PART 3 - ENVIRONMENTAL REPORT
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Chapter 1 Introduction

This Environmental Report (ER) is submitted pursuant to 10 CFR 52.17(a)(2) and 10 CFR Part 51 to support the application of Dominion Nuclear North Anna LLC (Dominion) for an early site permit (ESP). The report provides information to the Nuclear Regulatory Commission (NRC) sufficient to facilitate the preparation of an environmental impact statement in accordance with the National Environmental Policy Act (NEPA). In preparing this ER, Dominion has relied on the NRC's guidance contained in NUREG-1555, Regulatory Guide (RG) 4.2, and reference material contained in NUREG-1437 and NUREG-1437, Supplement 7.

1.1 The Proposed Action

This section provides a description of the proposed action, the applicant, site location, the plant facilities assumed for environmental analysis, and the applicant's pre-application public involvement.

The proposed action is the issuance of an ESP approving a site (the ESP site) within the existing North Anna Power Station (NAPS) site as suitable for the construction, operation, and decommissioning of new nuclear power generation facilities (new units). The proposed action does not include any decision or approval to build the new units, which are matters that would be considered only upon the filing of an application for a combined license (COL).

The purpose and need for the proposed action is to allow the applicant, Dominion Nuclear North Anna, LLC (Dominion), to determine whether the ESP site is suitable for new units before incurring the substantial additional time and expense of designing and seeking approval to construct such facilities at the ESP site. This process allows early resolution of those safety and environmental issues relating to the ESP site, and facilitates subsequent utility decision making and NRC licensing.

While the actual construction and operation of new units is not currently proposed, this environmental report does analyze the environmental impacts that would result from the construction, operation, and decommissioning of new units at the ESP site. These impacts are analyzed in order to determine whether the ESP site is suitable for new units, and to resolve as many of those issues as is practicable.

Dominion has included a site redress plan as part of its application for an ESP. If an ESP application contains a site redress plan, the permit holder may perform certain activities described in 10 CFR 50.10(e)(1) without further authorization, provided that the environmental impact statement prepared by the NRC for the permit has concluded that the activities would not result in any significant environmental impact which cannot be redressed. The impacts of the activities described in 10 CFR 50.10(e) are addressed in this environmental report.

1.1.1 The Applicant and Owner

Dominion is the applicant for the ESP addressed in this environmental report. Dominion is an indirect, wholly-owned subsidiary of Dominion Resources, Inc. (DRI).

The NAPS site, which encompasses the ESP site for which an ESP is sought, is owned by Virginia Electric & Power Company (Virginia Power) and Old Dominion Electric Cooperative (ODEC) as tenants in common. These companies also own all land outside the NAPS site boundary that forms Lake Anna, up to the expected high-water marks. Virginia Power is the licensed operator of the existing units, with control of the existing facilities and the authority to act as ODEC's agent. Virginia Power is also a wholly-owned subsidiary of DRI, and supports this application.

If Dominion decides to proceed with the development of new units at the ESP site, it would first enter into and obtain the appropriate regulatory approvals of an agreement to purchase or lease the ESP site.

1.1.2 Site Location

The ESP site is wholly within the confines of the NAPS site, which is located on a peninsula on the southern shore of Lake Anna, approximately 5 miles upstream of the North Anna Dam. Lake Anna, developed to supply cooling water for the power station, is approximately 17 miles long, with 272 miles of shoreline. The ESP site is located in Louisa County, Virginia, near the town of Mineral.

The NAPS site was originally intended for the construction of four nuclear units. The original Units 3 and 4 were abandoned after initial construction activities were terminated. These units were to be constructed adjacent to and west of the existing Units 1 and 2. The ESP site is in the same general location as the abandoned Units 3 and 4. The NAPS site is zoned as industrial.

Geographically, the ESP site is approximately 40 miles north-northwest of Richmond, Virginia; 36 miles east of Charlottesville, Virginia; and 22 miles southwest of Fredericksburg, Virginia. Interstates 95 and 64 pass 16 miles to the east and 18 miles to the southwest of the ESP site, respectively. The portion of the NAPS site for which an ESP is sought is shown on Figure 1.1-1.

1.1.3 Reactor Information

This ESP application is intended to demonstrate the suitability of the ESP site for construction and operation of up to two new units.

No specific plant design has been chosen for the ESP site. Instead, a set of bounding plant parameters has been developed to envelop future site development. This plant parameters envelope (PPE) is based on the addition of power generation from two distinct units, to be designated as North Anna Units 3 and 4. Each unit represents a portion of the total generation capacity to be added and would consist of one or more reactors or reactor modules. These multiple reactors or modules (the number of which may vary depending on the reactor type selected) would be grouped into distinct operating units. The total nuclear generating capacity to be added would not exceed 4500 MWt per unit. Additional information regarding reactors addressed in the PPE is provided in Chapter 3.

1.1.4 **Cooling System Information**

For normal plant cooling, a closed-cycle, dry and wet cooling tower system, with make-up water supply from Lake Anna, would be used for the new Unit 3, whereas closed-cycle cooling, using dry towers, would be used for Unit 4.

Lake Anna is divided into two parts separated by earthen dikes. The North Anna Reservoir is the source of water for the existing units. The Waste Heat Treatment Facility (WHTF) receives cooling water discharges from the existing units.

Make-up water for the Unit 3 closed-cycle, dry and wet tower system would be withdrawn from the North Anna Reservoir through a new intake structure located on a cove on the south shore of the lake, which was originally planned for the intake of the abandoned Units 3 and 4. This new structure would be adjacent to the existing units' intake structure. All cooling system discharges for both the existing units and the Unit 3 wet cooling tower blowdown would be sent to the WHTF via the existing discharge canal.

The new dry tower system of Unit 4 would introduce either no, or negligible, evaporative losses, and no additional heat load to Lake Anna.

Additional information on the cooling system is provided in Section 3.4.

1.1.5 **Transmission System Information**

The NAPS site is interconnected with the regional power grid system via three 500 kV transmission lines and one 230 kV transmission line from the station's switchyard. Any two 500 kV transmission lines, together with the 230 kV transmission line, are expected to have sufficient capacity to carry the total output of the existing units and the new units. If Dominion decides to proceed with development of new units at the ESP site, a system study (load flow) modeling these lines with the new units' power contribution would be performed at that time to confirm this conclusion. Additional information regarding the existing transmission system for the NAPS site is provided in Section 3.7.

1.1.6 **Pre-Application Public Involvement**

Dominion has established and maintains a positive relationship with the local population, civic leaders, and state and local governmental authorities in the area surrounding the ESP site. In a public opinion survey conducted in 2000, 86 percent of the population living in Louisa County believed that the existing units were a positive feature for the county.

In addition, Dominion has conducted an outreach program to pro-actively inform the local population of its interest in the NAPS site for purposes of early site permitting. Communications and meetings with various groups have been an ongoing practice since March 2002, when Dominion representatives first met with the Louisa County Board of Supervisors and advised them of Dominion's interest in early site permitting. Since that time, Dominion representatives have met with a variety of state and local authorities and other members of the public. Examples of interactions with stakeholders initiated by Dominion are listed below:

- July 2002 meeting with the Lake Anna Civic Association
- February 2003 meeting with the Virginia Department of Environmental Quality (VDEQ)
- February 2003 meeting with the Virginia Department of Emergency Management
- February 2003 meeting with the Virginia Department of Game and Inland Fisheries (VDGIF)
- March 2003 meeting with the Virginia Secretary of Natural Resources
- March 2003 meeting with emergency preparedness coordinators representing counties surrounding the North Anna site
- March 2003 meeting with Louisa County Board of Supervisors
- April 2003 meeting with the Virginia Department of Conservation and Recreation (VDCR)
- May 2003 meeting with VDEQ, VDGIF, VDCR, Department of Historic Resources, Department of Health, Department of Agriculture and Consumer Affairs, and Department of Transportation
- Teleconferences with non-government environmental organizations, such as the Chesapeake Bay Foundation

On April 1, 2003, the NRC held public meetings in the vicinity of the ESP site. The purpose of those meetings was to: 1) inform the public regarding elements of NRC's Part 52 regulations involving ESPs, and 2) advise the public of its opportunities to become involved in the licensing process. Notices of those public meetings were provided in the Federal Register and in local newspapers.

1.1.7 **Construction Start Date**

Because the ESP does not constitute a decision or approval to build new units, there is no date established for commencement of construction. Site preparation (pre-construction) activities authorized by 10 CFR 52.25 could be initiated after receipt of the ESP at any time during the 20-year permit term. It is estimated that such site preparation activities (pre-construction) would take between 12 to 18 months to complete. If a decision were made to build new units, construction of new units is estimated to occur over a 5 to 7-year period, presuming that the start of a second unit would lag that of the first by at least 12 months, commencing after NRC issuance of a COL.

Section 1.1 References

None

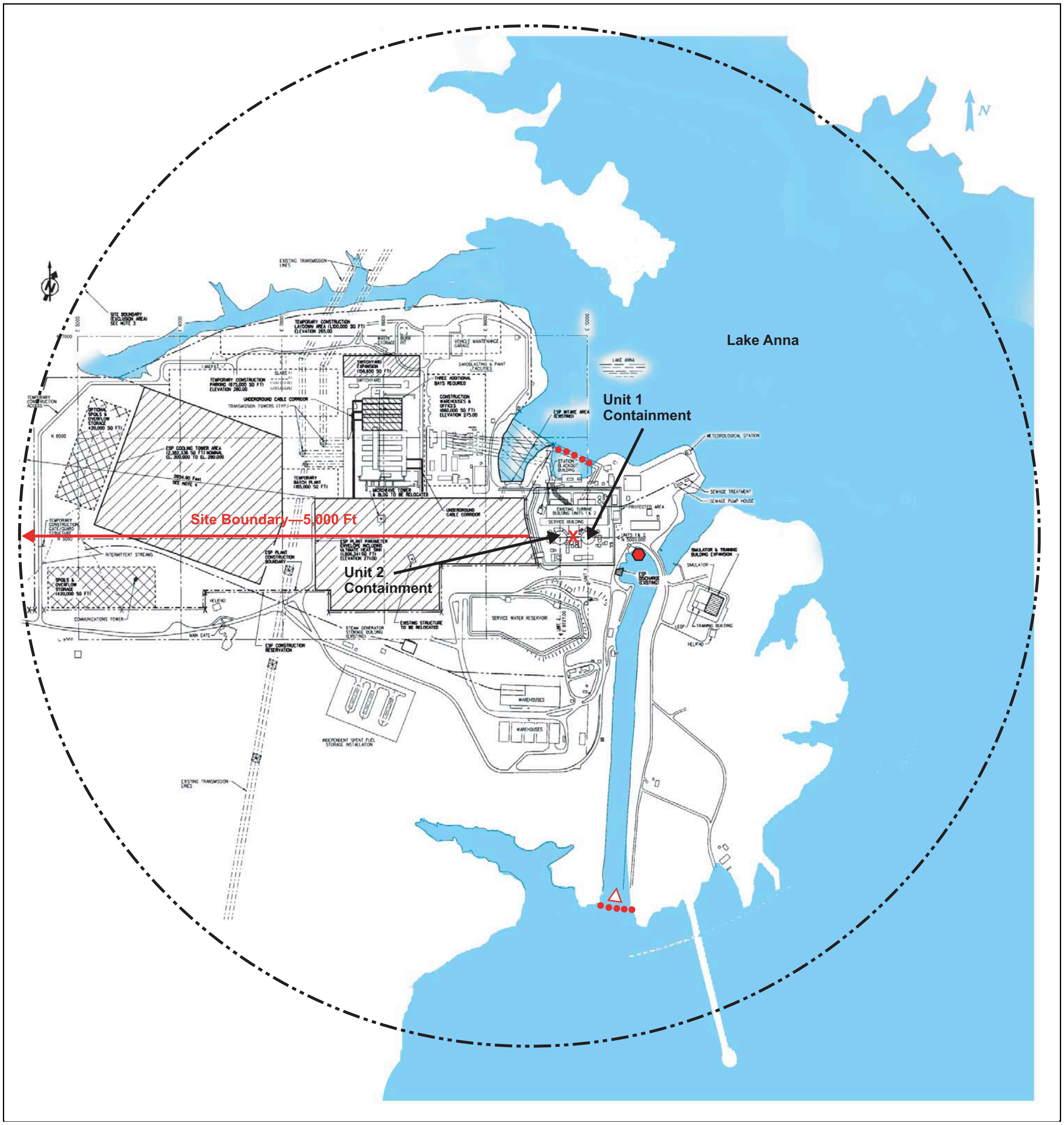

Figure 1.1-1 ESP Site

1.2 Status of Reviews, Approvals, and Consultations

A Coastal Zone Management Act compliance certification was provided to the VDEQ for concurrence review. This certification of compliance with Virginia's Coastal Program is due to Lake Anna's shoreline border with Spotsylvania County and North Anna River downstream flow into tidal areas. Appropriate regulatory approvals of an agreement between Dominion and the current site owners would be necessary before Dominion conducts any site preparation activities. Consultations with other federal and state agencies in connection with the preparation of the environmental impact statement for this ESP application, including consultations under the Endangered Species Act and National Historic Preservation Act, will be necessary.

Numerous reviews, approvals and consultations would be required for the construction of the new units. Table 1.2-1 provides a list of the environmental-related authorizations, permits, and certifications potentially required by federal, state, regional, local, and affected Native American tribal agencies for activities related to the construction and operation of any new units at the ESP site (Reference 1) (Reference 2) (Reference 3) (Reference 4).

The structure of the summary table is based primarily on NUREG-1555 guidance. Because the purpose of this application is to establish the acceptability of the proposed site for future development, the permits identified as being required for construction and operation are not needed to support issuance of the ESP. Because these permits will not be obtained until Dominion makes a decision to proceed with the development of the site, numbers and expiration dates for these permits do not currently exist.

Section 1.2 References

1. NUREG-1555, *Environmental Standard Review Plan*, Section 2 “Status of Reviews, Approvals, and Consultations”, U.S. Nuclear Regulatory Commission, October 1999.

2. NUREG-1437*, Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants, Supplement 7*, Section 1.5, “Compliance and Consultations,” and Appendix E, Virginia Electric and Power Company’s Compliance Status and Consultation Correspondence,” USNRC, November 2002.

3. Virginia Department of Environmental Quality (VDEQ), www.deq.state.va.us, February 12, 2003.

4. *Lake Anna Special Area Plan*, Lake Anna Special Area Plan Committee, March 2000.

Table 1.2-1 Federal, State, and Local Authorizations

Agency	Authority	Requirement	License/ Permit No. (a)	Expira- tion Date (a)	Activity Covered
FAA	49 USC 1501	Construction Notice			Notice of erection of structures (>200 feet) potentially impacting air navigation.
Lake Anna Special Area Plan Committee		Conditional Land Use Approval	N/A	N/A	Local land use approval – Lake Overlay District.
NRC	Atomic Energy Act (AEA), 10 CFR 51, 10 CFR 52.17	EIS	N/A	N/A	Environmental effects of construction and operation of a reactor
NRC	10 CFR 52, Subpart C	Combined License			Combined construction permit and operating license for a nuclear power facility
NRC	10 CFR 52, Subpart A	Early Site Permit			Approval of the site for one or more nuclear power facilities, and approval of limited construction as per 10 CFR 50.10(e)(1)
NRC	10 CFR 30	By-product License			Approval to possess special nuclear materials
NRC	10 CFR 70	Special Nuclear Materials License			Approval to possess fuel
SCC					Approval of the purchase or lease of the site
SCC	VA Code 56-580D				Approval for construction of new generating facility
USACE	Clean Water Act (CWA)	Section 404 Permit (individual, regional, general)			Disturbance or crossing wetland areas or navigable waters
USACE	Rivers and Harbors Act	Section 10 Permit			Impacts to navigable waters of the U.S.
USFWS	Endangered Species Act	Consultation regarding potential to adversely impact protected species. Letter of Concurrence	N/A	N/A	Concurrence with no adverse impact or consultation on appropriate mitigation measures

Table 1.2-1 Federal, State, and Local Authorizations

Agency	Authority	Requirement	License/ Permit No. (a)	Expira-tion Date (a)	Activity Covered
USFWS	Migratory Bird Treaty Act	Federal or State Permit			Adverse impact on protected species (e.g., eagles, ospreys) and/or their nests
VDEQ	9 VAC 5-20-160	Registration.			Annual re-certification of air emission sources.
VDEQ	Federal Clean Air Act Amendments (CAAA) Title V9 VAC 5-80-50	Title V Operating Permit.			Operation of air emission sources.
VDEQ	9 VAC 5-80-120	Minor Source - General Permit.			Construction and operation of minor air emission sources.
VDEQ	FWCA 9 VAC 25-10	Virginia Pollutant Discharge Elimination System Permit (VPDES).			Regulated limits of pollutants in liquid discharge to surface water
VDEQ	FWCA 9 VAC 25-150	General Permit Registration Statement for storm water discharges from industrial activity (VAR5).			General permit to discharge storm water from site during operations
VDEQ	FWCA 9 VAC 25-180	General Permit NOT for storm water discharges from industrial activity (VAR5).			Termination of coverage under the general permit for storm water discharge associated with operational site activities
VDEQ	Federal Clean Water Act 9 VAC 25-180	General Permit Notice of Termination (NOT) for storm water discharges from construction activities (VAR4).			Termination of coverage under the general permit for storm water discharge from construction site activities
VDEQ	9 VAC 25-210	Virginia Water Protection Permit (Individual or General)			Permit to dredge, fill, discharge pollutants into or adjacent to surface water. Joint application with USACE Section 404 permit.

Table 1.2-1 Federal, State, and Local Authorizations

Agency	Authority	Requirement	License/ Permit No. (a)	Expira- tion Date (a)	Activity Covered
VDEQ	Federal Clean Water Act	Section 401 Certification			Compliance with water quality standards.[b]
VDEQ	Federal Clean Water Act (FWCA) 9 VAC 25-220	Surface Water Withdrawal Permit			Permit to draw water from Lake Anna (unless otherwise regulated by State Water Control Board)
VDEQ	Coastal Zone Management Act, Section 307.	Consistency determination.			Compliance with Virginia Coastal Program.
VDEQ	Virginia Coastal Resources Management Program	Consistency determination			Compliance with Virginia Coastal Program.
VDEQ	Federal Clean Water Act 9 VAC 25-180	General Permit Registration Statement for storm water discharges from construction activities (VAR10).			General permit to discharge storm water from site during construction
VDHR	National Historic Preservation Act, 36 CFR 800	Cultural Resources Survey/Review	N/A	N/A	Confirm site does not contain protected historic/cultural resources
VMRC	9 VAC 25-210	VMRC Permit			Permit to fill submerged land. Joint application with USACE Section 404 permit.

N/A - Not applicable (A license or permit is not required at the ESP stage)

a. The information does not currently exist. Licenses and permits would be applied for and received at the appropriate time, which may not be until the COL phase.

b. A certification under Section 401 of the Federal Water Pollution Control Act (FWPCA) is not appropriate at this time because a specific scope and schedule for pre-construction activities and determination of specific activities that would result in a discharge have not been established. To address the timing of this certification, the ESP should include a condition prohibiting Dominion from conducting any pre-construction activity that would result in a discharge into navigable waters without first submitting to the NRC a Virginia Water Protection Permit (which under Virginia's State Water Control Law at Va. Code § 62.1-44.15:5(A) constitutes the certification required under FWPCA § 401), or a determination by VDEQ that no certification is required.

Chapter 2 Environmental Description

Chapter 2 describes the existing environmental conditions for the ESP site (see Section 1.1). The environmental description provides sufficient detail to identify those environmental resources that have the potential to be impacted by the construction, operation, or decommissioning of the new units. The environmental description, where referenced, includes the following definitions:

- NAPS site - the property within the NAPS site boundary, or fence line, including the Exclusion Area Boundary (EAB).
- ESP site - the property within the NAPS site intended for the construction and operation of new units
- Vicinity - the area within a 6-mile radius of the ESP site.
- Region - the area within a 50-mile radius of the ESP site.

The environmental description is segregated into the following discrete elements as outlined in NUREG-1555:

- Land
- Water
- Ecology
- Socioeconomics
- Geology
- Meteorology and air quality
- Related federal project activities

2.1 Site Location

The ESP site is contained within the NAPS site. The location for the new units would be confined to the plant envelope area see Figure 2.1-1. The eastern boundary of the ESP site is approximately 570 feet west of the center of the existing Unit 1 containment building. Universal Transverse Mercator (UTM) coordinates for the ESP plant envelope are not provided.

The ESP site is located in rural Louisa County in the northeastern portion of Virginia, approximately 7 miles east of the town of Mineral, Virginia, which had a population of 424 according to the 2000 census survey. The site is at the end of State Route 700 on a peninsula of the southern shore of Lake Anna. The earth dam that creates Lake Anna is about 5 miles southeast of the site. The North Anna River flows southeasterly, joining the South Anna River to form the Pamunkey River about 27 miles southeast of the site. Figure 2.1-2 shows the general location of the ESP site and localities surrounding the site within 10 miles.

Regionally, as shown in Figure 2.1-3, the site is about 40 miles north-northwest of Richmond, Virginia; 36 miles east of Charlottesville, Virginia; and 22 miles southwest of Fredericksburg, Virginia. Interstate 95 and U.S. Route 1 (parallel to I-95), the two principal highways joining Richmond with the rest of the eastern corridor, pass within 15 and 16 miles, respectively, east of the site.

Section 2.1 References

None

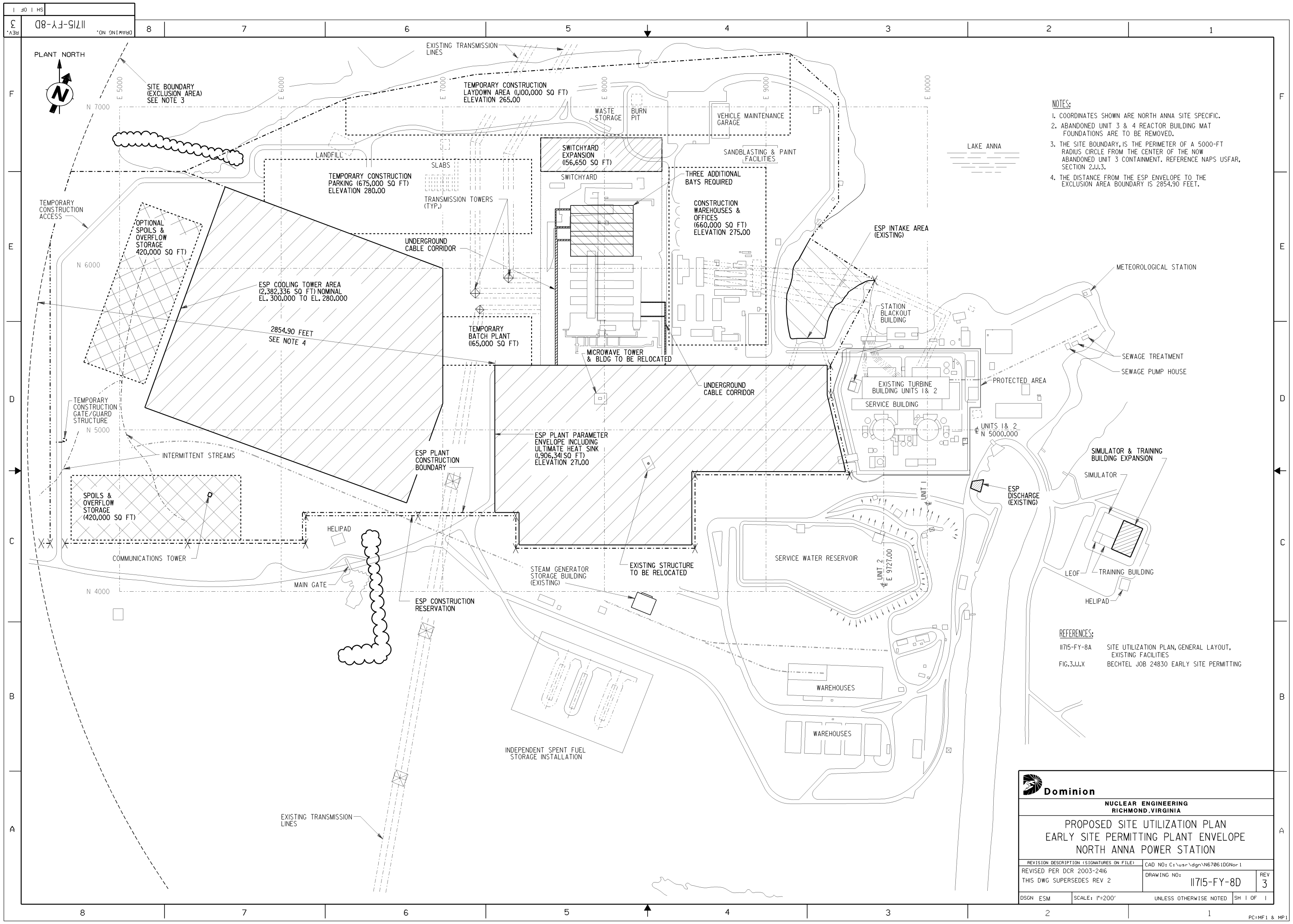

Figure 2.1-1 North Anna ESP Site Boundaries

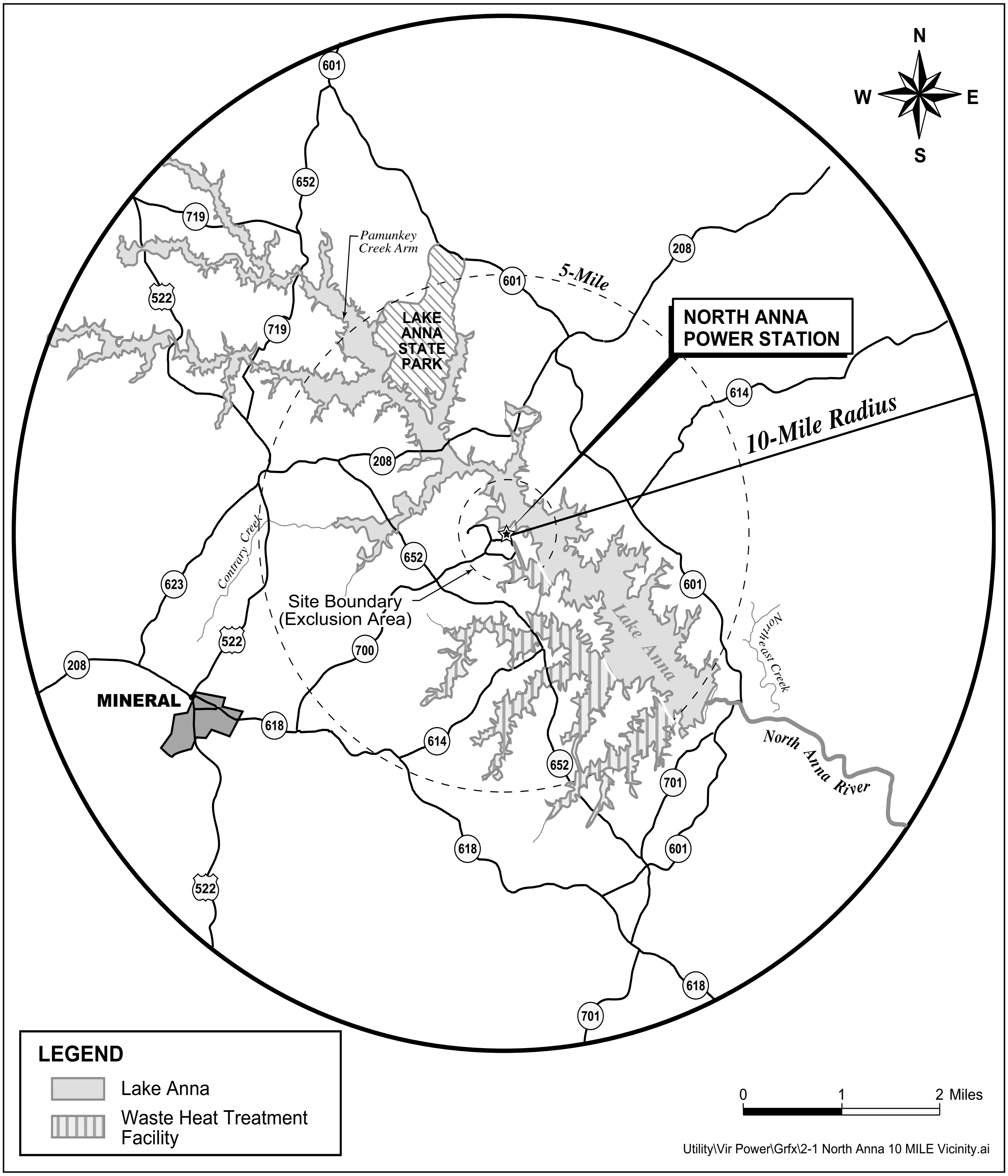

Figure 2.1-2 10 Mile North Anna Vicinity Map

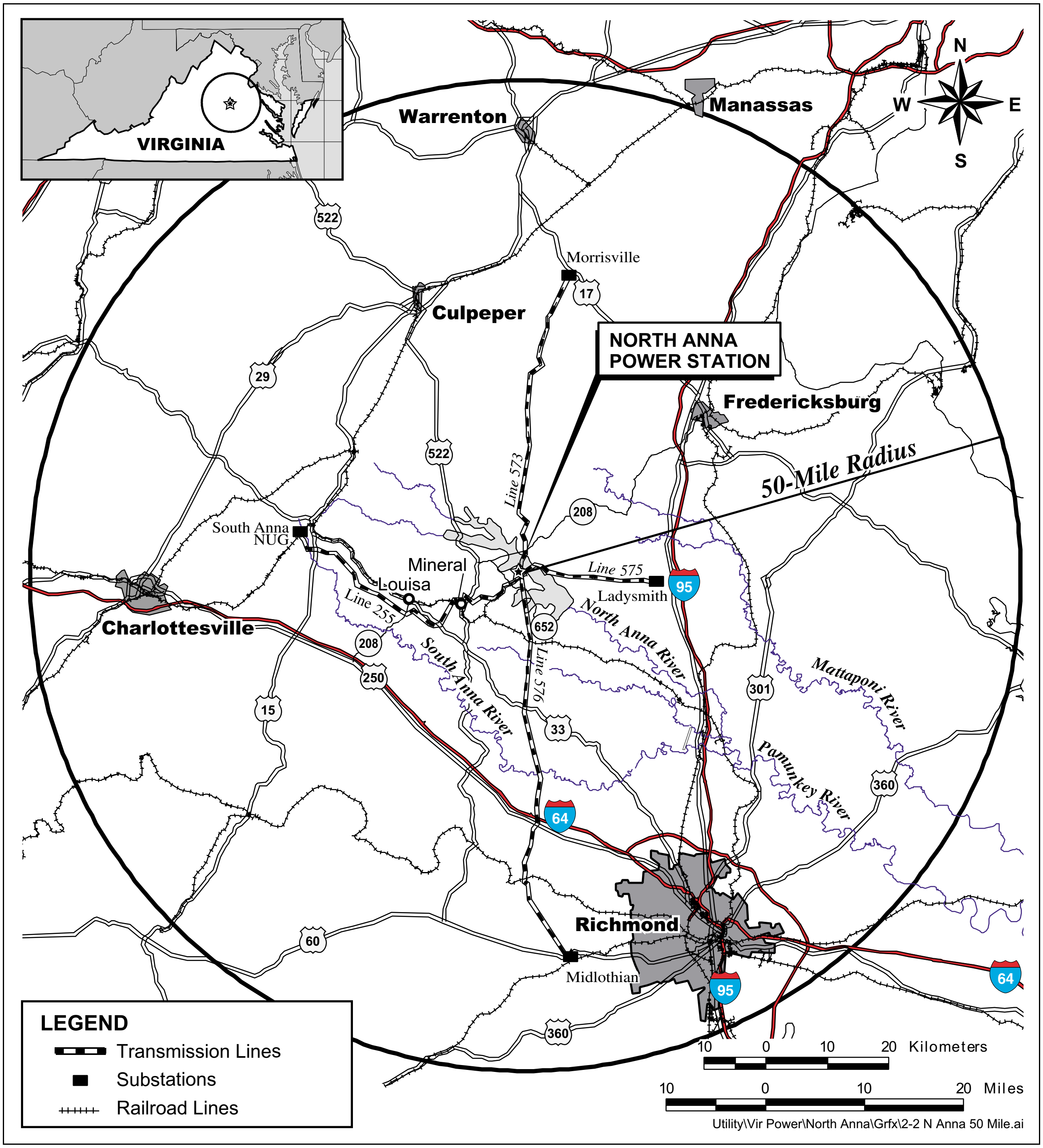

Figure 2.1-3 North Anna Power Station 50 Mile View

2.2 Land

This section describes the land characteristics of the areas within the ESP site (and where appropriate, the NAPS site) that are identified in this ESP application. This description was used as a baseline to assess the potential impacts on land uses that would result from the construction, operation, and decommissioning of the new units. This section is further segregated into three subsections: 1) site and vicinity, 2) transmission corridors and offsite areas, and 3) the region. These subsections include spatial considerations (e.g., region, vicinity, and site) as well as the nature and extent of current land uses and planned future land uses, where applicable, as referenced.

