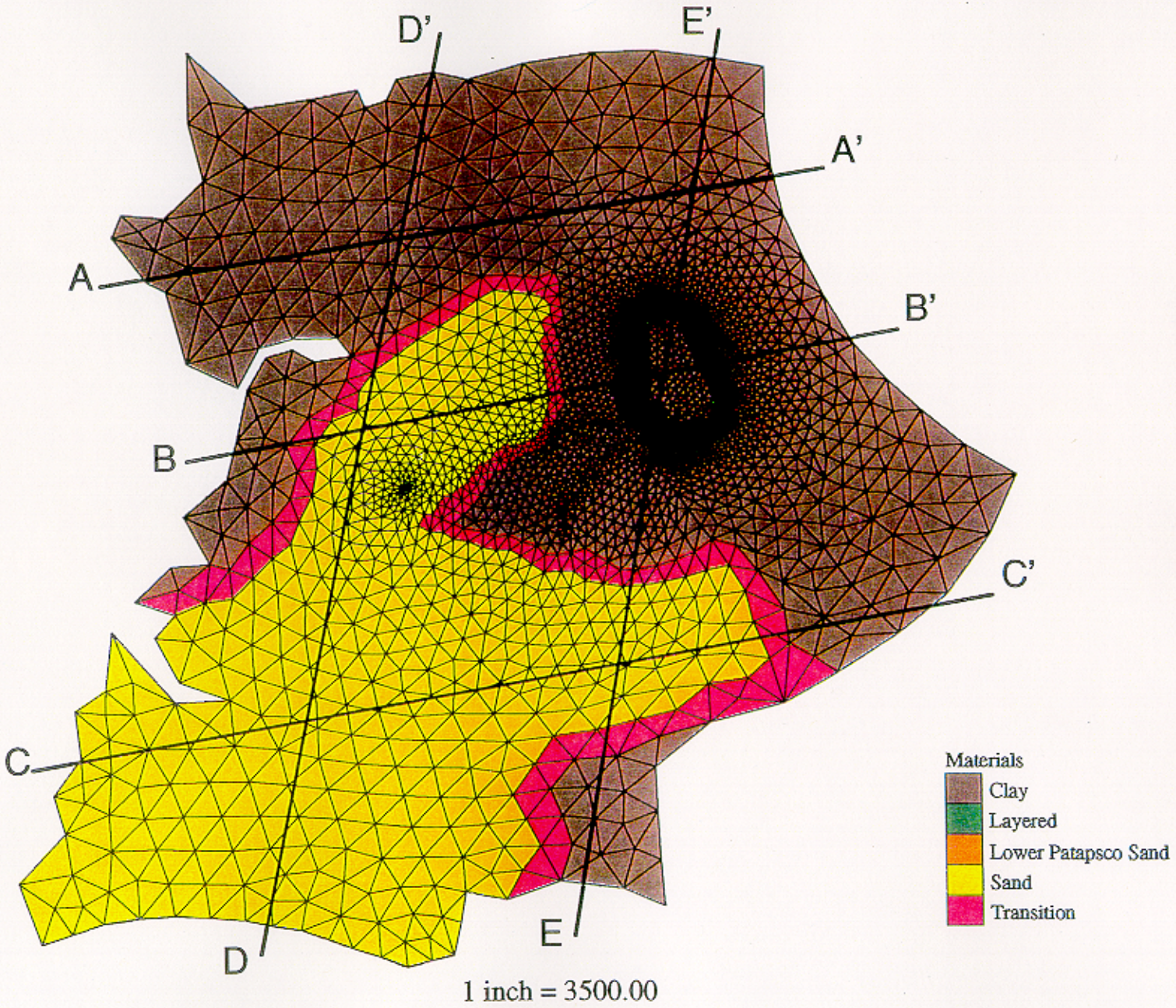


Figure 8a. Location of Cross-sections.

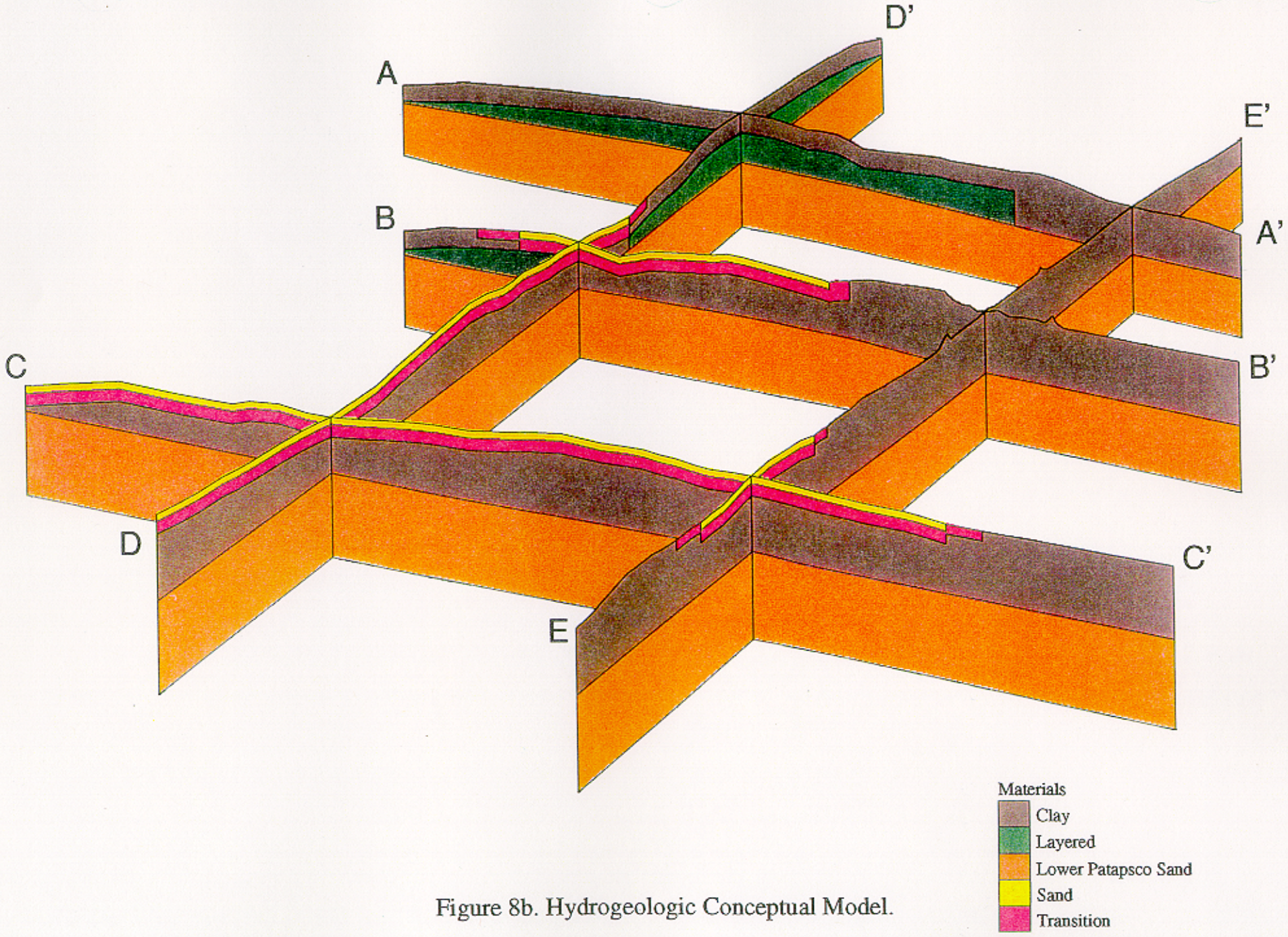
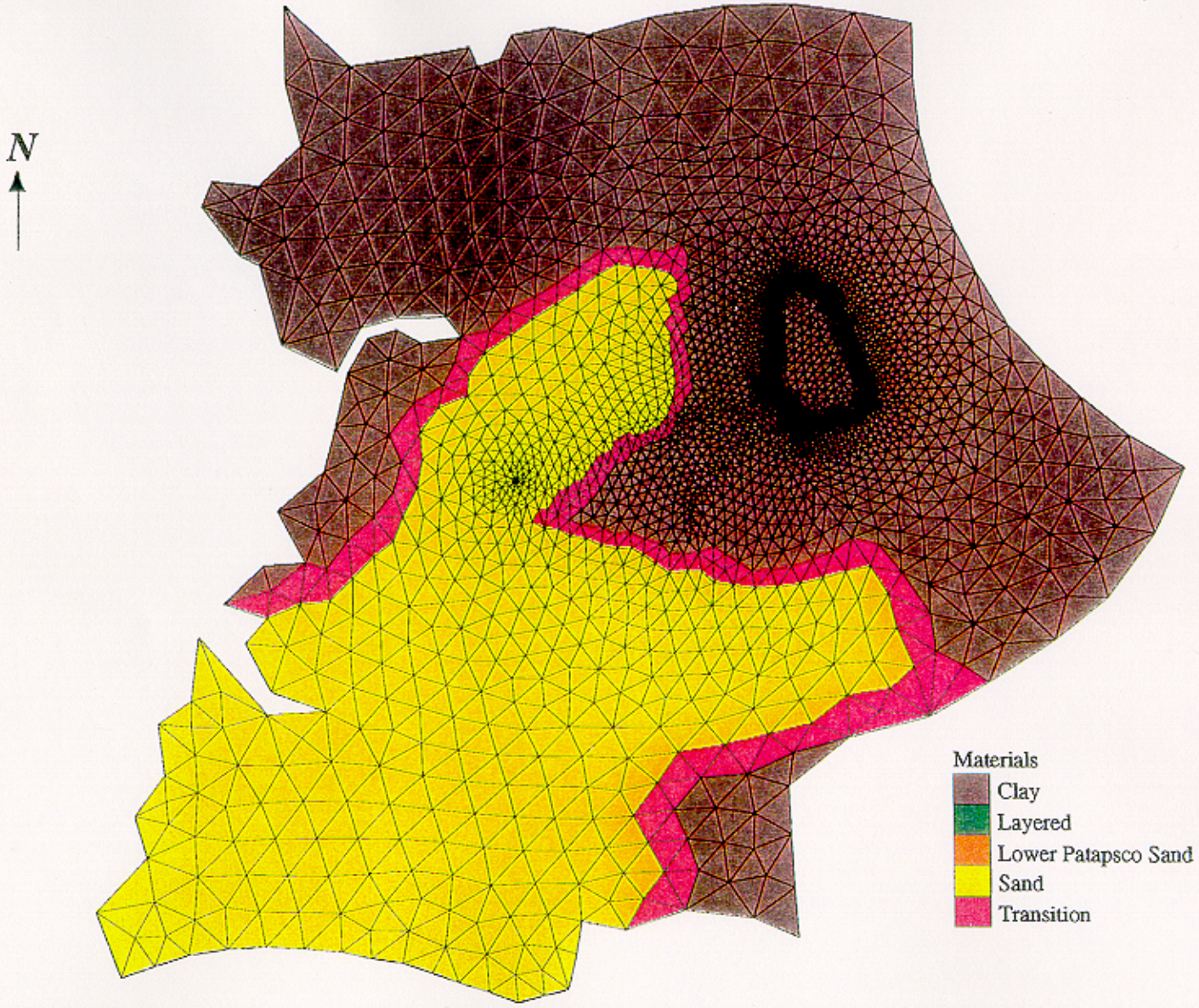
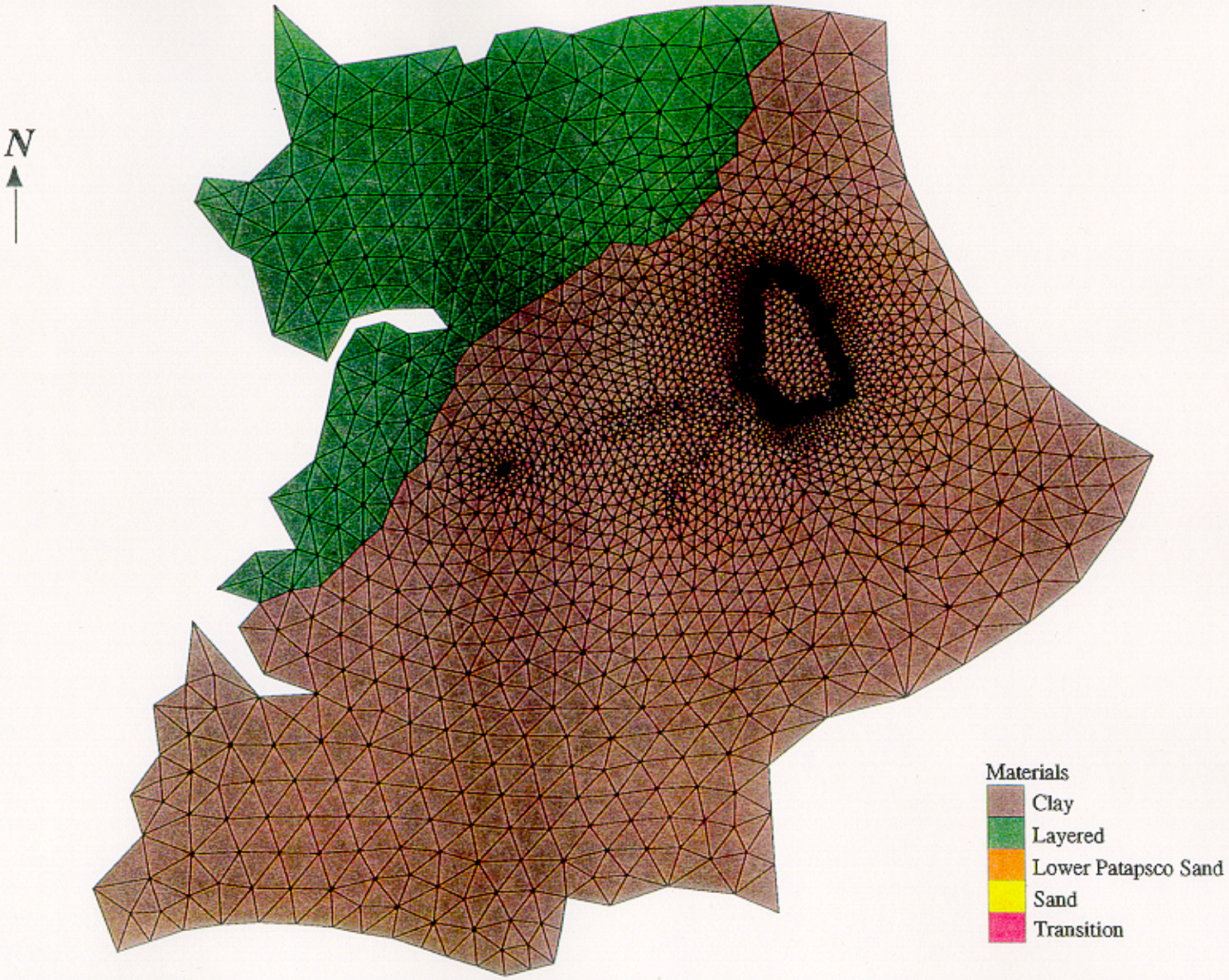


Figure 8b. Hydrogeologic Conceptual Model.



1 inch = 3500.00 feet

Figure 9. Layer 1 Materials.



1 inch = 3500.00 feet

Figure 10. Layer 2 Materials.

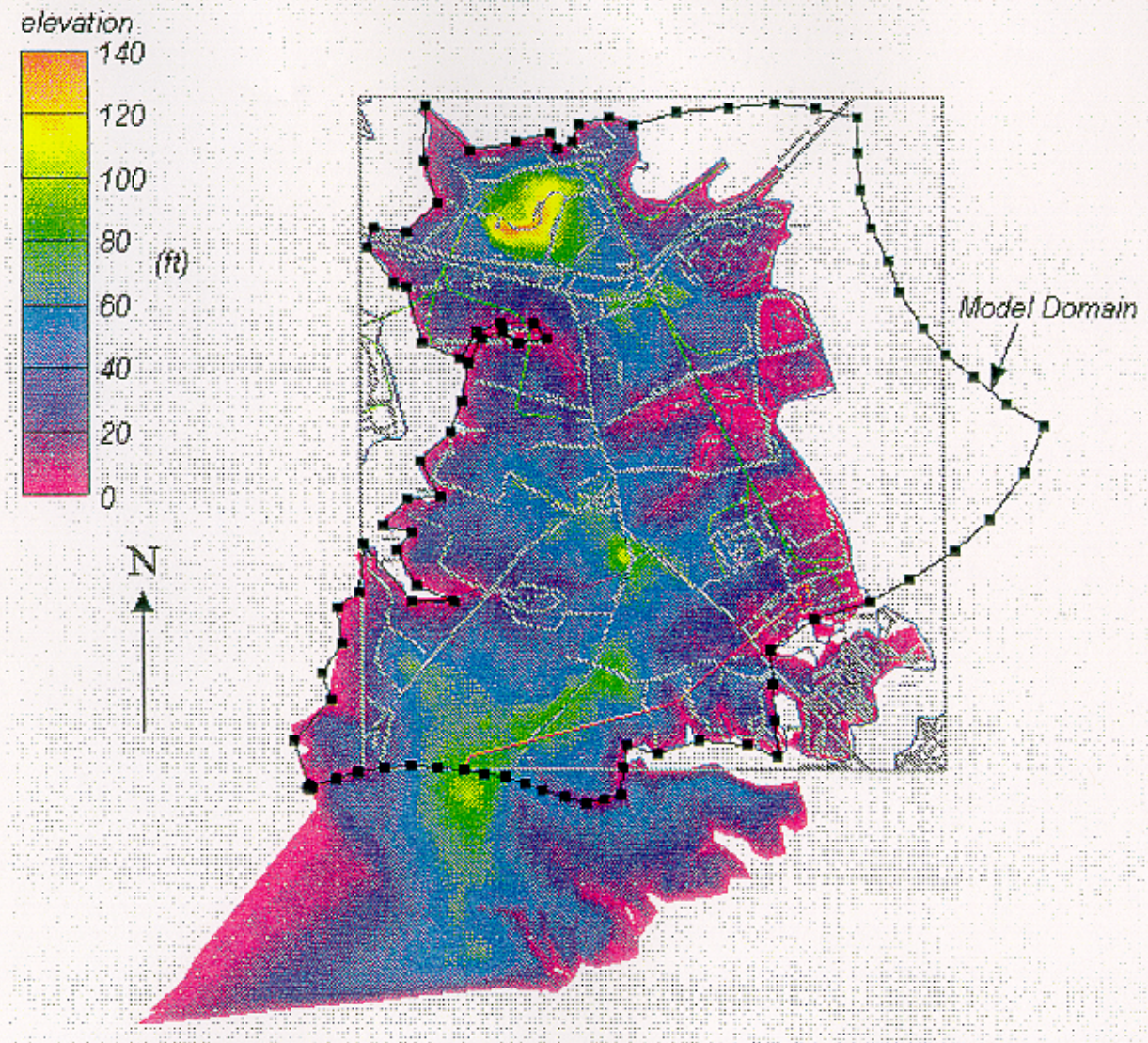


Figure 11. Elevation Top of Layer 1, Surface Topography.

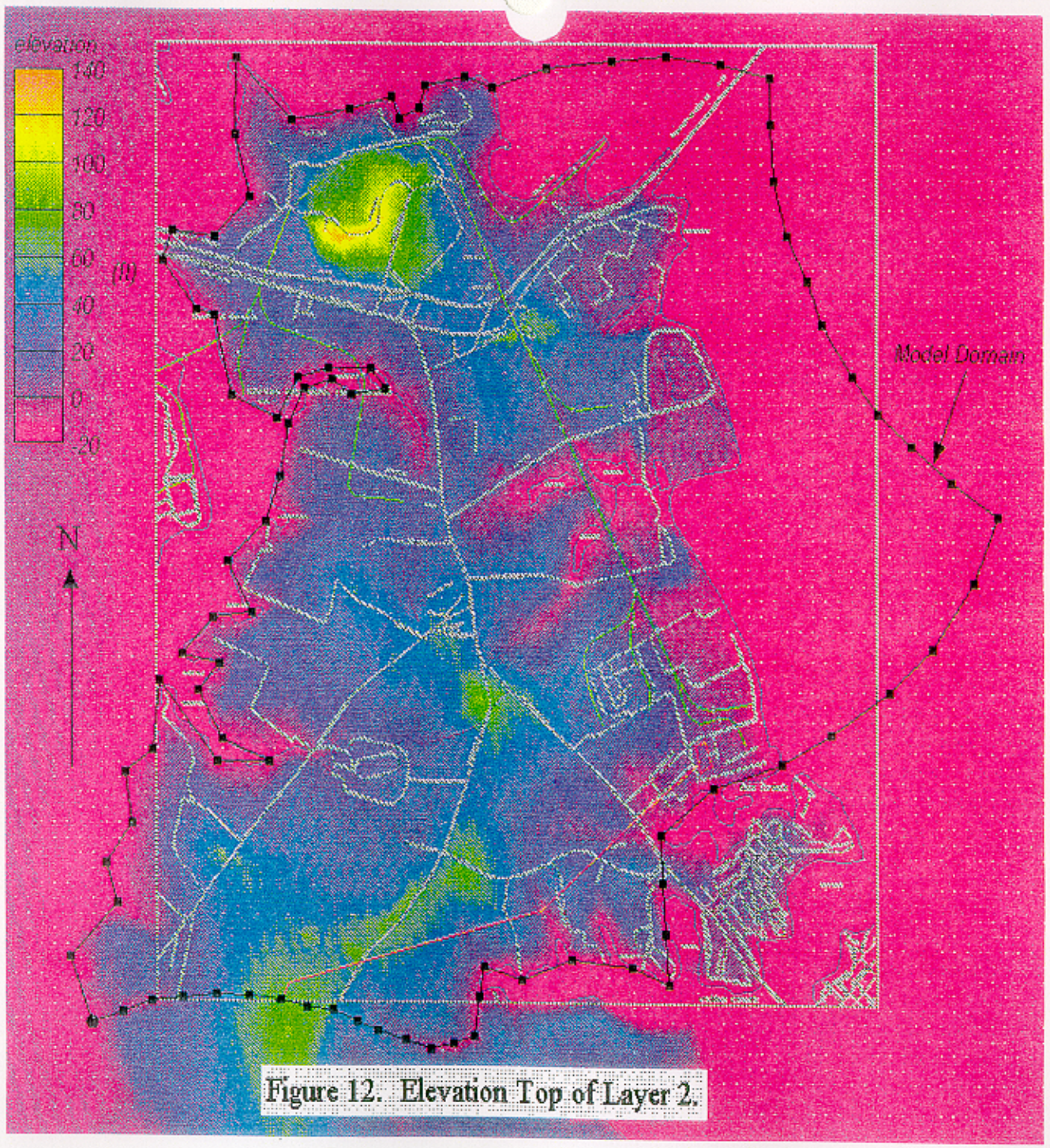


Figure 12. Elevation Top of Layer 2.

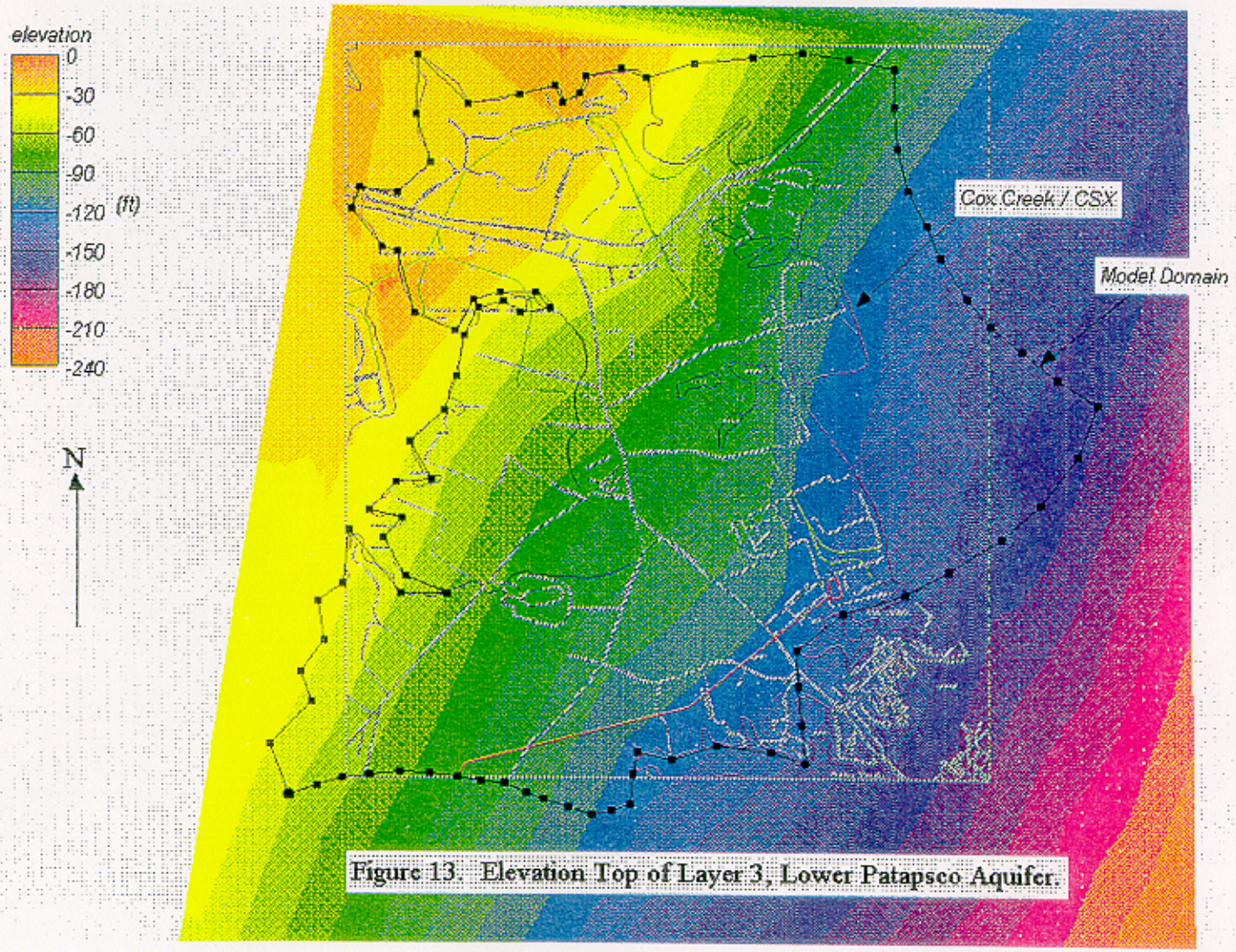


Figure 13. Elevation Top of Layer 3, Lower Patapsco Aquifer.

