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July 16, 2008

Terry J. Romine
Executive Secretary
Public Service Commission of Maryland
6 St. Paul Street
Baltimore, Maryland 21202

By electronic and surface mail

Re: PSC Case 9127, In the Matter of the Application of Unistar Nuclear Energy, LLC and Unistar Nuclear Operating Services, LLC for a CPCN to Construct a Nuclear Power Plant at Calvert Cliffs in Calvert County, Maryland.

Dear Ms. Romine:

Enclosed for filing in the above captioned case are the original and 16 copies of the Direct Testimony and Exhibits of the Power Plant Research Program of the Department of Natural Resources. Due to the size of the filing, it will be submitted in multiple parts. The first part will contain PPRP's direct testimony and the agency letter of recommendation. The second part will include the environmental review document.

Thank you for your attention to this matter.

Sincerely,

M. Brent Hare
Assistant Attorney General

cc: Parties/Service List
Brent A. Bolea, AAG
Susan Gray, PPRP

Fax: (410) 974-2250

Certificate of Service

I hereby certify this 16th Day of July 2008, that I served copies of the Direct Testimony and Exhibits of the Department of Natural Resources, Power Plant Research Program on the parties listed on the Commission's Service List for PSC Case 9127, dated July 10, 2008.

M. Brent Hare
Assistant Attorney General

MARYLAND DEPARTMENT OF NATURAL RESOURCES

PSC Case No. 9127

Exhibit ___ (SG-3)

PPRP

Environmental Review of Proposed Unit 3 at Calvert Cliffs Nuclear Power Plant

DRAFT

MARYLAND POWER PLANT RESEARCH PROGRAM

16 July 2008

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APPENDICES

A *INITIAL RECOMMENDED LICENSING CONDITIONS*

B *SELECTED RESPONSES FROM UNISTAR TO DEPARTMENT OF NATURAL RESOURCES DATA REQUESTS*

C *BACKGROUND INFORMATION ON RADIOLOGICAL EMERGENCY PLANNING*

D *AIR EMISSIONS CALCULATIONS*

E *CORRESPONDENCE FROM STATE AGENCIES*

1.0 INTRODUCTION

1.1 BACKGROUND

UniStar Nuclear Energy LLC and UniStar Nuclear Operating Services (UniStar, or the Co-Applicants) have submitted an application to the Maryland Public Service Commission (PSC) to add a third nuclear power reactor to Calvert Cliffs Nuclear Power Plant (CCNPP) in Calvert County, Maryland (see general location in Figure 1-1). The new unit would be designated as Calvert Cliffs Unit 3. The proposed new nuclear power unit would generate electricity to be sold into the regional PJM market.

The Department of Natural Resources (DNR) Power Plant Research Program (PPRP), coordinating with other State agencies, performed this environmental review of the Calvert Cliffs project as part of the PSC licensing process. Before development of the proposed Unit 3 can begin at the site, the PSC must grant a Certificate of Public Convenience and Necessity (CPCN). PPRP's review is being conducted to evaluate the potential impacts to environmental, socioeconomic and cultural resources from the proposed unit, pursuant to Section 3-304 of the Natural Resources Article of the Annotated Code of Maryland.

PPRP used the analysis of potential impacts as the basis for establishing initial recommended licensing conditions for constructing and operating the new facility, pursuant to Section 3-306 of the Natural Resources Article. PPRP's recommendations are made in concert with other programs within DNR as well as the Departments of Agriculture, Business and Economic Development, Environment, Planning, and Transportation, and the Maryland Energy Administration; they represent consolidated Executive Branch recommendations to the PSC. The initial recommended licensing conditions are included as Appendix A to this report.

The U.S. Nuclear Regulatory Commission (NRC) regulates the construction and operation of new nuclear power facilities at the federal level. The NRC is responsible for issuing standard design certifications and operating licenses for commercial nuclear power facilities. The NRC uses regulatory requirements, licensing, and oversight, including inspection, to regulate reactor siting, construction, and operation.

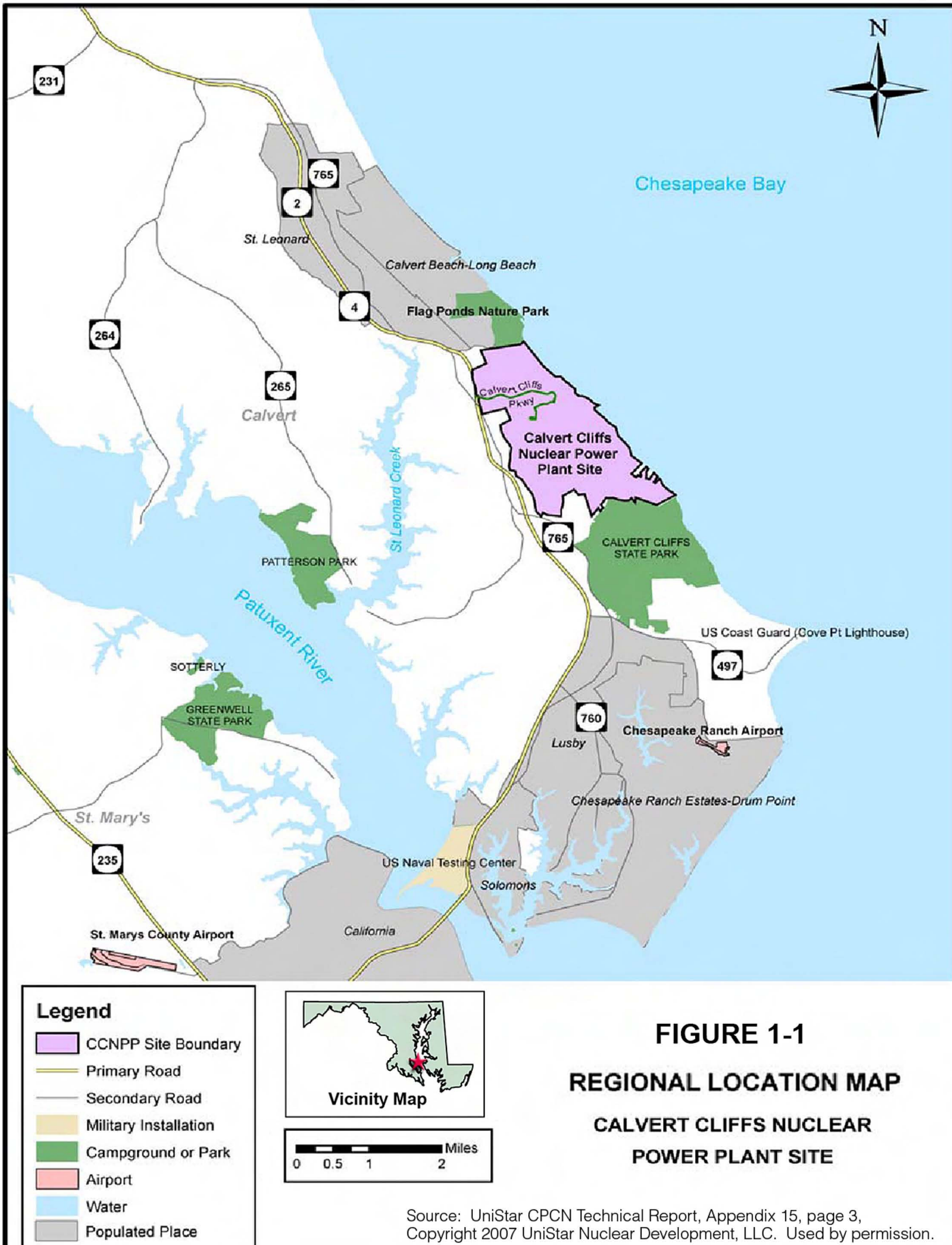


FIGURE 1-1

REGIONAL LOCATION MAP

CALVERT CLIFFS NUCLEAR POWER PLANT SITE

Source: UniStar CPCN Technical Report, Appendix 15, page 3,
Copyright 2007 UniStar Nuclear Development, LLC. Used by permission.

In addition to a Maryland CPCN, UniStar is seeking a combined operating license (COL) for construction and operation of Calvert Cliffs Unit 3 from the NRC. A COL, when issued, is authorization from the NRC to construct and operate a nuclear power plant at a specific site and in accordance with applicable laws and regulations. The NRC must be satisfied that the plant will be properly constructed and will operate safely. Through the COL review process, the NRC develops design-specific, pre-approved performance standards that a licensee must meet before the NRC will approve the loading of fuel and commencement of plant operation. The NRC estimates that a decision on the proposed Calvert Cliffs Unit 3 license will be made during 2011.

1.2 *PROJECT SCHEDULE AND NRC LICENSING*

UniStar's goal is for Calvert Cliffs Unit 3 to begin commercial operation in December 2015. To achieve that goal, UniStar states that it needs to begin site clearing and pre-construction activities as early as December 2008. UniStar seeks to obtain a CPCN by December 2008 and a COL from the NRC in 2011. After receiving a CPCN, NRC rules would allow UniStar to commence limited site preparation and certain non-safety related pre-construction[1] activities prior to obtaining final COL approval.

Specifically, under NRC regulations,[2] UniStar could conduct the following types of activities prior to obtaining its operating license:

- removal of trees and other vegetation;
- site grading;
- excavation for all permanent structures planned for the site;
- preparation of construction laydown areas, access roads, and parking lots;
- installation of concrete production facilities to support construction;
- installation of structures to support the construction project, such as trailers, sanitary water supply, and sewage systems; and

---

[1] NRC regulations also allow applicants to proceed with certain types of construction activities before obtaining a Combined License if they are granted a Limited Work Authorization from the NRC. 10 CFR 50.10(d).

[2] 10 CFR 50.10

- construction of permanent buildings that are not safety-related, such as administration or other support buildings.

These pre-construction activities would be allowed under a CPCN. In its response to DNR Data Request No. 7-5 in this licensing case (PSC Case No. 9127), UniStar states that it has not yet finalized plans for the specific activities it will undertake prior to receiving an NRC license to operate. The Co-Applicants currently plan to perform site clearing and preliminary grading, and possibly begin construction of non-safety related support structures (including but not limited to a warehouse and a concrete batch plant) that may support construction and possibly operation of the unit. UniStar notes that these activities will only be undertaken after the necessary State and federal approvals are received, including those from the Maryland Historical Trust, U.S. Army Corps of Engineers, Maryland Department of the Environment, Chesapeake Bay Critical Area Commission, and the PSC. The recommended licensing conditions included in Appendix A contain several conditions that would require UniStar to obtain these specific approvals. It should be noted that in the context of these conditions, "prior to construction" refers to any of the activities defined as site preparation or pre-construction under NRC rules.

PPRP recommends that UniStar be required to prepare a site redress plan in the event that UniStar commences site development activities and the NRC does not grant an operating license, or UniStar decides to abandon or indefinitely postpone its plans for Calvert Cliffs Unit 3. The specific measures to be taken would depend upon what stage of development the project had reached when work is halted. UniStar would be required to submit the site redress plan to the PSC within 60 days of announcing its decision to abandon construction.

1.3 REPORT OBJECTIVES AND ORGANIZATION

This document discusses the Executive Branch's analysis of potential environmental and socioeconomic impacts as a result of the construction and operation of Calvert Cliffs Unit 3. These evaluations form the basis for the Executive Branch's recommended licensing conditions, as mentioned earlier.

The scope of the CPCN review does not encompass those issues where the NRC has regulatory jurisdiction. Specifically, radiological safety, nuclear waste disposal, and similar topics are all analyzed in detail within the environmental and safety analysis review process under the NRC regulations.

This Environmental Review document is organized into the following major sections:

- Section 2 provides a description of the proposed facility, as well as a brief overview of the existing Calvert Cliffs Units 1 and 2.
- Section 3 describes existing conditions at the Calvert Cliffs site and vicinity.
- Section 4 includes the analysis of potential air quality impacts from construction and operation of Calvert Cliffs Unit 3.
- Section 5 discusses the potential impacts to aquatic and terrestrial resources, water quality, socioeconomics, and noise.
- Section 6 describes the water requirements for construction and operations, evaluates water supply sources, and presents potential impacts associated with water use.
- Section 7 summarizes the conclusions of PPRP's review.

2.0 PROJECT DESCRIPTION

2.1 SITE DESCRIPTION

The proposed project, Calvert Cliffs Unit 3, will be located just south of the existing Units 1 and 2, which have been in operation at the site since the mid-1970s, as shown in Figure 2-1. The entire Calvert Cliffs site consists of 2,070 acres, of which less than 300 acres would be permanently developed as a result of Unit 3 construction. The site is on the west bank of the Chesapeake Bay, 10.5 miles southeast of Prince Frederick in Calvert County, Maryland, and 4.5 miles northwest of Cove Point.

2.2 EXISTING FACILITY

Calvert Cliffs Units 1 and 2, owned by Constellation Nuclear, have been in operation since 1975 and 1977, respectively. Both are pressurized light-water reactors, which utilize water from the Chesapeake Bay in once-through condenser cooling systems. Unit 1 has a General Electric steam turbine, and the Unit 2 turbine is a Westinghouse Electric Corporation design. Each unit has a design rating of 845 MW of electric output. In 2000, Calvert Cliffs became the first U.S. nuclear power plant to obtain a 20-year license renewal from the NRC, extending the licensed life of the two units until 2034 and 2036. The existing facility includes an independent spent fuel storage installation (ISFSI) that has been licensed by the NRC and has adequate capacity to accommodate spent fuel from Units 1 and 2 through their permitted operating horizons.

PPRP has monitored radionuclide levels in the Chesapeake Bay and environment surrounding Calvert Cliffs since operation began in 1975. Reports documenting these monitoring activities and the data collected are available from PPRP (for instance, Jones *et al*., 2008; Jones and McLean, 2005).

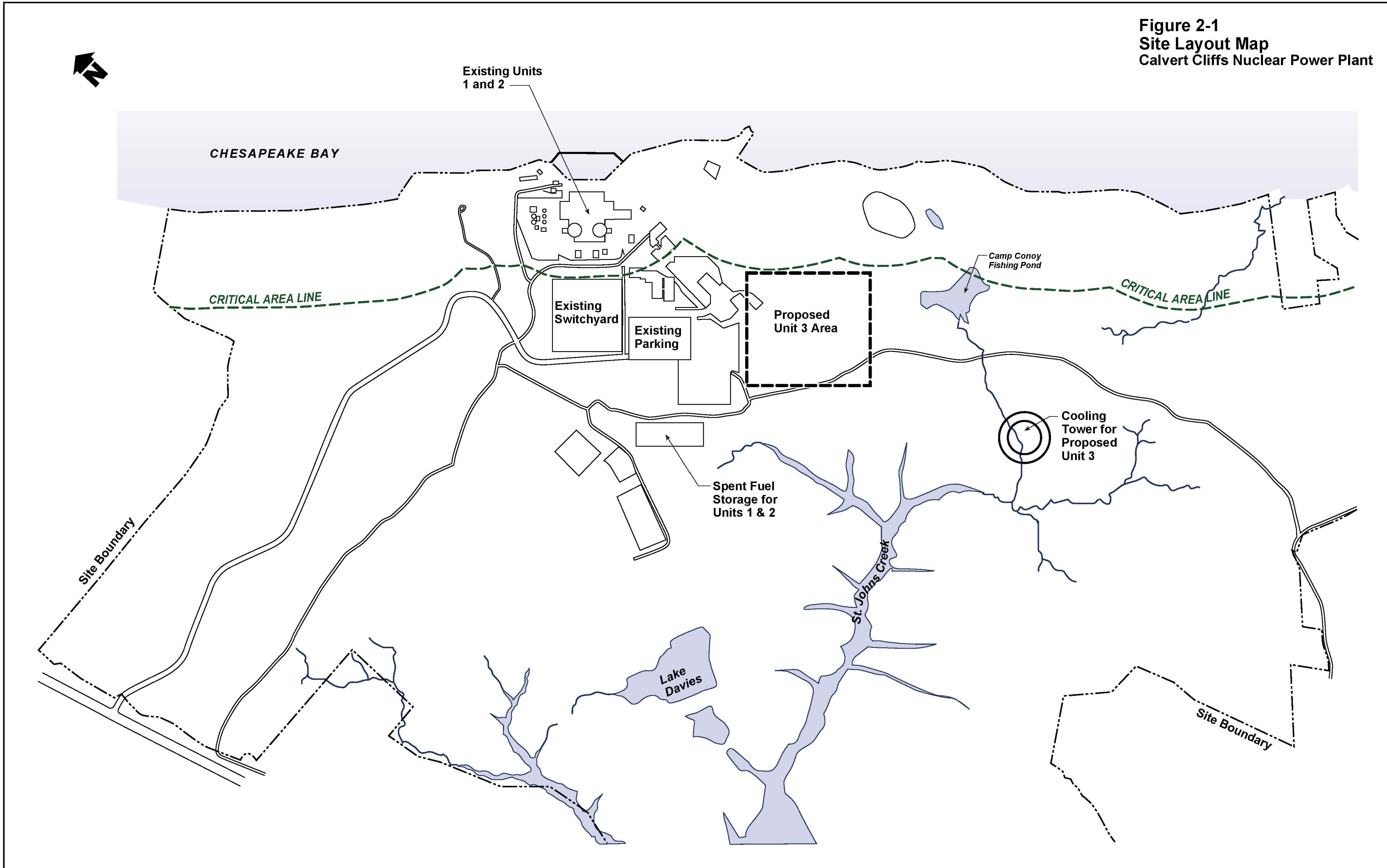


Figure 2-1
Site Layout Map
Calvert Cliffs Nuclear Power Plant
N
CHESAPEAKE BAY
Existing Units
1 and 2
CRITICAL AREA LINE
Existing
Switchyard
Existing
Parking
Proposed
Unit 3 Area
Camp Conoy
Fishing Pond
CRITICAL AREA LINE
Cooling
Tower for
Proposed
Unit 3
Spent Fuel
Storage for
Units 1 & 2
St. Johns Creek
Site Boundary
Lake
Davies
Site Boundary

2.3 PROPOSED PROJECT COMPONENTS

2.3.1 Power Block

The Co-Applicants are seeking to build and operate Calvert Cliffs Unit 3 utilizing the U.S. Evolutionary Power Reactor (U.S. EPR) manufactured by AREVA NP Inc.[1] The U.S. EPR is a four-loop nuclear power plant of the pressurized water reactor (PWR) type. Figure 2-2 depicts an overview of the U.S. EPR design that will be used for Calvert Cliffs Unit 3. Each loop has one reactor coolant pump, one steam generator, associated piping, and related control and protection systems, including a pressurizer to maintain system pressure. Unit 3 will utilize enriched uranium dioxide sintered pellets in zirconium-alloy clad tubing.

Support buildings in the power block include the reactor building, the turbine and switchgear buildings, Essential Service Water Buildings 1 – 4, Emergency Power Generating Buildings 1 – 4, Safeguard Buildings (Mechanical and Electrical) 1 – 4, the Nuclear Auxiliary Building, and the Radioactive Waste Processing Building.

Calvert Cliffs Unit 3 is expected to generate a net electrical output of approximately 1,600 MW[2] (nearly equaling the generation capacity of Calvert Cliffs Units 1 and 2 combined). It will be the largest single unit nuclear reactor in the United States and one of the largest reactors in the world. Two power plants using AREVA's EPR design are currently under construction, one in Olkiluoto, Finland, and the other in Flamanville, France.

2.3.2 Cooling Water Systems

Two major cooling systems will be used: the circulating water system (CWS) and the essential service water system (ESWS). These systems, as well as the overall steam cycle for the proposed facility, are schematically illustrated in Figure 2-3, with additional details provided in the flow diagrams in Figures 6-1 and 6-2. The steam cycle of a nuclear power plant operates in much the same way as that of a conventional fossil fuel-fired

---

[1] AREVA NP Inc., headquartered in Lynchburg, Virginia, is the U.S. subsidiary of AREVA NP, a French company providing equipment and services to the nuclear power industry.

[2] Nameplate capacity = 1710 MW. Plant operations at Calvert Cliffs Unit 3 will consume an estimated 110 MW onsite.

Figure 2-2
U.S. EPR Layout Schematic
Calvert Cliffs Unit 3

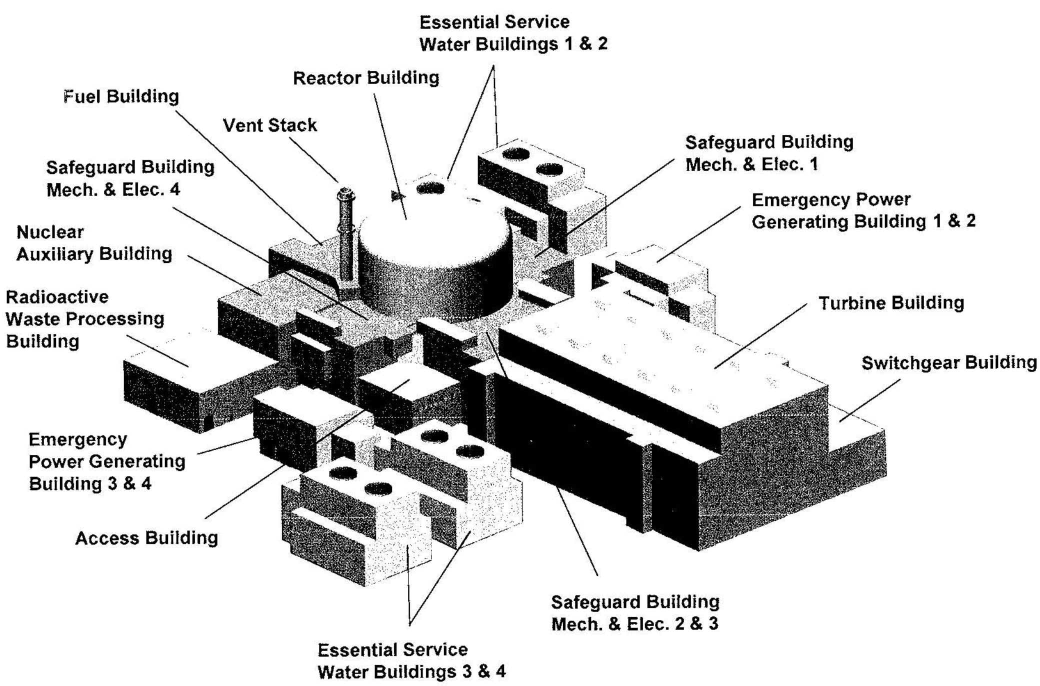
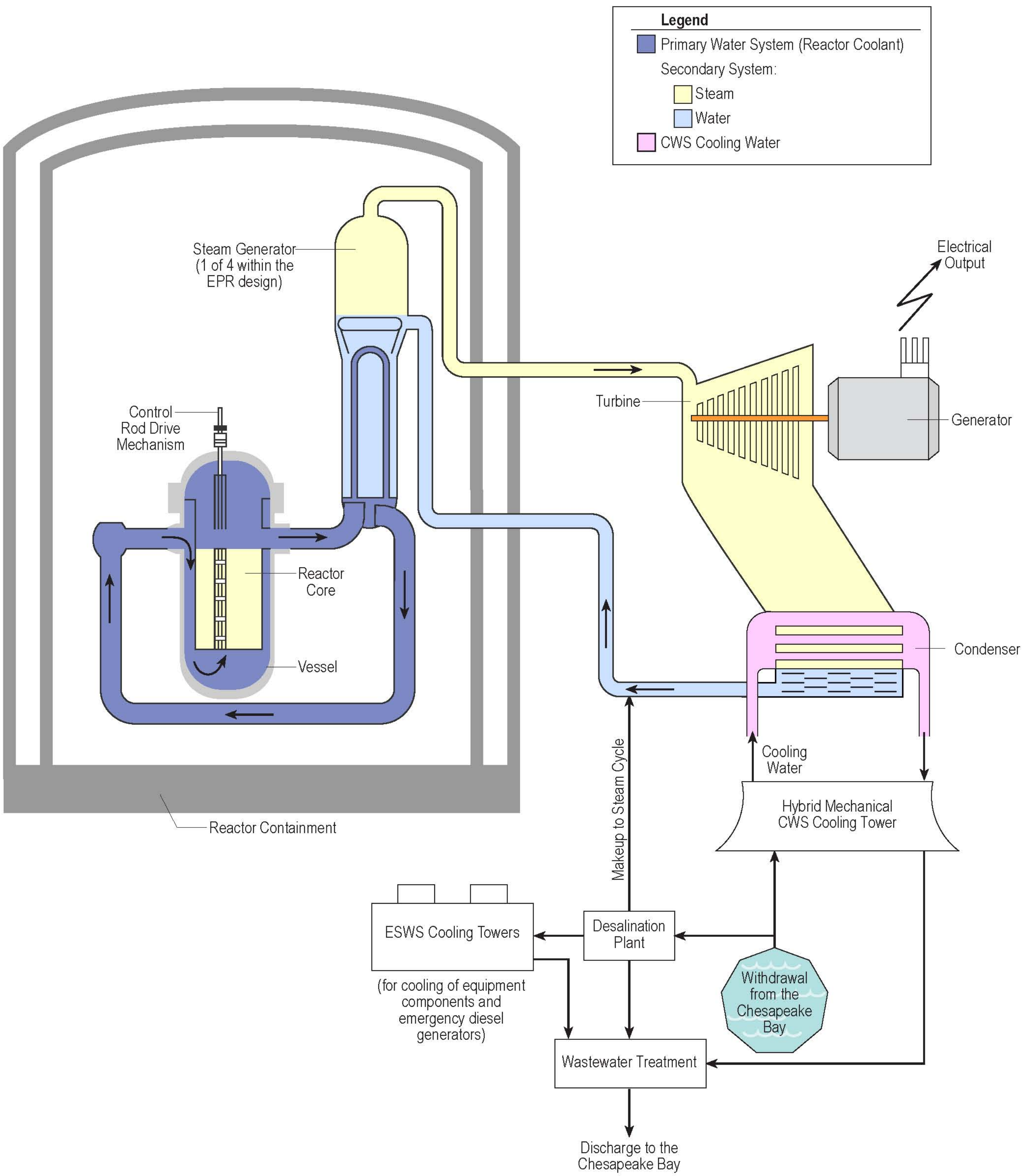


Figure 2-3
Illustration of Water Flow within the U.S. EPR Proposed at Calvert Cliffs



Source: Adapted from Areva NP, U.S. EPR booklet, pages 4-5 (provided to PPRP by UniStar in April 2007).

plant, except that the nuclear fission process within the reactor is the source of initial heat instead of the combustion of fossil fuel in a boiler. Water is used in the primary reactor cooling circuit to remove heat from the reactor core. This heat is transferred to the turbine through the steam generators. From the reactor core coolant circuit (primary circuit) to the steam circuit used to feed the turbine (secondary circuit), only heat is transferred and there is no water exchange.