2.2.1 The Site and Vicinity

The ESP site is within the existing boundaries of the NAPS site, with the new units to be sited adjacent to the existing Units 1 and 2. The ESP site is situated on a peninsula of Lake Anna's southern shore at the end of State Route 700 (see Figure 2.1-2). Geographically, the ESP site is located within the central Piedmont Plateau of Virginia. The topography of the NAPS site is characterized as a gently undulating surface that varies from 60 m (200 ft) to 150 m (500 ft) above mean sea level (msl). Forests primarily of pine and hardwoods cover the majority of the peninsula on which NAPS is sited.

Regionally, the ESP site is approximately 40 miles north-northwest of Richmond, Virginia; 36 miles east of Charlottesville, Virginia; 22 miles southwest of Fredericksburg, Virginia, and 70 miles southwest of Washington, D.C. Interstates 95 and 64 pass within 16 miles to the east and 18 miles to the south of the ESP site, respectively (see Figure 2.1-3).

2.2.1.1 Site Description

The ESP site is located in Louisa County in northeastern Virginia. Virginia Power and ODEC own, and Virginia Power controls, all of the land within the NAPS site boundary, both above and beneath water surfaces, including those portions of the North Anna Reservoir and WHTF, that lie within the site boundary. Both companies also own all the land outside the NAPS site boundary that forms Lake Anna, up to their expected high-water marks (i.e., Elevation 255 feet above msl). Virginia Power purchased and owns a total of 18,643 acres of rural land (approximately 80 percent forested) for the original development of NAPS, including the land for Lake Anna; the earthen dams, dikes, railroad spur, roads and bridges; and miscellaneous other structures and facilities. Virginia Power also owns and operates the North Anna Hydroelectric Project, an 855 kW-capacity hydroelectric power plant at the base of the North Anna Dam.

Lake Anna, a man-made reservoir, was created in 1971 by erecting a dam on the main stem of the North Anna River. The lake is approximately 27 km (17 miles) long with 435 km (272 miles) of irregular shoreline and approximately 3900 ha (9600 acres) of water surface. Lake Anna was created primarily as a source of cooling water for the power station, although it has become a popular recreation area. The dam provides downstream flood control. Lake Anna is not used as a source of potable or industrial water.

Virginia Power has granted easements to landowners abutting Lake Anna (including the WHTF) who request permission to use Virginia Power property for the erection of docks, jetties, or other recreational structures for access to the lake waters. These structures require a re-approval by Virginia Power with each property ownership transaction, and all permissions are expressly revocable. Public boaters have access to the lake, and private boaters have access to the WHTF.

No public or commercial highways, railroads, transmission corridors (other than those owned and operated by Virginia Power), or major waterways traverse the ESP site. Ingress and egress from the ESP site is primarily through a Virginia Power-owned and maintained access road off State Route 700.

The Virginia Department of Mines, Minerals, and Energy maintains maps of Louisa County showing mines that are currently active or that are known to have commercial value. The maps indicate no mines with commercial value (i.e., either metallic or non-metallic) exist within or adjacent to the ESP site.

The primary land cover on the NAPS site is pine and pine-hardwood mixed forest (70 percent). Portions of the NAPS site are used for facility activities (20 percent) and as cleared areas (10 percent). Facility uses include electricity generation, maintenance and distribution facilities, warehouses, training and administration buildings, lagoons and settling basin, parking lots, roads, a railroad line, information center, and the Independent Spent Fuel Storage Installation (ISFSI). Cleared areas include the landscaped grounds, open areas, lay down areas, three historic cemeteries, security weapons range, and the John Goode Recreation Area, a recreation and picnic area for use by employees of DRI and its subsidiaries only (see Figure 2.2-1).

2.2.1.2 The Vicinity

There are no communities in the vicinity of the ESP site. The nearest largest community is the town of Mineral, Virginia, (2000 Census population of 424) located in Louisa County, 7 miles west of the site. The town of Louisa (2000 population of 1401) is approximately 12 miles west of the ESP site. Lake Anna State Park lies 5 miles northwest of the NAPS site and provides public facilities for picnicking, fishing, boat launching, swimming, and biking (see Figure 2.1-2 and Figure 2.1-3).

The Commonwealth of Virginia mandates that cities and counties have comprehensive land use plans, and all three counties surrounding the Lake (Louisa, Orange, and Spotsylvania) have such plans. Figure 2.2-2 and Figure 2.2-3 show land use classifications in Louisa and Spotsylvania counties for the NAPS site and vicinity. Table 2.2-2 shows a breakdown of land use, type, and area in those counties.

The predominant land use in Louisa County, and a major contributor to the Louisa economy, is forestry, which uses approximately 68 percent of the county's land area. Most of the forested land is privately owned. Agricultural lands occupy 23.5 percent and water resources occupy about 3 percent of land. Developed land occupies 6 percent and residential development predominates with 5.5 percent.

Louisa county experienced a 25 percent population growth (i.e., approximately 5100 additional people) between 1990 and 2000. However, there has been little industrial growth. Residential land use increased from 1.8 percent in 1979 to 5.5 percent by 2000. The county has prepared over 50 industrial sites for development. Many have access to various combinations of rail, gas, water, and sewer. Louisa County has recently updated its Comprehensive Plan (Reference 1), which defines nine goals for future development in the county. These goals include preserving the rural character of Louisa County through designation of “growth centers” to accommodate future growth in a manner consistent with maintaining the rural heritage of the county and a healthy, diverse economy, as well as providing job opportunities for Louisa County citizens.

Spotsylvania County, which consists of forests and agriculture, is fast-growing because of its proximity to Washington, D.C. and northern Virginia. Spotsylvania County has also recently updated its Comprehensive Plan (Reference 2) to define several development goals that allow for the maintenance of the historic, agricultural, and forested character of the county, while recognizing the need to sustain residential and business growth and community services for the benefit of county residents.

In Orange County to the northwest, 95 percent of the land consists of forests and agriculture and is beginning to be impacted by development.

Recreational and retirement development has grown substantially in the immediate vicinity of Lake Anna. Land between the many embayments remains privately held. Lake Anna has influenced land use development in Louisa, Orange, and Spotsylvania counties. Residential development of mid-to-upscale homes characterizes development around the lake. Prior to 1998, the three counties did not coordinate land use planning activities in the Lake Anna watershed. In 1998, however, a committee was formed to examine the watershed and to develop a plan that enables the counties to coordinate their efforts to address growth and protect the Lake Anna region.

The final Lake Anna Special Area Plan was issued in March 2000 (Reference 3). Several major findings resulted from the Special Area Plan Committee’s examination. These include:

- Development patterns of sprawl threaten the rural character, the environment, and the existing quality of life in the Lake Anna watershed
- Responsibility for on-going review of environmental conditions in the watershed is unclear.
- The environmental database necessary for responsible and informed decision-making is not available.

The Committee developed “priority recommendations” to address the major findings. These included:

- Create a Lake Anna Watershed Overlay District in all three counties with a charter to maintain the rural character of the area by implementing a cooperative, coordinated, consistent watershed program for Lake Anna.
- Charge the Lake Anna Advisory Committee to track progress toward meeting plan goals and to prepare and submit annual reports on progress made.
- Develop monitoring programs for both tributaries and the lake that address levels of heavy metals, nutrients and other pollutants and help to identify reductions strategies for fecal contamination.

2.2.2 **Transmission Corridors and Offsite Areas**

NAPS has three 500-kV transmission lines and one 230-kV transmission line leaving the site from the switchyard. Each transmission line occupies a separate right-of-way. The rights-of-way range in width from 37 to 84 meters (120 to 275 feet) and in length from 24 to 66 km (15 to 41 miles), covering a total of approximately 1174 hectares (2900 acres) (Reference 4). The rights-of-way extend from NAPS to the north, south, east, and west, terminating in Morrisville, Midlothian, Ladysmith, and at the South Anna non-utility generator, respectively Figure 2.2-4.

The NAPS transmission corridors were constructed between 1973 and 1984. The corridors pass through land use categories typical of north-central Virginia, such as row crops, pastures, forests, and abandoned (old) fields. In addition, the transmission corridors pass through more natural habitat types, such as hardwood and pine-hardwood forests, bottomland hardwood forests, and shrub boggs. No areas designated by the U. S. Fish and Wildlife Service (USFWS) or VDEQ as “critical habitat” for endangered species exist at the ESP site or along or adjacent to associated transmission line. In addition, the transmission corridors do not cross any state or federal parks, wildlife refuges, or wildlife management areas. Physical features (e.g., length, width, and route) of each of the transmission lines associated with NAPS are described in Table 2.2-1.

Corridors in timberlands and in the vicinity of road crossings are maintained by Virginia Power on a 3-year cycle by mowing or, if inaccessible to mowers, by use of nonrestricted-use herbicides. In other areas (e.g., wetlands, dense vegetation), hand-cutting treatments are used. (Reference 5)

Vegetation treatments have been developed in cooperation with the VDCR Natural Heritage Program. Areas of rare and sensitive plant species are identified and avoided, or modified treatment practices are used to avoid adverse impacts. In addition, wildlife food plots and Christmas tree plantations are located along the corridors and supported through cost sharing by Virginia Power. (Reference 4)

Virginia Power allows landowners, hunting clubs, and conservation organizations to establish wildlife food plots, Christmas tree plantations (not to exceed a height of 15 feet), gardens, athletic and park facilities, and drain fields under transmission lines. Land uses not permitted under the transmission lines include permanent structures (i.e., houses and barns), trash and brush stockpiling, wells, septic systems, and ATV trails. (Reference 5)

Based on an initial evaluation, any two 500 kV transmission lines, together with the 230 kV transmission line to have sufficient capacity to carry the total output of the existing units and the new units. If Dominion decides to proceed with development of new units at the ESP site, a system study (load flow) modeling these lines with the new units' power contribution would be performed, to confirm this conclusion. Additional information regarding the existing transmission system for NAPS is provided in Section 3.7.

2.2.3 **The Region**

The region, defined as 50 miles beyond the ESP site boundary, includes all or portions of the following counties in Virginia: Amelia, Albemarle, Buckingham, Caroline, Chesterfield, Culpeper, Cumberland, Essex, Fauquier, Fluvanna, Goochland, Greene, Hanover, Henrico, King and Queen, King George, King William, Louisa, Madison, New Kent, Orange, Page, Powhatan, Prince William, Rappahannock, Richmond, Rockingham, Spotsylvania, Stafford, and Westmoreland. The region also includes a portion of Charles County in Maryland.

Major waterways, highways, roads, railroads, and other transportation routes in the region are shown in Figure 2.1-2 and Figure 2.1-3. There are two major airports within the region, Richmond International Airport and Charlottesville-Albemarle County Airport, approximately 45 miles southeast and 40 miles west of the ESP site, respectively. There are three smaller airports within 15 miles of the ESP site; Lake Anna Airport (Bumpass, VA), Louisa County Airport and Cub Field, 7 miles south-southwest, 11 miles west-southwest, and 10 miles southwest of the ESP site, respectively.

Fourteen counties in the eastern part of the region (i.e., Caroline, Chesterfield, Essex, Hanover, Henrico, King and Queen, King George, King William, New Kent, Prince William, Richmond, Stafford, Spotsylvania, Westmoreland) are within the VDEQ designated Chesapeake Bay Coastal Zone Management Area.

The following federally designated special land use classified areas exist within the region; George Washington Birthplace National Monument, Fredericksburg and Spotsylvania National Military Park, Thomas Stone National Historic Site, Richmond National Battlefield, Maggie L. Walker National Historic Site, Shenandoah National Park, Rappahannock National Wildlife Refuge, and Featherstone National Wildlife Refuge. There are no national forests, wilderness areas or wild and scenic rivers within the region. There are several Virginia state parks within the region. The closest, Lake Anna State Park, is approximately 5 miles northwest of the ESP site.

There are no Native American tribal land use plans for areas within the region. The closest reservations, the Mattaponi and Pamunkey, are outside of the ESP site region.

Land use within the region varies with distance from major population centers and high use transportation corridors. The metropolitan areas of Richmond, Fredericksburg, and Charlottesville, and the transportation corridors associated with Interstates 95 and 64 contain the highest density of residential, commercial, and industrial land use. As detailed in Section 2.2.1, land use in the immediate vicinity of ESP site and the areas outside the noted metropolitan areas and transportation corridors remains primarily in forestry and agriculture. A survey of land use development plans (i.e., comprehensive county plans) for the counties immediately adjacent to the ESP site indicate a primary goal of striking a balance between maintaining the historic rural character of the area with the recognized need for limited residential growth and business development. (Reference 1) (Reference 2)

The primary land use classifications for the region are representative of those noted for the Commonwealth of Virginia as a whole. The region, comprising about 20 percent of the total area of Virginia, encompasses four main land use classes: to the north are mainly urban areas surrounding Washington D.C. and cropland; to the east is primarily cropland; to the south is a mixture of cropland and pasture; and to the west is a mixture of forests and pasture. (Reference 6) (Reference 7)

Forests dominate Virginia, covering approximately 55.6 percent of the state's total land area (Table 2.2-3). The second most prevalent land use in Virginia is agriculture, covering 25.9 percent of the total land area. Cropland accounts for 2903 square miles, about 7.1 percent of the total area; pasture and hay production account for 6845.3 square miles, or about 16.8 percent of the state's land. Urban areas comprise 6029 square miles of land area, approximately 14.8 percent; and inland waters account for the remaining 3.7 percent.

In 2000, the four principal crops in Virginia in terms of acreage harvested, were hay (1,320,000 acres), soybeans (490,000 acres), corn (330,000 acres), and winter wheat (205,000 acres). The four principal livestock and products in Virginia for 2000, in terms of cash receipts, were broiler chickens ($441,320,000), cattle and calves ($307,862,000), wholesale milk ($278,832,000), and turkeys ($237,941,000) (Reference 11). In 2001, the four principal crops in Charles County Maryland in terms of total production were corn for grain (909,00 bushels), tobacco (450,000 bushels), soybeans (446,000 bushels), and wheat (169,000 bushels) (Reference 9).

Section 2.2 References

1. *Comprehensive Plan,* Louisa County Department of Planning/Zoning, County of Louisa, Virginia, September 4, 2001.

2. *2002 Comprehensive Plan*, Spotsylvania County Planning Department, Spotsylvania County, Virginia, February 12, 2002.

3. *Lake Anna Special Area Plan,* Special Area Plan Committee, March 2000.

4. Final Supplement 7 to the Generic Environmental Impact Statement (GEIS) Regarding License Renewal for the North Anna Power Station, Units 1 and 2, November 2002.

5. *Transmission Lines-Right-of-Way Encroachments,* Informational Bulletin, Department of Forestry, Dominion Energy, 2003.

6. Virginia County Data, Virginia Agricultural Statistics Service, 1997 Census Data, www.nass.usda.gov/va/page1.htm and www.nass.usda.gov/va/vpage2.htm (accessed July 10, 2003).

7. 1997 Census of Agriculture Volume 1: Part 46, Chapter 1, Virginia State-Level Data, Maps, United States Department of Agricultural, www.nass.usda.gov/census/census97/volume1/va-46/va1maps.pdf (accessed July 10, 2003).

8. *Land Use Classifications for Louisa County, Virginia (Site and Vicinity),* Louisa County Department of Planning/Zoning, Louisa County (Virginia), 2002.

9. Charles County 2001 Agricultural Profile, Charles County Agricultural Statistics www.nass.usda.gov/md/charles.pdf (accessed July 10, 2003).

10. *Land Use Classifications for Spotsylvania County, Virginia (Site and Vicinity),* Spotsylvania County Planning Department, Spotsylvania County (Virginia), 2002.

11. Virginia Agriculture – Facts and Figures, Virginia Department of Agriculture and Consumer Services (VCACS), 2000. www.vdacs.state.va.us/agfacts/index.html (accessed January 27, 2003).

12. Water Quality Assessment Report, Virginia Department of Environmental Quality (VDEQ), 2002, 2002 305(b), Table 2.1-2, Virginia Statewide Land Use Summary.

Table 2.2-1 North Anna Transmission Rights-of-Way[a]

		Length		Width	Area	
					Hectares (acres)	Construction Date
Substation	**kV**	**km (mi.)**	**Direction**	**m (ft.)**	**(acres)**	**Date**
Morrisville	500	53 (33)	N	72 (235)	366 (905)	1973
Midlothian[b]	500	66 (41)	S	72 (235)	469 (1160)	1979
Ladysmith	500	24 (15)	E	84 (275)	192 (475)	1976
South Anna	230	50 (31)	W	30-37 (100-120)	146 (360)	1984
Total		193 (120)			1174 (2900)	

a. Source: Reference 4, Table 2-1

b. The transmission line to Midlothian Substation runs an additional 26 km (16 mi.) in a shared right-of-way with a non-North Anna line.

Table 2.2-2 Land Use in Louisa, Orange and Spotsylvania Counties[a]

County and Land Use	Hectares	Acres	Percent of Total
Louisa County			
Residential	7,322	17,655	5.0
Agriculture	31,979	79,019	23.5
Forest	92,474	228,500	68.0
Water	3,994	9,868	3.0
Other[b]	649	1,605	0.5
Total Louisa	136,418	336,646	100.0[c]
Orange County			
Developed Land[d]	4,597	11,360	5.0
Agriculture	34,021	84,064	37.0
Forest	53,330	131,776	58.0
Water	N/A[e]	N/A	N/A
Total Orange	91,948	227,200	100.0[c]
Spotsylvania County			
Residential	22,793	56,320	22.0
Developed Land[f]	3,108	7,680	3.0
Agriculture	18,649	46,080	18.0
Forest	53,874	133,120	52.0
Other	5,180	12,800	5.0
Total Spotsylvania	103,604	256,000	100.0

a. Source: Reference 4, Table 2-9.
b. Includes commercial and industrial lands.
c. Numbers have been adjusted to achieve a total of 100 percent.
d. Developed land is defined to include residential, commercial, industrial, and public use.
e. N/A – Not available
f. Developed land is defined to include industrial and commercial.

Table 2.2-3 Virginia Statewide Land Use Summary[a]

Land Use	Square Miles (hectares)	Percent of Total
Commercial Forest	20,059 (5,195,154)	49.2
National Forests	2,550 (660,447)	6.4
Total Forested Land	22,609 (5,855,601)	55.6
Cropland	2,903 (751,977)	7.1
Pasture/Hay	6,845 (1,772,925)	16.8
Other	828 (214,477)	2.0
Total Agricultural Land	10,577 (2,739,379)	25.9
Other (Including Urban)	6,029 (1,561,530)	14.8
Inland Waters	1,526 (395,336)	3.7
Total Area	40, 741 (10,551,845)	100.0

a. Source: Reference 12, Table 2.1-2

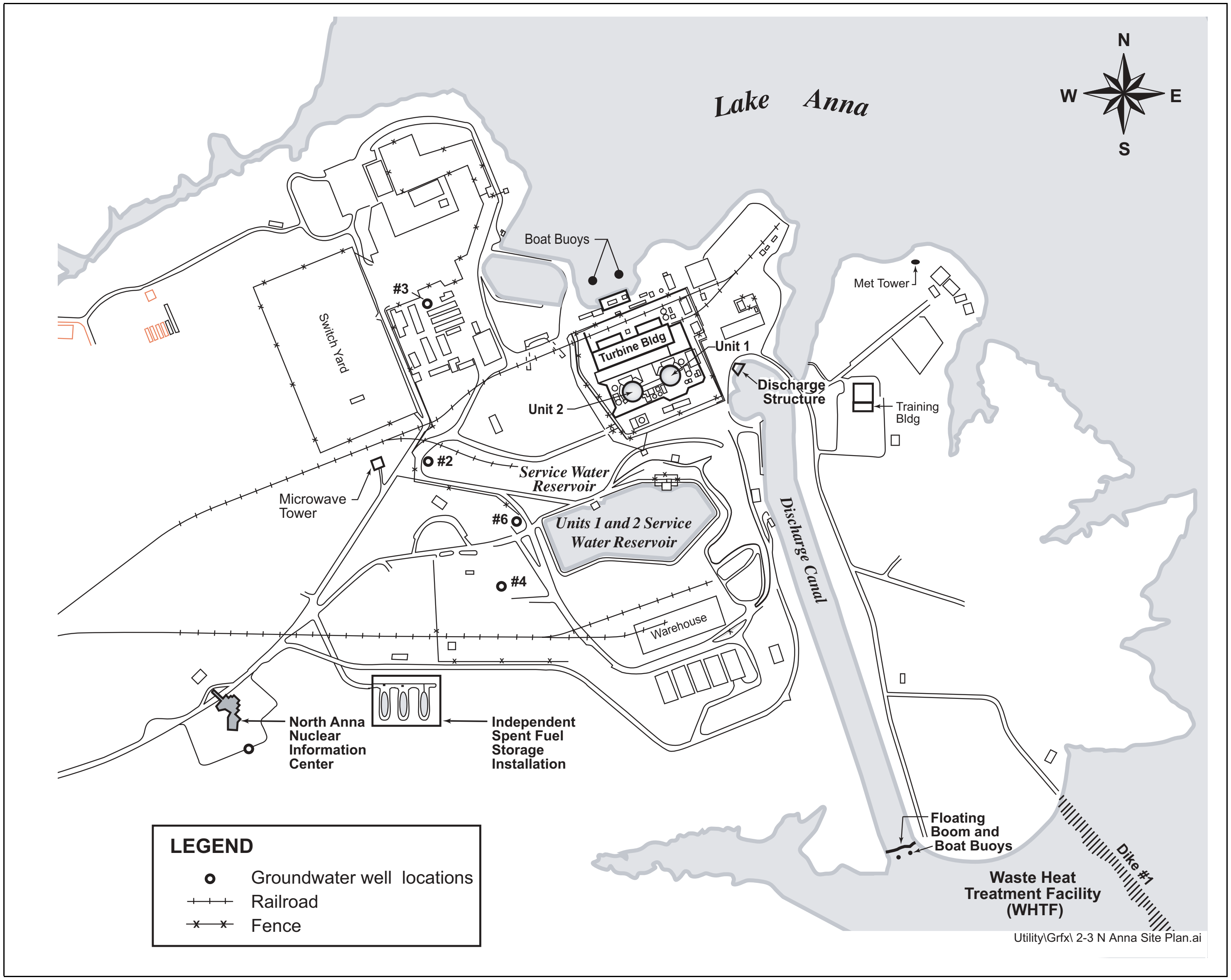

Figure 2.2-1 Existing NAPS Site Detail Map

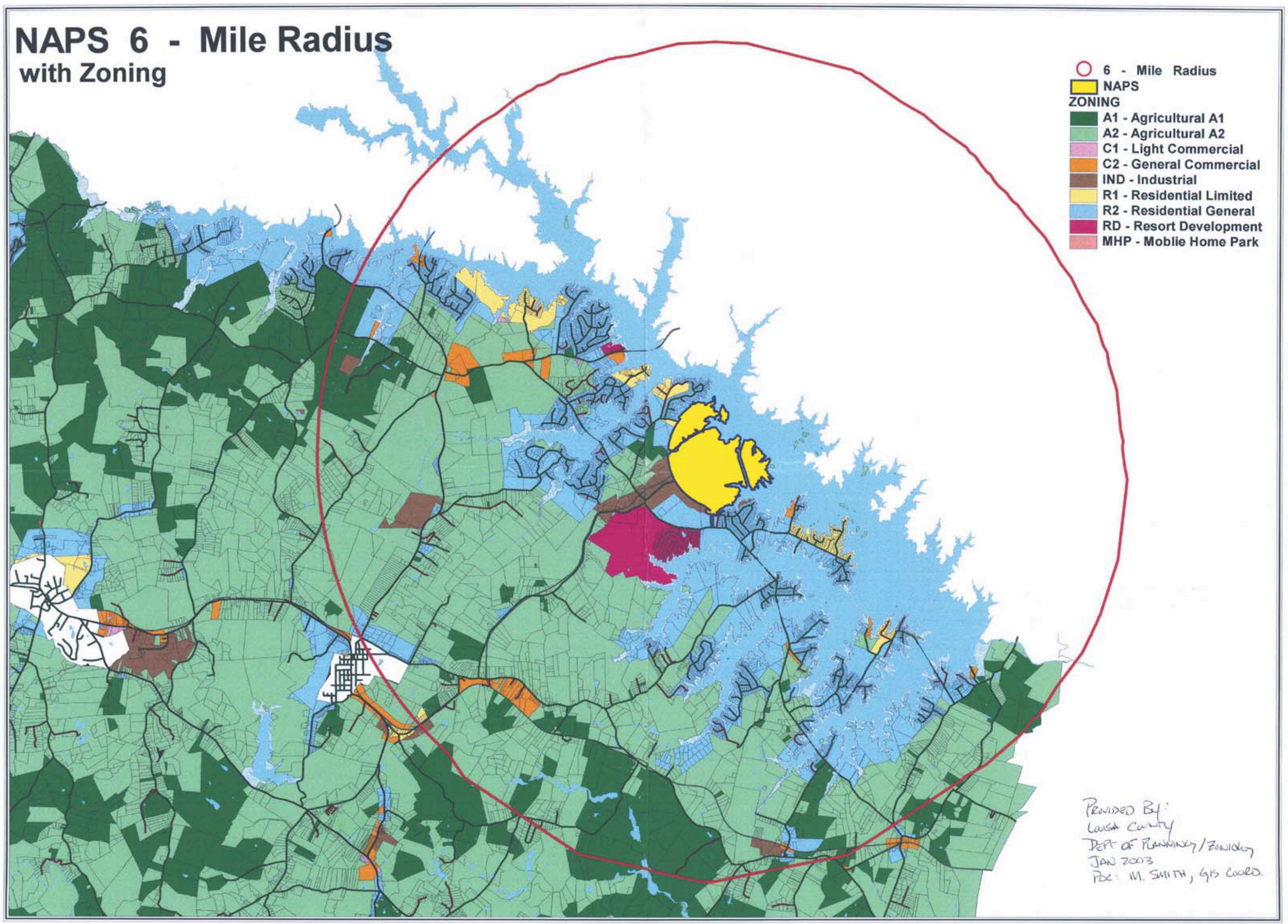

Figure 2.2-2 Land Use Classifications for Louisa County, Virginia (Site and Vicinity)

Source: Reference 8

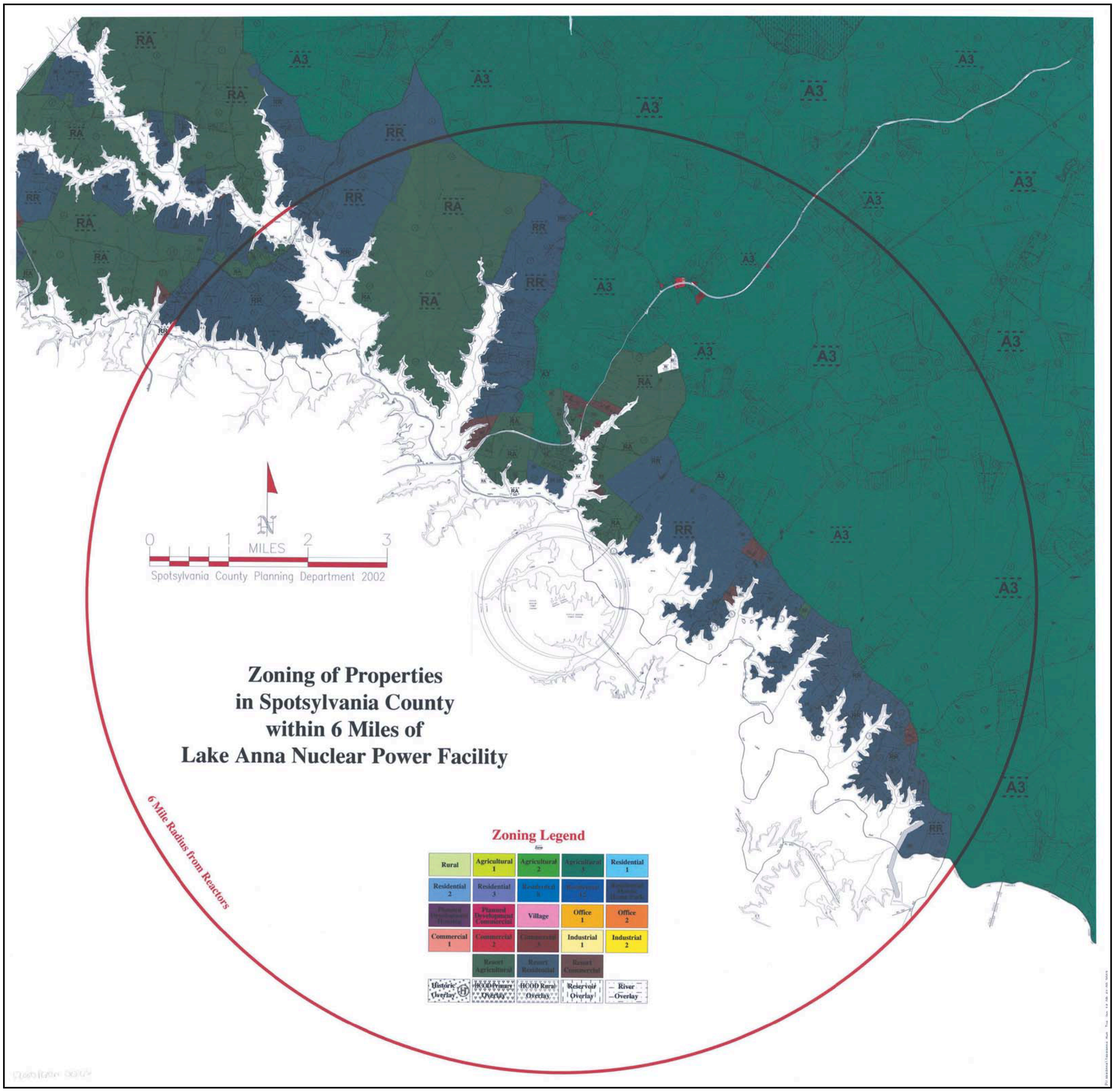

Figure 2.2-3 Land Use Classifications for Spotsylvania County, Virginia (Site and Vicinity)

Source: Reference 10

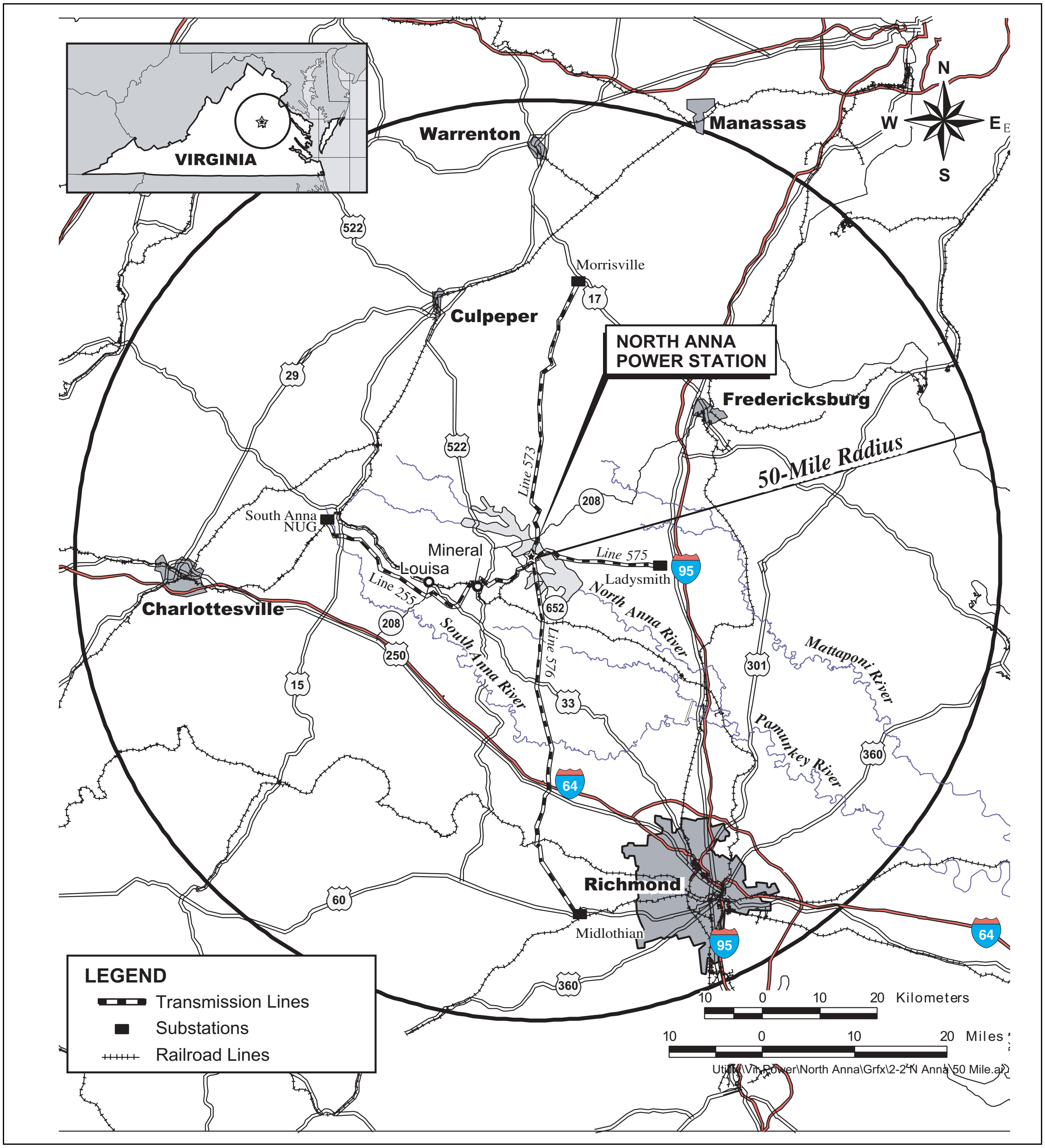

Figure 2.2-4 Existing Transmission Line Corridors

2.3 Water

This section includes site-specific and regional descriptions of the hydrology, water use, and water quality conditions that could affect, or be affected by, the construction, operation, or decommissioning of new units at the ESP site. The site-specific and regional surface water and groundwater information establishes the baseline hydrologic conditions against which to assess potential construction or operational impacts and the adequacy of related monitoring programs. The potential construction and operational impacts to water resources are presented in Chapter 4, and Chapter 5, respectively. Monitoring programs are presented in Chapter 6.