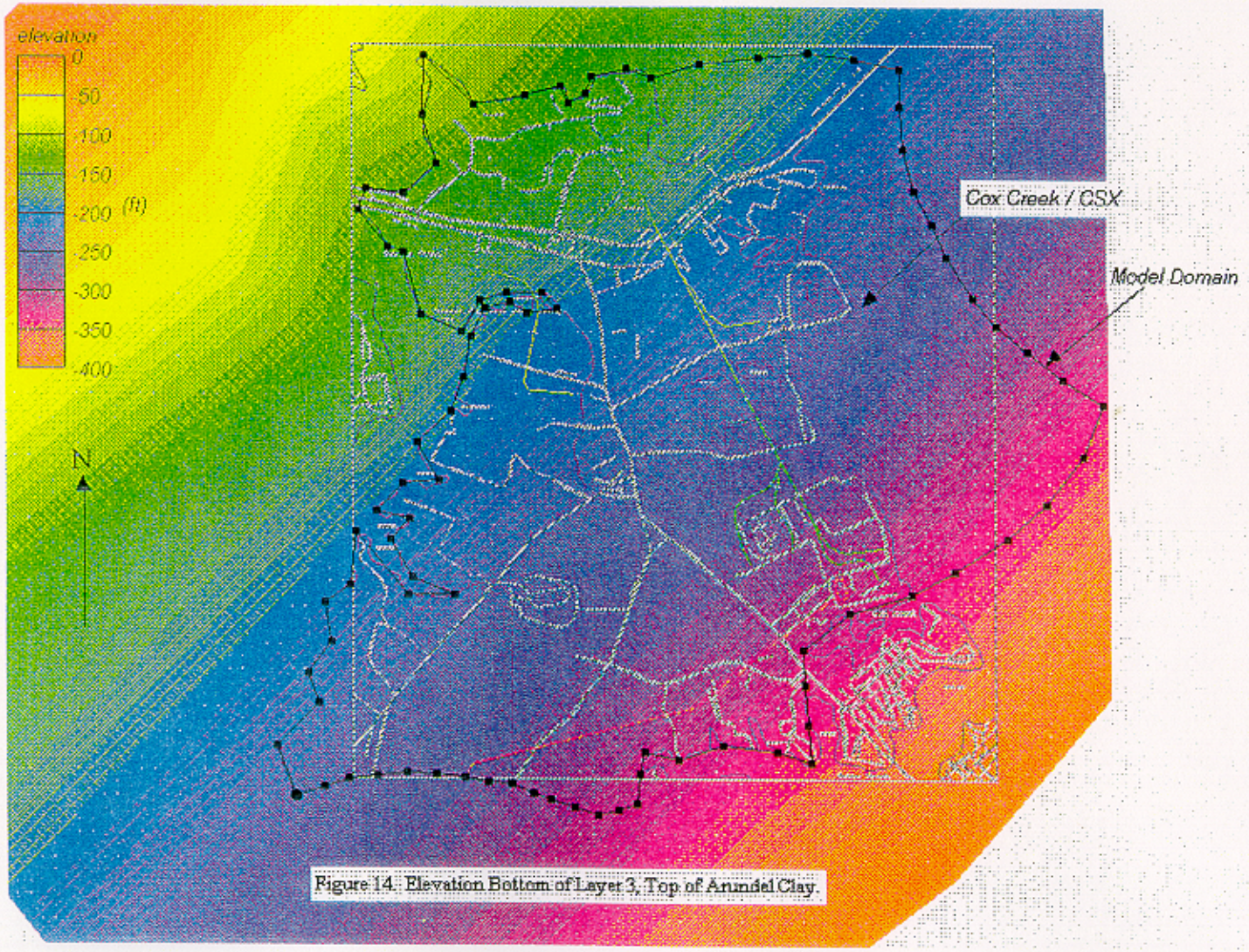


Figure 14. Elevation Bottom of Layer 3, Top of Arundel Clay.

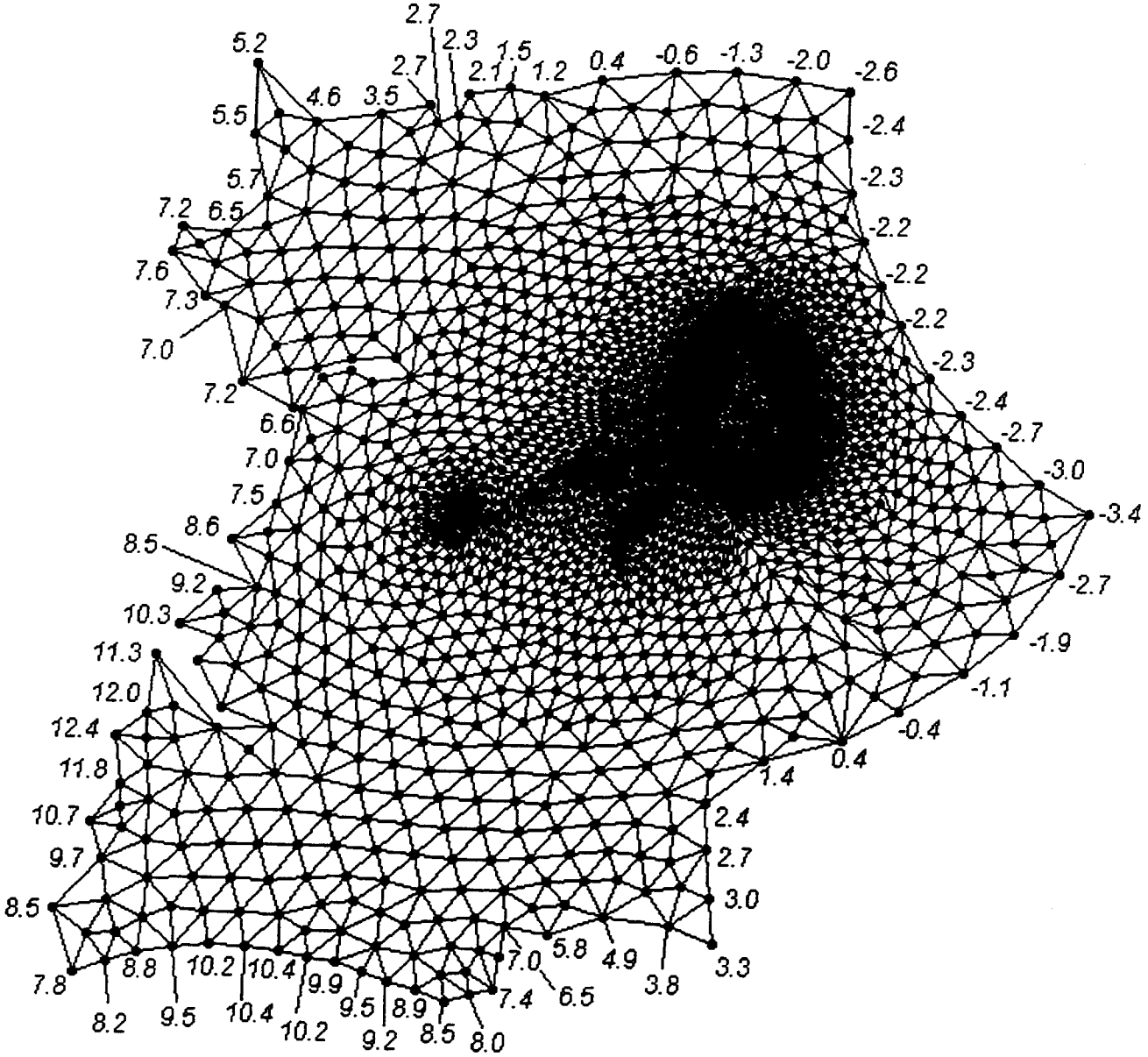
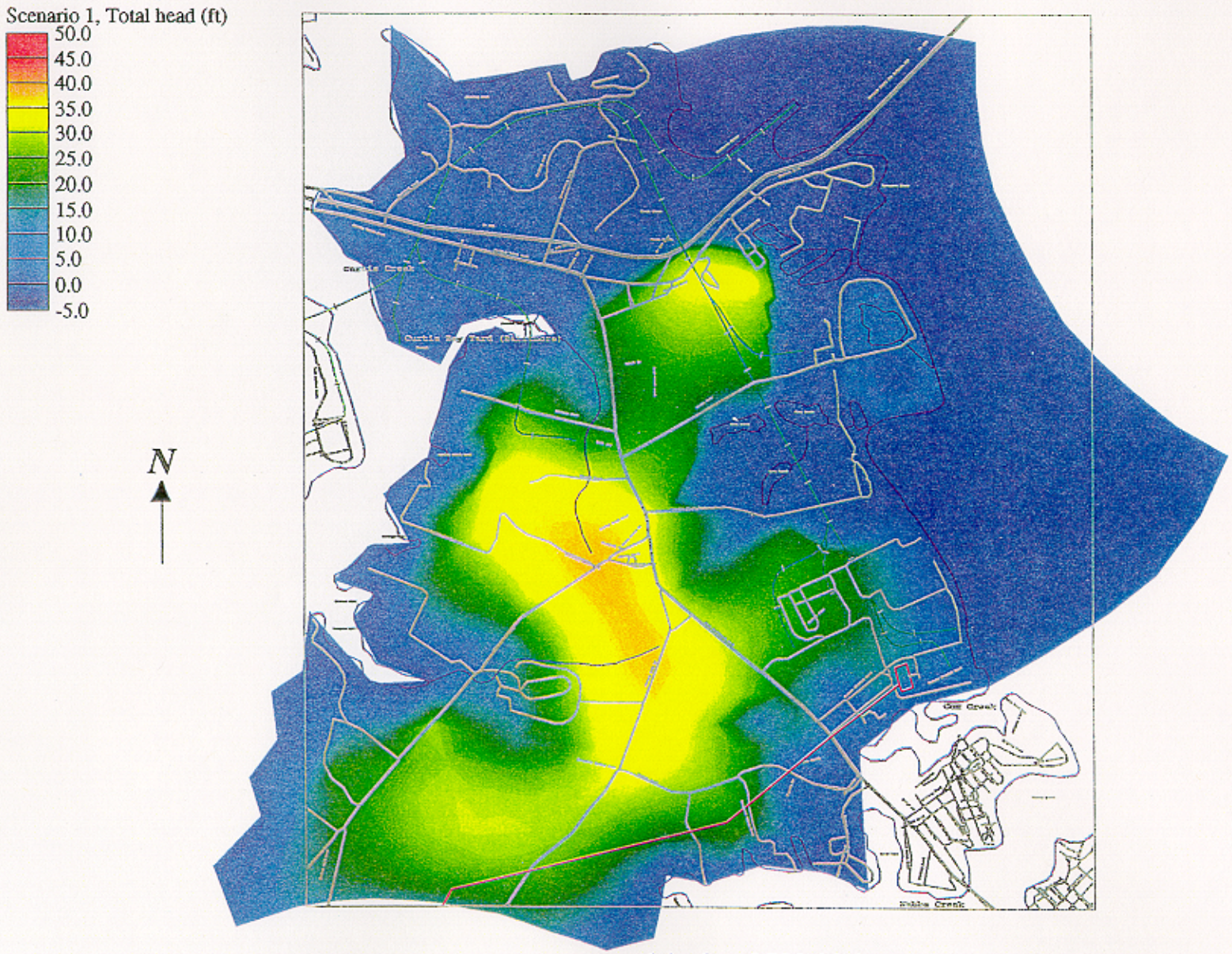


Figure 15. Layer 3 Constant Head Nodes (Elev. in ft.)

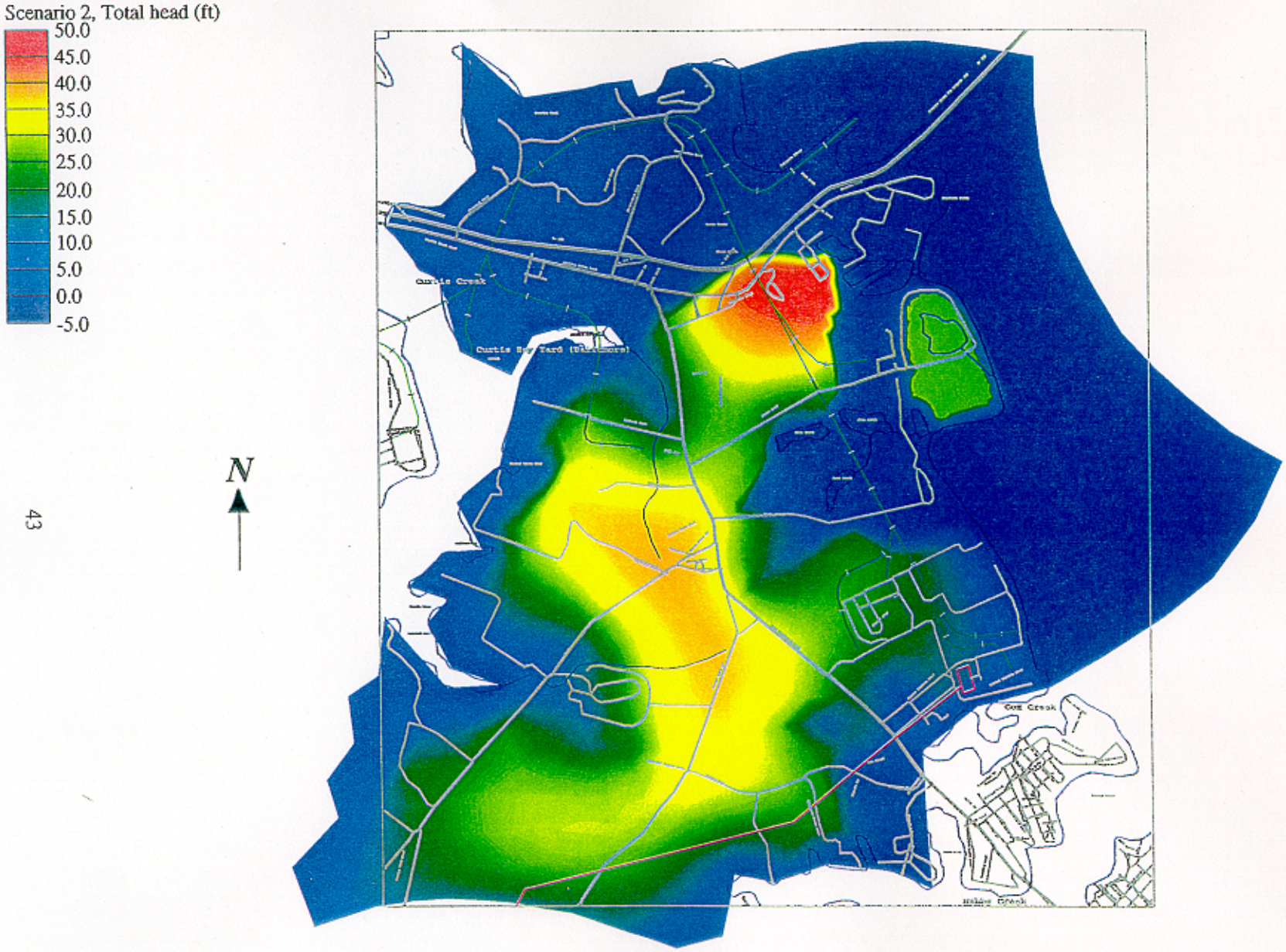


1 inch = 3500.00 feet

Figure 16. Scenario 1, Total head (ft), Layer 1.

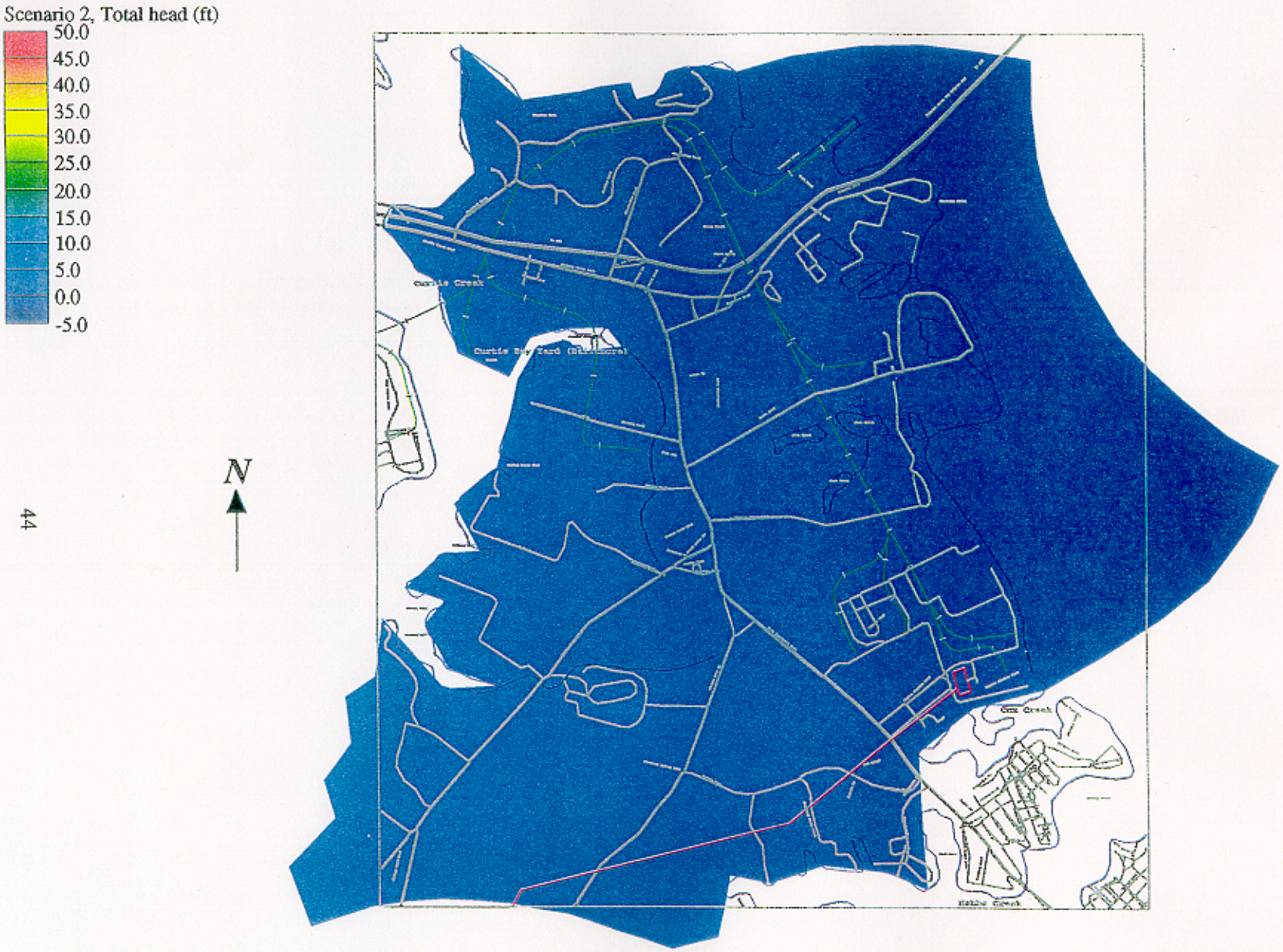
1 inch = 3500.00 feet

Figure 17. Scenario 1, Total head (ft), Layer 3.



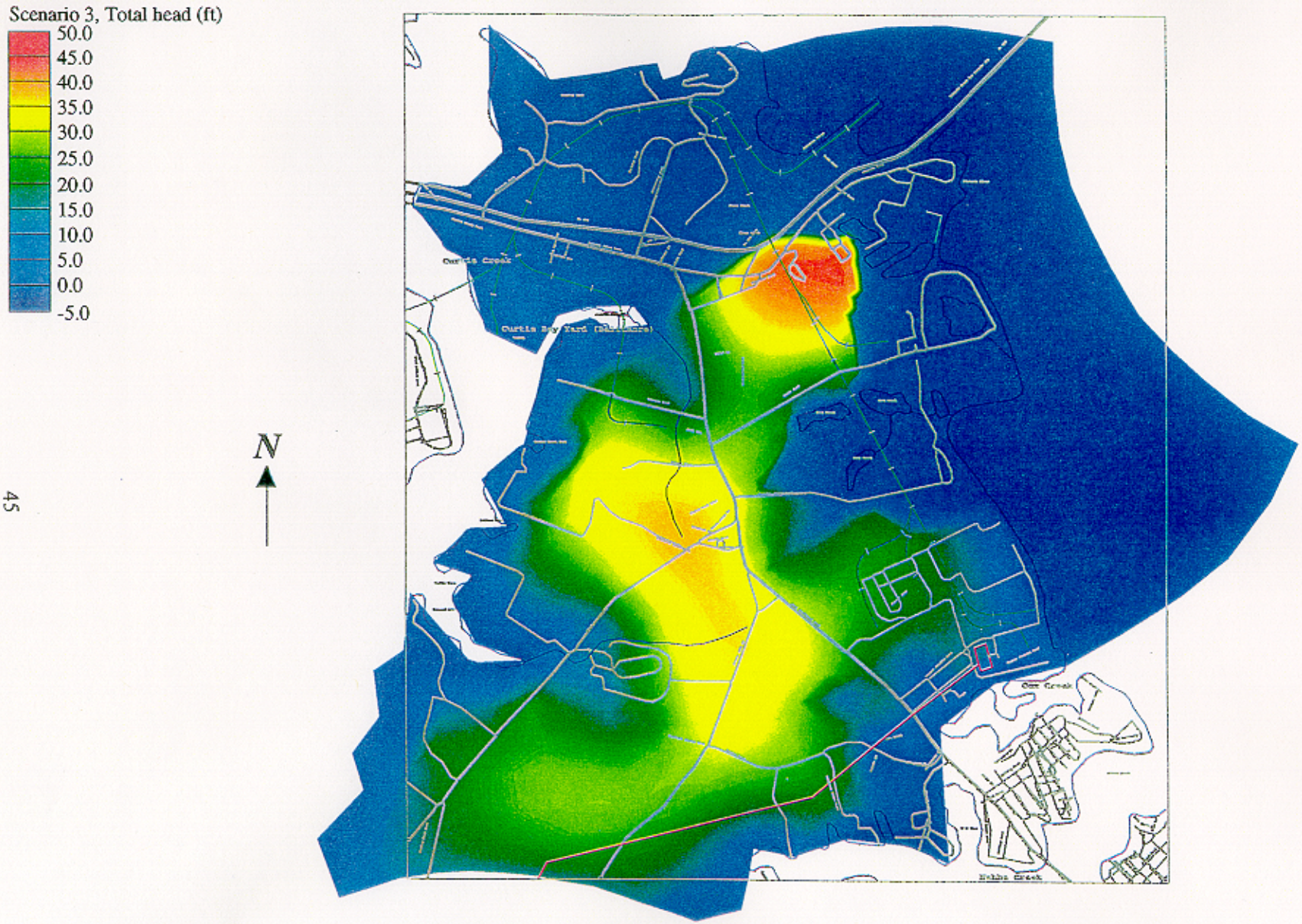
1 inch = 3500.00 feet

Figure 18. Scenario 2, Total head (ft), Layer 1.



