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Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site

Final Report

Main Report

U.S. Nuclear Regulatory Commission
Office of New Reactors
Washington, D.C. 20555-0001

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Division of Site and Environmental Reviews
Office of New Reactors
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Abstract

This environmental impact statement (EIS) has been prepared in response to an application submitted to the U.S. Nuclear Regulatory Commission (NRC) by Dominion Nuclear North Anna, LLC (Dominion), for an early site permit (ESP). The proposed action requested in Dominion's application is for the NRC to (1) approve a site within the existing North Anna Power Station (NAPS) boundaries as suitable for the construction and operation of one or more new nuclear power generating facilities and (2) issue an ESP for the proposed site located at NAPS. The proposed action does not include any decision or approval to construct or operate one or more units; these are matters that would be considered only upon the filing of applications for a construction permit and an operating license, or an application for a combined license.

In its application, Dominion proposed a plan for redressing the environmental effects of certain site preparation and preliminary construction activities; that is, those activities allowed by Title 10 of the Code of Federal Regulations (CFR) 50.10(e)(1), performed by an ESP holder under 10 CFR 52.25. In accordance with the site redress plan, the site would be redressed if the NRC issues the requested ESP (containing the site redress plan), the ESP holder performs these site preparation and preliminary construction activities, the ESP is not referenced in an application for a construction permit or combined license, and no alternative use is found for the site.

This EIS includes the NRC staff's analysis that considers and weighs the environmental impacts of constructing and operating two nuclear units at the North Anna ESP site or at alternative sites, mitigation measures available for reducing or avoiding adverse impacts, and public comments on both the staff's Draft EIS and the Supplement to the Draft EIS (SDEIS). It also includes the staff's recommendation to the Commission regarding the proposed action.

As part of the NRC review of the application, the NRC solicited comments from the public on the Draft EIS, which was issued in December 2004, and the SDEIS, which was issued in July 2006 in response to changes proposed by Dominion in Revision 6 of its Environmental Report. These changes involved adopting a different cooling approach for the proposed new Unit 3 and increasing the maximum power output for both of the proposed new units (i.e., Units 3 and 4). Volume II of this document sets forth all public comments received concerning the Draft EIS and the SDEIS and the NRC staff's responses to these comments, organized by subject matter. The comment letters on the Draft EIS are in the NRC's document management system (ADAMS) under accession number ML0514720560. Comment letters on the SDEIS are under accession number ML063060459. ADAMS can be accessed through the NRC's website at www.nrc.gov. Where appropriate, changes were made to the Draft EIS and SDEIS and are identified by change bars in the margins of this Final EIS.

The staff's recommendation to the Commission related to its environmental review of the proposed action is that the ESP should be issued. This recommendation is based on (1) the Environmental Report (ER) submitted by Dominion; (2) consultation with Federal, State, Tribal, and local agencies; (3) the staff's independent review; (4) the staff's consideration of public comments on both the Draft EIS and the SDEIS; and (5) the assessments summarized in this Final EIS, including the potential mitigation measures identified in the ER and in the EIS. In addition, in making its recommendation, the staff has concluded that the alternative sites considered are not obviously superior to the proposed site. Finally, the staff concludes that the site preparation and preliminary construction activities enumerated in 10 CFR 50.10(e)(1) would not result in any significant adverse environmental impact that cannot be redressed.

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Executive Summary

On September 25, 2003, the U.S. Nuclear Regulatory Commission (NRC) received an application from Dominion Nuclear North Anna, LLC (Dominion) for an early site permit (ESP) for two units located adjacent to the North Anna Power Station (NAPS), Units 1 and 2. The North Anna ESP site is located in Louisa County, Virginia, approximately 10 km (6 mi) northeast of the town of Mineral. On the basis of Revision 3 of Dominion's application, the staff issued a draft environmental impact statement (EIS) in December 2004. On April 13, 2006, Dominion submitted Revision 6 to its application, which included a revised Environmental Report (ER).

In Revision 6 (and reflected in subsequent revisions) to the North Anna ESP application, Dominion proposed (1) changing its approach for cooling proposed Unit 3 from a once-through cooling system, as described in previous versions of the ER, to a closed-cycle system and (2) increasing the maximum power level per unit from 4300 megawatts-thermal (MW(t)) to 4500 MW(t) for the proposed Units 3 and 4 (hereafter referred to as Units 3 and 4). Under the revised cooling system approach, Unit 3 would use a closed-cycle, combination wet and dry cooling system.

The NRC staff determined that the changes to the proposed action in Revision 6 of the application were substantial; therefore, the staff prepared a Supplement to its Draft EIS (SDEIS) pursuant to 10 CFR 51.72. In July 2006, the staff published a Notice of Availability for the Supplement to the Draft EIS for the North Anna ESP Application in the *Federal Register*. The scope of the SDEIS was limited to the environmental impacts associated with the change in the cooling system for Unit 3 and the increase in the maximum power level for both units. The evaluation presented in the SDEIS replaced the evaluation of the impacts associated with the originally proposed once-through cooling for Unit 3 and modifies the analysis of impacts related to the power level increase.

On September 13, 2006, Dominion submitted Revision 9 to the application. In this revision, Dominion reduced the value assumed for the release of liquid tritium. The effect of the change was to lower the calculated dose to the public. Any reference to the ER in this EIS refers to Revision 9 unless otherwise specified. The revised evaluations, based on all submittals through Revision 9, along with public comments received on the SDEIS, are incorporated into this Final EIS together with comments concerning the original Draft EIS, and the staff's consideration of such comments.

An ESP is a Commission approval of a site or sites for one or more nuclear power facilities. Issuance of an ESP is an action separate from the issuance of a construction permit (CP) or a combined construction permit and operating license (combined license or COL) for such a facility. An ESP application may refer to a reactor's or reactors' design parameters or a plant parameter envelope (PPE), which is a set of values of plant design parameters that an ESP applicant expects will bound the design characteristics of the reactor or reactors that might be built at a selected site; alternatively an ESP may refer to a detailed reactor design. An ESP is not a license to build a nuclear power plant; rather, the application for an ESP initiates a process undertaken to assess whether a proposed site is a suitable location for such a plant should the applicant decide to pursue a CP or COL.

Section 102 of the National Environmental Policy Act of 1969 (NEPA) (42 USC 4321 et seq.) directs that Federal agencies prepare an EIS for major Federal actions that significantly affect the quality of the human environment. The NRC has implemented Section 102 of NEPA in Title 10 of the Code of Federal Regulations (CFR) Part 51. Subpart A of 10 CFR Part 52 sets forth the NRC regulations related to ESPs. As set forth in 10 CFR 52.18, the Commission has determined that an EIS will be prepared during the review of an application for an ESP. The purpose of Dominion's proposed action, issuance of the ESP, is to provide stability in the licensing process by addressing site safety and environmental issues before the plants are built rather than after construction is completed. Part 52 of Title 10 describes the ESP as a "partial construction permit." An applicant for a CP or COL for a nuclear power plant or plants to be located at a site for which an ESP has been issued can reference the ESP, and matters resolved in the ESP proceeding are considered resolved in any subsequent proceeding absent the identification of new and significant information. However, issuance of either a CP (and operating license) or COL to construct and operate a nuclear power plant is a major Federal action that requires its own environmental review in accordance with 10 CFR Part 51.

Three primary issues – site safety, environmental impacts, and emergency planning – must be addressed in the ESP application. Likewise, in its review of the application, the NRC assesses the applicant's proposal in relation to these issues and determines whether the application meets the requirements of the Atomic Energy Act of 1954 and NRC regulations. Site safety and emergency planning are addressed in the staff's safety evaluation report. This EIS addresses the environmental impacts of the proposed action. Pursuant to 10 CFR 52.17(a)(2), however, Dominion did not address the benefits of the proposed action (e.g., the need for power). In accordance with 10 CFR 52.18, the Draft EIS, the SDEIS, and this Final EIS are focused on the environmental effects of construction and operation of a reactor, or reactors, that have characteristics that fall within the design parameters that would be specified in the ESP if it is granted.

The holder of an ESP, or an applicant for a CP or COL that references an ESP that includes a site redress plan, may, in accordance with 10 CFR 52.25, perform the site preparation and preliminary construction activities enumerated in 10 CFR 50.10(e)(1), provided that the Final EIS concludes that the activities will not result in any significant adverse environmental impacts that cannot be redressed. Dominion provided a site redress plan as part of its ESP application.