2.3.1 Hydrology

This section describes surface water bodies and groundwater aquifers that could affect the plant water supply, or that could be affected by the construction or operation of new units at the ESP site. The site-specific and regional data on the physical and hydrological characteristics of surface water and groundwater are summarized to provide the basic data for an evaluation of impacts on water bodies, aquifers, aquatic ecosystems, and social and economic structures of the area.

The following descriptions are based on a review of the NAPS Updated Final Safety Analysis Report (UFSAR) (Reference 1) and the Environmental Report Supplement (Reference 2), unless otherwise noted. The information has been verified and updated using current hydrologic databases.

2.3.1.1 Surface Water

The ESP site is located on the southern shore of Lake Anna adjacent to the existing units and approximately 8 km (5 miles) upstream of the North Anna Dam. Lake Anna was created by constructing a dam across the North Anna River as part of the overall development of the NAPS site. The North Anna Reservoir currently serves as the water source for the existing units, which use a once-through cooling system to dissipate heat from the turbine condensers.

Lake Anna is the primary surface water body that could affect plant water supply, or be affected by the construction and operation of new units at the ESP site based on the cooling systems proposed for the new units. New Unit 3 would use a closed-cycle, dry and wet cooling tower system for the circulating water system. A separate, service water cooling system would use a closed-cycle, wet cooling tower for dissipation of waste heat from auxiliary heat exchangers not cooled by the plant circulating water system. Make-up water for the wet cooling towers would be supplied from the North Anna Reservoir at a maximum instantaneous rate of 49.6 cubic feet per second (cfs). Blowdown discharge from the wet cooling towers would be returned to the reservoir at a maximum instantaneous rate of 12.4 cfs via the WHTF. New Unit 4 would use a closed-cycle cooling system with dry cooling towers in which the exhaust from the plant’s steam turbines would be directed to a surface condenser where the heat of vaporization would be rejected to a closed loop of cooling water. The heated cooling water would be circulated to the finned tubes of the dry cooling towers where heat content of the cooling water would be transferred to the ambient air. To increase heat rejection to the atmosphere, electric motor driven fans would be used to force airflow across the finned tubes. After passing through the cooling towers, the cooled water would be recirculated back to the surface condenser to complete the closed-cycle cooling water loop. Except for the initial filling of the cooling water loop, Unit 4 would have no make-up water need since dry tower systems typically have no evaporative water losses and would have no continuous blowdown discharge to the WHTF. In the event that the cooling water loop would use an open pump sump configuration with a free surface, a small amount of evaporation losses, estimated to be on the order of 1 gpm (0.002 cfs), would occur. Any make-up water necessary to replenish the small evaporative losses for Unit 4 would be obtained from the North Anna Reservoir. The plant service water cooling system for Unit 4 would use dry cooling towers, which would have minimal to no make-up water requirements.

The North Anna River rises in the eastern slopes of the Southwestern Mountains in the Appalachian Range near Gordonsville, Virginia, and flows along a southeasterly course to its confluence with the South Anna River 5 miles northeast of Ashland, Virginia, where the Pamunkey River is formed. The Pamunkey continues on a general southeasterly course to West Point, Virginia, where it is joined by the Mattaponi River to form the York River. The York River flows into the Chesapeake Bay about 15 miles north of Hampton, Virginia. The North Anna River drains a watershed of 343 square miles above the dam, which is located about 4 miles north of Bumpass, Virginia, and about 0.5 mile upstream of Virginia Route 601.

As shown in Figure 2.3-1, Lake Anna is about 17 miles long and inundates several small tributaries, thereby resulting in an irregular shape with a shoreline length of approximately 272 miles. To provide optimum thermal performance for the existing units, Lake Anna is separated into two sections by three dikes. The larger section of about 9600 acres, termed the North Anna Reservoir, is a storage impoundment for plant cooling water. The smaller section, the WHTF, has an area of about 3400 acres and functions as a heat exchanger to transfer most of the existing units' heat rejection to the atmosphere.

The elevation-volume curves for the North Anna Reservoir and the WHTF are provided in Figure 2.3-2. When both existing units are operating, eight circulating water pumps draw water from the North Anna Reservoir at a rate of 4246 cfs, circulate it through the condensers, and discharge it to the WHTF. Water moves through the three lagoons of the WHTF and back into the North Anna Reservoir at Dike 3 (Figure 2.3-1).

The North Anna Dam is an earth-filled structure about 5000 feet long and 90 feet high, with a central concrete spillway about 200 feet long. The dam crest is at Elevation 265 ft msl and has a width of 30 feet. The concrete spillway contains three radial crest gates, each 40 feet wide by 35 feet high, separated by concrete piers 10 feet wide. The discharge capacity of each of the three main gates is shown in Figure 2.3-4. The crest of the spillway ogee is at Elevation 219 ft msl. Two adjustable skimmer gates are provided for regulating small releases. The discharge capacity of each of the skimmer gates, which measure 8.5 feet by 8.5 feet, is shown in Figure 2.3-5. A concrete apron downstream from the spillway provides energy dissipation for releases from the North Anna Dam.

The North Anna Dam also incorporates at its base a small hydroelectric power plant of 855-kW capacity owned and operated by Virginia Power. The hydroelectric facility consists of two separate generating units (Units 5A and 5B), each unit possessing a single-state, open runner-type vertical turbine. Peak operational efficiency is at a flow of 40 cfs for Unit 5A and 133 cfs for Unit 5B. Water for the hydroelectric facility is withdrawn from near the surface of Lake Anna (depth of less than 7 feet). It comes through a skimmer gate and associated sluice pipe that is connected to a 5-foot diameter penstock. Water is then directed by a bifurcation piece through 24- and 48-inch conduits to Units 5A and 5B, respectively. After passing through the turbines, water is discharged into the North Anna River just downstream of the dam's spillway. (Reference 3)

The normal pool level for the North Anna Reservoir is maintained at Elevation 250 ft msl. The Commonwealth of Virginia requires a minimum discharge of 40 cfs from the North Anna Dam, except under drought conditions. These minimum flow requirements are established to maintain instream flows and water quality in the North Anna River below the dam, and in the Pamunkey and York Rivers further downstream. Should drought conditions occur and the Lake Anna water surface elevations fall below 248 ft msl, Virginia Power may reduce releases below 40 cfs in accordance with the Lake Level Contingency Plan as stipulated in Part I.F of the Virginia Pollutant Discharge Elimination System (VPDES) Permit (Reference 4). A flood surcharge of 15 feet above the normal pool level is provided for flood storage. The total Lake Anna volume of 550,000 acre-feet is allocated as described in Table 2.3-1.

Table 2.3-1 Lake Anna Storage Allocation

Purpose	Volume (acre-feet)
Minimum recreational pool and inactive storage below 246 ft msl	255,000
Conservation and active storage, 246 to 250 ft msl	50,000
Flood control storage, 250 to 265 ft msl	245,000
Total storage	550,000

Streamflows have been gauged at various locations in the North Anna River watershed. Table 2.3-2 summarizes the stream gauge site numbers, names, drainage areas, and periods of record, while Table 2.3-8 provides the associated monthly streamflow statistics. Figure 2.3-6 indicates the locations of the stream gauging stations. Inflows to Lake Anna have been gauged at Pamunkey Creek at Lahore, Virginia, and Contrary Creek, Near Mineral, Virginia. The Pamunkey Creek station gauges a drainage area of 40.5 square miles, while the Contrary Creek station gauges a drainage area of 5.53 square miles. Inflows from the remaining 297 square miles of the 343-square mile

Lake Anna catchment are not gauged. Outflows from Lake Anna have been measured on the North Anna River near Partlow, Virginia, which is located just downstream of the dam at the Virginia Route 601 bridge. The drainage area at this stream gauge is 344 square miles. Additional stream gauging stations are located further downstream on the North Anna River near Doswell, Virginia, and at Hart Corner Near Doswell, Virginia.

Table 2.3-2 USGS Stream Gauge Data

Site Number	Name	Location	Drainage Area (square miles)	Period of Record	Source
01670180	Pamunkey Creek at Lahore, VA	Latitude 38°11'33", Longitude 77°58'09"	40.5	1989-08-25 1993-07-19	(Reference 5)
01670300	Contrary Creek Near Mineral, VA	Latitude 38°03'53", Longitude 77°52'45"	5.53	1975-10-01 1987-01-09	(Reference 6)
01670400	North Anna River Near Partlow, Virginia	Latitude 38°00'46", Longitude 77°42'05"	344	1978-10-01 1995-10-09	(Reference 7)
01671000	North Anna River Near Doswell, VA	Latitude 37°53'15", Longitude 77°29'15"	441	1929-04-01 1988-09-30	(Reference 8)
01671020	North Anna River at Hart Corner Near Doswell, VA	Latitude 37°51'00", Longitude 77°25'41"	463	1979-10-01 2001-09-30	(Reference 9)
01673000	Pamunkey River Near Hanover, VA	Latitude 37°46'03", Longitude 77°19'57"	1081	1941-10-01 2001-09-30	(Reference 10)

Lake Anna water levels have been recorded since the existing units were placed into operation. The available record begins in August 1978 and continues to be recorded for each day. Table 2.3-3 summarizes the water level elevation statistics. Section 5.2.2 describes the historical variations in the Lake Anna water level and the dependability of the impoundment in more detail. That section also describes the net losses due to evaporation, including the forced evaporation associated with the existing units and the new units. Section 2.4.1.8 describes the wetlands located within the ESP site. Part 2: Section 2.4.3 provides the design basis flood elevation for Lake Anna.

Table 2.3-3 Monthly Water Level Statistics for Lake Anna, August 1978 through March 2003 (ft msl)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
N	22	23	24	22	21	23	24	25	22	23	24	24
Min	247.42	247.36	247.15	247.30	247.67	247.21	246.66	245.87	245.57	245.21	246.29	247.46
Mean	249.79	249.89	249.95	249.91	249.88	249.77	249.59	249.43	249.12	248.97	249.14	249.49
Max	250.25	250.39	250.30	250.21	250.15	250.12	250.12	250.06	250.11	250.10	250.13	250.31

Table 2.3-3 Monthly Water Level Statistics for Lake Anna, August 1978 through March 2003 (ft msl)

N = number of monthly observations (months with incomplete daily data excluded)
Min = minimum monthly value
Mean = average monthly value
Max = maximum monthly value

The hydrodynamic characteristics of Lake Anna are presented in Section 5.3.1.1. Section 5.3.2.1 provides information on the temperature distribution, stratification, and seasonal variation of density-induced currents.

2.3.1.2 Groundwater Aquifers

The ESP site lies within the Piedmont Physiographic Province. Three types of groundwater aquifers are present within the consolidated rocks of the Piedmont, along with a surficial aquifer system in the overlying unconsolidated sediments. The three consolidated-rock aquifers consist of: 1) crystalline and undifferentiated sedimentary rocks, 2) carbonate rocks, and 3) early Mesozoic age rift-basin sedimentary and igneous rocks. The unconsolidated sediments are likely to consist of residual soil, saprolite (bedrock that has been weathered to a soil but that retains the rock structure), or alluvial deposits along stream channels. Although crystalline rocks form the predominant aquifers in the Piedmont Province, carbonate rocks, which are primarily found in the portion of the Piedmont that extends from Maryland northward, form the most productive aquifers. (Reference 11)

Recharge to aquifers in the Piedmont aquifers occurs largely as infiltration of local precipitation in interstream areas. That portion of the precipitation that does not migrate laterally through the unconsolidated surficial materials for discharge to nearby streams or low areas percolates vertically downward to the bedrock, where it enters water-bearing openings in the rock. (Reference 11) The average recharge to aquifers from precipitation in the Virginia Piedmont is estimated to be about 8 to 10 inches per year (Reference 12) (Reference 13). Although an intricate network of rivers and streams that follow a dendritic drainage pattern generally dissects the Piedmont Province, some of the drainage (or portions thereof) follow nearly straight courses that are controlled by joint or fault systems in the underlying bedrock. Those streams passing through the area from other geologic provinces provide a secondary source of recharge to the groundwater. The Piedmont Province of Virginia is estimated to have as much as 1.5 billion gallons of water per square mile held in storage in the consolidated and unconsolidated aquifers. This volume of water is considered suitable for domestic and other small supply requirements. (Reference 13)

In the area around the ESP site, the bedrock consists of Precambrian to Paleozoic age crystalline metamorphic and igneous rocks, while the overlying unconsolidated material is largely a weathering product (residual soil or saprolite) of the underlying bedrock. Groundwater in the crystalline rocks is stored and transmitted through joints and fractures in the rocks, while the main body of the rock between the joints and fractures is essentially impermeable. The number and extent of the joints/fractures, and the width of the openings between their surfaces, generally decrease with depth, thus limiting the significance of the water-transmitting capability of the bedrock to its upper few hundred feet. (Reference 14)

Saprolite at the ESP site is generally exposed at the ground surface or underlies a thin layer of residual soil or fill. The saprolite extends to the top of the rock from which it was derived; however, the contact between the saprolite and sound rock may be gradational and not well defined (Reference 1). The saprolite is reported to range in thickness from about 2 to 125 feet and is of variable lithology, depending on the type of parent material from which it was derived (Reference 15). Borings drilled at the ESP site as part of the ESP subsurface investigation program penetrated saprolite to depths ranging from about 6 to 35 feet (Part 2: Appendix 2.5.4B). The saprolite penetrated by these borings is classified as a micaceous, silty-clayey, fine-to-coarse sand or sandy silt, with occasional rock fragments.

Bedrock beneath the saprolite belongs to the Ta River Metamorphic Suite. In the site area, these rocks are predominantly biotite gneiss and schist with smaller amounts of amphibolite gneiss. (Reference 16) The results of borings at the ESP site indicate the main rock type to be gneiss. The gneiss is generally described as quartz gneiss with some biotite quartz gneiss; and quartz gneiss, biotite quartz gneiss, and hornblende gneiss. The rock exhibits a variable weathering profile and joint/fracture presence. The degree of jointing and fracturing is the controlling factor for groundwater movement through the rock.

Groundwater at the ESP site occurs in unconfined conditions in both the saprolite and underlying bedrock. The results of previous investigations at the NAPS site indicate that a hydrologic connection exists between the saprolite and the bedrock. (Reference 17) This condition has been confirmed as part of the ESP subsurface investigation program (Part 2: Appendix 2.5.4B) by the presence of nearly equal water level elevations recorded in 2 observation wells (OW-845 and OW-846, Table 2.3-2) installed adjacent to each other and sealed in the bedrock and saprolite, respectively. At the ESP site, the water table is considered to be a subdued reflection of the ground surface and, therefore, the direction of groundwater movement is toward areas of lower elevations (Reference 17). Measurements made between December 2002 and June 2003 in observation wells at the ESP site exhibit water level elevations ranging from about Elevation 241 ft msl to Elevation 311 ft msl, with corresponding ground surface elevations of about Elevation 283 ft msl and Elevation 335 ft msl, respectively (Table 2.3-9). The measurements shown in Table 2.3-9 represent three quarterly rounds of groundwater level measurements taken at the ESP site to characterize seasonal variability in the water levels. Figure 2.3-7 presents hydrographs based on the water levels provided in this table for the nine observation wells (OW-841 through OW-849 on Figure 2.3-8) installed as part of the ESP subsurface investigation program. The other wells that were monitored (P- and WP-) were previously installed to monitor groundwater beneath the Service Water Reservoir (SWR) and the ISFSI, respectively.

A piezometric head contour map (Figure 2.3-8), prepared using the water levels measured in March 2003 (Table 2.3-9), indicates that groundwater flow is generally to the north and east, toward Lake Anna (). Freshwater Creek and Elk Creek, both of which flow to Lake Anna, form hydrologic boundaries to the west and south of the site, respectively (Reference 18). Because the water levels in the observation wells are generally above the top of the well screen, the water level elevation represents the piezometric head. An evaluation of the piezometric head contours shown on Figure 2.3-8 indicates a hydraulic gradient toward Lake Anna of about 3 feet per 100 feet. This gradient compares with an initial hydraulic gradient estimated for the NAPS site before the filling of Lake Anna of 8 feet per 100 feet (Reference 15). Prior to the filling of Lake Anna, it was estimated that a gradient of 6 feet per 100 feet would develop following the filling of the lake (Reference 1).

Prior to construction of the existing units, it was predicted that the filling of Lake Anna would raise the base level of groundwater discharge about 50 feet. It was estimated that this would result in a small rise in the water table where it intersects the surface of the impoundment area. Beyond this zone of intersection, however, it was estimated that the filling of the lake would have only a minor effect on the water table, and that the water table in the area of the existing units would essentially remain unchanged. (Reference 15) More recent evidence of the connection between Lake Anna and the surrounding groundwater regime is contained in the Lake Anna Special Area Plan (Reference 19). This Plan indicates that average well yields are higher in areas adjacent to the lake than in other areas of the Lake Anna watershed which are, in turn, slightly higher than in other areas of Louisa County. It was concluded that these higher yields are likely due to the presence of the lake, which enhances groundwater recharge.

The nine groundwater observation wells installed at the site as part of the ESP subsurface investigation program were tested using the slug test method to determine hydraulic conductivity values for the saprolite and underlying shallow bedrock (Part 2: Appendix 2.5.4B). Hydraulic conductivities calculated for the saprolite, based on tests in eight of the wells, range from about 0.2 to 3.4 feet per day, with a geometric mean value of 1.3 feet per day. The hydraulic conductivity of the shallow bedrock, as determined from the tests in one of the wells, is estimated to be about 2 to 3 feet per day, although the results of the test are of limited value due to the short duration of stable water level recovery measurements. Table 2.3-10 summarizes the available hydraulic conductivity data.

Laboratory tests performed on samples of saprolite from the site indicate a bulk density for this material of 125 to 130 pounds per cubic foot (pcf). Bulk densities for the bedrock range from 145 pcf for highly to moderately weathered rock to 163 pcf for moderately weathered to fresh rock. Laboratory tests to determine moisture contents of saprolite samples indicate an average moisture content of about 26 percent, while the moisture content in the vadose zone ranges from about 11 to 40 percent with an average of about 22 percent. Using the average moisture content of 26 percent and a value of 2.68 for the specific gravity of the saprolite (Reference 1), the void ratio of the saprolite is estimated to be about 0.7. A total porosity of about 41 percent is estimated from this void ratio and an effective porosity of about 33 percent is estimated based on 80 percent of the total porosity. The specific yield of the saprolite was not determined; however, an estimate of this value taken from published literature for materials of similar composition indicates that it may be in the range of 0.30 to 0.33 (Reference 20).

Based on the estimated hydraulic gradient, hydraulic conductivity, and effective porosity indicated above, groundwater beneath the ESP site is expected to flow toward Lake Anna at a rate of about 0.12 feet per day. Using a distance of approximately 1800 feet from the center of the proposed overall plant footprint for the new units to the closest point along the shoreline of Lake Anna, the groundwater travel time from the ESP site to Lake Anna is estimated to be about 40 years.

No aquifers in the Piedmont Province of Virginia have been designated as sole source by the U.S. Environmental Protection Agency (EPA) (Reference 21). The aquifer (designated as sole source) nearest the ESP site is about 120 miles to the southeast, at the southern end of the Delmarva Peninsula in Accomack and North Hampton Counties, Virginia, within the Coastal Plain Physiographic Province. An area southeast of the site has been designated as the Eastern Virginia Ground Water Management Area by the VDEQ. Groundwater withdrawal in this area is permitted based on need and an evaluation by the VDEQ of the impacts of proposed withdrawals. The area, comprised of several counties or portions thereof in southeastern Virginia, lies entirely within the Coastal Plain Province. (Reference 22)

2.3.2 **Water Use**

This section describes surface water and groundwater uses that could affect or be affected by the construction, operation, or decommissioning of new units at the ESP site. Included are descriptions of the types of consumptive and non-consumptive water uses, identification of their locations, and quantification of water withdrawals and returns. Plant water use is described in Section 3.3.

2.3.2.1 **Surface Water**

The surface water bodies that are within the hydrologic system in which the ESP site is located and that may affect or be affected by the construction, operation, or decommissioning of new units include Lake Anna and associated downstream surface water bodies. These downstream surface water bodies include the North Anna River from below the North Anna Dam to its confluence with the South Anna River where the Pamunkey River is formed, the Pamunkey River to its confluence with the Mattaponi River where the York River is formed, the York River estuary to the Chesapeake Bay, and the Chesapeake Bay. Figure 2.3-9 illustrates these surface water bodies.

Consumptive surface water users within this hydrologic system have been identified from the water use database maintained by VDEQ (Reference 24), which includes users whose average daily withdrawal during any single month exceeds 10,000 gallons per day (gpd). Users include the existing units, Bear Island Paper Company, the Doswell Water Treatment Plant, and St. Laurent Paper Products Corporation. Figure 2.3-10 identifies the locations of these surface water withdrawals. Table 2.3-4 identifies the water use and the water body from which withdrawals are made, while Table 2.3-5 summarizes the monthly withdrawal rates. These data indicate that withdrawal of water by the existing units from the North Anna Reservoir for cooling purposes represents the single largest consumptive use in the affected hydrologic system. Virtually all of the water withdrawn from the North Anna Reservoir portion of Lake Anna is returned to the reservoir via the WHTF (Reference 1). A portion of the returned water is lost to the atmosphere by evaporation as presented in Section 5.2.2.

Table 2.3-4 Consumptive Surface Water Users in the Affected Hydrologic System[a]

Facility	Water Use	Water Body
NAPS Unit 1	Cooling	Lake Anna
NAPS Unit 2	Cooling	Lake Anna
Bear Island Paper, Ashland Plant	Manufacturing	North Anna River
Doswell Water Treatment Plant	Municipal water system	North Anna River
St. Laurent Paper, West Point Plant	Manufacturing	Pamunkey River

a. (Reference 24)

No known future surface water withdrawals from the affected hydrologic system are planned for Louisa County, even though the county population and water supply demand is projected to increase (Reference 25). The surface water sources, such as Northeast Creek Reservoir and Lake Gordonsville, that are anticipated to supply the future demand are located outside the Lake Anna watershed and the affected hydrologic system.

Surface water bodies within a 10-km (6.2-mile) radius of the ESP site include Lake Anna and some of its tributaries, as illustrated on Figure 2.3-10. Non-consumptive water use of these surface water bodies is primarily recreational. Public use of the North Anna Reservoir includes fishing, boating, swimming, and water skiing. Public access is provided via Lake Anna State Park, which is on the Spotsylvania County side of the Lake. In the mid-1990s total park attendance peaked, reaching 180,000 visitors in 1997. In 1998, attendance decreased to about 142,500 visitors, with the beach area being the destination for about 20% of the park visitors. Access to the WHTF is limited to adjacent property owners. Recreational use of Lake Anna is seasonal with higher usage rates in the summer months. Future non-consumptive water use of the lake is expected to continue to be primarily recreational at usage rates comparable to current levels. (Reference 26)

The Commonwealth of Virginia's Surface Water Management Act of 1989 and associated regulations (9 VAC 25-220-10 et seq.) impose legal restrictions on surface water withdrawals where surface water resources have a history of low flow conditions that threaten important in-stream and off-stream uses. The purposes of these regulations are to maintain surface water flow at minimum

Table 2.3-5 Consumptive Surface Water Use Statistics for the Affected Hydrologic System[a]

Month	NAPS Unit 1	NAPS Unit 2	Bear Island Paper, Ashland Plant	St. Laurent Paper, West Point Plant[b, c]	Doswell [c] Water Treatment Plant
			(Millions of Gallons)		
January	24,930	24,833	8.02	-	-
February	20,555	22,645	24.32	-	-
March	21,869	20,445	8.15	-	-
April	26,665	21,845	14.15	-	-
May	33,653	36,947	8.36	-	-
June	37,693	39,465	19.70	-	-
July	41,975	41,975	40.78	-	-
August	41,713	41,749	35.33	-	-
September	32,319	31,303	29.63	-	-
October	32,974	34,136	22.92	-	-
November	30,818	29,278	31.53	-	-
December	27,573	26,954	12.33	-	-
Annual	372,737	371,576	252.22	-	-
Daily[d]	1,021	1,018	0.70	-	4.0[e]

a. Reference 24 numeric data represent mean values for the 1996-2001 period.

b. Listed in the VDEQ water use database, but no withdrawals reported in the 1996-2001 period.

c. Data not available.

d. Million gallons per day.

e. Rated capacity.

levels during periods of drought, ensure assimilation of treated wastewater, and support of aquatic and other water-dependent wildlife. In an area designated by the State Water Control Board as a surface water management area, water withdrawals of 300,000 gallons per month or more are required to have a surface water withdrawal permit. Permits and certificates must include a conservation plan that is activated during low-flow surface water conditions. As of October 2001, the Virginia State Water Control Board had not designated any surface water management areas in the state (Reference 27).

2.3.2.2 **Groundwater Use**

Groundwater for use at and in the vicinity of the ESP site is obtained from springs and wells in either the saprolite or underlying crystalline bedrock. Most wells completed in the saprolite have been excavated either by hand digging or augering. These wells are susceptible to becoming dry due to seasonal fluctuations in the water table. Drilled wells generally extend through the saprolite to depths of up to several hundred feet in the underlying bedrock. These wells are cased from the ground surface to the top of bedrock. (Reference 25) The production of groundwater in the vicinity of the ESP site is generally not sufficient to satisfy large water demands because of the relatively low yield of the aquifers, as presented in Section 2.3.1.2. The majority of groundwater development in the area is for domestic and agricultural use, with some public, light industrial and commercial use (Reference 28).

The following sections discuss groundwater use in the vicinity of the ESP site and by the existing units. Aquifers designated by the EPA as sole source are presented with respect to the ESP site in Section 2.3.1.2.

2.3.2.2.1 **Local Use**

There are no known users of large quantities of groundwater within 25 miles of the ESP site (Reference 1). The vast majority of wells in the area yield less than 50 gallons per minute (gpm) (Reference 25). Based on the presence of Lake Anna and the hydrologic boundary it presents to groundwater movement north and east of the ESP site, further discussion of groundwater use in the vicinity of the ESP site is limited to Louisa County.

Every 5 years, the U. S. Geological Survey (USGS) compiles national water-use estimates and publishes a report containing the results of this effort. Data from the latest available report, for the year 1995, are provided on the USGS web site for Virginia, by county or independent city (Reference 29). The following groundwater withdrawal estimates for Louisa County, in millions of gallons per day (mgpd), are provided by withdrawal category:

- Public water supply = 0.18 mgpd
- Domestic water supply = 1.45 mgpd
- Commercial/Industrial water supply = 0.10 mgpd
- Thermoelectric power water supply = 0.02 mgpd
- Agricultural water supply = 0.05 mgpd

VDEQ requires that any groundwater user in Virginia whose average daily withdrawal during any single month exceeds 10,000 gpd provide a report by January 31 of each year stating the water withdrawal and use data for the previous year. The only exceptions to this regulation are agricultural users who have slightly modified requirements based on their location, withdrawal, or withdrawal facility. (Reference 24) For the year 2001, no withdrawals were reported for Louisa County that meet or exceed this threshold.

A study previously performed for Louisa County included the compilation and evaluation of records of wells permitted by the Louisa County Health Department. (Reference 25) These records addressed 2155 drilled wells and 1743 dug or augered (bored) wells. The majority of the drilled wells serve single-family residences. The locations of the wells are currently referenced only to county tax maps.

The average yield of all wells in Louisa County is estimated to be about 14.5 gpm. However, the average yield of public wells is estimated to be about 42 gpm. The public water supply wells have an average depth of nearly 300 feet, and almost all are less than about 400 feet deep. The residential wells are generally only 100 to 200 feet deep. The Louisa County and previous studies in the Piedmont Province suggest that yields from individual wells in this area can vary greatly over distances as small as 100 feet. (Reference 25)

There are 45 public water supplies in Louisa County capable of obtaining their water from springs or wells. Data describing these public water supplies are presented in Table 2.3-11. The public supplies closest to the existing units are Lake Anna Plaza, about 2.6 miles to the northwest, and Jerdone Island, about 4.3 miles to the south-southeast. Based on their distance from the ESP site and the presence of one or more arms of Lake Anna between the site and these public water supplies, any impact the new units may have on the aquifers beneath the site is not expected to affect these supplies. Likewise, withdrawal by these public supplies is not expected to affect the ability of the new units to withdraw groundwater for potable water needs.

Private water wells provide about 80 percent of the domestic water supply to residents of Louisa County (Reference 30). The residential water supply well nearest the existing units is located about one mile to the south-southeast in Lot 32 of the Aspen Hill subdivision. Based on its distance from the ESP site and the presence of Sedges Creek between the site and this well, any impact the new units may have on the aquifers beneath the ESP site would not affect the domestic water supply provided by this well. Likewise, withdrawal by the well would not affect the ability of the new units to withdraw groundwater for potable water needs.

Population growth projections for Louisa County by the year 2015 range from about 32,000 to 46,000. Such growth would result in an estimated public water supply demand of between 2.8 and 4.1 mgpd for an average day and between 4.5 and 6.6 mgpd on a peak day. This water supply demand is expected to be satisfied largely by the use of surface water sources such as Northeast Creek Reservoir and Lake Gordonsville. However, these sources are expected to be supplemented by groundwater supply where available. To meet projected water demands beyond the year 2015, a large groundwater supply may need to be considered in conjunction with the development of alternative surface water sources. (Reference 25)

2.3.2.2.2 **On-Site Use**

Groundwater withdrawal for use by the existing units is accomplished from 4 water supply wells permitted for public use by the Virginia Department of Health (VDH). These 4 wells (Nos. 2, 3A, 4

[new], and 6) comprise a single water supply system at the site. A 5th well (No. 4 [old]) is no longer used as part of this system, but is available for emergency purposes only. A separately permitted well (NANIC) provides the water supply for the North Anna Nuclear Information Center. A new well was constructed at the site in 2003 to support an increase in water demand at the security training building. The proposed location of this well was evaluated by the VDH prior to its construction. The locations of these wells are shown on Figure 2.3-11 and the wells are described in Table 2.3-6. Four small wells not requiring permits at the NAPS site provide minor additional water for plant use (Reference 3). The locations of these 4 wells are not well documented. One of the wells is likely to be the well used to supply the Metrology laboratory and its location is shown on Figure 2.3-11. A second well is located at the security training building in the vicinity of the newly constructed well described above.

Table 2.3-6 North Anna Power Station Water Supply Wells

Well	Depth (ft)	Measured Yield (gpd)	Water Treatment
No. 2 [a, b]	385	12,960	Chlorination (normally not in use)
No. 3A [a, b]	185	74,880	
No. 4 (new) [a, b]	305	63,360	
No. 6 [a, b]	375	79,200	
No. 4 (old) [a, b] (not used)	200	77,760	NA
NANIC [a, c]	260	106,560	Calcite filtration
Security Training Building	[d]	[d]	[d]

a. Reference 25
b. Reference 31
c. Reference 32
d. Information not available.

The 4 active wells comprising the primary groundwater supply system for the new units have individual capacities ranging from 9 to 55 gpm and a total capacity of 160 gpm. However, these 4 wells are permitted for a total design capacity of only 53,040 gpd or about 37 gpm. This capacity is currently dictated by the available storage tank capacity at the site. The NANIC well has a measured capacity of 74 gpm (106,560 gpd) but a design capacity of 19,600 gpd. (Reference 31) (Reference 32)

As a condition of the well permits, Virginia Power is required to submit to the VDEQ by January 31 of every year an annual report of water withdrawals for the previous year. Table 2.3-12 shows the monthly withdrawal quantities that were reported for the year ending December 31, 2002. It can be determined from this table that the 4 primary wells withdrew a combined average of almost 14 gpm for the year, and that the NANIC well withdrew an average of a little over 1 gpm. The highest total monthly withdrawal in 2002 for the 5 wells averaged almost 38 gpm in January. The highest reported monthly withdrawal average was 41 gpm in March 1994 (Reference 3). The four wells not requiring permits are also not required to report their withdrawals, but based on their small size and limited use they are not expected to add more than 1 or 2 gpm to the average withdrawal by the permitted wells (Reference 3).