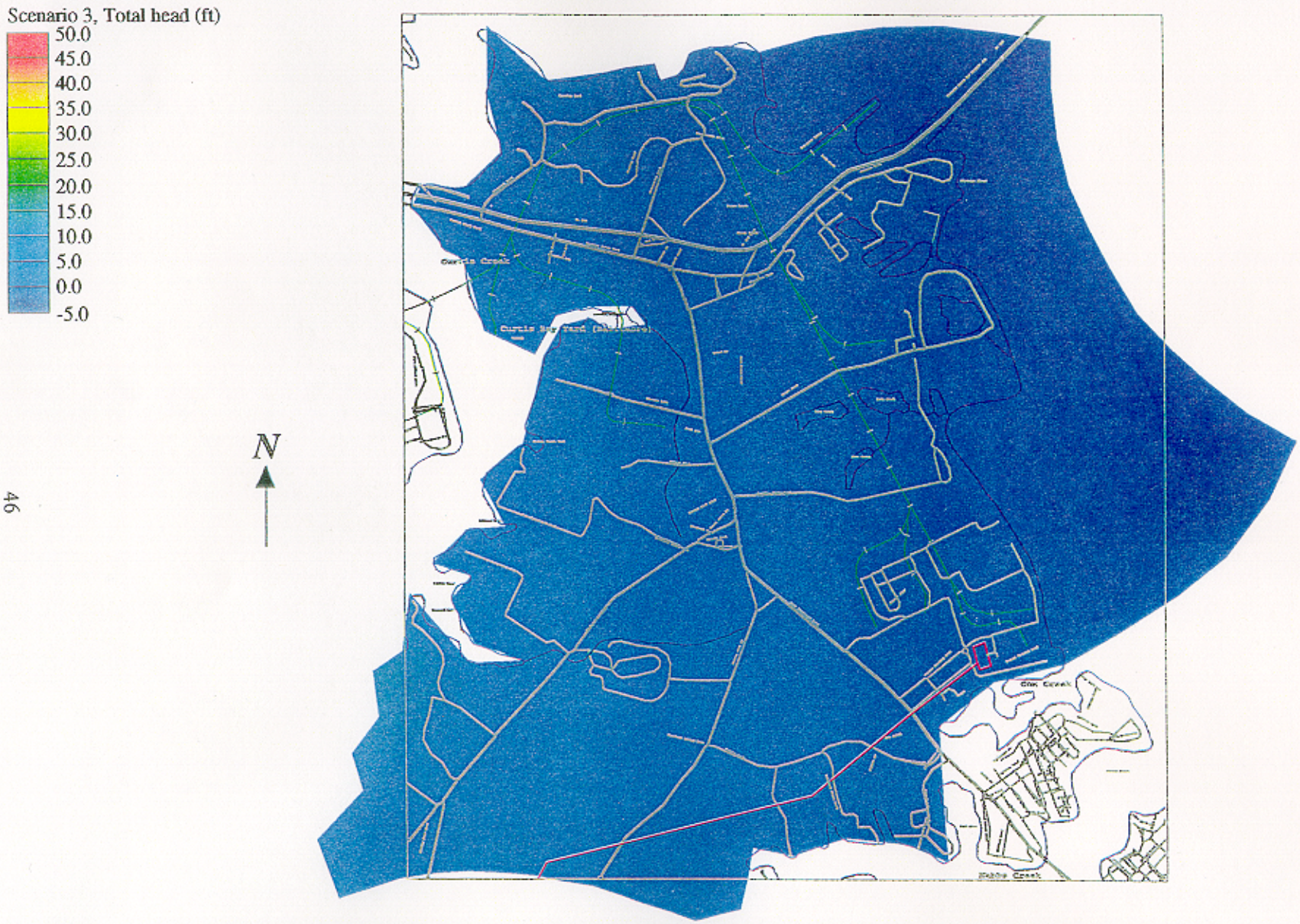
1 inch = 3500.00 feet

Figure 19. Scenario 2, Total head (ft), Layer 3.



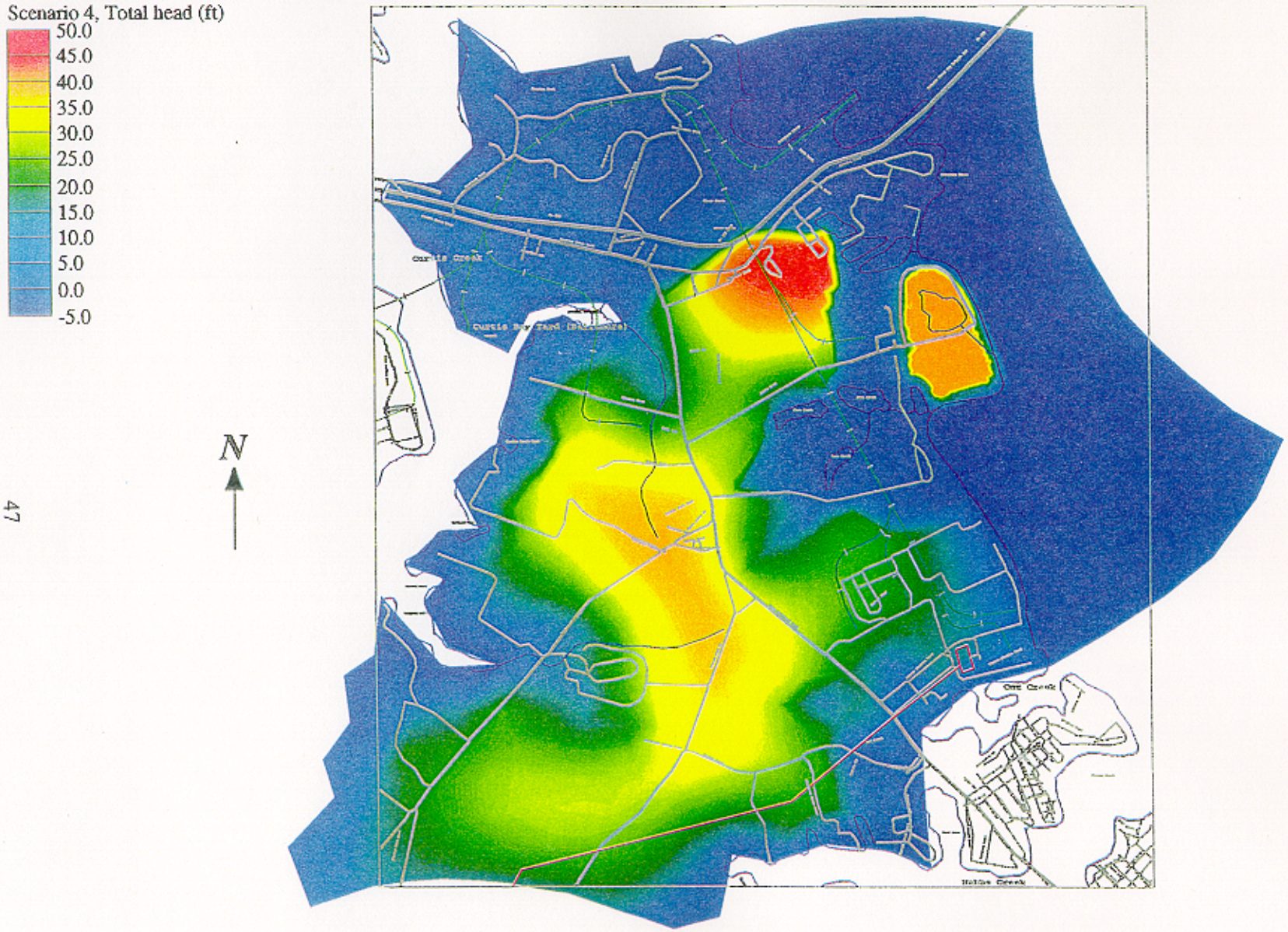
1 inch = 3500.00 feet

Figure 20. Scenario 3, Total head (ft), Layer 1.



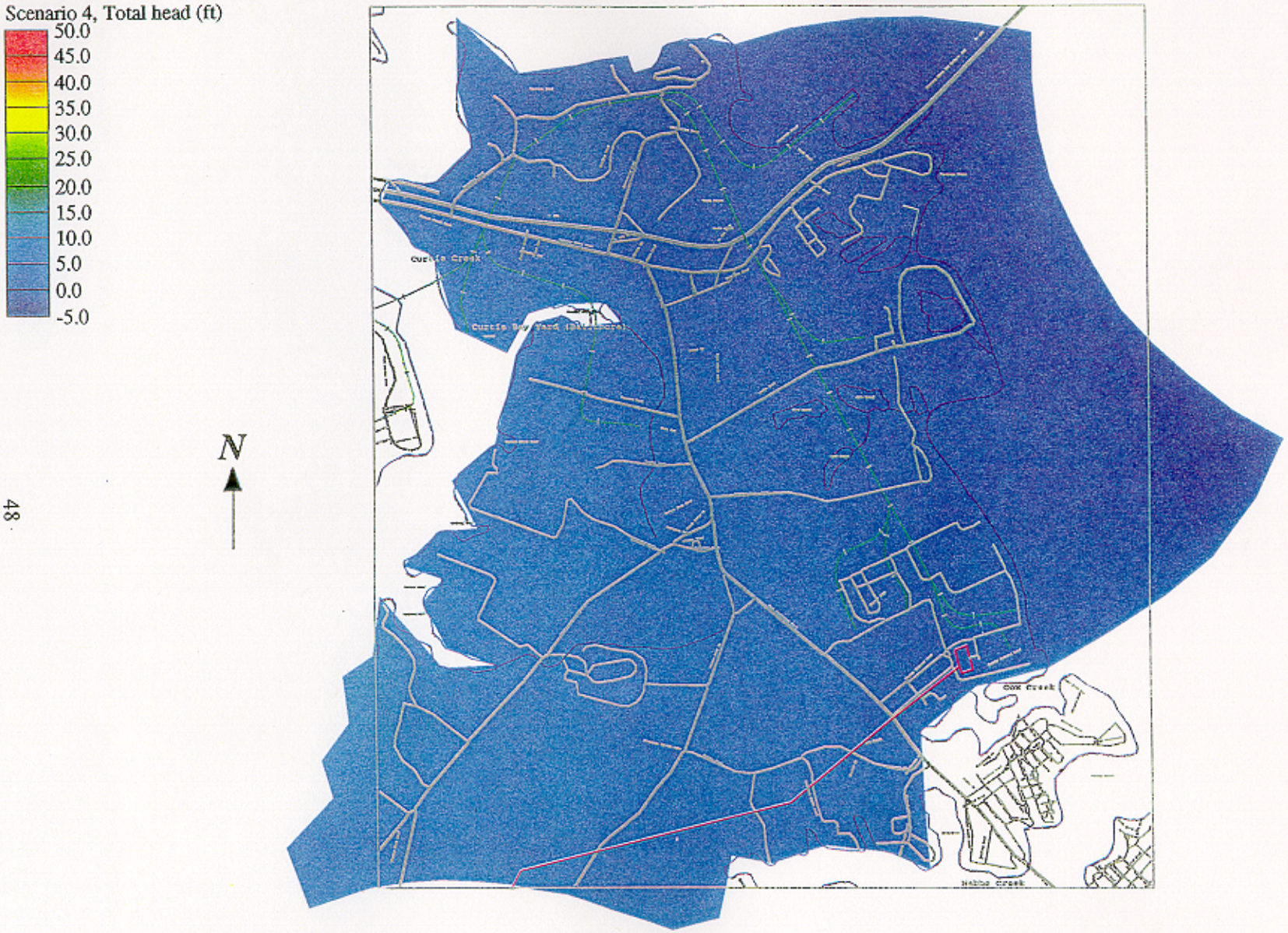
1 inch = 3500.00 feet

Figure 21. Scenario 3, Total head (ft), Layer 3.



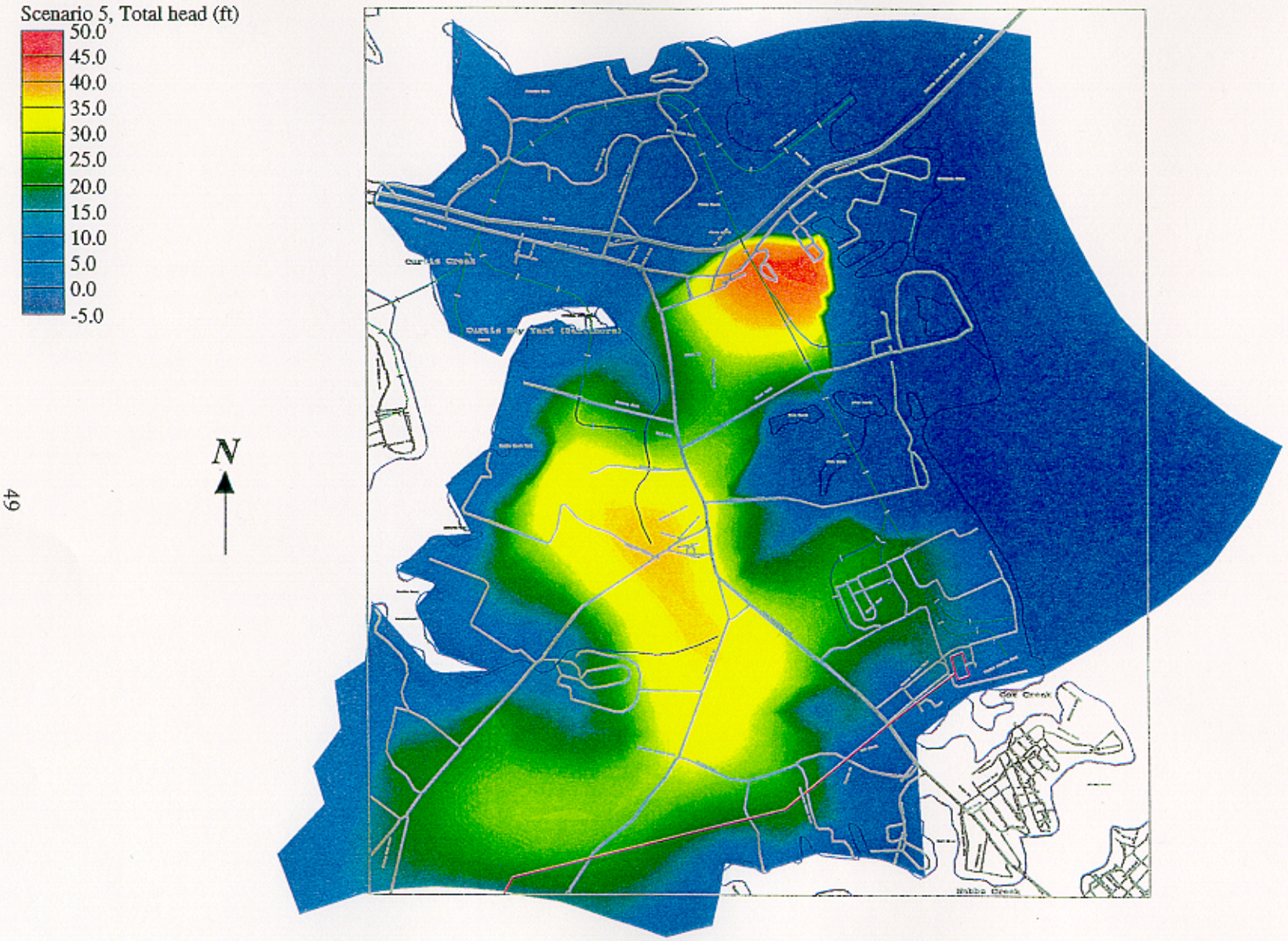
1 inch = 3500.00 feet

Figure 22. Scenario 4, Total head (ft), Layer 1.



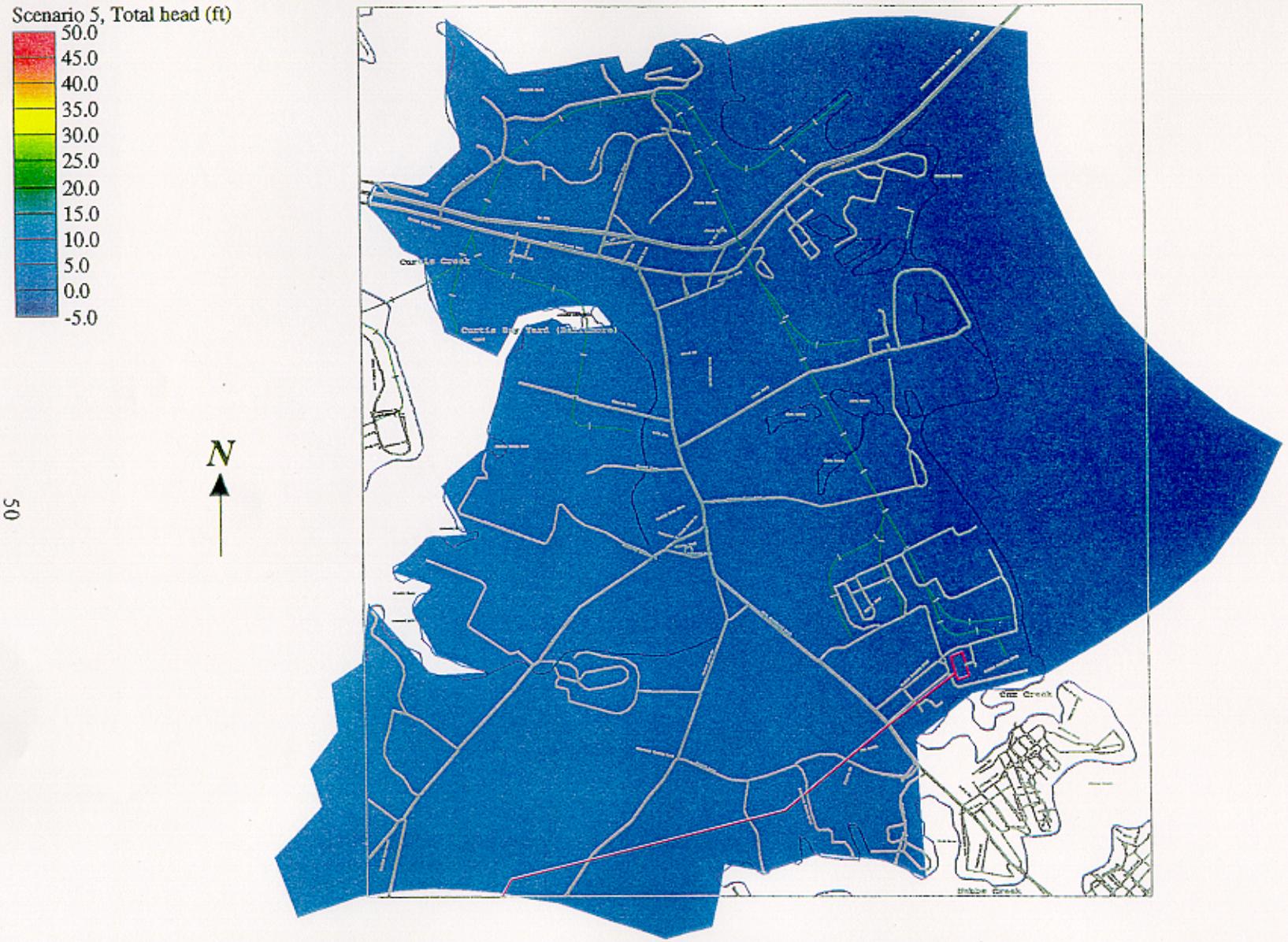
1 inch = 3500.00 feet

Figure 23. Scenario 4, Total head (ft), Layer 3.



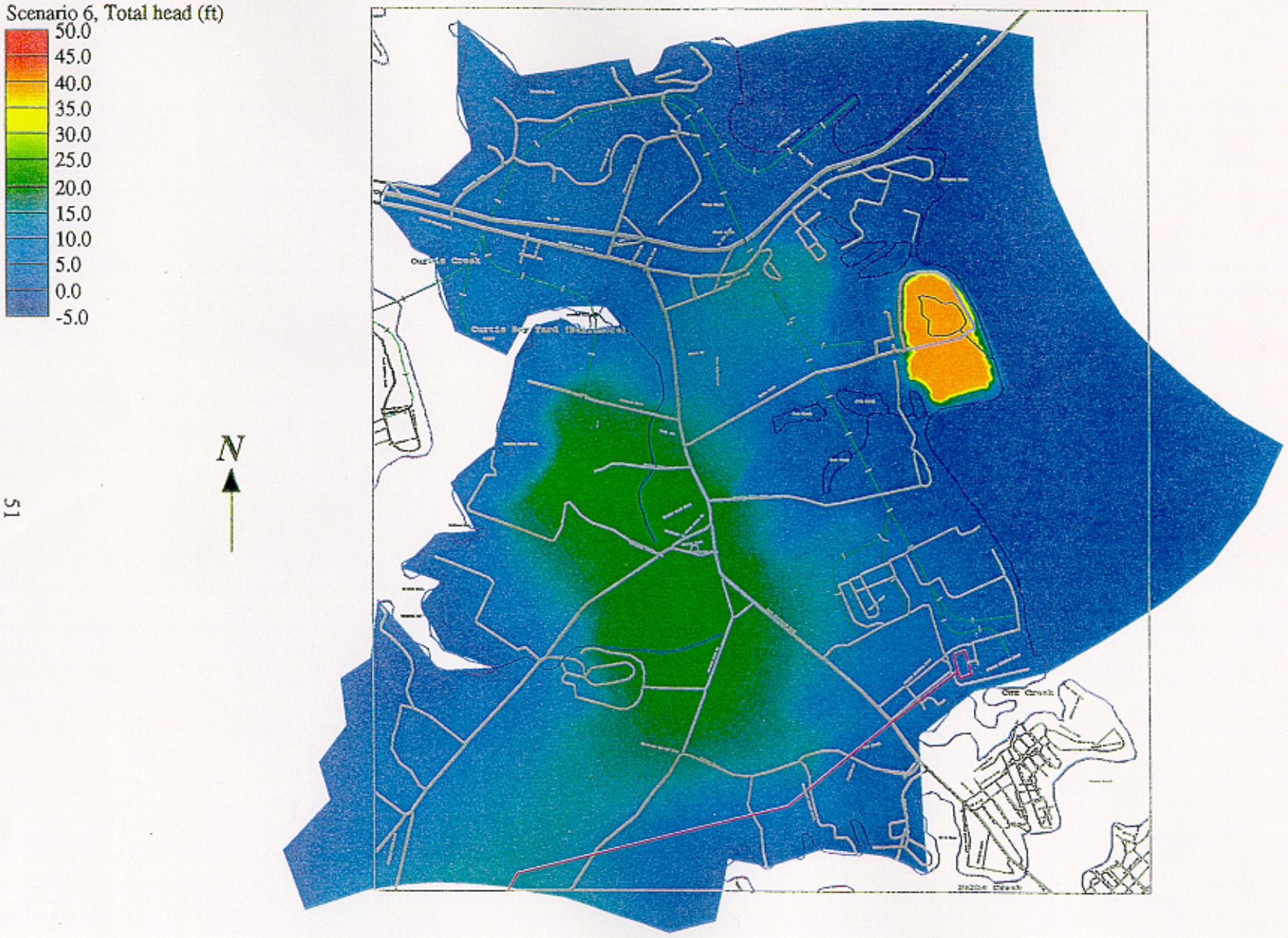
1 inch = 3500.00 feet

Figure 24. Scenario 5, Total head (ft), Layer 1.



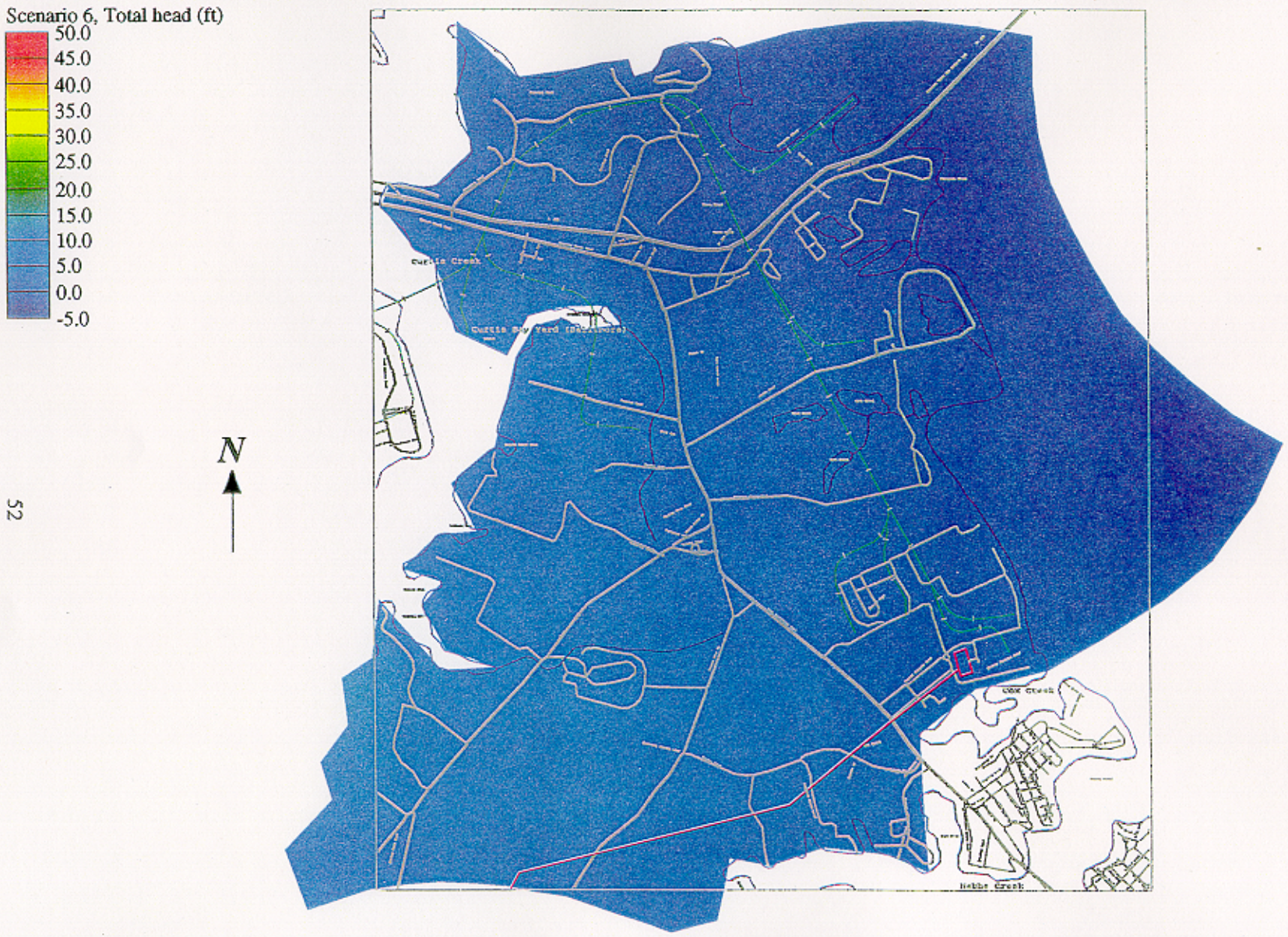
1 inch = 3500.00 feet

Figure 25. Scenario 5, Total head (ft), Layer 3.