Circulating Water System

The CWS and associated hybrid cooling tower will dissipate waste heat during normal plant operation. This is a closed-cycle, wet cooling system, and the majority of the water used at proposed Unit 3 is required to operate this system. The heated cooling water from the main condenser is sent to the spray headers of the cooling tower, where heat content of the cooling water is transferred to the ambient air via evaporative cooling and conduction. After passing through the cooling tower, the cooled water is recirculated back to the main condenser to complete the closed cycle cooling water loop. Makeup water from the Chesapeake Bay is required to replace evaporative water losses, drift losses, and blowdown discharge from the CWS cooling tower. The hybrid cooling tower is designed with a plume abatement system to minimize any visible water vapor plume from the tower.

Makeup water for the CWS will be taken from the Chesapeake Bay by pumps installed in a new intake structure located south of the existing Calvert Cliffs Units 1 and 2 intake structure. The makeup water is pumped through a common header directly to the cooling tower basin. Blowdown from the cooling tower discharges to a common retention basin to provide retention time for the settling of suspended solids and to permit further chemical treatment of the wastewater, if required, prior to discharge to the Chesapeake Bay.

Essential Service Water System

The U.S. EPR design has a safety-related Essential Service Water System (ESWS) to provide cooling water for various components located in the Safeguards Building and to the cooling jackets of the emergency diesel generators. The ESWS is a closed-loop system with four independent, two-cell mechanical draft cooling towers to dissipate heat.

A desalination plant processing water from the Chesapeake Bay will provide makeup water to the ESWS system. This is a much smaller flow compared to the CWS cooling tower makeup; of the approximately 54 million gallons per day (mgd) that would be withdrawn from the Bay as an annual average, less than 10 percent would be directed to the desalination plant. A more detailed and quantitative discussion of the overall water balance is provided in Section 6 of this report.

While the majority of the desalinated water supplies the ESWS, a small fraction of the desalinated water (less than 5 percent) is treated further and may be used to makeup losses in the secondary circuit feeding the steam generators. Reject water from the desalination plant would be combined with the blowdown from the CWS cooling tower and the ESWS cooling towers and would be monitored and treated prior to discharge to the Chesapeake Bay.

2.3.3 *Solid Waste*

Existing Units 1 and 2 generate non-hazardous waste, sanitary waste, hazardous waste, mixed waste, and nuclear waste in the form of low-level radiological waste and spent nuclear fuel. Unit 3 is anticipated to produce similar wastes to those produced by Units 1 and 2. Based on the operating experience at Calvert Cliffs Units 1 and 2, it is expected that Calvert Cliffs Unit 3 will recycle, recover, or send offsite for disposal virtually all solid waste (other than spent fuel).

Radioactive material includes the reactor core itself and the reactor coolant system, including its associated systems and components and water (system coolant). Effluent from the reactor coolant system is collected, processed, and monitored before it is discharged, while solid wastes are collected and packaged for temporary storage, shipment, and offsite disposal. Solid wastes, currently generated by Units 1 and 2 and anticipated to be generated by Unit 3, include resins from the spent fuel pool demineralization, reactor coolant purification, liquid waste demineralization, and the boron recycler ion exchange system; spent radiation filter cartridges; and dry active waste (DAW), which includes paper, rags, and other materials from inside the radiation control area. DAW wastes can be classified as compactable (such as paper or rags) or non-compactable (such as scrap metal or glass). Additionally, any sludges or solids which are generated during the treatment of liquid radioactive wastes (e.g., via centrifuge or tank bottoms) are also classified as low-level radiological waste and processed as solid wastes.

When spent fuel rods are removed from Unit 3's reactor core, the rods will be submerged in a spent fuel pool dedicated to Unit 3 to cool and allow for radioactive decay. Spent fuel rods will be stored in the pool until pool capacity is reached, which is estimated to occur after about 10 years of plant operation. If no permanent storage facility is operational after 10 years of plant operation, UniStar states that one option would be to locate a dry cask spent fuel storage facility on the Unit 3 site, similar to the existing storage facility associated with Units 1 and 2 (UniStar CPCN Technical Report, November 2007, Appendix D, page D-1).

Mid- and low-level radiological waste from Unit 3 will be handled and disposed of similar to wastes generated by Units 1 and 2. Resins are placed into 55-gallon drums, a vacuum and a heating element are applied, and any remaining liquid is removed from the resin in the drum. Once the resin has been dried and compacted, the drum is placed into a larger, shielded drum and moved to the mid-level radiological waste storage. Once sufficient decay has occurred, the drums are moved from mid-level storage to low-level storage, prior to off-site disposal by a licensed company. Spent filter cartridges are also placed into shielded drums and stored in the mid-level radiological waste storage area until sufficient decay has occurred to move them to the low-level waste storage area. Filters are also sent off-site for disposal with a licensed company.

DAW which is compactable is compressed into drums and stored in the low-level radiological waste storage area until it is disposed of. Non-compactable DAW is stored in containers capable of containing the waste until it can be disposed of.

Unit 3 is also anticipated to generate amounts of hazardous waste and mixed waste (non-hazardous solid waste mixed with radioactive waste) similar to the amounts currently generated by Units 1 and 2. Over the past six years, Units 1 and 2 generated an average of 11,400 pounds (5,200 kilograms) of hazardous waste annually, largely consisting of waste paint. Aqueous ammonia solution and used oil were also significant hazardous waste streams. Hazardous waste generated by Unit 3 will be handled similarly to the hazardous waste currently generated by Units 1 and 2, and will be transported by a licensed handler to a licensed treatment, storage and disposal facility. UniStar states that it will develop and maintain a Hazardous Waste Minimization Plan to document the current and planned efforts to reduce the amount or toxicity of the hazardous waste to be generated at Calvert Cliffs Unit 3.

Mixed wastes, or hazardous wastes which have become contaminated with radioactive wastes, are expected to be generated in very small amounts, similar to the amounts currently generated by Units 1 and 2. The last shipment of mixed waste from Calvert Cliffs's campus was approximately 55 gallons in 2004. Prior to that, the previous mixed waste shipment was in 1999.

Non-hazardous solid waste includes recyclable materials (such as office paper and aluminum cans), land-clearing debris (such as earthen material or vegetation debris), screen debris from Chesapeake Bay intakes, general refuse (such as food waste), and scrap metal and other recyclable materials (such as used oil or antifreeze). Materials which can be recycled are sent off-site to the appropriate recycling facilities, while land-clearing debris is placed in Calvert Cliffs's existing on-site facility. General refuse which can not be disposed of at Calvert Cliffs's existing on-site facility is transported to an off-site landfill facility.

2.3.4 *Transmission*

The existing transmission system consists of two circuits, the North Circuit which connects the Calvert Cliffs site to the Waugh Chapel Substation in Anne Arundel County and the South Circuit that connects the Calvert Cliffs site to the Mirant Chalk Point Generating Station in Prince George's County. No additional transmission corridors or other offsite land use would be required to connect the new reactor unit to the existing electrical grid. One new 500 kV substation to transmit power from Calvert Cliffs Unit 3, and two new 500 kV, 3500 MVA circuits, 1.0 mi (1.6 km) in length, on individual towers, will need to be constructed to connect the Calvert Cliffs Unit 3 substation to the existing Calvert Cliffs Units 1 and 2 substation. This line will be part of this CPCN and will not require a separate evaluation.

3.0 *EXISTING SITE CONDITIONS*

Information in this section of the report was adapted and supplemented from UniStar's Technical Report in support of its CPCN application before the Maryland Public Service Commission (UniStar, 2007).

3.1 *TOPOGRAPHY, SOILS, GEOLOGY, AND GROUND WATER*

3.1.1 *Topography*

The topography of the site varies from sea level along the shoreline of the Chesapeake Bay to just less than 140 feet above mean sea level (msl) in the uplands. Along the shoreline, elevations change abruptly from sea level to an average of approximately 100 feet msl along the cliff tops abutting the shoreline. The rolling hills in the upland areas grade into ravines that channel water to the creeks and streams that drain the site. The distinctive upland topography of the site area is a result of the repeated steepening and flattening of stream gradients in response to fluctuations in sea level (Glaser, 1968). Where upland areas have been dissected by streams, valley walls are typically steep with relatively sharp changes in relief. Delineated by a topographical divide, the eastern portion of the site drains into the Maryland Western Shore watershed and the western portion, the Lower Patuxent River watershed.

3.1.2 *Soils*

Located in the Atlantic Coastal Plain Physiographic province in Maryland, the soils of the proposed Unit 3 site consist of well drained gravelly loamy sand to loamy sand (USDA, 2008) typical of the upland areas of Southern Maryland. The capacity of a porous medium to transmit water through a unit cross-sectional area is represented by the magnitude of the hydraulic conductivity. Hydraulic conductivity is primarily dependent upon the physical properties of the porous medium and is expressed in units of length/time. Saturated hydraulic conductivities for surface soils vary from less than one foot per day (ft/day) to approximately 40 ft/day (USDA, 2008).

3.1.3 *Geology*

The Coastal Plain in southern Maryland consists of 2,600 feet of southeast dipping unconsolidated sedimentary deposits. The deposits are made up of clay, silt, sand, and gravel. The sediments of the Coastal Plain form a series of interbedded aquifers and confining beds ranging in age from Triassic to Holocene with the younger formations outcropping successively towards the southeast across southern Maryland and the Eastern Shore. Basement rocks of Precambrian and Paleozoic age underlie the Coastal Plain sediments.

Table 3-1 summarizes the Calvert Cliffs geologic and hydrostratigraphic units in southern Maryland. A schematic geologic cross-section for the region is shown in Figure 3-1. The Coastal Plain stratigraphy presented in Figure 3-1 and Table 3-1 and described below is based on the interpretations presented in Maryland Geological Survey Reports prepared by Achmad and Hansen (1997) and Drummond (2007).

- The undifferentiated sand, gravel, loam, and clay of upper Pliocene to Holocene age make up the minor and uppermost water bearing strata of the Lowland and Upland Deposits.
- The clayey and relatively impermeable formations of the Chesapeake Group underlie the surficial deposits and act as an effective upper confining unit for the Piney Point Formation.
- The Piney Point Formation consists of coarse quartz sand with commonly occurring zones of calcite-cemented sand and shell beds.
- The Nanjemoy Formation that progresses from sand at the Piney Point basal contact to predominately clayey material at depth.
- The generally pink to gray colored plastic clay of the Marlboro formation underlies the Nanjemoy.
- The Aquia Formation consists of a medium to coarse grained glauconitic quartz sand with typically minor amounts of shell material. Although the Aquia is predominately sand, some zones may contain significant quantities of clay and silt (Chappelle and Drummond, 1983). The Aquia aquifer is separated from the underlying Cretaceous age aquifers by the silty and clayey Cretaceous and Paleocene Brightseat confining unit within the Brightseat Formation.

Below the Brightseat Confining Unit are the Cretaceous age Magothy, Patapsco, and Patuxent Formations. Although potentially productive, the Patapsco and Patuxent Formations are not currently used extensively in southern Calvert County and not used at Calvert Cliffs as a source of ground water, and are therefore not discussed below.

3.1.4 Hydrogeology

The cross section in Figure 3-2 illustrates the hydrogeologic stratigraphy of the Calvert Cliffs site. The Surficial aquifer, Chesapeake confining bed,

Figure 3-1 Geologic Cross-Section Schematic

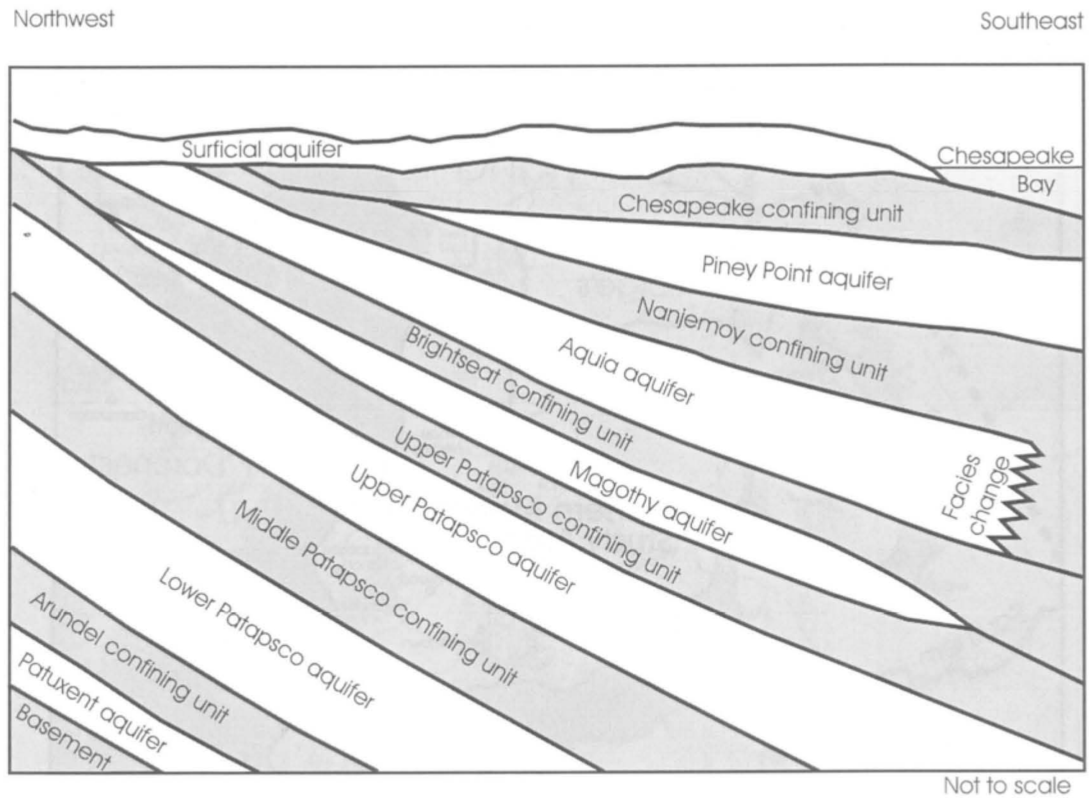
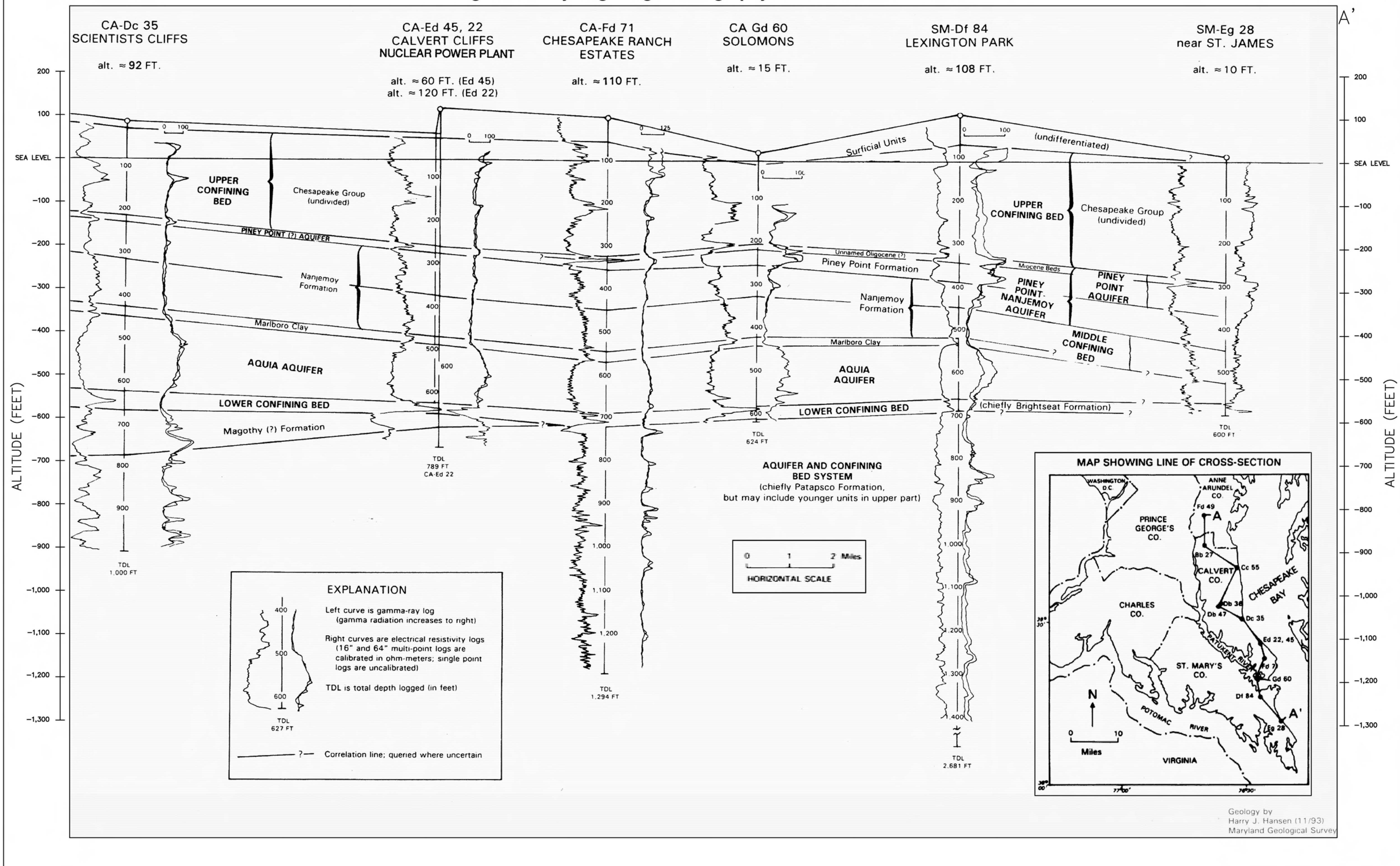


Table 3-1. Geologic and Hydrostratigraphic Units of Southern Maryland

[Modified from Hansen and Wilson, 1984: McCartan, 1989b, and Ashmad and Hansen, 1997 Fm. Formation]

ERATHEM	SYSTEM	SERIES	GROUP	FORMATION	THICKNESS (feet)	LITHOLOGY	HYDROSTRATIGRAPHIC UNIT
CENOZOIC	QUATERNARY	Holocene & Piestocene		Lowland deposits	0-150	Sand, gravel, sandy clay, and clay	SURFICIAL AQUIFER
CENOZOIC	NEOGENE	Plocene		Upland deposits	0-85	Irregularly stratified cobbles, gravel, sand and clay lenses	SURFICIAL AQUIFER
CENOZOIC	NEOGENE	Plocene	Chesapeake Group	Yorktown Fm.	0-20	Fine-grained glauconitic sand	CHESAPEAKE CONFINING UNIT
CENOZOIC	NEOGENE	Miocene	Chesapeake Group	Eastover Fm.	0.5-40	Clayey silt with thin laminee of silt, clay or sand	CHESAPEAKE CONFINING UNIT
CENOZOIC	NEOGENE	Miocene	Chesapeake Group	St. Mary's Fm. Choptank Fm. Calvert Fm.	0-335	Sand, clayey sand, and sandy clay, fossililerous and diatomaceous	CHESAPEAKE CONFINING UNIT
CENOZOIC	PALEOGENE	Oigocene	Chesapeake Group	Old Church Fm.	0-5	Patchy distribution; clayey, glauconitic sand	PINEY POINT AQUIFER
CENOZOIC	PALEOGENE	Eocene	Pamonkey Group	Piney Point Fm.	0-90	Sand, slightly glauconitic with intercalated indurated layers; fossiliferous	PINEY POINT AQUIFER
CENOZOIC	PALEOGENE	Eocene	Pamonkey Group	Nanjemoy Fm.	0-240	Glauconitic sand with clayey layers	PINEY POINT AQUIFER NANJEMOY CONFINING UNIT
CENOZOIC	PALEOGENE	Palocene	Pamonkey Group	Marlboro Clay	0-30	Pink and gray clay	NANJEMOY CONFINING UNIT
CENOZOIC	PALEOGENE	Palocene	Pamonkey Group	Aquia Fm.	30-205	Glauconitic greens to brown sand with indurated layers, fossilferous	AQUIA AQUIFER
CENOZOIC	PALEOGENE	Palocene	Pamonkey Group	Brightseat Fm.	0-40	Gray to dark-gray micaceous silty and sandy clay	BRIGHTSEAT CONFINING UNIT
MESOZOIC	CRETACEOUS	Upper	Monmouth Group Matawan Group	Formations undifferentiated	0-135	Sandy clay and sand, dark gray to black, with minor glauconite fossilferous	BRIGHTSEAT CONFINING UNIT
MESOZOIC	CRETACEOUS	Upper		Magothy Fm.	0-230	Light gray to white sand and fine gravel with interbedded clay layers, contains pyrite and lignite. Includes two sand units in southern Anne Arundel County where the formation is thickest	MAGOTHY AQUIFER
MESOZOIC	CRETACEOUS	Upper —— ? —— Lower	Potomac Group	Patapsco Fm.	0-1,200	Interbedded sand, clay and sandy clay; color variegated but chiefly hues of red, brown and gray; consists of several sandy intervals that function as separate aquifers	Patapsco Aquifer System: UPPER PATAPSCO CONFINING UNIT UPPER PATAPSCO AQUIFER MIDDLE PATAPSCO CONFINING UNIT LOWER PATAPSCO AQUIFER
MESOZOIC	CRETACEOUS	Lower	Potomac Group	Arundel Fm.	0-400	Red, brown and gray clay in places contains ironstone nodules, carbonaceous remains and lignite	ARUNDEL CONFINING UNIT
MESOZOIC	CRETACEOUS	Lower	Potomac Group	Patuxent Fm.	100-650	Interbedded gray and yellow sand and clay; kaolinized feldspar and lignite common. Locally clay layers predominate	PATUXENT AQUIFER
MESOZOIC	CRETACEOUS	Lower	Potomac Group	"Waste Gate FM"	32*	Light gray to gray tan, fine to medium, clayey sands and clayey silts; feldspathic	Not a fresh-water aquifer
PALEOZOIC PRECAMBRIAN	Undifferentiated pre-Cretaceous consolidated rock basement				Unknown	Igneous and metamorphic rocks; sandstone and shale	NOT RECOGNIZED

Figure 3-2 Hydrogeologic Stratigraphy at the Calvert Cliffs Site



Piney Point aquifer, Nanjemoy confining unit, Aquia aquifer and the Brightseat confining unit are the hydrogeologic units of interest for the Calvert Cliffs site. These hydrogeologic units are described below in order of descending geologic age.