Any groundwater supply required by the new units would likely come from an increase in the storage capacity for the existing wells or from drilling additional wells. In either event, additional groundwater withdrawal by the new units is not expected to impact any offsite wells due to: 1) their distance from the site, 2) the direction of the hydraulic gradient toward Lake Anna and the lake's recharge effect, and 3) the existence of hydrologic divides between the ESP site and the offsite wells.

2.3.3 Water Quality

This section describes the water quality characteristics of surface water bodies and groundwater aquifers that could affect plant water use and effluent disposal, or be affected by the construction, operation, or decommissioning of new units at the ESP site. Site-specific and regional data on the physical, chemical, and biological water quality characteristics of surface water and groundwater are summarized to provide the basic data for evaluating water quality impacts on water bodies, aquifers, aquatic ecosystems, and water use.

2.3.3.1 Surface Water

As described in Section 2.3.1, it is anticipated that new Unit 3 would use a closed-cycle, dry and wet cooling tower system for the main condenser, with make-up water for the wet cooling towers being supplied from the North Anna Reservoir and blowdown discharge being returned to the reservoir via the WHTF. It is anticipated that new Unit 4 would use a closed-cycle cooling system with dry system cooling towers with small make-up water requirements (1 gpm or less) supplied from the North Anna Reservoir and no blowdown discharge to the WHTF. Therefore, Lake Anna is the primary surface water body that could affect plant water use and effluent disposal, or be affected by the construction and operation of new units at the ESP site.

An extensive set of water temperature data for Lake Anna has been collected in accordance with the VPDES monitoring requirements for the existing units. The VPDES permit (Reference 4) requires continuous monitoring of temperature at 11 stations. Temperature measurements are taken hourly at the surface at Stations 1 through 9 inclusive and 11 and at a depth of 3 meters at Station 10. Figure 2.3-12 identifies the locations of the fixed continuous temperature recorders. The VPDES permit (Reference 4) also requires that a quarterly thermal plume survey be conducted at 14 stations located along the length of the North Anna Reservoir. At each station, temperature measurements are taken from the water surface to the lake bottom at one-meter intervals. Figure 2.3-12 identifies the locations of these stations, which are designated as Stations A through N.

Water temperature statistics from 4 of the fixed continuous monitors are summarized in Table 2.3-7. The locations of these stations are as follows:

- North Anna Reservoir near the cooling water intakes for the existing units (Station 2/NALINT)
- The end of the discharge canal leading into Lagoon 1 of the WHTF (Station 7/NADISC1)
- Upstream of Dike 3 in Lagoon 3 of the WHTF (Station 9/NAWHTF3)
- North Anna Reservoir across from Burrus Point (Station 3/NALBRPT)

The same data are plotted in Figure 2.3-13 from 1978 through 2001 to illustrate temporal trends.

Table 2.3-7 Daily Water Temperature Statistics for Lake Anna

Statistic	Station 2 (NALINT)	Station 7 (NADISC1)	Station 9 (NAWHTF3)	Station 3 (NALBRPT)
Number measurements	8087	8175	8301	7823
Average, °F	63.8	77.1	69.7	65.6
Minimum, °F	34.2	39.4	36.1	34.7
Maximum, °F	90.1	102.2	95.0	89.4
80% quantile, °F	80.6	92.1	85.5	81.1
90% quantile, °F	83.7	96.1	88.7	84.2
95% quantile, °F	85.1	97.7	90.1	85.8
99% quantile, °F	87.3	100.2	92.5	87.6

Additional physical and chemical water quality parameters were measured as part of a Clean Water Act (CWA) 316(a) demonstration for the existing units (Reference 33). Fifteen physical and chemical parameters, in addition to water temperature, were monitored at 14 water quality stations in the North Anna Reservoir and the WHTF. The locations of these stations are shown on Figure 2.3-12. Eight of these water quality monitoring stations coincide with current fixed continuous temperature recorders, while the remaining six were located independently. Virginia Power has also measured selected water quality parameters at the same 14 water quality stations to support their operation of the existing units. Table 2.3-13 summarizes the water quality data obtained from the sources cited above for each of the water quality stations.

Pre-existing environmental stresses on the water quality of Lake Anna are described in the CWA 316(a) demonstration report (Reference 33). One known impact is associated with acid mine drainage into Contrary Creek due to historical mining of the Contrary Creek watershed for pyrite ore. This drainage produced higher concentrations of metals and an acidic pH in the Contrary

Creek arm of Lake Anna relative to the rest of the lake, which is evident in the data presented in Table 2.3-13.

Other known lake water impacts include elevated concentrations of nutrients associated with the application of fertilizers for crop production in the watershed. With declining agricultural activity in recent years, however, nutrient concentrations have decreased and stabilized since inundation. Compared to other regional lakes, there does not appear to be an excess of nutrients (Reference 33).

Several tributaries to the North Anna Reservoir, and portions of North Anna Reservoir, appear on the VDEQ's 303(d) list of impaired waters (Reference 34). Many of these waterways have been listed based on the presence of fecal coliform bacteria. The source of fecal coliform bacteria is stated to be unknown in the 303(d) report. Sources might include livestock, wildlife, failing septic systems, pets, and waste from boats (Reference 19). Contrary Creek, Goldmine Creek, and Lake Anna are listed due to the presence of polychlorinated biphenyls in fish tissues at concentrations in excess of the human health-based screening value. The source of this impairment is unknown. Contrary Creek has also been listed because of low pH.

The known permitted discharges to Lake Anna are limited to those from the existing units. These sources and permitted discharge limits are described in the VPDES permit (Reference 4).

2.3.3.2 Groundwater Aquifers

Groundwater at the ESP site occurs under water table conditions at depths ranging from about 6 to 58 feet in the saprolite and underlying metamorphic bedrock. The most dependable supplies of groundwater are obtained by wells drilled into the lower part of the weathered zone and the upper part of the underlying fractured bedrock (Reference 35). As presented in Section 2.3.2, the existing units obtain potable water from wells in these zones. Regionally, this aquifer can be considered a Piedmont crystalline aquifer (Reference 13). This aquifer is the primary groundwater aquifer that could affect plant water use and effluent disposal, or be affected by the construction, operation, or decommissioning of new units at the ESP site.

No site-specific data are available to establish the physical, chemical, and biological water quality characteristics of the groundwater at the ESP site. However, a number of studies have been conducted to characterize the water quality of the Piedmont crystalline aquifers in the region. Data published in these studies are expected to be representative of site conditions. Table 2.3-14 summarizes these regional data.

In comparison with groundwater in widely scattered regions of the world, the water in the Piedmont region ranks among the best in chemical quality (Reference 36). The groundwater from most light-colored crystalline metamorphic and igneous rocks of the region is generally soft (hardness ≤60 mg/l), slightly acidic (pH <7.0), and low in dissolved solids; while that from the dark-colored crystalline metamorphic and igneous rocks is generally harder, slightly more alkaline, and moderately higher in dissolved solids (Reference 36). As Figure 2.3-13 illustrates, water from the crystalline rocks contains a balanced mixture of calcium, magnesium, and sodium ions. This figure also indicates that the water is rich in bicarbonate ions. The crystalline igneous and metamorphic rocks of the Piedmont province also have relatively high levels of naturally occurring radioactivity in the groundwater (Reference 37).

Based on the Louisa County Water Testing Program undertaken in 1992, there is evidence of groundwater quality degradation near the ESP site due to coliform contamination (Reference 19). Of the 119 wells tested by Louisa County in 1992, 29 wells were in the Lake Anna watershed. Of those 29, 18 were residential, 10 were on farms, and one was at a quarry. Sixteen of the 29 wells were in the lakeside area. All wells in the Louisa County Water Testing Program were tested for pH, total and fecal coliforms, metals, anions, and total organic carbon. Of the 29 wells in the Lake Anna watershed, total and fecal coliforms were present in 41 percent and 31 percent of the wells, respectively. Sources of this coliform contamination likely include the septic systems typically used by the residential developments and farms surrounding Lake Anna. Of the remaining parameters for which tests were conducted, only manganese and nitrate were found at elevated levels in the Louisa County portion of the Lake Anna watershed. Four of the 29 wells had manganese present at concentrations in excess of the secondary maximum contaminant level of 0.05 mg/l. One well, located on a farm, had nitrate present at a concentration in excess the maximum contaminant level of 10 mg/l. (Reference 19)

Section 2.3 References

1. *Updated Final Safety Analysis Report, North Anna Power Station Units No. 1 and 2,* Revision 38, Virginia Power.

2. *Applicant's Environmental Report Supplement, North Anna Power Station, Units 1 and 2 and Units 3 and 4*, Virginia Electric and Power Company, March 15, 1972.

3. *Appendix E, Applicant's Environmental Report – Operating License Renewal Stage, North Anna Power Station Units 1 and 2*, License Nos. NPF-4 and NPF-7, Virginia Electric & Power Company, May 2001.

4. *Authorization to Discharge Under the Virginia Pollutant Discharge Elimination System and the Virginia State Water Control Law, Virginia Electric & Power Company, North Anna Nuclear Power Station*, Permit No. VA0052451, Commonwealth of Virginia, Department of Environmental Quality, January 2001.

5. U. S. Geological Survey, USGS 01670180 Pamunkey Creek at Lahore, VA. Available at waterdata.usgs.gov/nwis/nwisman/?site_no=01670180&agency_cd=USGS. Accessed April 22, 2003.

6. U. S. Geological Survey. USGS 01670300 Contrary Creek Near Mineral, VA. Available at waterdata.usgs.gov/nwis/nwisman/?site_no=01670300&agency_cd=USGS. Accessed April 22, 2003.

7. U. S. Geological Survey, USGS 01670400 North Anna River Near Partlow, VA. Available at waterdata.usgs.gov/nwis/nwisman/?site_no=01670400&agency_cd=USGS. Accessed April 22, 2003.

8. U. S. Geological Survey, USGS 01671000 North Anna River Near Doswell, VA. Available at waterdata.usgs.gov/nwis/nwisman/?site_no=01671000&agency_cd=USGS. Accessed April 22, 2003.

9. U. S. Geological Survey, USGS 01671020 North Anna River at Hart Corner Near Doswell, VA. Available at waterdata.usgs.gov/nwis/nwisman/?site_no=01671020&agency_cd=USGS. Accessed April 8, 2003.

10. U. S. Geological Survey, USGS 01673000 Pamunkey Anna River Near Hanover, VA. Available at waterdata.usgs.gov/nwis/nwisman/?site_no=01673000&agency_cd=USGS. Accessed April 22, 2003.

11. Trapp, H., Jr., and Horn, M. A., *Ground Water Atlas of the United States, Segment 11, Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, West Virginia*, U.S. Geological Survey, Hydrologic Investigations Atlas 730-L, 1997.

12. van der Leeden, F., *Water Atlas of Virginia*, Tennyson Press, Lexington, Virginia, 1993.

13. Powell, J. D., and Abe, J. M., *Availability and Quality of Ground Water in the Piedmont Province of Virginia*, U.S. Geological Survey, Water Resources Investigations Report 85-4235, 1985.

14. Poff, J. A., *A Guide to Virginia's Ground Water*, Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, available at www.vwrrc.vt.edu/publications/educatio.htm, 1999.

15. *Report, Site Environmental Studies, Proposed North Anna Power Station, Louisa County, Virginia, Virginia Electric and Power Company* (Included in Units 1 and 2 PSAR as Appendix A), Dames & Moore, January 13, 1969.

16. Mixon, R. B., Pavlides, L., Powars, D. S., Froelich, A. J., Weems, R. E., Schindler, J. S., Newell, W. L., Edwards, L. E., and Ward, L. W., *Geologic Map of the Fredericksburg 30' x 60' Quadrangle, Virginia and Maryland*, U.S. Geological Survey, Geologic Investigations Series Map I-2607, 2000.

17. *Report, Site Environmental Studies, North Anna Nuclear Power Station, Proposed Units 3 and 4, Louisa County, Virginia*, Dames & Moore, August 18, 1971.

18. *Independent Spent Fuel Storage Installation Safety Analysis Report, North Anna Power Station, Units 1 and 2*, Revision 3, Virginia Electric and Power Company, June 2002.

19. *Lake Anna Special Area Plan*, Lake Anna Special Area Plan Committee, March 2000.

20. McWhorter, D. B., and Sunada, D. K., *Ground-Water Hydrology and Hydraulics*, Water Resources Publications, Littleton, Colorado, 1977.

21. *Source Water Protection, Designated Sole Source Aquifers in EPA Region III, District of Columbia, Delaware, Maryland, Pennsylvania, Virginia, West Virginia*, U.S. Environmental Protection Agency, Region 3, Water Protection Division, available at www.epa.gov/OGWDW/swp/ssa/reg3.html, November 26, 2002.

22. *Status of Virginia's Water Resources, A Report on Virginia's Water Supply Planning Activities*, A Report to the Honorable James S. Gilmore III, Governor, and the General Assembly of Virginia, Virginia Department of Environmental Quality, available at www.deq.state.va.us/pdf/gareports/waterresources2001.pdf, October 2001.

23. *Report of Installation of Standpipe Piezometers Along the Toe of the Service Water Reservoir, North Anna Power Station Units 1 and 2*, Virginia Geotechnical Services, P.C., July 21, 1998.

24. *Virginia DEQ Water Programs, Water Withdrawal Reporting*, Virginia Department of Environmental Quality, available at www.deq.state.va.us/water/waterwith.html, October 18, 2002.

25. *County of Louisa, Water Quality Management Plan and Groundwater Study,* Thomas Jefferson Planning District Commission, Virginia Division of Mineral Resources, Louisa County Planning Department, Louisa County Water Authority, Draper Aden Associates, January 1998.

26. *Lake Anna Special Plan*, Lake Anna Special Plan Committee, March 2000.

27. *Status of Virginia's Water Resources, A Report on Virginia's Water Supply Planning Activities*, Virginia Department of Environmental Quality, October 2001.

28. *Report, Site Environmental Studies, North Anna Nuclear Power Station, Proposed Units 3 and 4, Louisa County, Virginia*, Dames & Moore, August 18, 1971.

29. *Total Water Withdrawals for Virginia, 1995*, U.S. Geological Survey, available at va.water.usgs.gov/w_use/wu_index.htm, January 2, 2003.

30. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 7, Regarding North Anna Power Station, Units 1 and 2*, U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Regulatory Improvement Programs, November 2002.

31. *Water Description Sheet*, Virginia Department of Health, January 15, 1998.

32. *Engineering Description Sheet*, Virginia Department of Health, June 17, 1991.

33. North Anna Power Station Section 316(a) Demonstration, Virginia Power, June 1986.

34. 2002 303(d) Report on Impaired Waters, Virginia Department of Environmental Quality, September 30, 2002. Available at www.deq.state.va.us/water/303d.html. Accessed January 2, 2003.

35. Sinnott, A., and Cushing, E. M., Summary Appraisals of the Nation's Ground-Water Resources – Mid-Atlantic Region, Geologic Survey Professional Paper 813-I, 1978.

36. Powell, J. D., and Abe, J. M., Availability and Quality of Ground Water in the Piedmont Province of Virginia, U. S. Geological Survey, Water Resources Investigations Report 85-4235, 1985.

37. Powell, J. D., and Hamilton, P. A., Virginia Ground-Water Quality, U. S. Geological Survey Open-File Report 87-0759, 1987.

38. *Safe Drinking Water Information System (SDWIS), Virginia, Louisa County*, U.S. Environmental Protection Agency, letter from Karen D. Johnson to Bechtel Power Corporation, July 14, 2004.

39. *Engineering Description Sheet*, Virginia Department of Health Department, July 24, 1991.

40. *Engineering Description Sheet*, Virginia Department of Health, February 28, 2003.

41. *Annual Report of Water Withdrawals, North Anna Nuclear Power Plant, January 1, 2002 to December 31, 2002*, submitted by Dominion Virginia Power to Virginia Department of Environmental Quality, January 31, 2003.

42. LeGrand, H. E., Ground Water of the Piedmont and Blue Ridge Provinces in the Southeastern States, Geologic Survey Circular 538, 1967.

43. van der Leeden, F., *Water Atlas of Virginia – Basic Facts About Virginia's Water Resources*, A Hennyson Press Publication, Lexington, Virginia, 1993.

Table 2.3-8 Monthly Streamflow Statistics (cfs)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pamunkey Creek at Lahore, VA												
N	4	4	3	4	3	3	3	3	4	3	3	4
Min	25.7	25	37.9	35.3	19.9	14.4	14.9	1.46	2.03	2.3	6.25	24.6
Mean	61.2	37.5	49.0	62.0	43.0	23.9	19.3	9.72	14.5	31.8	31.8	47.6
Max	91.5	53.5	65.3	114	81	32.8	26.6	16.6	22.2	57.1	49.1	87.7
Contrary Creek near Mineral, VA												
N	11	11	11	11	11	11	11	11	11	12	12	12
Min	1.69	3.49	2.05	2.18	1.66	0.63	0.31	0.1	0.13	0.67	0.68	1.64
Mean	7.97	9.37	8.92	8.36	4.33	2.46	1.34	3.40	1.20	3.16	5.05	5.46
Max	20.1	25.5	21.9	21.1	12.8	6.76	2.27	14.3	4.13	10.5	19	8.68
North Anna River near Partlow, VA												
N	17	17	17	17	17	17	17	17	17	17	17	17
Min	45.2	55.6	51.8	55.7	53.5	46.1	45.7	49.1	44.3	42.4	44	45.4
Mean	401	507	601	485	330	215	133	134	109	138	244	265
Max	926	1361	1762	1378	947	784	563	478	530	1085	1230	682
North Anna River near Doswell, VA												
N	58	58	58	59	59	59	59	59	59	59	59	59
Min	68.1	87.2	77.7	91.6	111	71.2	32.2	14.7	6.16	5.45	24.8	53.2
Mean	554	602	645	592	368	244	210	269	177	230	285	407
Max	1974	1767	1515	1922	1043	1325	1321	2688	1490	1345	1464	1723
North Anna River at Hart Corner near Doswell, VA												
N	22	22	22	22	22	22	22	22	22	22	22	22
Min	71.9	100	90.5	108	61.9	50.6	47.7	49.3	41.7	43.7	46.7	75.2
Mean	536	677	820	648	424	244	159	155	144	207	315	377
Max	1389	2660	2345	1887	1217	795	591	614	1185	1428	1561	1320
Pamunkey River near Hanover, VA												
N	60	60	60	60	60	60	60	60	60	60	60	60
Min	197	396	248	434	197	82	91.9	63.1	30.3	60.6	113	166
Mean	1434	1624	1883	1535	1027	680	501	619	427	581	727	1114
Max	4334	7118	5430	5009	2821	4293	2747	6381	2939	3461	3505	3782

N = number of monthly observations
Min = minimum monthly value
Mean = average monthly value
Max = maximum monthly value

Table 2.3-9 Quarterly Groundwater Level Elevations

Observation Well No.	Well Depth* (ft)	Reference Point Elev. (ft)	Reference Point Stickup** (ft)	Top of Well Screen Elev. (ft)	Well Screen Length (ft)	Groundwater Level Elevations		
						12/17/02	03/17/03	06/17/03
OW-841	34.3	251.6	1.5	228.1	9.7	248.9	249.6	249.6
OW-842	49.6	336.7	1.5	297.8	9.6	307.5	308.9	310.8
OW-843	49.2	320.6	1.5	282.1	9.7	285.1	288.1	290.8
OW-844	24.6	273.5	1.5	257.6	9.6	265.5	266.7	267.3
OW-845	55.0	297.3	1.5	253.0	9.7	272.7	274.9	277.4
OW-846	32.7	297.3	1.5	273.5	9.8	272.5	274.8	277.1
OW-847	49.8	319.7	1.5	280.6	9.6	285.4	287.0	289.5
OW-848	47.3	284.5	1.5	240.8	5.0	241.7	242.9	243.6
OW-849	49.8	298.5	1.5	259.4	9.7	265.5	269.5	271.7
P-10	22.5	286.4	2.4	267.0	5	274.4	274.8	275.2
P-14	N/A	327.1	N/A	N/A	N/A	271.6	272.2	272.8
P-18	N/A	329.0	N/A	N/A	N/A	285.7	286.5	287.5
P-19	58.5	322.3	N/A	N/A	5	284.3	285.2	286.3
P-20	61.0	320.6	N/A	N/A	5	274.9	275.4	275.8
P-21	58.5	319.2	N/A	N/A	5	Dry	261.2	262.0
P-22	60.0	320.5	N/A	N/A	5	276.8	277.8	278.6
P-23	41.2	296.4	1.9	258.7	5	261.1	262.6	263.3
P-24	25.0	293.4	2.3	271.3	5	276.4	277.1	278.4
WP-3	N/A	317.9(?)	N/A	266.5	5	299.7	301.0	302.8
Lake Anna Water Level Elevation						248.1	250.1	250.4
Service Water Reservoir Water Level Elevation						314.6	313.3	314.6

OW - wells installed in December 2002 as part of ESP Subsurface Investigation Program.
P - wells installed previously to monitor NAPS Units 1 and 2 Service Water Reservoir.
WP - well installed previously as part of Independent Spent Fuel Storage Installation monitoring program.
* Below ground surface at time of installation.
** Above ground surface at time of installation.
N/A - not available

Table 2.3-10 Hydraulic Conductivity Values

Observation Well No.	Depth Interval Tested (ft)	Elevation	Material	Hydraulic Conductivity cm/sec	Hydraulic Conductivity ft/day
PT-1[a]	Near-surface	Unknown	Saprolite	2.8×10^{-5}	0.08
PT-2[a]	Near-surface	Unknown	Saprolite	1.4×10^{-5}	0.04
P-10[b]	14.5 - 22.5	269.5 - 261.5	Saprolite	6.1×10^{-4} to 6.1×10^{-5}	1.7 to 0.17
P-24[b]	16.8 - 25.0	274.3 - 266.1	Saprolite	2.9×10^{-4} to 6.6×10^{-6}	0.8 to 0.02
P-23[b]	33.7 - 41.2	260.7 - 253.2	Saprolite	6.6×10^{-5}	0.19
OW-844[c]	12.7 - 24.6	259.3 - 247.4	Saprolite	9.9 to 8.9×10^{-5}	0.28 to 0.25
OW-841[c]	20.1 - 34.3	230.0 - 215.8	Saprolite	8.2 to 7.8×10^{-4}	2.3 to 2.2
OW-846[c]	20.3 - 32.7	275.5 - 263.1	Saprolite	1.2×10^{-3} to 6.8×10^{-4}	3.4 to 1.9
OW-847[c]	35.0 - 49.8	283.2 - 268.4	Saprolite	2.3 to 2.1×10^{-4}	0.66 to 0.58
OW-842[c]	35.3 - 49.6	299.9 - 285.6	Saprolite	3.3×10^{-4}	0.93
OW-849[c]	35.6 - 49.8	261.4 - 247.2	Saprolite	1.1×10^{-3} to 7.0×10^{-4}	3.2 to 2.0
OW-843[c]	36.4 - 49.2	282.7 - 269.9	Saprolite	4.9 to 4.5×10^{-4}	1.4 to 1.3
OW-848[c]	39.1 - 47.3	243.9 - 235.7	Saprolite	1.2×10^{-3} to 9.9×10^{-4} [d]	3.4 to 2.8 [d]
OW-845[c]	39.7 - 55.0	256.1 - 240.8	Quartz Gneiss	1.1×10^{-3} to 6.3×10^{-4} [e]	3.1 to 1.8 [e]
Test Results					
B-48[a]	3.5	290.5	Sandy silt	1×10^{-6}	0.003
B-8[a]	5.5	293.5	Fine sand, tr. silt	1×10^{-6}	0.003
B-2[a]	15.5	269.5	Fine to med. sand, w/clayey silt	4×10^{-5}	0.11
B-15[a]	36	281	Silty fine sand	1.3×10^{-5}	0.04

a. Reference 15

b. Reference 23

c. Part 2: Appendix 2.5.4B

d. Results may not be accurate due to static water level approximately 0.5 ft below top of well screen.

e. Results not be accurate due to short duration of stable water level recovery measurements.

Table 2.3-11 Public Groundwater Supplies In Louisa County

Installation	Type[a]	Water Source	Depth (ft)	Measured Yield (gpd)	Design Yield (gpd)	Population Served [a]	Active/ Inactive (a)
Town of Louisa (b) (primary source is surface water)	Community	spring	NA	38,880		1950	
		3 wells	200–405	43,200–53,280			
Town of Mineral (b)	Community	2 springs	NA	57,600		670	A
		4 wells	200–600	14,400–165,600			
Acorn West Trailer Park (b)	Community	well	120	8640		70	I
Apple Grove School (a)	Transient Non-Community					200	I
Blue Ridge Shores (b)	Community	4 wells	163–405	288,000	160,000	1450	A
Bumpass Park/Lake Anna Rescue (a)	Transient Non-Community					250	A
Burger King Zion Crossroads (a)	Transient Non-Community					250	A
Cable Form (a)	Transient Non-Community					11	I
Christopher Run Campground (a)	Transient Non-Community					608	A
Country Side II (a)	Transient Non-Community					50	I
Crescent Inn Restaurant (a)	Transient Non-Community					150	A
Crossing Point (VA Oil Co) (b)	Non-Transient Non-Community	2 wells	305	21,600–28,800	10,400	45	A
Deb's Place (a)	Transient Non-Community					50	I

Table 2.3-11 Public Groundwater Supplies In Louisa County

Installation	Type[a]	Water Source	Depth (ft)	Measured Yield (gpd)	Design Yield (gpd)	Population Served [a]	Active/ Inactive (a)
East End Elementary School (b)		well	345	61,920	31,200		
Expressions Learning Center (b)	Non-Transient Non-Community	well	205	17,280		45	A
Green Springs School (a)	Transient Non-Community					300	I
Jerdone Island (b,c)	Community	well	200	83,520	19,600	49	A
Jouette Elementary School (b)	Non-Transient Non-Community	well	345	61,920	19,600	741	A
Junction Restaurant (a)	Transient Non-Community					25	I
Junction Restaurant (a)	Transient Non-Community					50	I
Klockner Barrier Films (b)		well	305	53,280	22,000		
Klockner-Pentaplast (b)	Non-Transient Non-Community	2 wells	205–280	21,600–57,600	44,000	526	A
Lake Anna Estates Trailer Park (a)	Community					50	I
L A Pizza (a)	Transient Non-Community					25	I
Lake Anna Plaza (d)	Community	2 wells	335–230	11,520–86,400	41,200	100	A
Louisa County Senior Center (a)	Transient Non-Community					45	I
Louisa County Water Authority (a,b)	Non-Transient Non-Community	well	550	34,560		192	I
Louisa County Zion Crossroads (a)	Non-Transient Non-Community					600	A

Table 2.3-11 Public Groundwater Supplies In Louisa County

Installation	Type[a]	Water Source	Depth (ft)	Measured Yield (gpd)	Design Yield (gpd)	Population Served [a]	Active/ Inactive [(a)]
Louisa Day Care Center [(a)]	Transient Non-Community					30	I
Louisa Intermediate School [(a)]	Transient Non-Community					900	I
Mount Garland School [(a)]	Transient Non-Community					140	I
Ole Country Inn [(a)]	Transient Non-Community					50	I
Prospect Hill [(a)]	Transient Non-Community					50	A
Raynell's [(a)]	Transient Non-Community					25	I
Sandra Carter [(a)]	Community					36	I
Shenandoah Crossing [(b)]	Non-Transient Non-Community	2 wells	280–300	123,840–97,920	98,400	850	A
Siebert's Amoco & Dairy Queen [(a)]	Transient Non-Community					950	A
Six-o-Five Village [(b)]	Community	2 wells	310–365	64,800–10,800	10,700	201	A
Small Country Campground [(a)]	Transient Non-Community					112	A
Tavern on the Rail [(a)]	Transient Non-Community					150	A
Trevillians Elementary School [(b)]	Non-Transient Non-Community	well	204	57,600	19,600	676	A
Trevilians Square Apartments [(a)]	Community					61	A

Table 2.3-11 Public Groundwater Supplies In Louisa County

Installation	Type[a]	Water Source	Depth (ft)	Measured Yield (gpd)	Design Yield (gpd)	Population Served [a]	Active/ Inactive [(a)]
Twin Oaks Community [(b)]	Community	well	250 [(e)]	7200		75	A
West End Elementary School [(b)]		well	204	57,600	20,000		
Wooden Nickle [(a)]	Transient Non-Community					25	I

Note: Blank entries indicate data not provided in cited reference.

a. Reference 38
b. Reference 25
c. Reference 39
d. Reference 40
e. Reference 1

Table 2.3-12 North Anna Power Station Groundwater Use[a] January 1, 2002 to December 31, 2002

Month	Well #2	Well #3A	Well #4	Well #6	NANIC
			(Millions of Gallons)		
January	0.0032	0.4268	0.4519	0.7444	0.0485
February	0.0032	0.1395	0.4010	0.5095	0.0467
March	0.0025	0.0263	0.1050	0.1642	0.0555
April	0.0046	0.0368	0.1253	0.1459	0.0474
May	0.0076	0.0376	0.2565	0.1041	0.0690
June	0.0021	0.0531	0.2524	0.1458	0.0502
July	0.0018	0.0511	0.3585	0.0189	0.0525
August	0.0077	0.0611	0.3434	0.0526	0.0656
September	0.0071	0.1020	0.4018	0.1655	0.0474
October	0.0062	0.0874	0.2118	0.1574	0.0651
November	0.0148	0.0694	0.2126	0.1846	0.0586
December	0.0037	0.2005	0.0648	0.2070	0.0482
Total	0.0645	1.2916	3.1850	2.5999	0.6547
Monthly Average	0.0054	0.1076	0.2654	0.2167	0.0546

a. Reference 41

Table 2.3-13 Water Quality Statistics for Lake Anna

Statistic	Hardness (mg/l as $CaCO_3$)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Total Phosphate (mg/l as P)	Ortho-phosphate (mg/l as P)	Meta-phosphate (mg/l as P)	Ammonia (mg/l as N)	Nitrate (mg/l as N)	Alkalinity (mg/l as $CaCO_3$)	Sulfate (mg/l as SO_4)	Copper (mg/l as Cu)	Iron (mg/l as Fe)	Lead (mg/l as Pb)	Zinc (mg/l as Zn)	pH (SU)
Pamunkey Creek Arm of Lake Anna at Route 719 Bridge (Station 5/NAL719N)															
Observations	84	192	192	97	49	79	106	99	192	116	22	99	5	33	206
Average	18.92	8.07	8.41	0.05	0.02	0.04	0.07	0.48	14.62	7.70	0.02	0.30	0.12	0.02	7.07
Maximum	39.3	37	13.6	0.33	0.26	0.21	0.24	3.16	21.2	17.5	0.05	3.4	0.3	0.15	8.9
Minimum	7.8	0.4	0.1	0.01	0	0	0.01	0.01	6.8	1.6	0.003	0.01	0.002	0.01	6.3
North Anna River Arm of Lake Anna at Route 719 Bridge (Station 6/NAL719S)															
Observations	84	192	192	94	45	88	95	95	192	115	24	98	9	34	206
Average	18.37	6.80	8.63	0.05	0.02	0.04	0.05	0.41	14.64	7.46	0.02	0.34	0.13	0.02	7.08
Maximum	39.3	41	14.2	0.16	0.05	0.16	0.2	2.05	25.8	18	0.04	6.81	0.38	0.11	8.5
Minimum	8.9	0.4	0	0.01	0	0	0.01	0.01	6.1	1.3	0.001	0.05	0.002	0.01	6.2
Lake Anna at Route 208 Bridge (Station 4/NAL208)															
Observations	51	192	192	53	8	50	73	80	192	80	28	102	7	66	213
Average	14.14	3.46	8.50	0.04	0.06	0.04	0.07	0.15	10.83	8.16	0.06	0.48	0.10	0.03	6.90
Maximum	22.2	20	13.8	0.3	0.3	0.25	0.91	0.58	19.3	11.6	1.1	22.15	0.38	0.11	7.4
Minimum	5.1	0.3	0.1	0.01	0.01	0.01	0.01	0.01	7.1	4	0.003	0.03	0	0.01	5.6
Contrary Creek Arm of Lake Anna															
Observations	36	176	176	8	5	5	36	32	167	36	50	85	6	78	191
Average	17.81	3.84	8.88	0.07	0.03	0.09	0.06	0.09	5.51	17.15	0.07	0.78	0.11	0.28	6.09
Maximum	32.5	40.4	13.5	0.32	0.06	0.26	0.35	0.22	15.2	39.8	0.22	6.4	0.18	1.14	7.4
Minimum	12	0.2	0.2	0.01	0.01	0.01	0.01	0.01	0	10.6	0.01	0.07	0.01	0.01	3.8

Note: Blank entries indicate no data available.