Upon acceptance of the Dominion ESP application for docketing, the NRC began the environmental review process described in 10 CFR Part 51 by publishing in the *Federal Register* a Notice of Intent (68 FR 65961) to prepare an EIS and conduct scoping. The staff visited the North Anna ESP site during December 2003 and held a public scoping meeting in Mineral, Virginia, on December 8, 2003. Subsequent to the site visit and the scoping meeting and in accordance with the provisions of NEPA and 10 CFR Part 51, the staff determined and evaluated the potential environmental impacts of constructing and operating two new nuclear power plants at the North Anna ESP site, and stated its preliminary findings in a Draft EIS, which was issued on December 2, 2004.

The Draft EIS set forth (1) the results of the NRC staff's preliminary analyses, which considered and weighed the environmental effects of the proposed action (issuance of the ESP) and of constructing and operating two new nuclear units at the ESP site; (2) mitigation measures for reducing or avoiding adverse effects; (3) the environmental impacts of alternatives; and (4) the staff's preliminary recommendation regarding the proposed action.

The staff conducted a public meeting on February 17, 2005, to describe the preliminary results of the NRC environmental review, answer questions, and provide members of the public with information to assist them in formulating comments on the Draft EIS. On April 13, 2006, Dominion submitted Revision 6 to its application, which included substantial changes and required the staff to develop the SDEIS, which was published in July 2006. The staff held a similar public meeting on August 15, 2006, for the SDEIS. After the comment period, the staff considered all comments received. The staff's disposition of the comments, on both the Draft EIS and the SDEIS are set forth in Volume II, Appendix E, of this Final EIS.

During the course of preparing the North Anna ESP EIS, the staff reviewed the revised ERs submitted by Dominion; consulted, as necessary, with Federal, State, Tribal and local agencies; and followed the guidance set forth in the NRC's review standard RS-002, *Processing Applications for Early Site Permits,* to conduct an independent review of the issues presented in the ER, as revised. The review standard draws from the previously published NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*, and NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants*.

To guide its assessment of environmental impacts of a proposed action or alternative actions, the NRC has established a standard of significance for impacts using guidance set forth by the Council on Environmental Quality (40 CFR 1508.27). Using this approach, the NRC has established three significance levels – SMALL, MODERATE, or LARGE – which are defined below:

SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

Mitigation measures, assumptions, and applicant commitments used in the staff's analysis are presented in Appendix J. Proposed permit conditions are also included in Appendix J.

The staff's recommendation, in view of the environmental impacts described in the EIS, is that the ESP for North Anna Units 3 and 4 should be issued. This recommendation is based on (1) the ER submitted by Dominion; (2) consultation with Federal, State, Tribal and local agencies; (3) the staff's independent review; (4) the staff's consideration of public comments related to the environmental review that were received during the review process; and (5) the assessments summarized in the EIS, including the potential mitigation measures identified in the ER and in the EIS. In addition, in making its recommendation, the staff has concluded that the alternative sites considered are not obviously superior to the proposed site. Finally, the staff concludes that the site preparation and preliminary construction activities enumerated in 10 CFR 50.10(e)(1) would not result in any significant adverse environmental impact that cannot be redressed.

Abbreviations/Acronyms

ABWR	advanced boiling water reactor
ac	acre(s)
ACE	U.S. Army Corps of Engineers
ACR-700	Advanced CANDU Reactor
ADAMS	Agencywide Documents Access and Management System
AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
ALWR	advanced light-water reactor
ATWS	anticipated transient without scram
BEA	Bureau of Economic Analysis
BMP	best management practices
Bq	becquerel(s)
Btu	British thermal unit(s)
BWR	boiling water reactor
C	Celsius
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
Ci	curie(s)
cm	centimeter(s)
COL	combined construction and operating license, combined license
CP	construction permit
CWA	Clean Water Act of 1977 (also known as the Federal Water Pollution Control Act)
CWIS	cooling water intake system
CZMA	Coastal Zone Management Act
d	day
DBA	design-basis accident
dBA	decibels
DEIS	draft environmental impact statement
DGIF	Department of Game and Inland Fisheries
DOE	U.S. Department of Energy
EAB	exclusion area boundary
EC	energy conservation mode
EIS	environmental impact statement

EPA	U.S. Environmental Protection Agency
ER	environmental report
ESBWR	economic simplified boiling water reactor
ESE	east-southeast
ESP	early site permit
ESRP	Environmental Standard Review Plan
F	Fahrenheit
FR	*Federal Register*
ft	foot, feet
FWPCA	Federal Water Pollution Control Act (also known as the Clean Water Act of 1977)
FWS	U.S. Fish and Wildlife Service
gal	gallon(s)
GEIS	generic environmental impact statement
gpd	gallons per day
gpm	gallons per minute
GT-MHR	gas turbine-modular helium reactor
ha	hectare(s)
HLW	high-level waste
HPS	Health Physics Society
hr	hour(s)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEEE	Institute of Electrical and Electronics Engineers, Inc.
in.	inch(es)
INEEL	Idaho National Engineering and Environmental Laboratory
IRIS	international reactor innovative and secure
ISFSI	independent spent fuel storage installation
kg	kilogram(s)
km	kilometer(s)
kV	kilovolt(s)
kWh	kilowatt hour(s)
L	liter(s)
LAAC	Lake Anna Advisory Committee
lb	pound(s)
LLW	low-level waste

LOCA	loss-of-coolant accident
LOS	level-of-service
LPZ	low population zone
LWR	light-water reactor
m	meter(s)
m/sec	meter(s) per second
m^3/d	cubic meter(s) per day
m^3/s	cubic meter(s) per second
MBq	million Becquerel(s)
mGy/yr	milligray per year
MGD	million gallons per day
mi	mile(s)
MIT	Massachusetts Institute of Technology
mL	milliliter(s)
mph	miles per hour
mrad	millirad(s)
mrem	millirem(s)
MSL	mean sea level
mSv	millisievert(s)
MT	metric ton(s) (or tonne[s])
MTU	metric ton(s)-uranium
MW	megawatt(s)
MWC	maximum energy conservation mode
MWd/MTU	megawatt-days per metric ton of uranium
MW(e)	megawatt(s)-electric
MW(t)	megawatt(s)-thermal
MWh	megawatt hour(s)
NA	not applicable
NAPS	North Anna Power Station
NCDC	National Climatic Data Center
NCHS	National Center for Health Statistics
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act of 1969
NESC	National Electric Safety Code
NHPA	National Historic Preservation Act
NIEHS	National Institute of Environmental Health Sciences
NNE	north-northeast
NOAA	National Oceanographic and Atmospheric Administration
NO_x	nitrogen oxide(s)

NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NUG	non-utility generator
ODCM	Offsite Dose Calculation Manual
OL	operating license
OSHA	Occupational Safety and Health Administration
PBMR	pebble bed modular reactor
PCB	polychlorinated biphenyl
PPE	plant parameter envelope
ppm	parts per million
PWR	pressurized water reactor
RCIC	reactor core isolation cooling
REMP	radiological environmental monitoring program
rms	root mean square
ROI	region of interest
RRY	reference reactor-year
RSA	Rapidan Service Authority
Ryr^{-1}	per reactor year
s	second
SAIC	Science Applications International Corporation
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SDEIS	Supplement to the Draft EIS
SER	safety evaluation report
SHPO	State Historic Preservation Officer
SODI	Southern Ohio Diversification Initiative
SO_x	sulfur oxide(s)
SPCC	Spill Prevention Control and Countermeasure
SR	State Route
SRS	Savannah River Site
SSAR	Site Safety Analysis Report
SSE	south-southeast
Sv	sievert(s)
SWR	Service Water Reservoir
SWU	separative work units
TEDE	total effective dose equivalent

TRU	transuranic (waste)
TVA	Tennessee Valley Authority
UCO	uranium oxycarbide
UFSAR	Updated Final Safety Analysis Report
UHS	ultimate heat sink
U.S.	United States
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USEC	United States Enrichment Corporation, Inc.
USGS	U.S. Geological Survey
VAC	Virginia Administrative Code
VTAX	Virginia Department of Taxation
VDCR	Virginia Department of Conservation and Recreation
VDEQ	Virginia Department of Environmental Quality
VDGIF	Virginia Department of Game and Inland Fisheries
VDOT	Virginia Department of Transportation
VDSS	Virginia Department of Social Services
VEC	Virginia Employment Commission
VEPCo	Virginia Electric & Power Company (Virginia Power)
VNHP	Virginia Natural Heritage Program
VPDES	Virginia Pollutant Discharge Elimination System
yd	yard(s)
yr	year(s)
WHTF	Waste Heat Treatment Facility

1.0 Introduction

On September 25, 2003, the U.S. Nuclear Regulatory Commission (NRC) received an application pursuant to Title 10 of the Code of Federal Regulations (CFR), Part 52 from Dominion Nuclear North Anna, LLC (Dominion) for an early site permit (ESP) for the North Anna ESP site located in Louisa County, Virginia near the town of Mineral, Virginia. The September 25, 2003 Environmental Report (ER) contained in the application was revised by letters dated October 2, 2003 (Revision 1), July 15, 2004 (Revision 2), September 7, 2004 (Revision 3), May 12, 2005 (Revision 4), July 25, 2005 (Revision 5), April 13, 2006 (Revision 6), June 21, 2006 (Revision 7), July 31, 2006 (Revision 8), and September 13, 2006 (Revision 9). Any reference in this environmental impact statement (EIS) to the ER refers to Revision 9 (Dominion 2006a), unless otherwise stated. Under the NRC regulations in 10 CFR Part 52 and in accordance with the applicable provisions of 10 CFR Part 51, which are the NRC regulations implementing the National Environmental Policy Act of 1969 (NEPA), the NRC is required to prepare an EIS as part of its review of an ESP application.