1 inch = 3500.00 feet

Figure 26. Scenario 6, Total head (ft), Layer 1.



1 inch = 3500.00 feet

Figure 27. Scenario 6, Total head (ft), Layer 3.

Appendix A. Stratigraphic Well Logs

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD.

SUBSURFACE EXPLORATION NOTES

1. EXPLORATION WAS PERFORMED DURING MAY THRU AUGUST 1996.

2. DRILL HOLES (DH) WERE ACCOMPLISHED BY STANDARD PENETRATION TEST PROCEDURE (SPT) USING A 1-3/8" ID X 2'-3/4" LONG SPLIT SPOON. SAMPLE SPOONS WERE ADVANCED BY A 140# HAMMER FALLING 30". THESE HOLES WERE ADVANCED BETWEEN DRIVES BY HOLLOW STEM AUGER(HSA), ROLLER BIT OR FISHTAIL BIT AS NOTED ON LOGS.

   P - INDICATES LOCATION OF PRESSED SHELBY TUBE SAMPLE

   RB - HOLE WAS ADVANCED BY ROCK BIT

   WH - WEIGHT OF HAMMER

3. BLOW COUNTS REQUIRED TO ADVANCE SAMPLE ARE SHOWN IN COLUMN (a).

4. SOIL DESCRIPTIONS ARE SHOWN IN COLUMN (c).

5. SOIL DESCRIPTIONS ARE FIELD CLASSIFICATIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487).

6. GROUNDWATER DEPTHS ARE INDICATED ON THE LOGS AS ▽ , ▼ & ▼ AND ARE SHOWN IN COLUMN (d). PERTINENT DATA FOR THESE READINGS ARE SHOWN AT THE BOTTOM OF LOG UNDER GROUNDWATER DATA OR ADDITIONAL GROUNDWATER DATA. ACTUAL GROUNDWATER LEVEL MAY VARY DEPENDING UPON SEASONS AND AMOUNT OF RAINFALL.

7. ELEVATIONS SHOWN ON THE BORING LOGS ARE THE TOP OF THE INTERIOR PVC CASING OF THE ACTUAL WELL. THEY WERE DETERMINED BY SURVEY.

STA.
OFFSET:
TOP ELEV: 39.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 494360.3
E 926572.9
COMPLETED: August 8, 1996

C-1

Depth	(c) Description	(d)	(a) Blows	(b)
0.2	Dry dk. brown silty CLAY -TOPSOIL w/ roots		4-7-8	
2.0	Dry brown to yellow-brown silty CLAY			
9.5	Dry lt. gray CLAY, mottled, iron stained 2.5'-4.0': w/ pieces of Lignite 7.5'-9.0': w/ orange-brown CLAY, some v. fine grained SAND		11-18-19 10-13-17 7-10-14	
12.0	Sli. moist gray silty CLAY w/ v. fine grained SAND, w/ veins of brown-orange sand		6-10-12	
14.5	Moist gray/orange silty SAND, areas that are clayey	▽	13-16-14	
17.0	Moist purple-gray clayey SAND, fine grained		8-11-18	
27.0	Sli. moist dk. gray silty CLAY w/ areas of lt. gray sandy SILT interbedded 22.5'-24.0' & 25.0'-26.5': moist w/ pieces of Lignite, more clayey		5-11-14 5-9-14 6-8-11 6-9-17	
29.5	Moist dk. gray silty CLAY w/ areas of lt. brown silty CLAY w/ v. fine grained sand in areas		9-10-11	
32.0	Sli. moist lavender-gray clayey SAND, v. fine grained w/ Lignite		7-10-20	
34.5	Sli. moist dk. gray clayey SILT w/ areas of lt. gray sandy SILT		6-11-18	
	Moist dk. gray clayey SILT, w/ fine brown mica flakes Last 0.5'(45.0'-46.45') lighter gray contains some v. fine grained silty SAND		10-22-23 23-35-54	

Depth scale: 5, 10, 15, 20, 25, 30, 35

C-1
GROUNDWATER DATA
▽ WHILE DRILLING: 12.0
▼ ON COMPLETION: NT
▼ 24 Hr. READING: NT

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:45

STA.
OFFSET:
TOP ELEV: 39.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 494360.3
E 926572.9
COMPLETED: August 8, 1996

	(c)	(d)	(a)	(b)
	Moist dk. gray clayey SILT, w/ fine brown mica flakes Last 0.5'(45.0'-46.45') lighter gray contains some v. fine grained silty SAND		18-30-49	
48.2	Moist yellowish-white silty SAND, v. fine grained, areas of red/orange		27-54-100/.45	
52.9	Moist v. lt. tan-white SAND, fine grained, bit clayey in areas 65.0'-65.8': silty & clayey all over w/ an area of greenish-white SILT in sample		89-100/.2	
67.9	Moist tan-orange/orange-brown silty SAND, iron stained, few areas of white SILT		67-100/.25	
72.9	Sli. moist yellow-white fine grained SAND, beach-like		45-100/.25	
77.7	Dk. grayish-white v. fine grained sandy SILT, clayey in shoe		42-100/.3	
82.7	Moist orange/ lt. gray/ yellow-white silty SAND, v. fine grained, iron stained, layered in spoon		67-100/.32	
			100/.45	
			100/.45	

45 50 55 60 65 70 75 80

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:46

STA.	CSX/COX CREEK PLACEMENT AREAS	N 494360.3	C-1
OFFSET:	AA COUNTY, MD	E 926572.9	3 of 4
TOP ELEV: 39.0		COMPLETED: August 8, 1996	

	(c)	(d)	(a)	(b)
87.7	Moist orange/ lt. gray/ yellow-white silty SAND, v. fine grained, iron stained, layered in spoon		100/.48	
98.0	Dry burgundy red/ lt. gray CLAY, marbled 90.0'-91.3': much more burgundy color 95.0'-95.98': much more lt. gray, contains some v. fine grain SAND		90: 61-71-100/.3 95: 47-100/.48	
107.7	Sli. moist grayish-white silty SAND, v. fine grained		100: 100/.45 105: 100/.45	
122.7	Sli. moist grayish-white fine grained SAND, less silty than before		110: 100-100/.2 115: 86-100/.2 120: 100/.45	
127.7	Moist yellow fine grained SAND		125: 100/.48	
	Moist tan/yellow/orange fine to medium grained SAND, iron stained			

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:46

STA.
OFFSET:
TOP ELEV: 39.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 494360.3
E 926572.9
COMPLETED: August 8, 1996

(c) (d) (a) (b)

Moist tan/yellow/orange fine to medium grained SAND, iron stained

137.9

Moist lt. brownish gray fine to medium gray SAND

147.7

Moist lt. brownish-tan fine to medium grained SAND w/ some dk. reddish-brown grains

150.3

BOTTOM OF HOLE

POCKET PENETROMETER

DEPTH	T/SQ. FT.
0.0'-0.3'	1.0, 1.25, 2.0
5.0'-6.5'	4.5+, 4.25, 4.5+
7.5'-9.0'	2.75, 3.5, 2.5, 4.5+
10.0'-11.5'	3.0, 2.75, 2.75, 3.0
17.5'-19.0'	2.0, 1.5, 1.0, 0.5
20.0'-21.5'	1.0, 2.0, 1.0, 1.5
22.5'-24.0'	2.75, 2.5, 3.0, 2.75
25.0'-26.5'	1.25, 1.5, 2.25
27.5'-29.0'	0.25, 0.5, 2.25
30.0'-31.5'	3.25, 3.5, 1.75
32.5'-34.0'	3.25, 1.25, 1.25
35.0'-36.5'	4.2, 4.1, 4.5
37.5'-39.0'	4.0, 4.3, 4.5
40.0'-41.5'	4.2, 4.0, 4.4
45.0'-46.45'	3.0, 3.25, 4.5
90.0'-91.3'	4.5+, 4.5+, 4.5+
95.0'-95.98'	3.0, 4.0, 4.5+

DRILLING PROCEDURE:
Failing F-10 Rig
Hole was advanced to 34.0' using SPT with 4-1/4" HSA between drives.
A 10" casing (PVC) was installed to 30.0', after re-drilling w/ 12-1/4" HSA Hole was advanced to 150.33' using SPT with fishtail bit & mud between drives.
Hole was cleaned out with a Hawthorne bit to 150.33'.

135 — 81-100/.2
81-100/.2
140 — 26-100/.2
145 — 100/.3
150 — 100/.33
155
160
165
170

GEO-2 MSC01 11/21/96 13:46

Fill Auger SPT RB Cored

STA.
OFFSET:
TOP ELEV: 39.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 497924.4
E 928772.6
COMPLETED: July 31, 1996

D-2

Depth	(c) Description	(d)	(a)	(b)
0.7	Moist dk. brown sandy SILT		2-4-11	
1.1	Moist reddish brown clayey SAND, medium to coarse grained			
3.3	Lt. yellowish brown medium grained SAND			
5.7	Wet grayish-brown fine to medium silty SAND		12-15-8	
8.3	Saturated lt. yellowish-brown fine to medium grained silty SAND			
11.0	Wet gray medium to coarse silty SAND		5-8-9	
35.0	Moist mottled reddish-brown, grayish white, olive yellow clayey SILT		11-15-16, 5-12-15, 22-43-52, 26-36-56	
37.0	Moist red/yellow-green/v. lt. grayish-white mottled CLAY, mainly red color		15-32-58	
38.5	Sli. moist gray-purple (lavender) CLAY w/ areas of lt. gray CLAY	▼	26-59-100.4	
39.5	Moist lt. gray CLAY, speckled w/ red & yellow-green CLAY			

D-2
GROUNDWATER DATA
▽ WHILE DRILLING: NT
▼ ON COMPLETION: NT
▼ 24 Hr. READING: 37.35

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:49

STA.
OFFSET:
TOP ELEV: 39.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 497924.4
E 928772.6
COMPLETED: July 31, 1996

D-2
2 of 4

	(c)	(d)	(a)	(b)
43.3	Sli. moist speckled lt. gray & red CLAY, veins of yellow-orange CLAY embedded		26-43-100	
48.3	Sli. moist dk. burgundy red CLAY, midway the sample is speckled burgundy red/lt. gray, then goes into lavender CLAY w/ yellow-green speckling of CLAY from 46.0'-46.35	45	40-100-100/.35	
53.2	Sli. moist lt. gray CLAY, speckled w/ dk. burgundy red CLAY	50	28-81-100/.4	
58.2	Sli. moist lt. gray/burgundy red CLAY, marbled looking, w/ some areas having green-brown CLAY embedded	55	37-76-100/.3	
63.2	Sli. moist lt. gray CLAY w/ veins of burgundy red CLAY. This burgundy color is lighter at beginning of sample, w/ areas of brown CLAY near & in spoon's shoe	60	33-89-100/.35	
68.3	Sli. moist lt. gray/lavender/burgundy CLAY, marbled. First foot has areas of dk. gray/yellow-brown on sides of sample. Last 0.5' has more lavender color	65	17-51-88	
78.1	Sli. moist lavender/lt. gray CLAY, marbled w/ veins of burgundy CLAY 75.0'-76.25': This drive has blotches of yellow-green CLAY in sample & larger veins of burgundy CLAY	70 75	45-100/.45 44-97-100/.25	
83.3	Sli. moist dk. brick red(brownish color) w/ lt. gray/lavender/yellow green CLAY	80	36-34-61	
	Sli. moist lavender & lt. gray CLAY w/ areas of burgundy & specks of yellow CLAY			

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:49

STA.
OFFSET:
TOP ELEV: 39.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 497924.4
E 928772.6
COMPLETED: July 31, 1996

D-2
3 of 4

Depth	(c) Description	(d)	(a)	(b)
	Sli. moist lavender & lt. gray CLAY w/ areas of burgundy & specks of yellow CLAY		30-100/.4	
88.0	Sli. moist burgundy red/lavender/lt. gray CLAY, marbled, w/ areas of yellow green CLAY	90	41-92-100/.25	
93.1	Sli. moist lt. silver gray fine grained silty SAND			
95.4	Sli. moist green-brown/burgundy CLAY, marbled, w/ areas of lt. silver gray silty SAND w/ lavender & lt. gray CLAY near & in spoon's shoe	95	45-92-100/.25	
98.1	Sli. moist reddish-brown silty CLAY			
100.7	Sli. moist reddish brown/greenish-brown/lavender CLAY, w/ some of lt. silver gray silty SAND embedded	100	35-70-100/.35	
103.2	Sli. moist lavender CLAY, mottled w/ areas of burgundy red/yellow-green/brown CLAY to 105.5' 105.5'-105.7': Sli. moist reddish- brn./lt. brn. silty sandy CLAY 105.7'-105.9': Sli. moist greenish-brn. CLAY w/ silver gray silty SAND 105.9'-106.3: Sli. moist reddish brn./lt. brn. silty SAND, fine grain	105	8-30-100/.45	
108.2	106.3'-106.45: Sli. moist reddish-brown/lt. brown silty sandy CLAY 110.0'-110.2': Moist lt. brown-fine grained clayey silty SAND 110.2'-110.9': Moist brownish white to v. lt. grayish-white silty clayey SAND, v. fine grain	110	37-100/.4	
113.0	Moist reddish-brown/lt. brown silty SAND, fine grain	115	100/.25	
117.3	V. moist lt. grayish-white silty SAND, fine grained 125.0'-125.8': @ 125.4 few veins of dk. gray CLAY in sample 130.0'-130.1': has 0.1' of grayish-white SILT w/ yellow colored veins of SILT.	120	50-100/.45	
		125	87-100/.3	

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:50

STA.
OFFSET:
TOP ELEV: 39.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 497924.4
E 928772.6
COMPLETED: July 31, 1996

(c) (d) (a) (b)

130.3

BOTTOM OF HOLE

POCKET PENETROMETER

DEPTH	T/SQ. FT.
35.0'-36.5'	4.5+, 4.5+,4.5+
37.5'-38.9'	4.25, 4.5, 4.25
40.0'-41.5'	4.5, 4.5,4.25
45.0'-46.35'	4.5+, 4.5+, 4.5+
50.0'-51.4'	4.5+, 3.5, 4.25
55.0'-56.3'	0.5, 0.5 0.5
60.0'-61.35'	0.75, 0.75, 1.25
65.0'-66.5'	4.5+, 4.5+, 4.5+
70.0'-70.95'	4.5+, 4.5+, 4.5+
75.0'-76.25'	4.5+, 4.5+, 4.5+
80.0-81.5'	3.75, 1.75, 2.0
85.0'-85.9'	4.5+, 4.5+, 4.5+
90.0'-91.25	2.5, 4.5+, 4.5+
95.4'-96.25'	2.5, 3.0
100.0'-101.35'	3.5, 4.0, 4.0
105.0'-106.45'	1.25, 1.75, 4.5

DRILLING PROCEDURE:
Failing F-10 Rig
Hole was advanced to 30.0' using SPT with 11-1/2" fishtail bit between drives.
A 10" casing (PVC) was installed to 30.0'.
Hole was advanced to 130.3' using SPT with fishtail bit & mud between drives.

135
140
145
150
155
160
165
170

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:50

STA.
OFFSET:
TOP ELEV: 15.7

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 495491.1
E 930024.5
COMPLETED: May 23, 1996

E-1
1 of 5

Depth	(c) Description	(d)	(a) Blows	(b)
1.0	Moist brownish orange to lt. brown SAND, med. grained, well sorted, subrounded, some CLAY		2-2-4	
	Moist mottled reddish brown, grayish white, pink silty CLAY			
5				
10			9-25-37	
15.8	Wet grayish white, yellowish brown clayey SAND, fine			
15				
20.2	Moist mottled grayish white, yellow, brown sandy silty CLAY, fine to medium grained sand	∇	15-23-19	
20				
25.8	Moist mottled reddish brown silty CLAY			
25				
30.3				
30.5	Moist yellowish brown , grayish white fine sandy CLAY		10-24-24	
	Moist mottled reddish brown silty CLAY			
30				
35.8	Moist mottled reddish brown, grayish white, yellowish brown silty CLAY pink, grayish white color 50.0'-51.5'			
35				

E-1
GROUNDWATER DATA
∇ WHILE DRILLING: 20.15
∇ ON COMPLETION: NT
∇ 24 Hr. READING: NT

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:50

STA.
OFFSET:
TOP ELEV: 15.7

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 495491.1
E 930024.5
COMPLETED: May 23, 1996

(c) (d) (a) (b)

Moist mottled reddish brown, grayish white, yellowish brown silty CLAY
pink, grayish white color 50.0'-51.5'

78.2

Moist grayish white sandy CLAY, some silt

80.7

81.2

Wet grayish white silty clayey SAND, fine grained

Moist grayish white CLAY

83.3

Moist to wet grayish white silty CLAY w/ some very fine sand

45 — 11-18-21

50 — 18-29-53

55

60 — 18-34-53

65

70 — 32-71-100/.4

75 — 34-60-100/.4

80 — 13-21-35

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:51

STA.
OFFSET:
TOP ELEV: 15.7

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 495491.1
E 930024.5
COMPLETED: May 23, 1996

(c)	(d)	(a)	(b)
Moist to wet grayish white silty CLAY w/ some very fine sand		20-34-39	
88.3			
Wet grayish white to white clayey SAND, medium grain, well sorted, some clay	90	25-65-100/.4	
93.3			
Wet grayish white medium SAND			
95.1			
95.3 Wet grayish white clayey SAND	95	61-33-38	
Moist mottled reddish brown CLAY			
98.3			
Moist mottled reddish brown, grayish white, pink silty CLAY with purple 105.0'-106.5'	100	27-84-100/.35	
	105	44-64-100	
108.3			
Moist reddish brown, grayish white silty CLAY	110	37-100/.3	
	115	35-47-74	
118.3			
Moist lt. gray silty CLAY, with some very fine sand	120	25-33-61	
123.3			
Moist dk. gray silty CLAY, with traces of thin black pieces of wood	125	31-46-100/.4	
128.2			
Moist dk. gray silty CLAY			

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:51

STA.
OFFSET:
TOP ELEV: 15.7

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 495491.1
E 930024.5
COMPLETED: May 23, 1996

Elev.	(c) Description	(a) Blows
	Moist dk. gray silty CLAY	26-43-81
133.3	Moist dk. gray CLAY	
135.1	Moist grayish white clayey SAND, fine	
135.7	Wet grayish white fine SAND	17-84-100/.35
136.2	Wet grayish white clayey SAND, fine to medium grained	
140.3	Wet grayish white fine SAND	
140.9	Moist grayish white silty CLAY	30-44-42
143.3	Moist grayish white sandy silty CLAY, fine grained sand	26-44-97
148.3	Moist mottled reddish brown, grayish white, pink silty CLAY	100/.45
152.7	Wet grayish white to reddish brown medium SAND, well sorted, rounded grains, tr. fine black gravel	113/.5
157.8	Moist grayish white silty CLAY	
160.3	Wet grayish white medium grained SAND	135/.5
162.8	Moist to wet grayish white clayey SAND	
165.3	Wet grayish white medium grained SAND	92-100/.25
167.0	BOTTOM OF HOLE	

(d) Elevation scale: 135, 140, 145, 150, 155, 160, 165, 170

(b)

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:51

STA.
OFFSET:
TOP ELEV: 15.7

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 495491.1
E 930024.5
COMPLETED: May 23, 1996

(c) (d) (a) (b)

POCKET PENETROMETER

DEPTH	T/SQ. FT.
1.0'-1.5'	3.0, 2.25, 3.0
10.0'-11.5'	4.5+, 4.5+, 3.8
20.2'-21.5'	1.5, 3.25, 4.5+
30.5'-31.5'	4.5+, 3.8, 4.5+
40.0'-41.5'	3.0, 1.75, 2.7
50.0'-51.5'	4.5+, 4.5+, 4.5+
60.0'-61.5'	4.5+, 4.5+, 3.5
70.0'-71.4'	4.5+, 4.25, 4.1
75.0'-76.4'	2.3, 2.8, 3.3
85.0'-86.5'	2.25, 3.0, 4.0
95.3'-96.5'	1.75, 1.75, 1.5
100.0'-101.35'	4.3, 3.75, 4.25
105.0'-106.5'	1.75, 1.5, 2.25
110.0'-110.8'	2.25, 3.8, 4.3
115.0'-116.5'	4.5+, 2.5
120.0'-121.5'	3.5, 4.5+, 4.5+
125.0'-126.4'	3.2, 3.1, 3.0
130.0'-131.5'	4.0, 4.5+, 3.8
140.9'-141.5'	4.25, 4.5, 4.5
145.0'-146.5'	4.5+, 2.25, 4.5
160.0'-160.25'	4.5+, 4.5+, 3.25

DRILLING PROCEDURE:
Failing F-10 Rig
Hole was advanced to 30.0' using SPT with 4-1/4" HSA between drives.
A 10" casing (PVC) was installed to 30.0', after re-drilling w/ 12-1/4" HS A.
Hole was advanced to 167.00' using SPT with fishtail bit & mud between drives.
Hole was cleaned out w/ a Hawthorne bit.

180
185
190
195
200
205
210
215

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:51

STA.
OFFSET:
TOP ELEV: 24.6

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496588.3
E 929959.3
COMPLETED: May 16, 1996

F-1

Depth	(c) Description	(d)	(a) Blows
	0.0'-0.1': Moist dk. brown ORGANIC MATTER 0.1'-0.2': Moist brown medium grain silty SAND 0.2'-2.0': Moist yellowish brown CLAY		1-2-4-8
3.5	Moist mottled gray, yellow brn. silty CLAY		
5.9			11-18-21-25
6.2	Moist dk. gray SILT w/ tr. medium sand		
	Moist mottled red brown, gray CLAY w/ some medium sand		
8.5	Sli. moist, mottled grayish white, red brown, pink CLAY, some silt		5-17-26-30
13.5	Sli. moist mottled reddish brown, grayish white, pink silty CLAY		7-12-14-17
21.2	Moist lt. tan CLAY		15-20-32-50
23.5	Moist mottled reddish brown, grayish white, pink silty CLAY 30.0'-32.0': moist to wet 35.0'-36.5': moist	▽	9-22-32-51 19-35-55-68 28-41-44

(b)

F-1
GROUNDWATER DATA
▽ WHILE DRILLING: 24.95
▽ ON COMPLETION: NT
▽ 24 Hr. READING: NT

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:52

STA.
OFFSET:
TOP ELEV: 24.6

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496588.3
E 929959.3
COMPLETED: May 16, 1996

F-1
2 of 5

(c)	(d)	(a)	(b)
Moist mottled reddish brown, grayish white, pink silty CLAY		60-48-90	
	45	29-49-54	
	50	29-32-49	
	55	27-49-82	
60.0	60	24-54-90	
No recovery in spoon			
61.5			
Moist mottled grayish white, pink, red silty CLAY	65	33-63-93	
70.0	70	22-36-38	
No recovery in spoon			
71.5			
Moist grayish white CLAY, w/ some very fine sand 80.0'-81.5': mottled grayish white, purple, red	75	29-45-71	
	80	24-37-44	
83.3			
Wet grayish white fine SAND, well sorted			

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:52

STA.
OFFSET:
TOP ELEV: 24.6

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496588.3
E 929959.3
COMPLETED: May 16, 1996

F-1
3 of 5

	(c)	(d)	(a)	(b)
	Wet grayish white fine SAND, well sorted		95-104-75	
88.3	Moist grayish white CLAY, some fine sand			
90.2				
90.8	Wet grayish white fine clayey SAND		19-31-44	
	Moist mottled silty CLAY			
93.3	Moist dk. gray silty CLAY 100.0'-101.5': moist to very moist 105.0'-106.5': moist, lighter gray color		20-30-53	
			32-48-67	
			30-63-103	
108.3	Moist mottled reddish brown, grayish white, purple silty CLAY		69-100/.1	
115.0				
115.5	No sample recovery Wet pale yellow, pale yellow brown, medium grained SAND, well sorted		100/.5	
			96-100/.2	
			123/.5	

90 95 100 105 110 115 120 125

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:52

STA.
OFFSET:
TOP ELEV: 24.6

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496588.3
E 929959.3
COMPLETED: May 16, 1996

F-1
4 of 5

(c) (d) (a) (b)

Wet pale yellow, pale yellow brown, medium grained SAND, well sorted
130.0'-130.5': grayish white

132.8

Wet light grayish white, medium grained SAND, tr. fine to coarse gravel
140.0'-140.3': w/ some white clay and more gravel than above

142.7

Moist to wet lt. grayish white clayey SAND, medium grained, some white clay

149.0

BOTTOM OF HOLE

POCKET PENETROMETER

DEPTH	T/SQ. FT.
0.2'-2.0'	2.7, 1.75, 1.75
5.0'-5.9'	1.7, 4.0, 3.0
6.2'-7.0'	3.5, 1.5, 2.0
10.0'-12.0'	4.5+, 4.5+, 4.5+
15.0'-17.0'	4.5, 4.25, 1.7
20.0'-22.0'	3.0, 4.5+, 3.25
25.0'-27.0'	4.5+, 4.5+, 4.5+
30.0'-32.0'	3.8, 4.5+, 3.25
35.0'-36.5'	3.7, 4.5+, 4.3
40.0'-41.5'	0.75, 0.8, 0.5
45.0'-46.5'	3.5, 4.5+, 4.1
50.0'-51.5'	4.25, 4.25, 4.5+,
55.0'-56.5'	2.8, 2.75, 3.3
60.0'-61.5'	No recovery
65.0'-66.5'	4.5+,4.5+, 4.5+
70.0'-71.5'	No recovery
75.0'-76.5'	1.5, 2.5, 3.2
80.0'-81.5'	3.2, 3.2, 3.7
90.0'-90.2'	2.6, 2.5, 2.5
90.2'-90.8'	3.25, 1.75, 2.25
90.8'-91.5'	4.5+, 4.5+, 4.5+
95.0'-96.5'	4.2, 3.75, 2.8
105.0'-106.5'	3.7, 3.5, 4.0
110.0'-110.6'	3.5, 2.75, 3.8
145.0'-145.6'	2.5, 3.3, 3.5

135 140 145 150 155 160 165 170

144/.5
104/.3
100/.3
90-100/.1

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:52

STA.
OFFSET:
TOP ELEV: 24.6

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496588.3
E 929959.3
COMPLETED: May 16, 1996

F-1
5 of 5

(c) (d) (a) (b)

DRILLING PROCEDURE:
Failing F-10 Rig
Hole was advanced to 30.0' using SPT with 4-1/4" HSA between drives.
A 10" casing (PVC) was installed to 30.0', after re-drilling w/ 12-1/4" HSA.
Hole was advanced 30.0'-60.0' using SPT with roller bit & mud between drives.
Hole was advanced 60.0'-100.0' using SPT with cutting bit & mud between drives.
Hole was advanced 110.0'-149.0' using SPT with fishtail bit & mud between drives.