Table 2.3-13 Water Quality Statistics for Lake Anna

Statistic	Hardness (mg/l as $CaCO_3$)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Total Phosphate (mg/l as P)	Ortho-phosphate (mg/l as P)	Meta-phosphate (mg/l as P)	Ammonia (mg/l as N)	Nitrate (mg/l as N)	Alkalinity (mg/l as $CaCO_3$)	Sulfate (mg/l as SO_4)	Copper (mg/l as Cu)	Iron (mg/l as Fe)	Lead (mg/l as Pb)	Zinc (mg/l as Zn)	pH (SU)
Lake Anna at North Anna Power Station Intakes (Station 2/NALINT)															
Observations	72	178	178	76	29	59	89	102	178	105	27	94	11	60	199
Average	14.14	2.66	8.46	0.04	0.03	0.04	0.07	0.39	10.13	9.06	0.02	0.23	0.07	0.02	6.89
Maximum	27.4	13	13.2	0.45	0.16	0.29	0.19	1.57	18	18	0.04	3.97	0.19	0.043	7.5
Minimum	5.2	0.6	0.1	0	0	0	0.01	0.04	6.9	3.5	0.001	0.03	0.002	0.008	5.1
Lake Anna at Mid Lake															
Observations	36	72	72	42	11	38	56	68	72	67	2	52	2	26	93
Average	13.65	2.42	8.30	0.05	0.07	0.04	0.07	0.17	9.17	8.44	0.02	0.38	0.01	0.02	6.88
Maximum	18.8	9.5	12.8	0.35	0.25	0.14	0.19	0.48	15	14	0.03	8.96	0.02	0.04	7.3
Minimum	10.3	0.6	0.2	0.01	0.01	0.01	0.02	0.05	6.9	3.6	0.003	0.03	0.001	0.01	6.1
Lake Anna Near Burrus Point															
Observations	33	72	72	14	6	13	36	36	72	36		35		18	72
Average	13.37	2.29	8.26	0.12	0.07	0.10	0.07	0.15	9.19	8.52		0.10		0.01	6.92
Maximum	18.8	6	12.8	0.45	0.18	0.41	0.12	0.34	16.4	11.8		0.16		0.02	7.3
Minimum	1.2	0.2	0.6	0.01	0.02	0.01	0.03	0.06	7.3	7.3		0.04		0.01	6.7
Lake Anna Near Dike 3 (Station 10/NALST10)															
Observations	36	72	72	13	5	10	36	36	72	36		36		21	72
Average	13.70	2.23	8.29	0.10	0.22	0.02	0.08	0.15	9.00	8.34		0.11		0.01	6.90
Maximum	17.1	7.4	12.5	0.9	0.9	0.04	0.13	0.3	12.1	9.8		0.17		0.03	7.2
Minimum	10.3	0.7	4.7	0.01	0.02	0.01	0.03	0.06	5	7.2		0.03		0.01	6.3

Note: Blank entries indicate no data available.

Table 2.3-13 Water Quality Statistics for Lake Anna

Statistic	Hardness (mg/l as $CaCO_3$)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Total Phosphate (mg/l as P)	Ortho-phosphate (mg/l as P)	Meta-phosphate (mg/l as P)	Ammonia (mg/l as N)	Nitrate (mg/l as N)	Alkalinity (mg/l as $CaCO_3$)	Sulfate (mg/l as SO_4)	Copper (mg/l as Cu)	Iron (mg/l as Fe)	Lead (mg/l as Pb)	Zinc (mg/l as Zn)	pH (SU)
Lake Anna at the Dam															
Observations	84	192	192	79	31	61	99	115	192	116		101		69	213
Average	15.27	3.03	7.89	0.03	0.01	0.03	0.10	0.39	10.64	9.01		0.29		0.03	6.86
Maximum	42.8	17	12.8	0.09	0.05	0.08	0.84	2.13	34.4	18.8		5.19		0.15	7.3
Minimum	5.1	0.2	0	0.01	0	0.01	0.01	0.01	6.6	3.5		0.01		0.01	6.2
Lagoon 1 of the WHTF (Station 7/NADISC1)															
Observations	72	180	180	75	35	59	92	100	180	101		85		44	194
Average	14.98	2.65	8.66	0.03	0.02	0.02	0.06	0.39	10.02	9.03		0.15		0.03	6.92
Maximum	29.1	8.5	13	0.17	0.16	0.08	0.18	1.57	18	16.8		0.71		0.17	7.3
Minimum	6.1	0.2	5	0	0	0	0.01	0.05	6.3	0.3		0.01		0.01	6.4
Elk Creek Arm of the Waste Heat Treatment Facility															
Observations		174	174						174						174
Average		2.48	8.69						9.91						6.98
Maximum		6.9	13.2						14.4						7.6
Minimum		0.2	1.2						6.2						6.5
Millpond Creek Arm of the Waste Heat Treatment Facility															
Observations		180	180						180						180
Average		2.66	8.56						9.76						6.97
Maximum		17	13						16.5						7.4
Minimum		0.2	0.3						6.5						6.5

Note: Blank entries indicate no data available.

Table 2.3-13 Water Quality Statistics for Lake Anna

Statistic	Hardness (mg/l as $CaCO_3$)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Total Phosphate (mg/l as P)	Ortho-phosphate (mg/l as P)	Meta-phosphate (mg/l as P)	Ammonia (mg/l as N)	Nitrate (mg/l as N)	Alkalinity (mg/l as $CaCO_3$)	Sulfate (mg/l as SO_4)	Copper (mg/l as Cu)	Iron (mg/l as Fe)	Lead (mg/l as Pb)	Zinc (mg/l as Zn)	pH (SU)
Lagoon 2 of the WHTF (Station 8/NAWHTF2)															
Observations	24	183	183	30	1	30	48	56	183	56	2	39	1	14	204
Average	13.06	2.36	8.08	0.04	0.13	0.04	0.05	0.17	9.75	8.30	0.03	0.20	0.02	0.02	6.90
Maximum	17.1	6.2	12.7	0.41	0.13	0.41	0.1	0.66	16	13.4	0.03	0.88	0.02	0.1	7.4
Minimum	10.3	0.2	0.2	0.01	0.13	0.01	0	0.01	6.6	6	0.02	0.04	0.02	0.01	6.2
Lagoon 3 of the WHTF (Station 9/NAWHTF3)															
Observations	69	180	179	71	30	56	84	101	180	101	24	89	6	45	200
Average	14.81	2.54	8.36	0.03	0.04	0.03	0.07	0.39	9.53	9.06	0.03	0.19	0.11	0.02	6.90
Maximum	32.5	7.2	12.7	0.4	0.42	0.15	0.14	2.89	17	16.8	0.05	3.01	0.18	0.06	7.3
Minimum	4.4	0.2	1.5	0.01	0	0	0.01	0	6.2	3.5	0.01	0.03	0.01	0.01	6.2

Note: Blank entries indicate no data available.

Table 2.3-14 Water Quality Data for the Piedmont Crystalline Aquifers

Parameter	Average	Maximum	Minimum	Source
Total Dissolved Solids (mg/l)	100	200	40	Reference 37
	70-150	250		Reference 42
	60-120			Reference 43
Hardness (mg/l as $CaCO_3$)	40	100	10	Reference 37
	10-50	100	10	Reference 42
	20-70			Reference 43
Nitrate (mg/l as N)	0.05	1	< 0.01	Reference 37
	< 10	20		Reference 42
Chloride (mg/l)	1-20	40	1	Reference 42
Sulfate (mg/l)	1-40	100	1	Reference 42
Calcium (mg/l)	5-20	60	5	Reference 42
Magnesium (mg/l)	5-20	60	5	Reference 42
Silica (mg/l)	20-35	45	15	Reference 42
Iron (mg/l)	20	600	< 10	Reference 37
	< 0.3			Reference 42
Bicarbonate (mg/l as HCO_3)	30-100	150	15	Reference 42
pH	5.5-6.8	7.5	5.5	Reference 42

Note: Blank entries indicate data not provided in cited reference.

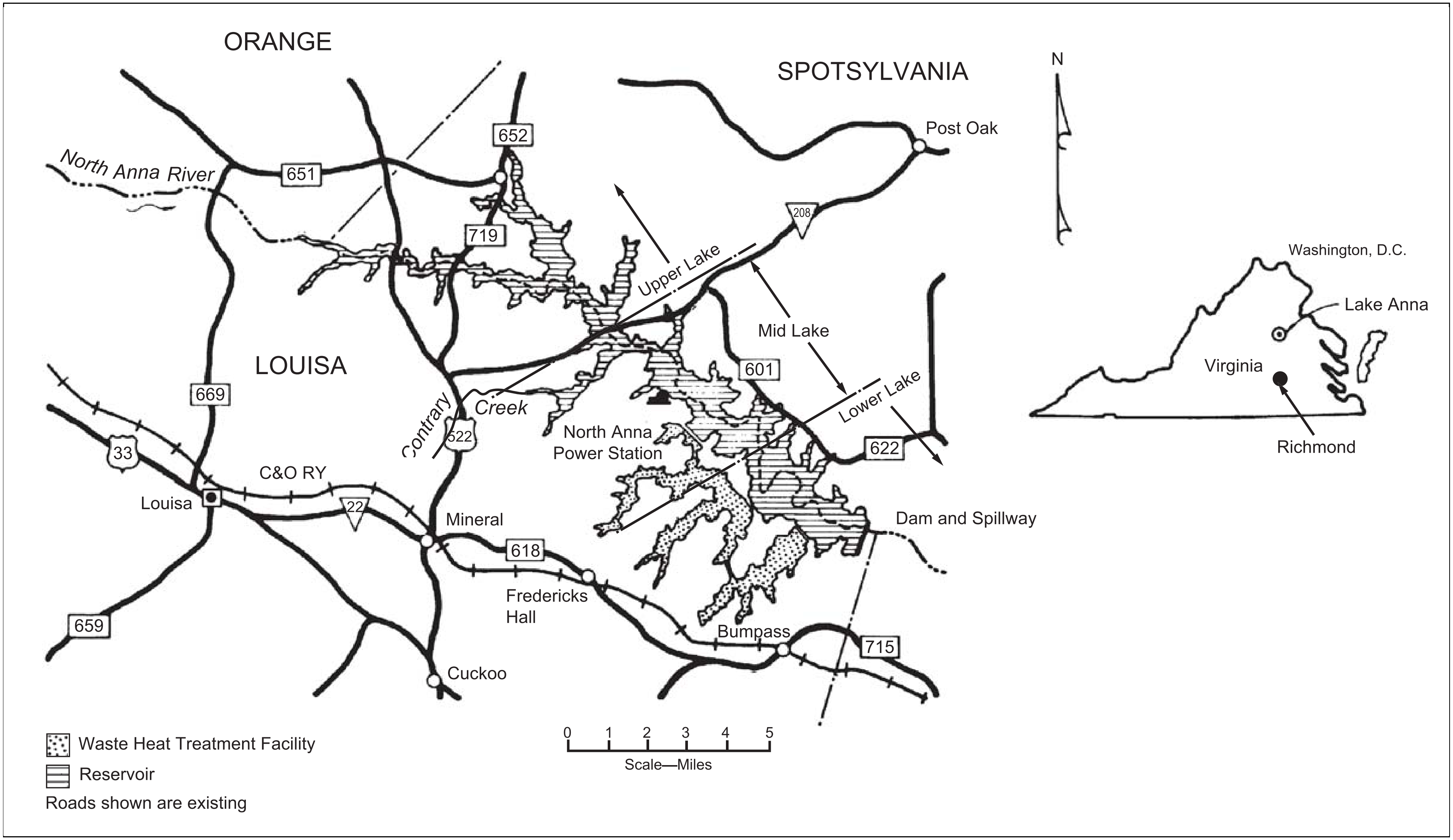

Figure 2.3-1 Lake Anna

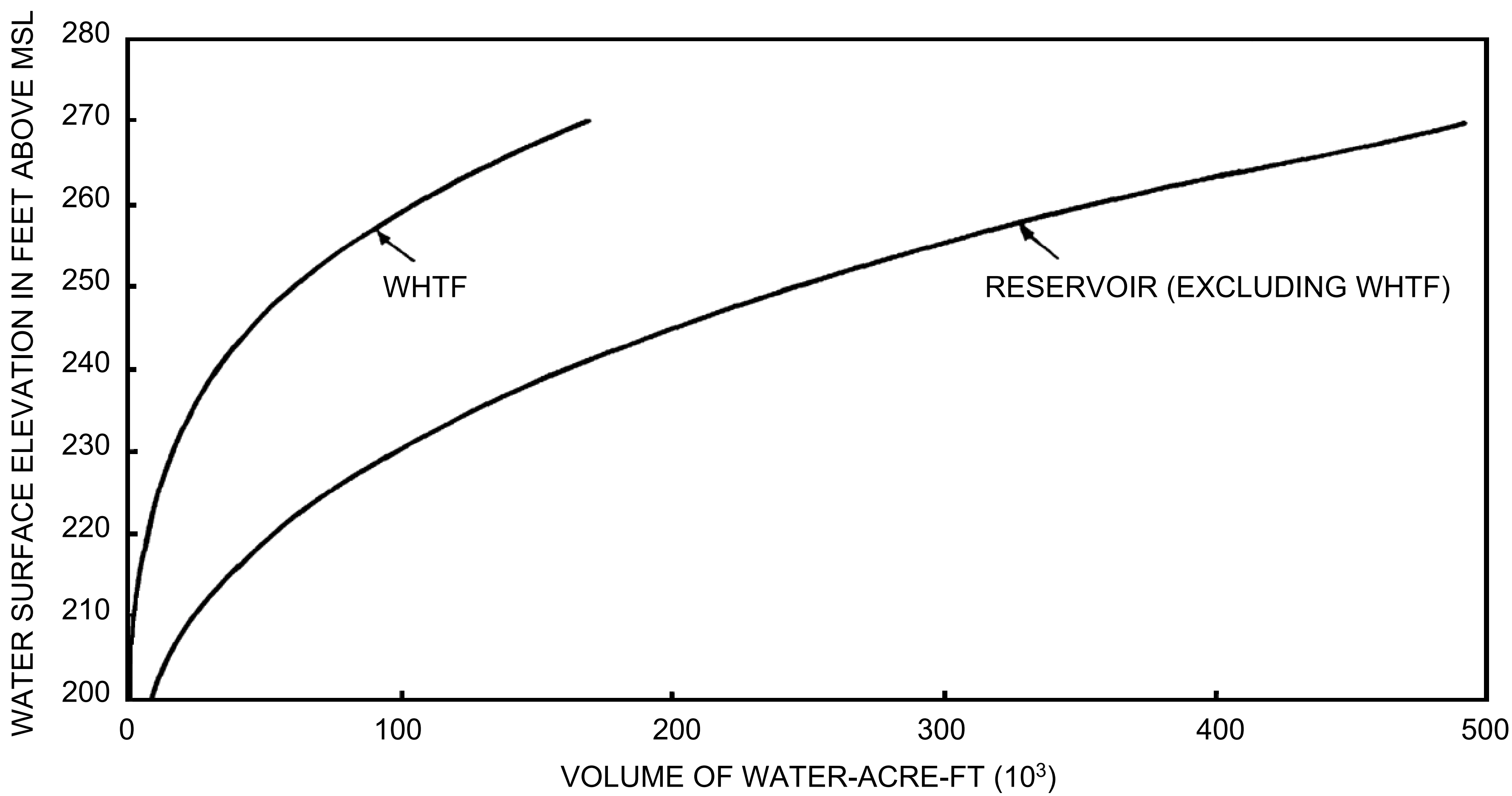

Figure 2.3-2 Elevation-Storage Curves for North Anna Reservoir and Waste Heat Treatment Facility

Figure 2.3-3 Deleted

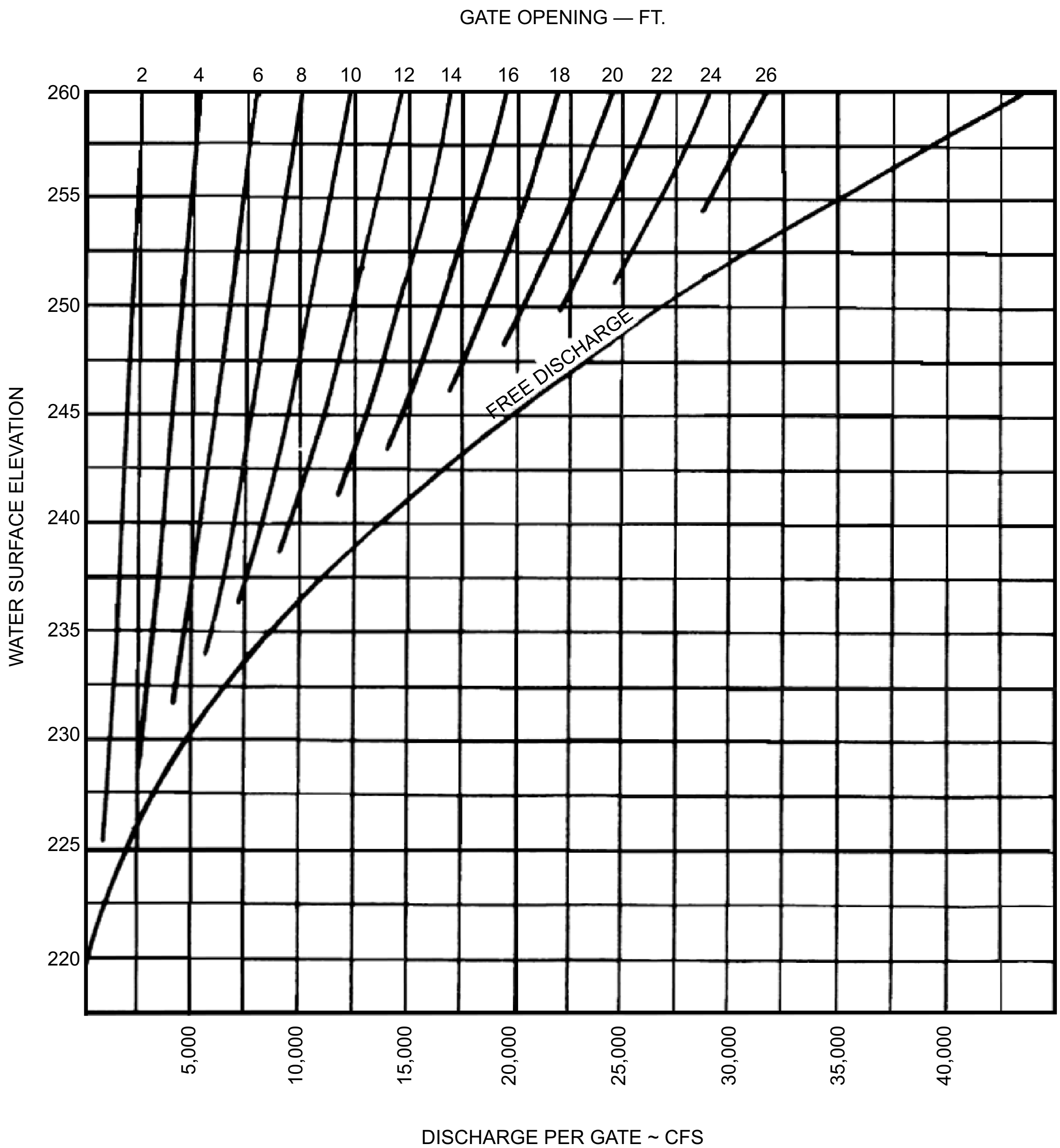

Figure 2.3-4 Spillway Discharge Capacity (One Gate of Three) North Anna Dam

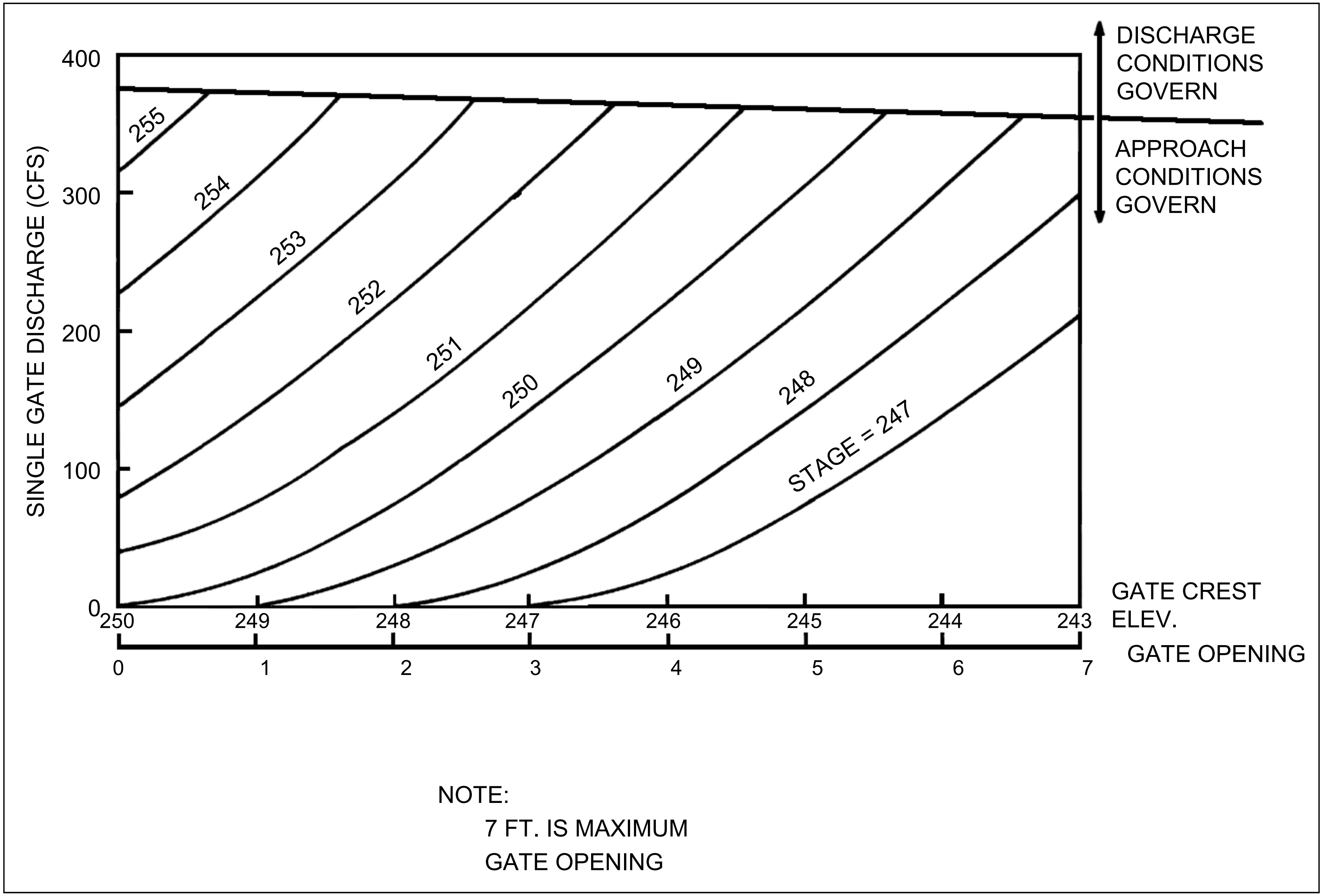

Figure 2.3-5 Skimmer Gate Discharge Capacity for North Anna Dam

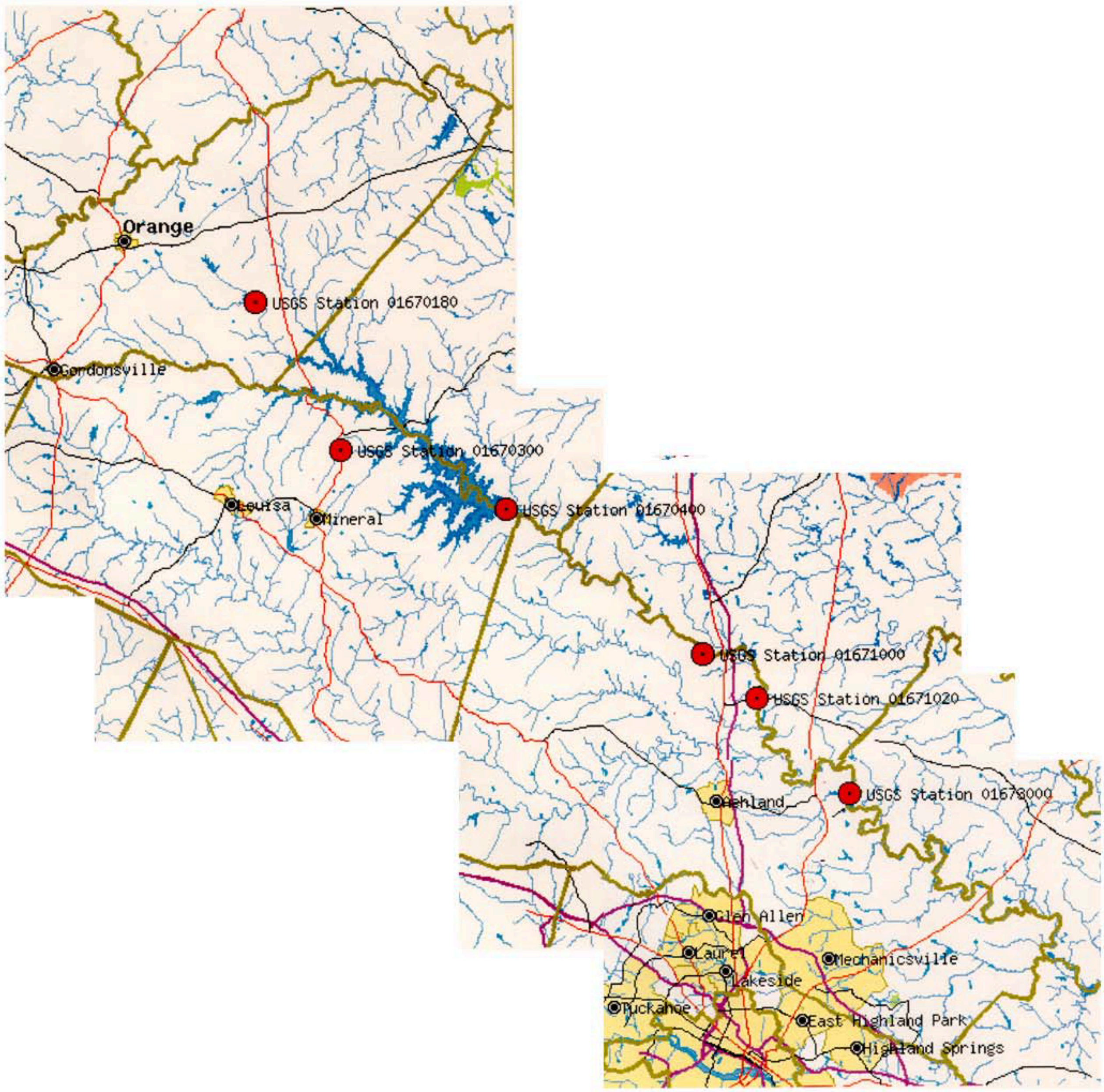

Figure 2.3-6 Locations of USGS Stream Gauging Stations in the North Anna River Watershed