3.1.4.1 *Surficial Aquifer*

The Surficial aquifer consists of a mix of gravel, sand, silt and clay associated with the Lowland and Upland deposits (Achmad and Hansen, 1997). Exposed to the atmosphere, the Surficial aquifer receives surface recharge from precipitation and streams. Ground water discharge from small springs may occur where the water table surface intersects stream beds or ground surface. The Surficial aquifer is not considered a reliable source of ground water due to vulnerability to contamination and limited dependability during drought conditions.

UniStar advanced borings and installed 16 monitoring wells into the Surfical aquifer, and evaluated the hydrogeologic regime using data collected from the wells. UniStar provided the results of the site-specific investigation in its response to DNR Data Request No. 1-14 (UniStar responses to selected DNR data requests are included in this document as Appendix B). In the area of the proposed Unit 3, the UniStar boring data indicated that the thickness of the Surficial aquifer varies from 0 to 50 feet, depending on the surface topography, with a seasonably variable water table. In the area of the proposed Unit 3 power block, the bottom of the Surficial aquifer is approximately 67 feet mean sea level (msl) based on UniStar's interpretation of the boring data presented in cross sections (Figures 5.4-5 and 6 in UniStar's Technical Report). The planned final grade for the ground surface of the power block is at an elevation of approximately 84 feet. The bottom of power block area excavation (44 feet msl) will be finished within the Chesapeake confining unit. Thus, the excavation of the power block will require removal of the Surficial aquifer within the power block area.

UniStar proposes to use ground water extracted from the Surficial aquifer during dewatering for dust control during Unit 3 construction. Ground water flow within the Surficial aquifer reflects topography, and thus flows towards the topographic lows, discharging ground water into the unnamed tributaries to the Chesapeake Bay to the east and Johns Creek and associated branches to the west.

As indicated in UniStar's response to DNR Data Request No. 1-14, ten slug tests were conducted in the monitoring wells installed in the Surficial aquifer within the power block area. For a slug test, a volume of water is released through a well screen into the aquifer to estimate the permeability the volume of material immediately surrounding the well. The limited aquifer volume impacted by the slug of water includes the area around the well impacted by well drilling and may preclude a representative estimate of the bulk hydraulic conductivity. In the area proposed for Unit 3, hydraulic conductivities ranging from 17.4 to 0.04 feet/day were calculated from slug testing data resulting in a geometric mean of 0.91 feet per day.

3.1.4.2 *Chesapeake Confining Unit*

The Chesapeake confining unit consists primarily of clayey silt and clayey sand which bound the base of the Surficial aquifer. Within the Chesapeake Group, the Yorktown, Eastover, St. Marys, Choptank, and upper Calvert Formations combine to form the Chesapeake confining bed. These confining beds are important because they limit leakage between aquifers and store significant amounts of water (Chappelle and Drummond, 1983). Leakage is controlled by the hydraulic conductivity and the thickness of the confining beds.

UniStar advanced borings and installed 24 monitoring wells into the Chesapeake confining unit, and evaluated the hydrogeologic regime using data collected from the wells. Twenty-one monitoring wells were completed in the upper portion of the Chesapeake confining unit, and three wells were completed in the lower part of the unit. Based on the cross section shown in Figure 5.4-6 of the UniStar Technical Report, the Chesapeake confining unit extends to a depth of -200 feet msl, which makes the unit 267 feet thick beneath the proposed Unit 3 site. Based on the water level measurements collected from the 20 monitoring wells completed in the upper portion of the Chesapeake confining unit, ground water flow in the upper portion of the unit is directed in a radial pattern from the power block area toward the Bay.

The downward vertical hydraulic gradients measured in nested monitoring wells completed in the Surficial aquifer and Chesapeake confining unit indicate that ground water flow between the two units is downward. Downward vertical hydraulic gradients are indicative of a recharge area.

Vertical hydraulic conductivities determined by laboratory methods for the Chesapeake confining bed in Calvert County range from 2.5×10^{-5} to 8.37×10^{-5} feet/day (Chappelle and Drummond, 1983). Due primarily to the orientation of sedimentary soil particles, vertical hydraulic conductivities are typically much lower than those in a horizontal direction, particularly in clayey confining sediments where plate-like particles interlock to limit vertical flow.

To characterize the aquitard characteristics at the proposed Unit 3 site, UniStar (2008) conducted 20 aquifer slug tests in the upper zone of the Chesapeake confining unit and three slug tests in the lower zone of the Chesapeake confining unit. Hydraulic conductivity values calculated from slug tests for the upper Chesapeake confining unit (UniStar, 2008) ranged from 13.7 to 0.01 feet/day with a geometric mean of 0.74 feet/day. Slug test values (UniStar, 2008) for the lower zone of the Chesapeake confining unit range from 0.09 to 0.02 feet/day with a geometric mean of 0.03 feet/day.

3.1.4.3 *Piney Point Aquifer*

The Piney Point aquifer below the Chesapeake confining bed consists of the sandy units of the Old Church Formation (Chesapeake Group), and the Piney Point and Nanjemoy Formations of the Pamunkey Group. Unlike the other confined aquifer units in Southern Maryland, the Piney Point aquifer does not outcrop at land surface and is recharged entirely by leakage through confining units. The Piney Point aquifer is bounded above by the Chesapeake confining unit, and below by the Nanjemoy confining unit and the Marlboro Clay. Due to the continuous nature of these confining layers, increased pumping of the Piney Point aquifer is not likely to have a significant impact on the overlying Surficial or underlying Aquia aquifers. The Piney Point aquifer is used extensively as a domestic water and small commercial water supply in southern Calvert County.

Based on the hydrogeologic cross-section shown in Figure 3-2 (from Achmad and Hansen 1997), the upper Chesapeake confining bed extends from -5 to -205 feet msl at the Calvert Cliffs site. Extending from approximately -205 to -225 feet msl, the Piney Point aquifer is bounded by the underlying Najemoy and Marlboro Clay from -225 to -435 feet msl.

Two key aquifer characteristics that describe an aquifer's ability to yield water are transmissivity and storativity. Transmissivity is the measure of the rate of flow of water through a vertical strip of aquifer which is one unit wide and which extends across the full thickness of the aquifer. Transmissivity is the hydraulic conductivity multiplied by the thickness of the aquifer. Storativity is defined as the volume of water that an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. The magnitude of the storativity depends on whether the aquifer is confined or unconfined. Generally, the value of storativity is 0.001 or lower where the unconfined aquifers have relatively higher values than confined aquifers.

Transmissivity values of the Piney Point aquifer within Southern Maryland range from 100 to 700 ft^2/day (Drummond, 2007). Hansen

(1972) has tabulated Piney Point storativity values ranging from 0.0003 to 0.0004. For the Marlboro Clay, the primary confining unit below the Piney Point and above the Aquia aquifer, a vertical hydraulic conductivity in Calvert County of 2.44 x 10^{-5} feet/day was determined from laboratory tests (Chappelle and Drummond, 1983). The Marlboro Clay is about 20 feet thick at the Calvert Cliffs site and has a much lower permeability than the clayey sands of the Nanjemoy confining unit bounding the base of the Piney Point aquifer (Achmad and Hansen, 1997).

Water levels have declined in the Piney Point aquifer since the 1970s to about 2 feet below sea level from a high of 12 feet above sea level in Calvert Cliffs State Park adjacent to the Calvert Cliffs Site. These declines, attributed to increased usage corresponding to population increases, have generally leveled off since 2000 (Drummond, 2007). Primary areas of drawdown are centered at pumping locations in the Lexington Park area of southern St. Mary's County due to relatively heavy use in this area. Pumping from the Piney Point aquifer at the Calvert Cliffs site has been minimal averaging 400 gallons per day on a yearly basis which would result in minimal impact on water level declines.

COMAR 26.17.06.05.D(3) indicates that an appropriation of ground water cannot be issued if the proposed withdrawal will exceed the sustained yield of the aquifer. COMAR 26.17.06.05.D(4) provides the tool to determine whether the regional sustained yield potentiometric surface of a confined aquifer is being exceeded, by ensuring that the regional sustained yield potentiometric surface not be lowered below 80 percent of the drawdown available between the top of the aquifer and the historical pre-pumping level of the potentiometric surface. Based on studies by Drummond (2007), the Piney Point aquifer has approximately 145 feet of available drawdown in the vicinity of the Calvert Cliffs site with the 80 percent management level of the aquifer at an elevation of about -150 feet msl.

3.1.4.4 *Aquia Aquifer*

The Aquia aquifer consists of the sandy Aquia Formation and is separated from the overlying Piney Point aquifer by the lower clayey portions of the Nanjemoy Formation and the Marlboro Clay. The base of the Aquia is bounded by the silty clayey portion of the Brightseat Formation and undifferentiated clayey formations collectively known as the Brightseat confining unit. As shown in Figure 3-2, the Magothy Formation is considered to be thin or absent at the Calvert Cliffs site.

The Aquia aquifer extends from an estimated elevation of -435 to -570 feet msl in the vicinity of the Calvert Cliffs site and is used extensively for domestic and major-user supplies in Southern Maryland and the Eastern Shore.

Ground water monitoring data and the relatively impermeable nature of the Marlboro Clay indicate that there is likely to be little hydraulic connection between the Aquia and the overlying Piney Point aquifer. Therefore, future withdrawals from the Aquia are not anticipated to adversely impact the Piney Point aquifer.

Within a radius of five miles of Calvert Cliffs, transmissivity values ranging from 876 to 935 ft^2/day have been determined from pumping tests (Chappelle and Drummond, 1983) with storage coefficients ranging from 0.0001 to 0.0004 (Hansen, 1972). Achmad and Hansen (1997) cite a calculated value of 935 ft^2/day for a pumping test performed at the Calvert Cliffs Units 1 and 2 site. In a study to estimate the water supply potential of the Aquia aquifer, Achmad and Hansen (1997) used a storativity value of 0.0001.

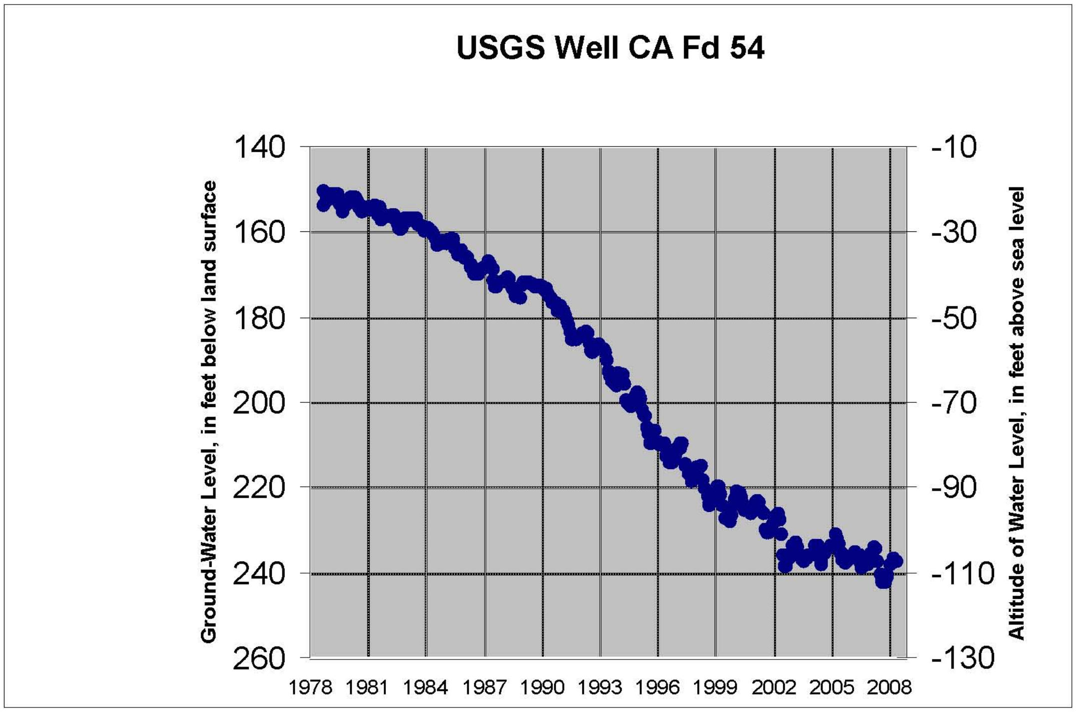
Water levels in the Aquia aquifer at Calvert Cliffs have declined approximately 58 feet over the period 1982 to 2006, with most of the decline occurring since 1990. This acceleration in water level declines is due to the withdrawal from municipal well fields at Lexington Park in St. Mary's County and Solomons Island in Calvert County. At Lexington Park and Solomons Island the water levels have declined nearly 18 feet since 1997 and approximately 108 feet since 1982.

A monitoring well on the Calvert Cliffs site with the well number Ca Ed 42 is completed in the Aquia aquifer and is monitored twice yearly by the USGS. Water level data from the well indicate that between 1975 and 2003, Aquia aquifer water levels declined by about 75 feet. However, more recently water levels remained relatively stable at about -90 feet msl since 2003. In the vicinity of the Calvert Cliffs site, the 80 percent management level is -350 feet msl (Drummond, 2007) with approximately 254 feet of available drawdown.

The USGS maintains a monitoring well at Calvert Cliffs State Park completed in the Aquia aquifer. The well has the well number CA Fd 54 and has a continuous recorder to measure the water level. The water level data collected since 1978 is shown in Figure 3-3. The data shows that there was a steep decline for the period between 1978 and 2003. However, the data in Figure 3-3 shows that for the decline in the water level in the Aquia aquifer over the past five years has slowed.

The regional rate of decline in the water level in an aquifer measures the feet per year that the water is dropping due to regional pumping. Based on the long-term decline in the water level measured in well CA Fd 54, the regional rate of decline in the Aquia aquifer water level over the past five years is estimated to be about 2 feet/year. Prior to 2003, the regional rate of water decline in the Aquia was greater than 3 feet/year.

Figure 3-3 ***Drawdown Measurements in USGS Well CA Fd 54***



3.1.4.5 *Patapsco Aquifer*

The Patapsco Formation of the Potomac Group is divided into four hydrogeologic units by Drummond (2007): the Upper Patapsco confining unit; the Upper Patapsco aquifer; the Middle Patapsco confining unit; and the Lower Patapsco aquifer. The Lower Patapsco aquifer is bounded by the clay of the Arundel confining unit. In Southern Maryland, the Patapsco aquifers consist of interwoven and locally discontinuous sand layers characteristic of floodplain and meandering streams deposits.

Evaluation of six aquifer pump tests resulted in transmissivity values ranging from 380 to 1,000 ft^2/day in the Upper Patapsco aquifer, and 200 to 4,000 ft^2/day in the Lower Patapsco aquifer (Drummond, 2007). Based on these six pump tests and previous studies (e.g., Wilson 1986 and Andreasen 1999), Drummond (2007) used a representative transmissivity value of 2,500 ft^2/day for the Upper Patapsco aquifer and 1,250 ft^2/day for the Lower Patapsco in the vicinity of the Calvert Cliffs site in ground water flow simulations.

Although an important aquifer in other areas of Southern Maryland, the Patapsco aquifer is not used as a significant source of water in Southern Calvert County. However, due to the declining water levels and naturally occurring elevated arsenic concentrations in the Aquia aquifer, water suppliers have increasingly shifted a portion of withdrawal to the Patapsco aquifer.

The 80 percent management level is -550 feet msl and -1050 feet msl in the Upper Patapsco and Lower Patapsco aquifer, respectively. Based on studies by Drummond (2007), the available drawdown in the Upper Patapsco and Lower Patapsco aquifer is about 520 feet and 1,035 feet , respectively.

The Patuxent aquifer underlies the Lower Patapsco aquifer separated by the Arundel confining unit. The Patuxent aquifer is not currently used in Calvert County due to the prohibitive depth to the aquifer and the productive nature of the shallower Piney Point and Aquia aquifers.

3.1.5 Ground Water Quality

Water quality data for the Surficial aquifer is vulnerable to surface contamination particularly chloride, nitrate and agricultural chemicals. UniStar characterized ground water quality in the Surficial aquifer by collecting samples from two monitoring wells (OW 752-A and OW 319-A). The ground water quality data is reported in Table 4.4-12 in UniStar's Technical Report. The ground water quality in the Surficial aquifer indicates that ground water quality is degraded with chloride, nitrate, phosphorus, and dissolved solids. With the exception of elevated iron in the ground water, the metals data was unremarkable.

UniStar characterized ground water quality in the Upper Chesapeake unit by collecting a ground water sample from one monitoring well (OW 319-B). Phosphorus was detected in the sample, and the total dissolved solids level is elevated, suggesting the ground water quality is degraded from an anthropogenic impact. With the exception of elevated iron in the ground water, the metals data was unremarkable.

The ground water quality of the Piney Point and Aquia aquifers is considered good with the exception of naturally occurring arsenic concentrations in Aquia aquifer in the vicinity of the Calvert Cliffs site. At Calvert Cliffs, arsenic concentrations in the Aquia aquifer ground water exceed the U.S. EPA established maximum contaminant level (MCL) of 0.010 milligrams per liter (mg/L). UniStar characterized ground water quality in the Aquia aquifer by collecting a ground water sample from production well No. 5 at Units 1 and 2. Well No. 5 is located on the northern edge of the Unit 3 site. The reporting limit for arsenic was 0.020 mg/L, which was too high to determine if arsenic was present in the well above the EPA's MCL. The water sample from well No. 5 contained a detectable concentration of phosphorus and elevated dissolved solids.

3.1.6 *Ground Water Use*

3.1.6.1 *On-site Ground Water Use*

Calvert Cliffs Nuclear Power Plant, Inc. is currently authorized by MDE to withdraw an annual average of 1,600 gallons per day (gpd) from four separate ground water appropriation permits in the Piney Point aquifer (permit numbers CA63G003 (07), CA83G008 (03), CA89G007 (02) and CA89G107(01)). At the Calvert Cliffs site, relatively minor appropriations are associated with the Piney Point aquifer ground water use such as water supply for the former Visitor Center, Camp Conoy (scheduled for demolition), and on-site trailers. According to UniStar's response to DNR Data Request No. 4-4, the Camp Conoy facilities include four wells. Three of the four wells are in the footprint of Unit 3 and will be abandoned. The fourth well is outside the Unit 3 footprint and will remain in service under an appropriation permit.

Calvert Cliffs Nuclear Power Plant, Inc. is currently authorized by MDE to withdraw an annual average of 450,000 gpd from one appropriation permit in the Aquia aquifer (permit number CA1969G010(05)). The month of maximum use limit for the Aquia withdrawal is 865,000 gpd. Five production wells are used to extract water for Units 1 and 2. The Aquia aquifer is the primary source of ground water at the Calvert Cliffs site and is used in Units 1 and 2 to provide boiler makeup for the steam cycle and for potable and other in-plant uses that require fresh water. Withdrawal data presented in PPRP's CEIR-14 indicates that Aquia withdrawals at Units 1 and 2 have ranged from 340,000 gpd to 420,000 over the ten year period spanning 1997 to 2006, with an average of 390,000 gpd.

3.1.6.2 *Off-site Ground Water Use*

For the Piney Point aquifer, major, local off-site ground water use includes permitted withdrawals by the communities of White Sands and Chesapeake Ranch. Chesapeake Ranch has the higher average ground water appropriation permit (GAP) of 40,000 gpd as of 2002; however, no usage has been associated with this permit (CA60G202) from 1952 through 2002 (Drummond, 2007). Calvert County Commissioners operates the White Sands community well systems as a public supply appropriation. As of 2002, White Sands had an average GAP of 10,000 gpd with usage averaging about 5,000 gpd from 1952 through 2002. Additionally, the Piney Point aquifer is used primarily for smaller domestic water supplies

The Aquia aquifer is used extensively in Calvert County. MDE Water Management Distraction reports that 186 individual ground water appropriations permits (GAP) have been issued for users in Calvert County. The communities of Chesapeake Ranch and Long Beach, and the Dominion Cove Point liquefied natural gas (LNG) facility are the local users of ground water from the Aquia aquifer in the vicinity of the Calvert Cliffs site. The average GAP for Chesapeake Ranch is 900,000 gpd as of 2002 with an average pumpage of 470,000 gpd from 1982 through 2002 (Drummond 2007). Long Beach community pumpage (operated under the name of the Beaches Water Company) averaged about 18,000 gpd over this same period with an average GAP of 49,000 gpd. Dominion Cove Point LNG had the lowest average GAP (22,000 gpd) as of 2002 with an average pumpage of about 3,000 gpd.

Numerous other individual users were reported in either MGS publications or from MDE WMA permit records. Two of the closest users identified are as follows:

- Southern Middle School located on HG Trueman Road, about 1.5 miles south of the intersection of Calvert Cliffs Parkway, uses a small amount of water from the Aquia. This well is 1.5 miles from the Unit 3 site; and
- The Rodney Getz Saw Mill, located on Saw Mill Road about 0.5 miles north of the intersection of Calvert Cliffs Parkway, uses the Aquia aquifer. The well at the saw mill is 2.0 miles from the Unit 3 site.

