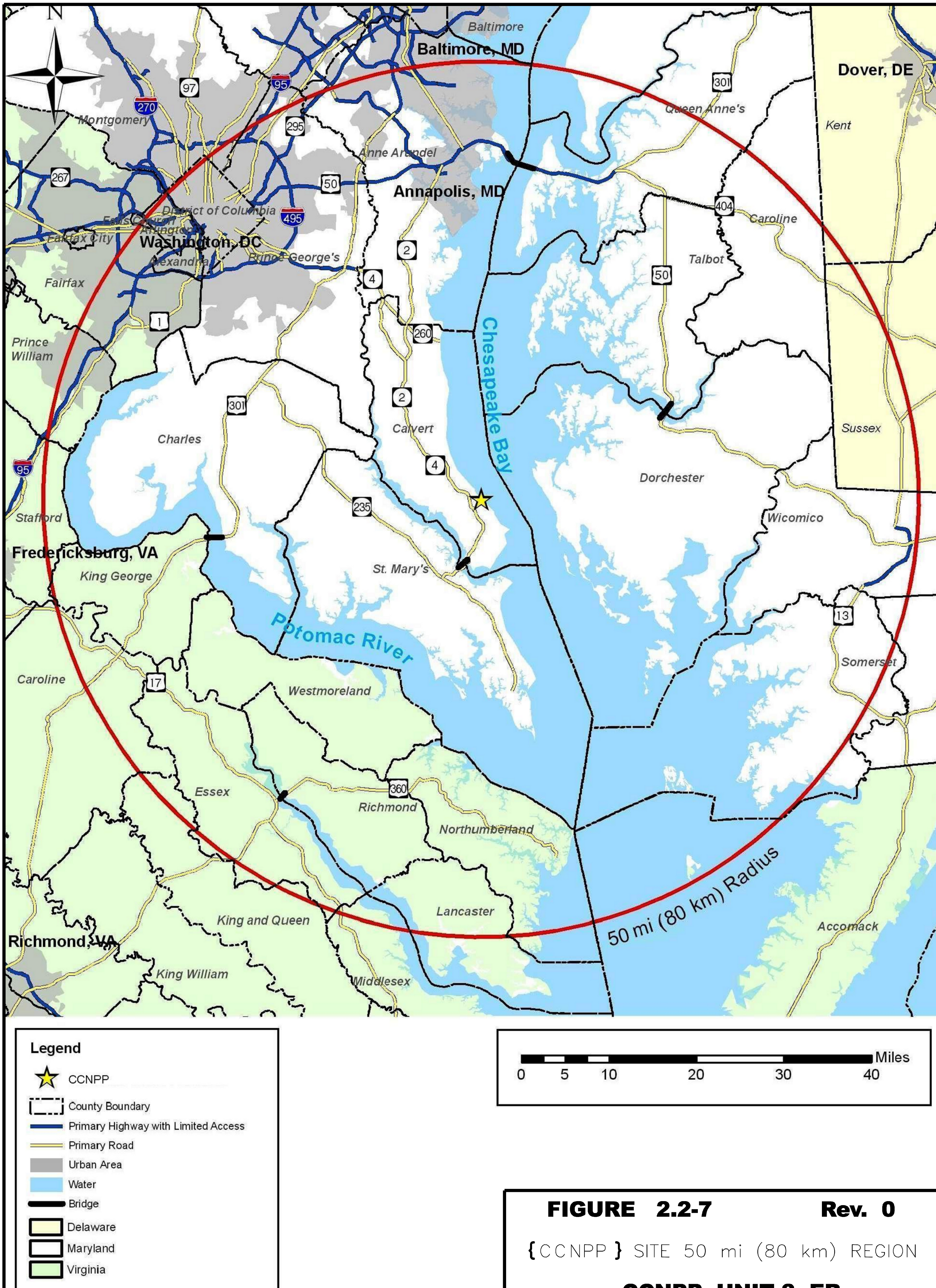

FIGURE 2.2-7 **Rev. 0**

{CCNPP} SITE 50 mi (80 km) REGION

CCNPP UNIT 3 ER

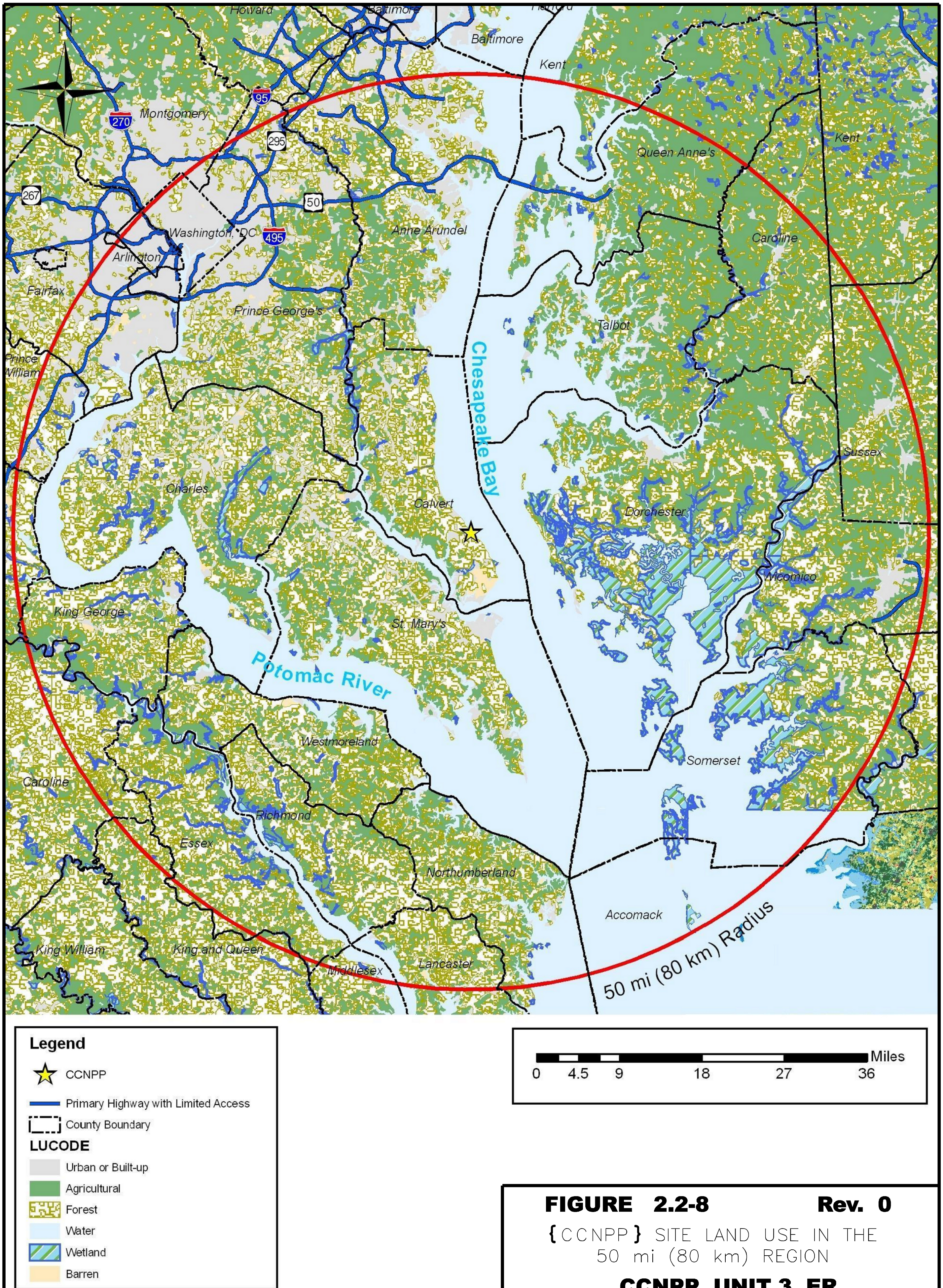

FIGURE 2.2-8 **Rev. 0**

{CCNPP} SITE LAND USE IN THE 50 mi (80 km) REGION

CCNPP UNIT 3 ER

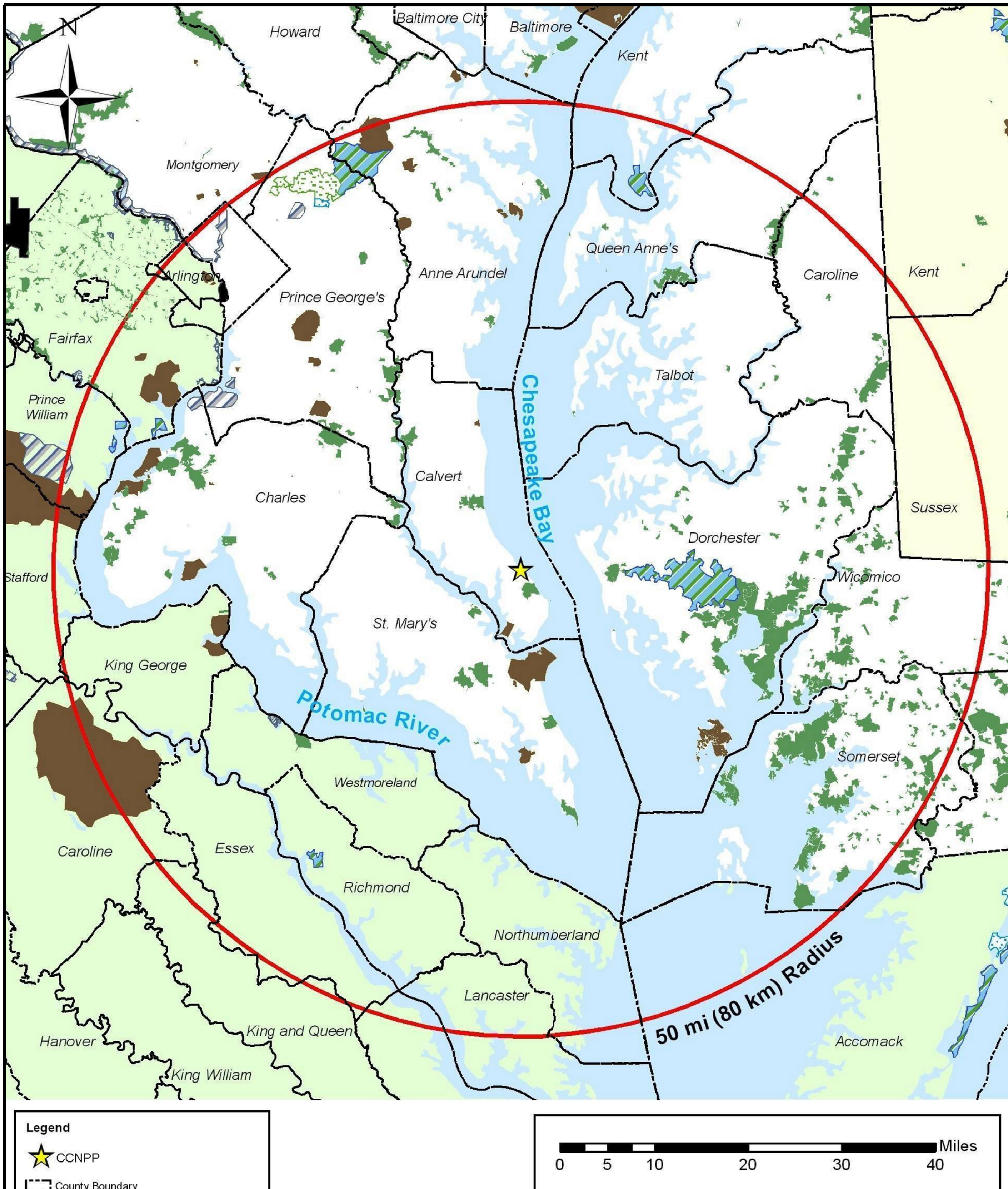

FIGURE 2.2-9 **Rev. 0**

MAJOR PUBLIC AND TRUST LANDS IN THE 50 mi (80 km) REGION

CCNPP UNIT 3 ER

2.3 WATER

2.3.1 HYDROLOGY

This section describes surface water bodies and ground water aquifers that could affect or be affected by the construction and operation of **{**CCNPP Unit 3**}**. The site-specific and regional data on the physical and hydrologic characteristics of these water resources are summarized to provide the basic data for an evaluation of impacts on water bodies, aquifers, human social and economic structures, and aquatic eco-systems of the area.

{The CCNPP site covers an area of approximately 2057 acres (832 hectares) and is located on the western shore of the Chesapeake Bay in Calvert County, MD near Maryland Route 2/4. The climate of the site area is primarily humid subtropical, with hot, humid summers and mild, rainy winters. The topography at the site is gently rolling with steeper slopes along stream banks. Local relief ranges from the sea level up to about 130 ft (40 m) NGVD 29 with an average relief of approximately 100 ft (30 m) NGVD 29. The Chesapeake Bay shoreline near the site, which constitutes the northeastern perimeter, consists mostly of steep cliffs with a narrow beach area.**}**

2.3.1.1 Surface Water Resources

{The CCNPP site is located on a high bluff on the Calvert peninsula within the Chesapeake Bay watershed with the bay influencing the siting of the CCNPP Unit 3. The Chesapeake Bay, with a watershed area in excess of 64,000 mi^2 (165,759, km^2), is the largest estuary in the U.S.

The Calvert peninsula is formed by the Chesapeake Bay to the east and the Patuxent River to the west. It has a width of approximately 5 mi (8.0 km) near the CCNPP site. The Patuxent River flows near the CCNPP site from the northwest to the southeast direction, and it discharges into the Chesapeake Bay approximately 8 mi (12.9 km) south of the CCNPP site. Drainage in the vicinity of the CCNPP site includes several small streams and creeks, which fall within two sub-watersheds of the Chesapeake Bay with the drainage divide running nearly parallel to the shoreline. These sub-watersheds include the Patuxent River watershed and the Maryland Western Shore watershed. Figure 2.3.1-1 (USGS, 2005e) shows the Chesapeake Bay watershed and sub-watersheds along with the CCNPP site location.**}**

2.3.1.1.1 Freshwater Streams

2.3.1.1.1.1 Local Drainage

{The CCNPP site is well drained by a natural network of short, ephemeral streams and creeks within the two sub-watersheds. Approximately 80% of the the CCNPP site is drained through the St. Leonard Creek drainage basin of the Lower Patuxent River watershed. The remaining 20% drains through the Maryland Western Shore watershed discharging northeastward and directly into the Chesapeake Bay by two unnamed creeks, identified as Branch 1 and Branch 2 in Figure 2.3.1-2. All the streams that drain the CCNPP site that are located east of Maryland Route 2/4 are non-tidal.

Runoff from the CCNPP site that lies within the St. Leonard Creek watershed mainly drains through Johns Creek, a tributary to St. Leonard Creek. The tributaries located upstream of Maryland Route 2/4 that contribute to Johns Creek are the Goldstein Branch, Laveel Branch, and two unnamed branches identified as Branch 3 and Branch 4 in Figure 2.3.1-2. Approximate lengths and average gradients of these streams are presented in Table 2.3.1-1.

The St. Leonard Creek watershed has a drainage area of approximately 35.6 mi^2 (92.2 km^2) (CWP, 2004) and mainly includes St. Leonard Creek and its tributaries, including the Perrin Branch, Woodland Branch, Planters Wharf Creek, Johns Creek and its tributaries, Grovers

Creek, Rollins Cove, and Grapevine Cove as shown in Figure 2.3.1-3. The combined flow from these streams discharge into the Patuxent River through St. Leonard Creek. St. Leonard Creek is tidally influenced at the confluence with Johns Creek.

The CCNPP Unit 3 power block will be located in the Maryland Western Shore Watershed as shown in Figure 2.3.1-2. The circulating water system (CWS) cooling towers and switchyard will be located in the St. Leonard Creek watershed. Power transmission lines from the CCNPP Unit 3 substation will use the CCNPP Units 1 and 2 transmission corridor. From the CCNPP Unit 3 substation, the transmission lines will proceed in a northwestward direction as shown in Figure 2.3.1-4. Site grading for CCNPP Unit 3 will affect the headwaters of the unnamed creek, Branch 1, in the Maryland Western Shore watershed. In the St. Leonard Creek watershed, the unnamed creek, Branch 3, will be affected by the switchyard. Post-construction drainage from the CCNPP Unit 3 power block area will be directed towards the Chesapeake Bay, while drainage from the CWS cooling towers and switchyard will be directed to Johns Creek.

The design basis flood elevation at the power block area is 81.5 ft (24.8 m) NGVD 29. However, the maximum water level associated with a safety-related structure is 81.4 ft (24.8 m) NGVD 29, which is 3.2 ft (1.0 m) below the reactor complex grade slab at elevation 84.6 ft (25.8 m) NGVD 29. The design basis flood elevation at the safety-related UHS makeup water intake structure is 39.4 ft (12 m) NGVD 29.

Wetlands near the CCNPP Unit 3 construction area consist of small headwater streams with narrow floodplains and associated riparian forest in the St. Leonard watershed; and minor Chesapeake Bay watershed, minor tributary streams and associated small impoundments. Major impoundments within the site include the Lake Davies stormwater impoundment, sequential perennial water bodies that drain the dredge spoil disposal area, and the Camp Conoy fishing pond, The Camp Conoy pond is located at the headwaters of unnamed creek Branch 1 as shown in Figure 2.3.1-4. Runoff from Lake Davis discharges west to Goldstein Branch, which then discharges to Johns Creek. The sequential ponds discharge directly to Johns Creek upstream of Goldstein Branch. Both the Camp Conoy fishing pond and Lake Davies are man-made. The U.S. Fish and Wildlife Services (USFWS, 2007) have designated the water bodies within the CCNPP site as palustrine wetlands. Camp Conoy pond and Lake Davies are further sub-classified as unconsolidated bottom permanently flooded and emergent semi-permanently flooded wetlands, respectively. Wetlands along the streams and creeks are mostly classified as forested or scrub-shrub wetlands that are seasonally or temporarily flooded.**}**

2.3.1.1.1.2 **{**Patuxent River Watershed

The Patuxent River is the largest river that is completely contained in Maryland. It drains an area of about 932 mi^2 (2,414 km^2) as shown in Figure 2.3.1-1, which includes portions of St. Mary's, Calvert, Charles, Anne Arundel, Prince George's, Howard, and Montgomery Counties (MDNR, 2006). The Patuxent River contributes slightly over 1% of the total streamflow delivered annually from the catchment of the Chesapeake Bay Basin (USGS, 1968). The river basin is situated between two large metropolitan areas, which are Baltimore, Maryland and Washington, D.C. Consequently, the Patuxent River watershed has gone through significant suburban development in the past few decades. Present land use in the basin is approximately 44% forest, 30% urban, and 26% agriculture (MDNR, 2006).

The Patuxent River watershed is divided into four sub-watersheds:

- Upper Patuxent River watershed
- Western Branch Patuxent River watershed

- Middle Patuxent River watershed
- Lower Patuxent River watershed

The Lower Patuxent River watershed area within Calvert County is approximately 174 mi^2 (451 km^2) and covers over 50% of land in the county. The major rivers contributing to the watershed are the Patuxent River, Hunting, Hall, St. Leonard, and Battle Creeks. The main stem of the Patuxent River is influenced by tidal fluctuation in the Chesapeake Bay. The tidal influence is observed over nearly the entire length of the river in the lower watershed with the head of tide located south of Bowie, MD. The town of Bowie, MD is depicted on Figure 2.3.1-1.**}**

2.3.1.1.1.3 Streamflow Data and Flooding Intensity for Freshwater Streams

{The U.S. Geological Survey (USGS) maintains a network of stream gauging stations on the rivers draining to the Chesapeake Bay, including the Patuxent River. The USGS gauging station on the Patuxent River that is closest to the CCNPP site is located at Bowie, MD (USGS Station No. 01594440), approximately 60 mi (97 km) upstream from the river mouth (USGS, 2006a). The drainage area at the gauging station is 348 mi^2 (901 km^2), approximately 37% of the total drainage area of the Patuxent River. The station is located in the non-tidal reach of the river. The nearest dam and reservoir, the Rocky Gorge Dam and Howard Duckett Reservoir, is located approximately 21 mi (34 km) upstream of the gauging station, and the streamflow may have been affected by this water control structure following the impoundment of the reservoir in 1953. A description of the reservoirs and associated dams is provided in Section 2.3.1.1.1.4.

The USGS records streamflow data on a water year basis, which starts on October 1 the preceding year and ends on September 30 of the water year. The gauge at Bowie, MD has recorded streamflow data from June 1977 to date. Table 2.3.1-2 (USGS, 2006a) shows the annual maximum streamflow data for the period of data records from 1978 to 2006. The table shows the highest peak flow at this station for the period of record as 12,700 cfs (359.6 cms) on June 26, 2006. However, before the official period of record, a higher peak flow rate was reported as 31,100 cfs (880.7 cms) on June 22, 1972. The maximum daily flow is reported to be 8,860 cfs (250.9 cms) on January 27, 1978. The minimum daily flow of 56 cfs (1.59 cms) was observed between September 17, 18, and 19, 1986. An instantaneous low flow of 32 cfs (0.9 cms) is reported at this location on August 9, 1966. The lowest recorded seven day flow is 57 cfs (1.6 cms) reported on September 15, 1986 (USGS, 2006c).

Monthly streamflows and mean, maximum and minimum daily streamflows at Bowie, MD are presented in Tables 2.3.1-3 through 2.3.1-6. Mean monthly streamflow discharges are also presented in Figure 2.3.1-5 along with the maximum and minimum of mean monthly values. While the mean monthly values show highest flow discharge in March, the maximum values indicate that highest mean monthly streamflows may occur in any month between December and June. The maximum of mean monthly streamflow shows an upper limit of approximately 1,350 cfs (38.2 cms) consistently for several months (Figure 2.3.1-5).

Because hydrologic conditions in the Patuxent River near the CCNPP site are estuarine as opposed to riverine, flood frequency distributions, maximum and minimum monthly streamflows, and the 10 year, 7 day low flow water level at the gauge location are not relevant for the CCNPP site. Also, water levels and streamflow characteristics of the Patuxent River near the site would have no affect on and would not be affected by the construction and operation of the CCNPP Unit 3.

The USGS operated a gauging station on St. Leonard Creek (USGS Station No. 01594800, St. Leonard Creek near St. Leonard, MD) from 1957 to 1968 and from 2000 to 2003 (USGS, 2006b). The gauging station has a drainage area of 6.73 mi^2 (17.43 km^2), which is approximately 19% of the total St. Leonard Creek watershed. Table 2.3.1-7 shows the annual maximum streamflow data for the period of data records. The table shows the highest peak flow at this station as 288 cfs (8.1 cms) on July 30, 1960. The maximum daily flow is reported to be 140 cfs (4.0 cms) on August 25, 1958. The station reported no flow several times during 1966, 2002, and 2003 with the minimum daily and instantaneous low flow of 0 cfs (0 cms) as noted in USGS, 2003a. The lowest recorded seven-day flow is 0 cfs (0 cms), as reported on August 24, 1966 as noted in USGS, 2003a.

Monthly streamflows and mean, maximum and minimum daily streamflows near St. Leonard, MD are presented in Tables 2.3.1-8 through 2.3.1-11. Mean monthly streamflow discharges are also presented in Figure 2.3.1-6 along with the maximum and minimum of mean monthly values. It shows that the maximum of mean monthly discharge at this location usually occurs in April and May.

Because the streamflow in St. Leonard Creek at the gauge location will not affect or be affected by the construction and operation of CCNPP Unit 3, flood frequency distributions, maximum and minimum monthly streamflows, and the 10 year, 7 day low flow water level at this gauge location have not been determined.

The U.S. Federal Emergency Management Agency Flood Insurance Rate Map for Calvert County shows that Zone A flood boundaries (flooding determined by approximate methods) extend up Johns Creek to a point upstream of the Maryland Route 2/4 (Solomon's Island Road) crossing near the mouth of Goldstein Branch as shown in Figure 2.3.1-7 (FEMA, 1998). A similar extent of flooding is also shown by the Maryland Western Shore Hurricane Evacuation Study being performed by the US Army Corps of Engineers, Baltimore District (USACE, 2006a), as shown in Figure 2.3.1-8. The figures indicate that the CCNPP site, which is located further to the northeast of the flood extent boundary, would be free from any flooding in the freshwater streams. There are no flood control structures on Johns Creeks or its tributaries.**}**

2.3.1.1.1.4 Dams and Reservoirs

{There are no dams or reservoirs on St. Leonard Creek or its tributaries. There are two dams on the Patuxent River. The Rocky Gorge Dam is located approximately 75 mi (121 km) from the mouth of the Patuxent River. The Brighton Dam is located approximately 85 mi (137 km) from the mouth of the Patuxent River. Details of each of the dams are provided in Table 2.3.1-12 (USACE, 2006b). These impoundments would not affect or be affected by the construction or operation of CCNPP Unit 3.**}**

2.3.1.1.2 {The Chesapeake Bay Estuary

2.3.1.1.2.1 Physical Setting

The Chesapeake Bay is one of the largest and most productive estuarine systems in the world. The Chesapeake Bay main stem, defined by tidal zones, is approximately 195 mi (314 km) long (measured from its entrance at the Atlantic Ocean near Norfolk, VA to the mouth of the Susquehanna River near Havre de Grace, MD). At the northern end, the estuary is connected to the Atlantic Ocean through the Chesapeake and Delaware Canal. The estuary varies in width from about 3.5 mi (5.6 km) near Aberdeen, MD to 35 mi (56 km) near the mouth of the Potomac River, with an approximate width of 6 mi (9.7 km) near the CCNPP site. It has an open surface area of nearly 4,480 mi^2 (11,603 km^2) and, including its tidal estuaries, has approximately 11,684 mi (18,804 km) of shoreline (USGS, 2003b) (CBP, 2006b).