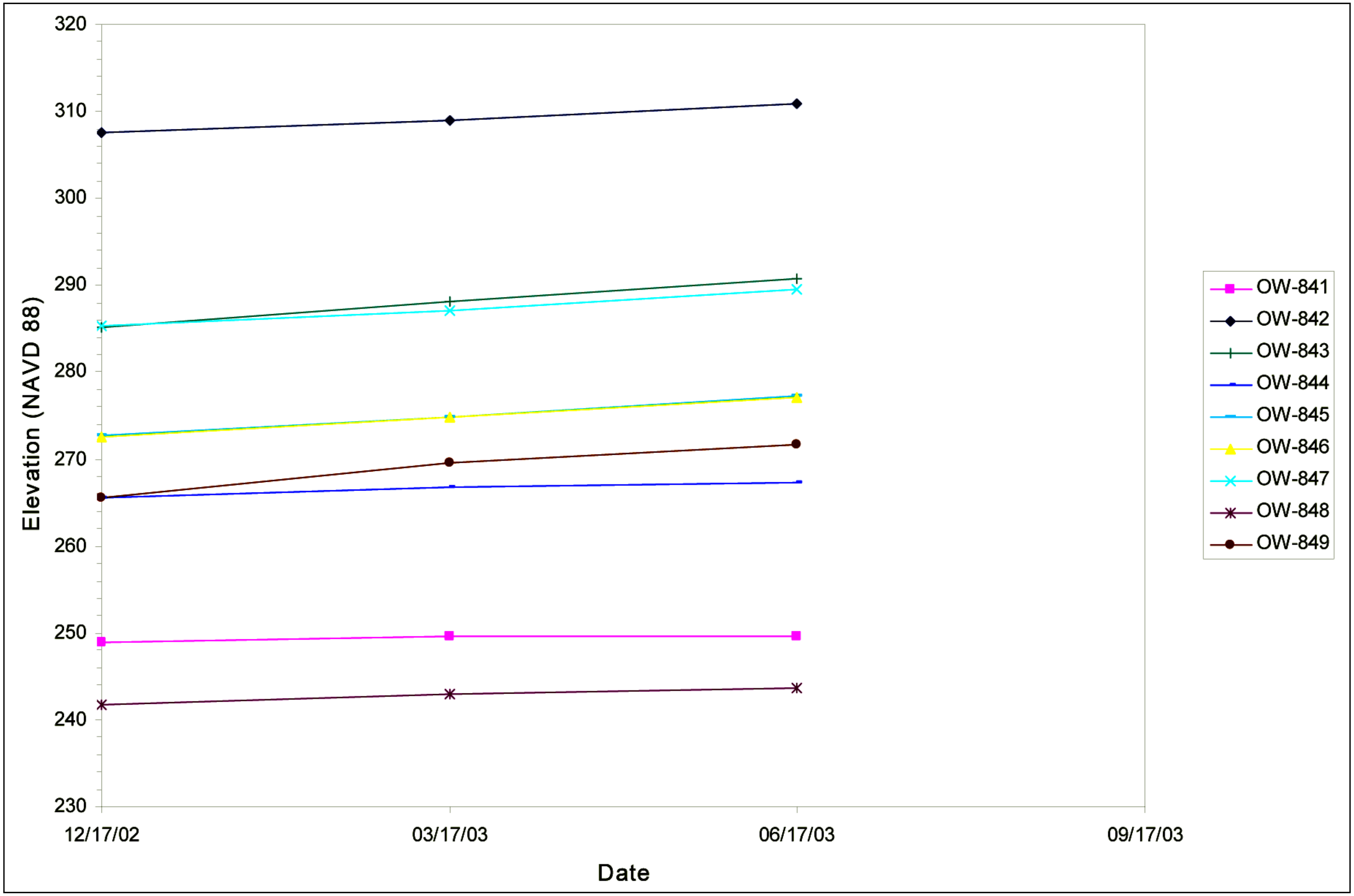

Figure 2.3-7 Ground Water Level Hydrographs

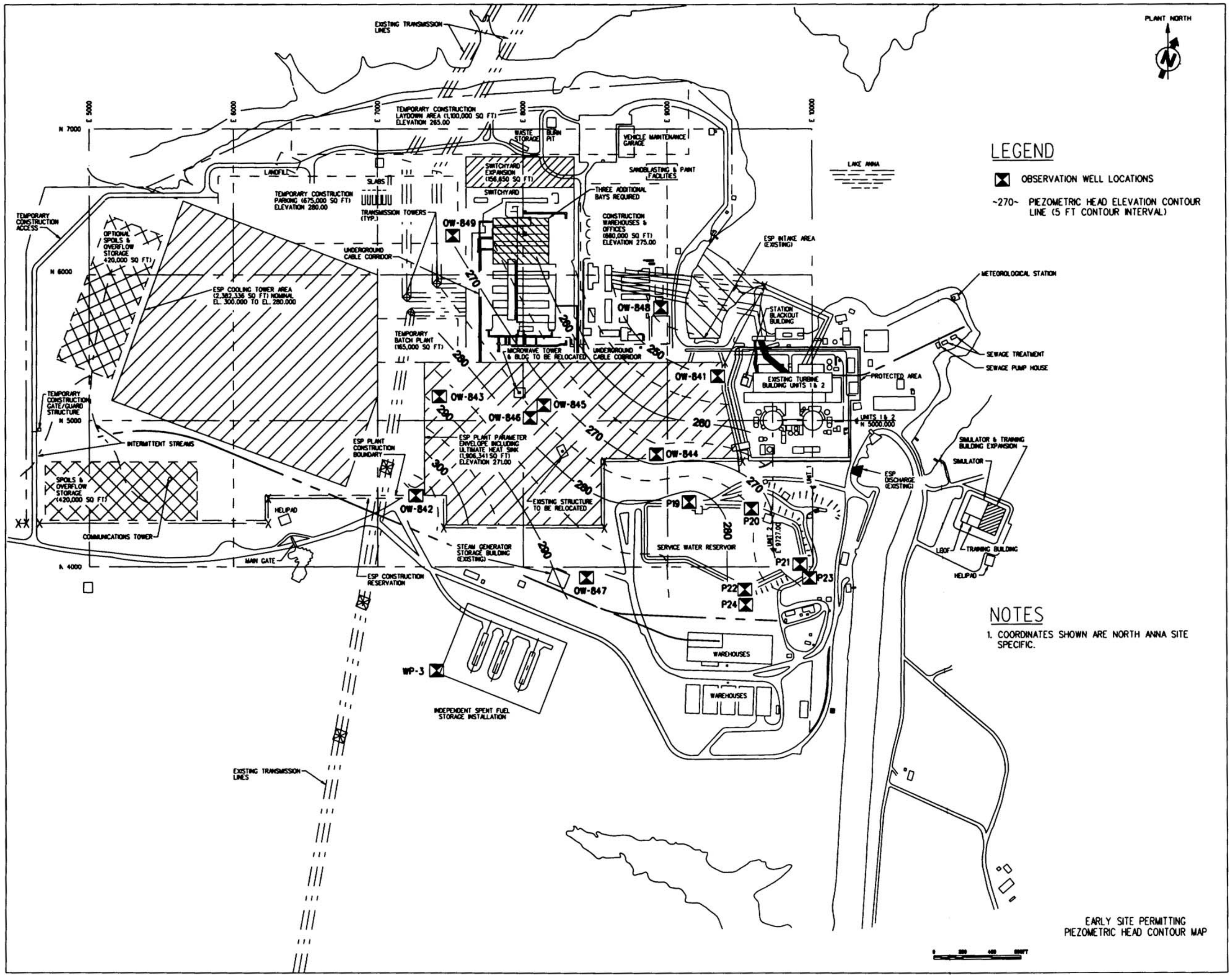

Figure 2.3-8 Piezometric Head Contour Map

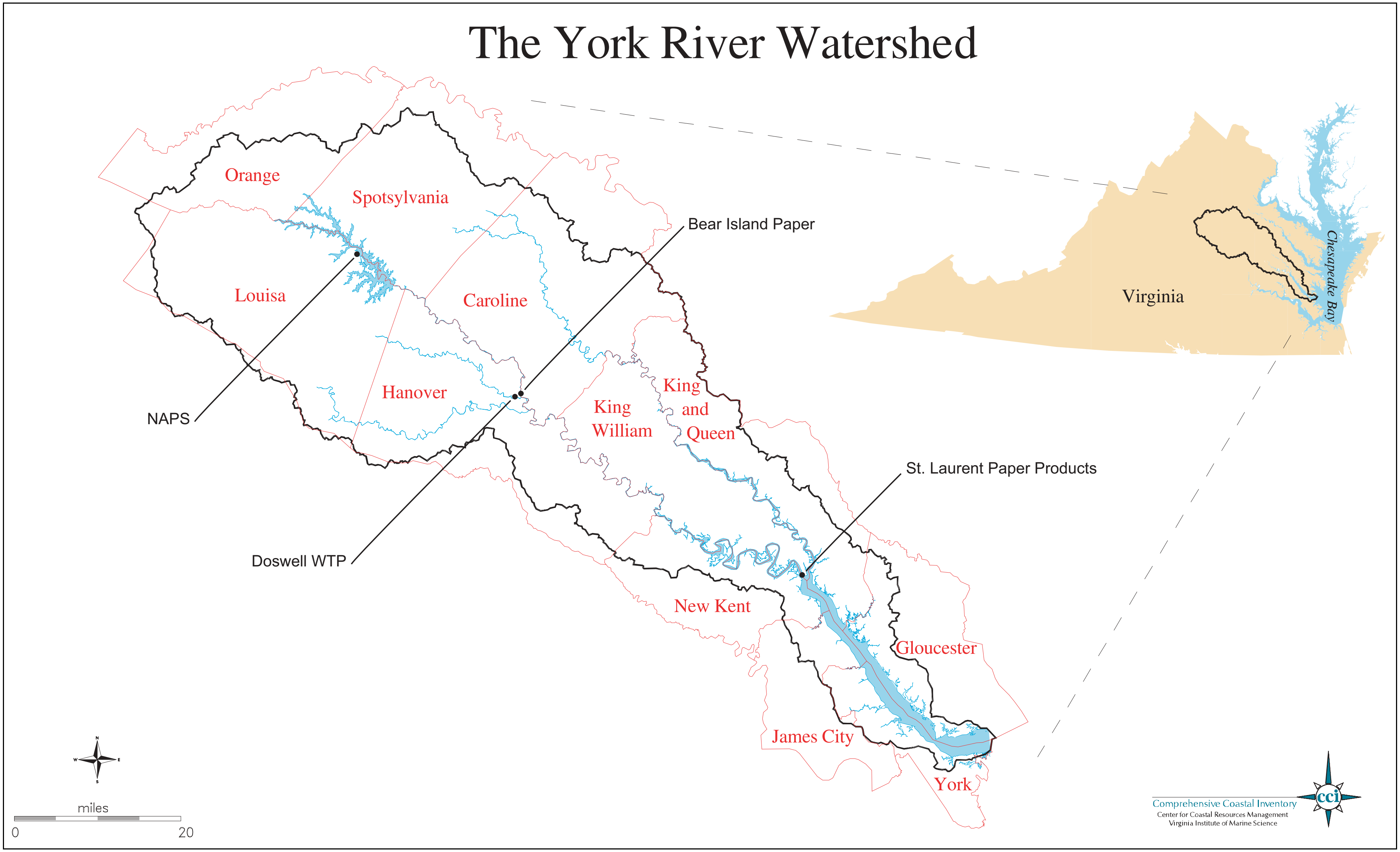

Figure 2.3-9 Surface Water Bodies That Could Affect or Be Affected by Plant Water Use

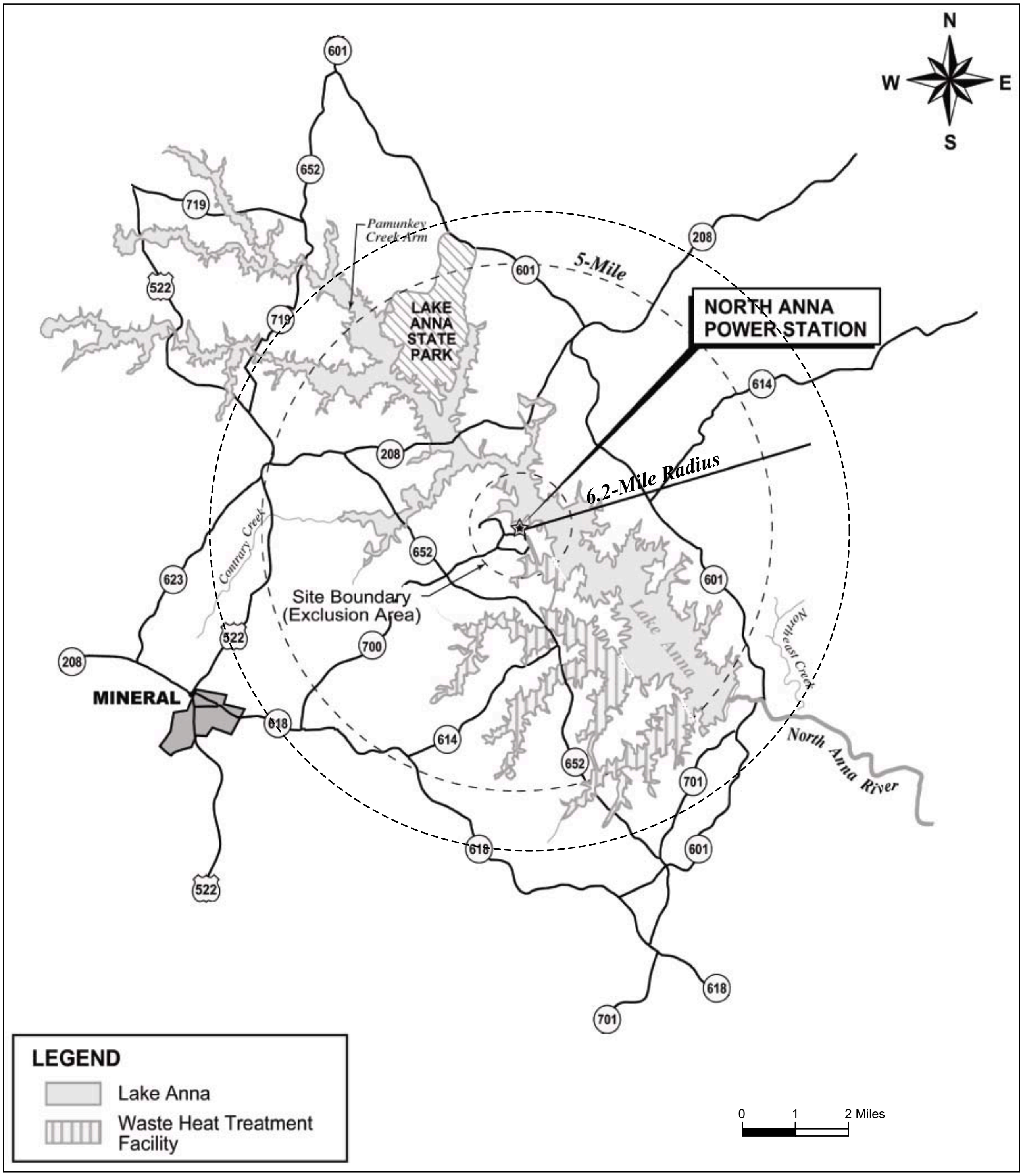

Figure 2.3-10 Surface Water Bodies Within 10 Kilometers (6.2 Miles)

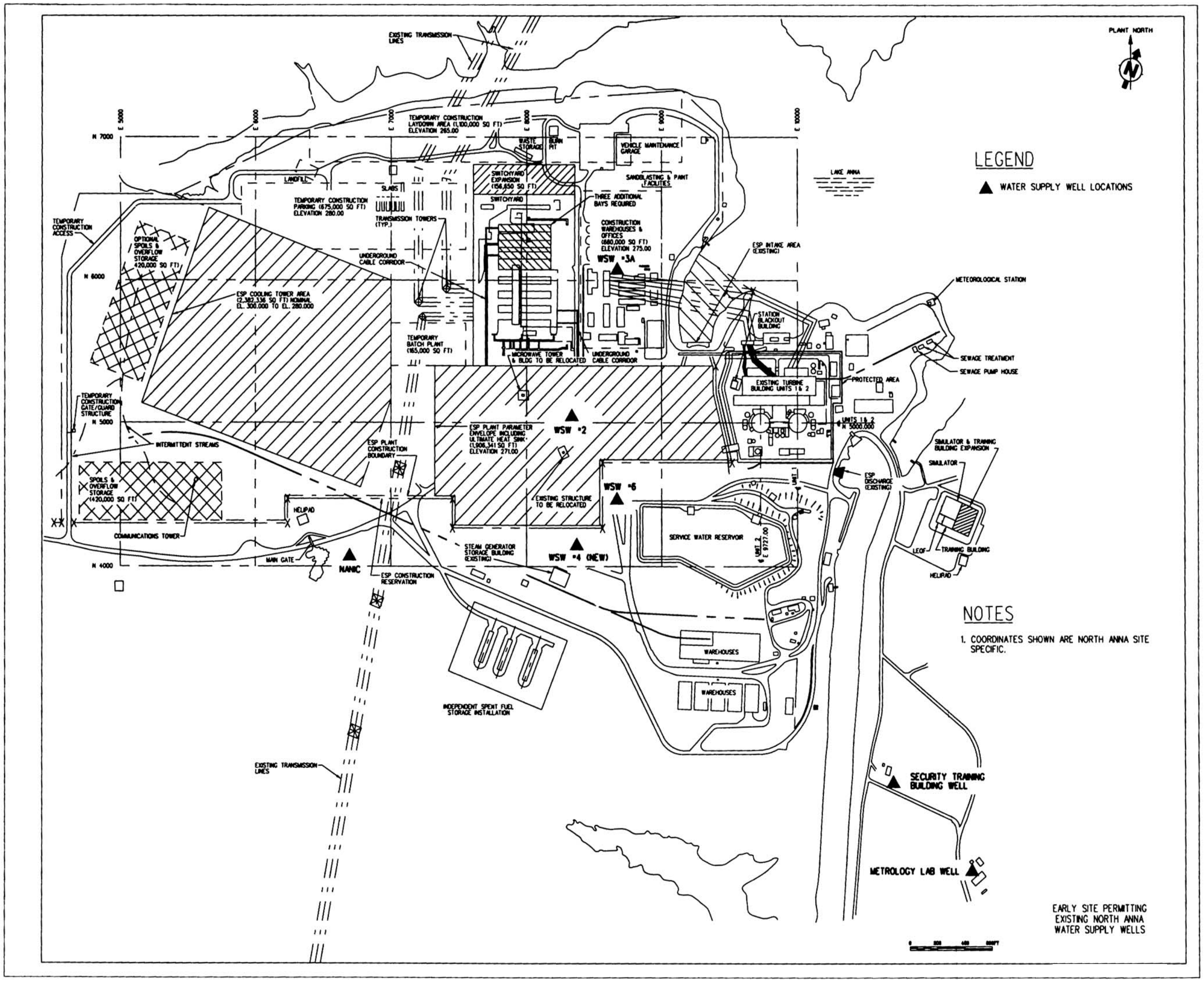

Figure 2.3-11 Existing Water Supply Wells

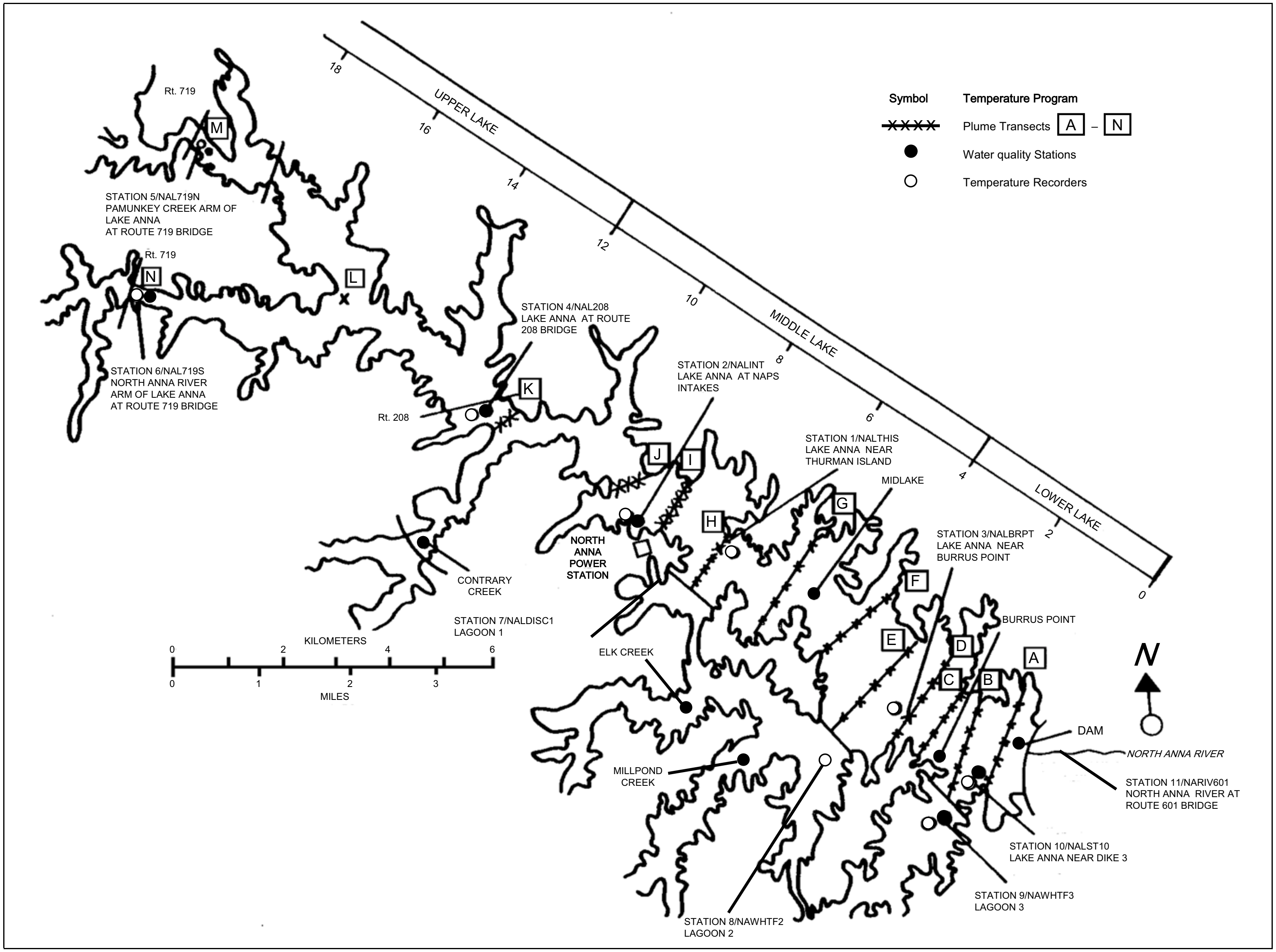

Figure 2.3-12 Temperature and Water Quality Sampling Stations

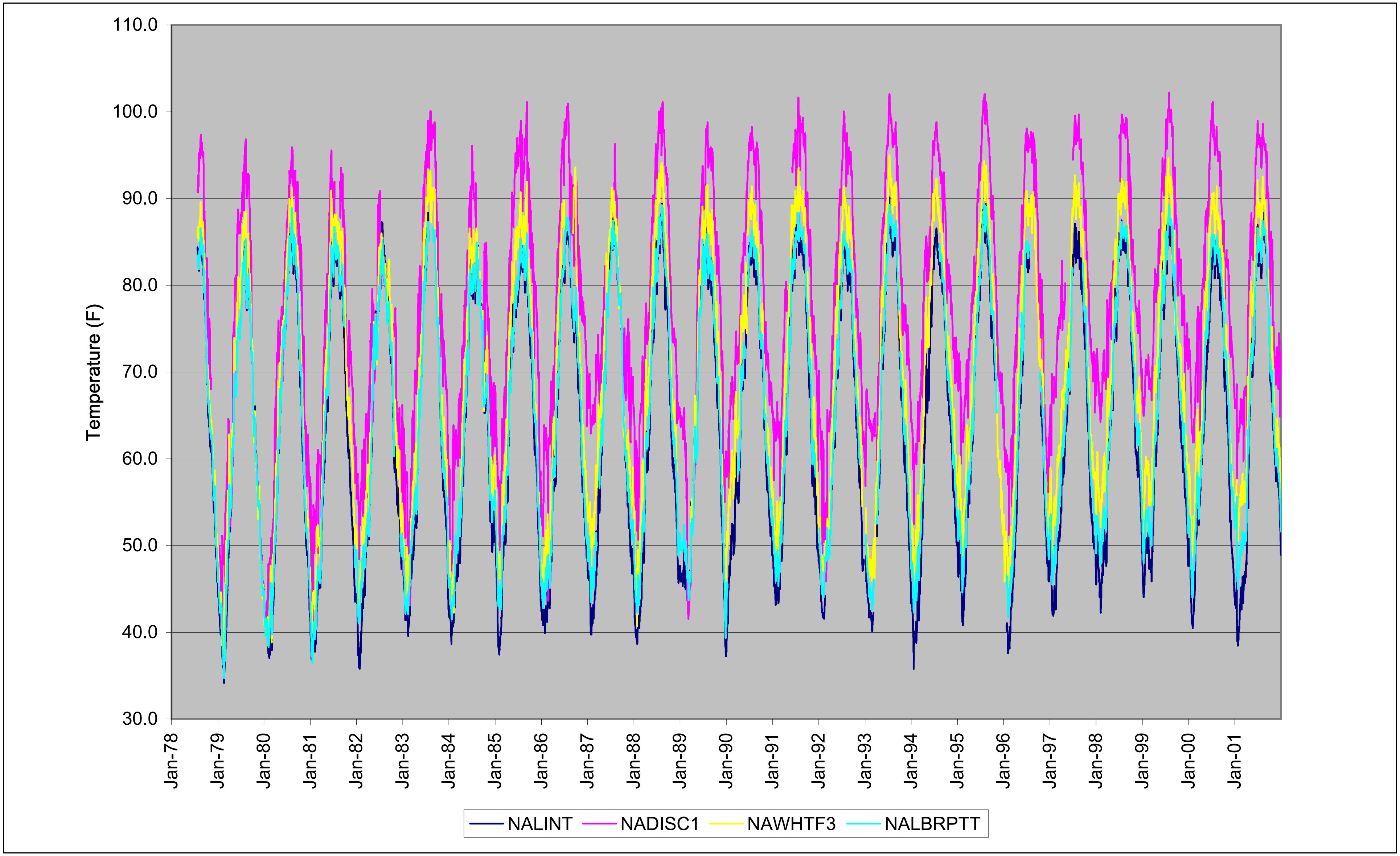

Figure 2.3-13 Temporal Variation in Lake Anna Water Temperature at Selected Locations

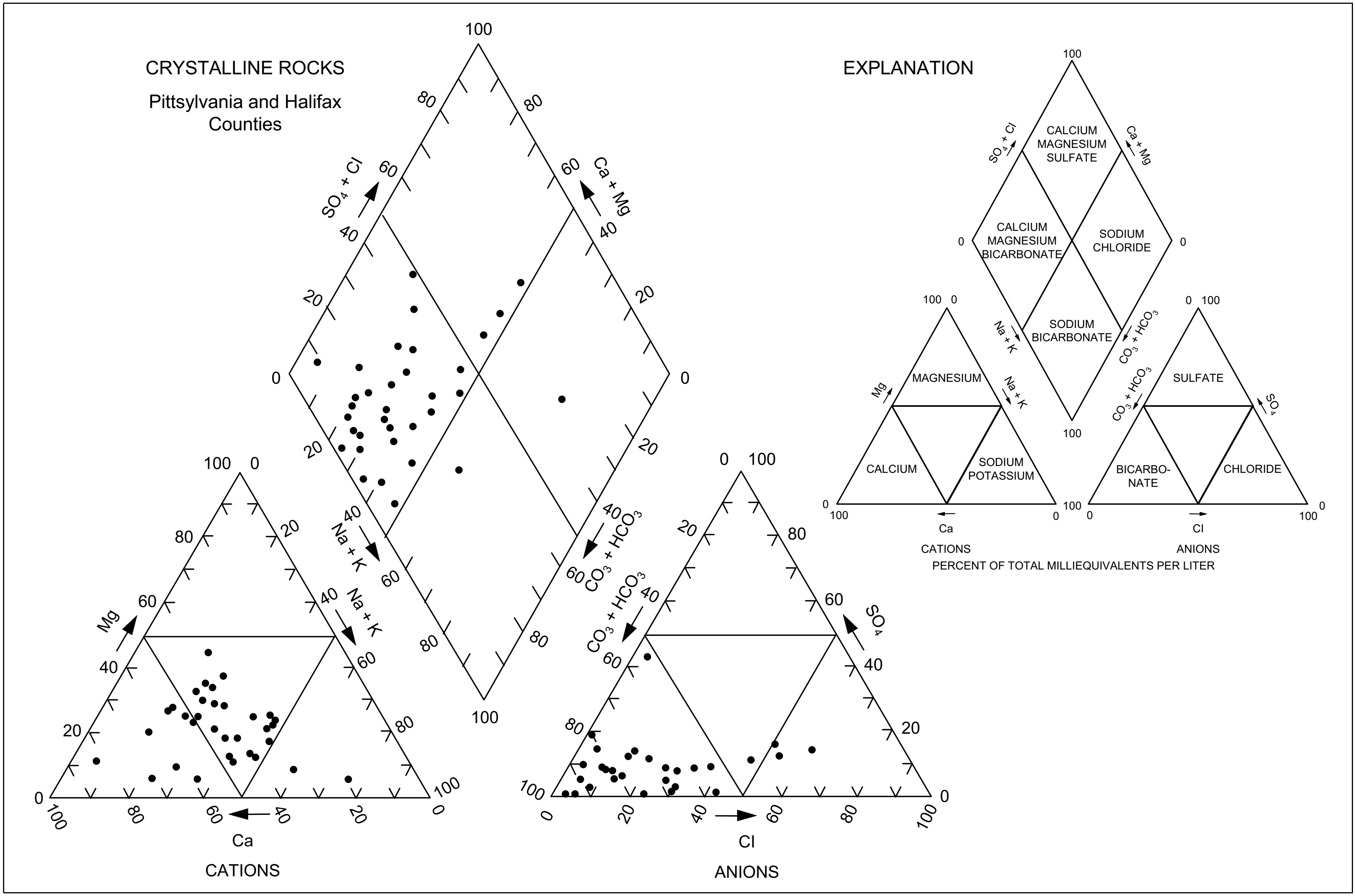

Figure 2.3-14 Water Quality in Crystalline Terrane (Pittsylvania and Halifax Counties, Virginia)

2.4 Ecology

This section describes the terrestrial and aquatic ecological resources that exist within the ESP site, vicinity, and correlating transmission corridors, and potential impacts on those resources from the new units. Ecological resources are those species and habitats that are considered “important” as presented in NUREG-1555, Tables 2.4.1-1 and 2.4.2-1. The description of ecological resources focuses on the terrestrial and aquatic environments that could affect or be affected by the construction or operation of the new units.

2.4.1 **Terrestrial Ecology**

This section describes the terrestrial ecology of the ESP site. Chapter 4 describes the impact of the construction of new units on the terrestrial ecology of the ESP site, and Chapter 5 describes the impact of the new units’ operation on the terrestrial ecology.

The ESP site is located in the Piedmont Physiographic Province. This portion of north-central Virginia, settled in the Colonial era, no longer contains virgin forests. Land use surrounding the ESP site is an irregular patchwork of row crops, pastures, pine plantations, abandoned (old) fields, and second growth forests of hardwoods and mixed pine-hardwoods.

Construction activities would occur within the NAPS site boundary, so no discussion of the terrestrial environment except at the NAPS site is presented here. Current land use at the ESP site is presented in Section 2.2. Approximately 30 percent of the NAPS site consists of generation and maintenance facilities, parking lots, roads, cleared areas, and mowed grass. No other pre-existing NAPS-generated site stresses or stressors to wildlife are known. Hardwood forests exist on the approximately 70 percent of the site that has not been cleared for the construction or operation of the existing units. These wooded areas are remnants of forests that were used for timber production prior to acquisition by Virginia Power and are dominated by a variety of oaks, yellow poplar, sweet gum, and red maple trees. Scattered loblolly pines, Virginia pines, and short-leaf pines exist in some wooded areas. Electric transmission corridors that originate at the existing units pass through forested and agricultural lands typical of north central Virginia.

2.4.1.1 **Terrain**

The Piedmont region of Virginia is characterized by gently rolling hills with scattered moderately steep ridges; although moderately steep ridges are absent from the ESP site. The rolling terrain at the site extends down slope to the waters of Lake Anna, resulting in essentially no marsh habitat along the shoreline. Hydrophytic vegetation, such as cattail and rushes, are typically absent or extend only 1 to 3 feet beyond the shoreline.

2.4.1.2 **Wildlife Species**

Wildlife species found in the forested portions of the NAPS site are those typically found in upland Piedmont forests of north-central Virginia. Frequently observed mammals, such as the white-tailed deer, raccoon, opossum, gray squirrel, and gray fox, exist at the site, as do smaller mammals such as moles, shrews, and a variety of mice and voles. Woodchucks live in the grassy areas near forest edges at the NAPS site, and beavers occur in Lake Anna and its tributaries. Various birds, reptiles, and amphibians (e.g., snakes, lizards, and toads) live in uplands and along the edge of Lake Anna.

2.4.1.3 **Common Bird Species**

Virginia Power has cooperated with the National Audubon Society in conducting periodic "Christmas Bird Counts" during December or January. Common bird species recorded in upland areas on and near the NAPS site during these surveys include the American crow, blue jay, Carolina chickadee, mourning dove, black vulture, turkey vulture, European starling, song sparrow, white-throated sparrow, dark-eyed junco, Northern cardinal, house finch, tufted titmouse, red-bellied woodpecker, downy woodpecker, and Northern flicker (Reference 1).

Birds known to nest within forested areas at the NAPS site, along forested edges, and in open areas (e.g., Northern cardinal, Carolina chickadee, blue jay) commonly nest in upland Virginia habitats. Virginia Power has placed bluebird nest boxes in suitable habitats at the NAPS site and has constructed roofed structures for swallows in some locations. Eastern bluebirds annually utilize the nest boxes, and barn swallows nest beneath the roofed structures.

2.4.1.4 **Wading Birds and Waterfowl**

Several species of residential and migratory wading birds and waterfowl utilize Lake Anna. Virginia Power biologists have documented breeding at Lake Anna by mallards, wood ducks, and Canada geese (Reference 2, Section 4.5). Virginia Power, in association with the Louisa County Chapter of Ducks Unlimited, has placed wood duck nest boxes on Lake Anna and wood ducks have utilized several of these nest boxes (Reference 2, Section 4.5). Belted kingfishers, great blue herons, and green-backed herons are present at Lake Anna throughout the year, and kingfishers and green-backed herons presumably nest on or near Lake Anna's shoreline. Great blue herons typically nest in rookeries, and because there are no known rookeries at Lake Anna (Reference 3), it is unlikely that great blue herons nest on the lake.

Waterfowl are typically most abundant at Lake Anna during the winter. Lake Anna provides important habitat for migratory waterfowl on the Atlantic Flyway, especially during extremely cold winters when the elevated water temperature from station operation maintains a large ice-free body of water. The most common ducks observed during winter are mallard, American black duck, bufflehead, and greater scaup. The Canada goose, American coot, ringed-billed gull, and herring gull are also abundant on Lake Anna during the winter. (Reference 1) (Reference 2, Section 4.5).

2.4.1.5 **Critical Habitat**

No areas designated by the USFWS as critical habitat for endangered species exist at or near the ESP site, or along or adjacent to associated transmission lines. In addition, the transmission corridors do not cross any state or federal parks, wildlife refuges, or wildlife management areas.

2.4.1.6 **Endangered Species**

The USFWS maintains current lists of threatened or endangered species at its website (Reference 4). The VDGIF also maintains lists of state protected species at its website (Reference 3). These lists have been consulted to determine the species that might live at the ESP site. This review identified no protected species other than those previously identified by Virginia Power.

Bald eagles, state and federally classified as threatened, are occasionally observed along Lake Anna. However, there are no known eagle nests at the ESP site (Reference 5). The nearest known bald eagle nest is near the north end of Lake Anna, approximately 10 miles upstream of the existing units. Dominion is not aware of any eagle nests along NAPS-associated transmission lines.

Loggerhead shrikes, classified by the state as threatened, have been observed in the vicinity of NAPS during Christmas bird counts, but breeding loggerhead shrikes have not been recorded at the NAPS site or along the transmission corridors (Reference 3). Loggerhead shrikes inhabit mowed or grazed grassy areas and margins of wooded areas.

With the exception of the bald eagle and loggerhead shrike, terrestrial species that are federally- and/or state-listed as endangered or threatened species are not known to exist at the NAPS site or along the transmission corridors.

2.4.1.7 **Rare Plant Species**

The transmission corridors are managed to prevent woody growth from reaching the transmission lines. The removal of woody species can provide outstanding grassland and bog-like habitat for many rare plant species dependent on open conditions. Virginia Power has cooperated with the VDCR’s Natural Heritage Program in rare plant surveys within transmission corridors. The Natural Heritage Program prepared reports on the results of the rare plant species surveys. Although several rare plant species have been located along other Virginia Power transmission corridors, no endangered or threatened plants were noted along the corridors associated with the NAPS site.

2.4.1.8 **Wetlands**

Two intermittent streams flowing north into an unnamed arm of Lake Anna, just northwest of the power-block area bisect the area where cooling towers would be located. A narrow band of wetlands is associated with each of these streams. Wetlands within and around the ESP site have been delineated and property surveys have been conducted to present to the U.S. Army Corps of Engineers for confirmation, and in preparation of appropriate wetlands permitting. See Figure 2.4-5 and Figure 2.4-6. These permitting actions will include decision-making for implementing approved mitigation options, when necessary. (Reference 44).

2.4.1.9 **Important Species**

No “important species” as defined by NUREG-1555 live on the NAPS site, and with the exception of the wetlands described above, no “important habitats” exist on the NAPS site. Important species are those that are: listed by the state or federal government as threatened or endangered, proposed for listing as threatened or endangered, commercially or recreationally valuable, essential to the maintenance or survival of species that are rare or commercially or recreationally valuable, critical to the structure and function of the local terrestrial ecosystem, or biological indicators. Important habitats are wildlife sanctuaries, refuges, or preserves; habitats identified by state or federal agencies as unique, rare, or of priority for protection; wetlands, floodplains, or other resources specifically protected by federal or state regulations; or land areas identified as “critical habitat” for threatened or endangered species.