3.2 *SURFACE WATER RESOURCES*

3.2.1 *Surface Water Bodies*

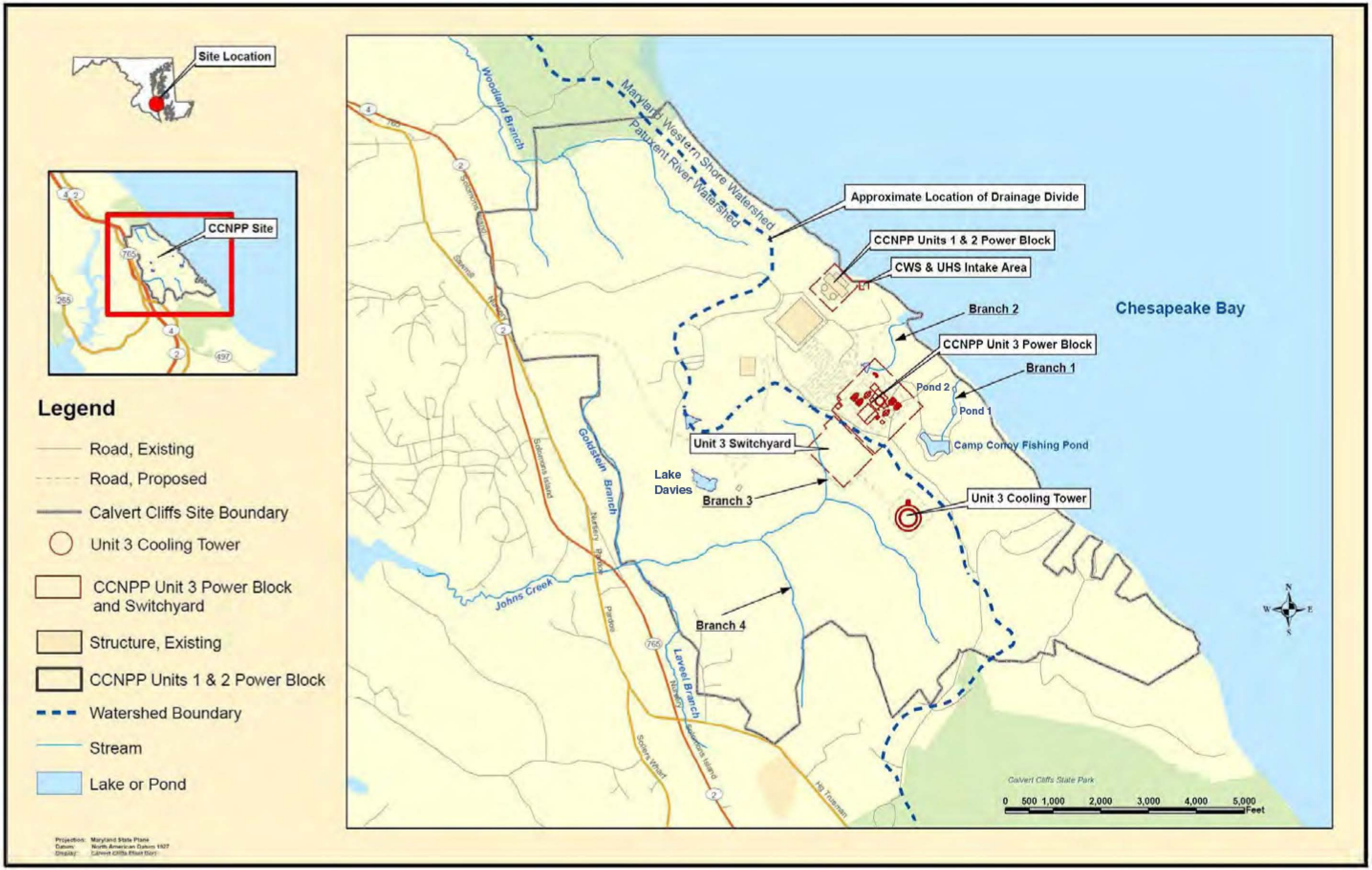
The Calvert Cliffs site is located on a high bluff on the Calvert peninsula within the Chesapeake Bay watershed. The Calvert peninsula is bounded by the Bay to the east and the Patuxent River to the west, with a width of about 5 mi (8.0 km) near the site. The Patuxent River flows near the site from the northwest to the southeast direction, and it discharges into the Bay about 8 mi (12.9 km) south of the site. Drainage in the vicinity of the site includes several small streams and creeks, which fall within two sub-watersheds of the 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.

3.2.1.1 *Freshwater Streams, Local Drainage*

The site is well drained by a natural network of short, ephemeral, intermittent, and perennial streams within the two sub-watersheds. Approximately 80 percent of the site is drained through the St. Leonard Creek drainage basin of the Lower Patuxent River watershed. The remaining 20 percent drains through the Maryland Western Shore watershed discharging northeastward and directly into the Bay by two unnamed creeks, identified by UniStar as Branch 1 and Branch 2. All the streams that drain the site that are located east of MD 2/4 are nontidal. Runoff from the 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 MD 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 3-4. The St. Leonard Creek watershed has a drainage area of approximately 35.6 mi^2 (92.2 km^2) 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. The combined flow from these streams discharges into the Patuxent River through St. Leonard Creek. St. Leonard Creek is tidally influenced at the confluence with Johns Creek. Wetlands near the 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 (also called Lake Conoy). The fishing pond is located at the headwaters of an unnamed creek. Runoff from Lake Davies 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 fishing pond and Lake Davies are man-made. The U.S. Fish and Wildlife Service (FWS) has designated the water bodies within the site as palustrine wetlands. Camp Conoy fishing pond and Lake Davies are further subclassified 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.

3.2.1.2 *Patuxent River Watershed*

The Patuxent River is the largest river completely contained in Maryland. It drains an area of about 932 mi^2 (2,414 km^2). The Patuxent River contributes slightly over 1 percent of the total streamflow delivered



Source: UniStar CPCN Technical Report, Figure 4.4-2, Copyright 2007 UniStar Nuclear Development, LLC. Used by permission.

Figure 3-4
Calvert Cliffs Site Area Topography and Drainage

annually from the catchment of the Bay Basin. The river basin is between two large metropolitan areas, Baltimore, Maryland and Washington, D.C. Thus, the Patuxent River watershed has been subject to significant suburban development. Present land use in the basin is about 44 percent forest, 30 percent urban, and 26 percent agriculture.

The Lower Patuxent River watershed area within Calvert County is about 174 mi^2 (451 km^2) and covers over 50 percent of the land in the county. 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 affected by tides from the Bay. The tidal influence affects nearly the entire river in the lower watershed with the head of tide extending just south of Bowie, Maryland.

3.2.1.3 *Chesapeake Bay*

The Chesapeake Bay main stem is about 195 mi (314 km) long from the Atlantic Ocean to the mouth of the Susquehanna River. Its width varies from about 3.5 mi (5.6 km) near Aberdeen, Maryland to 35 mi (56 km) near the mouth of the Potomac River, with a width of about 6 mi (9.7 km) near the Calvert Cliffs site. It has an open surface area of nearly 4,480 mi^2 (11,603 km^2) and, including its tidal tributaries, has approximately 11,684 mi (18,804 km) of shoreline. Although its length and width are quite large, the average depth of the Bay, including tidal tributary channels, is only about 21 ft (6.4 m). The Bay is shallow, 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 its length. Because it is so shallow, the Bay is more sensitive than the open ocean to temperature fluctuations and wind. The Bay is irregular in shape and is long enough to accommodate one complete tidal wave cycle at all times. 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 Bay Basin. The basin contains more than 150,000 stream miles (241,402 stream km). Nine rivers, including the Susquehanna, Patuxent, Potomac, Rappahannock, York (with its Mattaponi and Pamunkey tributaries), James, Appomattox, and Choptank, contribute over 90 percent of the Bay's mean annual freshwater inflow. The Susquehanna River, the largest river that enters the Bay, drains nearly 43 percent of the basin. It normally contributes about 50 percent of the freshwater reaching the Bay. Eighty percent to 90 percent of the freshwater entering the Bay comes from the northern and western portions of the basin. The remaining 10 percent to 20 percent is contributed by the eastern shore. Although the 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 Bay with variable geochemical and sediment origins.

3.2.2 *Water Quality*

3.2.2.1 *Freshwater Bodies*

Surface water channels, including Johns Creek and Goldstein Branch, and four perennial ponds (Camp Conoy fishing pond, Lake Davies, and Ponds 1 and 2) are present within the boundary of Calvert Cliffs Nuclear Power Plant. Water quality data for the on-site surface water bodies was collected in September 2006 and March 2007 as part of a biological study by UniStar (2007); results are listed in Tables 3-2 through 3-7. Based on dissolved oxygen and pH measurements, water quality is representative of a healthy aquatic environment in the streams and Camp Conoy fishing pond. Dissolved oxygen greater than 5 parts per million (ppm) and a neutral pH were recorded at Johns Creek, Goldstein Branch, and Camp Conoy fishing pond. Low dissolved oxygen concentrations were detected in Lake Davies and the two ponds during the September survey but were similar to the streams and Camp Conoy fishing pond during the March survey. Total organic carbon, alkalinity, and total dissolved solids are notably higher at Lake Davies and the downstream station on Johns Creek than the other site waters.

Despite the low dissolved oxygen concentration at Lake Davies and the two ponds in the fall samples, and the elevated nutrients at Lake Davies, the general water quality of these systems does not indicate any significant adverse conditions as the result of current operations at the site. Additional water quality parameters were tested in the spring survey period to obtain a more complete baseline profile of conditions (UniStar, 2007). The additional testing did not reveal any adverse water quality conditions. In particular, bacteria levels, chlorophyll-a, and total polynuclear aromatic hydrocarbons (PAHs)[1] were low. Toxic metals were all below State of Maryland acute water quality criteria for freshwater and all but one was below chronic water quality criteria; one wet weather sample from Goldstein branch was slightly above chronic water quality criteria for lead.

In Lake Davies elevated levels of barium, calcium, magnesium, potassium and sodium were observed. These findings are consistent with the high conductivity, alkalinity and total dissolved solids measurements in Lake Davies and reflect runoff from areas of past disposal of dredged material. To indicate variability in these waters due to varying meteorological conditions, wet weather (rainfall within the previous 24 hours) and dry

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[1] The term "polynuclear" refers to the chemical structure of a compound consisting of more than one benzene-type ring. It bears no relation to radiological activity.

Table 3-2 Fall 2006 Water Quality Analytical Data in Streams and Ponds

Water Body	**Units**	**Johns Creek**		**Goldstein Branch**	**Camp Conoy Fishing Pond[a]**				**Pond 1[a]**	**Pond 2[a]**	**Lake Davies**		
Parameter		**JCUS-01**	**JCDS-01**	**GB-01**	**LC-01**	**LC-02**	**LC-02 DUP**	**LC-03**	**P-01**	**P-02**	**LD-01**	**LD-02**	**LD-03**
Temperature[b]	°F (°C)	64 (18)	59 (15.5)	62 (16.9)	76 (24.9)	70 (21.3)	NA	70 (21.7)	65 (18.4)	63 (17.3)	68 (20)	70 (20.5)	71 (20.7)
Dissolved Oxygen[b]	ppm	6.4	6	6.7	7.6	6.1	NA	6.16	3.21	0.99	3.4	3.4	4
pH[b]	SU	6.4	7.63	7.4	7.8	7.72	NA	7.3	6.7	6.39	7.5	7.7	7.7
Conductivity[b]	µmhos/cm	50	484	737	66	63	NA	62	109	135	1566	1592	1591
Alkalinity	mg/L	3.5	76	100	14	8.5	4.5	4.5	30	56	330	280	270
Biological Oxygen Demand (BOD)	mg/L	<2.0	3.2	5.9	6.3	6.9	<2.0	4.5	18	14	9.8	7.2	9.1
Ammonia	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate plus Nitrite-N	mg/L	<0.05	<0.05	0.12	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phosphorus Dissolved-P	mg/L	0.021	0.018	0.011	<0.01	0.021	<0.01	0.011	0.011	<0.01	0.22	0.19	0.21
Phosphorus Total-P	mg/L	0.029	0.032	0.079	0.17	0.038	0.067	0.035	0.18	0.095	0.36	0.31	0.29
Total Dissolved Solids	mg/L	30	280	440	35	67	20	48	41	51	980	950	980
Total Kjeldahl Nitrogen	mg/L	2	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	3.1	1.4	2.2	1.8	1.7
Total Organic Carbon	mg/L	5.5	4	3.9	6.1	5.8	5.6	5.7	6.3	6.4	15	16	16
Total Suspended Solids	mg/L	4	5	62 (16.9)	27	<5.0	<5.0	150	56	11	6	6.5	8

[a] Pond 1 and Pond 2 are the first and second impoundments downstream of the Camp Conoy fishing pond.
[b] *In situ* measurements for Temperature, Dissolved Oxygen, pH, and Conductivity are for surface readings.

mg/L = Milligrams per liter
µmhos/cm = Microsiemens per centimeter
ppm = Parts per million
SU = Standard Units (pH)
NA = Not applicable. There is no duplicate sampling for *in situ* measurements.

Table 3-3 Fall 2006 Surface, Mid-Depth and Bottom in Situ Water Quality Data for Camp Conoy Fishing Pond and Lake Davies

Water Body	Units	Camp Conoy Fishing Pond			Lake Davies		
		LC-01	**LC-02**	**LC-03**	**LD-01**	**LD-02**	**LD-03**
Parameter – Surface							
Temperature	°F (°C)	76 (24.9)	70 (21.3)	70 (21.7)	68 (20)	70 (20.5)	71 (20.7)
Dissolved Oxygen	ppm	7.6	6.1	6.16	3.4	3.4	4
pH	SU	7.8	7.72	7.3	7.5	7.7	7.7
Conductivity	µmhos/cm	66	63	62	1566	1592	1591
Parameter – Mid-Depth							
Temperature	°F (°C)	NA	NA	70.6 (21.2)	68 (20)	68.4 (20.2)	68.5 (20.3)
Dissolved Oxygen	ppm	NA	NA	5.68	3.1	2.5	2.5
pH	SU	NA	NA	7.06	7.6	7.6	7.7
Conductivity	µmhos/cm	NA	NA	63	1581	1612	1581
Parameter – Bottom							
Temperature	°F (°C)	77.5 (25.3)	70.4 (21.34)	70.2 (21.2)	67.8 (19.9)	68.4 (20.2)	67.8 (19.9)
Dissolved Oxygen	ppm	6.7	5.88	5.06	2.2	2.6	2.2
pH	SU	7.5	7.44	6.77	7.5	7.6	7.7
Conductivity	µmhos/cm	65	62	62	1563	1608	1576

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mg/L = Milligrams per liter
µmhos/cm = Microsiemens per centimeter
ppm = Parts per million
SU = Standard Units (pH)
NA = Not applicable. There is no duplicate sampling for *in situ* measurements.

Table 3-4 Spring 2007 Water Quality Analytical Data in Streams and Ponds

Water Body		**Johns Creek**			**Goldstein Branch**		**Lake Canoy**			**Lake Davies**			**Pond 1**	**Pond 2**
Parameter	**Units**	**JCUS-01**	**JCDS-01 (Dry)**	**JCDS-01 (Wet)**	**GB-01 (Dry)**	**GB-01 (Wet)**	**LC-01**	**LC-02**	**LC-03**	**LD-01**	**LD-02**	**LD-03**	**P-01**	**P-02**
Conductivity	µS/cm	37	297	---	460	---	61	56	57	1209	1197	1202	79	89
Dissolved Oxygen	mg/L	11.1	12.1	---	13.4	---	11.6	12.8	13.4	18.8	18.6	17.4	11.8	11.5
Odor (Observation)	NA	None	None	None	None	None	None	None	None	None	None	None	None	None
pH	units	6.6	7.5	---	7.3	---	8.1	8.1	7.9	8.3	8.3	8.3	7.5	7.5
Temperature	Centigrade	6.6	13.0	---	11.1	---	14.2	11.8	12.4	11.0	10.9	10.6	9.0	9.9
Turbidity	NTU	4.1	9.9	---	8.1	---	2.4	3.3	3	3.1	3.3	2.8	18.3	10.3
Water Depth	feet	1	---	---	1	1	2	2	3.5	3	4	3	3	1.5
Alkalinity	mg/L	8.5	43	33	62	42	6.5	12	9.5	180	190	190	25	24
BOD	mg/L	<3.0	<3.0	5.6	<3.0	7.3	<3.0	<3.0	<3.0	4.1	4.1	9.1	<3.0	<3.0
Carbon, Total	mg/L	3.4	13.3	12.6	21.7	15.1	5.0	4.1	2.8	8.3	8.4	6.6	9.9	3.8
Carbon, Total Organic	mg/L	2.6	5	5.8	3.7	6.8	2.4	4.2	5.6	8.8	9.7	9.8	4.9	3.3
Chemical Oxygen Demand	mg/L	<10	21	32	<10	35	<10	23	25	37	33	23	28	28
Chloride (Titrimetric, Mercuric Nitrate)	mg/L	6.5	46	46	50	29	7.5	7.0	7.5	120	120	120	7	7.0
Chlorophyll-A	mg/M3	2.9	1.8	2.4	5.4	6.5	2.3	0.89	0.91	4.8	1.4	5.4	4.2	0.89
Color, True	color units	20	25	30	15	35	10	15	25	25	20	15	30	25
Fecal Coliform	MPN/100ml	<2.0*	<2.0*	1600	8*	500*	<2.0*	<2.0*	<2.0*	<2.0*	<2.0*	<2.0*	<2.0*	80*
Fecal Streptococcus	MPN/100ml	<2.0*	12*	90	4*	140*	<2.0*	<2.0*	<2.0*	<2.0*	<2.0*	<2.0*	33*	6.0*
Hardness, Total	mg/L	160	250	190	310	220	180	130	160	580	620	640	180	190
Nitrogen-Ammonia	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrogen, Total Kjeldahl	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrogen, Nitrate-Nitrite	mgJL	0.053	0.15	0.21	0.33	0.26	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.062	<0.050
Petroleum Hydrocarbons, Total	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Phosphorus, Dissolved	mg/L	<0.010	<0.010	0.013	<0.010	0.02	<0.010	<0.010	0.023	0.043	<0.010	<0.010	<0.010	0.013
Phosphorus, Ortho	mg/L	<0.010	<0.010	0.067	<0.010	0.024	0.010	0.010	0.030	0.031	0.040	0.077	<0.010	0.015
Phosphorus, Total	mg/L	0.044	0.034	0.19	0.077	0.21	0.024	0.054	0.086	0.070	0.063	0.014	0.073	0.037
Solids, Total Dissolved	mg/L	49	180	120	320	180	47	61	46	860	900	980	32	63
Solids, Total Suspended	mg/L	<5.0	<5.0	20	<5.0	120	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.5	11
Sulfate	mg/L	11	45	30	130	73	13	15	14	360	520	520	13	14

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* Sample analyzed past recommended holding time. Data are relevant for intra-study comparison but should not be used as the basis of management decisions for water use for primary contact recreation.

Table 3-5 Spring 2007 Surface, Mid-Depth and Bottom In Situ Water Quality Data for Camp Conoy Fishing Pond and Lake Davies

Water Body		**Camp Conoy pond**			**Lake Davies**		
Parameter	**Units**	**LC-01**	**LC-02**	**LC-03**	**LD-01**	**LD-02**	**LD-03**
Surface							
Temperature	Centigrade	NA	NA	12.4	11.0	10.9	10.6
Dissolved Oxygen	ppm	NA	NA	13.4	18.8	18.6	17.4
pH	units	NA	NA	7.9	8.3	8.3	8.3
Conductivity	µS/cm	NA	NA	57.0	1209.0	1197.0	1202.0
Turbidity	NTU	NA	NA	3.0	3.1	3.3	2.8
MidDepth							
Temperature	Centigrade	14.2	11.8	NA	11.0	11.0	10.6
Dissolved Oxygen	ppm	11.6	12.8	NA	19.3	18.8	17.5
pH	units	8.1	8.1	NA	8.3	8.3	8.3
Conductivity	µS/cm	61.0	56.0	NA	1208.0	1197.0	1201.0
Turbidity	NTU	2.4	3.3	NA	3.0	3.1	3.0
Bottom							
Temperature	Centigrade	NA	NA	10.3	11.0	10.9	10.2
Dissolved Oxygen	ppm	NA	NA	14.1	19.3	18.8	17.6
pH	units	NA	NA	7.8	8.3	8.3	8.3
Conductivity	µS/cm	NA	NA	54.0	1206.0	1194.0	1195.0
Turbidity	NTU	NA	NA	3.9	3.2	3.2	3.3

Source: UniStar CPCN Technical Report, page 4-19, Copyright 2007 UniStar Nuclear Development, LLC. Used by permission.

Table 3-6 Spring 2007 Metals in Streams and Ponds

Water Body		Johns Creek			Goldstein Branch		Camp Conoy Fishing Pond			Lake Davies			Pond 1	Pond 2
Parameter	**Units**	**JCUS-01**	**JCDS-01 (Dry)**	**JCDS-01 (Wet)**	**GB-01 (Dry)**	**GB-01 (Wet)**	**LC-01**	**LC-02**	**LC-03**	**LD-01**	**LD-02**	**LD-03**	**P-01**	**P-02**
Arsenic	mg/L	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0028	0.0024	0.0027	<0.0020	<0.0020
Barium	mg/L	0.023	0.027	0.066	0.030	0.04	0.016	0.016	0.016	0.015	0.014	0.015	0.012	0.0088
Cadmium	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Calcium	mg/L	0.98	22	14	52	33	1.9	1.8	1.8	84	84	85	8.7	11
Chromium	mg/L	<0.0025	<0.0025	<0.0025	<0.0025	0.0027	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Lead	mg/L	<0.0020	<0.0020	<0.0020	<0.0020	0.003	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Magnesium	mg/L	1.5	7.1	4.7	16	10	2.6	2.5	2.5	62	62	62	2.7	2.7
Mercury	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Potassium	mg/L	0.83	1.8	1.9	2.8	2.5	1.0	1.0	0.99	17	17	17	0.78	0.87
Selenium	rng/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.050	<0.0050	<0.0050	<0.0050
Silver	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Sodium	mg/L	4.1	30	30	31	20	5.3	5.3	5.4	170	170	170	5.2	5.3

Source: UniStar CPCN Technical Report, page 4-20, Copyright 2007 UniStar Nuclear Development, LLC. Used by permission.

Table 3-7 Spring 2007 Polynuclear Aromatic Hydrocarbons (PAHs) in Streams

Water Body		Johns Creek		Goldstein Branch	
Parameter	**Units**	**JCDS-01(Dry)**	**JCDS-01 (Wet)**	**GB-01 (Dry)**	**GB-01 (Wet)**
Acenaphthene	µg/L	<10	<10	<10	<10
Acenaphthylene	µg/L	<10	<10	<10	<10
Anthracene	µg/L	<10	<10	<10	<10
Benz(a)anthracene	µg/L	<10	<10	<10	<10
Benzo(a)pyrene	µg/L	<10	<10	<10	<10
Benzo(b)fluoranthene	µg/L	<10	<10	<10	<10
Benzo(g,h,i)perylene	µg/L	<10	<10	<10	<10
Benzo(k)fluoranthene	µg/L	<10	<10	<10	<10
Chrysene	µg/L	<10	<10	<10	<10
Dibenz(a,h)anthracene	µg/L	<10	<10	<10	<10
Florene	µg/L	<10	<10	<10	<10
Fluoranthene	µg/L	<10	<10	<10	<10
Indeno(1,2,3-cd)pyrene	µg/L	<10	<10	<10	<10
Naphthalene	µg/L	<10	<10	<10	<10
Phenanthrene	µg/L	<10	<10	<10	<10
Pyrene	µg/L	<10	<10	<10	<10

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weather (no rainfall within the previous 72 hours) samples were taken at the downstream station on Johns Creek and at the Goldstein Branch station in the spring of 2007. The wet weather results show increases in biological oxygen demand (BOD), chemical oxygen demand (COD), fecal coliform and fecal streptococci, phosphorus, and total suspended solids as would be expected. Wet and dry weather measurements of PAHs were also made and none were above a detection limit of 10 µg/l.