On average, the Chesapeake Bay holds more than 18 trillion gallons (68 trillion liters) of water. Although the Chesapeake Bay's length and width are dramatic, the average depth of the bay, including tidal tributary channels, is only about 21 ft (6.4 m). The Chesapeake Bay is shaped like a shallow tray, except for a few deep troughs that are believed to be paleo channels of the Susquehanna River. The troughs form a deep channel along much of the length of the Chesapeake Bay. This deep channel allows passage of large commercial vessels. Because it is so shallow, the Chesapeake Bay is more sensitive to temperature fluctuations and wind than the open ocean. The Chesapeake Bay is irregular in shape and is long enough to accommodate one complete tidal wave cycle at all times (CBP, 2006b).

The main stem of the bay is entirely within Maryland and Virginia. Nearly 50 rivers, with thousands of tributary streams and creeks, drain an area in excess of 64,000 mi^2 (165,759, km^2) forming the Chesapeake Bay Basin (CBP, 2006b). The basin contains more than 150,000 stream mi (241,402 stream km) in the District of Columbia and parts of six states: New York, Pennsylvania, Maryland, Virginia, West Virginia, and Delaware as shown in Figure 2.3.1-1. Nine rivers, including the Susquehanna, Patuxent, Potomac, Rappahannock, York (including its Mattaponi and Pamunkey tributaries), James, Appomattox, and Choptank, contribute over 90% of the Chesapeake Bay's mean annual freshwater inflow. The Susquehanna River, the largest river that enters the bay, drains nearly 43% of the basin. It normally contributes about 50% of the freshwater reaching the Chesapeake Bay. Eighty percent to 90% of the freshwater entering the Chesapeake Bay comes from the northern and western portions of the basin. The remaining 10% to 20% is contributed by the eastern shore (CBP, 2004). Although the Chesapeake Bay lies totally within the Atlantic Coastal Plain, the watershed includes parts of the Piedmont Province and the Appalachian Province that provide a mixture of waters to the Chesapeake Bay with variable geochemical and sediment origins (USGS 2003b) (CBP, 2006b).

2.3.1.1.2.2 Chesapeake Bay Circulation and Freshwater Flow

Circulation in the Chesapeake Bay is mainly governed by astronomical tides entering the Chesapeake Bay through the Chesapeake Bay mouth near Norfolk, VA; gravitational flow due to freshwater inflow from the rivers; and wind-driven and atmospheric pressure-driven circulation. The effect of these physical processes is further impacted by the irregular Chesapeake Bay shape and bathymetry variation. The combined interaction of these physical processes also causes a varying degree of mixing of tidal water to produce different salinity zones over the Chesapeake Bay length.

The USGS provides estimates of mean monthly freshwater inflow to the Chesapeake Bay based on a methodology (USGS, 1968) that uses index stream gauging data from the Susquehanna, Potomac, and James Rivers (USGS, 2007). Mean annual (water year) freshwater inflow to the Chesapeake Bay for a period from 1938 to 2006 is shown in Figure 2.3.1-9 (USGS, 2007). The estimated mean monthly freshwater inflow to the Chesapeake Bay between 1951 and 2000 is provided in Table 2.3.1-13 (USGS, 1968). The maximum, average, and minimum of mean monthly freshwater flows for the same period are shown in Figure 2.3.1-10 (USGS, 1968). The figure shows that March and April are the wettest months in the Chesapeake Bay basin with mean freshwater inflows of nearly 152,000 cfs (4304 cms) and 145,000 cfs (4106 cms), respectively. The maximum mean monthly freshwater inflow to the Chesapeake Bay, reported as 380,700 cfs (10,780 cms), occurred in April, 1993. August is the driest month with an approximate mean freshwater inflow of 30,800 cfs (872 cfs) from the rivers. The minimum monthly inflow of 7,800 cfs (221 cms) occurred in September, 1964. The annual average freshwater inflow to the bay for the period of record is estimated to be approximately 77,500 cfs (2195 cms).

The USGS provides estimates of freshwater inflows to different reaches of the Chesapeake Bay (USGS, 1968) (USGS, 2007). The reach of the Chesapeake Bay that includes the CCNPP site extends from the mouth of the Susquehanna River to just above the mouth of the Potomac River, as shown in Figure 2.3.1-11, between Sections A and B (USGS, 2007). The southern boundary of the reach, which is Section B, is located south of the CCNPP site. The only major tributary to the Chesapeake Bay south of the CCNPP site that contributes freshwater flow to this reach is the Patuxent River. The USGS estimates indicate that the freshwater inflow available at Section B constitutes approximately 60% of the total freshwater inflow to the Chesapeake Bay (USGS, 1968) (USGS, 2007). Using this ratio of flow distribution, a mean annual freshwater inflow rate of approximately 46,500 cfs (1317 cms) is estimated for the reach including the CCNPP site. Because the Patuxent River contributes only about 1% of total freshwater inflow to the Chesapeake Bay, the estimated mean annual freshwater flow rate for this reach is assumed available at the CCNPP site.

Tides primarily enter the Chesapeake Bay through the southern entrance from the Atlantic Ocean and propagate upstream. Tides can also enter the Chesapeake Bay through the Chesapeake and Delaware Canal, but these tidal influences are limited to the upper Chesapeake Bay region. The modifications of tidal characteristics and tidal circulation within the Chesapeake Bay are dependent on the width, depth, and configuration of the estuarine basins and tributaries. In the Chesapeake Bay, the mean tidal range varies from approximately 2.55 ft (0.78 m) near the Atlantic Ocean entrance (Chesapeake Bay Bridge Tunnel, VA), decreasing to approximately 1.04 ft (0.32 m) at Cove Point, MD near the CCNPP site, and increasing to nearly 1.9 ft (0.58 m) close to the northern head waters (Havre De Grace, MD) (NOAA, 2007a). Additional National Oceanic and Atmospheric Administration (NOAA) tidal records near the site are also available at Long Beach, MD on the western shore; Cambridge, MD on the eastern shore of the Chesapeake Bay; and at Solomons Island on the Patuxent River. The mean tidal range at these locations is estimated as 1.01 ft (0.31 m), 1.62 ft (0.49 m), and 1.17 ft (0.36 m), respectively (NOAA, 2007a).

Due to the effect of Coriolis force, the tidal range is higher on the eastern shore than the western shore of the Chesapeake Bay. The tidal range generally increases as the tidal wave propagates through the tributary rivers. For example, this phenomenon can be observed in the Patuxent River and Potomac River from NOAA tide measurements. The mean tidal range near the entrance of the Patuxent River (Solomons Island, MD) is about 1.17 ft (0.36 m), while the range at the upstream station Lower Marlboro, MD is about 1.79 ft (0.55 m). Similarly, on the Potomac River, between the entrance (Tangier Island, VA) and Washington, D.C., the mean tidal range increases from about 1.51 ft (0.46 m) to 2.79 ft (0.85 m) (NOAA, 2007a). Tides in the Chesapeake Bay are mainly semidiurnal with two nearly-equal tide peaks and two troughs each a day. However, in the upper part of the Chesapeake Bay, mixed-type tides are also observed with unequal tide peaks and troughs. Also, freshwater flow from the Susquehanna River can considerably modify the tidal behavior in the upper reach of the Chesapeake Bay.

Tidal currents in the Chesapeake Bay follow a distribution similar to that of mean tidal ranges. The spring tidal current, as predicted by NOAA at the entrance of the Chesapeake Bay, is about 1.7 knots (3.1 km/hr). At the entrance of Baltimore Harbor, the current magnitude reduces to approximately 1.1 knots (2.0 km/hr), but increases in the Chesapeake and Delaware Canal near Chesapeake City to about 2.5 knots (4.6 km/hr) (NOAA, 2006a). The tides and tidal currents in the Chesapeake Bay can be significantly affected by local meteorological conditions, including wind storms and barometric pressure changes.

The maximum tidal flow into the Chesapeake Bay during spring tides can be estimated from the tidal prism, which is the volume of ocean water entering or exiting the Chesapeake Bay over the flood or ebb tide (one-half tide period) (USACE, 2006c). Using a maximum spring tidal current of 1.7 knots (3.1 km/hr), the average tidal flow rate during spring tide (over one-half tide period) at the Chesapeake Bay entrance is estimated to be about 3,900,000 cfs (110,436 cms) as shown in Table 2.3.1-14. Interaction of freshwater flow from the rivers with tidal inflow produces a two-layered flow system with the net surface water flow over a tidal period directed towards the ocean and the net bottom water moving up the Chesapeake Bay. Records of field data collected at various locations in the Chesapeake Bay between 1976 and 1983 showed that the magnitude of near-surface and near-bottom residual currents, the net currents averaged over one tidal period, range within 0.1-0.2 knots (5-10 cm/s) with nearly the same magnitudes for surface and bottom layers (Johnson, 1993). In the vicinity of the CCNPP site, the length of tidal excursion, which is the range of water particle movement over a tidal cycle, is estimated to be approximately 1.75 mi (2.82 km).

2.3.1.1.2.3 Water Temperature and Salinity Distribution

The Chesapeake Bay Program (CBP) records water temperature and salinity distributions once and twice every month during winter and summer months, respectively, at several locations in the Chesapeake Bay. The stations in the upper Chesapeake Bay located near the CCNPP site are CB4.2C and CB5.2. Station CB4.2C is located in the middle of the bay across from the mouth of the Choptank River, while CB5.2 is located just upstream of the mouth of the Potomac River, as shown in Figure 2.3.1-1 (CBP, 2007a). The CCNPP site is located nearly halfway between the two stations. Water temperature and salinity data have been recorded at these stations since 1984 and are available for the 1984-2006 period (CBP, 2007b).

Recorded data from the stations show a strong seasonal dependence on vertical temperature distribution. Water surface temperatures vary within a range from approximately 32°F to 85.5°F (0°C to 29.7°C). Water temperatures near the bottom vary within a range from approximately 32.5°F to 81.3°F (0.3°C to 27.4°C). Vertical water temperature distributions for the two stations during 2004 are shown in Figure 2.3.1-12 and Figure 2.3.1-13 (CBP, 2007b). The figures show that the typical thermocline at these stations is located at water depths ranging from 5 to 15 ft (1.5 to 4.6 m) from the surface. The surface temperatures respond more quickly to seasonal air temperature change than the bottom temperatures. As a result, the bottom temperatures lag the surface temperatures over the seasonal cycle of temperature change. At the end of the winter, the vertical temperature distribution is nearly uniform. Towards the end of the spring and early summer, the surface quickly heats up, causing a sharp drop in temperature over the thermocline. By the end of the summer and early fall, the surface temperature begins to fall and it attains a nearly uniform vertical distribution. By the end of the fall (late November) and early winter, the surface has cooled rapidly with the temperature lower than the bottom. The temperature cycle then continues at the end of the winter.

The variation of mean monthly water surface temperatures at CB5.2 is shown in Figure 2.3.1-14 along with the range of monthly minimum and maximum values (CBP, 2007a). The figure indicates that the mean monthly water surface temperature varies between approximately 36.5°F (2.5°C) in February and 80.6°F (27°C) in June.

The NOAA Chesapeake Bay Office produces three-dimensional temperature and salinity maps for the entire Chesapeake Bay based on interpolation of measured data from the Chesapeake Bay and its tributaries (NOAA, 2007b). Maximum monthly water temperature distributions for February, May, and August in 2004 are shown in Figures 2.3.1-15 through 2.3.1-17. As Figure 2.3.1-12 and Figure 2.3.1-13 illustrate, the selected months represent the minimum monthly temperature condition, condition with the maximum temperature gradient across the thermocline, and a well mixed condition for the Chesapeake Bay.

Salinity concentrations in the Chesapeake Bay and its tributaries range from less than 0.5 parts per thousand (ppt) in non-tidal and tidal fresh water areas to about 30 ppt at the mouth of the Chesapeake Bay. Salinities are higher on the eastern side of the Chesapeake Bay than on the western side, due in part to the Coriolis effect of the earth's rotation and in part because more freshwater is discharged from rivers along the western shore of the Chesapeake Bay (CBP, 2004). Salinities are highest after dry weather periods and lowest after wet weather or snowmelt periods. Thus, salinities are usually lowest in April and May, after the spring rains, and increase in August and September after the drier summer months.

Vertical salinity distributions at the CBP stations CB4.2C and CB5.2 show that the typical halocline is located between 5 ft (1.5 m) and 15 ft (4.6 m) of water depth, which is similar to that for the thermocline. The surface salinity at the two stations over the period of record (1984-2006) varied between approximately 2.0 ppt and 21.8 ppt, while the salinity in the lower layer varied within a range of approximately 11.3 to 25.8 ppt (CBP, 2007b). Vertical salinity distributions at the two stations for 2004 are shown in Figure 2.3.1-18 and Figure 2.3.1-19. Although the salinity distribution shows a seasonal variation, the average salinity gradient across the halocline remains nearly unchanged throughout the year, unlike the water temperature. The maximum surface salinity recorded over the data period is considerably higher than the maximum surface salinity observed in 2004. This could be due to the fact that during 2004 the annual freshwater inflow to the bay was much higher than the freshwater inflow for an average year, as shown in Figure 2.3.1-9. The variation of mean monthly surface salinity along with the range of monthly minimum and maximum salinities at CBP station CB5.2 are shown in Figure 2.3.1-20 (CBP, 2007a). The mean monthly surface salinity at this location varies between approximately 11.6 ppt and 17.0 ppt.

Maps of the three-dimensional salinity field for the Chesapeake Bay and its tributaries for the months of February, May and August 2004 are shown in Figures 2.3.1-21 through 2.3.1-23 (NOAA, 2007b). Higher salinities along the eastern shore of the Chesapeake Bay can be observed in the figures.

2.3.1.1.2.4 Sediment Transport and Shoreline Erosion Characteristics

The major sources of sediment to the Chesapeake Bay estuary are from external and internal sources. The three major external sediment sources include a) the above-Fall Line watersheds, b) below-Fall Line watersheds, and c) oceanic inputs. The two main internal sources are a) tidal erosion and b) biogenic productivity (USGS, 2003b). It is estimated that 57% of the total sediment load into the Chesapeake Bay is from tidal erosion, which is the combination of both fastland erosion (shoreline erosion) and near-shore erosion (erosion at the shallow water areas close to the shoreline) (NOAA, 2007b). Approximately 35% of the total sediment load is the contribution from the watersheds above and below the Fall Line, and the remaining 8% of the estimated sediment load into the bay is from oceanic input. Sediment sources due to biogenic productivity are not included in this distribution. It has been assessed (USGS, 2003b) that nearly the entire volume of sediment supplied from the watersheds was fine grained silts and clays. Approximately 14% of the sediments from oceanic input and 67% of sediments from tidal erosion were also estimated to be fine grained silts and clays (USGS, 2003b). Combined annual suspended sediment loads and relation to annual flow for the Susquehanna, Potomac, and the James Rivers near the Fall Line are shown in Figure 2.3.1-24 for the 1985 to 2001 period (USGS, 2003b).

Both long-term and short-term processes are responsible for shore erosion of the Chesapeake Bay. The slow rise in sea level and wave action are the two primary long-term processes that cause the shoreline to recede. Over the past century, sea level rise in the estuary amounts to approximately 1.3 ft (0.4 m). It may rise by 2 to 3 ft (0.6 to 0.9 m) in the next 100 years, as suggested by some researchers (TSTF, 2005). Waves and surges due to occasional hurricane wind may considerably change coastal morphology. These short-term, high energy erosive waves often reach high, upland banks out of the range of normal tides and waves.

Near the middle reach of the Chesapeake Bay, sediment supply due to tidal erosion is much higher than the supply from the watersheds. In the Maryland Western Shore watershed, annual average fine grained sediment (silts and clays) loads from fluvial sources and from tidal erosion were estimated to be 0.2 and 0.4 million metric tons per year (USGS, 2003b), respectively. In a 433 mi (697 km) length of the shoreline in the Lower Maryland Western Shore watershed, where the CCNPP site is located, this erosion results in an annual average shoreline retreat of 0.47 ft (0.14 m) per year (TSTF, 2005). The local rate of shoreline change in the vicinity of CCNPP site, as estimated by the Maryland Department of Natural Resource (MDNR), is shown in Figure 2.3.1-25. The rate of shoreline erosion south of the existing barge jetty and near the CCNPP site has been estimated by MDNR to be between 2 and 4 ft (0.6 and 1.2 m) per year. North of the existing intake structure, MDNR has estimated the shoreline change to be between 2 ft (0.6 m) per year accretion and 4 ft (1.2 m) per year erosion. The shoreline near the CCNPP Units 1 and 2 intake structure is stabilized so that any shoreline retreat is precluded. Historic shoreline locations near the CCNPP site in 1848, 1942 and 1993 are shown in Figure 2.3.1-26 (MGS, 2001).

2.3.1.1.2.5 Chesapeake Bay Bathymetry

Near the CCNPP site, the Chesapeake Bay is approximately 6 mi (10 km) wide, and the bottom elevation of the Chesapeake Bay's deepest section is approximately -100 ft (-30 m) NGVD 29. The deepest portion of the Chesapeake Bay is located close to the eastern shore, opposite the CCNPP site. From the western shore to approximately 4 mi (6.4 km) across the Chesapeake Bay, the bottom elevation varies from about -15 ft to -50 ft (-5 to -15 m) NGVD 29. Near the CCNPP site, an intake channel that is perpendicular to the shoreline and is approximately 4,830 ft (1,472 m) long was dredged for CCNPP Units 1 and 2. The design bottom elevation of the dredged channel varied between -51 ft (-15.5 m) NVGD 29 near the intake to -40 ft (-12.2 m) NGVD 29 away from the intake structure. CCNPP Unit 3 will use the same intake channel for the UHS makeup water intake and the CWS makeup water intake. An approximate 123 ft (37 m) long and 100 ft (30 m) wide forebay with earth retaining side walls of appropriate design will be constructed to draw water from the intake channel to the new intake structures. The new UHS and CWS makeup water intakes will be located on the southeast bank of the existing intake. A recent bathymetric survey in front of the CCNPP Units 1 and 2 intake structure indicates that the bottom elevation of the intake channel near the structure has silted-in since the intake channel was dredged. The current bottom elevation of the intake channel near the intake structure is approximately -38 ft (-12 m) NGVD 29, as shown in Figure 2.3.1-27. The figure also shows that the bottom elevation within the intake channel remained nearly uniform over a length of about 2,000 ft (610 m).**}**

2.3.1.2 Groundwater Resources

This section contains a description of the hydrogeologic conditions present at, and in the vicinity of the **{**CCNPP**}** site. This section describes the regional and local groundwater resources that could be affected by the construction and operation of **{**CCNPP Unit 3**}**. The regional and site-specific data on the physical and hydrologic characteristics of these groundwater resources are summarized to provide the basic data for an evaluation of potential impacts on the aquifers of the area. The location of the site, including regional and local surface hydrologic features, is described in Section 2.3.1.1.

2.3.1.2.1 Hydrogeologic Setting

The location of the **{**CCNPP site in reference to the Mid-Atlantic States**}** is shown in Figure 2.3.1-28. The site is located in **{**Calvert County, MD, and lies within the Coastal Plain Physiographic Province, at a distance of about 50 mi (80 km) east of the Fall Line. The Coastal Plain Physiographic Province is a lowland that is bordered by the Atlantic Ocean to the east and the Fall Line to the west. The Fall Line is a demarcation, separating the eastern, unconsolidated coastal plain sediments from the consolidated rocks of the western physiographic provinces associated with the Appalachian Mountains. Although the Coastal Plain is generally a flat, seaward-sloping lowland, this province has areas of moderately steep local relief that reach elevations of several hundred feet (USGS, 1997b).

The CCNPP site is underlain by approximately 2500 ft (762 m) of Coastal Plain sedimentary strata of Cretaceous and Tertiary age that dips southeast. Underlying these sediments are crystalline and metamorphic rocks of Precambrian and Early Paleozoic age. The Cretaceous and Tertiary strata are comprised primarily of sedimentary deposits of silt, clay, sand, and gravel, which exhibit considerable lateral and vertical variations in lithology and texture. The stratum forms a wedge-shaped mass, which thickens and deepens to the southeast from the Fall Line towards the Atlantic Ocean. Water-bearing units within the Coastal Plain sediments consist of unconsolidated to semi-consolidated sand aquifers separated by clay confining units. The sediments that compose the aquifer system were deposited in non-marine, marginal marine, and marine environments during a series of marine transgressions and regressions during Cretaceous and Tertiary times (USGS, 1997b).

Parts of five physiographic provinces are present in Maryland as shown in Figure 2.3.1-29 and Figure 2.3.1-30). These include (from west to east):

- Appalachian Plateau Province
- Valley and Ridge Province
- Blue Ridge Province
- Piedmont Province
- Coastal Plain Physiographic Province

The provinces are illustrated in Figure 2.3.1-29 (USGS, 1997b), which also illustrates the aquifer systems associated with these provinces. Figure 2.3.1-30 (USGS, 1997b) is a cross-section view of these provinces. The Fall Line identifies a topographical contrast between the western physiographic provinces and the eastern Costal Plain Physiographic Province.

Groundwater occurrence is only significant to the site within the Coastal Plain Physiographic Province, specifically, the regional area of southern Maryland. However, a brief discussion of groundwater within the other provinces is included below to provide a more complete picture of Maryland's hydrogeologic regimes.**}**

2.3.1.2.1.1 **{**Appalachian Plateau Physiographic Province

The Appalachian Plateau Province extends over most of West Virginia, more than one-half of Pennsylvania, and small parts of westernmost Virginia and Maryland. The province lies approximately 150 mi (241 km) west of the CCNPP site. It is bounded on the east and southeast by the Valley and Ridge Province. The Appalachian Plateau Province is underlain by rocks that are continuous with those of the Valley and Ridge Province, but in the Appalachian Plateau Province the sedimentary rocks are nearly flat-lying, rather than being intensively folded and faulted (USGS, 1997b).

The Appalachian Plateau aquifers are contained in Paleozoic sedimentary rocks consisting mostly of shale, sandstone, conglomerate, and limestone. Coal beds are found in rocks of Pennsylvanian age. The water-yielding characteristics of these aquifers vary significantly due to local variations in lithology, fracture density, and thickness of the geologic units. Most of the productive aquifers lie within sandstones or conglomerates, but local limestone formations yield significant volumes of water (USGS, 1997b).

2.3.1.2.1.2 Valley and Ridge Physiographic Province

The northeast-southwest trending Valley and Ridge Physiographic Province lies southeast of the Appalachian Plateau Province and lies approximately 100 mi (161 km) west of the CCNPP site. This province is characterized by layered, sedimentary Paleozoic rocks that have been complexly faulted and folded. These rocks range in age from Cambrian to Pennsylvanian. Elongated mountain ridges are formed by well-cemented sandstones and conglomerates that are resistant to weathering. The less resistant limestone, dolomite, and shale are more easily eroded and form the intervening valleys between the ridges (USGS, 1997b). Additional information is described in Section 2.6.

The principal aquifers in the Valley and Ridge Province are carbonate rocks (limestone and dolomite) and sandstones that range in age from early to late Paleozoic. Most of the more productive aquifers are in carbonate rocks, primarily limestone, and most are in the valleys. However, the water-yielding character of the carbonate rocks depends upon the degree of fracturing and development of solution cavities in the rock. Sandstone formations can also yield large volumes of water where these rocks are well fractured. Generally, the carbonate aquifers predominate in early Paleozoic rocks, whereas the sandstone aquifers are more often found in late Paleozoic rocks (USGS, 1997b).