The NRC issued the EIS in draft form for public comment in December 2004 (NRC 2004a). A Supplement to the Draft EIS (SDEIS), issued in July 2006, evaluated changes to the cooling system for proposed Unit 3 and an increase in power level for Units 3 and 4 made by Dominion after the Draft EIS was published (NRC 2006a). The evaluation presented in the SDEIS replaced the evaluation of the impacts associated with the originally proposed once-through cooling system for Unit 3 and modified the analysis of impacts related to the power level increase. These revised evaluations, along with the public comments received on the analysis presented in the SDEIS, are incorporated into this Final EIS together with comments received concerning the original Draft EIS and the staff's consideration of such comments.

The North Anna Draft EIS, the SDEIS, and this Final EIS follow a similar structure of section contents. Traditionally, change bars are placed in the margins of a final EIS to identify where the final document has been changed from the Draft EIS in response to public comments or corrections. For the North Anna ESP, two previous draft documents exist for this Final EIS. They differ with respect to the changes to the Unit 3 cooling system and the increase in maximum power level proposed in Dominion's ER Revision 6. In this document, change bars are used primarily where new information is added in response to public comment, or a technically substantive change has been made.

1.1 Background

An ESP is a Commission approval of a site or sites for one or more nuclear power facilities. Issuance of an ESP is a process that is separate from the issuance of a construction permit (CP), an operating license (OL), or a combined construction and operating license (combined license or COL) for such a facility. The ESP application and review process makes it possible to evaluate and resolve safety and environmental issues related to siting before the applicant makes a large commitment of resources. If the ESP is approved, the applicant can "bank" the site for up to 20 years for future reactor siting. In addition, if the ESP includes a site redress plan, the ESP holder can conduct certain site preparation and preliminary construction activities enumerated in 10 CFR 50.10 (e)(1). An ESP does not authorize construction and operation of a nuclear power plant. To construct and operate a nuclear power plant, an ESP holder must obtain a CP and an OL, or a COL, which are separate major Federal actions that require their own environmental review in accordance with 10 CFR Part 51.

As part of its evaluation of the environmental aspects of the action proposed in an ESP application, the NRC prepares an EIS in accordance with 10 CFR 52.18 and 10 CFR Part 51. Because site suitability encompasses construction and operational parameters, the EIS addresses impacts of both construction and operation of reactors and associated facilities. In a review separate from the EIS process, the NRC analyzes the safety characteristics of the proposed site and emergency planning information. These latter two analyses are documented in a safety evaluation report that presents the conclusions reached by the NRC regarding the following issues:

- whether there is reasonable assurance that a reactor or reactors, having characteristics that fall within the parameters for the site, can be constructed and operated without undue risk to the health and safety of the public

- whether there are significant impediments to the development of emergency plans

- whether site characteristics are such that adequate security plans and measures can be developed.

The staff has issued a separate safety evaluation report for the North Anna ESP site in accordance with 10 CFR Part 52 (NRC 2005b, 2006b). In addition, if the applicant proposes either major features of emergency plans or complete and integrated emergency plans, the safety evaluation report documents whether such major features are acceptable, or whether the complete and integrated emergency plans provide reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Dominion chose to propose major features of emergency plans in its application.

1.1.1 Plant Parameter Envelope

The applicant for an ESP need not provide a detailed design of a reactor or reactors and the associated facilities, but should provide sufficient bounding parameters and characteristics of the reactor or reactors and the associated facilities so that an assessment of site suitability can be made. Consequently, the ESP application may refer to a plant parameter envelope (PPE) as a surrogate for a nuclear power plant and its associated facilities.

A PPE is a set of values of plant design parameters that an ESP applicant expects will bound the design characteristics of the reactor or reactors that might be constructed at a given site. The PPE values are a bounding surrogate for actual reactor design information. Analysis of environmental impacts based on a PPE approach permits an ESP applicant to defer the selection of a reactor design until the CP or COL stage. The PPE is discussed in more detail in Section 3.2 and is contained in Appendix I of this EIS.

1.1.2 Site Preparation and Preliminary Construction Activities

The holder of an ESP, or an applicant for a CP (10 CFR Part 50) or a COL (Subpart C of 10 CFR Part 52) that references an ESP with an approved site redress plan, may in accordance with 10 CFR 52.25(a) perform the site preparation and preliminary construction activities enumerated in 10 CFR 50.10(e)(1), provided the final ESP EIS concludes that the activities will not result in any significant adverse environmental impacts that cannot be redressed. Dominion provided a site redress plan as part of its ESP application (Dominion 2006b). Activities permitted under an ESP containing a site redress plan include preparation of the site for construction of the facility, installation of temporary construction support facilities, excavation for facility structures, construction of service facilities, and construction of certain structures, systems, and components that do not prevent or mitigate the consequences of postulated accidents (10 CFR 50.10(e)(1)). The site redress plan specifies how the applicant would stabilize and restore the site to its preconstruction condition (or conditions consistent with an alternative use) in the event these site preparation activities are performed but a nuclear power plant is not constructed on the ESP site.

Should the NRC grant the ESP and the ESP holder decides to perform the activities authorized by 10 CFR 52.25, “Extent of Activities Permitted,” the ESP holder must obtain from the landowner the authority to undertake those activities on the ESP site. In obtaining such a right, the ESP holder must also obtain the corresponding right to implement the site redress plan described in the staff’s Final EIS in the event that no plant is built on the ESP site. The staff proposes to include a condition in any ESP that might be issued requiring that the ESP holder obtain the right to implement the site redress plan before initiating any activities authorized by 10 CFR 52.25. In addition, Section 401 of the Clean Water Act requires that applicants for Federal permits that would allow discharges into navigable waters obtain a certification regarding the discharge or obtain a waiver for such a certification. As discussed in Section 1.5

of this chapter, the staff proposes to include a condition prohibiting the ESP holder 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 Virginia Code § 62.1-44.15:5(A) constitutes the certification required under Clean Water Act § 401) or a determination by the Virginia Department of Environmental Quality (VDEQ) that no certification is required.

1.1.3 ESP Application and Review

In accordance with 10 CFR 52.17(a)(2), Dominion submitted an ER as part of its ESP application (Dominion 2006a). The ER focuses on the environmental effects of construction and operation of reactors with characteristics that fall within the PPE. The ER also includes an evaluation of alternative sites to determine whether there is an obviously superior alternative to the proposed site. The ER is not required to include, nor does it include, an assessment of the benefits of the proposed action (e.g., the need for power) or a discussion of energy alternatives.

The NRC staff conducts its reviews of ESP applications in accordance with guidance set forth in review standard RS-002, *Processing Applications for Early Site Permits* (NRC 2004b). The review standard draws from the previously published NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants* (NRC 1987), and NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants* (ESRP) (NRC 2000). RS-002 provides guidance to NRC staff reviewers to help ensure a thorough, consistent, and disciplined review of any ESP application. As stated in RS-002, an applicant may elect to use a PPE approach instead of supplying specific design information. The staff's June 23, 2003, responses to comments received on draft RS-002 (in NRC's document system [ADAMS] under the Accession Number ML031710698) provide additional insights on the staff's expectations and potential approach to the review of an application employing the PPE approach (NRC 2003). Specifically, the NRC staff adapted the ESRP review guidance to the PPE concept. The findings in this EIS reflect the adaptation of the ESRP guidance to the PPE approach.