3.2.2.2 *Chesapeake Bay*

Physical Characteristics

The Chesapeake Bay estuary is influenced by freshwater inputs from rivers and streams mixing with saline water from the Atlantic Ocean. In the area of the Calvert Cliffs site, predominant physical characteristics of the Bay include sandy sediments, mesohaline salt concentrations, seasonal stratification, current patterns influenced by wind and tides, high levels of localized particulates, and moderate sedimentation and resuspension rates. The local aquatic ecosystem is driven by high spring nutrient influx, turbidity, high primary production and phytoplankton density with an intermediate benthic abundance, and a relatively low biological diversity. Throughout the Bay, distribution of pollutants is largely influenced by physical processes, with the movement of water and sediment providing the principal mechanism for transport. Winds, waves, currents, tidal actions, and episodic events such as storms and hurricanes, can cause major resuspension of bottom sediments and associated pollutants, and the frequency and intensity of these physical events will have a fundamental effect on residence time of contaminants in any given area. Likewise, stratification and subsequent mixing will determine vertical, as well as horizontal, movement of pollutants, an important factor in a two-layered estuary like the Bay.

The overall health of the Bay is considered degraded by nutrient, air, sediment, and chemical pollution. High levels of nutrients, such as phosphorus and nitrogen, enter the bay system via stormwater, industrial/utility effluent, and atmospheric deposition. Sediments are washed into the Bay by natural processes including stream and shoreline erosion and stormwater runoff. The mass influx of nutrients and sediments decreases water clarity and stimulates algal production, which can reduce dissolved oxygen in the water column. Low freshwater flows lead to increased salinity and mixing between surface freshwater (higher oxygen levels) and the more saline water (where nutrients become available) below. Several water quality databases, maintained by State agencies, federal agencies, and non-profit groups, contain water quality data relevant to the Bay water in the area of the Calvert Cliffs site. After examining these databases, UniStar judged that the most available data were found within the Chesapeake Bay Program (CBP) Water Quality Database (1984 to present). Using this database, the CBP manages water quality data recorded at monitoring stations throughout the Bay and its tributaries, including stations in the area of the Calvert Cliffs site. Data from three mainstem monitoring stations north of the Calvert Cliffs site (CB4.3W, CB4.3C, and CB4.3E) and three mainstem monitoring stations south of the Calvert Cliffs site (CB4.4, CB5.1, and CB5.1W) were used to characterize seasonal water quality trends for the Bay waters within the vicinity of the power plant (see Figure 3-5).

Data reviewed for this environmental report was based on water year (WY) 2005 (i.e., the natural, annual water cycle from October 2004 through September 2005). Availability of water quality data varies by parameter and not all data were collected at the same collection events. However, where possible, trends in the available data sets were evaluated for discussion herein.

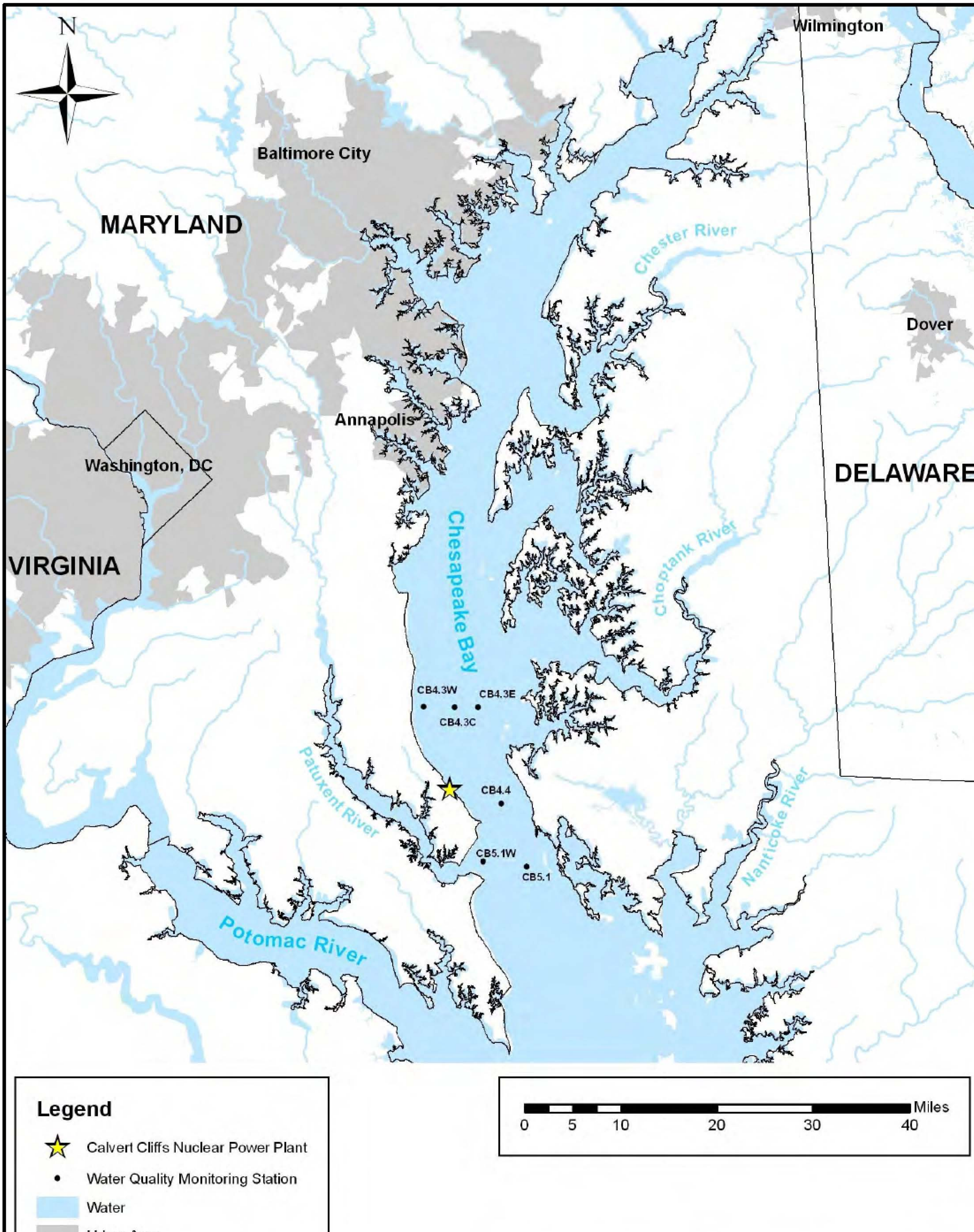
Salinity Zones

Freshwater flow is less dense than the cooler, saline waters entering the Bay from the Atlantic Ocean, creating vertical stratification of the water column and a zone (pycnocline) where the density changes rapidly due to temperature and salinity differences. The pycnocline plays an important role in determining seasonal changes in photosynthesis and nutrient distribution. Stratification and subsequent mixing will determine vertical, as well as horizontal, movement of pollutants, an important factor in a two-layered estuary such as the Chesapeake Bay. In some systems, stratification can represent a physical barrier to the mixing of the water column, thus minimizing the exchange of nutrients and oxygen through the pycnocline.

Sampling is conducted within the Bay to characterize the separate upper and lower water masses. UniStar obtained pycnocline data from the CBP to identify the depth and thickness of the pycnocline in the area of the Calvert Cliffs site. Four monitoring stations (CB4.3C, CB4.3E, CB4.4, and CB5.1) in the Calvert Cliffs site vicinity were found to have pycnocline data. A summary of the pycnocline data are provided in Table 3-8.

Temperature

Seasonal variations in the thermal stratification of the Bay are observed with generally well-mixed conditions during winter and strong stratification during summer. WY 2005 water temperature data are provided in Table 3-9. Water temperature affects chemical and



Source: UniStar CPCN Technical Report, Figure 4.5-1, Copyright 2007 UniStar Nuclear Development, LLC. Used by permission.

Figure 3-5
Chesapeake Bay Water Quality Monitoring Stations

Table 3-8 Summary of Pycnocline Data for Selected Chesapeake Bay Monitoring Stations, Water Year 2005

Station	Fall		Winter		Spring		Summer		Yearly
ID	Max	Min	Max	Min	Max	Min	Max	Min	Average
Depth to Pycnocline in feet (meters)									
CB4.3C	37.7 (11.5)	27.9 (8.5)	57.4 (17.5)	11.5 (3.5)	41 (12.5)	11.5 (3.5)	41 (12.5)	14.8 (4.5)	29.2 (8.9)
CB4.3E	34.4 (10.5)	11.5 (3.5)	--	--	44.3 (13.5)	14.8 (4.5)	27.9 (8.5)	14.8 (4.5)	25.7 (7.8)
CB4.4	44.3 (13.5)	18 (5.5)	44.3 (13.5)	27.9 (8.5)	34.4 (10.5)	8.2 (2.5)	41 (12.5)	27.9 (8.5)	31.4 (9.6)
CB5.1	47.6 (14.5)	8.2 (2.5)	54.1 (16.5)	18 (5.5)	41 (12.5)	11.5 (3.5)	37.7 (11.5)	14.8 (4.5)	27.9 (8.5)
Thickness of Pycnocline in feet (meters)									
CB4.3C	16.4 (5)	9.8 (3)	29.5 (9)	3.3 (1)	29.5 (9)	9.8 (3)	23 (7)	3.3 (1)	16.2 (4.9)
CB4.3E	19.7 (6)	16.4 (5)	--	--	6.6 (2)	<3 (<1)	26.2 (8)	9.8 (3)	13.1 (4)
CB4.4	49.2 (15)	9.8 (3)	19.7 (6)	9.8 (3)	32.8 (10)	19.7 (6)	23 (7)	6.6 (2)	19.9 (6.1)
CB5.1	52.5 (16)	6.6 (2)	32.8 (10)	9.8 (3)	49.2 (15)	23 (7)	49.2 (15)	9.8 (3)	23.6 (7.2)

Source: UniStar CPCN Technical Report, page 4-23,

Note:
-- = No data
Water Year 2005 runs from October 2004 through September 2005.

Table 3-9 Summary of Temperature Statistics (°F (°C)) for Selected Chesapeake Bay Monitoring Stations, Water Year 2005

Seasonal Statistics	CB4.3W	CB4.3C	CB4.3E	CB4.4	CB5.1W	CB5.1
Fall – September, October, November						
Max	78.3 (25.7)	79.7 (26.5)	79.5 (26.4)	80.6 (27.0)	80.2 (26.8)	79.9 (26.6)
Min	66.6 (19.2)	56.7 (13.7)	66.4 (19.1)	58.1 (14.5)	53.2 (11.8)	58.3 (14.6)
Average	71.9 (22.2)	69.9 (21.1)	73.4 (23.0)	69.7 (21.0)	70.7 (21.5)	69.9 (21.1)
N	15	66	37	74	22	78
Winter – December, January, February						
Max	--	54.5 (12.5)	--	54.5 (12.5)	47.7 (8.7)	54.5 (12.5)
Min	--	34.9 (1.6)	--	35.1 (1.7)	35.6 (2.0)	35.1 (1.7)
Average	--	42.8 (6.0)	--	42.7 (6.0)	43.0 (6.1)	43.2 (6.2)
N	0	69	0	75	10	75
Spring – March, April, May						
Max	61.7 (16.5)	61.5 (16.4)	61.3 (16.3)	61.9 (16.6)	62.8 (17.1)	62.2 (16.8)
Min	38.7 (3.7)	38.3 (3.5)	38.1 (3.4)	38.1 (3.4)	36.9 (2.7)	38.1 (3.4)
Average	51.0 (10.6)	49.0 (9.4)	50.0 (10.0)	49.8 (9.9)	51.2 (10.7)	49.2 (9.6)
N	41	105	93	123	26	131
Summer – June, July, August						
Max	82.9 (28.3)	83.5 (28.6)	83.1 (28.4)	85.3 (29.6)	83.5 (28.6)	84.4 (29.1)
Min	71.6 (22.0)	60.6 (15.9)	60.8 (16.0)	60.6 (15.9)	61.0 (16.1)	61.0 (16.1)
Average	79.0 (26.1)	74.9 (23.9)	75.0 (23.9)	75.4 (24.1)	77.6 (25.3)	74.8 (23.8)
N	50	126	108	135	24	148

Source: UniStar CPCN Technical Report, page 4-25, Copyright 2007 UniStar Nuclear Development, LLC. Used by permission.

Notes:
N = Number of measurements
-- = No data

biochemical reaction rates as well as physical processes such as current patterns and pollutant movement. With as little as an 18°F (10°C) water temperature increase, the speed of many chemical and physical reactions can double. Within the Bay, water temperature fluctuates throughout the year, ranging from 34 to 84°F (1 to 29°C). Based upon the WY 2005 temperature data, the water temperature dropped quickly in the winter months, with the minimum temperature of 34.9°F (1.6°C) at monitoring station CB4.3C and average temperatures ranging from 42.7 to 43.2°F (6.0 to 6.2°C). The greatest variability in temperature was observed during the fall months, with a maximum temperature of 80.6°F (27.0°C) and a minimum temperature of 53.2°F (11.8°C) recorded at monitoring stations CB4.4 and CB5.1W. Evaluation of the water temperature data compared to the pycnocline data showed unusually high variations in stratification across the Bay. The surface water (above the pycnocline) was found to have higher temperatures during the early spring through summer months that coincide with the establishment of the pycnocline. However, as the surface water temperatures dropped during late fall and winter the pycnocline began to decline, becoming less prominent within the water column.

Dissolved Oxygen

Dissolved oxygen (DO) concentrations in Bay waters fluctuate throughout the year in response to natural biological and physical processes. During the winter months, DO is relatively high throughout the water column in response to the increased solubility of DO in cooler water, reduced biologic activity and DO uptake, and a homogenizing of the water column produced by vertical mixing during turbulent seasonal weather (wind, storms). In the summer months, solubility decreases, biologic uptake increases, mixing becomes reduced, and the water column becomes stratified with the lowest DO concentrations typically observed below the pycnocline. Bacterial activity in organic material accumulating on the bay floor can produce DO-poor bottom water over large areas and the pycnocline can act as a barrier for bottom water exchange with DO-richer surface waters.

A summary of WY 2005 DO data is provided as Table 3-10. The data indicate that annual DO concentrations decrease with depth. The greatest variation in DO concentrations was observed in the middle of the water column, or within the area of the pycnocline. DO concentrations within the upper portion of the water column, or above the pycnocline, remained the most constant over the year. The lowest recorded DO concentration during the winter, at any depth, was 5.5 mg/L. Water below the pycnocline fell into severe hypoxic and anoxic conditions during the summer months. During the summer, low concentrations of 0.1 mg/L

Table 3-10 Summary of Dissolved Oxygen Concentrations (mg/L) for Selected Chesapeake Bay Monitoring Stations, Water Year 2005

Seasonal Statistics	CB4.3W	CB4.3C	CB4.3E	CB4.4	CB5.1W	CB5.1
Fall – September, October, November						
Max	9.1	9.2	8.1	8.6	10.1	8.3
Min	4.6	0.2	0.2	0.2	5.1	0.2
Average	7.6	4.6	4.4	4.8	7.1	4.7
N	15	66	37	74	22	78
Winter – December, January, February						
Max	--	13.6	--	13.2	13.8	13.3
Min	--	5.5	--	5.7	10.6	5.8
Average	--	10.1	--	9.9	11.9	9.8
N	0	69	0	75	10	75
Spring – March, April, May						
Max	13.2	12.6	12.5	12.8	13	12.3
Min	3.1	1.2	1.4	1.3	7.9	0.9
Average	9.3	7.1	7.7	7.0	10.7	7.1
N	41	105	93	123	26	131
Summer – June, July, August						
Max	10.2	10.4	9.2	9.8	9.7	8.6
Min	0.2	0.1	0.1	0.1	3.0	0.1
Average	5.7	2.7	2.8	2.7	6.4	2.1
N	50	126	108	135	24	148

Source: UniStar CPCN Technical Report, page 4-27, Copyright 2007 UniStar Nuclear Development, LLC. Used by permission.

Notes:
N = Number of measurements
-- = No data

occurred at four of the six monitoring stations, and a low concentration of 0.2 mg/L occurred at a fifth.

According to the CBP, water quality data gathered between 2003 and 2005 also indicate that only about 29 percent of the Bay's waters met DO standards during the summer months. State water quality standards have been developed to meet the DO needs of the Bay's aquatic life, and the standards vary with depth, season, and duration of exposure. The standards generally require 5.0 mg/L of DO for good aquatic conditions. If the water column contains DO concentrations below 2.0 mg/L, the water is considered "severely hypoxic," and DO concentrations below 0.2 mg/L are considered "anoxic." Evidence suggests there has been an increase in the intensity and frequency of hypoxia and anoxia in the Bay waters over the past 100 to 150 years, most notably since the 1960s.

Availability of DO is an important factor for biological and chemical processes within the Bay waters. Oxygen-rich shallow waters are most essential in the spring for spawning of aquatic species, and mortality rates for most aquatic species typically increase as DO concentrations decrease. DO additionally affects chemical processes such as the rate of flocculation, adsorption, and/or desorption of dissolved compounds (to organic or inorganic surfaces) within the Bay. Experiments have shown that the metals most strongly influenced by anoxia are manganese, zinc, nickel, and lead. Dissolved oxygen levels can drive the release of metals from sediments within the Bay due to oxidative/reductive processes. Elevated DO concentrations cause the release of such metals as copper and zinc, therefore causing greater contaminant exposure to organisms in the water column. On the other hand, decreased levels of oxygen (hypoxia or anoxia) cause metals to be bound in sediments, thus increasing exposure to bottom-dwelling organisms.

Salinity

Salinity levels are graduated vertically and horizontally within the Bay due to freshwater flows and are generally higher along the Bay's eastern shore. A summary of the WY 2005 seasonal salinity statistics is presented in Table 3-11. Based upon the WY 2005 CBP monitoring data as described in that table, salinity concentrations ranged between 4.1 parts per thousand (ppt) in spring and 22.2 ppt in summer. Salinity concentrations showed the least uniformity in spring, likely due to the high freshwater inflow caused by seasonal rainfall and snow melt; winter and fall showed the most uniform salinities. Salinity is a key factor in an estuarine ecosystem that affects distribution of living resources, circulation, and an integral fate and transport mechanism of chemical contaminants within the Bay. Aquatic species have varying degrees of tolerance for salinity.

Table 3-11 Summary of Salinity Statistics (parts per thousand) for Selected Chesapeake Bay Monitoring Stations, Water Year 2005

Seasonal Statistics	CB4.3W	CB4.3C	CB4.3E	CB4.4	CB5.1W	CB5.1
Fall – September, October, November						
Max	14.87	20.78	20.29	21.55	15.41	21.83
Min	7.93	7.93	8.89	9.98	8.44	10.69
Average	11.13	15.59	14.50	16.03	12.60	16.60
N	15	66	37	74	22	78
Winter – December, January, February						
Max	--	18.83	--	19.87	10.24	20.08
Min	--	5.82	--	7.12	8.69	8.38
Average	--	13.17	--	14.73	9.66	15.32
N	0	69	0	75	10	75
Spring – March, April, May						
Max	11.8	19.11	18.14	19.52	10.69	20.01
Min	4.6	4.06	4.3	4.42	5.39	4.18
Average	8.37	12.42	11.78	13.30	8.78	14.15
N	41	105	93	123	25	131
Summer – June, July, August						
Max	15.07	21.48	20.64	22.18	15	21.9
Min	10.5	10.56	10.63	10.95	9.33	10.95
Average	11.98	15.83	15.45	16.38	12.46	17.38
N	50	126	108	135	24	148

Source: UniStar CPCN Technical Report, page 4-28, Copyright 2007 UniStar Nuclear Development, LLC. Used by permission.

Notes:
N = Number of measurements
-- = No data

Because salinity affects various physiological mechanisms in an organism, such as movement across cell membranes, it can affect an organism's biological functioning, thus influencing how the organism may respond to the presence of contaminants. Most aquatic organisms therefore move to areas within the Bay with suitable habitat conditions. Salinity affects movement of waters by influencing stratification in the water column and determines what form chemical contaminants are likely to take, making them less available for uptake by Chesapeake Bay organisms.

Nutrients and Chemical Contaminants

Runoff within the Lower Maryland Western Shore watershed carries pollutants, such as nutrients and sediments, to rivers and streams that drain directly into the Bay. The entire watershed includes a land area of 83 mi^2 (215 km^2), with agricultural land uses comprising the second largest land use category at 14 percent; forested land made up 53 percent of the watershed area. Fertilizers containing nitrogen and phosphorus that are applied to agricultural lands are predominant sources of nutrient pollutants in stormwater. Most of the Bay mainstem, all of the tidal tributaries, and numerous segments of nontidal rivers and streams are listed as Federal Water Pollution Control Act (FWPCA) Section 303(d) “impaired waters” largely because of low DO levels and other problems related to nutrient pollution.

The Calvert Cliffs site lies within the Patuxent and Lower Maryland Western Shore watersheds, characterized by drainage to various creeks to the Patuxent River and the Bay. According to the MDE listing of Section 303(d) waters, the Patuxent River is the only contributing water body within the watershed with Section 303(d) status. The discussion of Section 303(d) waters is limited to those in the watershed in the area of the Calvert Cliffs site. The Patuxent River Lower Basin was identified on the 1996 Section 303(d) list submitted to the U.S. Environmental Protection Agency (EPA) by the MDE as impaired by nutrients and sediments, with listings of bacteria for several specified tidal shellfish waters added in 1998, and listings of toxics, metals, and evidence of biological impairments added in 2002. The Section 303(d) segments within the Patuxent River have been identified as having low priority. Only waters that may require the development of Total Maximum Daily Loads (TMDL) or that require future monitoring need a priority designation. Two approved TMDLs are already established within Calvert County, including a TMDL for fecal coliform for restricted shellfish harvesting areas and a TMDL for mercury in Lake Lariat. While the current Section 303(d) list identifies the lower Patuxent River and greater Chesapeake Bay as low priority for TMDL development, it does not reflect the high level of effort underway to identify and document pollution loadings in these watersheds.

Pursuant to the Federal Water Pollution Control Act, the water quality of effluent discharges to the Bay and its tributaries is regulated through the National Pollutant Discharge Elimination System (NPDES). Calvert Cliffs Units 1 and 2 maintain a current NPDES permit, State Discharge Permit 92-DP-0187; NPDES MD0002399. At the time of renewal in June 2004, the MDE was unaware of any major issue that would prevent renewal, and it was granted. The MDE noted that any new regulations promulgated by U.S. EPA or the MDE would be included in future permits and those may include development and implementation of TMDLs. NPDES data collected in 2005 were reviewed to determine the nature of effluent discharges from the Calvert Cliffs site. Discharge parameters including biological oxygen demand, chlorine (total residual), bromine (total residual), cyanuric acid, fecal coliform, oil and grease, pH, temperature, and total suspended solids were reported. Based upon the data reviewed, all discharges were within the acceptable range and no discharge violations were reported.