2.3.1.2.1.3 Blue Ridge Physiographic Province

The Blue Ridge Physiographic Province lies east of the Valley and Ridge Province. It forms a thin (generally 5 to 20 mi (8 to 32 km) wide) and continuous band of mountains trending from the northeast to southwest, from Pennsylvania to Georgia. The province boundary lies approximately 90 mi (145 km) northwest of the CCNPP Site. The rocks comprising the Blue Ridge Province are geologically similar to those of the bordering Piedmont Province. Therefore, from a hydrogeological standpoint, the two provinces are often described together. The principal differences between the two provinces are relief, altitude, and geographical position. The Blue Ridge mountain belt primarily contains crystalline, igneous, and high-grade metamorphic rocks consisting of coarse-grained gneisses and schists. Minor amounts of low-grade metamorphic rocks (i.e., as phyllites and slates) and Early Cambrian sedimentary rocks occur along its western margin (USGS, 1997b).

The primary features for the storage and transmission of groundwater in the Blue Ridge Province occur in surficial regolith and bedrock fractures. Although the porosity of the regolith varies, it is one to three orders of magnitude greater than the porosity of the crystalline bedrock. Accordingly, the regolith has the capacity to store a larger volume of water than the bedrock, which contains water only in its fractures. Because the size, number, and interconnection of bedrock fractures decreases with depth, most of the groundwater is stored in the regolith. Therefore, well yields are greatest in the thickest regolith areas (USGS, 1997b).

2.3.1.2.1.4 Piedmont Physiographic Province

The Piedmont Physiographic Province lies east of the Blue Ridge Province, and its eastern boundary lies approximately 50 mi (80 km) northwest of the CCNPP site. The Piedmont Province is bounded on the east by the Fall Line. The Fall Line is a zone of stream rapids that marks the position where streams flow from the Piedmont Province's consolidated rocks to the Coastal Plain's unconsolidated sediments as shown in Figure 2.3.1-29 and Figure 2.3.1-30. The Piedmont Province is an area of varied topography ranging from lowlands to peaks and ridges of moderate relief and elevation. The metamorphic and igneous rock types seen in the Blue Ridge Province are also present in the Piedmont Province. Sedimentary basins that formed within early Mesozoic crustal rift zones are also included in this province. These basins contain shale, sandstone, carbonates, and conglomerate interbedded locally with basalt lava flows and minor coal beds. In some places, these rocks are intruded by diabase dikes and sills (USGS, 1997b).

Aquifers in the Piedmont Province lie predominantly in the shallow, fractured igneous and metamorphic rocks that underlie both the Blue Ridge and Piedmont Provinces. In some topographically low areas of the Piedmont Province, aquifers exist within the carbonate rocks and sandstones associated with the Mesozoic rift basins (USGS, 1997b).

2.3.1.2.1.5 Coastal Plain Physiographic Province

The Coastal Plain Physiographic Province is located east of the Piedmont Province and extends to the Atlantic coastline. The CCNPP site lies on the western shore of Chesapeake Bay in Maryland within the Coastal Plain. Semi-consolidated to unconsolidated sediments from ages as old as Cretaceous form a northeast trending band that narrows to the northeast and parallels the coast as shown in Figure 2.3.1-29. These sediments overlie igneous and metamorphic basement rocks equivalent to those exposed in the Piedmont. The Coastal Plain sediments form a southeasterly, thickening wedge-shaped mass ranging in thickness from 0 ft (0 m) at the Fall Line to as much as 8,000 ft (2,438 m) along the Atlantic coastline of Maryland (USGS, 1997b).

The sediments in this province consist of layers of sand, silt, and clay with minor amounts of gravel and calcareous sediments. Aquifers are found primarily in the sand, gravel, and calcareous sediments. They can be traced over long distances, although some occur in lenses and some are localized. The aquifers are separated vertically by confining units primarily consisting of clay with lesser amounts of silt and sand. Depending on the thickness and sand content of the confining units, they can act locally as either aquitards or aquicludes by retarding vertical groundwater flow to varying degrees (USGS, 1997b).

In the Mid-Atlantic States, the aquifers within the Coastal Plain Physiographic Province are referred to as the Northern Atlantic Coastal Plain aquifer system (MGS, 2001). This aquifer system extends from New Jersey to the Carolinas. Water-bearing units within the Coastal Plain sediments consist of unconsolidated to semi-consolidated sand aquifers separated by clay confining units. Although water moves more readily through the aquifers than the intervening confining units, water can leak through the confining units and, therefore, the aquifer systems are considered to be hydraulically interconnected to some degree (USGS, 1997b).

The principal aquifers within the system (from shallow to deep) are as follows (USGS, 1997b):

- Surficial aquifer
- Chesapeake aquifer
- Castle Hayne-Aquia aquifer
- Severn-Magothy aquifer
- Potomac aquifer

Closer to the CCNPP Unit 3 site in southern Maryland, this nomenclature changes and is described in Section 2.3.1.2.2. The aquifer units dip east to southeast from the Fall Line towards the Atlantic Ocean. Outcrop areas are identified as areas where the up-dip portion of the aquifer unit reaches ground surface. The deeper aquifers outdrop further west and closer to the Fall Line. Similarly, the more shallow aquifers crop out toward the east.

The Fall Line is considered to be the western most boundary of the outcrop areas for the Coastal Plain aquifer system. In southern Maryland, recharge areas for the shallow aquifer systems (Surficial and Chesapeake aquifers) are localized while the recharge areas for the deeper aquifer systems (Caste Hayne-Aquia, Severn-Magothy, and Potomac aquifers) are the outcrop areas west and northwest in Charles, Prince George's, and Anne Arundel counties as shown in Figure 2.3.1-29.**}**

2.3.1.2.2 Regional Hydrogeologic Description

{Regionally, the CCNPP site is located in southern Maryland. It is underlain by approximately 2500 ft (762 m) of southeasterly dipping Coastal Plain sedimentary strata of Cretaceous and Tertiary ages. The Cretaceous and Tertiary strata are comprised primarily of sedimentary deposits of silt, clay, sand, and gravel which exhibit considerable lateral and vertical variations in lithology and texture. The stratum forms a wedge-shaped mass that thickens to the southeast from the Fall Line towards the Atlantic Ocean.

For southern Maryland, hydrogeologists have refined the aquifer nomenclature system described in Section 2.3.1.2.1.5 based on local hydrostratigraphic conditions. From shallow to deep, the local aquifer systems are as follows: Surficial aquifer, Piney Point-Nanjemoy aquifer, Aquia aquifer, Magothy aquifer, and the Potomac Group of aquifers (MGS, 1996) (MGS, 1997). The main difference between the nomenclatures is that in southern Maryland the Chesapeake aquifer is treated as a confining unit and that the Castle Hayne - Aquia aquifer system has been subdivided into the Piney Point - Nanjemoy and Aquia aquifers.

The refined nomenclature will be used to describe the regional hydrogeologic conditions in the vicinity of CCNPP site. The hydrostratigraphic column for the CCNPP site and surrounding area, identifying geologic units, confining units, and aquifers is shown in Figure 2.3.1-31 (MGS, 1997). A schematic cross-section of the southern Maryland hydrostratigraphic units is shown in Figure 2.3.1-32. Geologic and stratigraphic unit descriptions are provided in Section 2.6.

2.3.1.2.2.1 Surficial Aquifer

In Calvert County, the unconfined Surficial aquifer consists of two informal stratigraphic units, the Lowland Deposits and the Upland Deposits. The units comprising the Lowland Deposits are Holocene to Pleistocene in age. They consist of sands and clays deposited in fluvial and estuarine environments. The Upland Deposits are Pliocene in age and consist primarily of sands and gravels deposited in fluvial environments. In Calvert County and St. Mary's County, the Lowland Deposits outcrop along the Patuxent and Potomac Rivers and the Chesapeake Bay; however, these deposits appear to be absent in the immediate vicinity of the CCNPP site. The Upland Deposits are geographically more extensive in St. Mary's County than in Calvert County, but they are present at the CCNPP site and form the entirety of the Surficial aquifer at the site (MGS, 1996).

Recharge to the Surficial Aquifer is almost exclusively by infiltration from direct precipitation. Flow within the aquifer is localized with water moving from recharge areas (local land surface) along short flow paths to discharge areas (nearby streams or springs). Some of the water may percolate downwards to recharge underlying aquifers. The average annual precipitation in the region between 1951 and 1980 was estimated at 44 in (112 cm) with an average annual runoff estimated as 15 in (38 cm) or 34% (USGS, 1997b). The remaining 29 in (74 cm) of precipitation was available as recharge to the aquifer system, with the exception of that removed from the hydrologic cycle by direct evaporation and plant evapotranspiration.

Within the southern Maryland region, the Surficial aquifer (Upland Deposits) is not a reliable source of groundwater. This is due to its relative thinness, limited saturated thickness (particularly during prolonged drought) and topographic dissections, which causes local groundwater to discharge as small springs (USGS, 1997b). The Surficial aquifer is primarily tapped by irrigation wells and some old farm and domestic wells, but it is not widely used as a potable water supply because of its vulnerability to contamination and unreliability during droughts (MGS, 2005). Wells completed in this aquifer generally yield less than 50 gpm (189 lpm). The groundwater table is usually encountered within a depth of 50 ft (15 m) below ground surface (bgs).

2.3.1.2.2.2 Chesapeake Confining Unit

From youngest to oldest, the Miocene Chesapeake Group consists of the Saint Mary's, Choptank, and Calvert Formations. The Chesapeake Group is a significant aquifer east of the CCNPP site in the Delmarva Peninsula. However, beneath the western shore of Maryland, in the vicinity of the CCNPP site, the Chesapeake Group is described as a confining unit. With the exception of a relatively thin, sandy unit at its base (lower Calvert Formation), the silts and clays of the Chesapeake Group are hydrostratigraphically undifferentiated and define the Chesapeake Confining Unit. The overlying Surficial aquifer is separated from the underlying Piney Point-Nanjemoy aquifer by the Chesapeake Confining Unit (MGS, 1996), although thin and discontinuous sand units capable of producing small quantities of groundwater are present locally. These thin and discontinuous sand units beneath the western shore of Maryland may yield water but not of quantities sufficient for most uses. Within the region, localized sand units are recharged by direct precipitation and percolation through the Surficial aquifer, moving a few miles or less downgradient along the flow path, and discharging to the Chesapeake Bay, streams, or localized areas of pumping. The potentiometric surface of the localized sand aquifers in the Chesapeake Group is generally above mean sea level (USGS, 1997b).

In general, the Chesapeake Confining Unit thickens from northwest to southeast in Calvert County and ranges in thickness from approximately 115 to 300 ft (35 to 91 m). Boring logs from a production well at the CCNPP site indicate that the base of the Chesapeake Confining Unit is at an approximate elevation of –205 ft (-62 m) msl and its total thickness is approximately 250 ft (76 m) (MGS, 1996).

2.3.1.2.2.3 Piney Point-Nanjemoy Aqufier

The Piney Point - Nanjemoy aquifer is stratigraphically complex, consisting of several geologic units. From youngest to oldest, the aquifer includes: the basal sandy strata of the lower to middle Miocene Chesapeake Group (lower Calvert Formation): unnamed upper Oligocene beds: the middle Eocene Piney Point Formation: and the sandy, upper part of the lower Eocene Nanjemoy Formation. Recharge to this aquifer is interpreted to be from direct precipitation in northern Calvert County (lower Calvert Formation) and Anne Arundel County (Nanjemoy Formation) where these geologic units are exposed at the surface. Recharge also presumably occurs from leakage from overlying aquifers. Discharge of the Piney Point-Nanjemoy aquifer is primarily from subaqueous exposures of the aquifer that are presumed to occur along the Continental Shelf. However, the northern portion of the Chesapeake Bay is a discharge area where the aquifer system is eroded by ancestral Susquehanna River paleochannels. Additional discharge occurs at local pumping locations (MGS, 1996).

The basal beds of the Calvert Formation are hydraulically connected to the underlying Piney Point - Nanjemoy aquifer. This unit is generally 10 to 20 ft (3 to 6 m) thick and consists of green to gray, glauconitic fine to medium grained quartz sand. In places, this unit contains coarse shell fragments, phosphate nodules, and gravel (MGS, 1996). The underlying unnamed upper Oligocene beds are thin (less than 5 ft (1.5 m)) to locally absent and very difficult to map in the subsurface. Consequently, the basal Calvert Formation sands and the unnamed upper Oligocene beds are treated as a single subsurface mapping unit (MGS, 1997).

The middle Eocene Piney Point Formation underlies the unnamed upper Oligocene beds and consists of shelly, glauconitic, quartzose sands and carbonate cemented interbeds of sands up to 5 ft (1.5 m) in thickness. The Piney Point Formation thickens to the southeast and ranges from 0 ft (0 m) in central Calvert County to approximately 45 ft (14 m) thick in southern Calvert County at Solomons. Boring logs from a production well at the CCNPP site indicate that the base of the Piney Point Formation is at an approximate elevation of –225 ft (-69 m) msl and its total thickness is approximately 10 ft (3 m) (MGS, 1996).

The Piney Point Formation overlies lower Eocene beds of the Nanjemoy Formation. The Nanjemoy Formation coarsens upward overall from predominantly sandy silts and clays to dominantly clayey sands. This allows it to be subdivided into two hydrostratigraphic units. The sandy upper Nanjemoy Formation is hydraulically connected to the overlying Piney Point Formation and is assigned to the Piney Point-Nanjemoy aquifer. The more clayey sediments of the lower Nanjemoy Formation are placed in the Nanjemoy Confining Unit (MGS, 1996) (MGS, 1983). Boring logs from a production well at the CCNPP site indicate that the base of the coarser grained upper Nanjemoy Formation (bottom of the Piney Point - Nanjemoy aquifer) is at an approximate elevation of –315 ft (-96 m) msl and the total thickness of the Piney Point - Nanjemoy aquifer is approximately 115 ft (35 m) (MGS, 1996).

Results from six pumping tests conducted in the Piney Point - Nanjemoy aquifer in the late 1970s indicated transmissivity values ranging from 275 to 690 ft^2/day (26 to 64 m^2/day). Similar transmissivity values ranging from 125 to 740 ft^2/day (12 to 69 m^2/day) were estimated from well specific capacity data, derived from well completion reports (MGS, 1997). A storage coefficient of 3×10^{-4} was applied to this aquifer as part of a groundwater modeling effort by the State of Maryland (MGS, 1997).

Although a few major users in southern Calvert County and St. Mary's County pump from the Piney Point - Nanjemoy aquifer, it is primarily used for domestic water supply. Domestic well yields are generally less than 20 gpm (76 lpm) with maximum reported well yields of up to 200 gpm (757 lpm) in the Piney Point Formation and up to 60 gpm (227 lpm) in the Nanjemoy formation (MGS, 1996).

2.3.1.2.2.4 Nanjemoy Confining Unit

The Nanjemoy Confining Unit underlies the Piney Point - Nanjemoy aquifer and consists of the lower part of the early Eocene Nanjemoy Formation and the underlying late Paleocene Marlboro Clay. The lower Nanjemoy Formation consists of greenish-gray, glauconitic sandy clay. The underlying Marlboro Clay occurs at the base of the Nanjemoy Confining Unit and consists of a gray to pale red, plastic clay interbedded with reddish silt. Boring logs from a production well at the CCNPP site indicate that the base of the lower Nanjemoy is at an approximate elevation of -415 ft (-126 m) msl and attains a thickness of approximately 90 ft (27 m). These boring logs indicate that the base of the Marlboro Clay is at an approximate elevation of -440 ft (-134 m) msl and is approximately 25 ft (8 m) thick in the vicinity of the CCNPP site (MGS, 1997).

The Marlboro Clay is described as much “tighter” than the muddy sands of the Nanjemoy Formation. Vertical hydraulic conductivities from laboratory tests performed on Nanjemoy samples in Queen Anne’s county range from 6.6 x 10^{-3} ft/day to 6.8 x10^{-2} ft/day (2.0 x 10^{-3} m/day to 2.1 x10^{-2} m/day). Similar tests on Marlboro clay samples generated lower results ranging from 9.5 x 10^{-5} ft/day to 4.5 x 10^{-4} ft/day (2.9 x 10^{-5} m/day to 1.4 x 10^{-4} m/day). Specific storage values assigned to the Nanjemoy Confining Unit in several groundwater models range from 1.0 x 10^{-5} ft^{-1} to 7.6 x 10^{-5} ft^{-1} (3.3 x 10^{-5} m^{-1} to 2.5 x 10^{-4} m^{-1}) Laboratory results of specific storage tests on the Marlboro Clay range from 1.0 x 10^{-5} ft^{-1} to 1.1 x 10^{-4} ft^{-1} (3.3 x 10^{-5} m^{-1} to 3.6 x 10^{-4} m^{-1}) (MGS, 1997).

2.3.1.2.2.5 Aquia Aquifer

In southern Maryland, the Aquia aquifer correlates with the late Paleocene Aquia Formation. The Aquia Formation is poorly to well sorted, shelly and glauconitic quartz sand with carbonate cemented sandstones and shell beds. The Aquia Formation (aquifer) dips to the southeast with its upper surface ranging in elevation from approximately -100 ft (-30 m) msl in northern Calvert County to approximately -500 ft (-152 m) msl just off Solomon in southern Calvert County. The aquifer’s thickness varies considerably in Calvert County. It reaches a maximum thickness of approximately 200 ft (61 m) in east-central and northeastern Calvert County and thins to the northwest and southeast where it reaches a thickness of approximately 145 ft (44 m) at Solomons and 160 ft (49 m) at the boundary between Anne Arundel County and Calvert County. The Aquia aquifer thins progressively to the southeast where it grades into predominantly fine-grained sediments and hydraulically becomes a confining unit in southernmost St. Mary’s County where it is no longer used for water supply. Boring logs from a production well at the CCNPP site indicate that the base of the Aquia aquifer is at elevation –560 ft (-171 m) msl and its total thickness is approximately 145 ft (44 m) (MGS, 1996).

Aquia aquifer transmissivity maps derived from pumping tests display a general correlation to Aquia aquifer thickness maps with highest transmissivity values in areas of greatest aquifer thickness. Reported transmissivities in northern Calvert County at Randle Cliff Beach are 1330 ft^2/day (124 m^2/day) where the Aquia reaches its maximum thickness of approximately 200 ft (61 m). Farther south, at Solomons, reported transmissivities are 755 ft^2/day (70 m^2/day) where the aquifer thins to approximately 145 ft (44 m). A transmissivity of 935 ft^2/day (87 m^2/day) is reported at the CCNPP site (MGS, 1997). Storage coefficient values of the Aquia aquifer determined from pumping tests in southern Maryland range from 4 x 10^{-4} to 1 x 10^{-4} MGS, 1997).

The Aquia formation is a productive aquifer with reported yield of up to 300 gpm (1136 lpm). Recharge to the Aquia aquifer is from direct precipitation in central Anne Arundel and Prince George’s counties where these units outcrop at the surface. Natural discharge of the Aquia aquifer is to the southeast, primarily from subaqueous exposures of the aquifer that are presumed to occur along the Continental Shelf. Other discharge occurs at local pumping locations.

The Aquia aquifer is used extensively for domestic and major-user water supplies in southern Maryland. By the 1980s, a deep cone of depression (up to 100 ft (30 m)) had developed in the Solomons area of Calvert County and St. Mary’s County where it is heavily pumped for public, commercial, and military supplies as shown in Figure 2.3.1-33 (USGS, 2005a). This has diverted the groundwater flow direction in Calvert County to the south and southeast toward these pumping centers. Because of these considerations, water supply managers in these counties are seeking to shift some groundwater usage from the Aquia aquifer to the deeper Patapsco aquifers (MGS, 2005).

2.3.1.2.2.6 Brightseat Confining Unit

The confining unit underlying the Aquia aquifer is composed of several geologic units. These include the lower Paleocene Brightseat Formation and several upper Cretaceous units including the Monmouth, Matawan, and Magothy Formations. The fine-grained sediments of these formations combine to form the hydraulically indistinguishable Brightseat Confining Unit. The Brightseat Confining Unit has a composite thickness ranging from approximately 20 to 105 ft (6 to 32 m). Boring logs from a production well at the CCNPP site indicate that the base of the Brightseat Confining Unit is at an approximate elevation of -590 ft (-180 m) msl and attains a thickness of approximately 30 ft (9 m) (MGS, 1996).

Most researchers model the Brightseat Confining Unit as a no-flow boundary; however, a few vertical hydraulic conductivity and specific storage values have been reported. Samples from Prince George's County yielded vertical hydraulic conductivity and specific storage values of 9.5 x 10^{-4} ft/day (2.9 x 10^{-4} m/day) and 7.4 x 10^{-5} ft^{-1} (2.4 x 10^{-4} m^{-1}) respectively. Vertical hydraulic conductivities for the Matawan Formation in the Annapolis area range from 5.7 x 10^{-5} ft/day to 3.1 x 10^{-4} ft/day (1.7 x 10^{-5} m/day to 9.4 x 10^{-5} m/day (MGS, 1997).

2.3.1.2.2.7 Magothy Aquifier

In central Calvert County, the Magothy aquifer is contained in the Upper Cretaceous Magothy Formation. This unit consists of interbedded red, brown, and gray sands and clays. The Magothy aquifer is present in the northern and central portions of Calvert County. It thins to the south and pinches out in southern Calvert County where it is not a significant aquifer. The southern extent of the aquifer is estimated to lie somewhere between the CCNPP site and Solomons. Boring logs from a production well at the CCNPP site indicate that the base of the Magothy aquifer is at an approximate elevation of -610 ft (-186 m) msl and appears to attain a thickness of less than 25 ft (8 m) (MGS, 1996).

Transmissivities of 450 to 4,570 ft^2/day (42 to 425 m^2/day) have been reported for the Magothy aquifer in southern Anne Arundel County (MGS, 2002). Reported transmissivity values for southern Maryland range from 1,000 to 12,000 ft^2/day (93 to 1,115 m^2/day) with primary use occurring in Anne Arundel County, Prince George's County, and Charles County (MDE, 2004).

Recharge to the Magothy aquifer is from direct precipitation in northern Anne Arundel County where the Magothy Formation outcrops at the surface. In central Calvert County, flow is east-southeast, towards the Atlantic Coast. Other discharge occurs at local pumping locations (MGS, 1997) (USGS, 2005b).

A 2003 southern Maryland potentiometric surface map of the Magothy aquifer is presented in Figure 2.3.1-34 (USGS, 2005b) to establish the elevation and horizontal direction of groundwater flow.

2.3.1.2.2.8 Potomac Group

The lower Cretaceous Potomac Group consists of, in descending order, the Patapsco, Arundel, and Patuxent Formations. These units form a thick (greater than 1,500 ft (457 m)) series of unconsolidated sediments which locally contain three confining units and three aquifers. Because of the significant depth of these formations and the abundance of exploitable groundwater supplies in shallower aquifers, these units are not currently used as a significant source of groundwater in the vicinity of the CCNPP site. Consequently, available hydrogeologic information for the Potomac Group of aquifers and confining units is limited.

The Upper Patapsco aquifer underlies the Magothy aquifer. It is separated from the Magothy aquifer by clayey units in the top of the Patapsco Formation and bottom of the Magothy

Formation. Those clayey units are referred to as the Upper Patapsco confining unit. The Upper Patapsco aquifer includes sand units in the upper part of the Patapsco Formation. This aquifer is not continuous and is comprised of complexly stratified, sandy units separated locally by silts and clays. Individual sand units in the Upper Patapsco aquifer are difficult to correlate laterally, but they appear to be sufficiently interconnected at the regional scale to form a single aquifer (MGS, 2005). The aquifer extends to the northeast through Prince George's County and Anne Arundel County, and beneath Chesapeake Bay to the eastern shore of Maryland. The aquifer is recharged by direct precipitation at outcrops in western and northern Charles County, Prince George's County, and Anne Arundel County. It subcrops beneath the tidal part of the Potomac River where water intrusion has been documented in the Indian Head area near the Potomac River in Maryland (USGS, 1997a).

The Upper Patapsco aquifer is extensively used for public supply in central Charles County, where a cone of depression has formed at an approximate elevation of -136 ft (-41 m) msl. It is also pumped heavily by major users in Prince George's County and Anne Arundel County (MDE, 2004). A few major users pump the Upper Patapsco aquifer in northern St. Mary's County and Calvert County (MGS, 2005). Pumping tests performed in the Upper Patapsco aquifer in east-central Charles County yielded a transmissivity of 1110 ft^2/day (103 m^2/day) (MGS, 2007). Upper Patapsco transmissivities reported for southern Maryland range from 1,000 to 10,000 ft^2/day (93 to 929 m^2/day). Groundwater from this aquifer is primarily used in Charles County and Anne Arundel County.