180
185
190
195
200
205
210
215

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:52

STA.
OFFSET:
TOP ELEV: 25.9

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496581.9
E 929930.4
COMPLETED: July 14, 1996

F-2

(c) (d) (a) (b)

5
10
15
20
25
30
35

DRILLED WITH 5 3/4" FISHTAIL BIT AND MUD
NOT SAMPLED

F-2
GROUNDWATER DATA
▽ WHILE DRILLING: NT
▽ ON COMPLETION: NT
▼ 24 Hr. READING: NT

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:58

STA.
OFFSET:
TOP ELEV: 25.9

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496581.9
E 929930.4
COMPLETED: July 14, 1996

(c) (d) (a) (b)

45
50
55
60
65
70
75
80

DRILLED WITH 5 3/4" FISHTAIL BIT AND MUD
NOT SAMPLED

Fill Auger SPT RB Cored

STA.
OFFSET:
TOP ELEV: 25.9

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496581.9
E 929930.4
COMPLETED: July 14, 1996

(c)	(d)	(a)	(b)
DRILLED WITH 5 3/4" FISHTAIL BIT AND MUD NOT SAMPLED	115.0		
Moist dk. gray clayey SILT, with some fine mica flakes	118.0	42-100	
Moist mottled reddish brown, dk. pink, lt. pink, purple clayey SILT, fine mica	122.9	70-100/.2	
Saturated, bright orange red, yellow, yellow orange, white, medium grained SAND, well sorted		100/.4	

90
95
100
105
110
115
120
125

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:58

STA.
OFFSET:
TOP ELEV: 25.9

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496581.9
E 929930.4
COMPLETED: July 14, 1996

(c) (d) (a) (b)

130.2

Saturated lt. tan, white medium grained SAND

140.8

Wet to saturated white fine silty SAND

147.0

BOTTOM OF HOLE

POCKET PENETROMETER

DEPTH	T/SQ. FT.
115.0'-116.0'	4.5, 4.4, 3.5
120.0'-120.7'	3.75, 4.0, 3.5
145.0'-145.35'	1.75, 1.9, 1.5

DRILLING PROCEDURE:
Failing F-10 Rig
Hole was advanced to 115.0' using a 5-3/4" fishtail bit and mud.
Hole was advanced 115.0'-145.35' using SPT for samples, with fishtail bit & mud between drives.
Pulled out rods and fishtail bit and augered to 25.0' with 12-1/4" ID HSA.
Installed 25' of 12" ID steel casing and grouted in place.
Hole was re-drilled using an 11-1/2" fishtail bit and mud to 147.0' and installed a 6" ID PVC well.

135 — 100/ 35
140
145 — 200/ 35
150
155
160
165
170

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:59

STA.
OFFSET:
TOP ELEV: 22.6

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496516.1
E 929668.8
COMPLETED: July 8, 1996

F-3

Depth	(c) Description	(d)	(a) Blows	(b)
	Dry gray, reddish orange, purple sandy SILT, w/ thin clay layers, fine to medium sand		15-27-13	
3.3	Sli. moist to dry mottled olive yellow, reddish brown, brown sandy SILT, fine to medium sand		5-8-11	
8.3	Moist v. soft olive yellow, grayish brown sandy clayey SILT, fine gr. sand	▽		
10.7	Wet reddish orange fine to medium silty SAND		3-5-9	
13.3	Moist lt. gray mottled w/ yellow, reddish brown clayey SILT	▼	3-9-14	
18.3	Moist mottled grayish white, yellow, reddish brown clayey SILT		9-17-23	
23.3	Moist mottled reddish brown, grayish white clayey SILT		11-23-40	
28.3	Moist mottled grayish white, yellow, purple, reddish brown clayey SILT		19-35-52	
33.3	Moist olive yellow clayey SILT, with a little amount of fine sand		11-28-47	
38.3	Moist lt. gray sandy CLAY/clayey SAND, fine			

5 10 15 20 25 30 35

F-3
GROUNDWATER DATA
▽ WHILE DRILLING: 7.7
▼ ON COMPLETION: NT
▼ 24 Hr. READING: 13.13

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:59

STA.
OFFSET:
TOP ELEV: 22.6

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496516.1
E 929668.8
COMPLETED: July 8, 1996

(c)	(d)	(a)	(b)
40.7 Moist lt. gray sandy CLAY/clayey SAND, fine		23-37-38	
41.0 Sli. moist hard dk. brown clayey SILT			
41.2 Wet lt. gray fine SAND			
43.3 Sli. moist, dk. brown clayey SILT			
Wet lt. gray clayey SAND & SAND, fine grained		45 29-57-91	
48.3 Moist lt. gray clayey SILT		50 19-32-53	
		55 18-31-43	
		60 18-30-38	
		65 26-51-98	
68.3 Moist dk. gray clayey SILT		70 23-34-47	
		75 19-35-52	
		80 18-27-44	
83.3 Moist lt. gray, reddish brown, olive yellow clayey SILT			

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 13:59

STA.
OFFSET:
TOP ELEV: 22.6

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496516.1
E 929668.8
COMPLETED: July 8, 1996

	(c)	(d)	(a)	(b)
	Moist lt. gray, reddish brown, olive yellow clayey SILT		44-106	
88.0	Moist reddish brown, dk. pink, dk. brown clayey SILT, mica flakes	90	26-50-84	
93.3	Mottled olive brown, dk. brown, lt. gray clayey SILT, mica flakes	95	39-64-102	
98.3	Moist, dk. gray clayey SILT, hard	100	84-100/.3	
102.9	Moist to wet lt. gray sandy CLAY/some clayey SAND present	105	100/.3	
107.7	Saturated bright orange red silty SAND, fine grained, well sorted	110	100/.4	
112.7	Saturated bright yellow SAND, fine to medium grained, well sorted	115	100/.4	
117.7	Saturated lt. grayish white, lt. tan SAND, medium grained, well sorted	120	100/.45	
122.7	Saturated white, lt. tan SAND, medium graind, well sorted	125	101/.5	

Fill Auger SPT RB Cored

GEO.2 MSC01 11/21/96 14:00

STA.
OFFSET:
TOP ELEV: 22.6

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496516.1
E 929668.8
COMPLETED: July 8, 1996

		(c)	(d)	(a)	(b)
130.9		Saturated white, lt. tan SAND, medium graind, well sorted		67-100/.35	

BOTTOM OF HOLE

POCKET PENETROMETER

DEPTH	T/SQ. FT
0.0'-1.5'	4.2, 3.75, 2.5
5.0'-6.5'	2.75, 2.9, 2.0
10.0'-10.7'	1.5, 1.5, 1.5
15.0'-16.5'	4.5, 4.2, 3.4
20.0'-21.5'	4.25, 3.75, 3.2
25.0'-26.5'	3.3, 4.4, 4.5
30.0'-31.5'	4.5, 4.5, 4.5
35.0'-36.5'	3.7, 4.25, 4.25
40.0'-40.65	1.5, 1.8, 1.5
40.65'-40.95'	4.5, 3.5, 4.25
50.0'-51.5'	3.0, 3.2, 3.5
55.0'-56.5'	3.75, 4.0, 3.75
60.0'-61.5'	4.0, 4.0, 4.5
65.0'-66.5'	4.5+, 4.5+, 4.5+
70.0'-71.5'	4.25, 4.0, 4.5
75.0'-76.5'	3.2, 2.9, 3.25
80.0'-81.5'	4.5, 4.0, 4.5
85.0'-86.0'	4.5+, 4.5+, 4.5+
90.0'-91.5'	4.5+, 4.5+, 3.25
95.0'-96.5'	3.9, 4.5, 4.5
100.0'-100.8'	4.5+, 4.5+, 4.5+
105.0'-105.3'	1.0, 1.5, 2.0

DRILLING PROCEDURE:
Failing F-10 Rig
Hole was advanced to 25.0' using SPT with 4-1/4" HSA between drives.
A 6" casing (PVC) was installed to 25.0'.
Hole was advanced to 25.0'-130.9' using SPT with fishtail bit & mud between drives.

135
140
145
150
155
160
165
170

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:00

STA.
OFFSET:
TOP ELEV: 16.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496918.6
E 931714.3
COMPLETED: June 5, 1996

G-1
1 of 5

Depth	(c) Description	(d)	(a)	(b)
	Wet dk. gray, dk. brown sandy SILT, coarse sand grains, with organic matter		1-1-1	
3.3	Saturated black sandy silty CLAY, medium to coarse sand, some fine gravel, odor	▽		
5			WH	
8.3	Wet dk. brn. sandy silty CLAY, tr. coarse gravel, fine to coarse sand			
10.9	Wet gray sandy silty CLAY, fine to medium sand		2-3-2	
13.3	Wet mottled brown, gray sandy silty CLAY			
15.9	Moist to wet black CLAY		1-2-2	
20.6				
20.8	Wet reddish brown fine to medium SAND		3-3-10	
	Moist mottled reddish brown silty CLAY			
23.3	Moist mottled reddish brown, grayish white silty CLAY		3-2-6	
30			12-24-34	
35			7-15-23	

G-1
GROUNDWATER DATA
▽ WHILE DRILLING: 3.8
▽ ON COMPLETION: NT
▼ 24 Hr. READING: NT

Fill Auger SPT RB Cored

GEO:2 MSC01 11/21/96 14:00

STA.
OFFSET:
TOP ELEV: 16.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496918.6
E 931714.3
COMPLETED: June 5, 1996

G-1
2 of 5

	(c)	(d)	(a)	(b)
43.3	Moist mottled reddish brown, grayish white silty CLAY		12-14-23	
48.3	Moist mottled grayish white, olive brown sandy silty CLAY, fine to very fine sand	45	20-19-30	
58.3	Moist mottled reddish brown, grayish white, yellow silty CLAY 50.0'-51.5': dk. reddish brown	50	25-50-84	
68.3	Moist mottled grayish white, red, pink silty CLAY	55	23-32-68	
73.3	Wet light gray clayey silty SAND, fine to medium grained sand, some clay	60	19-35-52	
78.3	Moist to wet light gray silty CLAY, w/ tr. fine sand	65	13-28-57	
80.5	Wet lt. gray med. grained SAND	70	25-55-51	
83.3	Wet lt. gray clayey SAND	75	27-38-57	
	Moist dk. gray silty CLAY, w/ pieces of black wood	80	49-91-77	

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:00

STA.
OFFSET:
TOP ELEV: 16.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496918.6
E 931714.3
COMPLETED: June 5, 1996

G-1
3 of 5

Depth	(c) Description	(d)	(a)	(b)
	Moist dk. gray silty CLAY, w/ pieces of black wood		13-44-98	
88.3	Wet lt. grayish white medium SAND, well sorted grains			
		90	77-102	
93.0	Moist dk. gray silty CLAY			
		95	35-60-100/.35	
98.2	Wet lt. gray clayey SAND, fine grained, well sorted, rounded			
100.6	Wet lt. gray to gray sandy CLAY	100	26-39-68	
103.3	Wet grayish white, lt. reddish brown, dk. orange SAND, fine to medium grained			
		105	34-40-52	
108.3	Wet sandy CLAY			
110.4		110	20-28-41	
110.5	Wet reddish brown SAND, medium, tr. fine gravel			
111.1	Wet grayish white, reddish brown sandy CLAY			
113.3	Wet white fine SAND			
	Moist to white grayish white sandy CLAY, fine grained sand	115	34-77-100/.45	
118.2	Moist to white grayish white, reddish brown sandy CLAY, fine sand	120	47-100/.3	
122.9	Wet grayish white fine SAND			
125.3	Moist grayish white sandy silty CLAY	125	42-100/.2	
127.9	Wet lt. grayish white fine SAND			

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:01

STA.
OFFSET:
TOP ELEV: 16.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496918.6
E 931714.3
COMPLETED: June 5, 1996

G-1

(c)	(d)	(a)	(b)
Wet lt. grayish white fine SAND		71-100/.25	
	135	83-100/.3	
137.9			
Wet grayish white fine to medium SAND	140	68-100.3	
142.9			
Wet lt. grayish white fine SAND			
145.1			
145.6 Moist grayish white silty CLAY	145	51-100/.25	
Wet grayish white fine SAND			
147.9			
Moist mottled reddish brown, grayish white silty CLAY			
150.6	150	157-100/.05	
BOTTOM OF HOLE			
	155		
	160		
	165		
	170		

POCKET PENETROMETER

DEPTH	T/SQ. FT.
0.0'-1.5'	0.1, 0.5, 0.4
5.0'-6.5'	0.0, 0.0, 0.0
10.0'-11.5'	0.0, 0.0, 0.1
15.0'-16.5'	0.0, 0.0, 0.0
20.8'-21.5'	1.75, 1.9, 2.0
25.0'-26.5'	4.0, 2.6, 1.5
30.0'-31.5'	4.5+, 4.4, 4.3
35.0'-36.5'	3.7, 3.7, 2.0
40.0'-41.5'	3.5, 2.75, 2.75
45.0'-46.5'	4.5+, 3.6, 4.1
50.0'-51.5'	3.75, 4.2, 4.0
55.0'-56.5'	4.2, 4.5+, 4.5+
60.0'-61.5'	4.2, 3.25, 4.25
70.0'-71.5'	4.0, 1.5, 1.25
75.0'-76.5'	3.9, 4.2, 4.5
85.0'-86.5'	2.25, 4.25, 2.25
95.0'-96.35'	4.5, 4.0, 4.5
100.6'-101.5'	1.5, 1.2, 2.0
115.0'-116.45'	3.1, 2.1, 2.0
145.1'-145.5'	2.0, 1.75, 2.5
150.0'-150.55'	4.5+, 3.75, 4.5+

Fill Auger SPT RB Cored

STA.
OFFSET:
TOP ELEV: 16.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496918.6
E 931714.3
COMPLETED: June 5, 1996

(c) (d) (a) (b)

DRILLING PROCEDURE:
Failing F-10 Rig
Hole was advanced to 30.0' using SPT with 4-1/4" HSA between drives.
A 10" casing (PVC) was installed to 30.0'after redrilling with 12-1/4" HSA to 30'.
Hole was advanced to 30.0'-150.55' using SPT with fishtail bit & mud
between drives.
Hole was cleaned out to 142.0' with Hawthorne bit.
WH - Indicates weight of hammer advanced spoon

180
185
190
195
200
205
210
215

Fill Auger SPT RB Cored

STA.
OFFSET:
TOP ELEV: 18.8

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 498602.9
E 932605.3
COMPLETED: June 27, 1996

H-1
1 of 1

(c)	(d)	(a)	(b)
Augered to 24.0' with 4-1/4" ID HSA Not sampled			
24.0			
26.0 P Obtained Shelby tube sample			
28.0 Augered to 26.0' with 4-1/4" ID HSA Not sampled			
30.0 P Obtained Shelby tube sample			
Drilled to 57.0' using Hawthorne Bit and mud. Not sampled			
57.0			
BOTTOM OF HOLE			

5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75

H-1
GROUNDWATER DATA
WHILE DRILLING: 10.5
ON COMPLETION: NT
24 Hr. READING: NT

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:05

STA.
OFFSET:
TOP ELEV: 18.2

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 498617.1
E 932596.1
COMPLETED: June 22, 1996

H-2

Depth	(c) Description	(d)	(a) Blows
	Moist brown, reddish brown silty CLAY with some roots 2.5'-3.75' with fine gravel 3.75'-4.0'		2-3-5
			3-5-9
4.5	Moist reddish brown, reddish yellow sandy silty CLAY, medium to coarse sand, w/ fine gravel		5
			5-9-12
7.0	Moist mottled reddish brown, grayish brown silty CLAY		
8.1	Moist banded yellow, pale yellow, orange, medium grained SAND, fine gravel		9-13-15
9.5	Wet yellowish brown to brown, medium to coarse SAND, w/ fine to coarse rounded gravel	▽	10
			2-5-5
12.0	Wet dk. gray fine-medium SAND		
			5-6-7
14.5	Saturated dk. gray, dk. grayish black fine to coarse SAND, with broken sea shells & fine-coarse gravel 17.5'-19.0': medium-coarse sand grains, with tr. gravel		15
			12-10-7
			3-4-4
20.9			20
			2-3-4
22.0	Moist mottled reddish brown silty CLAY		
	Moist mottled reddish brown, grayish white, olive brown silty CLAY		3-5-7
24.5	Moist mottled reddish brown, purple, brownish yellow silty CLAY		25
			3-5-7
28.6			3-2-4
28.8	Very soft black, olive brown clayey SILT		
29.5	Wet black fine to medium SAND		30
	Moist, very soft black, olive brown clayey SILT, with mica flakes		1-2-2
32.0	Saturated gray clayey SILT, soft		
33.6			2-3-4
33.8	Saturated gray silty SAND, fine to medium, with shells		
34.5	Moist gray, olive brown clayey SILT		35
	Moist mottled lt. gray, olive brown clayey SILT, with fine mica flakes		13-12-13
38.8			5-6-12
	Saturated reddish brown medium to coarse silty SAND		

H-2
GROUNDWATER DATA
▽ WHILE DRILLING: 9.95
▽ ON COMPLETION: NT
▼ 24 Hr. READING: NT

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:07

STA.
OFFSET:
TOP ELEV: 18.2

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 498617.1
E 932596.1
COMPLETED: June 22, 1996

H-2
2 of 5

Elev.	(c) Description	(a) Blows
41.3	Saturated reddish brown medium to coarse silty SAND	6-6-7
43.3	Moist, very soft lt. gray CLAY	
48.3	Wet reddish brown, gray thin layers of sandy SILT & SAND, fine grained sand and fine mica flakes	5-3-6
53.3	Saturated gray, olive brown, clayey sandy SILT, fine grained sand, fine mica flakes, minor clay	2-4-4
58.3	Saturated gray sandy SILT, fine grained sand, fine mica flakes	2-3-7
60.7	Saturated olive brown, fine to coarse gravelly SAND	
61.2	Moist mottled reddish brown sandy gravelly CLAY	9-6-12
63.3	Moist mottled red, white, pink clayey SILT	
68.3	Alternating layers of wet white clayey SAND & yellow, olive brown sandy SILT	9-5-18
70.8	Moist to wet olive brown, yellow sandy SILT, fine grained sand	17-23-56
73.3	Wet grayish white silty SAND, fine grain	
75.6	Moist grayish white clayey SILT	
76.2	Wet grayish white, pale yellow fine grained SAND, with some clayey sand	20-49-110
78.3	Saturated tan fine SAND	
80.5	Saturated olive brown fine SAND, rounded gravel	
81.3	Moist mottled reddish brown, grayish white clayey SILT	19-20-42
83.3	Saturated pink fine SAND	
	Moist mottled reddish brown, grayish white, pink & yellow clayey SILT	

(d) 45 50 55 60 65 70 75 80

(b)

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:07

STA.
OFFSET:
TOP ELEV: 18.2

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 498617.1
E 932596.1
COMPLETED: June 22, 1996

H-2

	(c)	(d)	(a)	(b)
	Moist mottled reddish brown, grayish white, pink & yellow clayey SILT		16-47-57	
		90	13-32-49	
		95	23-39-58	
98.3	Wet grayish white sandy CLAY, fine grained sand, with some minor amounts of sand	100	32-76-100/.37	
103.2	Moist to wet grayish brown sandy silty CLAY, fine grained sand	105	25-56-100/.4	
108.2	Moist grayish brown sandy silty CLAY, with black wood artifacts, fine grained sand	110	32-100/.3	
112.9	Moist grayish white fine sandy CLAY	115	27-47-100/.3	
118.2	Moist grayish white fine sandy silty CLAY, with fine orange sand lenses	120	30-100/.4	
123.0	Wet grayish white clayey SAND, fine grained sand	125	200/.45	
127.7	Moist grayish white, pale yellow sandy CLAY, fine grained sand			

Fill Auger SPT RB Cored

GEO.2 MSC01 11/21/96 14:07

STA.
OFFSET:
TOP ELEV: 18.2

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 498617.1
E 932596.1
COMPLETED: June 22, 1996

H-2

(c) (d) (a) (b)

Moist grayish white, pale yellow sandy CLAY, fine grained sand

132.8

Saturated grayish white, lt. tan medium SAND, rounded grains
Grayish white to white only 145.0'-145.75'

145.8

BOTTOM OF HOLE

POCKET PENETROMETER

DEPTH	T\SQ. FT.
0.0'-1.5'	1.25, 1.1, 1.5
2.5'-3.75'	1.5, 1.5, 1.0
5.0'-6.5'	1.25, 2.5, 2.1
7.5'-8.1'	1.25, 1.5, 1.25
20.9'-21.5'	1.75, 2.0, 1.75
25.0'-26.5'	0.75, 0.25, 0.75
27.5'-28.6'	0.25, 0.2, 0.25
30.0'-31.5'	0.2, 0.25, 0.25
35.0'-36.5'	0.9, 1.1, 1.6, 1.0
37.5'-38.8'	0.75, 0.75, 1.0
40.0'-41.3'	1.75, 1.75, 1.7
41.3'-41.5'	0.2, 0.5, 0.6
45.0'-46.5'	0.0, 0.0, 0.1
50.0'-51.5'	0.1, 0.0, 0.1, 0.0
60.7'-61.2'	0.5, 0.2, 0.2
61.2'-61.5'	2.1, 2.1, 1.75
65.7'-66.0'	0.5, 0.5, 0.75
70.0'-70.8'	0.2, 0.2, 0.2
75.0'-75.6'	3.5, 2.5, 1.75
80.5'-81.3'	3.2, 3.1, 1.5
85.0'-86.5'	3.2, 3.0, 2.2
90.0'-91.5'	3.2, 3.7, 3.2
95.0'-96.5'	4.5+, 4.5+, 4.5+
100.0'-101.37'	2.2, 1.7, 2.2
105.0'-106.4'	0.8, 0.6, 0.7
110.0'-110.8'	2.8, 2.8, 3.4
115.0'-116.3'	3.25, 2.8, 3.0
120.0'-120.9'	3.5, 3.0, 3.25
130.0'-130.5'	4.4, 4.1, 3.2

135 — 153/.5
140 — 79-100/.4
145 — 65-100/.25
150
155
160
165
170

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:07

STA.
OFFSET:
TOP ELEV: 18.2

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 498617.1
E 932596.1
COMPLETED: June 22, 1996

(c) (d) (a) (b)

DRILLING PROCEDURE:
Failing F-10 Rig
Hole was advanced to 30.0' using SPT with 4-1/4" HSA between drives.
A 10" casing (PVC) was installed to 30.0'after re-drilling with 11-3/4" fishtail bit to 30'.
Hole was advanced to 30.0'-145.75' using SPT with fishtail bit & mud between drives.
Hole was cleaned out to 147.0' with Hawthorne bit.