2.4.1.10 **Proposed Site**

Section 4.1.1 provides information on the acreage that would comprise the construction site. Much of the proposed laydown area consists of dirt roads, cleared areas, parking lots, buildings, and weedy habitats. The western portion of the current and proposed laydown area can be classified as “old-field” habitat. None of the current or proposed laydown area is forested. The area proposed for temporary offices is an existing office complex; thus, natural habitats are absent from this area. Generally, wildlife species found in the forested portions of the ESP site and support areas are those typically found in the forested portions of the NAPS site and in upland Piedmont forests of north-central Virginia. Wildlife species in the old-field habitat of the laydown area and in the transmission rights-of-way within the ESP site would include most of those found in the adjacent wooded areas.

2.4.2 **Aquatic Ecology**

2.4.2.1 **North Anna Drainage System**

The North Anna River rises in Louisa and Orange Counties, Virginia, and flows east for about 60 miles before joining the South Anna River to form the Pamunkey River Figure 2.4-1. The Pamunkey River flows to the southeast, joining with the Mattaponi River to form the York River, which flows into the Chesapeake Bay north of the Hampton Roads area of Virginia. The entire North Anna River watershed is approximately 600 square miles (Reference 6).

Lake Anna, built to supply cooling water for the power station, was created in 1971 by erecting a dam on the main stem of the North Anna River, just upstream of the confluence of the North Anna River and Northeast Creek (Figure 2.4-2). Lake Anna drains an area of 343 square miles (Reference 2). The dam is approximately 90 feet high and 5,000 feet long and contains

900,000 cubic yards of earth and rock (Reference 6). Lake Anna began filling in January 1972 and reached full pool in December of that year (Reference 6). For discussion purposes, Lake Anna may be divided into two distinct bodies of water, the WHTF and the North Anna Reservoir. The WHTF is the smaller body of water into which existing units' waste heat is discharged via the discharge canal. The North Anna Reservoir is the larger body of water and is physically separated from the WHTF by a series of dikes.

Lake Anna is approximately 17 miles long, with 272 miles of shoreline. It is relatively shallow (maximum depth 90 feet; average depth approximately 25 feet at full pool), with a surface area of 13,000 acres (Reference 6). The normal elevation of the reservoir is 250 ft msl, at which stage it holds 305,000 acre-feet of water (Reference 6). The Commonwealth of Virginia requires a 40-cfs minimum discharge of water from the North Anna Dam, except under extreme drought conditions. These minimum flow requirements have been established to maintain instream flows and water quality in the North Anna River below the dam and in the Pamunkey and York Rivers further downstream (Figure 2.4-1). Should these types of drought conditions occur, and Lake Anna surface water levels fall to 248 ft msl, Virginia Power would begin reducing releases incrementally below the 40 cfs level in accordance with the Lake Level Contingency Plan, as stipulated in Part I.F of the VPDES Permit.

Prior to impoundment, water quality in the North Anna River was degraded by sedimentation and acid mine drainage from Contrary Creek, an 8.5-mile-long tributary that flowed into the river from the west, near the town of Mineral, Virginia (Figure 2.4-2). Land adjacent to Contrary Creek had been the site of extensive iron pyrite mining operations during the late 19th and early 20th centuries (Reference 2). When the mine was abandoned (circa 1920), mine shafts and tailings piles were left exposed to the weather. Runoff from the mine area was acidic, with high concentrations of metals. Virtually no aquatic life was found in Contrary Creek downstream of the mine site (Reference 6). Prior to impoundment, the density and diversity of fish and benthic macroinvertebrates were markedly reduced in the North Anna River immediately downstream of its confluence with Contrary Creek. Subtle changes were evident as far as 15 miles downstream, although water quality was generally satisfactory (Reference 2).

In 1976, the Virginia State Water Control Board, in association with the EPA, attempted to reclaim previously-mined and disturbed areas along Contrary Creek to reduce the impacts of sedimentation and acid mine drainage (Reference 2). The reclamation project reduced, to some extent, erosion and sedimentation in the area.

The creation of Lake Anna has mitigated most water quality impacts from Contrary Creek area runoff. Low-pH creek water is neutralized as it mixes with higher-pH reservoir water. Heavy metals are removed from the water column by adsorption to clay particles and the subsequent settling of these particles. Chemical precipitation (and co-precipitation with iron) may also remove zinc and copper ions from Contrary Creek water when it mixes with Lake Anna water.

A comprehensive study of Lake Anna's water quality and aquatic communities was conducted in support of a CWA Section 316(a) Demonstration for NAPS (Reference 2). This evaluation was based on five years (1973-1977) of pre-operational studies and eight years (1978-1985) of operational studies. Water quality, water temperature, and biological monitoring were conducted in upper, middle, and lower portions of the North Anna Reservoir, and in the North Anna River below the reservoir.

Water quality in Lake Anna has historically been good to excellent. Turbidity levels are generally low, except during periods of heavy inflows from tributary streams.

Nutrient levels (nitrates and phosphates) from flooded farmland were elevated in the years following impoundment of the river and its valley, but stabilized in the 1980s at low levels sufficient to support a thriving community of benthic macroinvertebrates, plankton, and fish. As noted previously, there have been no indications of nutrient enrichment or eutrophication in Lake Anna, beyond those associated with normal reservoir aging. Lake Anna and the North Anna River are not among the water bodies designated by the Virginia State Water Control Board as "nutrient-enriched waters." (Reference 7)

Recently, the Virginia DEQ has listed several of the upper-lake tributaries in its 303(d) list of impaired waters because of seasonal exceedances of fecal coliform. Also portions of the North Anna Reservoir itself have been added because of high values of PCBs in certain fish tissue analyses.

Since its creation, the North Anna Reservoir has developed into three ecological areas that were identified in the CWA 316(a) Demonstration as upper lake, mid- lake, and lower lake (Reference 2). The physical characteristics are different among the areas. The upper lake is primarily riverine and shallow (average depth of 13 feet), and shows some evidence of stratification in summer. The mid-lake is deeper and stratifies in summer. It receives waters from Contrary Creek that, because of years of mining in its floodplain, are sometimes low in pH and high in metals. The lower lake is the deepest part of the reservoir, with an average depth of 36 feet. It is clearer (with more light penetration), and shows pronounced annual patterns of winter mixing and summer stratification. The epilimnion (warm layer above the thermocline) was generally 8 feet deep during pre-operational years and 26 to 33 feet deep during operational years. The increase in depth of the epilimnion appears to be related to the heated discharge entering the reservoir from Dike 3 (see Figure 2.4-3) and the withdrawal of cooler, deeper water at the existing units intake (Reference 2). The heated discharge, attendant mixing, and withdrawal of water at the intake have also increased the depth of oxygenation, with the layer of water holding at least 5 milligrams per liter of dissolved oxygen increasing from 16 feet (pre-operational) to 29 feet (operational).

The existing units use a once-through cooling system that withdraws water from mid-Lake and discharges it into a discharge canal. The canal is approximately 3600 feet long and discharges into the WHTF, which was formed by diking off a portion of Lake Anna. The cooling water residence time in the WHTF is approximately 14 days, depending on condenser flow rate. More than half the existing units' waste heat is dissipated in the WHTF. The only discharge from the WHTF into the North Anna Reservoir is through Dike 3, which abuts the lower lake near the dam. The discharge is a submerged, high-velocity jet that promotes rapid mixing with reservoir waters.

Temperature monitoring at Lake Anna indicates that the shallower upper lake warms earlier in spring and reaches maximum temperature in summer sooner than the lower lake. The lower lake, with its greater depth and volume, warms more slowly in spring and retains its heat later in the year. It is estimated that the heat contributed by the existing units corresponds to about 10 percent of the solar heat entering the reservoir on summer days. (Reference 2)

From 1975 through 1985, Virginia Power monitored water temperatures at 10 (7 in North Anna Reservoir and 3 in WHTF) Lake Anna locations, as part of a CWA Section 316(a) Demonstration for NAPS (Reference 2, Section 3.5, Table 3.5-2). Temperatures were recorded hourly at most of these locations. Highest (hourly average) temperatures recorded in June, July, and August over this period were 91.8°F at an upper lake location in 1984, 92.7°F at an upper lake location in 1977, and 91.6°F at a lower lake location in 1980, respectively. The highest (hourly average) water temperature before the existing units began operating (92.7°F) was measured on July 19, 1977, at the northern-most location (Pamunkey Creek arm). The highest (hourly average) water temperature measured in an operational year was 92.3°F, recorded in July 1983. (Reference 2)

In recent years, Virginia Power has continued to monitor Lake Anna water temperatures, using fixed temperature recorders at 7 locations in North Anna Reservoir and 3 locations in the WHTF (Figure 2.4-4). This temperature monitoring is part of a larger post-316(a) Demonstration environmental monitoring effort that includes fish population studies. To allow for direct comparisons with historical data, temperatures in Lake Anna are reported as monthly means of daily high, mean, and low temperatures. The range of temperatures and between-location temperature trends recorded over a recent six-year period (1995–2000) have shown strong similarities to historical data (Reference 8) (Reference 9) (Reference 10) (Reference 11) (Reference 12) (Reference 13). These temperature data do not indicate an overall long-term warming trend in North Anna Reservoir. Further, differences in temperature throughout the reservoir continue to be small, regardless of time of year or power station operating levels. Virginia Power submits annual reports to VDEQ and VDGIF on water temperatures and fisheries monitoring in Lake Anna and the lower North Anna River.

2.4.2.2 **Biological Communities of Lake Anna**

The Environmental Impact Statement for NAPS License Renewal (Reference 5) summarizes studies of phytoplankton, zooplankton, and benthic organisms conducted by Virginia Power over the 1973-1985 period. These studies are not reviewed here. The plankton and benthos communities that developed over the first several years of the existing units' operation were typical of those seen in other Piedmont reservoirs.

The long narrow arm of Lake Anna just northwest of the power-block area is associated with two small intermittent streams that could be affected by the new units. Following heavy rainfall, these streams flow in a northerly direction into Lake Anna. Due to their intermittent nature, neither stream supports significant numbers or diversity of fish.

Because of the importance of recreational fishing in Lake Anna, its fish community has been the subject of wide-ranging studies. Abundance and distribution of fish were evaluated over a period from 1975-1985, using a variety of sampling methods to ensure that gear selectivity did not bias results. Larval fish studies, creel surveys, and a number of special studies focused on the reproduction and growth of important species, such as largemouth bass (*Micropterus salmoides*). Seasonal movement and habitat preferences of striped bass (*Morone saxatilis*) were investigated, using ultrasonic tags.

From 1975 through 1985, 39 species of fish (representing 12 families) were found in Lake Anna Reference 2. Species included those historically found in the North Anna River, those that had been in local farm ponds inundated by the new reservoir, and nine species (four non-native) introduced by the VDGIF.

The community structure remained relatively stable over the 1975–1985 period, with some year-to-year variation in species composition. These variations were caused by 1) normal population fluctuations, 2) reservoir aging, 3) the introduction of forage species and competing predators, 4) the installation of fish attractors and artificial habitat, and 5) the increase in *Corbicula fluminia* (Asiatic clam) densities. Post-1975 changes included 1) a decline in relative abundance of yellow perch (*Perca flavescens*) and black crappie (*Pomoxis nigromaculatus*), 2) an increase in the relative abundance of white perch (*Morone americana*) and threadfin shad (*Dorosoma petenense*), and 3) an increase in redear sunfish (*Lepomis microlophus*) abundance, with a corresponding decrease in pumpkinseed (*Lepomis gibbosus*). None of these changes appeared to be related to existing units operation.

From 1975 to 1984, the mean standing crop ranged between 232 and 296 pounds of fish per acre, but it increased substantially in 1985 (to 417 pounds per acre) because of a large increase in introduced threadfin shad and an increase in the abundance of gizzard shad (*Dorosoma cepedianum*). Both species provide forage for Lake Anna’s game fish, which include largemouth bass, walleye (*Stizostedion vitreum*), and striped bass. Lake Anna appears to support a standing crop of fish higher than most U.S. reservoirs, with thriving populations of several forage species and highertrophiclevel (gamefish) species.

Standing stocks of largemouth bass, Lake Anna’s most popular sport fish, remained stable over the 1975–1985 period. In 1985, Lake Anna produced more largemouth bass of “citation” size (eight pounds or more) than any other lake or reservoir in Virginia. Life history studies of Lake Anna largemouth bass, summarized in the 316(a) Demonstration (Reference 2), suggest that the reproductive success, feeding ecology, and growth of this species were similar in pre-operational and operational years.

Four non-native fish species (striped bass, walleye, threadfin shad, and blueback herring (*Alosa aestivalis*) have been stocked in the North Anna Reservoir by the VDGIF since 1972. Striped bass, introduced in 1973, have been stocked annually since 1975. They provide a “put-grow-and-take” fishery. Streams, including the North Anna River, that flow into the North Anna Reservoir lack the flow, depth, and length to support striped bass spawning runs. Studies show that striped bass grow and provide a substantial recreational fishery, but adults are subject to late-summer habitat restrictions (may be restricted to cooler-water refuge areas). As a consequence, they may lose weight and show a decline in condition. Walleyes are also stocked annually by the VDGIF and are highly sought-after game fish.

Threadfin shad, introduced in 1983 to provide additional forage for striped bass and other top-of-the-food-chain predators, are vulnerable to cold shock and winter kills, and would not be able to survive in Lake Anna if it were not for power station operation. Threadfin shad appear to be thriving and are an important source of food for game fish. Blueback herring, stocked by the VDGIF in 1980 as a forage species, have not been as successful.

In 1994, a fifth non-native species, the herbivorous grass carp (*Ctenopharyngodon idella*), was stocked by Virginia Power (with the approval of the VDGIF) in the WHTF to control the growth of the nuisance submersed aquatic plant hydrilla (*Hydrilla verticillata*).

In addition to the previously described stocking programs, which are designed to expand fishing opportunities in the North Anna Reservoir, Virginia Power, in cooperation with VDGIF, placed 20 underwater fish structures in the reservoir over the 1983–1990 period to provide additional fish habitat in areas with “clean” bottoms (Reference 14). The structures, consisting of conically-shaped piles of cinder blocks, small trees, and brush (secured to the blocks) were designed to provide escape cover for young fish and spawning and feeding areas for larger fish. Although designed to provide habitat for largemouth bass, black crappie, and bluegill (*Lepomis macrochirus*) in particular, these fish structures benefit a variety of other species.

As noted previously in this section, Virginia Power has continued to monitor fish populations in Lake Anna since 1986, as part of a larger post-316(a) Demonstration environmental monitoring program. Fisheries monitoring over a recent six-year period (1995–2000) reveals a balanced reservoir fish community comprised of healthy populations of top-of-the-food-chain predators (e.g., largemouth bass and striped bass) and the forage species on which they feed (e.g., threadfin shad and gizzard shad), panfish (e.g., bluegill, redear sunfish, redbreast), and catfish (channel catfish and white catfish), in particular.

Lake Anna is well known as a producer of trophy largemouth bass and large numbers of striped bass. In 2000, Lake Anna ranked third in the Commonwealth of Virginia in producing trophy certificate (“citation”) largemouth bass (Reference 13), with 72 fish meeting the standard (at least 22 inches in length or 8 pounds in weight).

2.4.2.2.1 Commercially-Important Fisheries

There is no commercial fishing on Lake Anna or the North Anna River. There are professional fishing guides who regularly take clients fishing for largemouth, striped bass and walleye on the North Anna Reservoir, but there are no commercial fishing operations in the sense that fish are netted or trapped and sold at market. Professional fishing guides must adhere to state fishing regulations, and are prohibited by law from selling their catch.

2.4.2.2.2 Recreationally Important Fisheries

Lake Anna is a popular destination for anglers from central and northern Virginia. Its healthy fish populations and its proximity to the cities of Washington, D.C., Richmond, and Charlottesville mean that the reservoir is heavily fished, particularly in spring and fall. In summer, an influx of recreational boaters, water-skiers, and jet skiers discourages some fishermen. The heated effluent that flows into the North Anna Reservoir at Dike 3 creates conditions conducive to good fishing in winter, making the reservoir a popular fishing spot when cold weather slows or shuts down fishing at other ponds and lakes in the region.

The VDGIF estimated that 42,731 anglers fished Lake Anna for 232,439 hours over a 12-month period in 2000 and 2001. The species most often sought were largemouth bass, striped bass, and crappie, with 69 percent, 15 percent, and 12 percent of anglers, respectively, pursuing these species (Reference 15). Black crappie, not largemouth bass, was the species most often harvested. Depending on the time of year, species such as bluegill, white perch, channel catfish, and walleye are also sought by Lake Anna fishermen.

2.4.2.2.3 Important North Anna Reservoir Species

The VDGIF manages the fisheries of the North Anna Reservoir “…with particular emphasis on providing quality largemouth and striped bass fisheries within the capacity of available habitat” (Reference 16). As a consequence, the VDGIF district biologists who conduct monitoring studies and research on the fishes of the North Anna Reservoir focus on these two species, both highly esteemed by local anglers. Other species, such as black crappie and channel catfish, are monitored by VDGIF but are not as actively managed.

a. **Largemouth bass**

   Electro-fishing catch rates for largemouth bass greater than 8 inches long in the North Anna Reservoir have been high in recent years (Reference 16) (Reference 17) (Reference 18). Young-of-the-year catch rates, although lower, have been indicative of consistent recruitment. Structural indices of the largemouth bass population indicate a population dominated by larger, older individuals. Growth of younger (1-to-4 year old) largemouth bass is excellent; however, growth of older bass (5 years and older) is below the district average (Reference 16).

On average (all age classes considered), largemouth bass in the North Anna Reservoir grow more rapidly than largemouth bass in other large Virginia impoundments (Reference 18).

In summary, largemouth bass tend to grow rapidly in their first four years of life, “plateau” at age 5, and grow relatively slowly thereafter. The population contains a high proportion of harvestable individuals, and provides excellent opportunities for anglers seeking larger, trophy-sized fish.

b. **Striped bass**

Annual stockings of fry and fingerlings sustain the North Anna Reservoir’s striped bass population. Normally, between 100,000 and 200,000 fingerlings are stocked annually, which equates to between 10 and 20 fish per acre (Reference 16). VDGIF is experimenting with lower (5 fish/acre) stocking rates to determine if recruitment is significantly affected.

Striped bass growth patterns in the North Anna Reservoir vary from year to year, with some of the variability apparently related to the size of fish stocked (dependent on size of fish supplied by hatcheries). Generally speaking, young striped bass grow rapidly, and reach harvestable size (20 inches) in about 30 months (Reference 16). Estimates of annual mortality range from 35 to 50 percent, depending on the cohort evaluated, with the lower percentage likely more accurate (Reference 16) (Reference 17) (Reference 18). Excellent year classes in 1997, 1998, and 1999 should provide outstanding fishing in 2003 and beyond. All three year classes should be of harvestable size by 2003.

Since the early 1990s, VDGIF has been evaluating late-summer striped bass habitat in the North Anna Reservoir, taking temperature and dissolved oxygen profiles at representative locations in the reservoir. In July-August 2000, temperature and dissolved oxygen profiles revealed that portions of the North Anna Reservoir, in the area between NAPS and the Lake Anna Dam, did not provide acceptable striped bass habitat (water temperature less than 26°C and dissolved oxygen concentration greater than 2.0 milligrams per liter) (Reference 17). However, the striped bass habitat uplake of the existing units was acceptable, and striped bass were presumed to have moved to these uplake areas seeking cooler, oxygenated water. This late-summer dispersal of striped bass has been observed in other southeastern reservoirs (Reference 19). No late-summer die-offs of striped bass have been observed in the North Anna Reservoir although they have occurred in reservoirs in North Carolina, South Carolina, Tennessee, and Alabama (Reference 20) (Reference 21).

c. **Black Crappie**

Based on experimental gill net catches, black crappie abundance in North Anna Reservoir was very high in 1997 and 1998, but has declined in recent years (Reference 16) (Reference 17) (Reference 18). Growth of black crappie is good, and agrees with other impoundments in the region. There is considerable year-to-year variability in population size structure (i.e., average size of fish captured), but it is unclear if this is an indication of changes in age composition or changes in growth rates. The catch-per-unit-effort of “quality” black crappie declined by 50 percent between 1997 and 1998, an indication that (fishing) mortality is high. Most crappie (92 percent) caught in gill nets were caught in the “upper lake” (Reference 16).

d. **Catfish**

Channel catfish ranked fifth in abundance in gill nets in 1997 and fourth in abundance in 1998 (Reference 16). Much higher numbers of channel catfish and white catfish were captured in gill nets in 1998 than in 1997, but this phenomenon was attributed to low reservoir levels (related to drought) rather than an actual increase in numbers of catfish. VDGIF reports provide no information on age and growth, condition, or age/size structure of catfish populations.

e. **Shad**

Because threadfin shad abundance is cyclic, gizzard shad serve in most years as North Anna Reservoir’s forage base (Reference 16). Gizzard shad are regarded by fisheries managers as a less-than-ideal forage species, because their rapid growth makes them unavailable to predators in a year or two. Threadfin shad, while the ideal size, are subject to mass die-offs from low temperatures or sudden temperature changes. In 1997 and 1998, gizzard shad numbered second and first, respectively, in North Anna Reservoir gill net catches. Threadfin shad were seventh in 1997 and eighth in 1998. Most shad (71 percent in 1997 and 76 percent in 1998) were caught in the upper reservoir (Reference 16).

2.4.2.2.4 Nuisance Species

Virginia Power first collected the non-native Asiatic clam in benthos samples in 1979. Densities increased sharply thereafter, as this species with its high reproductive potential quickly occupied suitable habitat in the reservoir (Reference 2). In response to NRC Generic Letter 89-13, Virginia Power initiated a semi-annual sampling program in the fall of 1990 to monitor Asiatic clam in the North Anna Reservoir, the WHTF, and the emergency SWR. Virginia Power biologists collect replicate samples at two North Anna Reservoir locations (i.e., at the intake and a location in mid lake), two WHTF locations, and a single location in the existing units’ SWR. They report the total number and density of clams at the various locations and discuss population trends in semi-annual reports.

These monitoring studies indicate that total numbers and densities of Asiatic clam at the various locations in the North Anna Reservoir and the WHTF show sizable fluctuations between years, mostly as a result of spawning activity (Reference 22) (Reference 23) (Reference 24) (Reference 25) (Reference 26) (Reference 27) (Reference 28) (Reference 29) (Reference 30). Small “sand-sized” clams less than 2 millimeters long are sometimes locally abundant immediately after spawning takes place, and inflate numbers and densities at a particular sampling location.

Asiatic clam numbers in the WHTF near the existing units discharge show the most dramatic fluctuations. For example, densities of clams at this location declined from 1,619 clams per square meter in Spring 1992 to 11 clams per square meter in fall 1992 (Reference 31) (Reference 32). Clams in this area are subject to “boom and bust” cycles, because under extreme conditions (high plant operating levels, high ambient temperatures, drought), water temperatures can get high enough to cause localized die-offs.

Larger (i.e., greater than 15 millimeters in length), older (i.e., 1 to 3 years old) Asiatic clams are uncommon in North Anna Reservoir samples, generally comprising less than 10 percent of the total collected (Reference 17) (Reference 23) (Reference 24) (Reference 25) (Reference 26) (Reference 27) (Reference 28) (Reference 29) (Reference 30). Larger Asiatic clams are generally uncommon in WHTF samples as well, but sometimes make up a significant percentage (i.e., greater than 50 percent) of the total at WHTF-3 when sample sizes are small (Reference 24) (Reference 25) (Reference 26) (Reference 29).

Although Asiatic clam shells have been observed in the SWR, Virginia Power biologists have collected no live clams at this location. The SWR is treated with algicides and molluscicides, preventing Asiatic clam from becoming established in this small reservoir.

When Virginia Power compared 1990-2002 Asiatic clam survey results to similar surveys conducted in the 1980s, data indicated a decline in the North Anna Reservoir population. The highest totals recorded in the spring in the 1980s were in 1988 and 1985, when 294 and 194 clams, respectively, were collected in replicate samples from a mid lake location. The highest totals recorded in the fall were in 1987 and 1986, when 1,227 and 237 clams were collected in replicate samples from a mid lake location. The highest number of clams collected over the 1990-2002 period from the mid lake location was 148, in Spring 1994 sampling. Operational experience at the existing units provides further evidence of a stable or declining North Anna Reservoir Asiatic clam population: no condenser tube blockages have been reported since Asiatic clam appeared in the North Anna Reservoir in the late 1970s.

In the course of monitoring Asiatic clam populations, Virginia Power also looks for evidence that the zebra mussel (*Dreissena polymorpha*) has invaded Lake Anna. Biologists conducting clam surveys examine all bottom samples for the presence of this nuisance species, which became established in the Great Lakes region in the late 1980s after being inadvertently introduced from Northern Europe. Zebra mussels have clogged pipes in power plants and municipal water systems and disrupted the ecological balance of streams, lakes, and reservoirs into which they have been introduced.

As of the end of 2002, Virginia Power biologists had observed no zebra mussels in the North Anna Reservoir or the WHTF. Dissolved calcium levels in North Anna Reservoir and the WHTF are well below those known to promote shell growth in zebra mussels, which should limit its establishment in those waterbodies (Reference 30). Zebra mussels are known from only one location in the state of Virginia: Millbrook Quarry, in Prince William County, Virginia, approximately 60 miles north of the site. This population, believed to have been unintentionally introduced by SCUBA divers, was discovered in August 2002 by a recreational diver who subsequently notified the VDGIF (Reference 33) (Reference 34).

2.4.2.2.5 Threatened and Endangered Aquatic Species

Virginia Power has monitored fish populations in Lake Anna and the North Anna River for more than 25 years. No federally- or state-listed fish species has been collected in any of these monitoring studies, nor has any listed species been observed in creel surveys or occasional special studies conducted by Virginia Power biologists. No state- or federally-listed fish species' range includes Lake Anna or the North Anna River, and none is believed to occur in counties adjacent to Lake Anna or the North Anna River (i.e., Caroline, Hanover, Louisa, Orange, and Spotsylvania Counties).

Based on VDGIF and VDCR (Division of Natural Heritage) databases, one federally-listed mussel species, one state-listed mussel species, and one mussel species that is a candidate for federal listing occur in counties that border Lake Anna or the North Anna River. None of the three has been found in Lake Anna or the North Anna River.

The dwarf wedgemussel (*Alasmidonta heterodon*) was historically found in Hanover, Louisa, and Spotsylvania Counties (Reference 35). It is listed as endangered by both the Commonwealth of Virginia and the USFWS. The USFWS Recovery Plan for the species, completed in 1993, indicated that one population survived in these counties, in the South Anna River, in Louisa County (Reference 36). The VDGIF Fish and Wildlife Information Service database currently lists a "remnant" population in the South Anna River in Louisa County, presumably the same population (Reference 37).

The VDCR database lists another mussel species, the slippershell mussel (*Alasmidonta viridis*), as occurring in Orange County. The slippershell mussel is listed by the Commonwealth of Virginia as endangered, but it has no federal status. Given the known distribution of this species, Virginia Power believes the reported occurrence of the slippershell mussel in Orange County may be in error. The slippershell mussel is widely distributed in the Upper Mississippi River basin and the Ohio River and Tennessee River sub-basins, including three streams in southwestern Virginia, but is not found in Atlantic Slope drainages (Reference 38) (Reference 39) (Reference 40).

A third mussel species reported as occurring in the vicinity of the NAPS site, the fluted kidneyshell mussel (*Ptychobranchus subtentum*), is a candidate for federal listing. The VDGIF's Fish and Wildlife Information Service database lists this species as occurring in a stream or streams in Louisa County. However, based on the fact that all other confirmed accounts of this species are confined to mountain streams in southwestern Virginia that are tributaries of the Tennessee River, it is unlikely that a disjunct population would occur several hundred miles away in a river system that flows eastward to the Atlantic Ocean. Virginia Power believes the reported occurrence of the fluted kidneyshell mussel in Louisa County may be in error.

None of these mussel species were collected in pre-impoundment surveys of the North Anna River, and none have been collected in more recent years during routine monitoring surveys.

2.4.2.3 **Biological Communities of North Anna River**

The North Anna River joins the South Anna River 23 miles downstream of the North Anna Dam, forming the Pamunkey River. Before 1972, when the river was impounded, flows varied considerably (1 to 24,000 cfs) from year to year and water quality was degraded by acid mine drainage from Contrary Creek. After 1972, fluctuations in flow were moderated (40 to 16,000 cfs from 1972 through 1985) and water quality has improved as a result of reclamation activities at the Contrary Creek mine site and the acid-neutralizing effect of Lake Anna's waters.

Water quality downstream of the North Anna Dam is strongly influenced by conditions in the reservoir and releases at the dam. Water moving from the North Anna Reservoir to the North Anna River is less turbid and more chemically stable than the pre-impoundment flow. Dissolved oxygen levels are high (averaging 9.6 milligrams per liter over the 1981–1985 period) immediately downstream of the North Anna Dam, and increase further downstream, presumably as a result of turbulent mixing (Reference 2).

Summer water temperatures from 1970 to 1985 were higher near the North Anna Dam than further downstream, reflecting temperatures in the reservoir. The highest water temperature recorded in pre-operational years in the river was 89.4°F in July 1977, at a location 0.6 miles below the dam. The highest temperature recorded in the river in operational years was slightly higher, 90.9°F, recorded in August 1983 at the same location.

Historically, the North Anna River periphyton community below the North Anna Dam was dominated by diatoms and was similar to that of other Southeastern streams. The benthic macroinvertebrate community in the stretch of the river below the dam was dominated by filter-feeding caddisflies that feed on seston (living and dead plankton, plus particulate matter) from the North Anna Reservoir. Farther downstream, macroinvertebrate communities showed more diversity and were similar to those of the South Anna River, which served as a control.

In pre-impoundment surveys, the fish community of the North Anna River downstream of the Contrary Creek inflow was dominated by pollution-tolerant species. In the years following impoundment (and reclamation of the Contrary Creek mine site), there was a steady increase in measures of abundance and diversity (species richness) of fish. In 1984–85, 38 species from 10 families were found in the North Anna River, compared to 25 species from 8 families in the control stream, the South Anna River. When species from the North Anna Reservoir were subtracted from the North Anna River totals, the 2 fish communities showed striking similarities, indicating that the operation of the existing units had little or no effect on fish populations downstream from the dam.

In 2000, the number of fish collected at 4 stations downstream of the North Anna Dam was low but similar to 1989, 1993, and 1996 collections. High spring flows and cancelled surveys in the fall may have contributed to the low fish numbers. Experience has shown that high flows are associated with low electrofishing catch rates, and vice versa. Although the number of fish collected in 2000 was low, the species composition of the catch was similar to previous years, with 6 species comprising 80 percent of the electrofishing catch by number and 6 species comprising 83 percent of the electrofishing catch by weight. All indications are that the low catch in 2000 was an anomaly, and the North Anna River continues to support a healthy, well-balanced community of aquatic organisms.

2.4.2.3.1 **Commercially-Important Fisheries**

As noted in Section 2.4.2.2, there is no commercial fishing in Lake Anna or the North Anna River. There are no runs of anadromous fish in the North Anna River. The North Anna River is a tributary of the Pamunkey River, which has an annual run of American shad; but these shad do not move into the North Anna River (Reference 41) (Reference 42). The Pamunkey Tribal Council operates an American shad hatchery on the Pamunkey River approximately 75 miles downstream of the North Anna Dam. Shad reared at this facility are normally stocked in the Pamunkey River and the James River as fry.

Young American eels (*Anguilla rostrata*) are found in the North Anna River, but are not sought by commercial fishermen. The American eel is a catadromous species, meaning that these fish begin their lives in the open ocean, then migrate into coastal rivers where they spend more of their lives in fresh water. (Reference 43) Upon reaching sexual maturity, at age 5 to 7 years, the eels migrate back to the ocean where they spawn and die. Eels in the North Anna River are juveniles, also known as “yellow eels.”

2.4.2.3.2 **Recreationally-Important Fisheries**

The lower North Anna River below the North Anna Dam is small, approximately 75 to 150 feet wide, but supports a diverse assemblage of stream fishes. It is a popular fishing spot. Unless stream flow is unusually high, powerboats are impractical: most anglers fish from shore or from canoes and kayaks. Recreational fishermen generally seek one or more of the following fish species: largemouth bass, smallmouth bass, or redbreast sunfish. Bluegill and redear sunfish are present as well, but receive less attention from anglers.