The Lower Patapsco aquifer underlies the Upper Patapsco aquifer. The two aquifers are separated by clayey units that form the Middle Patapsco confining unit in the middle part of the Patapsco Formation. The Lower Patapsco aquifer comprises sandy units in the lower part of the Patapsco Formation. The aquifer extends northeast to northern Anne Arundel County, but its correlation to the west and southwest is uncertain. It extends across the Chesapeake Bay to the eastern shore of Maryland. The Lower Patapsco aquifer is pumped heavily by users in central and northwestern Charles County, but it is not currently used in St Mary's County or Calvert County (MGS, 2005). Pumping tests performed in the Lower Patapsco aquifer in western Charles County yielded a transmissivity of 1,130 ft^2/day (105 m^2/day). Specific capacity values for the wells used in these pump tests ranged from 1.8 to 7.1 gpm/ft (196 to 772 lpm/m)(MDE,2004) (MGS, 2004). Lower Patapsco aquifer transmissivities reported for southern Maryland range from 1,000 to 5,000 ft^2/day (93 to 465 m^2/day) and the groundwater from this aquifer is primary used in Charles County and Anne Arundel Count.

The Patuxent aquifer lies below the Lower Patapsco aquifer. The two are separated at some locations by the Arundel confining unit. The Arundel Formation consists of a thick series of dense clays and silts and probably does not allow much leakage. However, further research is needed to properly identify the Arundel Formation. Section 2.6 provides addition information.

The Patuxent aquifer is the deepest Coastal Plain aquifer in Maryland, and rests on the Piedmont bedrock surface. Patuxent aquifer transmissivities reported for Charles and Anne Arundel counties range from 200 to 8,000 ft^2/day (19 to 743 m^2/day) (MDE, 2004). Pumping tests performed in the Patuxent aquifer in western Charles County yielded a transmissivity of 937 ft^2/day (87 m^2/day). The specific capacity for the single Patuxent aquifer well used in this pumping test was 2.6 gpm/ft (283 lpm/m) (MGS, 2004). Pumping tests performed on Patuxent aquifer municipal wells in Bowie, Maryland (northern Prince George's County) yielded an average transmissivity of 1,468 ft^2/day (136 m^2/day) (Bowie, 2007). Because of its great depth and the known presence of brackish water in places, its potential for development is thought to be limited (MDE, 2004).

A 2003 southern Maryland potentiometric surface map of the Upper and Lower Patapsco aquifers are presented in Figure 2.3.1-35 and Figure 2.3.1-36 (USGS, 2005c) (USGS, 2005d) to establish the elevation and horizontal direction of ground water flow.**}**

2.3.1.2.3 Local and Site-Specific Hydrogeologic Descriptions

{The Chesapeake Bay and Patuxent River define the eastern, southern, and western boundaries of Calvert County. The creeks and streams within the area influence the shallow aquifer systems beneath the site. Deeper aquifers are less influenced by incisions of streams and rivers. Natural flow directions in the deeper aquifers are southeasterly from the Fall Line towards the Atlantic Ocean. Localized areas of increasing groundwater withdrawals in southern Maryland have affected both local and regional groundwater movement. With the exception of the Surficial aquifer and the Chesapeake Group, recharge areas are west and northwest of the CCNPP site, towards the Fall Line, in Charles County, Prince George’s County, and Ann Arundel County.

The topography at the CCNPP site is gently rolling with steeper slopes along stream courses as shown in Figure 2.3.1-2. Local relief ranges from sea level up to approximately elevation 130 ft (40 m) msl with an average elevation of approximately 100 ft (30.5 m). The Chesapeake Bay shoreline consists mostly of steep cliffs with narrow beach areas. The CCNPP site is well drained by short, intermittent streams. A drainage divide, which is generally parallel to the coastline, extends across the CCNPP site. The area to the east of the divide drains into the Chesapeake Bay. The western area is drained by tributaries of Johns Creek and Goldstein Branch, which flow into St. Leonard Creek, located west of Maryland Highway 2/4, and subsequently into the Patuxent River. The Patuxent River empties into the Chesapeake Bay approximately 10 mi (16 km) southeast from the mouth of St. Leonard Creek.

The geotechnical and hydrogeological investigations provide information on the CCNPP site to depths of 400 ft (122 m) below ground surface. Subsurface information was collected from over 180 borings and cone penetrometer tests (CPTs). Forty groundwater observation wells were installed across the CCNPP site, completed in the Surficial aquifer and the water-bearing materials in the Chesapeake Group. The wells were located in order to provide adequate distribution with which to determine CCNPP site groundwater levels, subsurface flow directions, and hydraulic gradients beneath the CCNPP site. Well pairs were installed at selected locations to determine vertical gradients. Field hydraulic conductivity tests (slug tests) were conducted in each observation well. The hydrogeologic conditions interpreted from the information collected during the 2006 through 2007 subsurface CCNPP site field investigation are described in the following sections.

A detailed description of the geotechnical subsurface investigation, is provided in FSAR Section 2.5. The locations of the soil borings that are within the power block area are shown in Figure 2.3.1-37. Hydrogeologic cross sections for the strata penetrated by the soil borings in the vicinity of the CCNPP Unit 3 area are shown in Figure 2.3.1-38 and Figure 2.3.1-39.

2.3.1.2.3.1 Geohydrology

The elevations, thicknesses and geologic descriptions of the sediments comprising the shallow hydrogeologic units (depths to 400 ft (122 m) below ground surface) were determined from CCNPP Unit 3 geotechnical and hydrogeological borings. Geotechnical and geological descriptions of the material encountered are described in Section 2.6.

Surficial Aquifer

The elevations, thicknesses, and geologic descriptions of the sediments comprising the Surficial aquifer, as determined from the CCNPP Unit 3 geotechnical and hydrogeological borings, are summarized as follows.

- The unconsolidated sediments comprising the Surficial aquifer primarily consist of fine to medium grained sands and silty or clayey sands. At relatively few locations and intervals, coarse grained sands were observed to comprise the bulk of the interval sampled.
- The Surficial aquifer is present above elevation 65 to 70 ft (20 to 21 m) msl at the CCNPP site as shown in Figure 2.3.1-38 and Figure 2.3.1-39. The thickness of the Upland deposits containing the Surficial aquifer ranges from 0 ft (0 m), where local drainages have dissected the unit, to approximately 55 ft (17 m) at the site's higher elevations.

Chesapeake Confining Unit

The Chesapeake Confining Unit thickens from northwest to southeast in Calvert County and ranges in thickness from approximately 115 to 300 ft (35 to 91 m). Boring logs from a production well at the CCNPP site indicate that the base of the Chesapeake Confining Unit is at an elevation of approximately -205 ft (-62 m) msl and its total thickness is approximately 250 ft (76 m) (MGS, 1996). The CCNPP Unit 3 soil borings advanced to this depth confirm this observation.

The elevations, thicknesses, and geologic descriptions of the sediments comprising the Chesapeake Confining Unit as determined from the CCNPP Unit 3 geotechnical and hydrogeological borings are summarized as follows.

- The unconsolidated sediments comprising the Chesapeake Confining Unit consist primarily of silty clays, silt, and silty fine grained sands. Thin, interbedded, fine to medium grained fossiliferous sands are common.
- The base of the Chesapeake Confining Unit is observed at an elevation of approximately –205 ft (-62 m) msl in Boring B-301 and -215 ft (-66 m) msl in Boring B-401.
- The top of the Chesapeake Confining Unit ranges from an elevation of approximately 8 ft (2 m) msl in Boring B-701 at the Chesapeake Bay shore to approximately elevation 65 to 70 ft (20 to 21 m) msl in borings where the overlying Upland Deposits comprising the Surficial aquifer were encountered.
- The thickness of the Chesapeake Confining Unit, as observed in Borings B-301 and B-401, is approximately 280 ft (85 m) and 277 ft (84 m), respectively.
- Two thin, semi-continuous, water-bearing sand units were encountered in the upper portion of the Chesapeake Confining Unit. These units are informally referred to as the "Upper Chesapeake unit and the Lower Chesapeake unit."
- The base of the Upper Chesapeake unit ranges in elevation from approximately 8 ft (2 m) msl to -19 ft (-6 m) msl and has a mean thickness of approximately 21 ft (6 m) and reaches a maximum thickness of approximately 44 ft (13 m) at boring B-331. The minimum observed thickness of the Upper Chesapeake unit was 8 ft (2 m) at borings B-720 and B-721. The elevation of the top of the Upper Chesapeake unit occurs at an average elevation of approximately 20 ft (6 m) msl.
- The Lower Chesapeake unit is thicker than the Upper Chesapeake unit and contains a higher silt and clay content than the Upper Chesapeake unit. The base of the Lower Chesapeake unit ranges from elevation -38 ft (-12 m) msl to -92 ft (-28 m) msl and has a mean thickness of approximately 36 ft (11 m) and reaches a maximum thickness of

approximately 62 ft (19 m) at boring B-311. The minimum observed thickness of the Lower Chesapeake unit was 19 ft (6 m) at boring B-323.

- The Upper Chesapeake unit is separated from the overlying Surficial aquifer by the informally named, relatively thin, Upper Chesapeake aquitard. The Upper Chesapeake aquitard ranges in thickness from approximately 4 to 36 ft (1 to 11 m) and averages approximately 20 ft (6 m). The lower Chesapeake unit is separated from the underlying Piney Point - Nanjemoy aquifer by the informally named and relatively thick Lower Chesapeake aquitard. Two of the CCNPP Unit 3 soil borings penetrated the Lower Chesapeake aquitard which is approximately 190 ft (58 m) thick.

Piney Point-Nanjemoy Aquifer

The basal beds of the Calvert Formation are readily identified in the two CCNPP site borings (B-301 and B-401) that penetrate this unit. The top of the basal Calvert Formation sands is observed at an approximate elevation of –207 ft (-63 m) msl in Boring B-301 and elevation -215 ft (-66 m) msl in Boring B-401. The base of the Piney Point Formation was encountered at approximately elevation -230 ft (-70 m) msl and -234 ft (-71 m) msl, respectively. Borings B-301 and B-401 did extend into the Nanjemoy Formation but did not penetrate through the Nanjemoy Confining Unit.

2.3.1.2.3.2 Observation Well Data and Subsurface Pathways

Data collected from groundwater observation wells installed for the CCNPP site subsurface investigation were used to develop groundwater elevation contour maps and to present groundwater elevation trends. A total of 40 new observation wells with depths extending to 122 ft (37 m) below ground surface were installed from May to July 2006. Observation wells were installed in three distinct groundwater bearing intervals: the Surficial aquifer (17 wells), a deeper sand unit at the top of the Chesapeake Formation informally referred to as the Upper Chesapeake unit in this report (20 wells), and an even deeper sand unit in the Chesapeake Formation informally called the Lower Chesapeake unit in this report (3 wells). No wells were installed in the deeper Piney Point - Nanjemoy aquifer.

The base of the well screens in the Surficial aquifer wells were placed at elevations ranging from approximately 81.6 ft (24.9 m) msl to 63.7 ft (19.4 m) msl. Elevations for the base of well screens in the Upper Chesapeake unit range from approximately 27.1 ft (8.3 m) msl to -2.3 ft (-0.7 m) msl, while the corresponding elevations for the Lower Chesapeake unit wells range from approximately -32.4 ft (-9.9 m) msl to -54.3 ft (-16.6 m) msl as shown in Table 2.3.1-15.

Three well series designations are assigned to the CCNPP Unit 3 observation wells.

- OW-300 Series wells are located in the proposed CCNPP Unit 3 power block area.
- OW-400 Series wells are located adjacent to the Unit 3 power block, generally to the southeast.
- The OW-700 Series wells include all of the wells located outside of the power block areas. The OW-700 Series wells are located in the proposed cooling tower, switchyard, and support facility areas.

Three wells screened in the Surficial aquifer water levels (OW-413A, OW-729, and OW-770) are at or below the bottom of the well screens and exhibit minimal water level fluctuations and, therefore, are not included in the analysis. The data are not considered true indicators of aquifer conditions. Additionally, observation well OW-744 appears to have been screened in a discontinuous sand unit between the water bearing sand units of the Surficial aquifer and the

Upper Chesapeake unit and could not be grouped into one of the water-bearing units described above. Accordingly, the groundwater elevation trends, flow directions, and rates presented below do not consider data from this well. Observation well locations are shown in Figure 2.3.1-40.

To evaluate vertical hydraulic gradients, several observation wells were installed as well clusters. Well clusters are a series of wells placed at the same location, with each well monitoring a distinct water bearing interval. Four well clusters were installed to evaluate the hydraulic gradient between the Surficial aquifer and the Upper Chesapeake unit, and three well clusters were installed to evaluate the gradient between the Upper Chesapeake and Lower Chesapeake units. Table 2.3.1-15 provides well construction details for the observation wells installed onsite. Table 2.3.1-16 provides the groundwater elevation from these wells over time, listed in numerical order, while Table 2.3.1-17 presents a summary of the observation wells data, segregated by aquifer, and used in the following evaluations.

Monthly water levels in the observation wells were measured to characterize seasonal trends in groundwater levels and flow directions for the CCNPP Unit 3 site. A 9-month data set representing July 2006 through March 2007 is utilized for this evaluation. The following groundwater potentiometric surface trend discussion is based on this information.

A detailed description of the geotechnical subsurface site investigation is described in FSAR Section 2.5.

Surficial Aquifer

Recent groundwater data for the Surficial aquifer are shown in Figure 2.3.1-41. These data exhibit little variability in groundwater elevations during the observation period (July 2006 to March 2007). A slight seasonal influence during this monitoring period is indicated by groundwater elevation lows in late summer (August and September) followed by gradually increasing levels for the remainder of the observation period. In general, groundwater elevation fluctuations averaged approximately 1.3 ft (0.4 m), and the maximum observed fluctuation of 3.6 ft (1.1 m) was observed in OW-765A.

The groundwater elevation data summarized in Table 2.3.1-17 were used to develop groundwater surface elevation contour maps for the Surficial aquifer on a quarterly basis. These maps are presented in Figures 2.3.1.2-42 through 2.3.1-45 for July 2006, September 2006, December 2006, and March 2007. For each quarter, the spatial trend of the water table surface and horizontal gradients are similar, with elevations ranging from a high of approximately 84.8 ft (25.8 m) msl at well OW-423 to a low of approximately 68.1 ft (20.8 m) msl at well OW-743.

The groundwater surface contour maps indicate that horizontal groundwater flow in the Surficial aquifer is generally bi-modal. A northwest trending groundwater divide roughly following a line extending through the southwestern boundary of the CCNPP Unit 3 power block area is present at the CCNPP site. Northeast of this divide, horizontal groundwater flow is northeast toward the Chesapeake Bay. Because the Surficial aquifer is not present below elevation 65 to 70 ft (20 to 21 m) msl, groundwater flowing in the northeastern direction likely discharges to small seeps and springs before reaching the Chesapeake Bay or CCNPP site streams. Groundwater southwest of this divide flows to the southwest. Groundwater flowing between the divide and the hydraulic boundary created by John’s Creek and Branch 3 presumably discharges from seeps and springs above the 65 ft to 70 ft (20 to 21 m) msl elevation level along these stream valleys.

In general, the horizontal hydraulic gradient for the Surficial aquifer decreases from north to south across the CCNPP site. In the northern portion of the CCNPP site, the hydraulic gradients associated with the southwesterly and northeasterly flow components are similar with values ranging from 0.0147 ft/ft and 0.0138 ft/ft, respectively. In the southern portion of the CCNPP site, where a northeasterly flow predominates, the hydraulic gradient is lower (approximately 0.0086 ft/ft). In the northwest portion of the CCNPP site, where a small portion of the site's groundwater flow emanating from the groundwater divide is to the north and west, the hydraulic gradient is approximately 0.0150 ft/ft.

Groundwater elevations collected from the five well clusters that monitor head differences between the Surficial aquifer and the Upper Chesapeake unit indicated a downward vertical gradient between the Surficial aquifer and the Upper Chesapeake unit. Water table elevations in the Surficial aquifer range from approximately 34.5 to 42.0 ft (10.5 to 12.8 m) higher than the potentiometric surface of the Upper Chesapeake unit, as detailed in Table 2.3.1-17. This indicates that a less-permeable material separates the two water-bearing units.

<u>Upper Chesapeake Unit</u>

Groundwater elevation data for the Upper Chesapeake unit in 2006 and 2007 are shown in Figure 2.3.1-46. The data exhibit slightly more variability in groundwater elevations during the observation period (July 2006 to March 2007) than those for the Surficial aquifer. Seasonal trends for the Upper Chesapeake are very similar to those in the Surficial aquifer; however, they are slightly more pronounced. A slight seasonal influence during the monitoring period is indicated by groundwater elevation lows in August 2006 followed by gradually increasing levels through March 2007. On average, groundwater elevations fluctuated approximately 3.6 ft (1.1 m), and the maximum observed fluctuation of 8.3 ft (2.5 m) was observed in OW-708A.

The groundwater potentiometric data summarized in Table 2.3.1-17 were used to develop groundwater surface elevation contour maps for the Upper Chesapeake unit on a quarterly basis. These maps are presented in Figures 2.3.1-47 through 2.3.1-50 for July 2006, September 2006, December 2006, and March 2007. For each quarter, the spatial trends of the potentiometric surface and the horizontal hydraulic gradient are similar, with elevations ranging from a high of approximately. 41.7 ft (12.7 m) msl in observation well OW-401 to a low of approximately 17.6 ft (5.4 m) msl at well OW-703A.

The groundwater surface contour maps indicate that horizontal groundwater flow in the Upper Chesapeake unit ranges from north to east across most of the site. Groundwater flowing in this direction likely discharges to the lower reaches of Branch 1 and Branch 2 and to seeps and springs in topographically low areas where the Upper Chesapeake unit is presumably exposed at the surface (below an elevation of approximately 20 ft (6 m) msl), including at the face of the Calvert Cliffs. It is also possible that a component of the Upper Chesapeake unit flow discharges directly to the Chesapeake Bay. The south central portion of the CCNPP site exhibits a very flat horizontal hydraulic gradient over a large area centered over an area just south of the CCNPP Unit 3 power block area. It is possible that a groundwater hydraulic divide exists along the southwestern boundary of the CCNPP Unit 3 power block area, resulting in a flow direction beneath the western switchyard area towards St. John's Creek and Branch 3. A potential exists for localized Upper Chesapeake unit recharge associated with seepage from the small pond southeast of the CCNPP Unit 3 power block area at Camp Canoy (Figures 2.3.1-47 to 2.3.1-50). In this area, the base of the pond is approximately 20 ft (6 m) above the water bearing sands of the Upper Chesapeake unit.

In general, three different horizontal hydraulic gradients can be observed from the potentiometric surface data:

- The highest gradients, at approximately 0.0170 ft/ft are observed to the north and east of the CCNPP Unit 3 power block area.
- The horizontal hydraulic gradient southeast of the CCNPP Unit 3 power block area is slightly lower at approximately 0.0091 ft/ft.
- The lowest horizontal hydraulic gradient observed at the CCNPP site was in the southwestern corner of the site where the gradient approaches zero.

Lower Chesapeake Unit

Groundwater data for the Lower Chesapeake unit are shown in Figure 2.3.1-51. The data exhibit similar groundwater elevation trends to those observed in the Surficial aquifer and exhibit little variability in groundwater elevations during the observation period (July 2006 to March 2007). A slight seasonal influence during this monitoring period is indicated by groundwater elevation lows in late summer (August and September) followed by gradually increasing levels for the remainder of the observation period. In general, groundwater elevations fluctuated approximately 3.4 ft (1.0 m), and the maximum observed fluctuation of 5.2 ft (1.6 m) was observed in OW-703B.

The groundwater elevation data summarized in Table 2.3.1-17 were used to develop groundwater surface elevation contour maps for the Lower Chesapeake unit on a quarterly basis. These maps are presented in Figures 2.3.1-52 through 2.3.1-55 for July 2006, September 2006, December 2006, and March 2007. It should be noted that only three observation wells penetrate the Lower Chesapeake unit, and the monitoring area is limited to the area within and immediately north of the CCNPP Unit 3 power block area. For each quarter, the spatial trend in the potentiometric surface shows very little change, with elevations ranging from a high of approximately 35.0 ft (10.7 m) msl in the vicinity of well OW-418B to a low of approximately 17.6 ft (5.4 m) msl at well OW-703B.

The potentiometric surface contour maps suggest that horizontal groundwater flow in the Lower Chesapeake aquifer is to the north-northeast across the coverage area. Groundwater flowing in this direction likely discharges directly to the Chesapeake Bay since the silty sand unit containing the Lower Chesapeake unit is below sea level. Very little change in horizontal hydraulic gradient was observed during the monitoring period with values averaging approximately 0.0140 ft/ft.

Groundwater elevations collected from the three well clusters that monitored head differences between the Upper Chesapeake unit and the Lower Chesapeake unit indicated a slight downward vertical gradient. Potentiometric surface elevations in the Upper Chesapeake unit range approximately 3 to 5 ft (0.9 to 1.5 m) higher than the ranges in the Lower Chesapeake unit at well cluster locations OW-313 and OW-418. Potentiometric surface elevations are basically identical at the well cluster closest to the Chesapeake Bay, location OW-703.

2.3.1.2.3.3 Hydrogeologic Properties

The 40 groundwater observation wells installed in connection with CCNPP Unit 3 site subsurface evaluation were slug tested to determine in-situ hydraulic conductivity values for the Surficial aquifer and Upper and Lower Chesapeake units. Table 2.3.1-18 summarizes the test results.

Ten of the 17 Surficial aquifer wells tested were used to calculate hydraulic conductivity values. Three wells screened in the Surficial aquifer had measurable water but at or below the bottom of the well screen (OW-413A, OW-729, and OW-770); therefore, the slug test results from these wells are not included in this analysis. The slug test data from three additional Surficial aquifer wells (OW-714, OW-718, and OW-766) were not used in this evaluation because the static water levels were below the top of the solid slugs inserted into the well to displace the water level. Additionally, observation well OW-744 appears to have been screened in a discontinuous sand unit between the water bearing sand units of the Surficial aquifer and the Upper Chesapeake unit. Because the following slug test analyses are categorized by the three distinct water bearing units encountered onsite, the hydraulic conductivity evaluations presented below do not consider slug test data from this well. Slug test data from all the Upper and Lower Chesapeake unit wells were used in the hydraulic conductivity evaluations.

Soil samples collected from the Surficial aquifer, Upper Chesapeake and Lower Chesapeake units during the geotechnical investigation were submitted for laboratory tests to determine moisture unit weight, moisture content, and specific gravity. Testing results are included in Table 2.3.1-19. The results of these laboratory analyses were used to calculate mean void ratio and porosity values for the three water bearing units cited above. The following discussions on hydrogeological properties are derived from the CCNPP Unit 3 data evaluations for the Surficial aquifer, Upper Chesapeake unit, and Lower Chesapeake unit. Hydrogeological property discussions for the Chesapeake Group aquitards comprising the Chesapeake Confining Unit and all deeper units described in Section 2.3.1.2.2 were summarized from the literature, where available. A detailed description of the geotechnical subsurface site investigation is described in FSAR Section 2.5.

Surficial Aquifer

Hydraulic conductivities determined from slug test results for the Surficial aquifer range from 0.040 to 17.40 ft/day (0.01 to 5.30 m/day), with a geometric mean of 0.91 ft/day (0.28 m/day) as detailed in Table 2.3.1-18. The range in values is considered to be indicative of the variability of the subsurface material composition. This is additionally discussed in Section 2.6. A transmissivity of 10.9 ft^2/day (1.01 m^2/day) for the Surficial aquifer is calculated using the mean hydraulic conductivity value cited above and the average saturated thickness of approximately 12 ft (3.7 m).

Table 2.3.1-19 summarizes the laboratory test results for the three geotechnical samples collected from the Surficial aquifer sediments, which were at elevations ranging from elevation 66.3 to 75.3 ft (20.2 to 23.0 m) msl. These samples were collected from geotechnical borings B-320, B-722, and B-732. Sand and clayey sand make up the majority of the samples. Measured moisture unit weight ranges from 120 to 124 pounds/cubic feet (pcf) (1922 to 1986 kg/cubic meter). Measured moisture contents, by weight, range from 23.1% to 29.4%. Specific gravity values range between 2.63 and 2.76. Using these values, the mean void ratio is estimated to be about 0.75. A mean total porosity of 42.7% is calculated from this void ratio. A mean effective porosity of about 34.1% (Table 2.3.1-19) is estimated based on 80% of the total porosity (Marsily, 1986).

Information on the vadose zone above the Surficial aquifer is limited. As described in the FSAR Section 2.5, measured moisture contents by weight range from approximately 2.5% to 19.1%. The majority of the values ranged between 5% and 15%. Hydraulic conductivity for the Upland Deposits was estimated from grain size analyses as part of the CCNPP Unit 1 and 2 FSAR investigation. A maximum hydraulic conductivity of 400 gpd/ft^2 (16,299 lpd/m^2)(53.6 ft/day (16.3 m/day)) was reported.

Chesapeake Group

The following discussion presents the evaluations of the hydrogeologic properties of the two water bearing units in the upper Chesapeake Group, informally named the Upper Chesapeake and Lower Chesapeake units. This is followed by a description of the intervening and underlying Chesapeake Clay and Silt units comprising the remainder of the Chesapeake Group.