180
185
190
195
200
205
210
215

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:07

STA.
OFFSET:
TOP ELEV: 19.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496515.3
E 933589.4
COMPLETED: June 17, 1996

		(c)	(d)	(a)	(b)
		Drilled to 22.0' with 8-1/2" fishtail bit and mud. Not sampled			
22.0					
24.0	P	Obtained Shelby tube sample			
		Drilled to 52.0' with 8-1/2" fishtail bit and mud. Not sampled			
52.0		BOTTOM OF HOLE			

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

I-1
GROUNDWATER DATA
▽ WHILE DRILLING: NT
▼ ON COMPLETION: NT
▼ 24 Hr. READING: 15.21

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:06

STA.
OFFSET:
TOP ELEV: 19.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496530.6
E 933583.7
COMPLETED: June 13, 1996

I-2

Depth	(c) Description	(d)	(a) Blows
1.0	Dry mottled grayish white, red silty CLAY, with roots, tr. coarse gravel		30-16-14
4.5	Moist black, dk. gray, reddish brown silty CLAY		4-4-4
6.2	Moist brown medium to coarse sandy silty CLAY		3-8-13
7.0	Moist brown medium SAND		
9.5	Dry to moist mottled reddish brown silty CLAY		3-3-5
12.0	Moist mottled reddish brown, white CLAY 10.5'-10.65': Wet medium grained SAND		5-6-10
14.5	Moist gravelly CLAY, mottled red, white, yellow	▽	4-5-5
15.6	Black, dk. brown silty CLAY w/ fine gravel		
17.0	Wet brown fine to med. SAND		7-9-10
18.3	Moist mottled red brown, purple, soft, silty CLAY		
19.5	Wet brown fine to med. SAND		8-6-5
22.0	Moist black silty CLAY Hard conglomerate 20.3'-20.4'		10-3-3
31.0	Moist dk. brown, black silty CLAY, very soft		1-2-3 5-6-6 2-5-5
34.5	31.0'-31.1': Coarse clayey SAND 31.1'-34.5': Moist to wet olive brown to dk. olive brown silty CLAY		2-2-2 1-2-3
36.1	Wet gray olive brown silty CLAY		
37.0	Saturated gray medium silty SAND		2-2-12
38.1	Wet gray, olive brown silty CLAY		
39.5	Saturated tan to brown fine to coarse silty SAND		9-25-31

(b)

I-2
GROUNDWATER DATA
▽ WHILE DRILLING: 13.77
▽ ON COMPLETION: NT
▼ 24 Hr. READING: NT

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:08

STA.
OFFSET:
TOP ELEV: 19.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496530.6
E 933583.7
COMPLETED: June 13, 1996

	(c)	(d)	(a)	(b)
	Wet to saturated, tan to brown silty SAND, fine to medium grained, tr. coarse sand & fine gravel		20-25-30	
43.3				
	Saturated tan to rose silty SAND, fine to medium grained, tr. coarse sand	45	17-23-16	
48.3				
	Saturated, tan to brown silty SAND, fine to coarse grained, some fine rounded gravel	50	9-10-16	
53.3				
	Wet orange brown silty SAND, fine to medium grained, some coarse sand & fine gravel	55	13-9-8	
58.3				
	Wet brown, orange brown silty SAND, fine grained well sorted, with fine mica flakes	60	9-10-10	
63.3				
	Wet yellowish brown silty SAND, fine grained	65	6-9-7	
68.3				
	Moist mottled reddish brown, grayish white, purple silty CLAY	70	5-10-15	
71.2				
	Sandy gravelly mottled CLAY			
75.0				
	NO SAMPLE	75	NR	
76.5				
	Sli. moist mottled lavender, grayish white silty CLAY, hard			
80.9		80	28-35-54	
	Moist mottled reddish brown silty CLAY			
83.3				
	Slightly moist mottled reddish-brown, grayish white, purple silty CLAY			

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:09

STA.
OFFSET:
TOP ELEV: 19.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496530.6
E 933583.7
COMPLETED: June 13, 1996

(c) (d) (a) (b)

100.0'-101.45': moist, not as hard as above
105.0'-111.5': slightly moist sample
120.0'-121.5': slightly moist, hard

26-48-60

90

35-70-100/.42

95

25-53-100/.4

100

28-60-100/.45

105

43-87-99

110

27-43-68

115

29-57-77

120

31-55-102

123.3

Moist mottled grayish white, olive yellow silty CLAY

125

42-100/.45

128.0

Sli. moist, grayish white sandy silty CLAY, very fine to fine sand grains

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:09

STA.
OFFSET:
TOP ELEV: 19.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496530.6
E 933583.7
COMPLETED: June 13, 1996

Depth	(c) Description	(d) Elevation	(a) Samples	(b)
130.5	Sli. moist, grayish white sandy silty CLAY, very fine to fine sand grains		39-92-100/.25	
	Sli. moist mottled silty CLAY			
133.1	Moist grayish white fine clayey SAND			
135.3		135		
135.6	Olive brown silty CLAY		36-44-100/.4	
135.8	Moist white fine sandy CLAY			
138.2	Sli. moist mottled silty CLAY			
	Sli. moist grayish white silty CLAY			
140.4		140	200/.5	
	Moist grayish white fine clayey SAND			
142.8	Wet white, fine to medium grained SAND			
		145	112-100/.15	
		150	97-100/.2	
155.8		155	142-100/.3	
157.0	NO SAMPLE - Hole cleaned out with Hawthorne bit			
	BOTTOM OF HOLE			
		160		
		165		
		170		

Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:09

STA.
OFFSET:
TOP ELEV: 19.0

CSX/COX CREEK PLACEMENT AREAS
AA COUNTY, MD

N 496530.6
E 933583.7
COMPLETED: June 13, 1996

(c) (d) (a) (b)

POCKET PENETROMETER

DEPTH	T/SQ. FT.
2.5'-4.0'	2.0, 1.0, 1.25
5.0'-6.2'	1.25, 1.0, 1.0
10.0'-10.5'	4.5+, 4.5+, 4.5+
10.65'-11.5	1.25, 2.75, 2.25
15.0'-15.6'	1.5, 1.0, 0.5
17.5'-18.3'	0.1, 0.1, 0.3
20.0'-20.3'	0.0, 0.0, 0.5
20.4'-21.5'	0.0, 0.0, 0.1
22.5'-24.0'	0.0, 0.0, 0.0
25.0'-26.5'	0.0, 0.0, 0.0
27.5'-29.00'	0.0, 0.0, 0.0
30.0'-31.0'	0.0, 0.0, 0.0
31.1'-31.5'	0.1, 0.25, 0.1
32.5'-34.0'	0.25, 0.5, 0.3
35.0'-36.1'	0.1, 0.1, 0.1
70.0'-71.2'	1.2, 1.1, 0.5
80.0'-80.9'	4.5+, 4.5+, 3.75
85.0'-86.5'	4.5+, 4.5+, 4.0
90.0'-91.42'	4.5+, 4.5+, 4.5+
95.0'-96.4'	4.5+, 4.5+, 4.5+
100.0'-101.45'	3.75, 4.5+, 4.25
105.0'-106.5'	4.5+, 4.5+, 4.5+
110.0'-111.5'	3.25, 3.25, 3.0
115.0'-116.5'	3.25, 3.2, 4.5+
120.0'-121.5'	4.5+, 4.5+, 4.5+
125.0'-125.95	2.3, 2.9, 3.5
130.0'-130.5'	3.2, 2.25, 3.5
130.5'-131.25'	4.5+, 4.5+, 4.5+
135.3'-135.55'	2.4, 2.2, 3.0
135.75'-136.4'	4.0, 2.75, 3.0
140.0'-140.35'	4.0, 3.0, 2.5, 4.0

DRILLING PROCEDURE:
Failing F-10 Rig
Hole was advanced to 30.0' using SPT with 4-1/4" HSA between drives.
A 10" casing (PVC) was installed to 30.0'after redrilling with 12-1/4" HSA to 30'.
Hole was advanced to 30.0'-155.00' using SPT with fishtail bit & mud between drives.
Hole was cleaned out to 157.0' with Hawthorne bit.

180
185
190
195
200
205
210
215

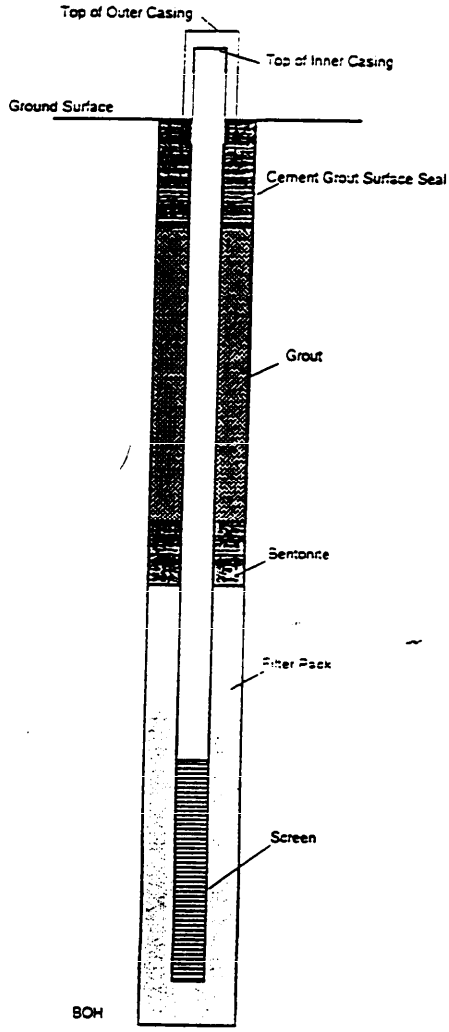
Fill Auger SPT RB Cored

GEO-2 MSC01 11/21/96 14:09

Appendix B. Well Construction Diagrams

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: H-1	LOCATION: AA County, MD	DRILLER: Dan Bowden
PROJECT: CSX/COX CREEK PLACEMENT AREAS	ELEVATIONS (FT MSL)	DEPTH TO GW (FT)*: 10.5' 6-26-96
DATE WELL COMPLETED: 6-27-96	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING: 2.5' AGS	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith, Jr.	TOP OF OUTER CASING: 3.35' AGS	



COORDINATES:

DEPTH TO TOP OF OUTERCASING: 3.35' AGS
DEPTH TO TOP OF INNER CASING: 2.5' AGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: 33.87'

I.D. OF SURFACE CASING: 8" dia.
TYPE OF SURFACE CASING: Stainless Steel

I.D. OF RISER PIPE: 4" dia.
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 33.87' BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 39.17' BGS
TYPE OF FILTER PACK: Morie #0 Sand, Morie FJ-90 sand

DEPTH TO TOP OF SCREEN: 45.0' BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020" / 10'
I.D. OF SCREEN: 4" dia

DEPTH TO BOTTOM OF SCREEN: 55.0 BGS
BOREHOLE DIAMETER: 8.5" dia.

BOTTOM OF HOLE: 57.0' BGS

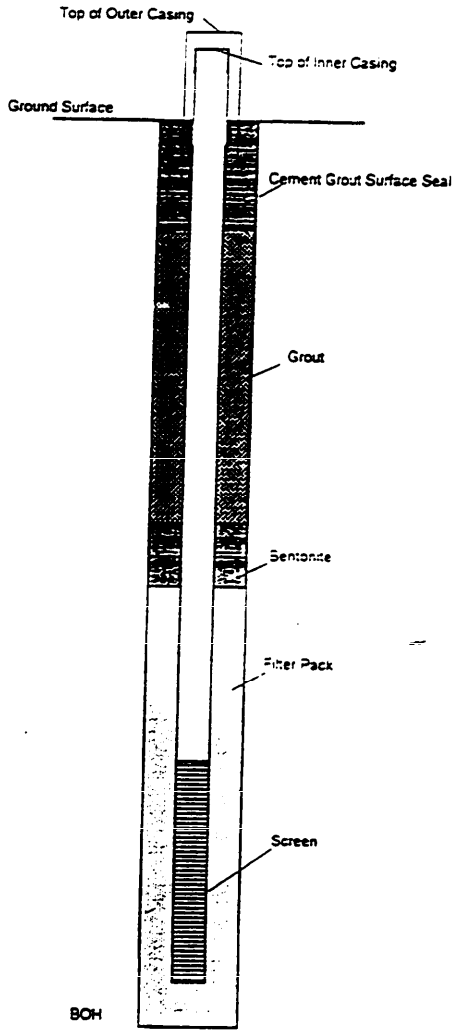
* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

PROJECT:	HOLE NO.:
CSX/COX CREEK PLACEMENT AREAS	H-1

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: F-2	LOCATION: AA County, MD	DRILLER: Dan Bowden
PROJECT: CSX / COX CREEK	ELEVATIONS (FT MSL)	DEPTH TO GW (FT)*: 22.29' 7-17-96
DATE WELL COMPLETED: 7-16-96	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING: 2.5' AGS	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith, Jr.	TOP OF OUTER CASING:	



COORDINATES:

DEPTH TO TOP OF OUTERCASING:
DEPTH TO TOP OF INNER CASING: 2.5' AGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: 109'

I.D. OF SURFACE CASING:
TYPE OF SURFACE CASING:

I.D.OF RISER PIPE: 6" dia
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 109' BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 115' BGS
TYPE OF FILTER PACK: Morie #0 Sand

DEPTH TO TOP OF SCREEN: 125' BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020" / 20'
I.D. OF SCREEN: 6" dia

DEPTH TO BOTTOM OF SCREEN: 145' BGS
BOREHOLE DIAMETER: Top 25' 18" dia
Below 25' 11 1/2" dia
BOTTOM OF HOLE: 147' BGS

* Depth to groundwater measured relative to ground surface

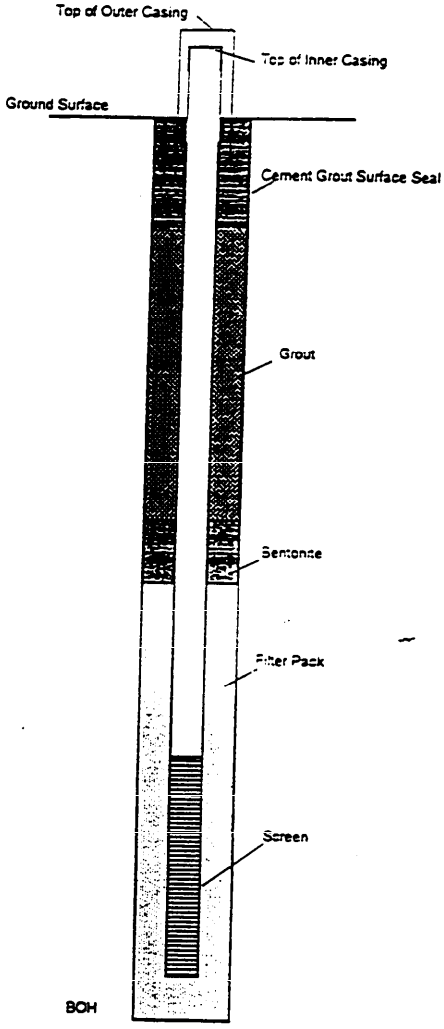
USACE - Baltimore District

PROJECT: CSX / COX CREEK PLACEMENT AREAS

HOLE NO.: F-2

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: F-3	LOCATION: AA County, MD		DRILLER: Dan Bowden
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 7.7' BGS
DATE WELL COMPLETED: 7-8-96	SURFACE:		DRILLING METHOD: HSA, Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING:	2.44' AGS	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith, Jr.	TOP OF OUTER CASING:	3.22 AGS	



COORDINATES:

DEPTH TO TOP OF OUTERCASING: 3.22' AGS
DEPTH TO TOP OF INNER CASING: 2.44' AGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: 96.8'

I.D. OF SURFACE CASING: 6" dia.
TYPE OF SURFACE CASING: Stainless Steel

I.D. OF RISER PIPE: 2" dia.
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 96.8' BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 110.2' BGS
TYPE OF FILTER PACK: Morie #0 sand

DEPTH TO TOP OF SCREEN: 120' BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020" / 10'
I.D. OF SCREEN: 2" dia.

DEPTH TO BOTTOM OF SCREEN: 130' BGS
BOREHOLE DIAMETER: 5 3/4" dia.

BOTTOM OF HOLE: 130' BGS

* Depth to groundwater measured relative to ground surface

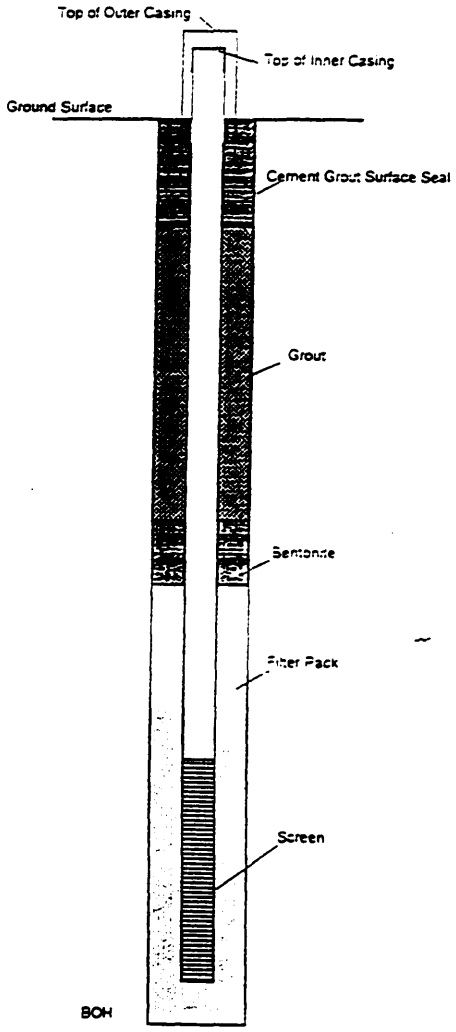
USACE - Baltimore District

PROJECT: CSX/COX CREEK PLACEMENT AREAS

HOLE NO.: F-3

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: D-2	LOCATION: AA County, MD		DRILLER: Carpenter/Bowden
PROJECT: CSX / COX CREEK	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:
DATE WELL COMPLETED:	SURFACE:		DRILLING METHOD: Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING:	2.5' AGS	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith, Jr.	TOP OF OUTER CASING:	3.0' AGS	



COORDINATES:

DEPTH TO TOP OF OUTERCASING: 3.0' AGS
DEPTH TO TOP OF INNER CASING: 2.5' AGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: BGS

I.D. OF SURFACE CASING: 8" dia.
TYPE OF SURFACE CASING: Stainless Steel

I.D.OF RISER PIPE: 4" dia.
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 'BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 111.8 'BGS
TYPE OF FILTER PACK: Morie #0 + #90

DEPTH TO TOP OF SCREEN: 120.0 'BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020"/10'
I.D. OF SCREEN: 4" dia.

DEPTH TO BOTTOM OF SCREEN: 130.0 'BGS
BOREHOLE DIAMETER: 11.5"

BOTTOM OF HOLE: 132.5' BGS

* couldn't get exact measurement w/bentonite slurry

* Depth to groundwater measured relative to ground surface

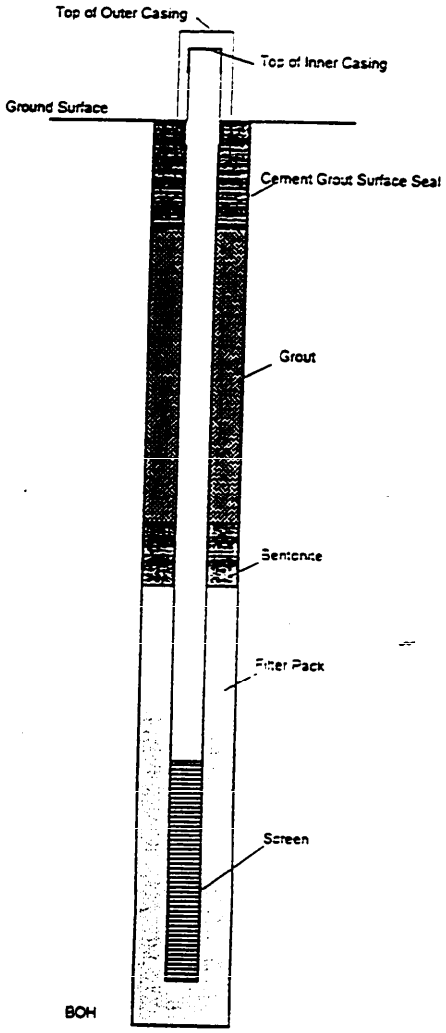
USACE - Baltimore District

PROJECT: CSX / COX CREEK PLACEMENT AREAS

HOLE NO.: D-2

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: C-1	LOCATION: AA County, MD			DRILLER: D. Bonden
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)			DEPTH TO GW (FT)*:
DATE WELL COMPLETED: 8/9/96	SURFACE:			DRILLING METHOD: mud rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING:	2.5 ' AGS		DEVELOPMENT METHOD:
INSPECTOR: BROCK	TOP OF OUTER CASING:	3.0 ' AGS		



COORDINATES:

DEPTH TO TOP OF OUTERCASING: 3.0 'AGS
DEPTH TO TOP OF INNER CASING: 2.5' AGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL:

I.D. OF SURFACE CASING: 8" dia.
TYPE OF SURFACE CASING: Stainless Steel

I.D.OF RISER PIPE: 4" dia
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 'BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 125.0 'BGS
TYPE OF FILTER PACK: Mocie #0 & F590

DEPTH TO TOP OF SCREEN: 130.0 'BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020"/
I.D. OF SCREEN: 4" dia

DEPTH TO BOTTOM OF SCREEN: 140.0 'BGS
BOREHOLE DIAMETER:

BOTTOM OF HOLE: 140.0 'BGS

B.O. sampled hole - 150.33'

* couldn't get exact measurement w/bentonite slurry

* Depth to groundwater measured relative to ground surface

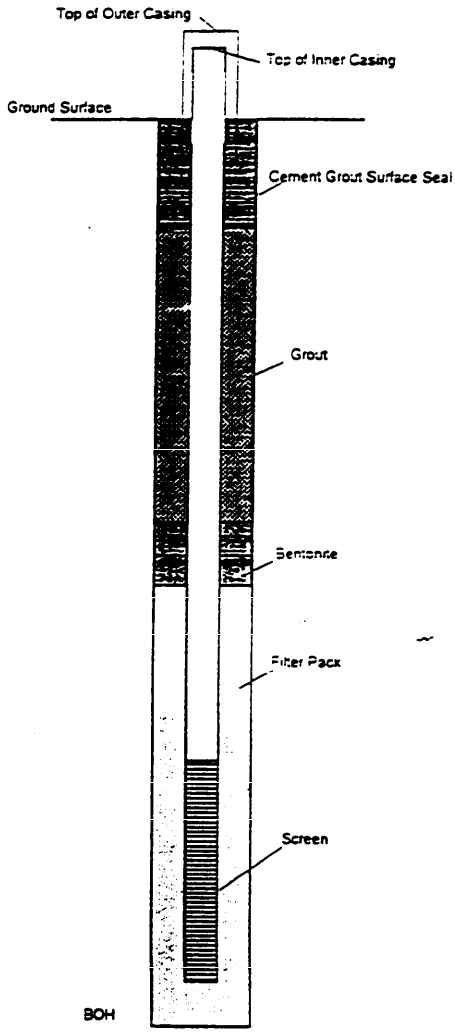
USACE - Baltimore District

PROJECT: CSX/COX CREEK PLACEMENT AREAS

HOLE NO.: C-1

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: E-1	LOCATION: AA County, MD	DRILLER: Bowden
PROJECT: CSX/COX CREEK PLACEMENT AREAS	ELEVATIONS (FT MSL)	DEPTH TO GW (FT)*: 5.89' 5/31/96
DATE WELL COMPLETED: 5-30-96	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING: 2.31'	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith, Jr.	TOP OF OUTER CASING: 3.08'	



COORDINATES:

DEPTH TO TOP OF OUTERCASING: 3.08' AGS
DEPTH TO TOP OF INNER CASING: 2.31' AGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: 134' BGS

I.D. OF SURFACE CASING: 8" dia.
TYPE OF SURFACE CASING: Stainless Steel

I.D.OF RISER PIPE: 4" dia.
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 134' BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 141' BGS
TYPE OF FILTER PACK: Morie #0 sand

DEPTH TO TOP OF SCREEN: 155' BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020" / 10'
I.D. OF SCREEN: 4" dia.

DEPTH TO BOTTOM OF SCREEN: 165' BGS
BOREHOLE DIAMETER: Top 30' 13 5/8"
Below 30' 8.5"
BOTTOM OF HOLE: 167' BGS

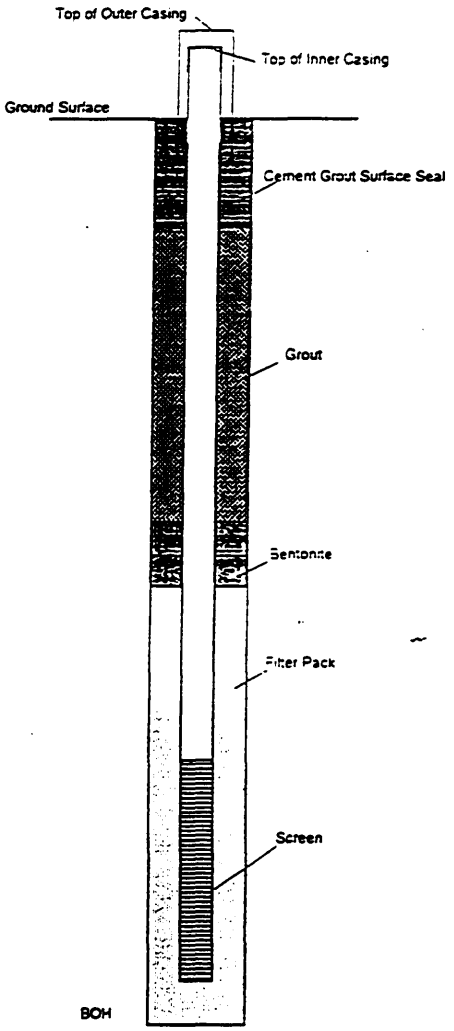
* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

PROJECT:	HOLE NO.:
CSX/COX CREEK PLACEMENT AREAS	E-1

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: F-1	LOCATION: AA County, MD		DRILLER: Bowden/Kyle/Carpenter
PROJECT: CSX/COX CREEK PLACEMENT AREAS	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 14.90'
DATE WELL COMPLETED: 5-18-96	SURFACE:		DRILLING METHOD: HSA, Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING:	2.5'	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith, Jr.	TOP OF OUTER CASING:	3.37'	



COORDINATES:

DEPTH TO TOP OF OUTERCASING: 3.37' AGS
DEPTH TO TOP OF INNER CASING: 2.5' AGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: 112' BGS

I.D. OF SURFACE CASING: 8" dia.
TYPE OF SURFACE CASING: Stainless Steel

I.D.OF RISER PIPE: 4" dia.
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 112' BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 119' BGS
TYPE OF FILTER PACK: Morie FJ-90 sand, Morie #0 sand

DEPTH TO TOP OF SCREEN: 127' BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020" / 20'
I.D. OF SCREEN: 4" dia.