In addition, the staff also considered the information and analyses provided in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS)* (NRC 1996)[a] in its review. Because the GEIS included a review of data from all operating nuclear power plants, some of the information was useful for the environmental review of the proposed action. The staff has identified in the text those areas where this information has been used.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and Addendum 1

Pursuant to 10 CFR 52.18, an EIS prepared by the NRC staff on an application for an ESP focuses on the environmental effects of construction and operation of a reactor, or reactors, that have characteristics that fall within the postulated site parameters. Such an EIS must also include an evaluation of alternative sites to determine whether there is any obviously superior alternative to the site proposed. The Commission's regulations recognize that certain matters need not be resolved at the ESP stage (e.g., an assessment of the benefits, need for power) and, thus, may be deferred until an applicant decides to apply for a CP or COL. Further, the NRC staff realizes that certain information pertaining to the environmental impacts of construction and operation of new nuclear power facilities may not be available when the NRC staff reviews an ESP application.

Dominion's ESP application, including its ER, was submitted under oath or affirmation. Applicants use the body of NRC regulatory guidance (e.g., Regulatory Guides, Review Standards, and Standard Review Plans) and can take advantage of approaches and methods that are acceptable to the NRC to analyze environmental impacts. The staff relied upon the ER as a source of basic information about the plant parameters, the site, the region, and the environment. The applicant and the NRC are not required to have identical positions on the significance of environmental impacts; nevertheless, at times there are different conclusions reached based on different methods and assumptions. Subsequent to the acceptance of the application, the staff visited the site; consulted with local, State, Tribal and Federal agencies; and conducted its own independent review. The Draft EIS, the SDEIS, and this Final EIS are the result of the staff's review and properly include material from various sources including the ER. Ultimately, the NRC is responsible for the reliability of all of the information used in its EIS. If, as part of its independent review, the NRC determines that information presented in the ER is useful and the NRC confirms its accuracy, then the NRC may use the information in its EIS.

With regard to the environmental impacts associated with construction and operation of the proposed North Anna Units 3 and 4, Dominion made a number of representations in its application. As discussed in the evaluations in this EIS, the staff relied on these representations and staff-developed assumptions in assessing the environmental impacts associated with construction and operation of Units 3 and 4. As such, fulfillment of these representations and assumptions provide part of the basis for the final impact assessment. Should a CP or COL applicant reference the ESP, and the staff ultimately determines that a representation or an assumption has not been satisfied at the CP/COL stage, that information would be considered new and potentially significant, and the affected impact area could be subject to re-examination.

In its application and in responses to requests for additional information (RAIs), Dominion did not or was unable to provide information and analysis for certain issues sufficient to allow the NRC staff to complete its analysis. For such issues, Dominion did not offer, nor did the staff identify, bases for assumptions that would allow resolution. The staff was unable to determine a unique significance level for such issues, and therefore, these issues are not resolved for the North Anna ESP site.

As provided by 10 CFR 52.39(a)(2), the Commission shall treat those matters that are resolved through this EIS as resolved in any later proceeding on an application for a CP or COL referencing the requested North Anna ESP. However, as discussed in the NRC staff's July 6, 2005, letter to Mr. A. Heymer of the Nuclear Energy Institute, a CP or COL applicant must identify whether there is new and significant information on these resolved issues (NRC 2005a). This requirement complements the obligation of a CP or COL applicant referencing an ESP to provide information to resolve any significant environmental issue not considered in the previous proceeding on the ESP. Issuance of either a CP (and OL) or a COL to construct and operate a nuclear power plant is a major Federal action that requires its own environmental review in accordance with 10 CFR Part 51. As provided in 10 CFR 52.79 and under NEPA, the CP or COL environmental review will be informed by the EIS prepared at the ESP stage, and the NRC staff intends to use tiering and incorporation-by-reference whenever it is appropriate to do so. The CP or COL applicant must address any other issue not considered or not resolved in the EIS for the ESP. Moreover, pursuant to 10 CFR 51.70(b), the NRC is required to independently evaluate and be responsible for the reliability of all information used in the environmental review for a CP or COL application, and the staff may (1) inquire into the continued validity of information disclosed in an EIS for an ESP that is referenced in a COL application, and (2) look for any new information that may affect the assumptions, analyses, or conclusions reached in the ESP EIS.

In addition, measures and controls to limit any adverse impact will be identified and evaluated for feasibility and adequacy in limiting adverse impacts at the ESP stage, where possible, and at the CP or COL stage. As a result of the staff's environmental review of the ESP application, the staff may determine that conditions or limitations on the ESP may be necessary in specific areas, as set forth in 10 CFR 52.24. Therefore, the staff identified in the Draft EIS, SDEIS, and this Final EIS when and how assumptions and PPE values limit its conclusions on the environmental impacts to a particular resource (see also Appendix J).

Following requirements set forth in 10 CFR Part 51 and the guidance in RS-002, the NRC environmental staff (and technical experts from the Pacific Northwest National Laboratory retained to assist the staff) visited the North Anna ESP site and alternative sites in December 2003; January, February, September, and December 2005; and May 2006 to gather information and to become familiar with the sites and their environs. During these site visits, the staff and its contractor personnel met with the applicant's staff, public officials, Federal and State regulators, local officials, and the public. A list of the organizations contacted is provided in Appendix B. Other documents related to the North Anna ESP site were reviewed and are listed as references where appropriate.

Upon acceptance of the Dominion ESP application for docketing, the NRC began the environmental review process described in 10 CFR Part 51 by publishing in the *Federal Register* a Notice of Intent (68 FR 65961) to prepare an EIS and conduct scoping. The staff held a public scoping meeting on December 8, 2003, in Mineral, Virginia. Subsequent to the scoping meeting and in accordance with NEPA and 10 CFR Part 51, the staff determined and evaluated the potential environmental impacts of constructing and operating two new nuclear power plants at the North Anna ESP site, and stated its preliminary findings in a Draft EIS issued on December 2, 2004 (NRC 2004a). On December 10, 2004, the staff issued a Notice of Availability in the *Federal Register* (69 FR 71854). On December 17, 2004, the U.S. Environmental Protection Agency (EPA) issued a Notice of Filing (69 FR 75535), and initiated a 75-day comment period for the Draft EIS, which ended March 2, 2005.

A public meeting was conducted on February 17, 2005, at Mineral, Virginia, to describe the results of the NRC environmental review, answer questions related to the review, and provide members of the public with information to assist them in formulating their comments on the Draft EIS.

On April 13, 2006, Dominion submitted Revision 6 to its application. The staff issued a Notice of Intent to prepare a supplement to the Draft EIS (71 FR 28392). In response to the changes proposed in ER Revision 6 related to the Unit 3 cooling system and the maximum power level of both Units 3 and 4, the NRC staff re-evaluated the environmental impacts of these issues and documented its conclusions in the SDEIS (NRC 2006a). The scope of the SDEIS was limited to the environmental impacts associated with the changes in the ER Revision 6 cooling system for Unit 3 and the maximum power level for the proposed new units. This evaluation replaced the evaluation of the impacts of once-through cooling for Unit 3 in the Draft EIS and modified the analysis of impacts related to the power level. On July 12, 2006, the staff issued a Notice of Availability for the SDEIS in the *Federal Register* (71 FR 39372). On July 14, 2006, the U.S. Environmental Protection Agency (EPA) published the Notice of Filing of the SDEIS (71 FR 40096) initiating a 45-day comment period during which the public could comment on the SDEIS. Subsequently, the comment period was extended an additional 15 days, ending September 12, 2006 (71 FR 46927). A public meeting was held August 15, 2006, in Mineral, Virginia. Comments received at the public meeting and those received by letter and e-mail are included in Appendix E (Volume II) of this Final EIS along with those received on the Draft EIS. Revised evaluations, along with public comments received on the analysis presented in the SDEIS, are incorporated into this Final EIS together with public comments and the staff's consideration of comments received concerning the Draft EIS.

To guide its assessment of environmental impacts of a proposed action or alternative actions, the NRC has established a standard of significance for impacts using Council on Environmental Quality (CEQ) guidance (40 CFR 1508.27). Using this approach, the NRC has established three significance levels – SMALL, MODERATE, or LARGE – which are defined below:

> SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

This EIS presents the staff's analysis that considers and weighs the environmental impacts of the proposed action at the North Anna ESP site, including the environmental impacts associated with construction and operation of reactors at the site, the impacts of constructing and operating reactors at alternative sites, the environmental impacts of alternatives to granting the ESP, and mitigation measures available for reducing or avoiding adverse environmental effects. It also provides the NRC staff's recommendation to the Commission regarding the suitability of the North Anna ESP site for construction and operation of reactors with characteristics that fall within the PPE.