Upper Chesapeake Unit

The top of the silty sand unit comprising the informally named Upper Chesapeake unit lies approximately 50 ft (15 m) below the base of the Surficial aquifer. Hydraulic conductivities determined from the slug test results for the Upper Chesapeake unit range from 0.12 to 13.70 ft/day (0.04 to 4.18 m/day), with a geometric mean of 0.740 ft/day (0.23 m/day) as detailed in Table 2.3.1-18. The range in values is indicative of the variability of the grain size and clay content of the material. A transmissivity of 15.8 ft^2/day (1.5 m^2/day) for the Upper Chesapeake unit is calculated using the mean hydraulic conductivity value cited above and an average saturated thickness of 21.4 ft (6.5 m).

Table 2.3.1-19 summarizes the laboratory test results for the five geotechnical samples collected from the Upper Chesapeake Unit sediments. Measured moisture unit weights range from 116 to 121 pcf (1859 to 1939 kg/cubic meter). Measured moisture contents, by weight, range from 23.1% to 44.2%. Specific gravity values range between 2.66 and 2.75. Using these values, the mean void ratio is estimated to be about 0.86. A mean total porosity of 46.2% is calculated from this void ratio, and mean effective porosity of about 37.0% (Table 2.3.1-19) is estimated based on 80% of the total porosity (Marsily, 1986).

Lower Chesapeake Unit

The top of the informally named Lower Chespeake unit generally lies approximately 35 ft (10.7 m) below the base of the Upper Chesapeake unit. Hydraulic conductivities determined from the slug test results for the three wells screened in the Lower Chesapeake unit range from 0.019 to 0.093 ft/day (0.006 to 0.028 m/day), with an arithmetic mean of 0.045 ft/day (0.014 m/day) as detailed in Table 2.3.1-18. The arithmetic mean for the hydraulic conductivity was used instead of the geometric mean due to the very small sample size. These values are lower than those observed in the Surficial aquifer and the Upper Chesapeake unit by more than one order of magnitude. A transmissivity of 1.6 ft^2/day (0.15 m^2/day) for the Lower Chesapeake unit is calculated using the mean hydraulic conductivity value cited above and an average approximate saturated thickness of 36.1 ft (11.0 m).

Table 2.3.1-19 summarizes the laboratory test results for the three geotechnical samples collected from the Upper Chesapeake Unit sediments. Measured moisture unit weights range from 113 to 116 pcf (1811 to 1859 kg/cubic meter). Measured moisture contents, by weight, range from 37.3% to 50.5%. Specific gravity values range between 2.64 and 2.70. Using these values, the mean void ratio is estimated to be about 1.06. A mean total porosity of 51.5% is calculated from this void ratio, and mean effective porosity of about 41.2% is estimated based on 80% of the total porosity.

Chesapeake Clay and Silts

The Upper Chesapeake's clay and silt separates the Surficial aquifer from the underlying Upper Chesapeake unit. It immediately underlies the Surficial aquifer below an elevation between approximately 65 to 70 ft (19.8 to 21 m) msl. Laboratory tests performed on core samples in support of southern Maryland hydrogeologic studies reported vertical hydraulic conductivities ranging between 5.9×10^{-5} ft/day to 2.5×10^{-2} ft/day (1.8×10^{-5} m/day to 7.6×10^{-3} m/day (MGS, 1997). Vertical hydraulic conductivities established for groundwater model calibrations associated with these studies range from 8.6×10^{-6} ft/day to 8.6×10^{-5} ft/day (2.6×10^{-6} m/day to 2.6×10^{-5} m/day), except for channeled areas where higher values were assigned to accommodate infilled deposits of sand and gravel (MGS, 1997). These sand units presumably correlate to the Upper and Lower Chesapeake units described herein. Assigned specific storage values ranged between 6.0 x 10^{-6} ft^{-1} and 1 x 10^{-5} ft^{-1} (2.0 x 10^{-5} m^{-1} and 3.3 x 10^{-5} m^{-1}) for the Chesapeake Group aquitards in the Chesapeake Confining Unit (MGS, 1996).

2.3.1.2.3.4 Groundwater Flow and Transport

The following sections present the most probable groundwater flow direction and travel time from the CCNPP Unit 3 power block area to nearby surface water features. Based on the evaluation summarized in the above sections, only the shallow water bearing units (the Surficial aquifer and the Upper Chesapeake and the Lower Chesapeake water-bearing units) would be affected by construction and operation of the new units with the exception of groundwater use in support of facility operations, discussed in Section 2.3.2.2. Accidental release parameters and pathways for liquid effluents in groundwater and surface water are presented in FSAR Chapter 2.

The groundwater seepage velocity is defined as distance over time and is calculated as follows:

Velocity = [(hydraulic gradient) x (hydraulic conductivity)] / (effective porosity).

The travel time is defined as rate of groundwater movement for a set distance and is calculated as follows:

Travel Time = (distance) / (velocity).

Surficial Aquifer

In the vicinity of the CCNPP site, the Surficial aquifer is capable of transmitting groundwater but is of limited areal and vertical extent. The Surficial aquifer (Upland Deposits) is not a reliable source of groundwater because of its relative thinness, limited saturated thickness, and dissected topography that causes local groundwater to discharge as small seeps and springs.

The groundwater travel time in the Surficial aquifer was calculated from the center of the groundwater divide in the CCNPP Unit 3 power block to the projected discharge point in the headwater area of Branch 3. An average horizontal groundwater velocity of 0.040 ft/day (0.012 m/day) was calculated using a mean horizontal hydraulic gradient of 0.0150 ft/ft between the groundwater divide and Branch 3 (Figures 2.3.1-42 through 2.3.1-45), a hydraulic conductivity of 0.910 ft/day (0.28 m/day), and an effective porosity of 34.1% (Section 2.3.1.2.3.3). Using a mean travel distance of approximately 1315 ft (400.8 m) from the groundwater divide in the CCNPP Unit 3 power block to the closest downgradient point above 65 ft (19.8 m) msl in Branch 3, the groundwater travel time from the power block area to Branch 3 is estimated to be about 90 years. East of the CCNPP Unit 3 reactor building, the flow paths to adjacent springs and seeps are presumed to be shorter, with shorter corresponding travel times for spring/seep discharge.

Upper Chesapeake Unit

Direct groundwater discharge to surface water from the Upper Chesapeake unit likely occurs along the lower reaches of Branch 1 and Branch 2 at elevations below approximately 20 ft (6 m) msl where the Upper Chesapeake unit presumably outcrops. The groundwater travel time in the Upper Chesapeake unit was calculated from the center of the CCNPP Unit 3 power block northward to the projected discharge point at an elevation of 20 ft (6 m) msl in Branch 2. An average horizontal groundwater velocity of 0.034 ft/day (0.010 m/day) was calculated using a mean horizontal hydraulic gradient of 0.017 ft/ft along the projected flowpaths between the center of the CCNPP Unit 3 power block and the discharge point in Branch 2 (Figures 2.3.1-47 to 2.3.1-50), a hydraulic conductivity of 0.740 ft/day (0.226 m/day), and an effective porosity of

37.0% (Section 2.3.1.2.3.3). Using a mean travel distance of approximately 1425 ft (434 m) from the center of the CCNPP Unit 3 power block to the projected downgradient discharge point at 20 ft (6 m) msl in Branch 2, the groundwater travel time from the power block area to Branch 2 is estimated to be about 115 years. Similarly, the groundwater travel times in the Upper Chesapeake unit were calculated from a point south of the CCNPP Unit 3 power block area northeastward to the projected discharge point at an elevation of 20 ft (6 m) msl in Branch 1 and farther downgradient to Chesapeake Bay. Using the same average horizontal groundwater velocity of 0.034 ft/day (0.010 m/day) and mean path distances of 1415 ft (431 m) and 1685 ft (514 m) to Branch 1 and the Chesapeake Bay, respectively, travel times of approximately 114 years and 138 years were calculated. It is possible that a groundwater hydraulic divide exists along the southwestern boundary of the CCNPP Unit 3 power block area resulting in a flow direction beneath the western switchyard area as towards St. John's Creek and Branch 3.

<u>Lower Chesapeake Unit</u>

Groundwater in the Lower Chesapeake unit likely discharges to the Chesapeake Bay because this unit is entirely below sea level. The groundwater travel time in the Lower Chesapeake unit was calculated from the center of the CCNPP Unit 3 power block northeastward to the downgradient location of the Chesapeake Bay shoreline. An average horizontal groundwater velocity of 0.0015 ft/day (0.00046 m/day) was calculated using a mean horizontal hydraulic gradient of 0.014 ft/ft along the projected flowpaths between the center of the CCNPP Unit 3 power block and the shoreline (Figures 2.3.1-52 through 2.3.1-55), a hydraulic conductivity of 0.045 ft/day (0.014 m/day), and an effective porosity of 41.2%. The arithmetic mean (versus the geometric mean) for the hydraulic conductivity was applied to the Lower Chesapeake unit due to the very small sample size Using a distance of approximately 1,540 ft (469 m) from the center of the CCNPP Unit 3 power block area to a downgradient point on the shoreline of the Chesapeake Bay, the groundwater travel time from the power block to the Chesapeake Bay is estimated to be about 2810 years.**}**

2.3.1.3 References

Bowie, 2007. Wellhead Protection Program, City of Bowie, Website: http://www.cityofbowie.org/water/hydrogeology.htm, Date accessed: January 22, 2007.

CBP, 2004. Chesapeake Bay: Introduction to an Ecosystem (EPA 903-R-04-003, CBP/TRS 230/00), Chesapeake Bay Program, 2004.

CBP, 2006a. The Chesapeake Bay Watershed, Chesapeake Bay Program, Website: http://www.chesapeakebay.net/wspv31/(ojtvye45vgw30j55kcanqc45)/WspAboutPrint.aspx?basno=1, Date accessed: August 31, 2006.

CBP, 2006b. Did You Know? Bay Factoids About the Bay, Chesapeake Bay Program, Website: http://www.chesapeakebay.net/info/factoids.cfm, Date accessed: November 30, 2006.

CBP, 2007a. Chesapeake Bay Water Quality— Current Conditions, Water Quality: Tidal River and Main Bay, Chesapeake Bay Program, Website: http://www.chesapeakebay.net/status/WQcrntcond.cfm?subjectarea=TIDAL, Date accessed: January 3, 2007.

CBP, 2007b. CBP Water Quality Database, 1984-Present, Chesapeake Bay Program, Website: http://www.chesapeakebay.net/data/WQ_query2.cfm, Date accessed: February 23, 2007.

CWP, 2004. Lower Patuxent River Watershed Restoration Action Strategy In Calvert County, MD (prepared for Calvert County, MD), Center for Watershed Protection, 2004.

FEMA, 1998. Flood Insurance Rate Map, Calvert County, Maryland (Community Panel Numbers: 240011 0026B and 240011 0027D), Federal Emergency Management Agency, 1984 and 1998.

Johnson, 1993. Validation of Three-Dimensional Hydrodynamic Model of Chesapeake Bay, Journal of Hydraulic Engineering, B. Johnson, K. Kim, R. Heath, B. Hsieh, and H. Butler, 1993.

Marsily, 1986. Quantitative Hydrogeology,Groundwater Hydrology for Engineers, (p. 36), G. Marsily, 1986.

MDE, 2004. Southern Maryland Pilot Study (Appendix E), Advisory Committee on the Management and Protection of the State's Water Resources: Final Report, Maryland Department of the Environment, G. Wolman, May 2004, Website: http://www.mde.state.md.us/Programs/WaterPrograms/Water_Supply/WR_Advisory_Committee.asp

MDNR, 2006. Data in Maryland Tributary Strategy Patuxent River Basin Summary Report for 1985-2004, Maryland Department of Natural Resources, 2006.

MDNR, 2007. Maryland Shorelines Online, Maryland Department of Natural Resources. Website: http://shorelines.dnr.state.md.us/shoreMapper/standard/, Date accessed: February 7, 2007.

MGS, 1983. Hydrogeology, Digital Simulation, and Geochemistry of the Aquia and Piney Point-Nanjemoy Aquifer System in Southern Maryland, Maryland Geological Survey Report of Investigations No. 38, Maryland Geological Survey, F. Chappelle and D. Drummond, 1983.

MGS, 1996. Hydrostratigraphic Framework of the Piney Point-Nanjemoy Aquifer and Aquia Aquifer in Calvert and St. Mary's Counties, Maryland, Maryland Geological Survey Open File Report No. 96-02-8, Maryland Geological Survey, H. Hansen, 1996.

MGS, 1997. Hydrogeology, Model Simulation, and Water-Supply Potential of the Aquia and Piney Point-Nanjemoy Aquifers in Calvert and St. Mary's Counties, Maryland, Maryland Geological Survey Report of Investigations No. 64, Maryland Geological Survey, G. Achmad and H. Hansen, 1997.

MGS, 2001. Shoreline Change Maps, Shoreline Changes, Cove Point Quadrangle, MD, Maryland, 7.5 Minute Series: Orthophotoquad, Coastal and Estuarine Geology Program, Maryland Geological Survey, 2001, Website: http://www.mgs.md.gov/coastal/maps/schangepdf.html, Date accessed: January 4, 2007.

MGS, 2002. Future of Water Supply from the Aquia and Magothy Aquifers in Southern Anne Arundel County, Maryland, Maryland Geological Survey, D. Andreasen, 2002.

MGS, 2004. Optimization of Ground Water Withdrawals from the Lower Patapsco and Patuxent Aquifers in the Bryans Road Service Area, Charles County, Maryland, Maryland Geological Survey Administrative Report, Maryland Geological Survey, D. Andreasen, 2004.

MGS, 2005. Water Supply Potential of the Coastal Plain Aquifers in Calvert, Charles, and St. Mary's Counties, Maryland, with Emphasis on the Upper Patapsco and Lower Patapsco Aquifers, Maryland Geological Survey Administrative Report, Maryland Geological Survey, D. Drummond, June 2005.

MGS, 2007. Drill Site at Hughesville Community Park: Hughesville, Maryland, Southern Maryland Project, Maryland Geological Survey, Website: http://www.mgs.md.gov/hydro/somd/site3.html, Date accessed: January 22, 2007.

NOAA, 2006a. Tidal Currents (information extracted from the National Oceanic and Atmospheric Administration for tidal range at various locations along the Chesapeake Bay), National Oceanic and Atmospheric Administration, Website: http://tidesandcurrents.noaa.gov, Date accessed: November 29, 2006.

NOAA, 2006b. Chesapeake Bay, VA/MD (M130), National Ocean Serviced (NOS) Estuarine Bathymetry Data, Nation Oceanic and Atmospheric Administration, Website: http://egisws01.nos.noaa.gov/servlet/BuildPage?template=bathy.txt&parm1=M130&B1=Submit, Date accessed: September 6, 2006.

NOAA, 2007a. Tidal Range, National Oceanic and Atmospheric Administration, Website: http://tidesandcurrents.noaa.gov, Date accessed: March 6, 2007.

NOAA, 2007b. Chesapeake Bay and Tidal Tributary Interpolator, NOAA Chesapeake Bay Office, Website: http://chesapeakebay.noaa.gov/interpolator.aspx, Date accessed: March 13, 2007.

TSTF, 2005. Sediment in the Chesapeake Bay and Management Issues: Tidal Erosion Processes, CBP-TRS276-05, Tidal Sediment Task Force of the Sediment Workgroup under the Chesapeake Bay Program, Nutrient Subcommittee, May 2005.

USACE, 2006a. Maryland Western Shore Hurricane Evacuation Study: Draft Maps and Data (Calvert County, Baltimore District), U.S. Army Corps of Engineers, Website: http://www.nab.usace.army.mil/hes.htm, Date accessed: December 21, 2006.

USACE, 2006b. Detailed Information, Brighton and Rocky Gorge Dam, National Inventory of Dams, U.S. Army Corps of Engineers, Website: http://crunch.tec.army.mil/nid/webpages/niddetails.cfm?ID=26707&ACC=1, Date accessed: November 21, 2006.

USACE, 2006c. Coastal Engineering Manual, U.S. Army Corps of Engineers, Coastal Engineering Research Center, June 1, 2006.

USFWS, 2007. Wetlands Online Mapper, U.S. Fish and Wildlife Service, Website: http://wetlandsfws.er.usgs.gov/, Date accessed: March 2, 2007.

USGS, 1968. Monthly Surface-Water Inflow to Chesapeake Bay, (USGS Survey Open-File Report), U.S. Geological Survey, C. Bue, 1968. Website: http://md.water.usgs.gov/publications/ofr-68-Bue10/ofr-68-bue10.html, Date accessed: September 22, 2006.

USGS, 1997a. Geologic Framework, Hydrogeology, and Groundwater Quality of the Potomac Group Aquifer System, Northwestern Charles County, Maryland (USGS Water Resources Investigation Report 91-4059), U.S. Geological Survey, S. Hiortdahl, 1997.

USGS, 1997b. Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, West Virginia, In Ground Water Atlas of the United States (Hydrologic Investigations Atlas 730-L), U.S. Geological Survey, H. Trapp and M. Horn, 1997.

USGS, 2003a. "Surface-Water Data," (vol. 1). Water Resources Data: Maryland, Delaware, and Washington D.C.: Water Year 2003 (Water-Data Report MD-DE-DC-03-1), U.S. Geological Survey, R. James, R. Saffer, R. Pentz, and A. Tallman, 2003.

USGS, 2003b. A Summary Report of Sediment Processes in Chesapeake Bay and Watershed, (Water Resources Investigation Report 03-4123), U.S. Geological Survey, E. Langland and T. Cronin, 2003.

USGS, 2005a. Potentiometric Surface of the Aquia Aquifer in Southern Maryland: September 2003, (USGS Open-File Report 2005-1004), U.S. Geological Survey, S. Curtin, D. Andreasen, and J. Wheeler, 2005.

USGS, 2005b. Potentiometric Surface of the Magothy Aquifer in Southern Maryland: September 2003 (USGS Open-File Report 2005-1006), U.S. Geological Survey, S. Curtin, D. Andreasen, and J. Wheeler, 2005.

USGS, 2005c. Potentiometric Surface of the Upper Patapsco Aquifer in Southern Maryland: September 2003 (USGS Open-File Report 2005-1008), U.S. Geological Survey, S. Curtin, D. Andreasen, and J. Wheeler, 2005.

USGS, 2005d. Potentiometric Surface of the Lower Patapsco Aquifer in Southern Maryland, September 2003 (USGS Open-File Report 2005-1010), U.S. Geological Survey, S. Curtin, D. Andreasen, and J. Wheeler, 2005.

USGS, 2005e. Summary of Suspended-Sediment Data for Streams Draining the Chesapeake Bay Watershed, Water Years 1952–2002 (Scientific Investigation Report 2004-5056), U.S. Geological Survey, A. Gellis, W. Banks, M. Langland, and S. Martucci, 2005.

USGS, 2006a. Patuxent River near Bowie, MD, (USGS 01594440), U.S Geological Survey, National Water Information System: Web Interface, Website: http://waterdata.usgs.gov/md/nwis/nwisman/?site_no=01594440&agency_cd=USGS, Date accessed: November 27, 2006.

USGS, 2006b. St. Leonard Creek near St Leonard, MD, (USGS 01594800), U.S. Geological Survey, National Water Information System: Web Interface, Website: http://waterdata.usgs.gov/md/nwis/nwisman/?site_no=01594800&agency_cd=USGS, Date accessed: November 3, 2006.

USGS, 2006c. Surface-Water Data (Vol.1), Water Resources Data, Maryland, Delaware, and Washington D.C., Water Year 2005 (Water-Data Report MD-DE-DC-05-1), U.S. Geological Survey, R. Saffer, R. Pentz, and A. Tallman, 2006.

USGS, 2007. Estimated Streamflow Entering Chesapeake Bay, USGS Chesapeake Bay Activities, U.S. Geological Survey, Website: http://md.water.usgs.gov/monthly/bay.html, Date accessed: March 5, 2007.

Table 2.3.1-1 Peak Annual Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD) (Page 1 of 1)

#	River/Creek Name	Sub-watershed Name	Valley Length	Average Slope
			ft (m)	%
1	Johns Creek Upper Reach (to the confluence with Branch 3)	Lower Patuxent River Watershed	4,200 (1280)	1.15
2	Johns Creek Lower Reach (from confluence with Branch 3 to river mouth)	Lower Patuxent River Watershed	14,600 (4450)	0.33
3	Branch 3 (unnamed branch)	Lower Patuxent River Watershed	2,200 (670)	2.59
4	Branch 4 (unnamed branch)	Lower Patuxent River Watershed	3,800 (1200)	1.29
5	Goldstein Branch	Lower Patuxent River Watershed	4,300 (1300)	1.02
6	Laveel Branch	Lower Patuxent River Watershed	4,700 (1400)	1.02
7	Branch 1 (unnamed branch)	Maryland Western Shore Watershed	1,500 (460)	3.33
8	Branch 2 (unnamed branch)	Maryland Western Shore Watershed	3,100 (950)	1.94

Table 2.3.1-2 Peak Annual Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD)

Year	Date	Discharge (cubic feet per second)
1978	Jan. 27, 1978	10,600
1979	Sep. 06, 1979	11,500
1980	Oct. 11, 1979	3,940
1981	Feb. 24, 1981	1,640
1982	Feb. 04, 1982	3,380
1983	Jun. 21, 1983	5,750
1984	Mar. 30, 1984	4,340
1985	Feb. 13, 1985	4,730
1986	Apr. 16, 1986	1,520
1987	Dec. 25, 1986	4,060
1988	Nov. 30, 1987	3,510
1989	May 7, 1989	9,190
1990	May 30, 1990	3,140
1991	Mar. 24, 1991	4,750
1992	Mar. 27, 1992	3,200
1993	Mar. 05, 1993	5,550
1994	Nov. 29, 1993	6,960
1995	Mar. 09, 1995	4,100
1996	Jan. 20, 1996	8,280
1997	Jan. 20, 1997	6,900
1998	Mar. 10, 1998	4,840
1999	Sep. 17, 1999	8,200
2000	Mar. 22, 2000	3,640
2001	Jun. 08, 2001	3,800
2002	Mar. 21, 2002	957
2003	Feb. 23, 2003	6,990
2004	Dec. 12, 2003	5,790
2005	Apr. 03, 2005	5,210
2006	Jun. 26, 2006	12,700

Table 2.3.1-3 Monthly Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD) (June 27, 1977 through September 30, 2005) (Page 1 of 2)

Discharge (cubic feet per second)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977							131.1	126.5	77.8	220.7	314.3	748.2
1978	1,316	358.6	854.2	372.7	884.0	233.8	298.5	293.2	130.0	109.6	201.8	347.9
1979	1,290	1,232	817.5	523.8	460.8	611.6	220.0	531.9	1,358	1,093	458.8	384.5
1980	496.6	262.8	693.9	806.0	670.3	308.5	210.3	157.3	106.7	201.1	181.9	135.7
1981	119.2	319.5	173.2	188.1	236.6	209.7	145.6	90.7	116.9	117.4	107.6	158.3
1982	211.9	507.8	328.0	344.8	206.2	439.0	124.5	111.8	147.2	130.5	177.5	204.8
1983	173.2	317.8	683.0	1,247	719.9	766.9	176.6	137.5	110.4	285.8	424.2	1,030
1984	407.0	658.3	843.1	843.2	657.5	262.1	371.6	343.3	182.8	155.7	225.5	306.1
1985	173.7	536.1	203.9	167.4	238.4	193.6	134.5	104.5	211.4	163.0	276.1	214.9
1986	218.4	379.5	294.3	328.9	153.8	116.4	102.3	121.5	65.2	80.4	251.6	489.1
1987	428.3	286.2	365.1	459.8	291.2	192.4	176.1	86.1	379.0	160.0	316.4	368.6
1988	453.2	566.2	364.2	351.9	730.1	190.7	189.8	130.4	119.0	114.1	278.6	180.0
1989	287.1	326.9	532.1	453.0	1,291	845.6	491.8	304.5	243.4	391.4	348.5	182.0
1990	462.1	424.5	374.8	581.8	578.4	324.7	209.9	306.3	125.6	332.6	305.6	459.4
1991	720.5	266.4	650.5	376.8	194.7	114.9	103.0	111.4	133.5	145.8	148.1	295.3

Table 2.3.1-3 Monthly Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD) (June 27, 1977 through September 30, 2005) (Page 2 of 2)