DEPTH TO BOTTOM OF SCREEN: 147' BGS
BOREHOLE DIAMETER: Top 30' 17 5/8"
Below 30' 8.5"
BOTTOM OF HOLE: 149' BGS

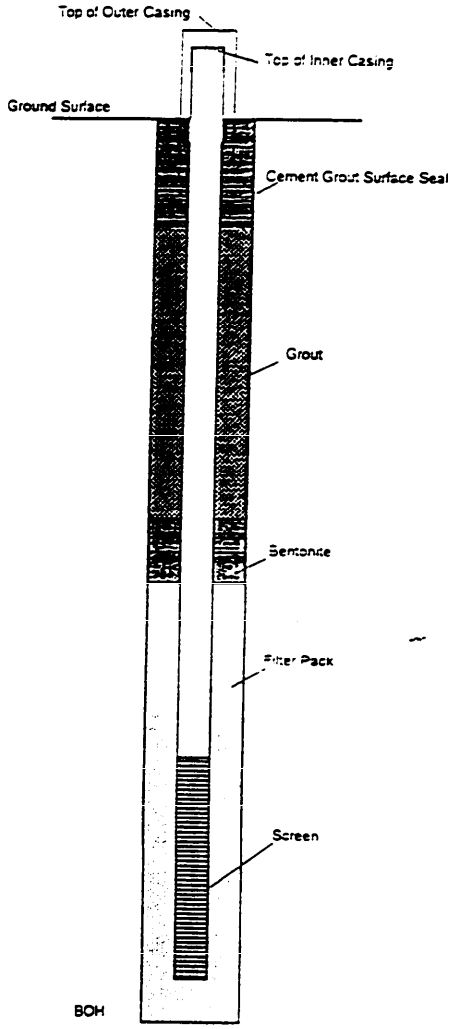
* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

PROJECT: CSX/COX CREEK PLACEMENT AREAS	HOLE NO.: F-1

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: G-1	LOCATION: AA County, MD	DRILLER: Bowden
PROJECT: CSX/COX CREEK PLACEMENT AREAS	ELEVATIONS (FT MSL)	DEPTH TO GW (FT)*: 12.30' on 6-7-96
DATE WELL COMPLETED: 6/6/96	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING: 2.5' AGS	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith Jr	TOP OF OUTER CASING: 2.98' AGS	



COORDINATES:

DEPTH TO TOP OF OUTERCASING: 2.98' AGS
DEPTH TO TOP OF INNER CASING: 2.5' AGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: 115' BGS

I.D. OF SURFACE CASING: 8" dia.
TYPE OF SURFACE CASING: Stainless Steel

I.D. OF RISER PIPE: 4" dia.
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 115' BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 122' BGS
TYPE OF FILTER PACK: Morie #0 Sand

DEPTH TO TOP OF SCREEN: 130' BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020" / 10'
I.D. OF SCREEN: 4" dia.

DEPTH TO BOTTOM OF SCREEN: 140' BGS
BOREHOLE DIAMETER: Top 30' 13 5/8"
Below 30' 8.5"
BOTTOM OF HOLE: 142' BGS

* Depth to groundwater measured relative to ground surface

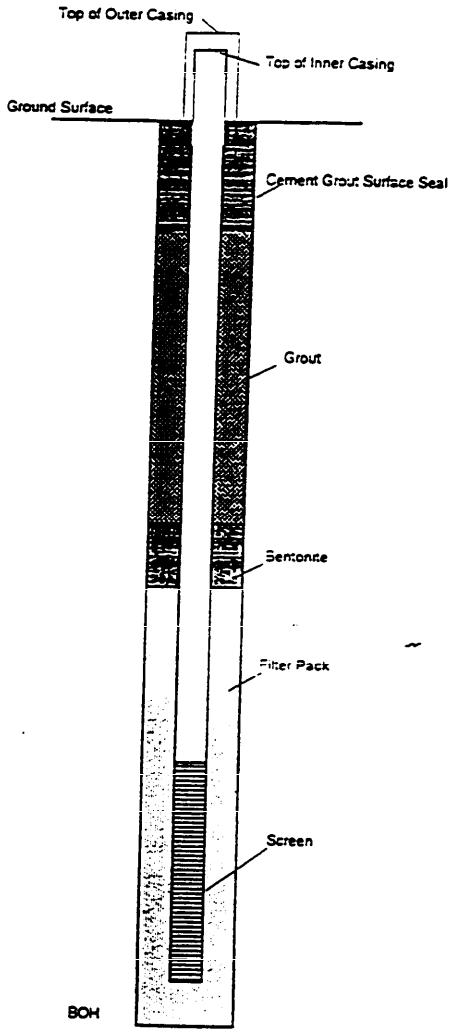
USACE - Baltimore District

PROJECT: CSX/COX CREEK PLACEMENT AREAS

HOLE NO.: G-1

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: H-2	LOCATION: AA County, MD	DRILLER: Bowden
PROJECT: CSX/COX CREEK PLACEMENT AREAS	ELEVATIONS (FT MSL)	DEPTH TO GW (FT)*: 13.3' 6-26-96
DATE WELL COMPLETED: 6/25/96	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING: 2.0' AGS	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith, Jr.	TOP OF OUTER CASING: 3.35' AGS	



COORDINATES:

DEPTH TO TOP OF OUTERCASING: 3.35' AGS
DEPTH TO TOP OF INNER CASING: 2.0' AGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: 93.8 BGS

I.D. OF SURFACE CASING: 8" dia.
TYPE OF SURFACE CASING: Stainless Steel

I.D.OF RISER PIPE: 4" dia
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 93.8 BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 104.4' BGS
TYPE OF FILTER PACK: Morie #0 sand, Morie FJ-90 sand

DEPTH TO TOP OF SCREEN: 135 BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020" / 10'
I.D. OF SCREEN: 4" dia.

DEPTH TO BOTTOM OF SCREEN: 145 BGS
BOREHOLE DIAMETER: Top 30' 11 3/4", Below 30' 8.5"
BOTTOM OF HOLE: 147 BGS

* Depth to groundwater measured relative to ground surface

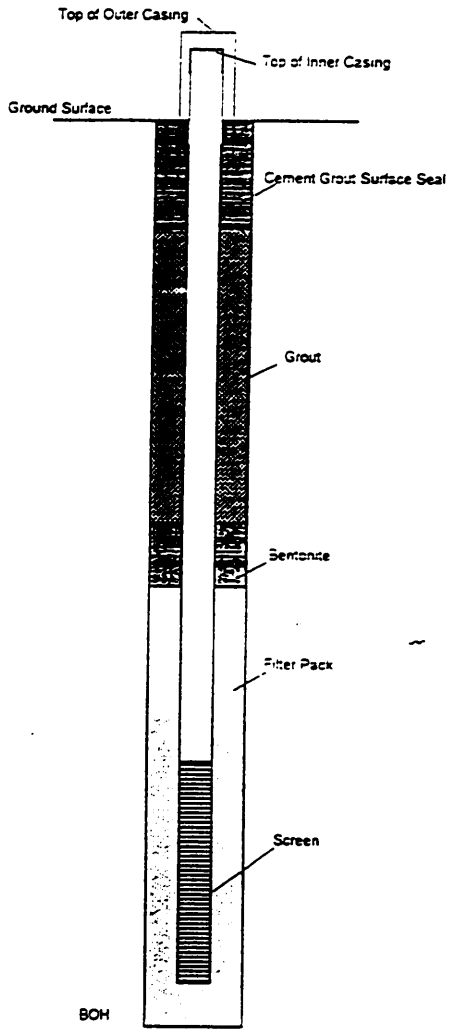
USACE - Baltimore District

PROJECT: CSX/COX CREEK PLACEMENT AREAS

HOLE NO.: H-2

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: I-1	LOCATION: AA County, MD	DRILLER: Bowden
PROJECT: CSX/COX CREEK PLACEMENT AREAS	ELEVATIONS (FT MSL)	DEPTH TO GW (FT)*: 17.48' on 6-25-96
DATE WELL COMPLETED: 6/17/96	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING: 0.58' BGS	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith, Jr.	TOP OF OUTER CASING: 0.0'	



COORDINATES: FLUSH MOUNTED

DEPTH TO TOP OF OUTERCASING: 0.0'
DEPTH TO TOP OF INNER CASING: 0.58' BGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: 27.5' BGS

I.D. OF SURFACE CASING: 18"
TYPE OF SURFACE CASING: 18" square steel vault

I.D. OF RISER PIPE: 4" dia.
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 27.5' BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 34.5' BGS
TYPE OF FILTER PACK: Morie #0 Sand

DEPTH TO TOP OF SCREEN: 40' BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020" / 10'
I.D. OF SCREEN: 4" dia.

DEPTH TO BOTTOM OF SCREEN: 50' BGS
BOREHOLE DIAMETER: 8.5"

BOTTOM OF HOLE: 52' BGS

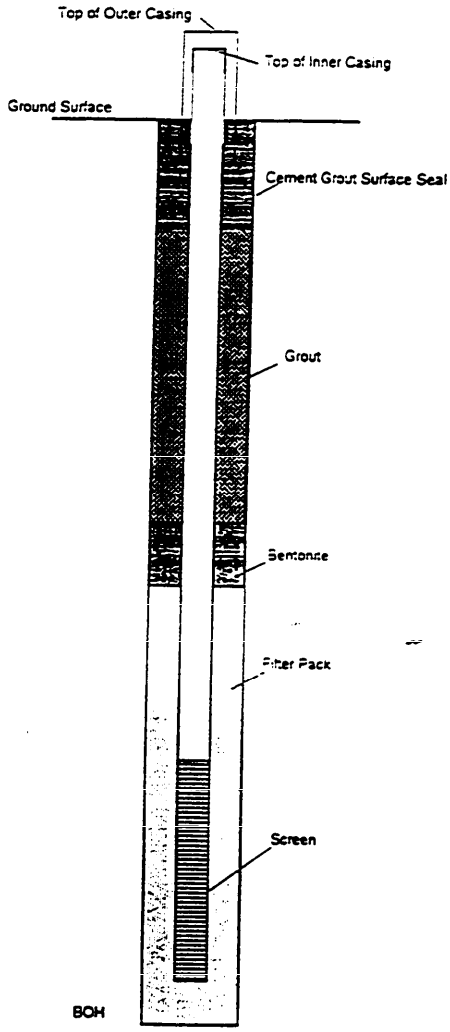
* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

PROJECT: CSX/COX CREEK PLACEMENT AREAS	HOLE NO.: I-1

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: I-2	LOCATION: AA County, MD	DRILLER: Bowden
PROJECT: CSX/COX CREEK PLACEMENT AREAS	ELEVATIONS (FT MSL)	DEPTH TO GW (FT)*: 15.52' on 6-17-96
DATE WELL COMPLETED: 6/15/96	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
DATE DEVELOPMENT COMPLETED:	TOP OF PVC CASING: 0.63' BGS	DEVELOPMENT METHOD:
INSPECTOR: Lyle Griffith, Jr.	TOP OF OUTER CASING: 0.0'	



COORDINATES: Flush Mounted

DEPTH TO TOP OF OUTERCASING: 0.0'
DEPTH TO TOP OF INNER CASING: 0.63' BGS

TYPE OF SURFACE SEAL: Type I Portland Cement
DEPTH OF SEAL: 111' BGS

I.D. OF SURFACE CASING: 18"
TYPE OF SURFACE CASING: 18" square steel vault

I.D.OF RISER PIPE: 4" dia.
TYPE OF RISER PIPE: PVC

TYPE OF GROUT: Type I Portland Cement

DEPTH TO TOP OF SEAL: 111' BGS
TYPE OF SEAL: Bentonite Slurry

DEPTH TO TOP OF FILTER PACK: 118' BGS
TYPE OF FILTER PACK: Morie #0 sand

DEPTH TO TOP OF SCREEN: 145' BGS
TYPE OF SCREEN: PVC
SLOT SIZE AND LENGTH: .020" / 10'
I.D. OF SCREEN: 4" dia.

DEPTH TO BOTTOM OF SCREEN: 155' BGS
BOREHOLE DIAMETER: Top 30' 13 3/8"
Below 30' 8.5"
BOTTOM OF HOLE: 158' BGS

* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

PROJECT: CSX/COX CREEK PLACEMENT AREAS

HOLE NO.: I-2

Appendix C. Well Development Records

MONITORING WELL DEVELOPMENT RECORD

HOLE NUMBER: I-2	DEPTH OF GW (FT): 15.52' BGS	INSPECTOR: Lyle Griffith, Jr.
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)	DRILLER: Dan Bowden
LOCATION: AA County, MD	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
INSTALLATION DATE: 6-15-96	TOP OF PVC CASING: 0.63' BGS	DEVELOPMENT METHOD:
DEVELOPMENT DATE: 6-26-96	BOTTOM OF HOLE: 158' BGS	Pumping and Surging

Well Construction Details

Total Well Depth (ft) 155' BGS	Top of Casing Below Grnd Surface(ft) 0.63' BGS	Screened Interval (ft) 145' to 155' BGS
Borehole Diameter (in) 8.5"	Well Diameter (in) 4"	Static Water Level (ft) 6/26/96 20.51' BGS

Pumping Rate: 6/26/96 30 gpm

Pumping Depth(s):

Development Start Time: 6/26 0813 hrs Stop Time: 6/26 1415 hrs

Physical Appearance of Water:

Initial: Cloudy

During: Clear

Final: Clear

Well Volume (including filter pack): Assuming 20.51' water level on 6/26/96, and 30% porosity of sand equals 115.9 gallons.

Field Analysis	Initial	During #'s			Final
Time:	0940 hrs	1030 hrs	1210 hrs	1315 hrs	1410 hrs
Conductivity ~~(x100)~~:	0.9 µS/cm	0.85 µS/cm	0.6 µS/cm	0.6 µS/cm	0.6 µS/cm
pH:	6.08 pH	5.97 pH	5.89 pH	5.64 pH	5.64 pH
Temperature ~~(F)~~ F ~~°C~~:	68.2 °F	67.4 °F	68.4 °F	68.6 °F	68.5 °F

Total Quantity of Water Removed: 6/21 - 1650 gallons, 6/22 - 2400 gallons, 6/24 - 690 gallons 6/25 - ~~505~~ 4230 gallons, 6/26 - 10,860 gallons

Method of Water Disposal: Pumped water onto ground

Sample Jar Collected: No sample collected

Comments: A total of 19,830 gallons of well water was removed from well I-2 between 6/21 & 6/26, inclusive.

USACE - Baltimore District

Project: CSX/COX CREEK PLACEMENT AREAS	Hole #: I-2

MONITORING WELL DEVELOPMENT RECORD

HOLE NUMBER: G-1	DEPTH OF GW (FT): 12.30' BGS	INSPECTOR: Lyle Griffith, Jr.
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)	DRILLER: Dan Bowden
LOCATION: AA County, MD	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
INSTALLATION DATE: 6-6-96	TOP OF PVC CASING: 2.5' AGS	DEVELOPMENT METHOD:
DEVELOPMENT DATE: 6-20-96	BOTTOM OF HOLE: 142' BGS	Pumping and Surging

Well Construction Details

Total Well Depth (ft) 140' BGS	Top of Casing ~~Below~~ Above Grnd Surface(ft) 2.5' AGS	Screened Interval (ft) 130' to 140' BGS
Borehole Diameter (in) 8.5"	Well Diameter (in) 4"	Static Water Level (ft) 6/20/96 ~~15.2~~ 12.7' BGS

Pumping Rate: 6/20/96 5 gpm

Pumping Depth(s):

Development Start Time: 6/20 0905 hrs Stop Time: 6/20 1210 hrs

Physical Appearance of Water:

Initial: Turbid, Slightly Cloudy

During: Almost Clear

Final: Almost Clear

Well Volume (including filter pack): Assuming 12.7' water level on 6/20/96, and 30% porosity of sand equals 97.3 gallons.

Field Analysis	Initial	During #'s			Final
Time:	0905 hrs	1000 hrs	1100 hrs	1200 hrs	1210 hrs
Conductivity (~~x100~~):	—	.154 mS/cm	.142 mS/cm	.145 mS/cm	—
pH:	—	6.83 pH	6.93 pH	6.92 pH	—
Temperature (~~F~~):	—	20.2 °C	20.1 °C	20.1 °C	—

Total Quantity of Water Removed: 6/12 - 450 gallons, 6/13 - 2100 gallons, 6/14 - 2325 gallons, 6/17 - 3100 gallons, 6/18 - ~~17,600~~ 3,950 gallons, 6/20 - 1075 gallons

Method of Water Disposal: Pumped water onto ground

Sample Jar Collected: No sample collected

Comments: A total of 13,000 gallons of well water was removed from well G-1 between 6/12 & 6/20, inclusive.
On 6/20/96, an additional 450 gallons was removed from 0900 to 0905 (pumped @ 30 gpm).

USACE - Baltimore District

Project: CSX/COX CREEK PLACEMENT AREAS	Hole #: G-1

MONITORING WELL DEVELOPMENT RECORD

HOLE NUMBER: I-1	DEPTH OF GW (FT): 17.48' BGS	INSPECTOR: Lyle Griffith, Jr.
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)	DRILLER: Dan Bowden
LOCATION: AA County, MD	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
INSTALLATION DATE: 6-17-96	TOP OF PVC CASING: 0.58' BGS	DEVELOPMENT METHOD:
DEVELOPMENT DATE: 6-28-96	BOTTOM OF HOLE: 52' BGS	Pumping and Surging

Well Construction Details

Total Well Depth (ft)	Top of Casing Below Grnd Surface(ft)	Screened Interval (ft)
50' BGS	0.58' BGS	40' to 50' BGS
Borehole Diameter (in)	**Well Diameter (in)**	**Static Water Level (ft)**
8.5"	4"	6/28/96 18.39' BGS

Pumping Rate: 6/28/96 5 gallons per 3 minutes = 100 gph

Pumping Depth(s):

Development Start Time: 6/28 0758 hrs Stop Time: 6/28 1520 hrs

Physical Appearance of Water:

Initial: Very Cloudy

During: Cloudy to Slightly Cloudy

Final: Clear

Well Volume (including filter pack): Assuming 18.39' water level on 6/28/96, and 30% porosity of sand equals 33.08 gallons.

Field Analysis	Initial	During #'s			Final
Time:	0815 hrs	1002 hrs	1108 hrs	1210 hrs	1511 hrs
Conductivity ~~(x100)~~ X 1000:	11.34	10.18	10.94	11.02	11.55
pH:	8.18 pH	7.72 pH	7.75 pH	6.90 pH	6.91 pH
Temperature (F):	71.2 °F	69.3 °F	77.3 °F	77.3 °F	77.1 °F

Total Quantity of Water Removed: 6/25 - 10 gallons, 6/26 - 180 gallons, 6/27 - 600 gallons 6/28 - 735 gallons

Method of Water Disposal: Pumped water onto ground

Sample Jar Collected: No sample collected

Comments: An approximate total of 1,525 gallons of well water was removed from well I-1 between 6/25 and 6/28, inclusive.

At 1410 hrs, Cond. = 11.53 pH = 6.84 Temp = 77.4 °F

USACE - Baltimore District

Project:	Hole #:
CSX/COX CREEK PLACEMENT AREAS	I-1

MONITORING WELL DEVELOPMENT RECORD

HOLE NUMBER: H-2	DEPTH OF GW (FT): 13.3' BGS	INSPECTOR: Lyle Griffith, Jr.
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)	DRILLER: Dan Sowden
LOCATION: AA County, MD	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
INSTALLATION DATE: 6-25-96	TOP OF PVC CASING: 2.0' AGS	DEVELOPMENT METHOD:
DEVELOPMENT DATE: 7-8-96	BOTTOM OF HOLE: 147' AGS	Pumping and Surging

Well Construction Details

Total Well Depth (ft) 145' BGS	Top of Casing ~~Below~~ Above Grnd Surface(ft) 2.0' AGS	Screened Interval (ft) 135' - 145' BGS
Borehole Diameter (in) 8.5"	Well Diameter (in) 4"	Static Water Level (ft) 7/8/96 14.63' BGS

Pumping Rate: 7/8/96 5 gallons per minute

Pumping Depth(s):

Development Start Time: 7/8 0735 hrs Stop Time: 7/8 1230 hrs

Physical Appearance of Water:

Initial: Clear

During: Clear

Final: Clear

Well Volume (including filter pack): Assuming 14.63' water level on 7/8/96, and 30% porosity of sand equals 114.85 gallons.

Field Analysis	Initial	During #'s			Final
Time:	/	0905 hrs	1020 hrs	1110 hrs	1222 hrs
Conductivity ~~(x100)~~:	/	0.02	0.03	0.02	0.03
pH:	/	7.15	5.66	5.28	5.42
Temperature (F):	/	63.2	62.9	62.9	64.0

Total Quantity of Water Removed: 6/29/96 - 880 gallons, 7/1/96 - 1,630 gallons, 7/2/96 - 2,400 gallons, 7/3/96 - 10,500 gallons, 7/8/96 - 1,475 gallons

Method of Water Disposal: Pumped water onto ground

Sample Jar Collected: No sample collected

Comments: An approximate total of 16,885 gallons of well water was removed from well H-2 between 6/29 and 7/8, inclusive.

USACE - Baltimore District

Project: CSX/COX CREEK PLACEMENT AREAS	Hole #: H-2

MONITORING WELL DEVELOPMENT RECORD

HOLE NUMBER: H-1	DEPTH OF GW (FT): 10.5' BGS	INSPECTOR: Lyle Griffith, Jr.
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)	DRILLER: Dan Bowden
LOCATION: AA County, MD	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
INSTALLATION DATE: 6-27-96	TOP OF PVC CASING: 2.5' AGS	DEVELOPMENT METHOD:
DEVELOPMENT DATE: 7-11-96	BOTTOM OF HOLE: 57.0' AGS	Pumping and Surging

Well Construction Details

Total Well Depth (ft) 55.0' BGS	Top of Casing ~~Below~~ Above Grnd Surface(ft) 2.5' AGS	Screened Interval (ft) 45' - 55' BGS
Borehole Diameter (in) 8.5"	Well Diameter (in) 4"	Static Water Level (ft) 7/11/96 14.62' BGS

Pumping Rate: 7/11/96 5 gpm

Pumping Depth(s):

Development Start Time: 7/11 0735 hrs Stop Time: 7/11 1320 hrs

Physical Appearance of Water:

Initial: Cloudy - orangish tint

During: Same as above

Final: Slightly cloudy - orangish tint

Well Volume (including filter pack): Assuming 14.62' water level on 7/11/96, and 30% porosity of sand equals 39.02 gallons.

Field Analysis	Initial	During #'s			Final
Time:	/	0821 hrs	1111 hrs	1236 hrs	1315 hrs
Conductivity ~~(µmhos)~~:	/	6.97	6.31	6.17	6.08
pH:	/	6.30 pH	7.19 pH	7.31 pH	6.95 pH
Temperature (F):	/	60.1 °F	73.9 °F	72.6 °F	73.9 °F

Total Quantity of Water Removed: 7/2/96 - 300 gallons, 7/3/96 - 2,650 gallons, 7/8/96 - 1,635 gallons, 7/9/96 - 1,675 gallons, 7/10/96 - 1,760 gallons, 7/11/96 - 1,725 gallons

Method of Water Disposal: Pumped water onto ground

Sample Jar Collected: No sample collected

Comments: An approximate total of 9,745 gallons of well water was removed from well H-1 between 7/2 and 7/11, inclusive.

USACE - Baltimore District

Project: CSX/COX CREEK PLACEMENT AREAS	Hole #: H-1

MONITORING WELL DEVELOPMENT RECORD

HOLE NUMBER: F-3	DEPTH OF GW (FT): 7.7' BGS	INSPECTOR: Lyle Griffith, Jr.
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)	DRILLER: Dan Bowden
LOCATION: AA County, MD	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
INSTALLATION DATE: 7-8-96	TOP OF PVC CASING: 2.44' AGS	DEVELOPMENT METHOD:
DEVELOPMENT DATE: 7-15-96	BOTTOM OF HOLE: 130 AGS	Pumping and Surging

Well Construction Details

Total Well Depth (ft) 130' BGS	Top of Casing ~~Below~~ Above Grnd Surface(ft) 2.44 AGS	Screened Interval (ft) 120 - 130' BGS
Borehole Diameter (in) 5 3/4"	Well Diameter (in) 2"	Static Water Level (ft) 7/15/96 18.94' BGS

Pumping Rate: 7/15/96 5 gpm

Pumping Depth(s):

Development Start Time: 7/15 ~ 0900 hrs Stop Time: 7/15 1245 hrs

Physical Appearance of Water:

Initial: Cloudy

During: Clear

Final: Clear

Well Volume (including filter pack): Assuming 18.94' water level on 7/15/96, and 30% porosity of sand equals 26.78 gallons.

Field Analysis	Initial	During #'s			Final
Time:	0903 hrs	0947 hrs	1036 hrs	1122 hrs	1237 hrs
Conductivity (~~x100~~):	0.01	0.01	0.02	0.02	0.02
pH:	7.62 pH	6.54 pH	5.36 pH	5.21 pH	5.23 pH
Temperature (F):	60.5 °F	60.5 °F	61.0 °F	59.5 °F	60.2 °F

Total Quantity of Water Removed: 7/10/96 - 1,200 gallons, 7/11/96 - 1,152 gallons, 7/12/96 - 2,700 gallons, 7/15/96 - 975 gallons

Method of Water Disposal: Pumped water onto ground

Sample Jar Collected: No sample collected

Comments: An approximate total of 6,027 gallons of well water was removed from well F-3 between 7/10 and 7/15, inclusive. Static Water Level was collected on 7/15 @ 1315 hrs, 30 minutes after turning off ardvark pump. Used gallons per linear ft conversion factor for a 6" borehole instead of for a 5 3/4" borehole.