The comment letters on the Draft EIS and SDEIS are in the NRC's document management system (ADAMS) under accession numbers ML043380308 and ML061800217, respectively.

1.2 The Proposed Federal Action

The proposed Federal action is the issuance, under the provisions of 10 CFR Part 52, of an ESP for the North Anna ESP site for nuclear power facilities with characteristics that fall within the PPE. In addition, Dominion proposes a plan for redressing the environmental effects of certain site preparation and preliminary construction activities (i.e., those activities enumerated in 10 CFR 50.10(e)(1)) performed by an ESP holder under 10 CFR 52.25. In accordance with the plan, the site would be redressed if the NRC issues the requested ESP (containing the site redress plan), the ESP holder performs these site preparation and preliminary construction activities, the ESP is not referenced in an application for a CP or COL, and no alternative use is found for the site. While Dominion is not currently proposing construction and operation of new units, this EIS analyzes the environmental impacts that could result from the construction and operation of two new nuclear units at the North Anna ESP site, or at three alternative sites. These impacts are analyzed to determine whether the proposed ESP site is suitable for the new units and whether there is an alternative site that is obviously superior to the proposed site.

The North Anna ESP site proposed by Dominion is located in Louisa County in northeastern Virginia, near the town of Mineral. It is completely within the confines of the current North Anna Power Station (NAPS) site, which is located on a peninsula on the southern shore of Lake Anna approximately 8 km (5 mi) upstream of the North Anna Dam. The NAPS site contains two nuclear generating units managed by Dominion Generation. Lake Anna is approximately 27 km (17 mi) long with 435 km (272 mi) of shoreline. The lake was created in 1971 by the construction of a dam on the main stem of the North Anna River. Virginia Electric and Power

Company, a subsidiary of Dominion Resources, Inc., owns the land above and below the lake surface and around the lake up to the expected high-water mark.

For purpose of the ESP application, no specific plant design was selected by Dominion for the ESP site; instead, a set of values of plant parameters (i.e., the PPE) has been specified for the staff's evaluation of the future development of the North Anna site. Dominion has for the purpose of preparation of a COL application selected the Economic Simplified Boiling Water Reactor (ESBWR) (Dominion 2005a). However, for the ESP review, Dominion's application uses the PPE approach. The 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 4500 MW(t) 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, proposed Units 3 and 4. The ESP application does not propose construction and operation of Units 3 and 4. The phrase "proposed Units 3 and 4," as used in this EIS, indicates surrogate reactors with the design parameters specified in the PPE for environmental evaluation. The total nuclear generating capacity to be added would not exceed 9000 MW(t). Cooling water for Unit 3, the first of the proposed new units, was originally envisioned as being provided by Lake Anna using a once-through cooling system. With the changes proposed in ER Revision 6, Unit 3 would now be cooled using a closed-cycle, combination wet and dry cooling tower system. Unit 4 would use dry cooling towers.

1.3 The Purpose and Need for the Proposed Action

The purpose and need for the proposed action (i.e., ESP issuance) is to provide stability in the licensing process by addressing site safety and environmental issues before the plants are built rather than after construction is completed. The ESP process allows for early resolution of many safety and environmental issues that may be identified for the ESP site. In the absence of an ESP, safety and environmental reviews of applications for OLs under 10 CFR Part 50 would take place during plant construction. Alternatively, all safety and environmental issues would have to be addressed at the time of the staff's review of a COL submitted under 10 CFR Part 52 if no ESP for the site were referenced. Although actual construction and operation of the facility would not take place unless and until a COL is granted, certain lead-time activities, such as ordering and procuring certain components and materials necessary to construct the plant, may begin before the COL is granted. As a result, without the ESP review process, there could be a considerable expenditure of funds, commitment of resources, and passage of time before site safety and environmental issues are finally resolved.

1.4 Alternatives to the Proposed Action

Section 102(2)(C)(iii) of NEPA states that EISs will include a detailed statement on alternatives to the proposed action. The NRC regulations for implementing Section 102(2) of NEPA provide for inclusion of a chapter in an EIS that discusses the environmental impacts of the proposed action and the alternatives (10 CFR Part 51, Subpart A, Appendix A). Chapter 8 of this EIS discusses the environmental impacts of three categories of alternatives: (1) alternative sites, (2) system design alternatives, and (3) the no-action alternative. The Commission determined that evaluation of energy alternatives is not required for an ESP.

The three alternative sites that are considered in detail in this EIS include lands within Dominion's Surry Power Station in Virginia, the U.S. Department of Energy Portsmouth Gaseous Diffusion Plant in Ohio, and the U.S. Department of Energy Savannah River Site in South Carolina. Chapter 8 also includes sections discussing (1) Dominion's region of interest for identification of alternative plant sites, (2) the methodology used by Dominion to select the proposed ESP site and alternative sites, and (3) generic issues that are consistent among the alternative sites. Chapter 9 compares the environmental impacts at the North Anna ESP site to the alternative sites and to the no-action alternative, and qualitatively determines whether any one of the alternative sites considered is obviously superior to the proposed site.

1.5 Compliance and Consultations

Prior to construction and operation of a new reactor or reactors, Dominion is required to hold certain Federal, State, and local environmental permits, as well as meet relevant Federal and State statutory requirements. In its ER, Dominion provided a list of environmental approvals and consultations associated with the North Anna ESP. Because an ESP is limited to establishing the acceptability of the proposed site for future development, with the exception of Clean Water Act and Coastal Zone Management Act certifications, the authorizations Dominion will need from Federal, State, and local authorities for construction and operation are not yet necessary; therefore, they have not been obtained.

Section 401 of the Clean Water Act specifies that "Any applicant for a Federal license or permit to conduct any activity including, but not limited to, the construction or operation of facilities, which may result in any discharge into the navigable waters, shall provide the licensing or permitting agency a certification from the State..." (401 certification). Dominion stated that it is unable to obtain 401 certification from the Commonwealth of Virginia at the ESP stage. In a letter dated October 6, 2005 (Dominion 2005b), responding to a request for additional information, Dominion stated:

> 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 the Virginia DEQ that no certification is required.

The Commonwealth of Virginia agreed to a permit condition prohibiting discharges to navigable waters until a 401 certification is obtained or waived by the Commonwealth (VDEQ 2006).

On November 10, 2006, Dominion requested a permit condition should an ESP be granted. The permit condition was submitted in response to a request from the Virginia Department of Game and Inland Fisheries (VDGIF) to perform an Instream Flow Incremental Methodology Study (IFIM). The staff recommends that the permit condition below be included in the ESP.

> Dominion shall conduct a comprehensive IFIM study, designed and monitored in cooperation and consultation with the VDGIF and the VDEQ, to address potential impacts of the proposed Units 3 and 4 upon the fishery and other aquatic resources of Lake Anna and downstream waters. Development of the scope-of-work for the IFIM study shall begin in 2007, and the IFIM study shall be completed prior to issuance of a COL for this project. Dominion agrees to consult with VDGIF and VDEQ regarding analysis and interpretation of the results of that study, and to abide by surface weather management, release, and instream flow conditions prescribed by VDGIF and VDEQ upon review of the completed IFIM study, and implemented through appropriate state or federal permits or licenses.

On November 22, 2006, Dominion provided certification from the Commonwealth of Virginia that its project complied with the enforceable policy of Virginia Coastal Zone Management Program. In addition, Dominion would need to obtain the other necessary authorizations in order to conduct the site preparation and preliminary construction activities allowed by 10 CFR 52.25(a). Authorizations and consultations potentially relevant to the proposed ESP are included in Appendix L.

The staff considered the necessary authorizations and consultations and contacted the appropriate Federal, State, and local agencies to identify any compliance, permit, or significant environmental issues of concern to the reviewing agencies that may impact the suitability of the North Anna ESP site for the construction and operation of the reactors that fall within the PPE.

1.6 Report Contents

The subsequent chapters of this EIS are organized as follows. Chapter 2 describes the proposed site and discusses the environment that would be affected by the addition of new reactor units. Chapter 3 examines the power plant characteristics to be used as the basis for evaluation of the environmental impacts. Chapters 4 and 5 examine site suitability by analyzing the environmental impacts of construction (Chapter 4) and operation (Chapter 5) of the proposed new units. Chapter 6 analyzes the environmental impacts of the fuel cycle, transportation of radioactive materials, and decommissioning, while Chapter 7 discusses the cumulative impacts of the proposed action. Chapter 8 explains how the alternative sites were selected, and analyzes the alternative sites and systems. Chapter 9 compares the proposed action with the alternatives, and Chapter 10 summarizes the findings of the preceding chapters and presents the staff's recommendation with respect to (1) the Commission's approval of the proposed site for an ESP based on the staff's evaluation of environmental impacts and (2) the site redress plan.