Sediments

The lands surrounding the Bay are mostly comprised of Pleistocene era deposits. Erosion of these deposits along the shoreline releases sediment that flows southward as littoral drift. The general flow of nearshore sediment transport is from north of Long Beach to a location just north of Calvert Cliffs. The Calvert Cliffs site is situated in an area of net loss of sediment as the result of a circulating eddy in the Flag Pond Nature Park area. The eddy influences the transport and deposition of sediments along the shoreline, most evidently to the south of the Calvert Cliffs site in the area of Cove Point. Cove Point is a littoral promontory that is slowly moving in a southerly direction, due to the transport and deposition of shoreline erosion sediments from beaches two to three miles to the north.

Turbulent weather conditions, prevailing wind patterns, currents, and tidal forces influence the spatial distribution of chemical pollutants in the Bay by driving resuspension of benthic sediments. Resuspension rates are generally higher in well-mixed areas, while sediments become buried faster and incorporated into the bottom in less vigorously mixed environments. Stratification in the water column due to temperature or salinity gradients can additionally limit the height to which eroded sediments can be resuspended, keeping them low in the water column.

Within the Bay, burial rates of heavy metals and movement of chemical pollutants out of sediments is moderate due to sedimentation and resuspension rates and low benthic cycling. Based upon the localized flow rates and pycnocline data presented in this section, resuspended bottom sediments are likely to settle rapidly within the area of the Calvert

Cliffs site. The bottom of the Bay in the Calvert Cliffs site area is characterized as having a hard substrate composed of compacted sand, mud, and calcareous shell fragments, overlain in some areas by scattered stones of various sizes. UniStar collected sediment grabs in September 2006 to assess the sediments and benthic biota. The samples were taken in the vicinity of the Calvert Cliffs Unit 3 discharge point (sample CCNPP-1) and at two locations within 500 ft (152 m) of this point and were analyzed for the following physical/chemical parameters:

- Percent solids,
- Ammonia nitrogen,
- Total Kjeldahl nitrogen (TKN),
- Total phosphorus,
- Metals (arsenic, cadmium, chromium, copper, lead, mercury, zinc),
- Pesticides,
- Polychlorinated biphenyl (PCB) congeners,
- Volatile organic compounds (VOCs),
- Semivolatile organic compounds (SVOCs) (including polyaromatic hydrocarbons),
- Grain size,
- Total organic carbon, and
- Specific gravity.

Concentrations of TKN, total organic carbon, total phosphorus, arsenic, chromium, lead, zinc, and PCB-18 were detected at levels that were above their respective method detection limits; however, based upon the relatively low concentrations of these analytes in samples, there is no evidence of sediment contamination.

Existing Thermal Impacts

Calvert Cliffs Units 1 and 2 use water from the Bay for condenser cooling (once-through systems), drawing bottom water through a 45 ft (15 m) deep, dredged channel that extends about 4,500 ft (1,400 m) offshore. Water passes through the plant in approximately 4 minutes and is discharged from an outfall north of the plant. A curtain wall that extends to a depth of 30 ft (9 m) across the intake channel limits the cooling water withdrawal to mostly bottom water, although there is evidence that mixing of surface and lower depth water occurs before entrance to the plant.

Proposed Calvert Cliffs Unit 3 will use a close-looped condenser cooling system, withdrawing makeup water from the Bay through a new intake structure located immediately south of the existing intake structure and adjacent to the existing curtain wall. All cooling system discharges from the new unit, including the cooling tower blowdown, will be discharged to the Bay via a new discharge structure to be built north of the barge pier. Impacts of the proposed Unit 3 discharge are discussed in Section 5 of this report.

Calvert Cliffs Units 1 and 2 use water from the Bay to provide condenser cooling at a rate of 5490 cubic feet per second (cfs) or 155 m^3/sec. At full plant load, cooling water is heated about 10°F (5.6°C) (USAEC, 1973). The heated effluent is discharged through four 12.6 ft^2 (3.8 m^2) concrete conduits which rest on the Bay bottom (two for each of the two units) about 850 feet (260 m) from the shoreline. The tops of the discharge conduits are about 6 feet (1.8 m) below the water surface and the velocity through each conduit is about 8.9 feet per second (2.7 m/s). Thermal plume studies were conducted at Calvert Cliffs Units 1 and 2 in 1978 to determine the distribution of temperature near the facility and to estimate the configuration and extent of the thermal plume resulting from the cooling water discharge; details of these studies are provided in BG&E and ANSP (1979).

Maryland Thermal Regulations

COMAR 26.08.03.03 describes the factors, criteria, and standards for thermal effluent limitations, including definitions of regulatory mixing zones that apply to cooling water discharges from power plants and other large industrial facilities. Dischargers unable to meet mixing zone criteria can request alternative effluent limitations (AELs) which "assure the protection and propagation of a balanced, indigenous community [BIC] of shellfish, fish and wildlife in and on the body of water into which the discharge is made." In making such a request, dischargers are required to show that the thermal discharge limitations that would otherwise apply to them are more stringent than necessary to protect the BIC. The regulations also require AELs to consider: 1) cumulative impacts of the thermal discharge together with all other significant impacts on the species affected, including impingement and entrainment impacts; 2) a significant increase in abundance or distribution of any species considered to be nuisance species; 3) a significant change in biological productivity; 4) a significant elimination or impairment of economic or recreational resources; and 5) a significant reduction in the successful completion of the life cycle of Representative Important Species (RIS) (defined according to COMAR 26.08.03.04).

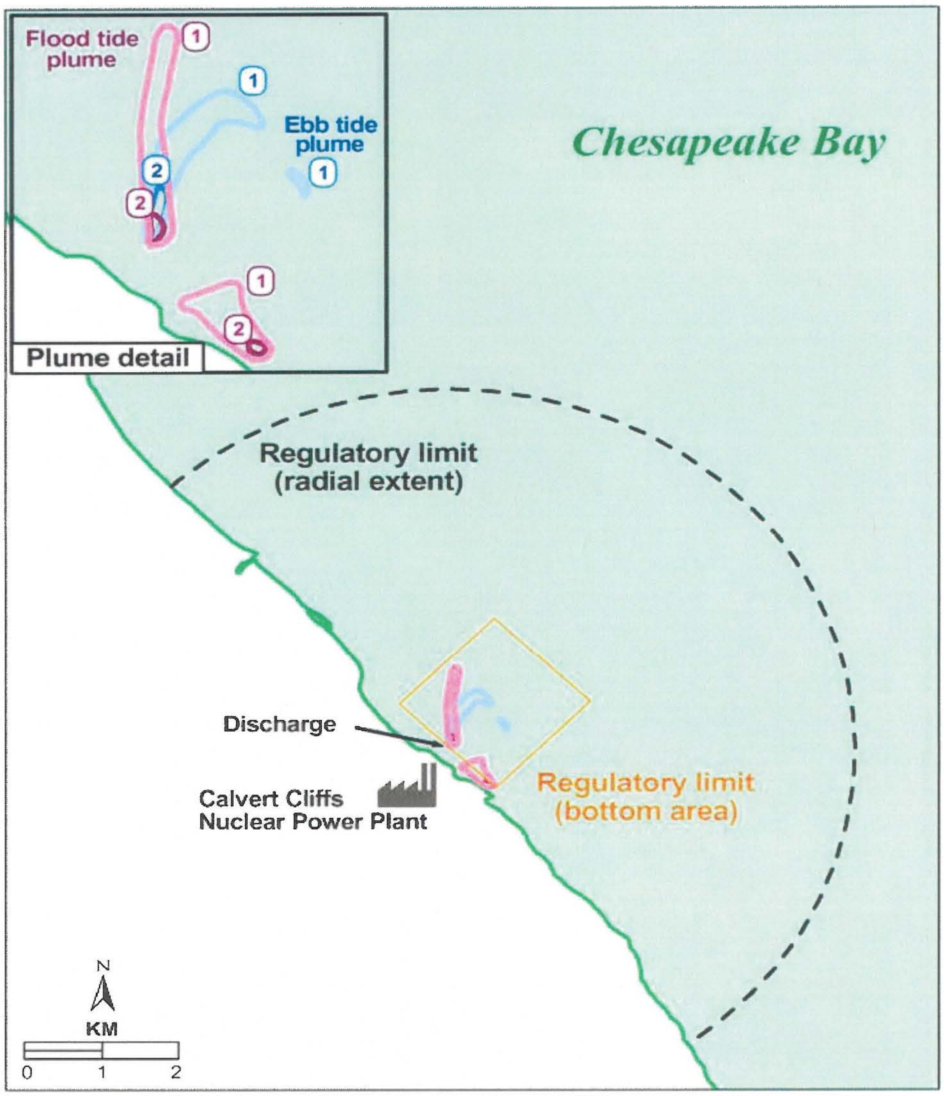
Existing dischargers at the time the regulations were issued (1974) were allowed to base their demonstration of AELs on the absence of prior appreciable harm instead of predictive studies. These demonstrations had to show that: 1) appreciable harm has not resulted from the thermal component of the discharge, taking into account the interaction of the thermal component with other pollutants and the additive effect of other thermal sources, to a BIC of shellfish, fish and wildlife in and on the body of water into which the discharge is made; or, 2) despite the occurrence of the previous harm, the desired AELs, or appropriate modifications to them, will nevertheless assure the protection and propagation of a BIC of shellfish, fish and wildlife in and on the body of water into which the discharge is made. In determining whether prior appreciable harm has occurred, MDE considers the length of time an applicant has been discharging and the nature of the discharge. If the discharger fails to demonstrate that existing facilities, or AELs together with all other impacts, will assure the protection and propagation of a BIC of shellfish, fish, other aquatic life, or wildlife in and on the receiving water, then the discharger is to make changes in the facility processes or operations, or both, sufficient to assure the protection and propagation of a balanced indigenous population of shellfish, fish, other aquatic life, or wildlife in and on the receiving water.

Mixing Zone Regulations

Maryland's thermal mixing zone regulations include three sets of mixing zone definitions laid out in the first part of the regulations (paragraph C, numbers 1, 2, 3): 1) a 50-foot mixing zone, meant to screen out small dischargers from further analysis; 2) a case-by-case mixing zone which may be requested when the detailed analysis required for tidal and non-tidal waters would not be applicable for some reason; and 3) compliance with maximum thermal limits and with specific mixing zone sizes depending on the type of receiving water. The maximum thermal limit criteria vary with the Use type definition as listed in COMAR 26.08.02.02B; however, all existing and recently proposed facilities in the state are located on waters defined as Use I or II, for which the thermal limit is 90°F (32°C). If this criterion is not met, regardless of other aspects of the mixing zone criteria, AELs would be requested.

Figure 3-6 illustrates a plan view of the Calvert Cliffs Units 1 and 2 discharge, showing an example of a thermal plume from one of the original studies as described in Schreiner *et al.* (2004) and BG&E and ANSP (1979). The figure also illustrates the surface dimensions of two of the mixing zone criteria in relation to the point of discharge and a representative discharge plume. These plume dimensions are based on estimates made in ANSP 1980. The figure shows that the discharge plume

Figure 3-6
Limits of Regulatory Mixing Zone in the Vicinity of Calvert Cliffs Units 1 and 2 Compared to Flood and Ebb Tide Thermal Plume Examples



Source: Schreiner, et al. 2004

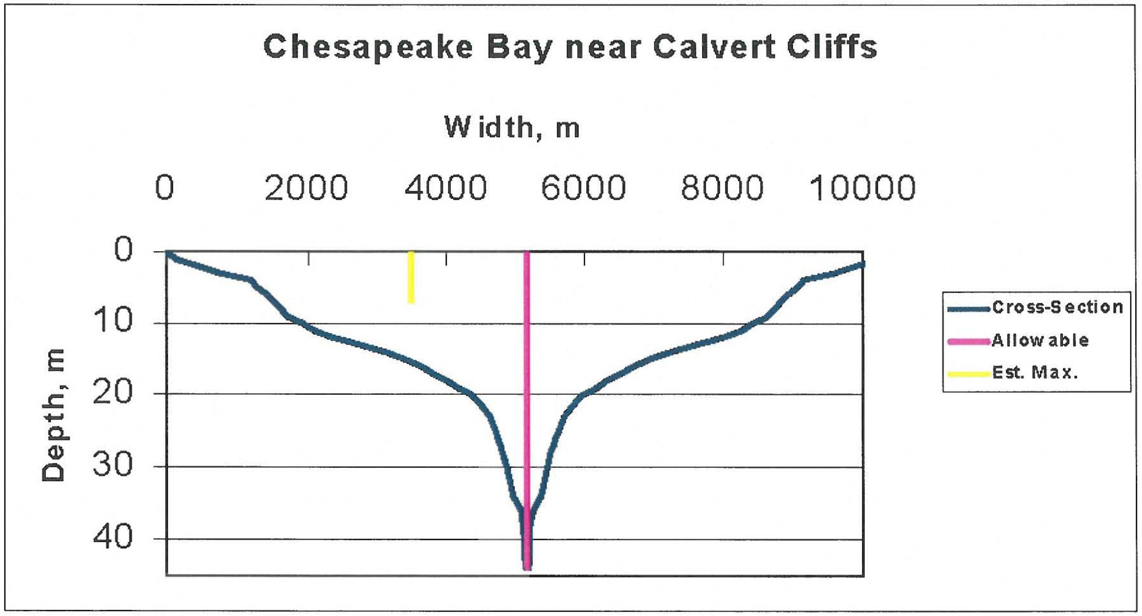
is well within the regulatory limits for the maximum radial extent and bottom area. Figure 3-7 illustrates a cross-section of the Bay in the vicinity of the existing Calvert Cliffs discharge, along with the allowable limit (50 percent of the cross-section) and the estimated maximum distance that the plume extended. This figure also shows that the discharge plume is well within regulatory limits, not an unexpected result since the discharge is located in a large open waterbody with plenty of room for dilution of the plume without impacting a large area.

Table 3-12 summarizes the results illustrated in the figures, providing a list of allowed dimensions for each of the three mixing zone criteria, in comparison with estimated actual dimensions of the thermal plume. The ratios of actual to allowed dimensions are all well less than 100 percent, indicating that the mixing zone criteria are easily passed. Thus, no further thermal studies were required to be performed at this facility.

Table 3-12 Calvert Cliffs Units 1 and 2 Mixing Zone Dimensions and Compliance with Maryland Regulations

Mixing zone specification	Allowed dimensions	Estimate of actual dimensions	Ratio of actual to allowed dimension
Maximum radial extent of 2ºC-above ambient isotherm, 24-hr average (km)	5.3	1.8	34%
2ºC-above ambient isotherm thermal barrier, 24-hr average (% of cross-section) (km)	9.1 - 14.3	3.5	25 – 38%
Area of bottom touched by waters heated 2ºC or more above ambient (km^2)	3.1	.34	11%

Figure 3-7
Limits of Regulatory Mixing Zone in the Vicinity of Calvert Cliffs Units 1 and 2 Compared with an Estimate of Maximum Plume Extent



3.3 CLIMATOLOGY AND AIR QUALITY

3.3.1 Climate

The following climate information is based on on-site meteorological data that the facility collected at Calvert Cliffs between 2001 and 2005. The on-site meteorological data were supplemented with information from the Bennett Airport near Salisbury, Maryland (referred to as Salisbury Airport), which is the closest station where data is collected by the Federal Aviation Administration. Salisbury Airport is located approximately 40 miles east of Calvert Cliffs.

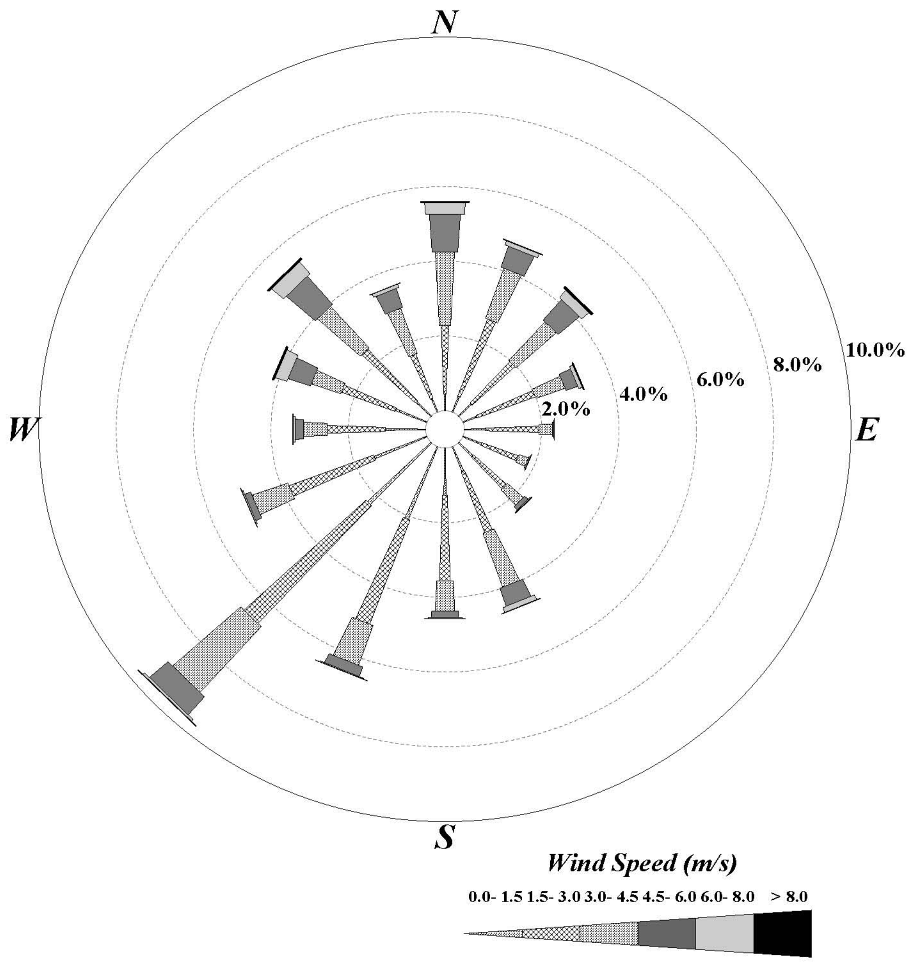
Calvert Cliffs lies between the Potomac River and the Chesapeake Bay, which is typically referred to as Southern Maryland. According to National Oceanic and Atmospheric Administration (NOAA) website, rainfall in this area is generally uniform; however, the greatest intensities are confined to the summer and early fall months, the season for hurricanes and severe thunderstorms. The average annual rainfall is about 45 inches per year.

January is the coldest month, and July is the warmest. The average high temperature usually occurs in July (2001-2005 average was 82°F) and the average low temperature usually occurs in January (2001-2005 average was 28°F). Snowfall occurs on about 11 days per year on the average; however, only about 6 of those days, on average, produce snowfalls of 1 inch or greater. Snow is frequently mixed with rain and sleet, and snow seldom remains on the ground more than a few days.

The annual prevailing wind direction is from the southwest. Winter and spring months have the highest average wind speed. Destructive velocities are rare and occur mostly during summer thunderstorms. Only rarely have hurricanes in the vicinity caused widespread damage, then primarily through flooding.

A wind rose based on five years of data (2001-2005) from Calvert Cliffs on-site meteorological data is presented as Figure 3-8. This figure depicts how often, over the course of a year, winds are blowing from each specified direction. The most frequent winds are coming from the southwest.

Figure 3-8
Wind Rose for Calvert Cliffs
On-site Meteorological Data for Five Years (2001-2005)



3.3.2 *Ambient Air Quality*

EPA and state agencies monitor concentrations of the "criteria" pollutants, nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter (PM), ozone, carbon monoxide (CO), and lead at various locations across the United States near ground level. If monitoring indicates that the concentration of a criteria pollutant exceeds the National Ambient Air Quality Standard (NAAQS) in any area of the country, that area is labeled a "nonattainment area" for that pollutant, meaning that the area is not meeting the NAAQS. Conversely, any area in which the concentration of a criteria pollutant is below the NAAQS is labeled an "attainment area," indicating that the NAAQS is being met.

The attainment/nonattainment designation is made by states and EPA on a pollutant-by-pollutant basis. Therefore, the air quality in an area may be designated attainment for some pollutants and nonattainment for other pollutants at the same time. For example, many cities are designated nonattainment for ozone, but are in attainment for the other criteria pollutants.

Since the late 1980s, the NAAQS for PM covered "PM10," which represents PM less than 10 microns in diameter. In 1997, EPA revised the NAAQS for PM and added a standard for a new form of PM known as PM2.5, PM less than 2.5 microns in diameter. PM2.5, or "fine particulates," are of concern because the particles' small size allows them to be inhaled deeply into the lungs and the particles contribute to haze and other air quality issues. In December 2004, EPA published its final designation of PM2.5 nonattainment areas.

EPA and states make attainment designations based on air quality surveillance programs that measure pollutants in a network of nationwide monitoring stations known as the State and Local Air Monitoring Stations (SLAMS), National Air Monitoring Stations (NAMS), and Photochemical Air Monitoring Stations (PAMS) (USEPA, 1998). NAMS are a subset of the SLAMS focused on urban and multi-source areas. PAMS are also a subset of the SLAMS, and are focused on areas of the country with ozone nonattainment issues. Appendix D of Part 58 of the Code of Federal Regulations establishes air quality monitoring network design specifications.

Calvert County, where Calvert Cliffs is located, is in attainment of the NAAQS for all criteria pollutants with the exception of ozone. Calvert County is part of the Southern Maryland Intrastate Air Quality Region which is as a designated "moderate" ozone nonattainment area (on a scale that ranges from worst to best air quality of extreme – severe – serious – moderate – marginal).

Figure 3-9 illustrates ambient air quality monitoring stations in and around Calvert County, operated under the SLAMS network. The monitoring data are collected and maintained by EPA's Air Quality System (AQS) database and are available from the EPA's website (www.epa.gov/air/data/). Table 3-13 presents the existing ambient air concentrations for ozone and PM2.5 in Calvert County.