USACE - Baltimore District

Project: CSX/COX CREEK PLACEMENT AREAS	Hole #: F-3

MONITORING WELL DEVELOPMENT RECORD

HOLE NUMBER: F-1	DEPTH OF GW (FT): 14.90' BGS	INSPECTOR: Lyle Griffith Jr.
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)	DRILLER: Bowden/Kyle/Carpenter
LOCATION: AA County, MD	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
INSTALLATION DATE: 5-18-96	TOP OF PVC CASING: 2.5' AGS	DEVELOPMENT METHOD:
DEVELOPMENT DATE: 5/28, 29, 30, 31	BOTTOM OF HOLE: 149' BGS	Pumping and Surging

Well Construction Details

Total Well Depth (ft) 147'	Top of Casing ~~Below~~ Above Grnd Surface(ft) 2.5'	Screened Interval (ft) 127' - 147' BGS
Borehole Diameter (in) 8.5"	Well Diameter (in) 4"	Static Water Level (ft) 20.98

Pumping Rate: 5/31/96 5 gallons in 38 seconds

Pumping Depth(s):

Development Start Time: 5/31 1250 hrs Stop Time: 5/31 1630 hrs

Physical Appearance of Water:

Initial: Cloudy, light rose colored liquid

During: Same

Final: Same

Well Volume (including filter pack): Assuming 20.98' water level on 5/31/96, and 30% porosity of sand equals 102.35 gallons

Field Analysis	Initial	During #'s			Final
5/31/96 Time:	1250 hrs	1350 hrs	1450 hrs	1550 hrs	1630 hrs
Conductivity ~~(x100)~~:	.056 mS/cm	.035 mS/cm	.033 mS/cm	.031 mS/cm	.030 mS/cm
pH:	6.78 pH	5.64 pH	5.37 pH	5.30 pH	5.28 pH
Temperature ~~(F)~~:	15.9 °C	16.1 °C	15.5 °C	16.9 °C	16.9 °C

Total Quantity of Water Removed: 5/28/96 - 325 gallons 5/31 - ~~345~~ 1735 gallons

5/29/96 - 1165 gallons

Method of Water Disposal: 5/30/96 - 3060 gallons Pumped onto ground.

Sample Jar Collected: Yes on 5-31-96

Comments: Purged well w/ air compressor on 5/28, 5/29, Purged with submersible pump on 5/30, 5/31.

USACE - Baltimore District

Project: CSX/COX CREEK PLACEMENT AREAS	Hole #: F-1

MONITORING WELL DEVELOPMENT RECORD Addendum

HOLE NUMBER: F-1	DEPTH OF GW (FT): 14.90' BGS	INSPECTOR: Lyle Griffith Jr.
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)	DRILLER: Bowden / Kyle / Carpenter
LOCATION: AA County, MD	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
INSTALLATION DATE: 5-18-96	TOP OF PVC CASING: 2.5' AGS	DEVELOPMENT METHOD:
DEVELOPMENT DATE: 6/4, 5	BOTTOM OF HOLE: 149' BGS	Pumping and Surging

Well Construction Details

Total Well Depth (ft)	Top of Casing ~~Below~~ Above Grnd Surface(ft)	Screened Interval (ft)
147'	2.5'	127' to 147' BGS
Borehole Diameter (in)	**Well Diameter (in)**	**Static Water Level (ft)**
8.5"	4"	6/5/96 20.5' BGS

Pumping Rate: 6/5/96 30 gallons in 1 minute. Same as on 6/4/96

Pumping Depth(s):

Development Start Time: 6/5/96 0930 hrs Stop Time: 6/5/96 1625 hrs

Physical Appearance of Water:

Initial: cloudy rose colored liquid

During: clear liquid

Final: clear liquid

Well Volume (including filter pack): Assuming 20.5' water level on 6/5/96, and 30% porosity of sand equals 103.65 gallons

Field Analysis	Initial	During #'s			Final
6/5/96 Time:	0930 hrs	1100 hrs	1250 hrs	1454 hrs	1611 hrs
Conductivity ~~(x100)~~:	Not Taken	.033 ms/cm	.031 ms/cm	.030 ms/cm	.032 ms/cm
pH:	Not Taken	4.68 pH	4.66 pH	4.54 pH	4.60 pH
Temperature ~~(F)~~:	Not Taken	17.2 °C	17.9 °C	16.9 °C	17.2 °C

Total Quantity of Water Removed: 6/4/96 - 9,000 gallons
6/5/96 - 12,450 gallons

Method of Water Disposal: Pumped onto ground

Sample Jar Collected: Yes on 6-5-96

Comments: Well F-1 pumped further on 6/4 and 6/5 with the submersible pump. This sheet is an addendum to the original well development sheet on 5/31/96.

USACE - Baltimore District

Project:	Hole #:
CSX/COX CREEK PLACEMENT AREAS	F-1

MONITORING WELL DEVELOPMENT RECORD

HOLE NUMBER: E-1	DEPTH OF GW (FT): 6/1/96 9.57' BGS	INSPECTOR: Lyle Griffith, Jr.
PROJECT: CSX/COX CREEK	ELEVATIONS (FT MSL)	DRILLER: Dan Bowden
LOCATION: AA County, MD	SURFACE:	DRILLING METHOD: HSA, Mud Rotary
INSTALLATION DATE: 5-30-96	TOP OF PVC CASING: 2.31' AGS	DEVELOPMENT METHOD:
DEVELOPMENT DATE: 6-17-96	BOTTOM OF HOLE: 167' BGS	Pumping and Surging

Well Construction Details

Total Well Depth (ft) 165'	Top of Casing ~~Below~~ Above Grnd Surface(ft) 2.31'	Screened Interval (ft) 155' to 165' BGS
Borehole Diameter (in) 8 1/2"	Well Diameter (in) 4"	Static Water Level (ft) 11.68' on 6-17-96

Pumping Rate: 6/17 10 gallons per minute

Pumping Depth(s):

Development 6/17 Start Time: 0945 hrs Stop Time: 1245 hrs

Physical Appearance of Water:

Initial: Very cloudy liquid

During: Slightly cloudy

Final: Clear

Well Volume (including filter pack): Assuming 11.68' water level on 6-17-96, and 30% porosity of sand equals 118.41 gallons.

Field Analysis	Initial	During #'s			Final
Time:	0945 hrs	1045 hrs	1145 hrs		
Conductivity (~~x100~~):	.230 mS/cm	.210 mS/cm	.298 mS/cm		
pH:	6.19 pH	6.61 - pH	6.49 pH		
Temperature (~~F~~):	20.6 °C	10.8 °C	10.6 °C		

Total Quantity of Water Removed: 6/5 - 700 gallons, 6/8 - 435 gallons, 6/11 - 1720 gallons, 6/12 - 750 gallons, 6/13 - 5180 gallons, 6/14 - 4650 gallons, 6/17 - 1800 gallons

Method of Water Disposal: Pumped water onto ground

Sample Jar Collected: No

Comments: Development performed by Chuck Kyle, FEU.

The total quantity of water removed between 6/5/96 and 6/17/96 inclusive is approximately 15,235 gallons.

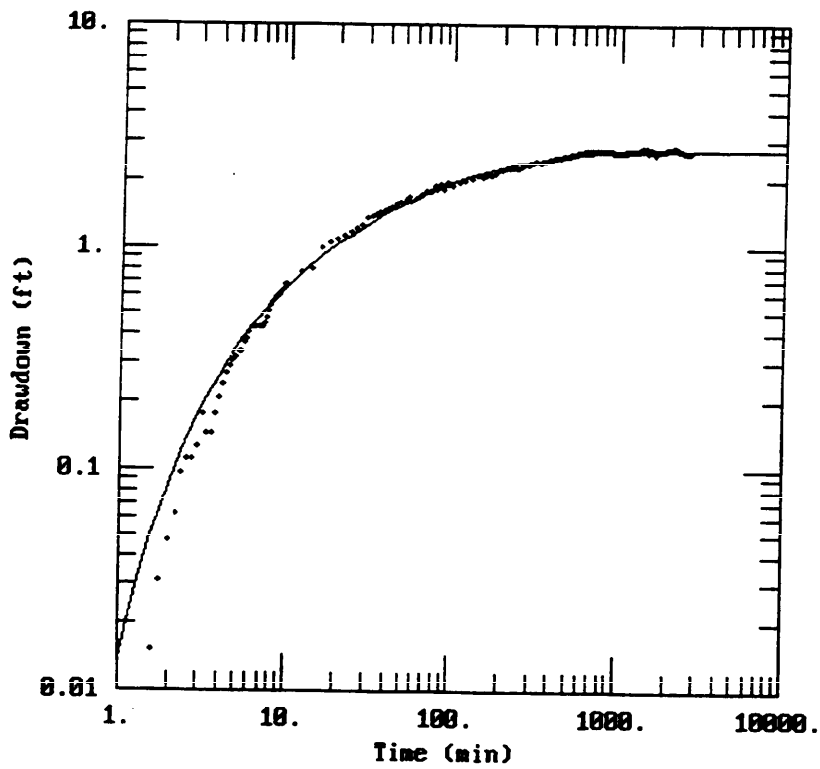
USACE - Baltimore District

Project: CSX/COX CREEK PLACEMENT AREAS	Hole #: E-1

Appendix D. Pump Test Data and Results

CLIENT: MD Port Authority	COMPANY: USACE
LOCATION: Cox Creek	

Cox Creek



DATA SET:
F-3.AQT
09/15/96

AQUIFER MODEL:
Leaky

SOLUTION METHOD:
Hantush (no stor.)

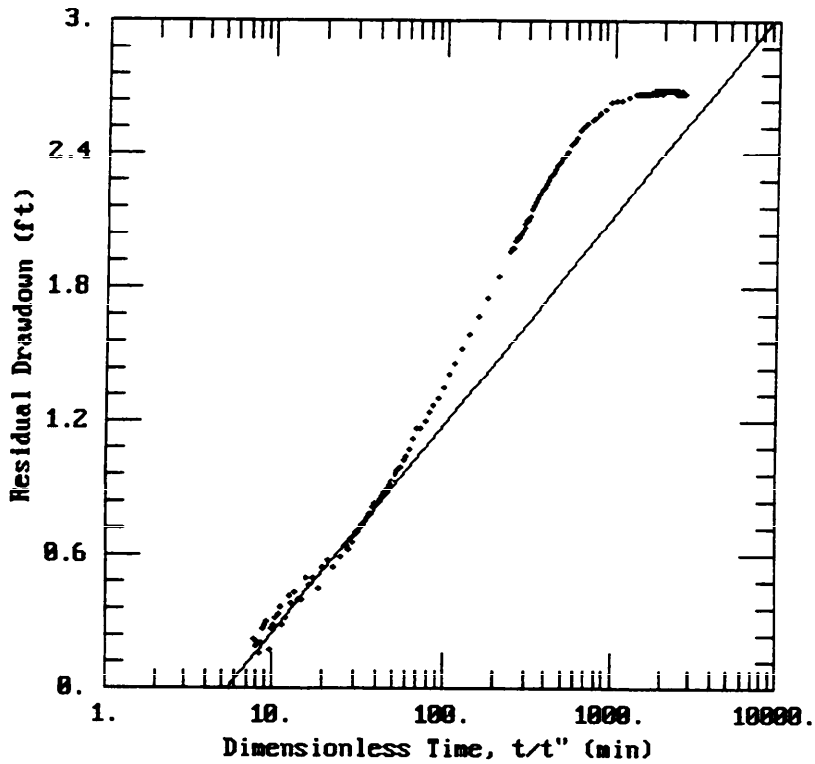
PROJECT DATA:
test date: 24-26 July 96
test well: F-1
obs. well: F-3

TEST DATA:
Q = 62. gal/min
r = 300. ft
r_c= 0.167 ft
r_w= 0.345 ft
b = 150. ft
Pumping Well Screen Depth:
top = 107. ft
bot.= 127. ft
Obs. Well Screen Depth:
top = 100. ft
bot.= 120. ft

PARAMETER ESTIMATES:
T = 1411.2 ft^2/day
S = 0.0001183
r/B= 0.1491

AQTESOLV

CLIENT: MD Port Authority	COMPANY: USACE
LOCATION: Cox Creek	



DATA SET:
F-3RC.AQT
09/15/96

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Theis Recovery

PROJECT DATA:
test date: 24-26 July 96
test well: F-1
obs. well: F-3

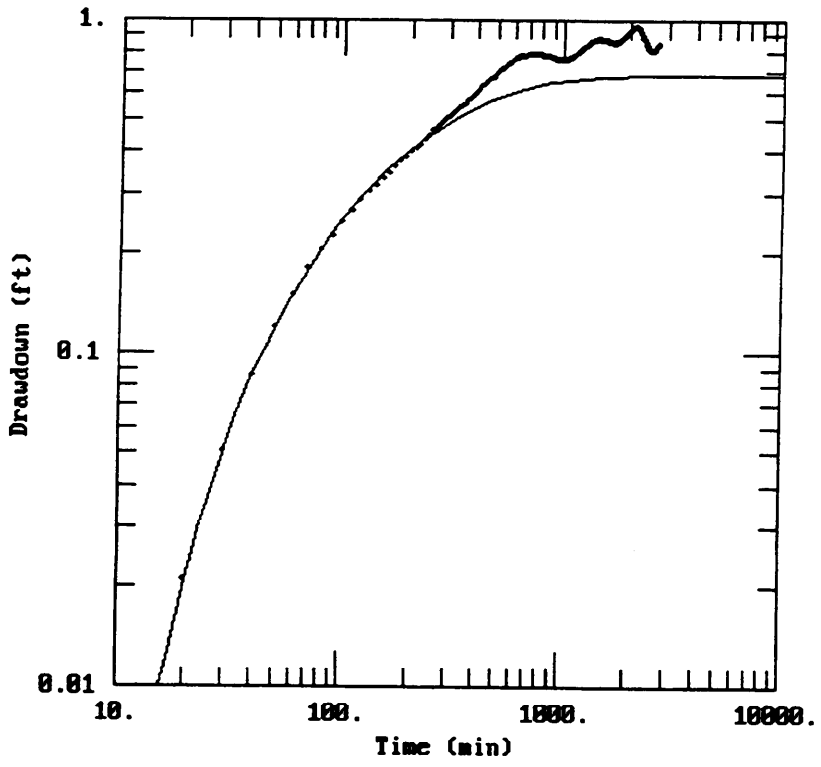
TEST DATA:
Q = 62. gal/min
r = 300. ft
r_c= 0.167 ft
r_w= 0.345 ft
b = 150. ft

PARAMETER ESTIMATES:
T = 2349.5 ft^2/day
S' = 5.352

AQTESOLV

CLIENT: MD Port Authority	COMPANY: USACE
LOCATION: Cox Creek	

Cox Creek



DATA SET:
E-1.AQT
09/23/96

AQUIFER MODEL:
Leaky

SOLUTION METHOD:
Hantush (no stor.)

PROJECT DATA:
test date: 24-26 July 96
test well: F-1
obs. well: E-1

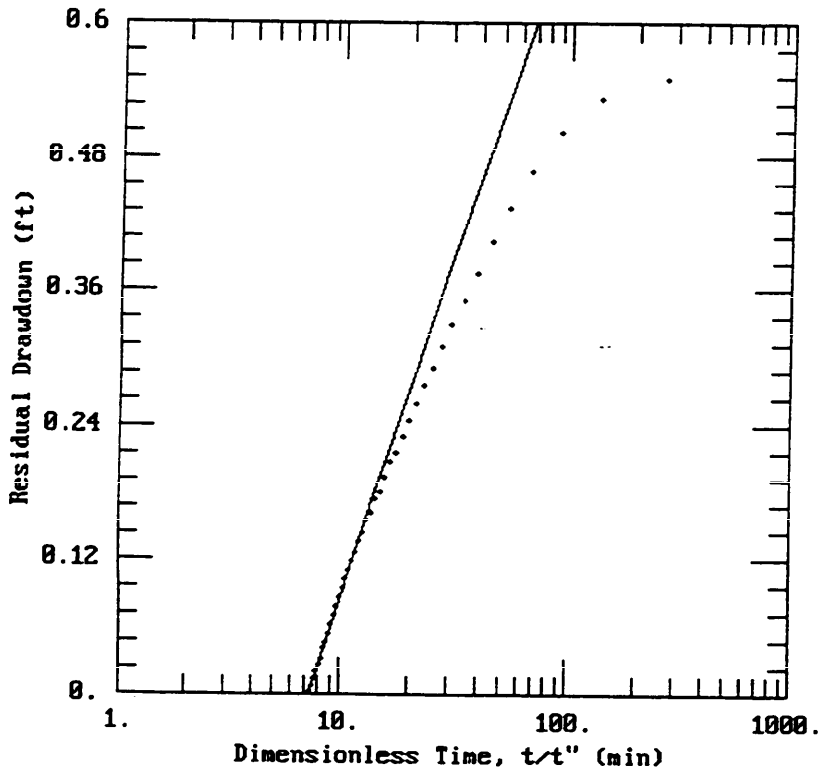
TEST DATA:
Q = 62. gal/min
r = 1099. ft
r_c= 0.167 ft
r_w= 0.345 ft
b = 150. ft

PARAMETER ESTIMATES:
T = 2506.9 ft^2/day
S = 0.0002222
r/B= 0.5176

AQTESOLV

CLIENT: MD Port Authority	COMPANY: USACE
LOCATION: Cox Creek	

Cox Creek



DATA SET:
E-1RC.AQT
09/23/96

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Theis Recovery

PROJECT DATA:
test date: 24-26 July 96
test well: F-1
obs. well: E-1

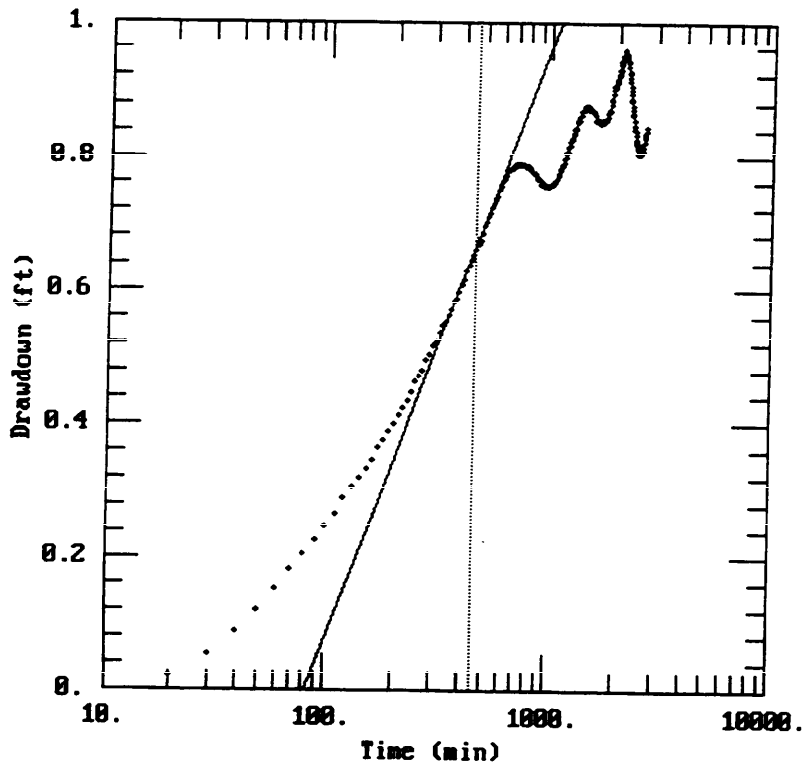
TEST DATA:
Q = 62. gal/min
r = 1099. ft
r_c= 0.167 ft
r_w= 0.345 ft
b = 150. ft

PARAMETER ESTIMATES:
T = 3554.7 ft^2/day
S' = 7.286

AQTESOLV

CLIENT: MD Port Authority	COMPANY: USACE
LOCATION: Cox Creek	

Cox Creek



DATA SET:
E-1.AQT
09/20/96

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Cooper-Jacob

PROJECT DATA:
test date: 24-26 July 96
test well: F-1
obs. well: E-1

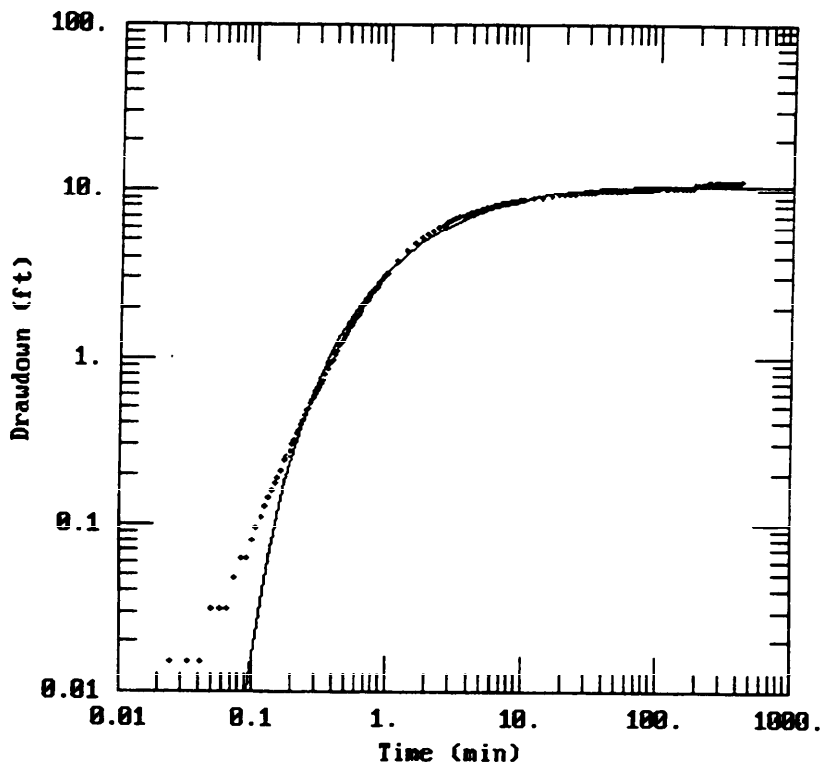
TEST DATA:
Q = 62. gal/min
r = 1099. ft
r_c = 0.167 ft
r_w = 0.345 ft
b = 150. ft

PARAMETER ESTIMATES:
T = 2450.3 ft^2/day
S = 0.0002599

AQTESOLV

CLIENT: MD Port Authority	COMPANY: USACE
LOCATION: Cox Creek	

COX CREEK



DATA SET:
F-2B.AQT
09/15/96

AQUIFER MODEL:
Leaky

SOLUTION METHOD:
Hantush (no stor.)

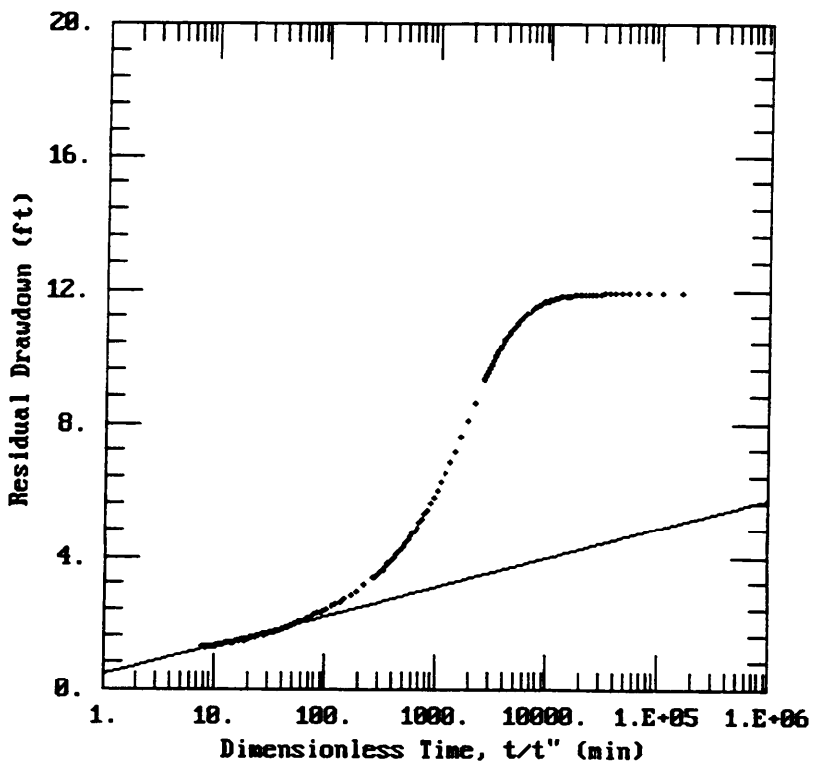
PROJECT DATA:
test date: 24-26 July 96
test well: F-1
obs. well: F-2

TEST DATA:
Q = 62. gal/min
r = 30. ft
r_c= 0.167 ft
r_w= 0.345 ft
b = 150. ft
Pumping Well Screen Depth:
top = 107. ft
bot.= 127. ft
Obs. Well Screen Depth:
top = 105. ft
bot.= 125. ft

PARAMETER ESTIMATES:
T = 453.7 ft^2/day
S = 0.0006592
r/B= 0.2546

AQTESOLV

CLIENT: MD Port Authority	COMPANY: USACE
LOCATION: Cox Creek	



DATA SET:
F-2RC.AQT
09/15/96

AQUIFER MODEL:
Confined

SOLUTION METHOD:
Theis Recovery

PROJECT DATA:
test date: 24-26 July 96
test well: F-1
obs. well: F-2

TEST DATA:
Q = 62. gal/min
r = 30. ft
r_c= 0.167 ft
r_w= 0.345 ft
b = 150. ft

PARAMETER ESTIMATES:
T = 2484.1 ft^2/day
S' = 0.3002

AQTESOLV