The appendices provide the following additional information:

- Appendix A – Contributors to the Environmental Impact Statement Related to Dominion Nuclear North Anna, LLC's Application for an Early Site Permit at the North Anna ESP Site

- Appendix B – Organizations Contacted

- Appendix C – Chronology of NRC Staff Environmental Review Correspondence Related to Dominion Nuclear North Anna, LLC's Application for an Early Site Permit (ESP) at the North Anna ESP Site

- Appendix D – Scoping Meeting Comments and Responses

- Appendix E – Comments and Responses to the Draft Environmental Impact Statement and Supplement to the Draft Environmental Impact Statement (Volume II)

- Appendix F – Key Correspondence (Volume II)

- Appendix G – Environmental Impacts of Transportation

- Appendix H – Supporting Documentation on Radiological Dose Assessment

- Appendix I – ESP Site Characteristics and Plant Parameter Envelope

- Appendix J – Dominion Nuclear North Anna, LLC Commitments and Assumptions and Permit Conditions

- Appendix K – Staff's Independent Review of Water Budget and Water Temperature Impacts

- Appendix L – Authorizations and Consultations.

1.7 References

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy,* Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy,* Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 52. Code of Federal Regulations, Title 10, *Energy,* Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

40 CFR Part 1508. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 1508, "Terminology and Index."

68 FR 65961. "Dominion Nuclear North Anna, LLC, North Anna Early Site Permit; Notice of Intent To Prepare an Environmental Impact Statement and Conduct Scoping Process." Vol. 68, No. 226. November 24, 2003.

69 FR 71854. "Dominion Nuclear North Anna, LLC; Notice of Availability of the Draft Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site and Associated Public Meeting." Vol. 68, No. 237. December 10, 2004.

69 FR 75535. "Environmental Protection Agency Environmental Impact Statements; Notice of Availability." Vol. 69, No. 242. December 17, 2004.

71 FR 28392. "Dominion Nuclear North Anna, LLC; Notice of Intent to prepare a supplement to the Draft Environmental Impact Statement." Vol. 71, No. 94. May 16, 2006.

71 FR 39372. "Dominion Nuclear North Anna, LLC; Notice of Availability of the Supplement to the Draft Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site and Associated Public Meeting." Vol. 71, No. 133. July 12, 2006.

71 FR 40096. "Environmental Protection Agency, Environmental Impact Statements; Notice of Availability." Vol. 71, No. 135. July 14, 2006.

71 FR 46927. "Dominion Nuclear North Anna, LLC; Notice of the extension of the Public Comment Period on the Supplement to the Draft Environmental Impact Statement for the Early Site Permit (ESP) at the North Anna ESP Site." Vol. 71, No. 157. August 15, 2006.

Clean Water Act (also referred to as the Federal Water Pollution Control Act). 33 USC 1251,et seq.

Coastal Zone Management Act of 1972 (CZMA). 16 USC 1451, et seq.

Code of Virginia, §62.1-44:(5a). Online at: http://leg1.state.va.us/cgi-bin/legp504.exe?000+cod+62.1-44.15.

Dominion Nuclear North Anna, LLC (Dominion). 2005a. Letter to the NRC dated November 22, 2005, Dominion's Submittal of ESP Application Schedule. Accession No. ML053260619.

Dominion Nuclear North Anna, LLC (Dominion). 2005b. Letter Response to Request for Additional Information dated July 20, 2005, Glen Allen, Virginia, October 6, 2005. Accession No. ML052790657.

Dominion Nuclear North Anna, LLC (Dominion). 2006a. *North Anna Early Site Permit Application – Part 3 – Environmental Report*. Revision 9, Glen Allen, Virginia.

Dominion Nuclear North Anna, LLC (Dominion). 2006b. *North Anna Early Site Permit Application – Part 4 – Programs and Plans*. Revision 9, Richmond, Virginia.

National Environmental Policy Act of 1969 (NEPA). 42 USC 4321, et seq.

U.S. Nuclear Regulatory Commission (NRC). 1987. *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*. NUREG-0800, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* NUREG-1437, Vols. 1 and 2, NRC, Washington, D.C. Available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437.

U.S. Nuclear Regulatory Commission (NRC). 2000. *Standard Review Plan for Environmental Reviews for Nuclear Power Plants*. NUREG-1555, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2003. Response to comments on Draft RS-002 *Processing Applications for Early Site Permits*. Accession No. ML031710698.

U.S. Nuclear Regulatory Commission (NRC). 2004a. *Draft Environmental Impact Statement for an Early Site Permit (ESP) for the North Anna ESP Site*. NUREG-1811, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2004b. *Processing Applications for Early Site Permits*. RS-002, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2005a. Letter Response to NEI Letter dated February 10, 2005, Concerning Industry Feedback and Position on the Extent of NRC Environmental Reviews at the Combined License Stage when an Applicant References an Early Site Permit. July 6, 2005. Washington D.C. Accession No. ML051050031.

U.S. Nuclear Regulatory Commission (NRC). 2005b. *Safety Evaluation Report for an Early Site Permit (ESP) at the North Anna ESP Site.* NUREG-1835. Accession No. ML052710305. Available at http://www.nrc.gov/reactors/new-licensing/esp/north-anna.html.

U.S. Nuclear Regulatory Commission (NRC). 2006a. *Draft Environmental Impact Statement for an Early Site Permit (ESP) for the North Anna ESP Site, Supplement 1*. NUREG-1811, Washington D.C.

U.S. Nuclear Regulatory Commission (NRC). 2006b. *Supplement to the Final Safety Evaluation Report for an Early Site Permit (ESP) at the North Anna ESP Site.* September 2006. Accession No. ML063170371.

Virginia Department of Environmental Quality (VDEQ). 2006. Letter to NRC concerning Dominion Nuclear North Anna Early Site Permit Application, § 401 Certification of the Federal Clean Water Act. June 16, 2006. Accession No. ML061720278.

2.0 Affected Environment

The site proposed by Dominion Nuclear North Anna, LLC (Dominion) for an early site permit (ESP) is located in Louisa County, Virginia, within the existing boundaries of the currently operating North Anna Power Station (NAPS) (Dominion 2006a). Virginia Electric and Power Company (referred to as Virginia Power or VEPCo) and Dominion are wholly owned subsidiaries of Dominion Resources, Inc. The site is on the shore of Lake Anna approximately 64 km (40 mi) north-northwest of Richmond. Two operating nuclear generating units, Units 1 and 2, are currently located on the NAPS site, and a small hydroelectric power plant is located at the base of the North Anna Dam.

The station location is described in Section 2.1, followed by a description of associated land, meteorology and air quality, geology, radiological environment, hydrology, ecology, socioeconomics, historic and cultural resources, and environmental justice in Sections 2.2 through 2.10, respectively. Section 2.11 examines related Federal projects, and references are presented in Section 2.12.

2.1 Site Location

The proposed location for Units 3 and 4 is wholly within the NAPS site and is west of and adjacent to the existing facilities of NAPS Units 1 and 2 (Figure 2-1). Two other NAPS units received construction permits on July 26, 1974, but were not constructed. The NAPS site is located in rural Louisa County, which had a population of about 25,000 in 2000. NAPS is located within a triangle formed by the cities of Richmond, Charlottesville, and Fredericksburg, Virginia. Figure 2-2 shows the location of NAPS in relation to the major cities and towns within an 80-km (50-mi) radius. Interstate Highway 95 (I-95) passes within 26 km (16 mi) of the NAPS site, and Interstate 64 passes within 29 km (18 mi). The nearest incorporated community is the town of Mineral, which is approximately 10 km (6 mi) southwest of NAPS. Louisa, the county seat, is 19 km (12 mi) west of the site. NAPS is situated on a peninsula on the southern shore of Lake Anna, approximately 8 km (5 mi) upstream from North Anna Dam.

NAPS occupies approximately 422 ha (1043 ac) of land. In addition, the waste heat treatment lagoons cover approximately 1400 ha (3400 ac), as shown in Figure 2-3. All site land, subsurface lands, and mineral rights are owned jointly by Virginia Power, a subsidiary of Dominion Resources, Inc., and Old Dominion Electric Cooperative. No public or commercial highways, railroads, or waterways traverse the site. 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.