Figure 3-9
Location of Pollutant Monitoring Stations in the Vicinity of Calvert Cliffs

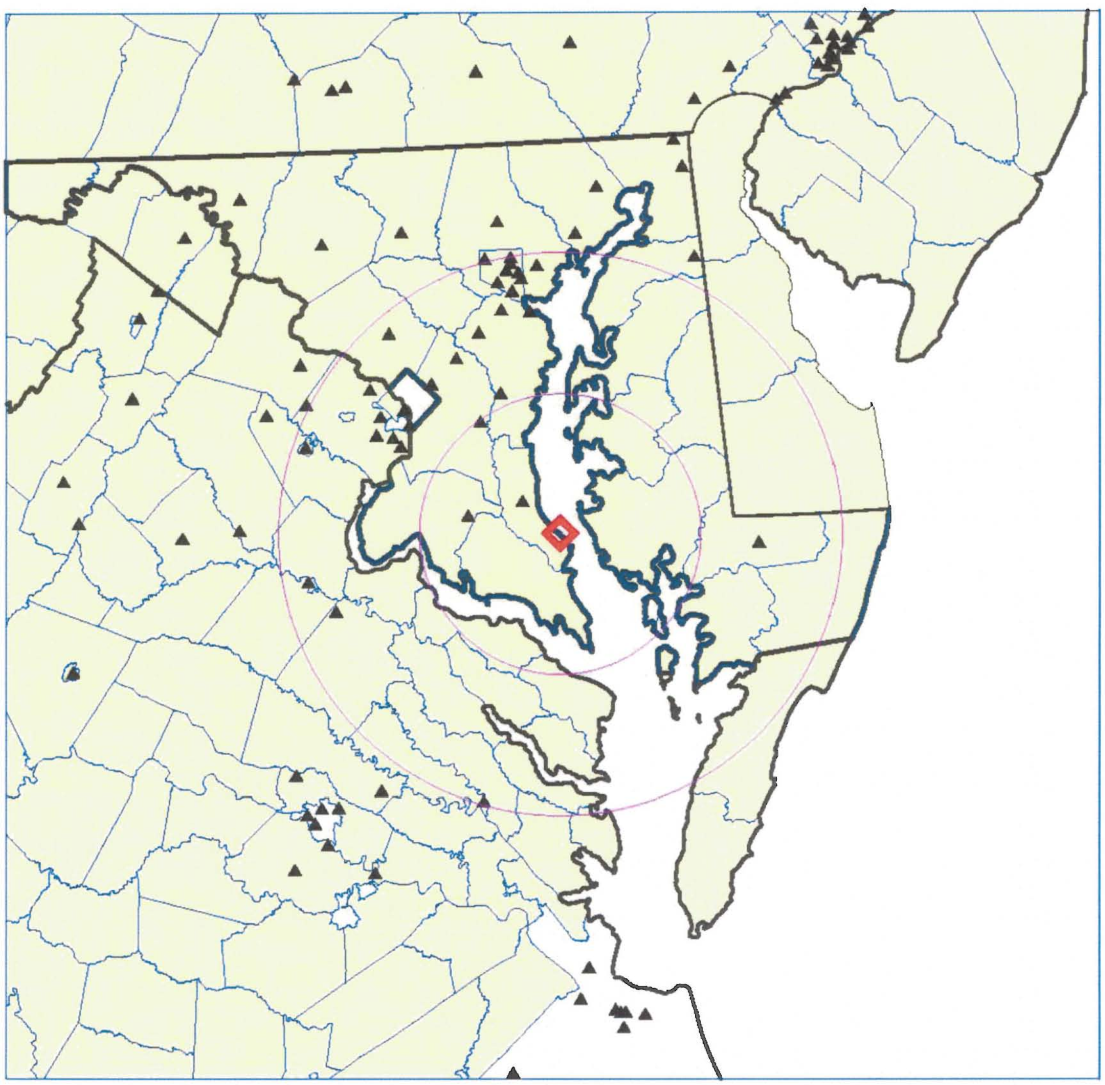


Table 3-13 Summary of Monitoring Data for Ozone in Calvert County (2005-2007)

Pollutant	Averaging Period	Maximum Concentration (1st Max.), in ppm	NAAQS in ppm
Ozone	1-hour 8-hour	0.112 0.092	0.12 0.08

3.4 BIOLOGICAL RESOURCES

3.4.1 Terrestrial Ecology

The terrestrial ecology of the Calvert Cliffs site, including the Calvert Cliffs Unit 3 construction area, was characterized in a series of field studies conducted over a one year period by UniStar and its consultants from May 2006 to April 2007. The field surveys included a floral survey, a faunal survey, a rare tiger beetle survey, a rare plant survey, and a wetland delineation report. More recently as part of the Joint Application for wetlands permit, UniStar conducted general site reconnaissance of representative wetland and upland habitats from November 2007 through February 2008 to assess the potential for occurrence of protected animal and plant species at the project site. Additionally, a Forest Stand Delineation (FSD) and Forest Conservation Plan (FCP) were prepared as required by the Maryland Forest Conservation Act (FCA), and provide additional descriptions of forest resources in the Project Area and impacts associated with development of the proposed project. The subsections below summarize relevant information from each of these studies and provide other data on existing terrestrial ecology.

3.4.1.1 *Vegetation and Land Cover*

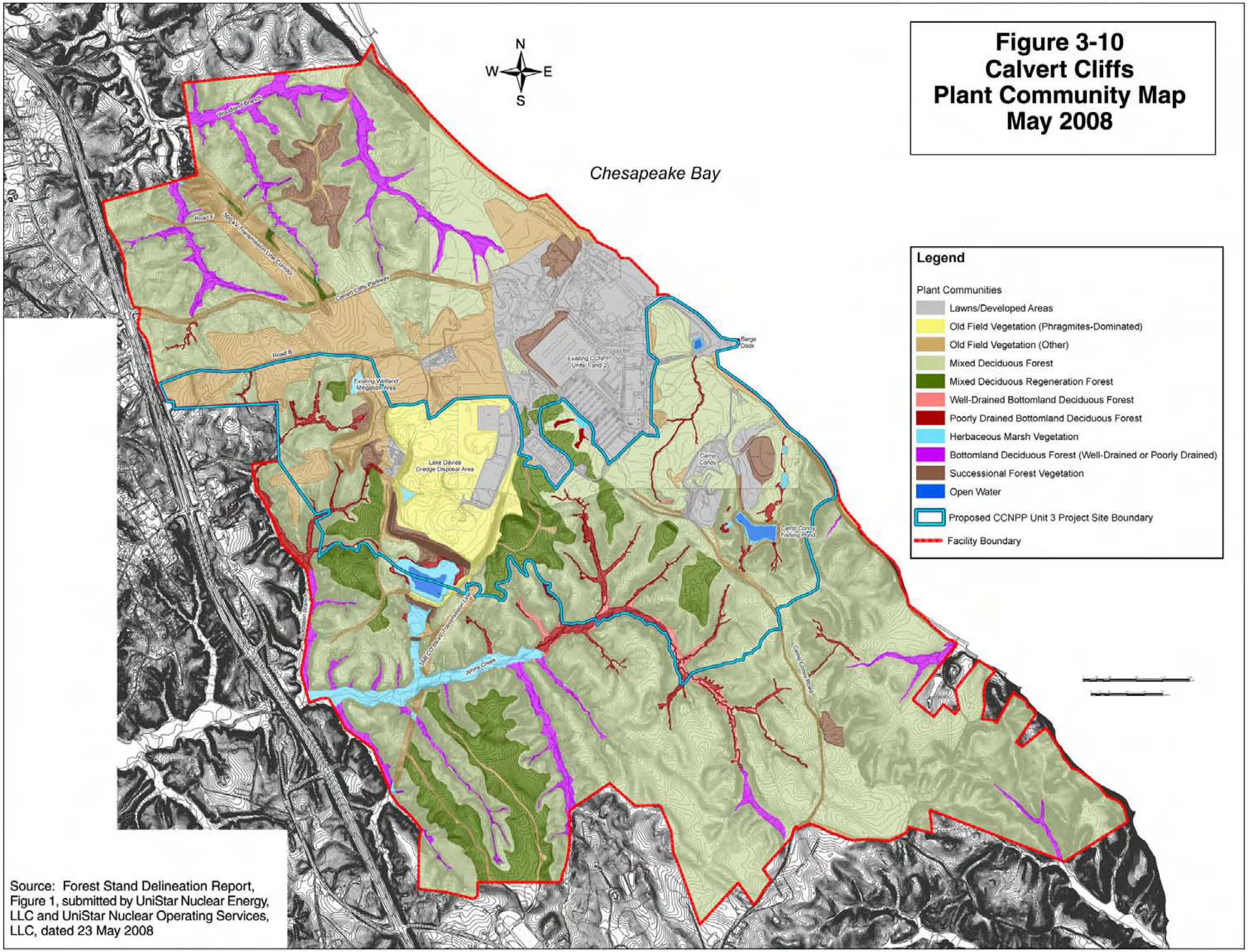
In its Flora Survey Report (May 2007), UniStar mapped the plant communities for the 2,070-acre Calvert Cliffs site (Figure 3-10). A number of communities were characterized including both upland and wetland communities.

Upland Communities

The upland vegetation and land cover types currently present at the Calvert Cliffs site are briefly discussed below.

- *Lawns and Developed Land.* Lawns and developed land occurs over a broad area in the east-central part of the Calvert Cliffs site (surrounding the two existing Calvert Cliffs reactor units and other smaller areas) and in Camp Conoy (see Figure 3-10). Camp Conoy includes several athletic fields and other lawn areas surrounding

Figure 3-10
Calvert Cliffs Plant Community Map May 2008



Source: Forest Stand Delineation Report, Figure 1, submitted by UniStar Nuclear Energy, LLC and UniStar Nuclear Operating Services, LLC, dated 23 May 2008 recreational facilities. The lawns on the Calvert Cliffs site consist only of a groundcover stratum, with broadly scattered shrubs and trees.

Most of the lawns consist of cool season grasses (grasses that typically seed during spring and fall) such as tall fescue *(Festuca arundinacea)*, bluegrass *(Poa pratensis)*, large crabgrass *(Digitaria sanguinalis)*, and Bermuda grass *(Cynodon dactylon)*. Common broadleaf weeds typical of lawns are also present, such as white clover *(Trifolium repens)*, broadleaf plantain *(Plantago major)*, dandelion *(Taraxicum officinale)*, and yellow hawkweed *(Hieracium pretense)*.

- *Oldfield.* The largest area of oldfield vegetation at the Calvert Cliffs site is on the dredged materials deposited since the early 1970s on lands extending west from Calvert Clifs Units 1 and 2 (see Figure 3-10). The dredged materials are covered by a dense stand of common reed (*Phragmites australis*). Plants more typical of old fields, such as common blackberry (*Rubus allegheniensis*) and tall fescue (*Festuca arundinacea*), are also present on the dredged materials but are not as dominant as common reed. Old field vegetation is also located in some small fields in the northwestern part of the Calvert Cliffs Unit 3 construction area, in scattered forest clearings around the perimeter of the dredged materials, and in other developed areas on the Calvert Cliffs site, as well as along roadsides. Many such areas were disturbed during construction of Calvert Cliffs Units 1 and 2 and various support facilities, such as the spent fuel storage structures. Vegetation in these areas is dominated by tall fescue, sericea lespedeza *(Lespedeza cuneata)*, common blackberry, Canada goldenrod *(Solidago canadensis)*, and asters *(Aster sp.)*.

- *Mixed Deciduous Forest.* Most forested uplands on the Calvert Cliffs site (see Figure 3-10), as well as the southern and western parts of the Calvert Cliffs Unit 3 construction area, possess deciduous forest dominated by tulip poplar *(Liriodendron tulifera)*, chestnut oak *(Quercus prinus)*; white oak *(Quercus alba)*; black oak *(Quercus velutina)*, southern red oak *(Quercus falcata)*, and scarlet oak (*Quercus coccinia*); American beech (*Fagus grandifolia);* and Virginia pine *(Pinus virginiana)*. Other canopy trees include hickories such as pignut hickory *(Carya glabra)* and bitternut hickory (*Carya cordiformis)*, red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua)*, swamp chestnut oak *(Quercus michauxii)*, and black gum (*Nyssa sylvatica*). The forest understory consists of dense patches of mountain laurel *(Kalmia latifolia)*, pawpaw (*Asimina trilobata*), and American holly *(Ilex opaca)*, with scattered but frequent saplings of canopy species. Ground cover is sparse except where recently fallen trees have left gaps in the tree canopy. Scattered patches of the following species are present in the groundcover: partridgeberry *(Mitchella repens)*, Christmas fern *(Polystichum* *acrostichoides)*, common violet *(Viola papilionacea*), and large whorled pogonia *(Isotria verticillata)*.

Several areas of relatively level uplands that formerly possessed mixed deciduous forest have been selectively logged within the past 20 years. These areas presently possess dense thickets of deciduous trees and Virginia pines. The deciduous trees consist of tulip poplar, oaks, sweet gum, and red maple. Virginia pine is generally more frequent in the regenerating forest than in adjoining areas of mature mixed deciduous forest. The regenerating forest lacks a distinct understory but does contain scattered mountain laurel and American holly. Little groundcover is present other than along fire roads or in other small openings.

Small patches of forest on recently disturbed lands in the central part of the Calvert Cliffs site possess forest cover dominated by fast growing tree species that establish in sunny areas such as old fields. Dominant tree species include black locust *(Robinia pseudoacacia*), black cherry (*Prunus serotina)*, and eastern red cedar (*Juniperus virginiania*). The understory generally consists of the same shrub, vine, and herbaceous species described for oldfield vegetation. Most of the canopy trees are less than 10 inches in diameter at breast height (DBH). The canopy trees cast only weak shade and allow dense undergrowth by old field species.

- *Well-Drained Bottomland Deciduous Forest (Well-Drained)*. Areas of well-drained soils in lowlands adjoining Johns Creek, Goldstein Branch, their headwaters, and other streams on the Calvert Cliffs site (see Figure 3-10). These areas possess bottomland deciduous forest dominated by tulip poplar, American beech, sweet gum, black gum, and red maple. This vegetation represents an ecotone (transition) between the mixed deciduous forest on the adjoining upland slopes and the bottomland hardwood forest in wetter areas closer to the stream channel. The understory is generally sparse, although some mountain laurel and American holly are present. While groundcover is generally sparse, dense patches of New York fern *(Thelypteris noveboracensis*) are frequent.

Maryland Forest Conservation Act

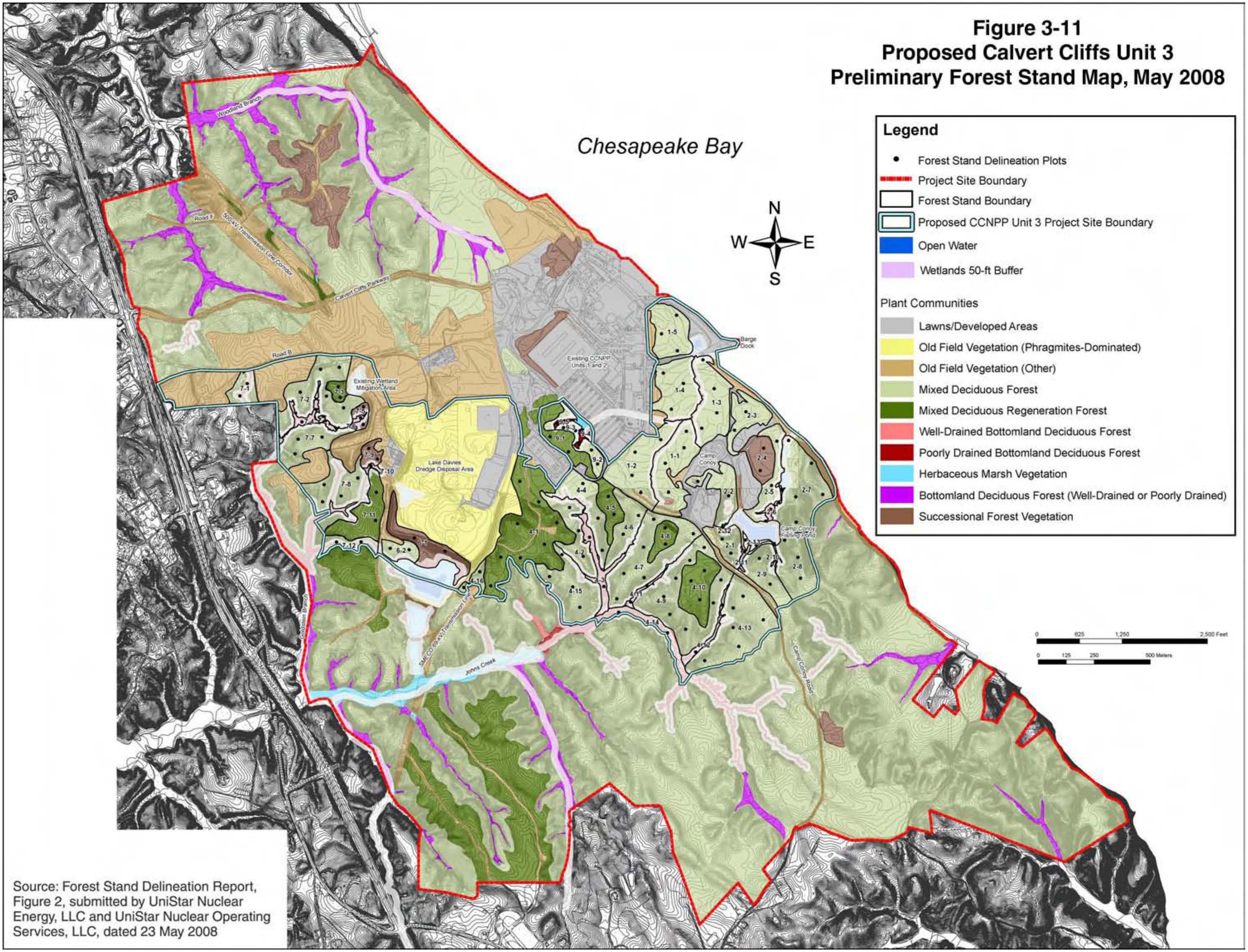
The Maryland Forest Conservation Act (FCA) was passed to conserve the State's forest resources during development activities by requiring identification of existing forest stands, protection of the most desirable forest stands, and establishment of areas where new forests can be planted (DNR 1997). As required by the FCA, UniStar conducted a Forest Stand Delineation (FSD) of forested areas that would be affected by construction of the proposed project. In total, 53 forest stands were delineated, which comprised a forested area of 385.6 acres distributed among six forest types (Figure 3-11 and Table 3-14). Each forest stand was identified in reference to the Wetland Assessment Area (see Final Wetlands Delineation Report, May 2007) receiving surface runoff from the stand. Because UniStar restricted the construction footprint to avoid disturbing forest cover draining into Wetland Assessment Areas III, V, and VIII, no forest stands were delineated in those areas. Additional data were collected for each forest stand including basal area, tree tally, and percent cover, as well as identifying Specimen Trees, which are individual trees having a diameter measuring 30 inches DBH or more, or having a diameter 75 percent or more than that of the current state champion tree of that species.

Table 3-14 FSD Delineated Forest Stands of the Calvert Cliffs Unit 3 Project Area

Forest Type	**Number of Stands**	**Acreage of Forest**
Sweetgum – Tulip Poplar	9	93.7
Chestnut Oak	19	194.8
Virginia Pine – Oak	7	62.8
Black Locust	3	12.5
Sycamore – Sweetgum – American Elm	14	21.1
Virginia Pine	1	0.7
Total	**53**	**385.6**

Along with the FSD, a Forest Conservation Plan (FCP) is prepared, which is a planning and construction document that outlines the mitigation requirements for a project. The FCP calculates the amount of forest that should be retained for permanent preservation, and the extent of land that should be reforested or afforested depending upon the existing land cover. The results of the calculations are affected by a two threshold values – Conservation Threshold and Afforestation Threshold – that vary according to how the property is zoned. The Calvert Cliffs property is zoned for Commercial and Industrial Uses Areas which has the lowest Conservation and Afforestation Thresholds, with both at 15 percent. The results of the FCP describing the impacts of the Calvert Cliffs Unit 3 construction and mitigation requirements will be discussed in Section 5.

Figure 3-11
Proposed Calvert Cliffs Unit 3
Preliminary Forest Stand Map, May 2008



Source: Forest Stand Delineation Report, Figure 2, submitted by UniStar Nuclear Energy, LLC and UniStar Nuclear Operating Services, LLC, dated 23 May 2008

Wetland Communities

The following are descriptions of vegetation and land cover in the principal wetlands types in the vicinity of the proposed Calvert Cliffs Unit 3 site:

- *Poorly Drained Bottomland Deciduous Forest.* Areas of poorly drained, seasonally saturated soils in lowlands adjoining Johns Creek, Goldstein Branch, their headwaters, and other streams on the Calvert Cliffs site (see Figure 3-10) possess bottomland hardwood forest dominated by red maple, sweet gum, and black gum. The shrub layer is generally sparse. The groundcover is generally dense, dominated by ferns such as New York fern, sensitive fern *(Onoclea sensibilis*), and royal fern (*Osmunda regalis*); sedges and rushes such as tussock sedge *(Carex stricta)*, eastern bur-reed (*Sparangium americanum*), and soft rush (*Juncus effusus)*; and forbs such as lizard tail (*Saururus cernuus*) and skunk cabbage (*Symplocarpus foetidus*).
- *Herbaceous Marsh Vegetation.* Herbaceous marsh vegetation occurs throughout much of the broad bottomland areas adjoining Johns Creek in the western part of the Calvert Cliffs site as well as in localized gaps in the forest cover in the narrower bottomlands adjoining the headwaters of Johns Creek, Goldstein Branch, and other streams (Figure 3-10). It is dominated in many places by invasive common reed. Other areas are dominated by sedges, rushes, and bulrushes; lizard tail, which forms localized dense patches; and various other wetland forbs such as dotted smartweed *(Polygonum punctatum*), Pennsylvania smartweed (*Polygonum pensylvanicum),* jewelweed (*Impatiens capensis),* and halberd-leaved tearthumb (*Polygonum arifolium).* These areas include a marshy fringe surrounding the shore of Camp Conoy fishing pond, two smaller impoundments on the stream carrying the outflow from the fishing pond to the Chesapeake Bay, a constructed wetland in the northwestern part of the Calvert Cliffs site, and a marshy fringe surrounding a stormwater detention pond west of a dock on the Chesapeake Bay.
- *Chesapeake Bay Shoreline.* Where the Chesapeake Bay shoreline has not been developed with the existing reactor units and barge dock, it consists of a narrow sandy beach at the base of steep, sandy cliffs. The beach is generally less than 20 ft (6 m) wide during normal low tides. There are no tidal marshes on the Calvert Cliffs site. However, small tidal marshes are present in the Flag Ponds Natural Area north of the Calvert Cliffs site and on the shoreline of tidal reaches of St. Leonard's Creek and its tributaries. Some forested areas close to the Chesapeake Bay or other tidal waters possess forest dominated by loblolly pine (*Pinus taeda*), and some inland areas possess forest dominated by Virginia pine. The latter consist primarily of recently abandoned

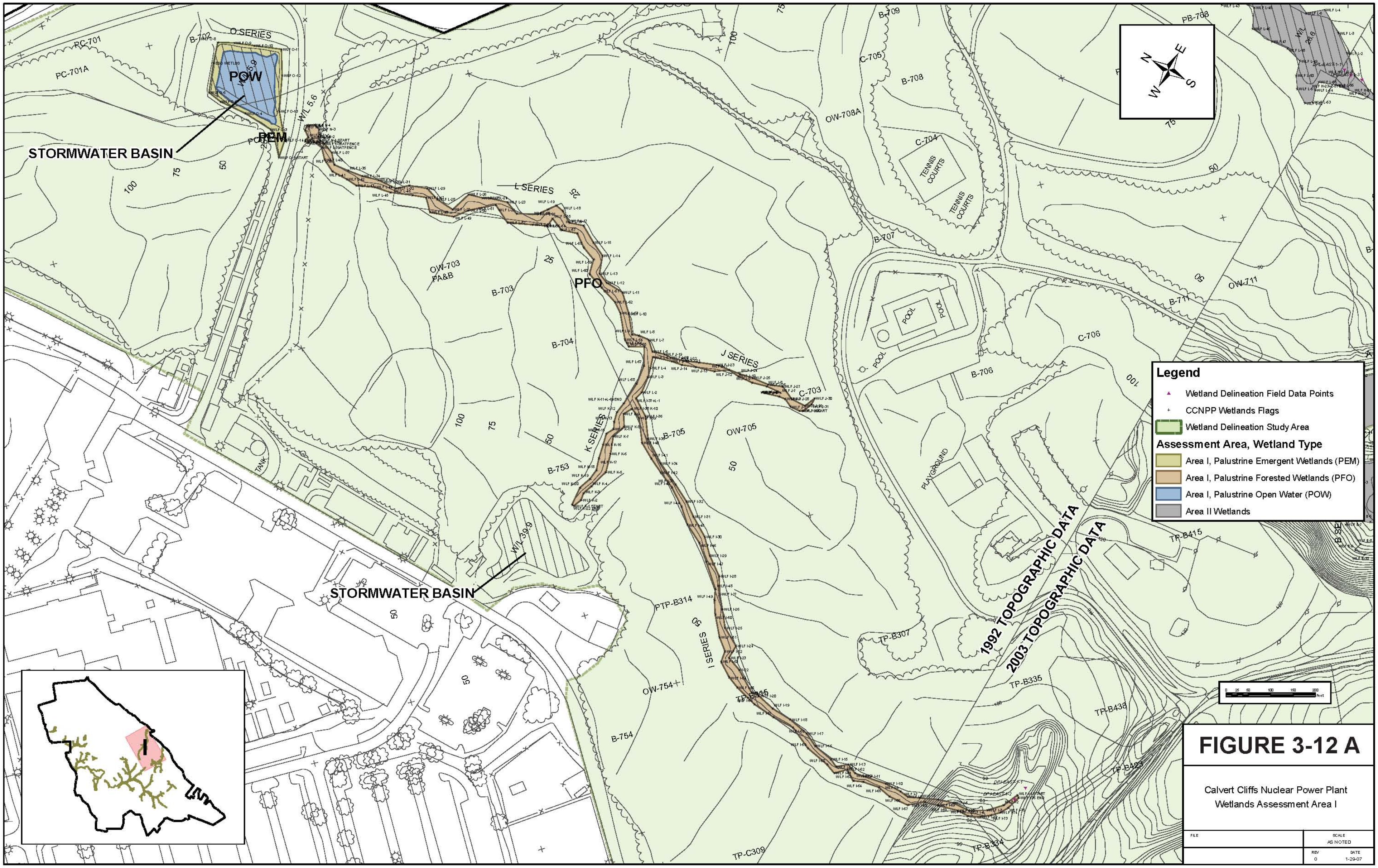
farmlands or other lands recently disturbed and left to naturally regenerate.