2.4.2.3.3 **Important Species in North Anna River**

Although the VDGIF periodically surveys the fish of the lower North Anna River and monitors the condition of the recreational fishery, it does not actively manage these populations. VDGIF is most concerned about the largemouth bass and smallmouth bass populations in the lower river, as these are the species most often sought by anglers and the species most likely to attain harvestable size. Recent VDGIF surveys have indicated that largemouth bass and smallmouth bass populations are healthy, despite the river’s limited supply of forage.

a. **Largemouth Bass and Smallmouth Bass**

Since 1987, Virginia Power biologists have gathered data on the abundance and distribution of these bass species in the lower North Anna River via direct (snorkel) observation (Reference 13). Biologists swim established transects at four locations in the lower river, counting and categorizing (by size) all bass that are observed and noting the type of cover being used. Historically, largemouth bass have dominated the fish counts at upstream locations, while smallmouth bass have been more prevalent at downstream locations (Reference 13). In recent years, both species have occupied the entire study area. As a general rule, however, largemouth bass are more abundant at the upstream locations and smallmouth bass are more abundant at the downstream locations. Density estimates for both largemouth and smallmouth bass at all locations were lower in 2000 than average densities for the entire study period, but dense growth of hydrilla adjacent to stream banks limited the ability of observers to accurately count fish (Reference 13).

b. **Redbreast**

Redbreast ranked first in abundance in North Anna River electrofishing samples in 1998, 1999, and 2000, and have ranked in the top four every year since 1981 (Reference 13). The redbreast is found across the coastal plain and Piedmont of Virginia in warm-water creeks and rivers of low-to-moderate gradient (Reference 41). It is an adaptable species, and may also be found in ponds, lakes, reservoirs, and even slightly brackish waters near the coast. The redbreast of the lower North Anna River appear to be a typical stream-dwelling population, with unremarkable growth rates, food habits, and spawning habits.

2.4.2.3.4 **Nuisance Species**

Asiatic clams first appeared in benthos samples from the North Anna River during the operational phase of the NAPS 316(a) study, conducted over the period 1981–1985. By the end of this period, Asiatic clams were firmly established in the lower North Anna River and were a “major” component of the benthos at several sampling locations (Reference 2).

2.4.2.3.5 **Threatened and Endangered Aquatic Species**

As presented in Section 2.4.2.2, Virginia Power has monitored fish populations in Lake Anna and the North Anna River for more than 25 years. No federally-listed or state-listed fish species has been collected in any of these monitoring studies, nor has any listed species been observed in creel surveys or occasional special studies conducted by Virginia Power biologists. No state- or federally-listed fish species’ range includes Lake Anna or the North Anna River, and none is believed to occur in counties adjacent to Lake Anna or the North Anna River (i.e., Caroline, Hanover, Louisa, Orange, and Spotsylvania Counties).

Section 2.4 References

1. *The Christmas Bird Count Historical Results* [Online]. National Audubon Society. 2003. Available at www.audubon.org/bird/cbc, accessed January 13, 2003.

2. *North Anna Power Station Section 316(a) Demonstration*, "Section 4.5 Waterfowl," Water Quality Department, Virginia Power, June 1986.

3. Fish and Wildlife Information Service, Virginia Department of Game and Inland Fisheries. 2003. Geographic Search. vafwis.org/perl/vafwis.pl/vafwis.login. Note: This is a protected website that is accessible only through VDGIF authorization.

4. "Threatened and Endangered Species System (TESS) Listings by State and Territory as of 3/19/2003. Virginia," USFWS (U.S. Fish and Wildlife Service), 2003. ecos.fws.gov/tess_public/TESSWebpageUsaLists?state=VA. accessed March 19, 2003.

5. NUREG-1437, Supplement 7. *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants Regarding North Anna Power Station, Units 1 and 2*. U.S. Nuclear Regulatory Commission (USNRC), Office of Nuclear Reactor Regulation, April, 2002.

6. *Final Environmental Statement Related to the Continuation of Construction and the Operation of Units 1 & 2 and the Construction of Units 3 & 4, North Anna Power Station*, Directorate of Licensing, U.S. Atomic Energy Commission (AEC), Washington, DC, 1973.

7. 9 VAC 25-260-5 et seq., Water Quality Standards, Part VII: Nutrient Enriched Waters, Virginia State Water Control Board. 2003.

8. *Environmental Study of Lake Anna and the Lower North Anna River: Annual Report for 1995*, Virginia Power, Richmond, VA, 1996.

9. *Environmental Study of Lake Anna and the Lower North Anna River: Annual Report for 1996*, Virginia Power, Richmond, VA, 1997.

10. *Environmental Study of Lake Anna and the Lower North Anna River: Annual Report for 1997*, Virginia Power, Richmond, VA, 1998.

11. *Environmental Study of Lake Anna and the Lower North Anna River: Annual Report for 1998*, Virginia Power, Richmond, VA, 1999.

12. *Environmental Study of Lake Anna and the Lower North Anna River: Annual Report for 1999*, Virginia Power, Richmond, VA, 2000.

13. *Environmental Study of Lake Anna and the Lower North Anna River. Annual Report for 2000, including summary for 1998-2000*, Virginia Power, Richmond, Virginia, 2001.

14. “Lake Anna Fish Structures,” Pamphlet, Virginia Power, (undated).

15. “Lake Anna,” Virginia Department of Game and Inland Fisheries (VDGIF), 2002a. Available online at www.dgif.state.va.us/fishing/lakes/lake_anna/index.html. Accessed March 16, 2003.

16. Odenkirk, J., *Large Impoundment Management Report: Lake Anna*, Virginia Department of Game and Inland Fisheries, prepared by John Odenkirk, District Fishery Biologist, 1999.

17. Odenkirk, J., *Large Impoundment Investigations: Lake Anna*, Virginia Department of Game and Inland Fisheries, prepared by John Odenkirk, District Fishery Biologist, Dingell-Johnson Grant F-111-R-9, Project I, 2001.

18. Odenkirk, J., *Large Impoundment Investigations: Lake Anna*, Virginia Department of Game and Inland Fisheries, prepared by John Odenkirk, District Fishery Biologist. Dingell-Johnson Grant F-111-R-10, Project I, 2002.

19. “Summer Striped Bass Habitat in Virginia/North Carolina,” Reservoir Newsletter, Volume 2, Issue 2, Southern Division, American Fisheries Society (SDAFS). Published by the Reservoir Committee, Southern Division, American Fisheries Society, August 1994.

20. “Lake Murray Striped Bass Die-off Linked to Heat, Layering of Lake,” News Release, South Carolina Department of Natural Resources (SCDNR), August 10, 1998.

21. Moss, J, “Cool Striped Bass,” Fisheries Section News Article, Alabama Wildlife & Freshwater Fisheries Division, 2000. Available online at www.dcnr.state.al.us/agfd/fish/FNACoolStripedBass.html. Accessed on March 19, 2003.

22. Willis, W. R., Corbicula Survey Report 1998, Prepared by Virginia Power Environmental Biology group, April 1998.

23. Willis, W. R., Corbicula Survey Report 1999a, Prepared by Virginia Power Environmental Biology group, October 1998.

24. Willis, W. R., Corbicula Survey Report 1999b, Prepared by Virginia Power Environmental Biology group, April 1999.

25. Willis, W. R., Corbicula Survey Report 2000a, Prepared by Virginia Power Environmental Biology group, October 1999.

26. Willis, W. R. Corbicula Survey Report 2000b, Prepared by Virginia Power Environmental Biology group, April 2000.

27. Willis, W. R., Corbicula Survey Report 2000c, Prepared by Virginia Power Environmental Biology group, October 2000.

28. Willis, W. R., Corbicula Survey Report 2001a, Prepared by Dominion Environmental Biology group, April 2001.

29. Willis, W. R., Corbicula Survey Report 2002a, Prepared by Dominion Environmental Biology group, October 2001.

30. Willis, W. R., Corbicula Survey Report 2002b, Prepared by Dominion Environmental Biology group, April 2002.

31. Willis, W. R., Corbicula Survey Report 1992a, Prepared by Virginia Power FBO, April 1992.

32. Willis, W. R., Corbicula Survey Report 1992b, Prepared by Virginia Power FBO, October 1992.

33. "Zebra mussels found in Virginia waters for the first time," United States Geological Survey (USGS), 2002. Available at the Non-indigenous Aquatic Species website maintained by Florida Caribbean Science Center, Biological Resources Division of the United States Geological Survey at nas.er.usgs.gov/zebra.mussel/.

34. "Exotic zebra mussels threaten native wildlife," Virginia Department of Game and Inland Fisheries (VDGIF), 2002b. VDGIF news release dated September 6, 2002. Available at www.dgif.state.va.us/newsroom/pr-090602-Zebras.html.

35. Online Information on Virginia's Natural Communities, Rare, Threatened and Endangered Animals and Plants, Virginia Department of Conservation & Recreation (VDCR). 2002. Available at www.dcr.state.va.us/dnh/nhrinfo.htm. Accessed March 20, 2003.

36. Moser, G. A., Dwarf Wedge Mussel (*Alasmidonta heterodon*) Recovery Plan, Prepared by Annapolis Field Office, U.S. Fish and Wildlife Service, Annapolis, MD. February 1993.

37. 060003 wedgemussel, dwarf. The Virginia Fish and Wildlife Information Service, Virginia Department of Game and Inland Fisheries (VDGIF) 2003. Available at vafwis.org. Accessed March 20, 2003.

38. Kitchel, L., Slippershell mussel, In *Virginia's Endangered Species* (K. Terwilliger, ed.), The McDonald and Woodward Publishing Company, Blacksburg, VA.

39. Cummings, K. S. and C. A. Mayer, *Field Guide to Freshwater Mussels of the Midwest*, Illinois Natural History Survey Manual 5, 1992.

40. North Carolina Atlas of Freshwater Mussels & Endangered Fish, NCWRC (North Carolina Wildlife Resources Commission), prepared by staff of the Non-game and Endangered Wildlife Program, North Carolina Wildlife Resources Commission, undated. Available online at www.ncwildlife.org/pg07_WildlifeSpeciesCon/pg7b1a1_11.htm.

41. Jenkins, R. E. and N. M. Burkhead, *Freshwater Fishes of Virginia*. American Fisheries Society, Bethesda, Maryland, 1994.

42. Bilkovic, D. M., C. H. Hershner, and J. E. Olney, *Macroscale Assessment of American Shad Spawning and Nursery Habitat in the Mattaponi and Pamunkey Rivers, Virginia*; North American Journal of Fisheries Management 22:1176-1192; 2002.

43. Rohde, F. C., R. G. Arndt, D. G. Lindquist, and J. F. Parnell, *Freshwater Fishes of the Carolinas, Virginia, Maryland, and Delaware*, The University of North Carolina Press, Chapel Hill, 1994.

44. *Wetland Delineation at the North Anna Power Station*, Davis Environmental Consultants, Inc., November 14, 2005.

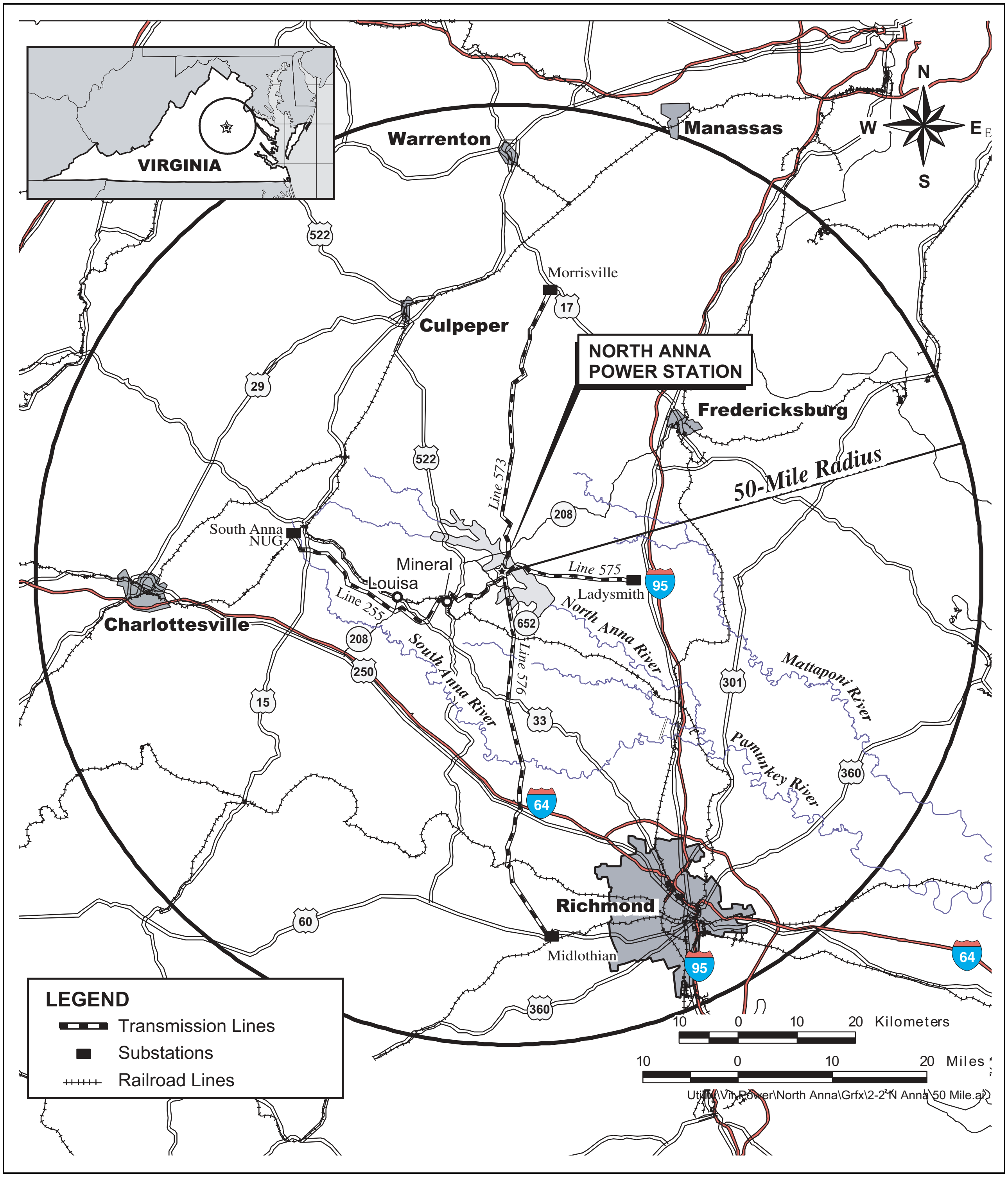

Figure 2.4-1 Lake Anna and the North Anna River

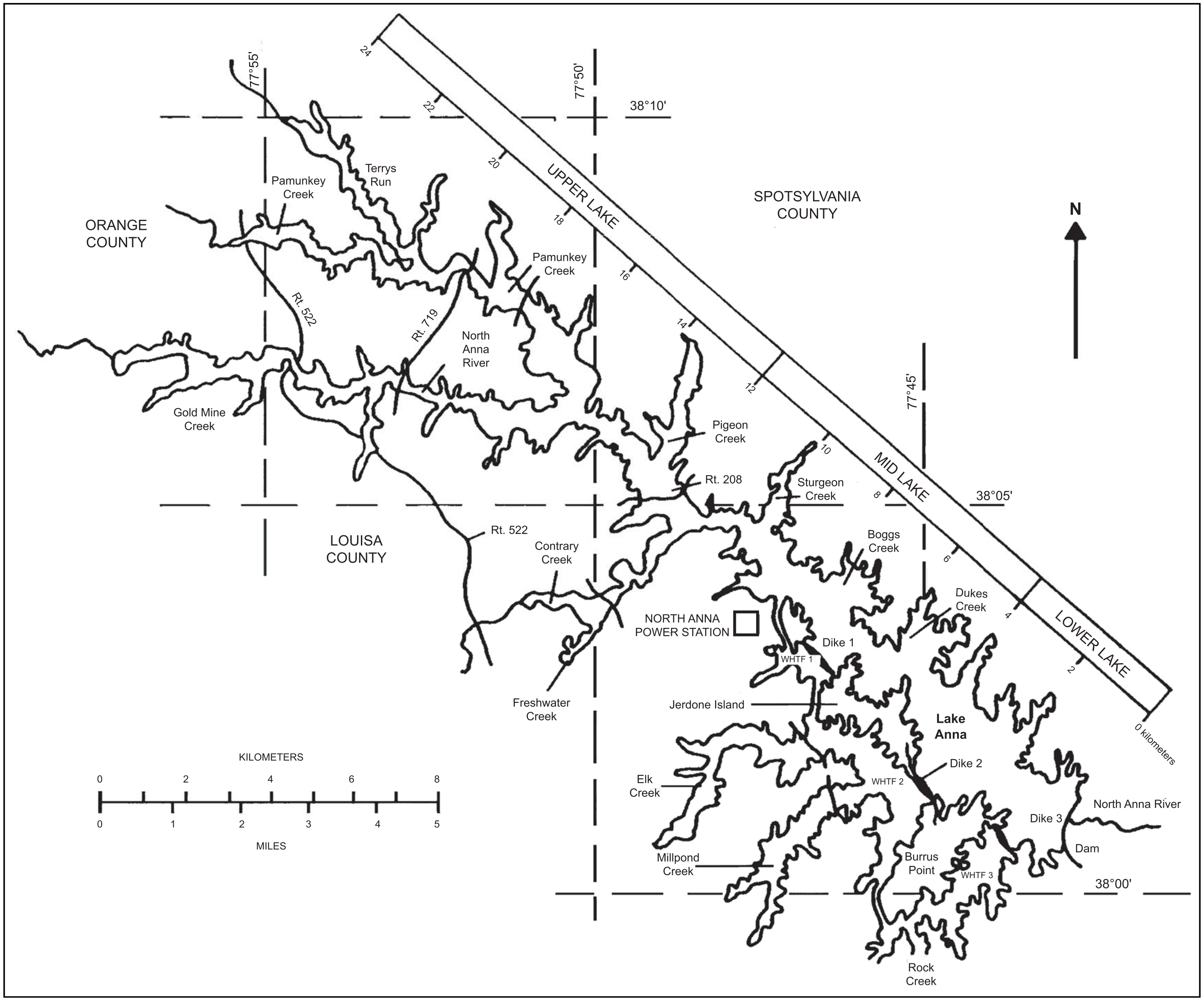

Figure 2.4-2 North Anna River; Northeast Creek; Contrary Creek

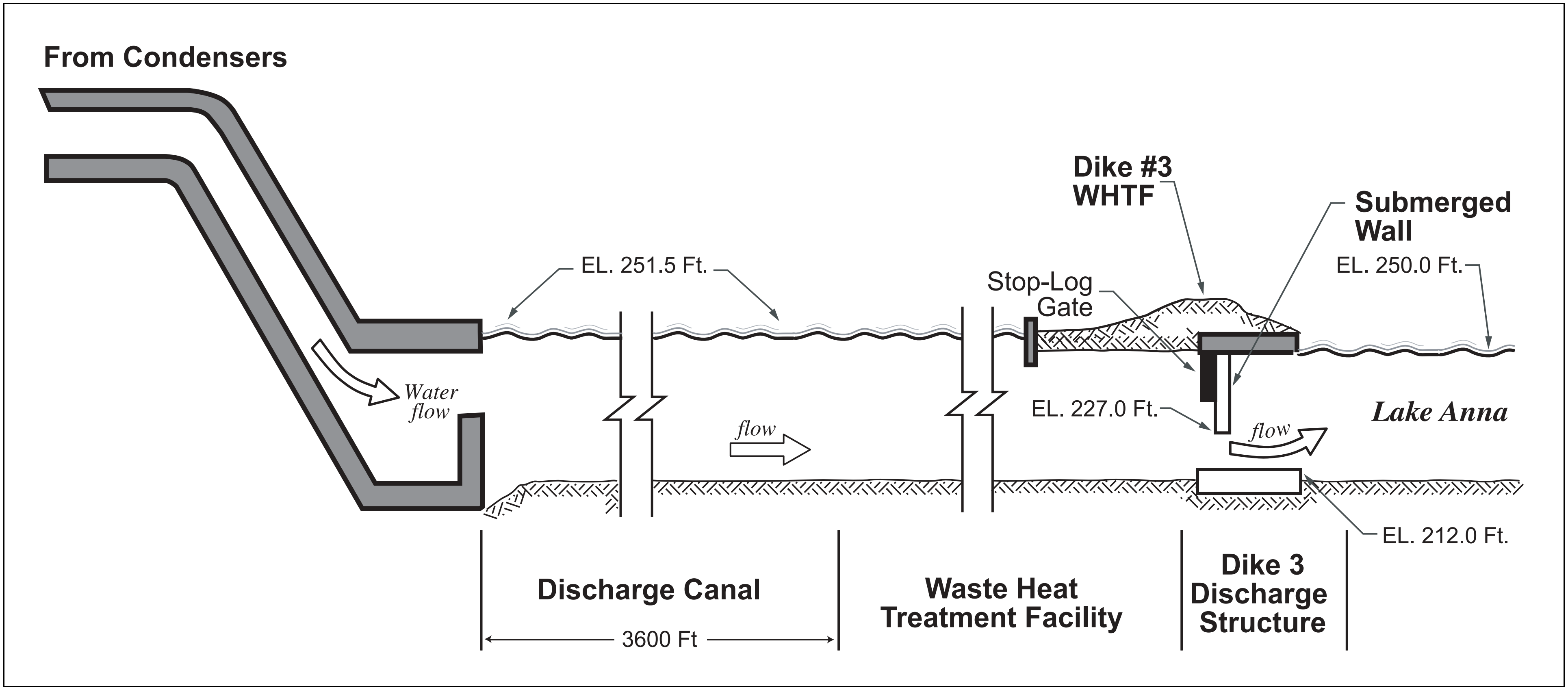

Figure 2.4-3 Schematic Cross-Sectional Diagram of Water-Discharge System at Dike 3 WHTF

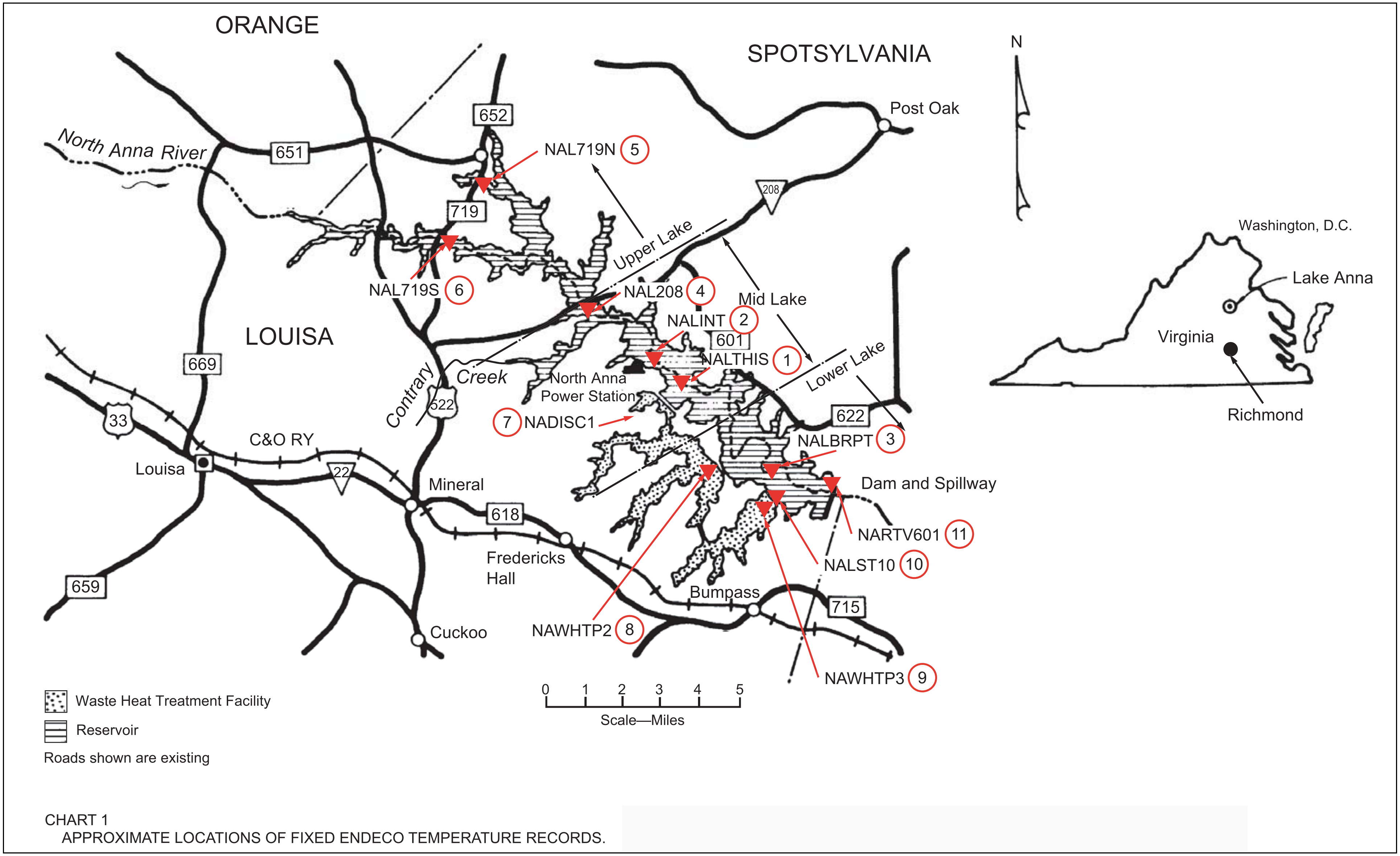

Figure 2.4-4 Location of Temperature Sensors - Lake Anna

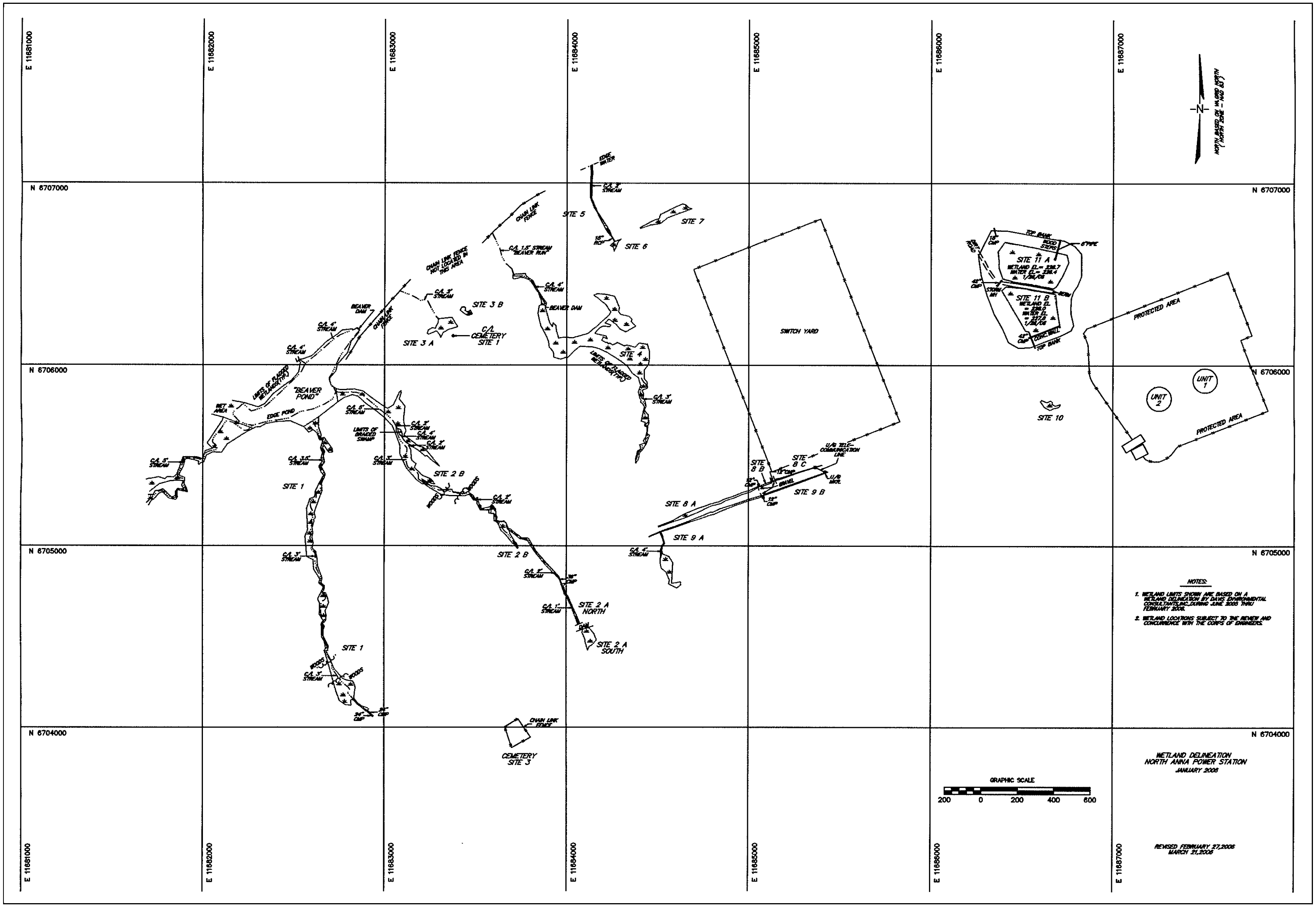

Figure 2.4-5 Overall ESP Site Wetlands Survey

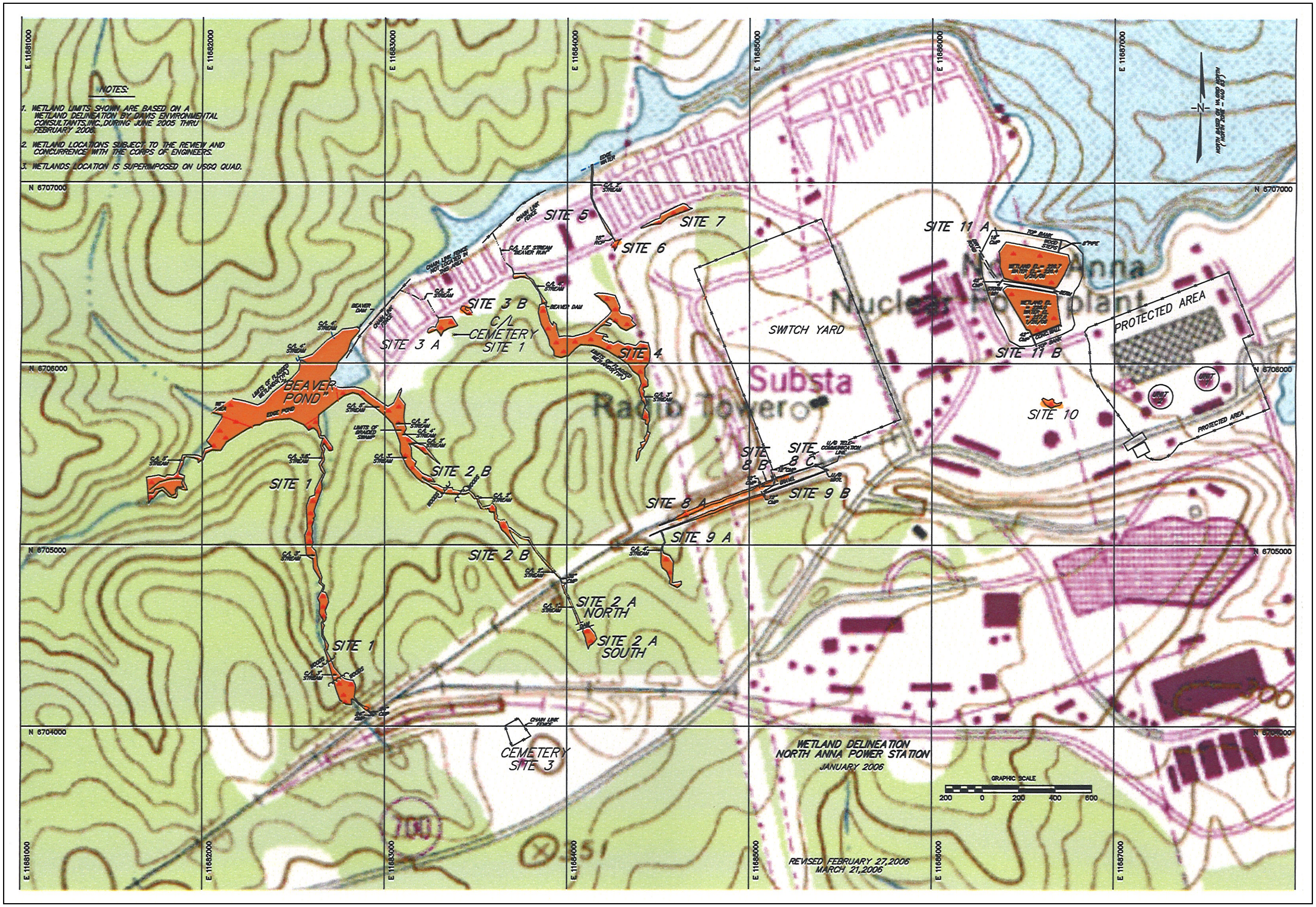

Figure 2.4-6 Sketched ESP Site Wetlands on Topo