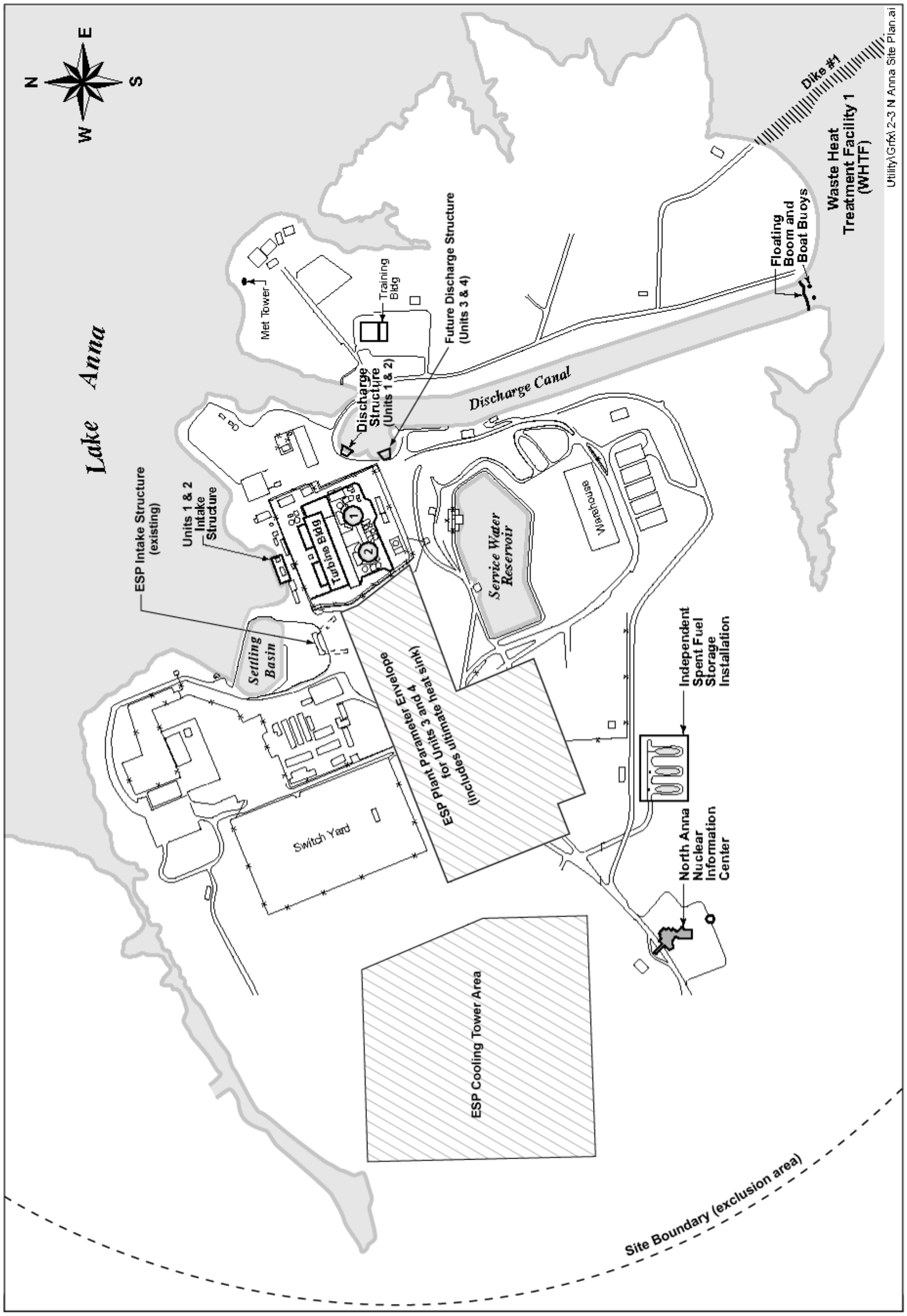

Figure 2-1. North Anna ESP Site Boundaries within the Existing NAPS Site

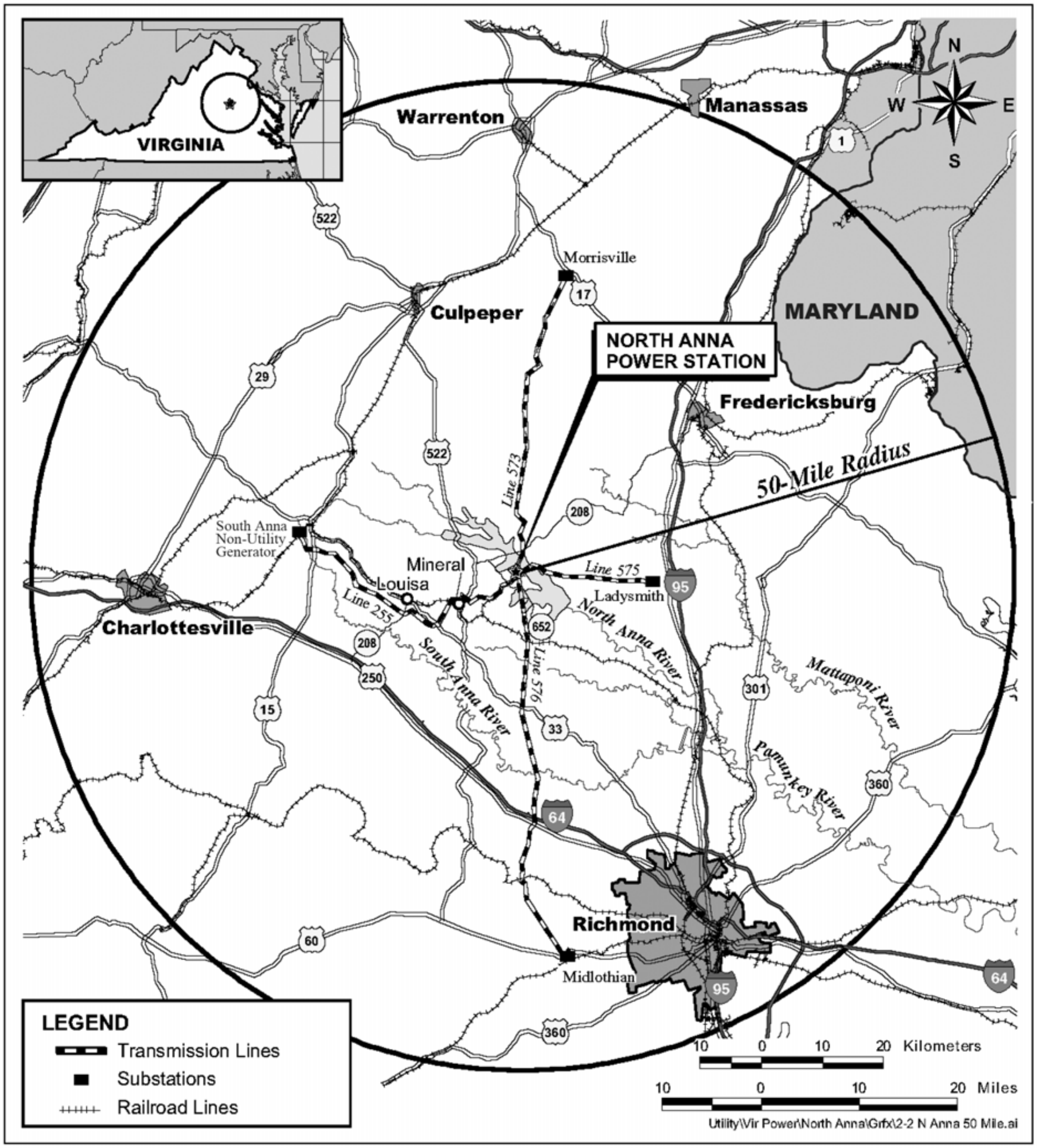

Figure 2-2. Location of North Anna Power Station, 80-km (50-mi) Region

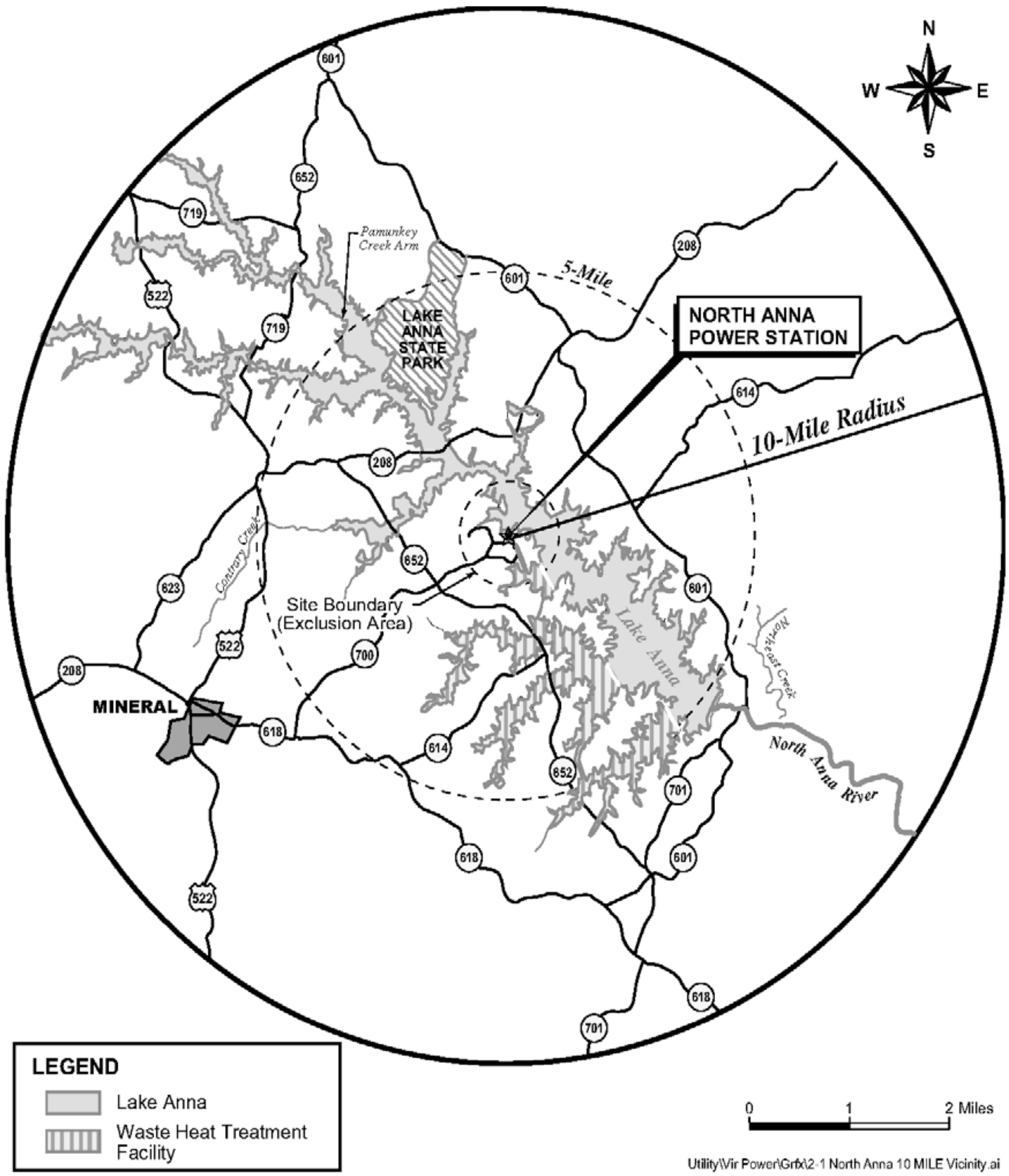

Figure 2-3. North Anna Power Station Vicinity Map, 16-km (10-mi) Region

The Lake Anna reservoir (or “the reservoir”) was formed by impounding the North Anna River above the North Anna Dam. Construction of the dam was permitted by the Virginia State Corporation Commission in 1969 (Virginia State Corporation Commission 1969). The Lake Anna reservoir is divided into two distinct bodies of water, Lake Anna and the Waste Heat Treatment Facility (WHTF). The WHTF is composed of three lagoons and is designated by the Commonwealth of Virginia as a waste heat treatment facility in Dominion’s Virginia Pollutant Discharge Elimination System (VPDES) permit (VDEQ 2001) for NAPS.

Lake Anna, which was created as a source of cooling water for NAPS, has become a popular recreation area, and the dam provides downstream flood control. The lake is not used as a source of potable or industrial water, except for the NAPS Units 1 and 2. Virginia Power owns the land below the surface of and around the lake up to the 78-m (255-ft) high-water mark above MSL. Since its completion, recreational use and residential development has grown significantly around Lake Anna.

A Lake Anna Special Area Plan was developed by local jurisdictions to coordinate planning efforts by Louisa, Orange, and Spotsylvania Counties for the Lake Anna region and watershed. The plan was released in March 2000 (Lake Anna Special Area Plan Committee 2000).

2.2 Land

This section discusses land-related issues for the North Anna ESP site. Section 2.2.1 describes the site and the vicinity around the site. Section 2.2.2 discusses the existing electric power transmission line rights-of-way and offsite areas. Section 2.2.3 discusses the region, defined as the area within 80 km (50 mi) of the NAPS boundary.

2.2.1 The Site and Vicinity

The plant site proposed by Dominion in its ESP application is located in Louisa County in northeastern Virginia. The proposed site is wholly within the existing boundaries of the NAPS site. The proposed Units 3 and 4 would be sited adjacent to Dominion’s existing Units 1 and 2.

The NAPS site is situated on a peninsula of Lake Anna’s southern shore at the end of State Route (SR) 700. Lake Anna, an artificial reservoir, was created in 1971 by Virginia Power by erecting a dam on the main stem of the North Anna River. The reservoir was filled by December 1972. Downstream of the dam, the North Anna River flows southeasterly, joining the South Anna River to form the Pamunkey River about 43 km (27 mi) southeast of the NAPS site. The earthen dam that creates Lake Anna is about 8 km (5 mi) southeast of NAPS.

The Lake Anna reservoir (or “the reservoir”) was formed by impounding the North Anna River above the North Anna Dam. Construction of the dam was licensed by the Virginia State