3.4.1.2 *Wetland Delineations and Functional Assessment*

Wetlands were delineated by UniStar and their consultants at the proposed Calvert Cliffs Unit 3 site in 2006 and 2007 (Figures 3-12 A through L). The wetland delineation consisted primarily of forested areas south and southwest of the existing reactors. It included Camp Conoy; the Camp Conoy Fishing Pond; Lake Davies, a disposal area for dredged materials; and other forested and grassy areas that form part of a buffer of undeveloped lands surrounding the two existing reactors. The wetland delineation did not include the existing reactors, associated parking and appurtenant facilities, or the existing 500-kV transmission corridor.

Herbaceous marsh and poorly-drained bottomland deciduous forest at the Calvert Cliffs site meet the definition of wetlands established in 33 CFR 328.3 for the Federal Clean Water Act and COMAR 26.23.01.01(B)(62) for the Maryland Nontidal Wetland Protection Act. The wetland boundaries were marked in the field using sequentially numbered flags; coordinates for each flag were surveyed by UniStar and their consultants in the field. The USACE inspected the delineated wetland areas and stream channels on the Calvert Cliffs Unit 3 site on January 14 and 15 and February 5, 2008. The field visit resulted in some modifications to the delineated wetlands lines. Final USACE verification of the Jurisdictional Determination is forthcoming.

For purposes of characterization and discussion, the delineated wetlands were grouped by UniStar into nine Assessment Areas. Assessment Areas I, II, III correspond to small unnamed watersheds that drain directly to the Chesapeake Bay (Assessment Area III flows out of the Wetland Delineation Project Area before reaching the Chesapeake Bay). Assessment Areas IV, V, and VI form the Johns Creek watershed (upstream of Goldstein Branch). Assessment Area IV constitutes the up-gradient headwaters to Johns Creek and their adjoining wetlands, while Assessment Area V constitutes the main channel and their adjoining wetlands. Assessment Area VI comprises a sequence of man-made basins carrying stormwater runoff from the Lake Davies dredged material disposal area to Johns Creek. Assessment Area VII constitutes the headwaters, main channel, and associated wetlands of Goldstein Branch. Assessment Area VIII consists of a small cluster of seepages and headwaters that flow north past the northern perimeter of the Wetland Delineation Project Area and ultimately contribute to Woodland Branch and St. Leonard Creek. Assessment Area IX comprises a series of seepages and headwaters that drain into a storm drain system under the



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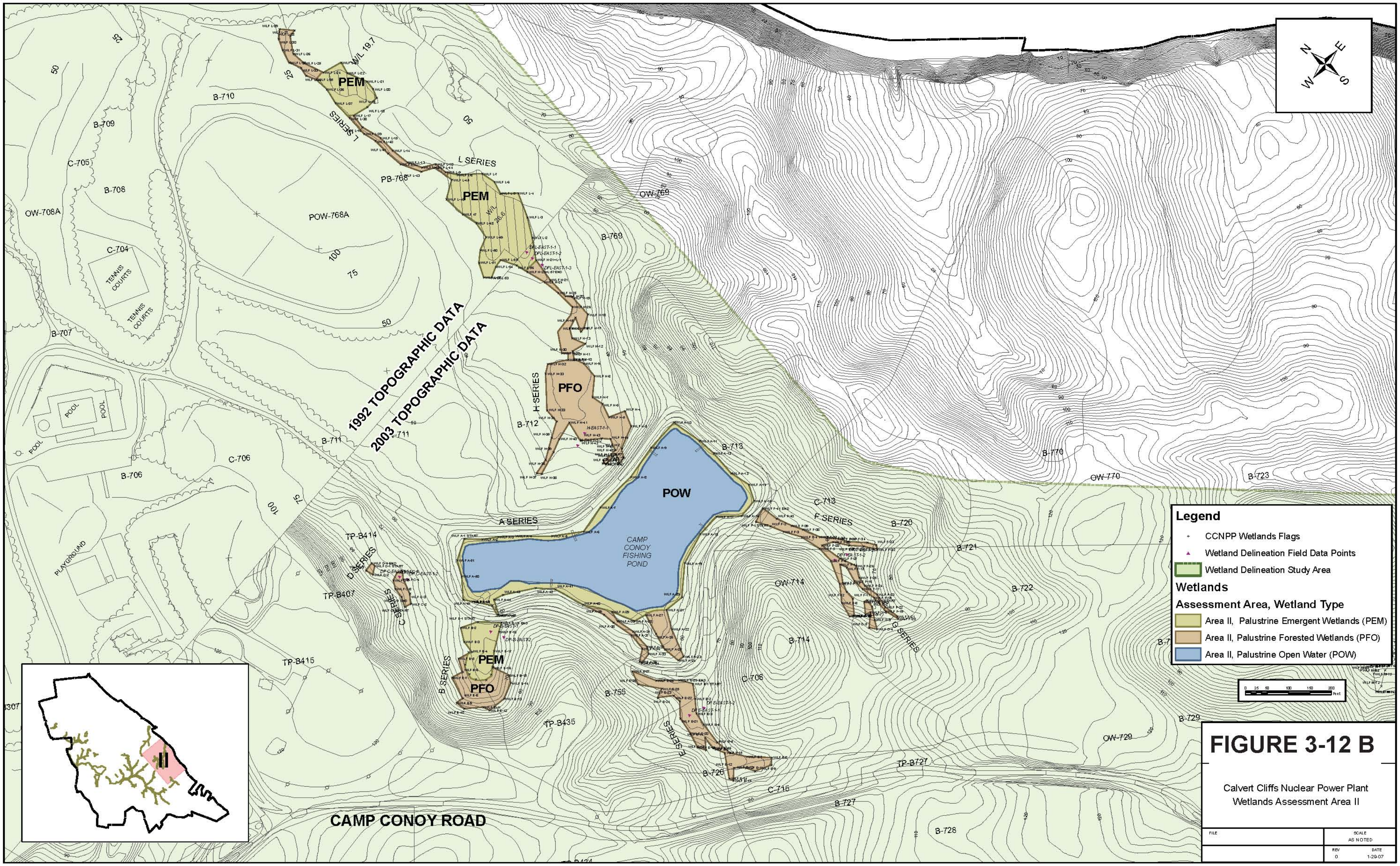

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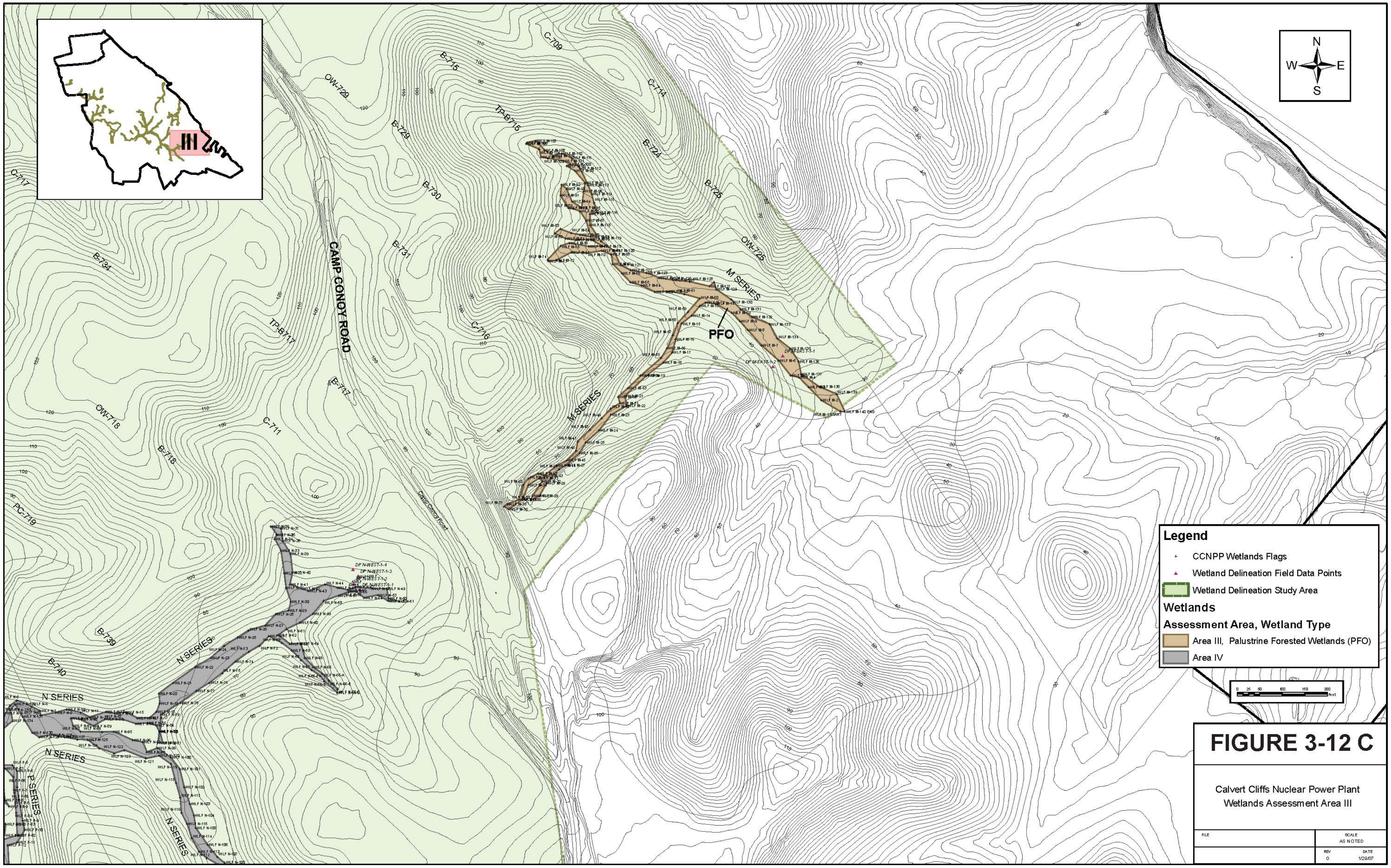

FIGURE 3-12 C

Calvert Cliffs Nuclear Power Plant
Wetlands Assessment Area III

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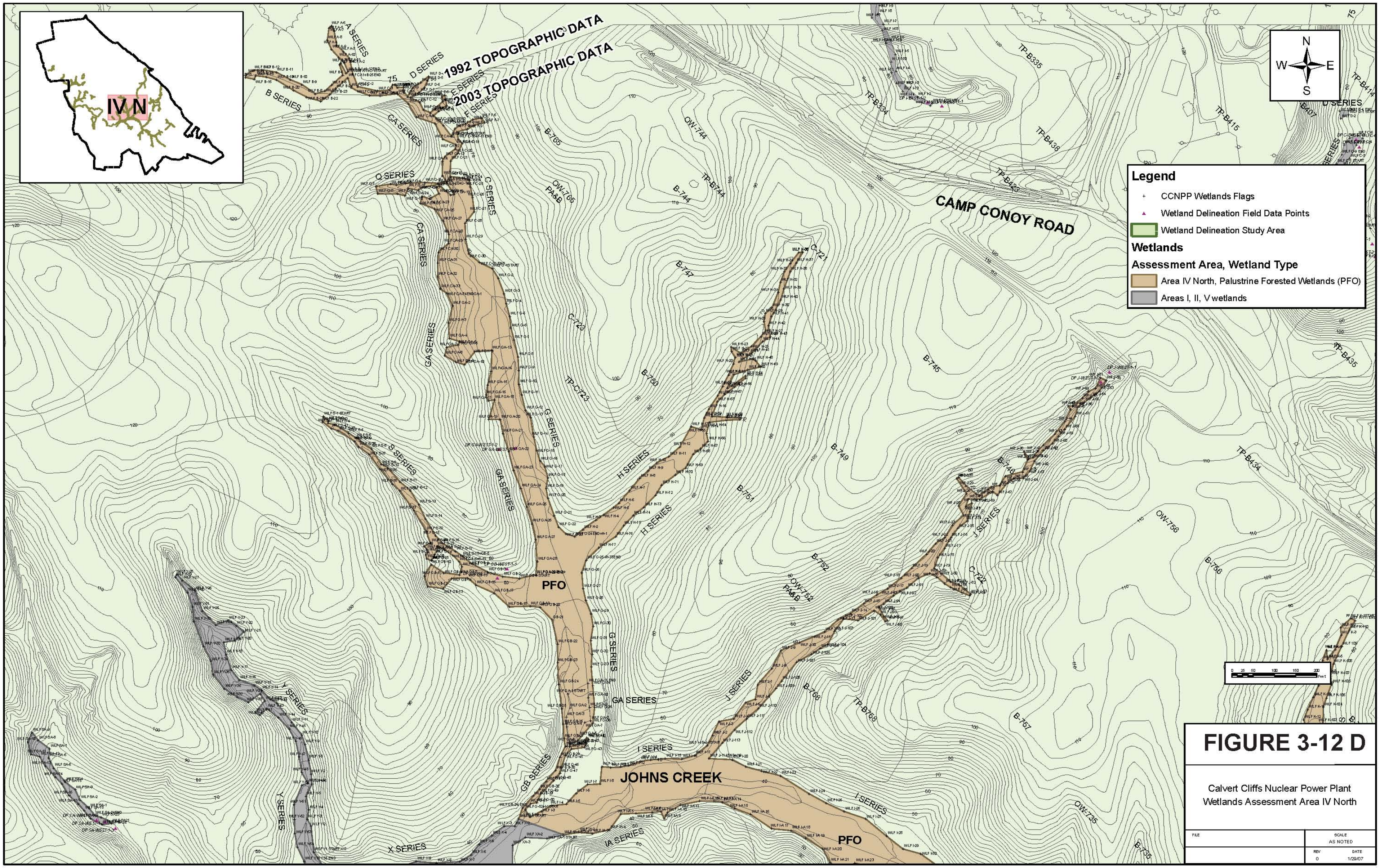

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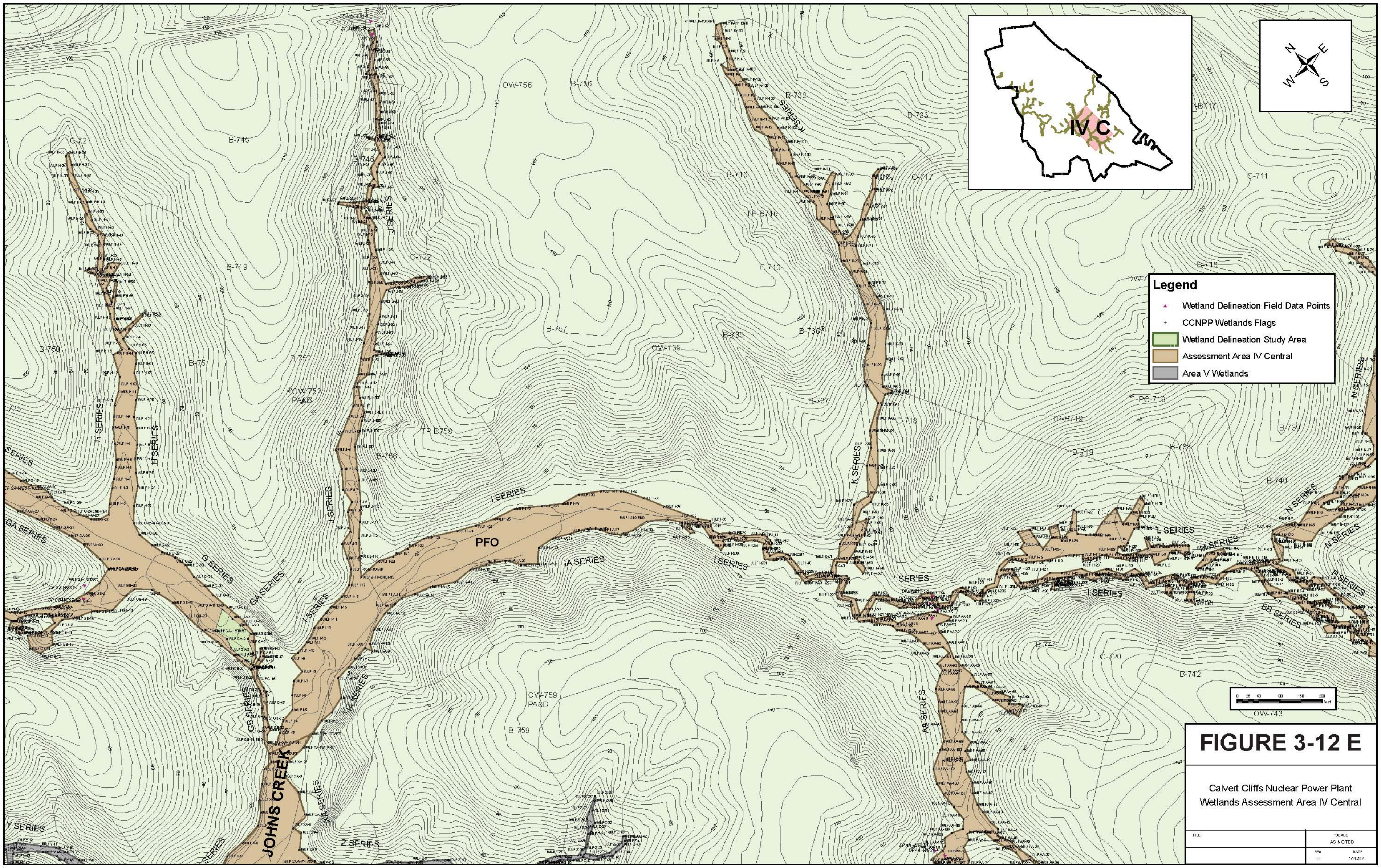

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FIGURE 3-12 F

Calvert Cliffs Nuclear Power Plant
Wetlands Assessment Area IV South

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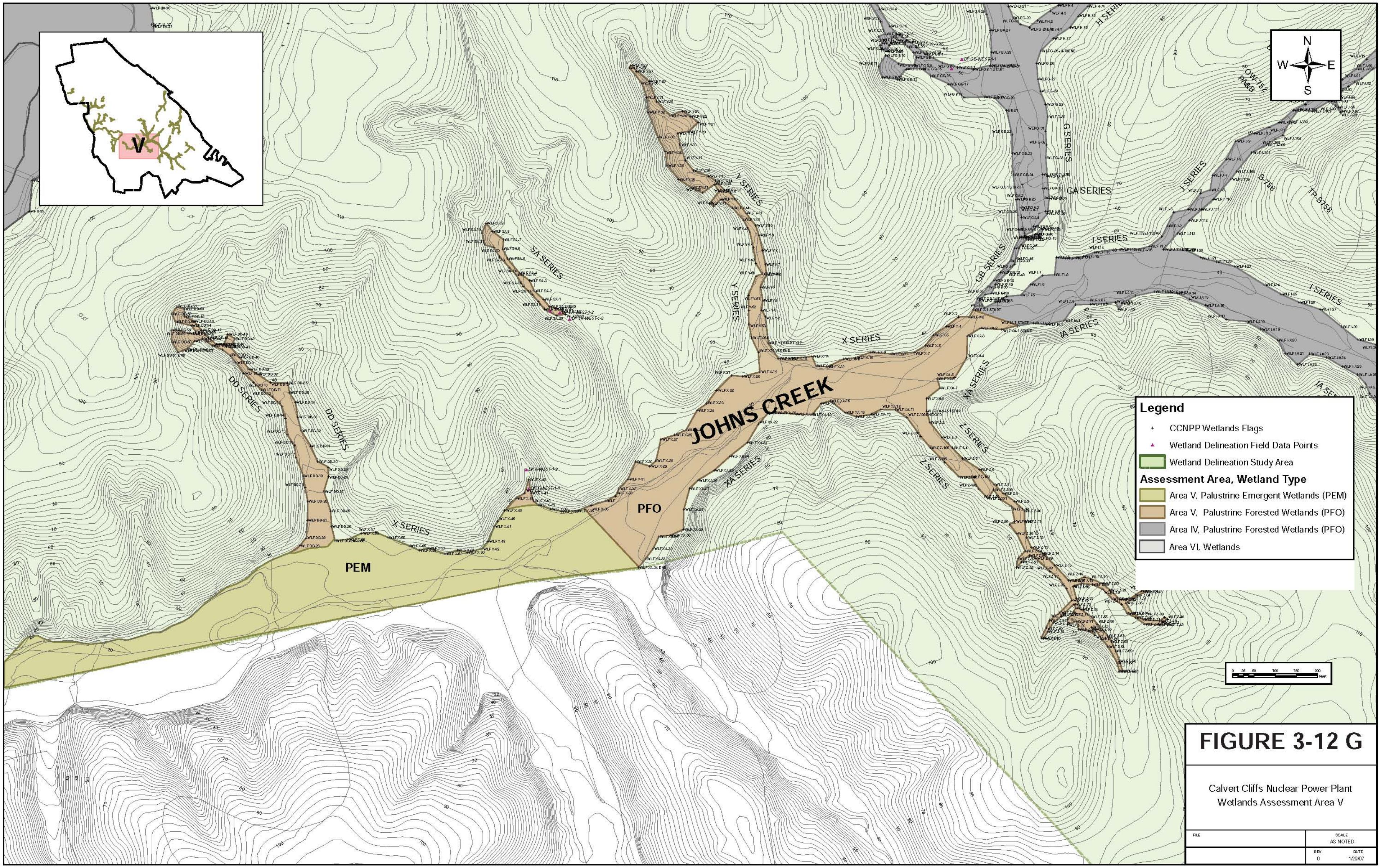

FIGURE 3-12 G

Calvert Cliffs Nuclear Power Plant
Wetlands Assessment Area V

FILE	SCALE AS NOTED
	REV 0	DATE 1/29/07

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