	Discharge (cubic feet per second)											
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1992	217.8	251.6	399.5	260.9	221.2	234.6	248.4	153.7	188.0	167.7	350.5	537.5
1993	473.3	335.2	1,358	1,021	429.5	268.6	126.1	132.9	138.2	141.9	392.8	539.2
1994	657.6	930.1	1,318	648.5	347.4	182.9	239.7	319.0	202.3	153.4	193.9	237.6
1995	389.5	228.1	397.6	198.6	308.2	178.8	156.9	168.3	127.6	381.3	491.0	332.1
1996	1,035	549.5	566.6	598.3	575.9	654.4	579.2	474.8	701.6	614.1	747.2	1,357
1997	652.3	683.3	870.9	531.6	391.7	319.0	136.1	177.3	136.1	180.1	448.5	231.0
1998	605.6	890.7	1,124	648.5	669.1	361.7	163.3	124.8	111.2	114.6	123.4	128.1
1999	377.6	237.5	392.0	258.6	169.6	126.5	97.3	200.1	722.9	263.2	229.1	341.0
2000	269.0	420.7	511.9	581.3	271.0	318.9	293.9	225.3	362.9	166.1	171.1	312.5
2001	324.8	390.8	506.4	404.5	350.5	595.5	268.5	186.2	169.2	122.2	151.3	166.8
2002	177.4	141.6	244.2	291.5	269.9	135.1	116.5	98.6	124.4	239.7	371.2	477.7
2003	431.2	786.1	1,014	548.4	715.9	1,320	509.9	328.2	1,066	652.9	937.3	1,256
2004	449.5	919.2	507.0	697.3	437.5	347.3	364.4	336.8	254.7	178.3	343.5	372.1
2005	510.8	383.1	700.6	746.2	414.4	321.9	500.0	219.0	107.8			
Mean	476	485	610	517	460	363	237	210	273	253	320	421

Table 2.3.1-4 Mean Daily Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD) (June 27, 1977 through September 30, 2005) (Page 1 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	341	378	482	686	394	388	247	245	190	195	227	351
2	439	385	510	640	424	387	294	223	159	286	215	374
3	503	418	546	716	426	352	250	209	149	261	236	366
4	440	488	629	626	395	424	281	211	177	245	256	397
5	421	507	655	625	423	446	294	228	194	257	273	404
6	351	441	594	544	542	420	249	250	429	287	289	531
7	336	461	587	473	685	488	229	255	466	192	278	382
8	382	387	535	502	494	578	241	198	284	186	340	306
9	437	359	687	513	432	402	296	188	257	220	400	302
10	374	353	667	627	406	344	204	224	222	243	334	365
11	346	342	547	614	417	272	196	195	209	289	338	458
12	404	415	467	485	392	272	171	305	199	202	342	675
13	435	505	428	490	403	301	256	323	195	174	366	485
14	422	398	468	472	366	363	316	279	213	171	306	673
15	484	460	504	461	361	337	288	215	155	255	334	593

Table 2.3.1-4 Mean Daily Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD) (June 27, 1977 through September 30, 2005) (Page 2 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
16	401	441	447	614	508	293	202	187	261	213	268	492
17	351	420	440	608	664	313	225	176	482	230	325	441
18	364	453	548	554	562	347	196	175	355	246	296	461
19	487	477	570	542	478	375	194	161	382	294	236	527
20	726	474	569	479	443	444	206	183	287	310	308	432
21	668	453	666	403	419	636	233	221	201	274	312	356
22	521	485	884	418	398	569	199	194	276	289	293	388
23	452	665	646	381	468	373	218	169	386	211	338	371
24	494	825	789	377	524	357	209	160	339	275	298	399
25	646	679	631	406	505	324	209	158	257	239	252	513
26	705	694	521	391	565	270	254	188	353	284	305	469
27	795	686	714	432	547	216	248	191	361	310	350	308
28	616	556	848	525	408	196	299	245	308	391	384	282
29	590	461	872	491	384	193	258	192	249	282	635	327
30	433		768	417	434	206	194	184	196	279	476	308
31	394		703		395		203	191		245		321

Table 2.3.1-5 Maximum Daily Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD) (June 27, 1977 through September 30, 2005) (Page 1 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1,140	1,040	2,210	2,040	1,130	1,000	991	1,060	615	940	1,280	1,250
2	2,460	1,100	2,270	1,680	1,320	1,570	1,680	986	575	2,960	837	2,730
3	3,160	959	3,090	4,510	1,400	1,220	1,250	744	557	2,170	778	2,290
4	1,360	2,790	3,330	2,780	1,190	2,940	1,810	917	785	2,480	936	2,000
5	995	3,320	4,480	1,850	1,260	2,930	1,450	1,070	900	2,370	997	1,930
6	1,170	2,550	2,290	1,520	2,350	1,120	1,020	646	7,350	2,470	1,430	4,430
7	932	4,390	2,120	1,000	8,400	1,790	1,050	1,520	7,500	1,430	1,480	1,850
8	1,400	2,700	1,660	1,220	4,020	3,950	896	642	2,780	1,430	2,650	1,820
9	1,920	1,400	3,170	1,160	1,620	2,520	2,750	499	1,800	1,690	4,190	1,660
10	1,650	1,260	3,780	2,320	1,040	1,650	660	1,240	1,460	1,740	3,360	1,310
11	777	1,400	2,490	3,430	1,460	1,160	899	817	1,180	3,350	1,730	2,240
12	2,180	1,310	1,330	1,600	1,240	1,110	599	1,880	1,490	1,220	1,200	5,240
13	2,310	3,750	1,270	1,700	2,010	1,270	1,210	1,360	938	815	1,590	2,670
14	1,560	1,440	1,640	1,500	1,250	2,070	3,800	1,940	1,520	632	934	5,220
15	3,960	2,140	1,490	1,220	1,580	1,610	1,230	722	602	1,560	2,470	2,800
16	1,270	2,270	1,130	3,730	3,630	1,220	631	638	2,740	881	1,360	1,900
17	1,080	1,300	1,030	3,180	4,560	1,280	1,460	654	7,110	1,140	1,700	1,680

Table 2.3.1-5 Maximum Daily Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD) (June 27, 1977 through September 30, 2005) (Page 2 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
18	1,500	1,620	3,350	1,890	2,940	1,480	741	495	1,840	1,190	1,630	2,360
19	1,910	1,370	1,870	1,660	1,550	2,210	534	334	4,940	2,030	593	5,700
20	6,350	1,600	1,750	1,220	1,010	3,000	901	568	3,240	2,860	3,010	3,470
21	4,170	1,600	3,190	1,310	1,640	4,280	1,510	1,300	1,040	1,840	2,180	1,410
22	3,920	1,300	3,440	1,450	1,200	3,630	742	932	1,870	2,300	1,330	1,380
23	2,850	5,600	2,140	1,220	3,000	1,480	975	572	3,450	575	1,200	1,780
24	2,610	4,540	3,770	964	2,170	2,110	768	526	4,890	1,410	1,630	1,460
25	4,650	4,500	2,450	1,880	1,830	1,370	1,350	488	1,900	900	845	2,500
26	4,430	8,000	1,350	974	2,690	826	1,560	1,030	2,110	980	1,390	2,600
27	8,860	8,470	3,720	931	2,580	614	1,260	1,560	1,400	1,220	1,290	830
28	4,430	4,430	3,420	1,830	1,310	432	1,940	1,830	2,330	3,020	1,720	768
29	4,110	918	3,440	1,980	893	396	1,850	1,000	1,520	2,000	5,190	1,380
30	1,340		3,620	1,390	2,530	479	718	833	664	2,600	2,720	964
31	1,080		2,010		1,500		638	800		1,490		1,550

Table 2.3.1-6 Minimum Daily Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD) (June 27, 1977 through September 30, 2005) (Page 1 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	113	105	132	183	122	121	79	69	67	59	82	98
2	115	158	136	182	122	118	88	68	71	64	107	119
3	123	151	169	171	176	115	85	66	71	66	107	118
4	114	148	165	159	173	112	82	66	70	63	105	117
5	121	140	180	152	157	109	79	65	74	63	106	115
6	118	136	175	155	150	110	77	73	75	60	107	110
7	118	128	166	153	143	111	76	70	72	57	106	105
8	119	145	161	140	135	111	76	70	72	57	107	105
9	117	145	157	147	126	108	78	70	69	58	108	107
10	115	136	169	158	120	105	81	73	66	57	105	103
11	107	133	160	157	128	105	81	73	65	57	104	98
12	104	134	150	158	128	105	79	73	64	58	102	99
13	105	141	161	156	115	108	79	74	62	63	98	101
14	104	133	156	154	110	102	85	73	61	76	99	103
15	106	132	147	153	106	99	81	73	59	76	99	124
16	111	134	151	153	102	99	80	71	58	77	101	126

Table 2.3.1-6 Minimum Daily Streamflow for the Patuxent River at Bowie, MD (USGS Station No. 01594440, Patuxent River near Bowie, MD) (June 27, 1977 through September 30, 2005) (Page 2 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17	112	136	151	149	100	98	78	75	56	77	100	123
18	112	134	149	143	98	94	79	74	56	73	99	120
19	111	132	143	143	105	92	74	70	56	71	97	118
20	112	130	143	140	149	94	73	70	57	71	97	120
21	122	135	139	136	144	105	79	69	60	70	98	106
22	130	135	142	134	139	96	80	66	59	70	95	109
23	130	133	138	131	135	86	79	67	59	71	117	116
24	130	133	137	130	132	87	76	67	57	71	102	115
25	120	134	134	138	120	87	81	66	59	70	96	115
26	120	132	130	127	114	86	78	65	60	84	96	114
27	110	139	131	124	108	81	77	65	60	105	96	114
28	110	132	131	127	119	80	75	64	59	108	94	120
29	100	222	129	127	133	90	73	62	59	106	95	124
30	100		159	123	127	88	77	68	58	96	94	118
31	100		164		123		72	70		86		111

Table 2.3.1-7 Peak Annual Streamflow for the St. Leonard Creek at St. Leonard, MD (USGS Station No. 01594800, St. Leonard Creek near St. Leonard, MD) (December 2, 1956 through September 30, 2003) (Page 1 of 1)

Year	Date	Discharge (cfs)
1958	Aug. 25, 1958	195
1959	Jul. 15, 1959	108
1960	Jul. 30, 1960	288
1961	Oct. 28, 1960	114
1962	Jan. 07, 1962	105
1963	Jun. 03, 1963	130
1964	Nov. 07, 1963	103
1965	Nov. 26, 1964	70
1966	Sep. 21, 1966	168
1967	Oct. 19, 1966	77
1968	Jan. 14, 1968	111
2001	May 26, 2001	48
2002	Sep. 01, 2002	33
2003	Sep. 19, 2003	68

Table 2.3.1-8 Monthly Streamflow for St. Leonard Creek at St. Leonard, MD (USGS Station No. 01594800, St. Leonard Creek near St. Leonard, MD) (December 1, 1956 through September 30, 2003) (Page 1 of 1)

Discharge (cubic feet per second)												
YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1956												6.74
1957	6.02	8.99	12.5	7.7	4.11	2.46	1.57	4.7	7.04	4.15	4.96	11.9
1958	13.3	15.2	22.9	26.1	26.1	13.9	10.8	14.9	9.1	9.65	8.46	8.78
1959	9.2	7.59	8.63	10.1	5.93	4.26	7.81	4.73	2.44	4.18	8.12	7.61
1960	7.98	9.68	8.89	11.8	13.5	9.57	10.5	8.23	13.1	10.4	11	10.9
1961	12.9	24.8	22	20.3	16.5	9.88	6.53	4.63	2.84	3.76	4.37	6.79
1962	7.69	7.51	12.1	14	7.45	6.39	3.85	2.78	3.03	3.79	10.1	6.49
1963	7.16	6.31	12.3	7.46	5.67	8.91	2.3	1.14	2.64	2.31	7.65	5.58
1964	9.67	10.5	9.49	10.8	6.16	3.93	3.45	1.37	1.71	4.06	5.12	5.88
1965	6.58	7.33	9.26	8.59	4.49	4.88	3.56	3.12	2.44	2.69	3.06	3.23
1966	4.33	9.53	5.55	5.49	5.32	1.72	0.8	0.326	4.59	4.42	3.08	4.99
1967	5.19	5.91	6.43	4.29	5.82	2.5	2.14	3.45	1.31	1.73	2.41	7.23
1968	8.75	3.69	9.09	5.43	4.94	5.16	1.17	2.59	1.94			
2000										3.35	4.34	6.2
2001	8.94	11.2	11.4	8.65	9.58	9.82	6.91	5.43	2.44	1.91	2.92	3.11
2002	4.25	3.45	4.73	4.32	3.76	1.14	0.074	0.415	1.63	1.93	5.7	6.26
2003	4.89	8.14	11.3	8.21	9.35	9.92	5.49	4.8	8.73			
Mean	7.8	9.3	11	10	8.6	6.3	4.5	4.2	4.3	4.2	5.8	6.8

Table 2.3.1-9 Mean Daily Streamflow for St. Leonard Creek at St. Leonard, MD (USGS Station No. 01594800, St. Leonard Creek near St. Leonard, MD) (December 2, 1956 through September 30, 2003) (Page 1 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	10	8	13	12	9	7	3.5	4.1	3.8	5.3	5.1	4.8
2	8.3	7.1	9.8	11	9.1	9.6	3.6	3.1	3.5	4.1	5.7	4.5
3	7.1	6.4	9.7	10	8.4	14	4.3	3.4	3.6	3.6	6.3	5.9
4	6.7	8.5	8.9	9.8	8	7.9	3.9	3.9	3.4	3.6	4.9	6.6
5	5.9	9.3	11	10	9.6	7.2	3.7	4.8	2.9	3.5	4.6	5.5
6	8.1	8.9	12	9.9	8.5	6.2	4.2	4.5	2.6	4.6	6.7	6.2
7	9.6	9	10	11	11	7.4	3.4	3.3	6.7	4.4	11	5.6
8	7.1	10	11	12	9.9	7.7	4.3	5	2.9	3.6	5.2	5.5
9	7.6	9.6	11	11	9.1	5.8	4.3	2.9	2.7	3.9	4.7	7
10	7.6	8	8.6	9.8	7.5	6.5	4.3	3.1	3.9	3.2	8	6
11	6.6	8.2	8.4	13	9.3	5.2	4.9	3.8	6.2	2.9	4.9	6.7
12	6.4	8.7	13	11	8.5	5.3	5.4	3.8	10	2.8	4.9	9.5
13	6.6	9.9	10	13	7.5	5.8	5	4.8	4.6	2.8	5	7
14	15	8.7	10	11	7.3	7.6	5.8	3.9	4.4	3.7	4.6	7.6
15	10	8.2	8.9	9.3	7	5.5	7.4	2.9	3	3.7	4.7	6.3
16	7.7	9.9	9	9.4	7.4	5.4	5.6	3	3.6	3.4	4.5	8.2

Table 2.3.1-9 Mean Daily Streamflow for St. Leonard Creek at St. Leonard, MD (USGS Station No. 01594800, St. Leonard Creek near St. Leonard, MD) (December 2, 1956 through September 30, 2003) (Page 2 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17	6.5	9.3	11	9.2	6.5	5.6	3.4	3.5	4.4	4.4	5.3	8.5
18	6.1	8.8	12	9	7.3	5.2	3.3	2.5	4.1	3.7	5.4	7.8
19	6.5	14	12	9.1	7.8	5.7	3.2	3	5.5	6.1	5.6	5.7
20	9.7	9	17	9.8	8.1	6.3	3	4.8	4.9	5.5	5.2	5.9
21	8.9	8.6	16	9	6.9	6.8	3.4	3	8.4	4	4.7	7
22	8.4	9.3	15	9.4	8.2	5.4	3.1	3.5	3.9	6.1	5.9	5.2
23	8.3	11	13	12	8.5	5.2	3.6	3.2	4.1	4.1	5.2	6.3
24	7.8	9.1	11	9	6.7	6	4.5	4.8	3	4.3	7.2	6.6
25	8.9	10	10	9.1	7.3	6.2	3.5	17	3.1	3.5	7.3	6.7
26	6.7	11	11	8.4	11	5.1	3.9	6.5	2.9	4.1	8.3	7.4
27	6.7	12	11	8.8	9.1	5.5	5.4	4.6	4.8	3.6	5.3	6.8
28	7	11	9.5	11	11	4.1	3.4	3.3	3.4	5.6	5	7.6
29	6.6	8.4	9.1	9.3	13	4.1	4.5	3.4	4.6	6.2	6.5	9.9
30	6.6		11	10	7.8	3.6	12	2.8	4.6	4.5	6.2	9.9
31	6.3		11		8.9		4.1	3.3		4.1		6

Table 2.3.1-10 Maximum Daily Streamflow for St. Leonard Creek at St. Leonard, MD (USGS Station No. 01594800, St. Leonard Creek near St. Leonard, MD) (December 2, 1956 through September 30, 2003) (Page 1 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	54	28	43	39	22	16	8.7	14	11	29	21	9.4
2	24	18	20	31	27	33	8.7	9.4	13	10	22	8.7
3	18	13	18	25	22	71	15	9.1	10	8.7	22	23
4	12	40	18	23	25	23	11	13	13	9.1	18	19
5	11	30	29	41	54	14	9.8	16	9.4	7.9	15	16
6	27	22	22	30	38	13	16	21	9.1	24	19	19
7	41	25	25	24	51	28	10	11	60	19	60	13
8	11	30	28	43	32	27	13	38	11	9.6	14	17
9	19	50	32	21	28	16	12	9.4	9.1	13	10	32
10	17	29	18	23	25	30	13	7.9	23	7.9	49	24
11	11	22	17	63	46	15	14	8.7	27	6.9	13	16
12	13	22	57	28	32	16	25	15	115	6.6	11	26
13	11	49	21	50	21	24	16	23	18	6.9	15	15
14	90	26	28	35	20	46	19	18	17	14	10	15
15	33	20	18	24	20	12	53	9.1	7.9	7.5	9.8	11
16	16	35	20	23	19	11	34	8.7	14	6.9	9.8	42

Table 2.3.1-10 Maximum Daily Streamflow for St. Leonard Creek at St. Leonard, MD (USGS Station No. 01594800, St. Leonard Creek near St. Leonard, MD) (December 2, 1956 through September 30, 2003) (Page 2 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17	13	30	30	21	19	18	9.4	15	16	15	17	35
18	12	28	40	19	18	11	8.3	7.5	16	8.5	14	21
19	13	57	29	19	30	17	7.9	9.8	27	41	10	12
20	35	24	95	20	35	15	7.5	28	30	23	9.4	12
21	23	24	48	22	21	22	9.1	11	69	9.8	9.4	25
22	21	26	34	21	24	17	9.1	13	11	40	25	9.5
23	15	47	47	73	31	14	19	13	24	19	11	15
24	21	27	31	30	17	24	22	23	11	16	22	12
25	40	26	27	24	30	16	12	140	8.8	8.3	26	16
26	20	22	29	22	45	18	9.8	32	7.2	8.3	36	26
27	13	46	33	24	35	28	20	18	23	7.9	11	16
28	12	41	26	40	44	11	11	16	11	39	9.8	28
29	13	11	22	26	53	10	18	14	17	47	15	33
30	14		27	27	21	9.1	124	12	19	14	20	36
31	14		33		37		16	12		13		12

Table 2.3.1-11 Minimum Daily Streamflow for St. Leonard Creek at St. Leonard, MD (USGS Station No. 01594800, St. Leonard Creek near St. Leonard, MD) (December 2, 1956 through September 30, 2003) (Page 1 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1.1	3.5	2.1	4.4	3.5	1.4	0.18	0	0	0.2	1.1	2.4
2	1	3.7	2.8	3.9	3.3	1.1	0.13	0	0	0.15	1.2	2.4
3	1.4	3.4	3.7	3.7	3.5	0.64	0.13	0	0	0.1	1.2	2.6
4	2.1	3.4	4.4	3.7	3.5	0.64	0.13	0	0	0	1.3	2.7
5	2.5	2.8	4	3.7	3.3	0.76	0.1	0	0	0	2	2.8
6	4.2	3.2	3.9	3.5	3.3	1.4	0.08	0.06	0	0	2.1	2.8
7	3.8	3	3.9	3.5	3.1	1.6	0	0	0	0	2.1	2.8
8	3.6	3.5	3.9	3.3	2.9	1.8	0	0	0	0	2.1	2.9
9	3.4	3.6	3.8	3.3	2.9	1	0	0	0	0	2.1	2.9
10	3.7	3.4	4.1	3.3	2.9	1	0	0	0	0.1	2.1	2.8
11	3.3	3.2	4	3.3	2.7	0.64	0	0	0.01	0.2	2.1	2.9
12	3	3	3.9	3.6	3.1	0.64	0	0	0	1	2.1	2.9
13	3.3	2.8	4.4	3.6	3.1	0.9	0	0	0	1.1	2.1	2.6
14	3.3	2.8	4.2	3.4	2.7	1	0.13	0	0	0.5	2.1	3
15	3.2	3	4.1	3.4	2.7	1.1	0.13	0	0.13	0.39	2.3	2.6
16	3	3.2	3.9	2.6	2.9	1	0.06	0	0.4	1.5	2	2.1

Table 2.3.1-11 Minimum Daily Streamflow for St. Leonard Creek at St. Leonard, MD (USGS Station No. 01594800, St. Leonard Creek near St. Leonard, MD) (December 2, 1956 through September 30, 2003) (Page 2 of 2)

	Discharge (cubic feet per second)											
Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17	2.9	3.8	4	2.3	2.6	0.9	0.06	0	0.2	1.5	2.1	2.3
18	2.6	3.6	4.1	1.9	2.3	0.76	0.01	0	0.2	1.5	2.1	3.1
19	2.8	3.5	4.1	2.4	2.6	0.52	0	0	0.23	1.5	2.3	2.7
20	3.1	2.9	3.9	3.4	3.1	0.64	0	0	0.13	0.62	2	2.6
21	3	2.9	3.9	2.9	2.7	0.77	0	0	0.13	0.48	2	2.1
22	3.5	2.8	3.9	4.1	2.7	0.65	0	0.01	0.06	0.35	2	1.9
23	3.5	2.3	3.9	3.7	2.4	0.46	0	0.06	0.06	0.35	2.4	2.1
24	3.1	2.2	4.1	3.7	3.2	0.46	0.13	0	0.01	0.35	2.4	3.3
25	3.4	2.3	3.9	3.3	2.8	0.2	0.01	0	0	0.62	2.6	3.5
26	3.7	2.5	4	3.9	2.7	0.2	0.1	0	0.34	1.8	2.6	2.9
27	3.8	2.9	4.4	4.4	2.5	0.23	0.2	0	0.4	1.7	2.4	2.3
28	3.6	1.8	3.9	4.6	2.1	0.2	0.3	0	0.4	1.6	2.3	1.9
29	3.5	5	3.9	3.9	2.1	0.67	0.23	0	0.52	1.3	2.3	2.1
30	3		3.9	3.7	1.8	0.47	0.01	0	0.32	1.2	1.7	1.5
31	2.5		4.5		1.7		0	0		1.2		1.2

Table 2.3.1-12 Details of Brighton and Rocky Gorge Dams
(Page 1 of 1)

Information	Brighton Dam	Rocky Gorge Dam
Record Number	26707	26722
Dam Name	Brighton Dam	Rocky Gorge Dam
Other Dam Name	Tridelphia Lake Dam	Duckett Dam
State ID	5	20
NID ID	MD00005	MD00020
Longitude (decimal degree)	-77.005	-76.8767
Latitude (decimal degree)	39.1933	39.1167
County	Montgomery	Prince Georges
River	Patuxent River	Patuxent River
Owner Name	Washington Suburban Sanitary Commission	Washington Suburban Sanitary Commission
Year Completed	1943	1953
Year Modified	1999	1986
Dam Length (ft, top of the dam)	995	840
Dam Height (to the nearest ft)	80	134
Maximum Discharge (cfs)	83,000	65,200
Maximum Storage (ac-ft)	27,000	22,000
Normal Storage (ac-ft)	19,000	17,000
Surface Area (acres)	800	773
Drainage Area (mi^2)	77.3	132.0
Down Stream Hazard Potential	High	High
State Regulated Agency	MD Water Management Administration	MD Water Management Administration
Spillway Type	Controlled	Controlled
Spillway Width (to the nearest ft)	260	190

Table 2.3.1-13 Estimated Monthly Mean Inflow to the Chesapeake Bay (Based on Three Reference Stations) (1951-2000) (Page 1 of 2)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1951	119,400	175,400	148,100	179,100	66,000	87,900	42,100	22,700	16,300	13,600	41,600	82,200	82,100
1952	173,500	123,300	182,100	180,100	142,100	47,000	33,500	30,400	38,800	16,800	68,300	97,100	94,400
1953	136,000	111,100	170,700	129,000	123,600	74,400	23,700	17,000	12,700	10,800	17,900	48,000	72,800
1954	39,700	71,800	135,100	95,200	99,900	45,400	19,100	14,000	13,600	41,600	51,100	78,300	58,700
1955	83,300	79,400	208,800	90,300	46,300	44,900	19,100	93,400	26,800	79,700	74,000	33,300	73,400
1956	27,400	107,900	161,400	161,500	82,800	45,000	49,900	39,500	30,700	36,400	69,400	101,900	76,000
1957	76,400	109,900	114,800	183,800	62,700	37,500	19,500	11,900	17,900	19,700	30,600	93,000	64,400
1958	89,100	72,900	160,900	238,900	154,400	51,500	43,000	40,400	24,900	25,400	37,400	37,500	81,400
1959	72,800	71,900	96,700	138,200	69,800	46,100	20,600	18,900	19,100	55,400	70,500	117,700	66,400
1960	95,500	118,100	84,000	230,700	145,700	92,900	32,100	26,100	42,600	22,100	24,300	20,100	77,400
1961	30,000	144,300	181,400	202,900	111,000	55,700	31,700	29,200	23,200	38,000	31,500	63,800	78,000
1962	78,500	71,800	207,200	195,300	61,000	38,800	21,900	16,800	13,700	31,500	60,500	41,700	69,800
1963	65,800	43,200	228,600	86,400	55,700	40,600	17,200	12,200	10,600	8,600	18,800	38,200	52,400
1964	103,400	80,600	222,700	127,300	88,700	23,600	16,300	11,400	7,800	13,000	14,000	33,200	61,900
1965	65,200	110,300	118,000	112,900	59,300	23,900	13,000	12,000	11,700	21,300	20,500	25,500	49,000
1966	29,600	110,200	130,100	66,500	105,800	30,700	10,500	9,300	23,600	35,000	30,500	61,400	53,300
1967	61,000	67,000	205,100	101,300	120,900	38,700	30,600	47,800	27,500	51,000	67,000	104,600	77,200
1968	62,800	86,600	129,100	64,800	81,200	86,000	31,500	16,900	23,700	19,700	67,900	52,600	60,100
1969	46,900	58,800	68,800	93,100	57,300	39,100	36,200	80,700	23,800	17,300	44,300	62,200	52,300
1970	66,200	132,000	95,800	218,500	73,500	38,200	39,100	24,400	17,300	29,000	111,800	80,200	76,500
1971	74,100	163,000	167,400	73,300	104,500	68,000	22,900	32,400	32,400	54,500	47,300	108,800	78,600
1972	82,300	107,700	183,500	159,600	145,300	324,600	117,100	42,400	19,900	58,600	131,800	209,000	131,700
1973	108,400	144,800	138,500	174,700	127,000	76,400	44,900	34,500	30,100	34,600	52,300	176,000	94,900
1974	153,900	88,600	109,000	156,000	81,000	56,500	40,100	27,400	46,800	25,200	38,500	99,400	76,800
1975	97,600	155,600	185,000	96,700	121,800	77,700	56,100	30,200	155,100	118,000	77,400	66,000	102,700

Table 2.3.1-13 Estimated Monthly Mean Inflow to the Chesapeake Bay (Based on Three Reference Stations) (1951-2000) (Page 2 of 2)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1976	118,200	155,400	104,400	85,900	59,400	74,400	41,900	33,600	22,900	173,900	73,400	68,300	84,100
1977	31,100	34,500	195,600	152,600	49,830	23,800	29,700	22,600	44,600	97,400	124,100	155,100	80,400
1978	171,800	75,800	231,600	158,500	182,700	53,500	39,900	46,100	25,300	22,500	25,600	61,900	91,700
1979	188,700	131,200	253,400	122,200	94,600	81,500	32,600	34,300	98,800	132,600	107,800	87,200	113,700
1980	88,800	42,900	151,000	205,200	104,800	40,800	28,800	21,000	15,000	14,000	24,200	31,100	64,000
1981	17,800	151,900	58,600	69,600	78,900	68,900	36,100	20,600	23,200	31,100	50,000	44,200	53,500
1982	60,900	134,900	169,900	123,000	54,100	147,200	42,400	25,900	15,700	17,300	25,700	58,500	72,400
1983	39,500	100,800	128,500	264,000	149,000	64,400	33,300	16,900	13,000	26,800	55,100	167,000	88,000
1984	56,000	216,300	151,000	251,000	134,000	76,000	62,700	73,600	27,900	22,800	33,200	92,300	99,100
1985	62,100	97,000	95,100	86,000	58,800	40,800	25,700	36,600	21,100	28,700	164,000	104,300	68,000
1986	53,700	125,000	169,000	95,800	52,400	45,900	29,700	31,900	17,400	25,900	72,400	114,200	69,100
1987	68,200	69,500	121,100	226,000	76,500	38,600	36,200	15,400	73,600	33,100	47,600	82,100	73,800
1988	66,500	93,200	78,300	70,300	139,000	36,400	21,000	17,600	25,200	16,900	47,200	31,200	53,400
1989	49,100	54,100	97,300	104,900	223,900	117,800	87,000	39,800	47,700	76,600	71,800	37,500	84,200
1990	94,100	153,600	78,600	104,300	113,500	67,200	50,500	38,100	30,300	135,400	80,400	134,800	89,800
1991	167,200	94,600	156,500	110,400	58,800	24,600	24,400	21,700	13,200	14,700	21,900	51,900	63,300
1992	58,000	54,600	124,800	134,600	77,600	68,400	43,300	37,900	38,200	35,700	92,600	103,600	72,400
1993	125,300	58,500	230,700	380,700	89,000	35,800	20,900	18,000	20,400	24,000	78,600	125,200	100,600
1994	69,500	152,400	298,000	230,500	87,500	45,300	43,800	83,900	37,400	28,500	41,300	83,300	99,800
1995	128,600	55,000	88,100	58,400	61,700	77,000	60,500	20,700	13,200	63,500	80,100	69,800	64,900
1996	244,600	142,200	152,200	139,000	155,900	86,300	54,100	57,600	142,000	97,900	130,000	219,900	135,200
1997	77,500	109,700	160,300	80,500	61,300	62,200	25,000	19,000	20,300	18,600	81,400	55,800	64,000
1998	199,700	235,900	223,100	178,700	152,900	57,300	41,600	20,900	14,100	17,500	14,400	16,400	97,700
1999	80,200	70,500	108,000	98,800	45,000	17,400	13,100	13,600	47,300	48,700	33,200	66,400	53,500
2000	44,500	85,200	141,500	149,000	83,300	70,000	34,000	34,200					

Table 2.3.1-14 Estimated Tidal Inflow Rate at the Chesapeake Bay Entrance for Spring Tides and Tidal Excursion Length Near the CCNPP Unit 3 Site (Page 1 of 1)

Parameters	Assumptions	Formulation Used	Results	Comments
Tidal inflow rate during spring tide over flood or ebb tidal periods (one-half tide period)	Vm = maximum cross-sectional average velocity over a tidal cycle at the mouth = 1.7 knots	Step 1: Calculate tidal prism, P P = (Ts.Vm.Aav)/π	8.691×10^{10} ft^3	The tidal flow rate is assumed as the average flow rate over one-half tide period during spring tides.
	Ts = semi-diurnal tide period = 12.42 hrs			
	Aav = average area over channel length, assumed the same as the area of Chesapeake Bay entrance. = 2.214 x 106 ft^2	Step 2: Calculate corresponding tidal flow rate, qm, over Ts/2 qm = P/(Ts/2)	3.89×10^6 cfs Use 3,900,000 cfs	
Tidal excursion length near the CCNPP site	Hs = mean tidal range at Cove Point = 1.04 ft	Step 1: Calculate wave celerity (Cs), long-wave approximation Cs = (g.hav)0.5	26 ft.s-1	It is assumed that the average Chesapeake Bay water depth near the CCNPP site is the same as the average depth of the entire Chesapeake Bay. However, the average water depth near the CCNPP site could be higher, in which case the particle displacement range would be smaller. The higher range is considered as conservative.
	Hav = cross-sectional average water depth near the site, assumed the same as the average bay water depth = 21 ft	Step 2: Calculate tidal wave length, Ls Ls = Cs.Ts	220.12 mi	
		Step 3: Calculate horizontal particle displacement amplitude, a1, for shallow water waves a1 = Hs/2. Ls/(2 π.hav)	0.87 mi	
	q = acceleration due to gravity = 32.17 ft.s-2	Step 4: Calculate horizontal particle displacement length (As) As = 2.a1	1.74 mi Use 1.75 mi	

Table 2.3.1-15 CCNPP Unit 3 Observation Wells Construction Details (Page 1 of 3)

Well ID	Northing[1] (ft)	Easting[1] (ft)	Ground Surface Elevation (ft)	Well Pad Elevation (ft)	Top of Casing[2] Elevation (ft)	Boring Depth (ft)	Well Depth (ft)	Screen Diameter & Slot Size (in)	Screen Interval Depth		Screen Interval Elevation		Filterpack Interval Depth		CCNPP Hydrostratigraphic Unit
									Top (ft)	Bottom (ft)	Top (ft)	Bottom (ft)	Top (ft)	Bottom (ft)	
OW-301	217048.02	960814.47	94.51	94.78	96.27	80.0	77.0	2 / 0.010	65.0	75.0	29.5	19.5	61.0	80.0	Upper Chesapeake Unit
OW-313A	217367.31	960705.30	51.03	51.31	53.20	57.5	52.5	2 / 0.010	40.0	50.0	11.0	1.0	35.0	57.5	Upper Chesapeake Unit
OW-313B	217372.35	960713.67	50.73	51.16	53.54	110.0	107.5	2 / 0.010	95.0	105.0	-44.3	-54.3	91.0	110.0	Lower Chesapeake Unit
OW-319A	216962.56	961116.12	103.13	103.31	104.91	35.0	32.0	2 / 0.010	20.0	30.0	83.1	73.1	15.0	35.0	Surficial Aquifer
OW-319B	216957.32	961125.02	103.53	103.85	105.35	85.0	82.0	2 / 0.010	70.0	80.0	33.5	23.5	65.0	85.0	Upper Chesapeake Unit
OW-323	217034.46	960057.07	106.96	107.55	109.69	43.5	42.0	2 / 0.010	30.0	40.0	77.0	67.0	26.0	43.5	Surficial Aquifer
OW-328	216828.86	960493.21	76.29	76.55	77.85	72.0	72.0	2 / 0.010	60.0	70.0	16.3	6.3	56.5	72.0	Upper Chesapeake Unit
OW-336	216643.18	960746.61	97.11	97.50	99.07	74.0	72.0	2 / 0.010	60.0	70.0	37.1	27.1	53.0	74.0	Upper Chesapeake Unit
OW-401	216348.86	961530.99	71.38	71.91	73.49	77.5	75.3	2 / 0.010	63.0	73.0	8.4	-1.6	57.0	77.5	Upper Chesapeake Unit
OW-413A	216703.14	961418.81	123.15	123.51	125.04	50.0	47.0	2 / 0.010	35.0	45.0	88.2	78.2	30.0	50.0	Surficial Aquifer
OW-413B	216694.88	961413.25	122.90	123.25	124.85	125.0	122.0	2 / 0.010	110.0	120.0	12.9	2.9	105.0	125.0	Upper Chesapeake Unit
OW-418A	216340.41	961966.46	43.66	44.31	45.83	40.0	37.0	2 / 0.010	25.0	35.0	18.7	8.7	21.0	40.0	Upper Chesapeake Unit
OW-418B	216340.25	961976.71	43.67	44.13	45.77	92.0	87.0	2 / 0.010	75.0	85.0	-31.3	-41.3	72.0	92.0	Lower Chesapeake Unit
OW-423	216339.99	960882.24	111.12	111.67	113.16	43.0	40.3	2 / 0.010	28.0	38.0	83.1	73.1	23.0	43.0	Surficial Aquifer
OW-428	216105.21	961212.38	113.92	114.32	115.92	50.0	47.0	2 / 0.010	35.0	45.0	78.9	68.9	30.0	50.0	Surficial Aquifer
OW-436	215922.47	961446.87	108.13	108.53	110.39	50.0	41.0	2 / 0.010	29.0	39.0	79.1	69.1	24.0	50.0	Surficial Aquifer
OW-703A	218171.23	960967.72	44.02	44.44	45.65	49.0	47.0	2 / 0.010	35.0	45.0	9.0	-1.0	32.5	49.0	Upper Chesapeake Unit
OW-703B	218171.67	960958.91	45.57	45.97	47.53	80.0	80.0	2 / 0.010	68.0	78.0	-22.4	-32.4	65.0	80.0	Lower Chesapeake Unit

Table 2.3.1-15 CCNPP Unit 3 Observation Wells Construction Details (Page 2 of 3)

Well ID	Northing[1] (ft)	Easting[1] (ft)	Ground Surface Elevation (ft)	Well Pad Elevation (ft)	Top of Casing[2] Elevation (ft)	Boring Depth (ft)	Well Depth (ft)	Screen Diameter & Slot Size (in)	Screen Interval Depth		Screen Interval Elevation		Filterpack Interval Depth		CCNPP Hydrostratigraphic Unit
									Top (ft)	Bottom (ft)	Top (ft)	Bottom (ft)	Top (ft)	Bottom (ft)	
OW-705	217566.62	960917.18	47.71	47.77	50.22	52.0	52.0	2 / 0.010	40.0	50.0	7.7	-2.3	35.0	52.0	Upper Chesapeake Unit
OW-708A	217586.23	961803.52	37.44	37.82	39.61	34.0	34.0	2 / 0.010	22.0	32.0	15.4	5.4	19.0	34.0	Upper Chesapeake Unit
OW-711	216748.48	961741.61	52.92	53.26	55.31	50.0	47.0	2 / 0.010	35.0	45.0	17.9	7.9	30.0	50.0	Upper Chesapeake Unit
OW-714	215705.73	962034.37	116.02	116.32	117.98	50.0	50.0	2 / 0.010	38.0	48.0	78.0	68.0	36.0	50.0	Surficial Aquifer
OW-718	214133.58	961924.87	118.53	118.96	120.41	43.0	42.0	2 / 0.010	30.0	40.0	88.5	78.5	28.0	43.0	Surficial Aquifer
OW-725	214649.30	963212.73	58.04	58.38	59.94	60.0	60.0	2 / 0.010	48.0	58.0	10.0	0.0	46.0	60.0	Upper Chesapeake Unit
OW-729	214872.58	962445.93	118.88	119.44	121.11	42.0	42.0	2 / 0.010	30.0	40.0	88.9	78.9	28.0	42.0	Surficial Aquifer
OW-735	214805.48	961021.83	91.20	91.81	93.44	72.0	72.0	2 / 0.010	60.0	70.0	31.2	21.2	58.0	72.0	Upper Chesapeake Unit
OW-743	213320.62	961234.01	103.65	104.05	105.89	55.0	52.0	2 / 0.010	40.0	50.0	63.7	53.7	36.0	55.0	Surficial Aquifer
OW-744	216405.37	960089.41	97.50	97.96	99.81	50.0	50.0	2 / 0.010	38.0	48.0	59.5	49.5	36.0	50.0	Chesapeake Unit
OW-752A	215482.18	960250.12	95.30	95.73	97.00	37.0	37.0	2 / 0.010	25.0	35.0	70.3	60.3	19.0	37.0	Surficial Aquifer
OW-752B	215489.21	960257.57	95.79	96.09	97.41	97.0	97.0	2 / 0.010	85.0	95.0	10.8	0.8	83.0	97.0	Upper Chesapeake Unit
OW-754	217369.78	960290.37	67.00	67.21	68.85	44.0	44.0	2 / 0.010	32.0	42.0	35.0	25.0	30.0	44.0	Upper Chesapeake Unit
OW-756	215497.07	961212.39	106.56	107.07	108.77	42.0	42.0	2 / 0.010	30.0	40.0	76.6	66.6	28.0	42.0	Surficial Aquifer
OW-759A	214536.47	960055.02	97.78	98.05	99.69	35.0	32.0	2 / 0.010	20.0	30.0	77.8	67.8	17.0	35.0	Surficial Aquifer
OW-759B	214526.25	960056.32	98.35	98.72	100.14	90.0	87.0	2 / 0.010	75.0	85.0	23.4	13.4	70.0	90.0	Upper Chesapeake Unit
OW-765A	216424.51	959701.22	97.37	97.92	99.60	29.0	29.0	2 / 0.010	17.0	27.0	80.4	70.4	15.0	29.0	Surficial Aquifer
OW-765B	216420.42	959693.64	96.82	97.19	98.47	102.0	94.0	2 / 0.010	82.0	92.0	14.8	4.8	80.0	102.0	Upper Chesapeake Unit
OW-766	216932.89	959791.50	108.89	109.32	110.72	50.0	32.0	2 / 0.010	20.0	30.0	88.9	78.9	15.0	37.0	Surficial Aquifer
OW-768A	217106.06	962238.98	48.48	48.96	49.84	42.0	42.0	2 / 0.010	30.0	40.0	18.5	8.5	28.0	42.0	Upper Chesapeake Unit

Table 2.3.1-15 CCNPP Unit 3 Observation Wells Construction Details (Page 3 of 3)

Well ID	Northing[1] (ft)	Easting[1] (ft)	Ground Surface Elevation (ft)	Well Pad Elevation (ft)	Top of Casing[2] Elevation (ft)	Boring Depth (ft)	Well Depth (ft)	Screen Diameter & Slot Size (in)	Screen Interval Depth		Screen Interval Elevation		Filterpack Interval Depth		CCNPP Hydrostratigraphic Unit
									Top (ft)	Bottom (ft)	Top (ft)	Bottom (ft)	Top (ft)	Bottom (ft)	
OW-769	216589.75	962559.47	54.23	54.39	56.43	42.0	42.0	2 / 0.010	31.8	41.8	22.4	12.4	18.0	42.0	Upper Chesapeake Unit
OW-770	215466.60	962826.95	121.59	121.79	123.08	42.0	42.0	2 / 0.010	30.0	40.0	91.6	81.6	28.0	42.0	Surficial Aquifer

Notes:

(1) Maryland State Plane (NAD 1927). The Maryland State Plane 1927 coordinate system is based on North American Datum of 1927 (NAD27). NAD27 is a surface (or plane) to which horizontal positions in the U.S., Canada and Mexico is surveyed and referenced.

(2) Elevation is top of PVC Well Casing. Reference Point for Groundwater Level Monitoring

Table 2.3.1-16 CCNPP Unit 3 Observation Well Water Level Elevations (Page 1 of 3)

Well ID	Ground Surface Elevation	Water Level Monitoring Reference Point Elevation	Depth to Water									Water Level Elevation								
			July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007	July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
OW-301	94.51	96.27	58.85	59.45	59.37	58.34	58.00	58.04	57.33	57.00	56.78	37.42	36.82	36.90	37.93	38.27	38.23	38.94	39.27	39.49
OW-313A	51.03	53.20	19.80	20.40	20.08	19.57	18.80	18.90	17.93	18.25	17.12	33.40	32.80	33.12	33.63	34.40	34.30	35.27	34.95	36.08
OW-313B	50.73	53.54	23.05	23.65	23.47	23.17	22.76	22.52	21.89	21.80	21.44	30.49	29.89	30.07	30.37	30.78	31.02	31.65	31.74	32.10
OW-319A	103.13	104.91	26.48	26.58	26.25	26.08	26.28	26.22	26.25	26.44	26.25	78.43	78.33	78.66	78.83	78.63	78.69	78.66	78.47	78.66
OW-319B	103.53	105.35	67.49	67.97	67.95	67.53	66.57	66.49	65.74	65.52	65.27	37.86	37.38	37.40	37.82	38.78	38.86	39.61	39.83	40.08
OW-323	106.96	109.69	27.80	28.22	28.37	28.13	27.96	27.26	26.88	26.45	26.52	81.89	81.47	81.32	81.56	81.73	82.43	82.81	83.24	83.17
OW-328	76.29	77.85	40.77	41.40	41.35	40.68	40.33	40.13	39.63	39.42	39.32	37.08	36.45	36.50	37.17	37.52	37.72	38.22	38.43	38.53
OW-336	97.11	99.07	60.99	61.36	61.52	60.45	60.42	60.19	59.65	59.20	59.25	38.08	37.71	37.55	38.62	38.65	38.88	39.42	39.87	39.82
OW-401	71.38	73.49	34.13	34.95	34.73	33.72	32.95	33.37	32.33	32.45	31.76	39.36	38.54	38.76	39.77	40.54	40.12	41.16	41.04	41.73
OW-413A	123.15	125.04	45.87	45.85	45.87	45.87	45.87	45.86	45.83	45.77	45.76	79.17	79.19	79.17	79.17	79.17	79.18	79.21	79.27	79.28
OW-413B	122.90	124.85	86.60	87.30	87.13	86.46	85.14	85.56	84.40	84.75	83.57	38.25	37.55	37.72	38.39	39.71	39.29	40.45	40.10	41.28
OW-418A	43.66	45.83	8.22	9.44	8.60	7.97	6.45	7.60	6.40	6.91	5.68	37.61	36.39	37.23	37.86	39.38	38.23	39.43	38.92	40.15
OW-418B	43.67	45.77	12.52	13.36	12.90	12.47	11.67	12.85	11.03	11.27	10.74	33.25	32.41	32.87	33.30	34.10	32.92	34.74	34.50	35.03
OW-423	111.12	113.16	29.77	30.04	30.03	29.93	29.78	29.54	29.02	28.76	28.38	83.39	83.12	83.13	83.23	83.38	83.62	84.14	84.40	84.78
OW-428	113.92	115.92	37.82	37.92	37.98	38.07	38.01	37.89	37.69	37.25	37.17	78.10	78.00	77.94	77.85	77.91	78.03	78.23	78.67	78.75
OW-436	108.13	110.39	31.68	32.06	31.85	31.55	31.08	31.40	30.60	31.05	30.28	78.71	78.33	78.54	78.84	79.31	78.99	79.79	79.34	80.11

Table 2.3.1-16 CCNPP Unit 3 Observation Well Water Level Elevations (Page 2 of 3)

Well ID	Ground Surface Elevation	Water Level Monitoring Reference Point Elevation	Depth to Water									Water Level Elevation								
			July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007	July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
OW-703A	44.02	45.65	27.33	27.84	28.05	27.93	27.60	27.12	25.16	25.60	22.15	18.32	17.81	17.60	17.72	18.05	18.53	20.49	20.05	23.50
OW-703B	45.57	47.53	29.34	29.85	29.95	29.73	29.40	29.10	27.45	27.72	24.74	18.19	17.68	17.58	17.80	18.13	18.43	20.08	19.81	22.79
OW-705	47.71	50.22	20.28	21.10	20.67	20.10	19.02	19.40	17.82	18.60	16.57	29.94	29.12	29.55	30.12	31.20	30.82	32.40	31.62	33.65
OW-708A	37.44	39.61	13.39	15.01	13.85	12.78	10.46	12.58	8.96	12.20	6.71	26.22	24.60	25.76	26.83	29.15	27.03	30.65	27.41	32.90
OW-711	52.92	55.31	19.26	20.64	19.50	18.43	16.14	18.33	15.94	17.70	14.33	36.05	34.67	35.81	36.88	39.17	36.98	39.37	37.61	40.98
OW-714	116.02	117.98	45.93	46.28	46.33	46.36	46.19	45.87	45.60	45.42	45.21	72.05	71.70	71.65	71.62	71.79	72.11	72.38	72.56	72.77
OW-718	118.53	120.41	40.47	40.56	40.80	41.07	41.29	41.37	41.18	40.40	40.22	79.94	79.85	79.61	79.34	79.12	79.04	79.23	80.01	80.19
OW-725	58.04	59.94	32.80	33.87	33.92	33.56	32.54	32.30	30.77	30.77	29.77	27.14	26.07	26.02	26.38	27.40	27.64	29.17	29.17	30.17
OW-729	118.88	121.11	44.08	41.99	41.96	41.96	41.92	41.99	41.98	41.98	41.98	77.03	79.12	79.15	79.15	79.19	79.12	79.13	79.13	79.13
OW-735	91.20	93.44	54.18	55.17	55.14	54.57	53.31	53.24	52.36	52.13	52.16	39.26	38.27	38.30	38.87	40.13	40.20	41.08	41.31	41.28
OW-743	103.65	105.89	37.22	37.77	37.52	37.35	37.22	36.99	36.61	36.03	35.80	68.67	68.12	68.37	68.54	68.67	68.90	69.28	69.86	70.09
OW-744	97.50	99.81	32.97	33.52	33.15	32.96	32.47	32.52	32.06	31.97	31.73	66.84	66.29	66.66	66.85	67.34	67.29	67.75	67.84	68.08
OW-752A	95.30	97.00	24.76	25.18	25.35	25.36	25.23	24.08	23.34	22.77	22.68	72.24	71.82	71.65	71.64	71.77	72.92	73.66	74.23	74.32
OW-752B	95.79	97.41	59.55	60.25	60.05	59.75	59.38	59.16	58.77	58.60	58.58	37.86	37.16	37.36	37.66	38.03	38.25	38.64	38.81	38.83
OW-754	67.00	68.85	31.32	32.05	31.80	31.05	30.73	30.93	30.24	30.12	29.67	37.53	36.80	37.05	37.80	38.12	37.92	38.61	38.73	39.18
OW-756	106.56	108.77	29.98	30.17	30.42	30.55	30.59	30.46	30.04	29.42	29.18	78.79	78.60	78.35	78.22	78.18	78.31	78.73	79.35	79.59
OW-759A	97.78	99.69	26.88	27.53	28.00	28.12	28.32	27.41	26.77	25.50	24.41	72.81	72.16	71.69	71.57	71.37	72.28	72.92	74.19	75.28
OW-759B	98.35	100.14	63.09	63.80	63.56	63.31	63.11	62.87	62.54	62.32	62.30	37.05	36.34	36.58	36.83	37.03	37.27	37.60	37.82	37.84
OW-765A	97.37	99.60	21.72	22.02	21.87	21.70	21.20	20.10	18.95	19.25	18.38	77.88	77.58	77.73	77.90	78.40	79.50	80.65	80.35	81.22

Table 2.3.1-16 CCNPP Unit 3 Observation Well Water Level Elevations
(Page 3 of 3)

Well ID	Ground Surface Elevation	Water Level Monitoring Reference Point Elevation	Depth to Water									Water Level Elevation								
			July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007	July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
OW-765B	96.82	98.47	60.22	60.72	60.55	60.40	59.92	59.77	59.73	59.45	59.37	38.25	37.75	37.92	38.07	38.55	38.70	38.74	39.02	39.10
OW-766	108.89	110.72	28.88	29.36	29.42	29.20	29.20	28.76	28.11	27.60	27.30	81.84	81.36	81.30	81.52	81.52	81.96	82.61	83.12	83.42
OW-768A	48.48	49.84	24.05	24.88	24.04	23.67	23.12	23.65	23.10	23.26	22.53	25.79	24.96	25.80	26.17	26.72	26.19	26.74	26.58	27.31
OW-769	54.23	56.43	26.50	27.96	27.37	26.74	24.13	25.74	23.48	24.43	20.55	29.93	28.47	29.06	29.69	32.30	30.69	32.95	32.00	35.88
OW-770	121.59	123.08	dry	42.10	42.09	42.08	42.09	42.11	42.10	42.10	42.10	dry	80.98	80.99	81.00	80.99	80.97	80.98	80.98	80.98

Notes:

Highlighted wells: Questionable water level readings due to proximity of depth of water to bottom of well screen and/or minimal water level fluctuations with time

Reading from water level round was 41.90. Review suggested questionable reading. Retaken 5 days later and reading was 30.04 ft

Table 2.3.1-17 CCNPP Unit 3 Observation Wells used in the Hydrogeologic Evaluation (Page 1 of 2)

Well ID	Aquifer Unit	Ground Surface Elevation	Water Level Monitoring Reference Point Elevation	Depth to Water											Water Level Elevation						
				July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007	July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Surficial Aquifer (SA)																					
OW-319A	SA	103.13	104.91	26.48	26.58	26.25	26.08	26.28	26.22	26.25	26.44	26.25	78.43	78.33	78.66	78.83	78.63	78.69	78.66	78.47	78.66
OW-323	SA	106.96	109.69	27.80	28.22	28.37	28.13	27.96	27.26	26.88	26.45	26.52	81.89	81.47	81.32	81.56	81.73	82.43	82.81	83.24	83.17
OW-423	SA	111.12	113.16	29.77	30.04	30.03	29.93	29.78	29.54	29.02	28.76	28.38	83.39	83.12	83.13	83.23	83.38	83.62	84.14	84.40	84.78
OW-428	SA	113.92	115.92	37.82	37.92	37.98	38.07	38.01	37.89	37.69	37.25	37.17	78.10	78.00	77.94	77.85	77.91	78.03	78.23	78.67	78.75
OW-436	SA	108.13	110.39	31.68	32.06	31.85	31.55	31.08	31.40	30.60	31.05	30.28	78.71	78.33	78.54	78.84	79.31	78.99	79.79	79.34	80.11
OW-714	SA	116.02	117.98	45.93	46.28	46.33	46.36	46.19	45.87	45.60	45.42	45.21	72.05	71.70	71.65	71.62	71.79	72.11	72.38	72.56	72.77
OW-718	SA	118.53	120.41	40.47	40.56	40.80	41.07	41.29	41.37	41.18	40.40	40.22	79.94	79.85	79.61	79.34	79.12	79.04	79.23	80.01	80.19
OW-743	SA	103.65	105.89	37.22	37.77	37.52	37.35	37.22	36.99	36.61	36.03	35.80	68.67	68.12	68.37	68.54	68.67	68.90	69.28	69.86	70.09
OW-752A	SA	95.30	97.00	24.76	25.18	25.35	25.36	25.23	24.08	23.34	22.77	22.68	72.24	71.82	71.65	71.64	71.77	72.92	73.66	74.23	74.32
OW-756	SA	106.56	108.77	29.98	30.17	30.42	30.55	30.59	30.46	30.04	29.42	29.18	78.79	78.60	78.35	78.22	78.18	78.31	78.73	79.35	79.59
OW-759A	SA	97.78	99.69	26.88	27.53	28.00	28.12	28.32	27.41	26.77	25.50	24.41	72.81	72.16	71.69	71.57	71.37	72.28	72.92	74.19	75.28
OW-765A	SA	97.37	99.60	21.72	22.02	21.87	21.70	21.20	20.10	18.95	19.25	18.38	77.88	77.58	77.73	77.90	78.40	79.50	80.65	80.35	81.22
OW-766	SA	108.89	110.72	28.88	29.36	29.42	29.20	29.20	28.76	28.11	27.60	27.30	81.84	81.36	81.30	81.52	81.52	81.96	82.61	83.12	83.42
Upper Chesapeake Unit (CU)																					
OW-301	CU	94.51	96.27	58.85	59.45	59.37	58.34	58.00	58.04	57.33	57.00	56.78	37.42	36.82	36.90	37.93	38.27	38.23	38.94	39.27	39.49
OW-313A	CU	51.03	53.20	19.80	20.40	20.08	19.57	18.80	18.90	17.93	18.25	17.12	33.40	32.80	33.12	33.63	34.40	34.30	35.27	34.95	36.08
OW-319B	CU	103.53	105.35	67.49	67.97	67.95	67.53	66.57	66.49	65.74	65.52	65.27	37.86	37.38	37.40	37.82	38.78	38.86	39.61	39.83	40.08
OW-328	CU	76.29	77.85	40.77	41.40	41.35	40.68	40.33	40.13	39.63	39.42	39.32	37.08	36.45	36.50	37.17	37.52	37.72	38.22	38.43	38.53
OW-336	CU	97.11	99.07	60.99	61.36	61.52	60.45	60.42	60.19	59.65	59.20	59.25	38.08	37.71	37.55	38.62	38.65	38.88	39.42	39.87	39.82

Table 2.3.1-17 CCNPP Unit 3 Observation Wells used in the Hydrogeologic Evaluation (Page 2 of 2)

Well ID	Aquifer Unit	Ground Surface Elevation	Water Level Monitoring Reference Point Elevation	Depth to Water											Water Level Elevation						
				July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007	July 2006	August 2006	September 2006	October 2006	November 2006	December 2006	January 2007	February 2007	March 2007
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Surficial Aquifer (SA)																					
OW-401	CU	71.38	73.49	34.13	34.95	34.73	33.72	32.95	33.37	32.33	32.45	31.76	39.36	38.54	38.76	39.77	40.54	40.12	41.16	41.04	41.73
OW-413B	CU	122.90	124.85	86.60	87.30	87.13	86.46	85.14	85.56	84.40	84.75	83.57	38.25	37.55	37.72	38.39	39.71	39.29	40.45	40.10	41.28
OW-418A	CU	43.66	45.83	8.22	9.44	8.60	7.97	6.45	7.60	6.40	6.91	5.68	37.61	36.39	37.23	37.86	39.38	38.23	39.43	38.92	40.15
OW-703A	CU	44.02	45.65	27.33	27.84	28.05	27.93	27.60	27.12	25.16	25.60	22.15	18.32	17.81	17.60	17.72	18.05	18.53	20.49	20.05	23.50
OW-705	CU	47.71	50.22	20.28	21.10	20.67	20.10	19.02	19.40	17.82	18.60	16.57	29.94	29.12	29.55	30.12	31.20	30.82	32.40	31.62	33.65
OW-708A	CU	37.44	39.61	13.39	15.01	13.85	12.78	10.46	12.58	8.96	12.20	6.71	26.22	24.60	25.76	26.83	29.15	27.03	30.65	27.41	32.90
OW-711	CU	52.92	55.31	19.26	20.64	19.50	18.43	16.14	18.33	15.94	17.70	14.33	36.05	34.67	35.81	36.88	39.17	36.98	39.37	37.61	40.98
OW-725	CU	58.04	59.94	32.80	33.87	33.92	33.56	32.54	32.30	30.77	30.77	29.77	27.14	26.07	26.02	26.38	27.40	27.64	29.17	29.17	30.17
OW-735	CU	91.20	93.44	54.18	55.17	55.14	54.57	53.31	53.24	52.36	52.13	52.16	39.26	38.27	38.30	38.87	40.13	40.20	41.08	41.31	41.28
OW-752B	CU	95.79	97.41	59.55	60.25	60.05	59.75	59.38	59.16	58.77	58.60	58.58	37.86	37.16	37.36	37.66	38.03	38.25	38.64	38.81	38.83
OW-754	CU	67.00	68.85	31.32	32.05	31.80	31.05	30.73	30.93	30.24	30.12	29.67	37.53	36.80	37.05	37.80	38.12	37.92	38.61	38.73	39.18
OW-759B	CU	98.35	100.14	63.09	63.80	63.56	63.31	63.11	62.87	62.54	62.32	62.30	37.05	36.34	36.58	36.83	37.03	37.27	37.60	37.82	37.84
OW-765B	CU	96.82	98.47	60.22	60.72	60.55	60.40	59.92	59.77	59.73	59.45	59.37	38.25	37.75	37.92	38.07	38.55	38.70	38.74	39.02	39.10
OW-768A	CU	48.48	49.84	24.05	24.88	24.04	23.67	23.12	23.65	23.10	23.26	22.53	25.79	24.96	25.80	26.17	26.72	26.19	26.74	26.58	27.31
OW-769	CU	54.23	56.43	26.50	27.96	27.37	26.74	24.13	25.74	23.48	24.43	20.55	29.93	28.47	29.06	29.69	32.30	30.69	32.95	32.00	35.88
Lower Chesapeake Unit (CL)																					
OW-313B	CL	50.73	53.54	23.05	23.65	23.47	23.17	22.76	22.52	21.89	21.80	21.44	30.49	29.89	30.07	30.37	30.78	31.02	31.65	31.74	32.10
OW-418B	CL	43.67	45.77	12.52	13.36	12.90	12.47	11.67	12.85	11.03	11.27	10.74	33.25	32.41	32.87	33.30	34.10	32.92	34.74	34.50	35.03
OW-703B	CL	45.57	47.53	29.34	29.85	29.95	29.73	29.40	29.10	27.45	27.72	24.74	18.19	17.68	17.58	17.80	18.13	18.43	20.08	19.81	22.79

Table 2.3.1-18 CCNPP Unit 3 Observation Wells Hydraulic Conductivities from Slug Tests (Page 1 of 1)

Well ID	Surficial Aquifer	Kh	Kh	Kh
		(ft/sec)	(cm/sec)	(ft/day)
OW-319A	SA	2.89E-06	8.81E-05	2.50E-01
OW-323	SA	6.24E-05	1.90E-03	5.39E+00
OW-423	SA	6.86E-05	2.09E-03	5.93E+00
OW-428	SA	1.19E-05	3.63E-04	1.03E+00
OW-436	SA	2.80E-06	8.53E-05	2.42E-01
OW-743	SA	6.23E-07	1.90E-05	5.38E-02
OW-752A	SA	7.03E-05	2.14E-03	6.07E+00
OW-756	SA	2.01E-04	6.13E-03	1.74E+01
OW-759A	SA	4.64E-07	1.41E-05	4.01E-02
OW-765A	SA	1.00E-05	3.05E-04	8.64E-01
	max	**2.01E-04**	**6.13E-03**	**1.74E+01**
	min	**4.64E-07**	**1.41E-05**	**4.01E-02**
	mean	**4.31E-05**	**1.31E-03**	**3.72E+00**
	geo mean	**1.05E-05**	**3.21E-04**	**9.10E-01**

Well ID	Upper Chesapeake Unit	Kh	Kh	Kh
		(ft/sec)	(cm/sec)	(ft/day)
OW-301	CU	1.58E-04	4.82E-03	1.37E+01
OW-313A	CU	7.50E-06	2.29E-04	6.48E-01
OW-319B	CU	3.42E-05	1.04E-03	2.95E+00
OW-328	CU	3.79E-06	1.16E-04	3.27E-01
OW-336	CU	2.10E-05	6.40E-04	1.81E+00
OW-401	CU	6.77E-06	2.06E-04	5.85E-01
OW-413B	CU	2.78E-06	8.47E-05	2.40E-01
OW-418A	CU	4.41E-06	1.34E-04	3.81E-01
OW-703A	CU	1.34E-05	4.08E-04	1.16E+00
OW-705	CU	4.99E-06	1.52E-04	4.31E-01
OW-708A	CU	2.56E-05	7.80E-04	2.21E+00
OW-711	CU	6.04E-06	1.84E-04	5.22E-01
OW-725	CU	7.54E-06	2.30E-04	6.51E-01
OW-735	CU	5.48E-05	1.67E-03	4.73E+00
OW-752B	CU	3.35E-06	1.02E-04	2.89E-01
OW-754	CU	5.29E-06	1.61E-04	4.57E-01
OW-759B	CU	1.77E-06	5.39E-05	1.53E-01
OW-765B	CU	1.36E-06	4.15E-05	1.18E-01
OW-768A	CU	5.29E-06	1.61E-04	4.57E-01
OW-769	CU	1.74E-05	5.30E-04	1.50E+00
	max	**1.58E-04**	**4.82E-03**	**1.37E+01**
	min	**1.36E-06**	**4.15E-05**	**1.18E-01**
	mean	**1.93E-05**	**5.87E-04**	**1.66E+00**
	geo mean	**8.56E-06**	**2.61E-04**	**7.40E-01**

Well ID	Lower Chesapeake Unit	Kh	Kh	Kh
		(ft/sec)	(cm/sec)	(ft/day)
OW-313B	CL	2.74E-07	8.35E-06	2.37E-02
OW-418B	CL	2.16E-07	6.58E-06	1.87E-02
OW-703B	CL	1.08E-06	3.29E-05	9.33E-02
	max	**1.08E-06**	**3.29E-05**	**9.33E-02**
	min	**2.16E-07**	**6.58E-06**	**1.87E-02**
	mean	**5.23E-07**	**1.60E-05**	**4.52E-02**
	geo mean	**4.00E-07**	**1.22E-05**	**3.45E-02**

Note: Slug test results for 7 Surficial Aquifer wells (OW-413A, OW-714, OW-718, OW-729, OW-766, and OW-770) are not included because of invalid test conditions, questionable data, or the well was screened in a discontinuous sand unit.

Table 2.3.1-19 CCNPP Unit 3 Aquifer Unit Geotechnical Parameters (Page 1 of 1)

Exploratory Boring	Sample Top Elevation ft (m)	Geotechnical Laboratory Test Results			Calculated Values		
		Natural Moisture (%)	Moisture Unit Weight (PCF)	Specific Gravity	Void Ratio	Porosity (%)	Effective Porosity (%)
Surficial Aquifer							
B-320	67.9 (20.7)	29.4%	124	2.63	0.713	41.6%	33.3%
B-722	66.3 (20.2)	26.8%	120	2.76	0.820	45.0%	36.0%
B-732	75.3 (23.0)	23.1%	124	2.75	0.704	41.3%	33.0%
				Mean =	0.745	42.7%	34.1%
Upper Chesapeake							
B-328	12.8 (3.9)	44.2%	121	2.66	0.978	49.4%	39.6%
B-321	-2.8 (-0.85)	28.5%	120.5	2.67	0.777	43.7%	35.0%
B-423	6.6 (2.0)	23.1%	120	2.74	0.754	43.0%	34.4%
B-420	-0.9 (-0.27)	28.3%	117	2.75	0.882	46.9%	37.5%
B-440	5.3 (1.6)	30.0%	116	2.75	0.923	48.0%	38.4%
				Mean =	0.863	46.2%	37.0%
Lower Chesapeake							
B-304	-30.5 (-9.3)	42.1%	113.2	2.65	1.076	51.82%	41.5%
B-401	-26.4 (-8.0)	50.5%	117	2.70	1.167	53.86%	43.1%
B-701	-38.8 (-11.8)	37.3%	116	2.64	0.950	48.71%	39.0%
				Mean =	1.064	51.5%	41.2%

Calculations:

Void Ratio = {Specific Gravity (x) Unit Weight of Water (x) [1+ Natural Moisture]/[Moisture Unit Weight]-1}

Unit Weight Water = 62.4

Porosity = {(Void Ratio)/(1+Void Ratio)}

Effective Porosity = 80% of Total Porosity)

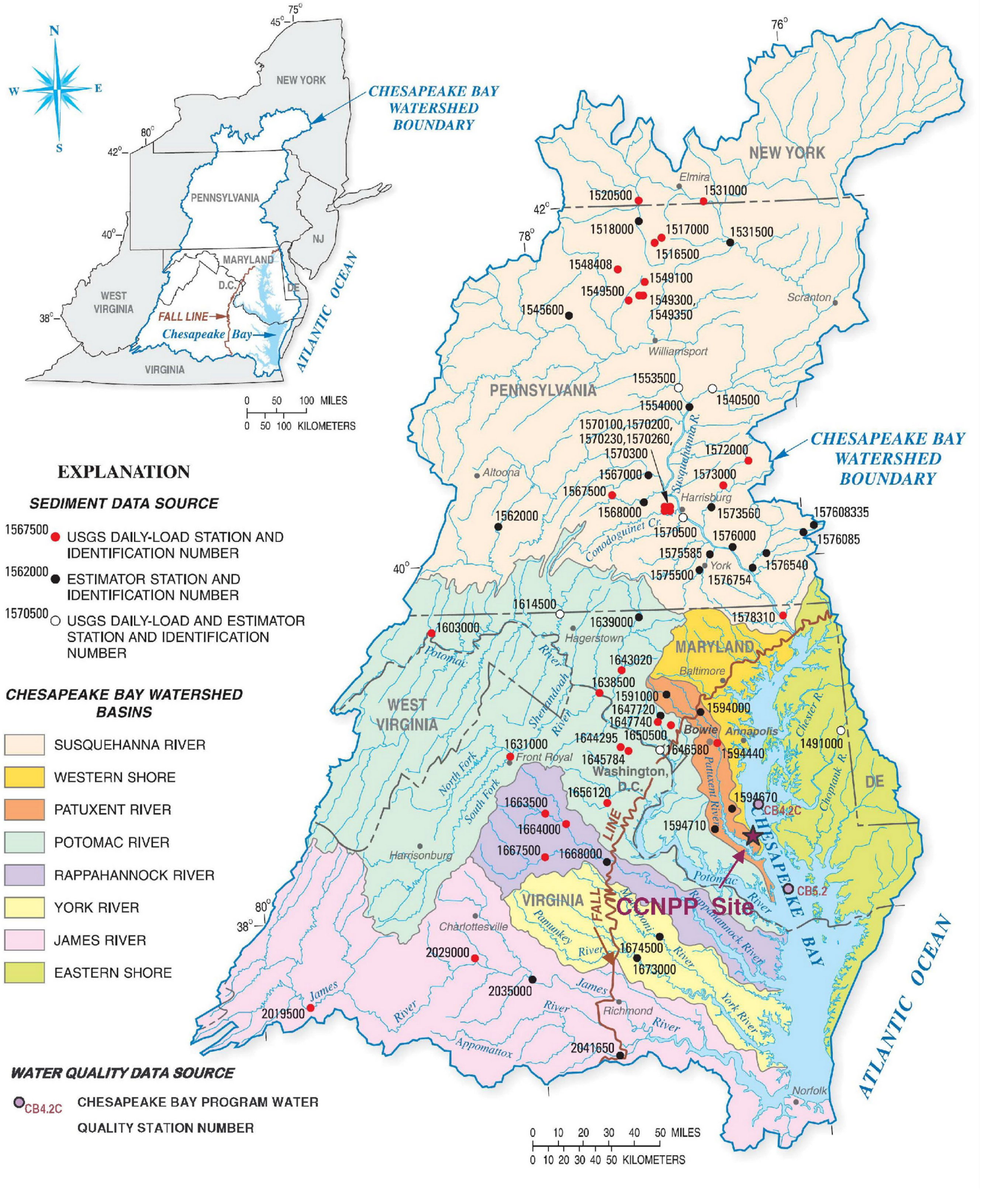

FIGURE 2.3.1-1 Rev. 0

CHESAPEAKE BAY WATERSHED

CCNPP UNIT 3 ER

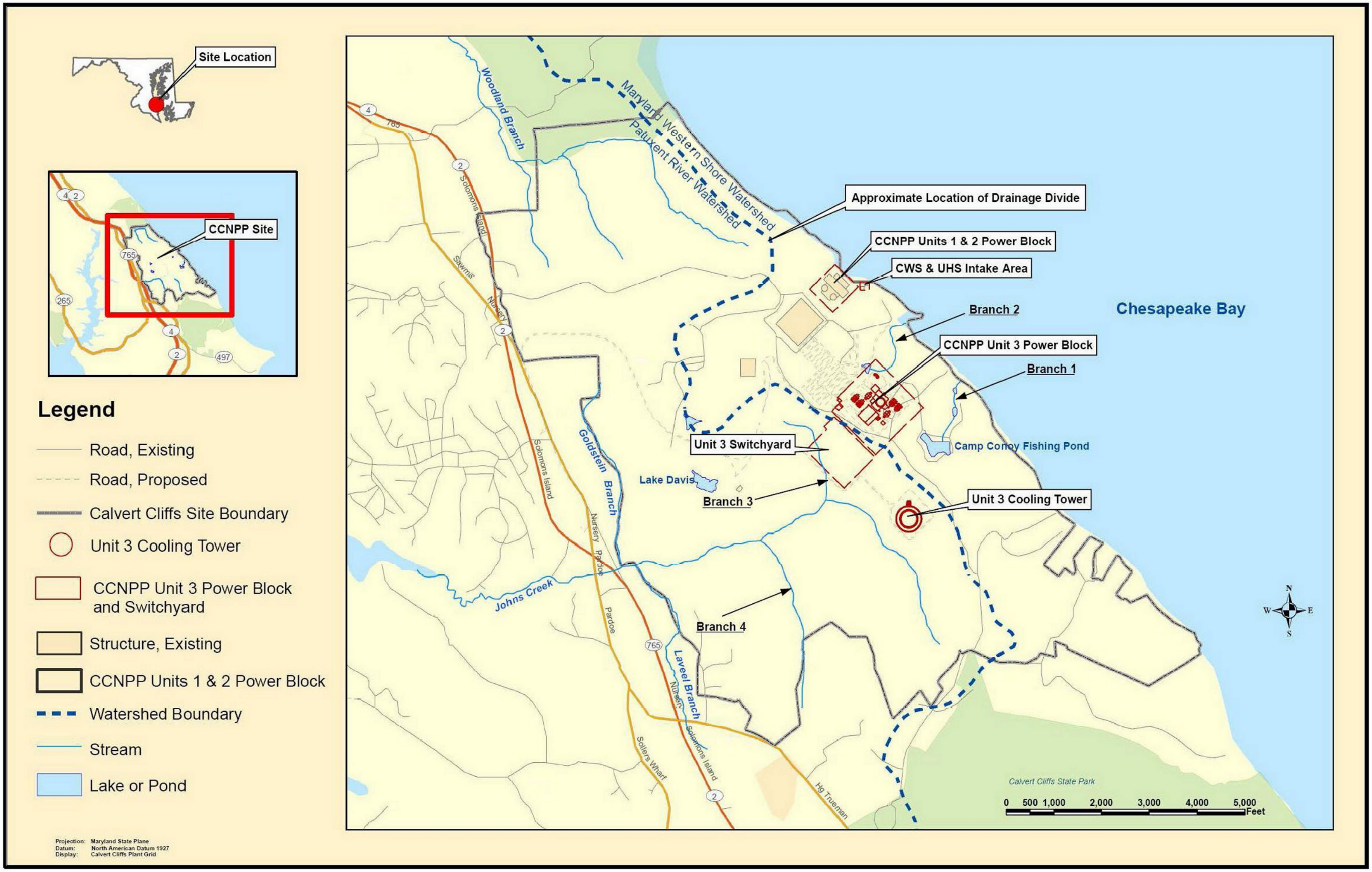

FIGURE 2.3.1-2 Rev. 0

CCNPP SITE AREA
TOPOGRAPHY AND DRAINAGE

CCNPP UNIT 3 ER