Corporation Commission in 1969 (Virginia State Corporation Commission 1969). The Lake Anna reservoir is divided into two distinct bodies of water, Lake Anna and the Waste Heat Treatment Facility (WHTF). The WHTF is composed of three lagoons and is designated by the Commonwealth of Virginia as a waste heat treatment facility (Figure 2-4). The lagoons have a total surface area of approximately 1400 ha (3400 ac) and are separated from Lake Anna by a series of dikes. The main body of the lake is approximately 27 km (17 mi) long with 435 km (272 mi) of irregular shoreline and approximately 3900 ha (9600 ac) of water surface. The land adjacent to Lake Anna is becoming increasingly residential as the area is developed. No new transportation routes (roads or railroad lines) or new industrial activities are currently planned in the vicinity of NAPS.

Virginia Power and Old Dominion Electric Cooperative own, and Virginia Power controls, all of the land within the NAPS boundary, both above and beneath the water surface, including those portions of Lake Anna and the waste heat treatment lagoons that lie within the site boundary. The NAPS property comprises 729 ha (1803 ac), about 307 ha (760 ac) of which are covered by water. Virginia Power and Old Dominion Electric Cooperative also own all the land outside the NAPS boundary that forms Lake Anna, up to the expected high-water mark (i.e., elevation 78 m [255 ft] above MSL). The NAPS site and all supporting facilities, including Lake Anna and the waste heat treatment lagoons, the earthen dam that forms Lake Anna, dikes, railroad spur, and roads constitute approximately 7544 ha (18,643 ac). Virginia Power also owns and operates the North Anna Hydroelectric Project, an 855-kW(e)-capacity hydroelectric power plant at the base of the dam that forms Lake Anna.

The primary land cover on the NAPS site is pine and pine-hardwood mixed forest (70 percent). Approximately 20 percent of the site is used for nuclear power station facilities and activities including 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). About 10 percent of the site is cleared area that includes the landscaped ground, open areas, laydown areas, three historic cemeteries, a weapons range used for security training, and a recreation and picnic area used by employees of Dominion Resources, Inc., and its subsidiaries.

Geographically, NAPS is located within the central Piedmont Plateau Physiographic Province. The topography of the site is characterized as a gently undulating surface that varies from 60 m (200 ft) to 152 m (500 ft) above MSL. The Blue Ridge Mountains lie approximately 73 km (45 mi) northwest of the site.

Louisa County has two incorporated towns, Louisa and Mineral. Louisa is the county seat and has a population of approximately 1400. Mineral has a population of approximately 425 and is the largest community within 16 km (10 mi) of NAPS. The county is largely rural with a

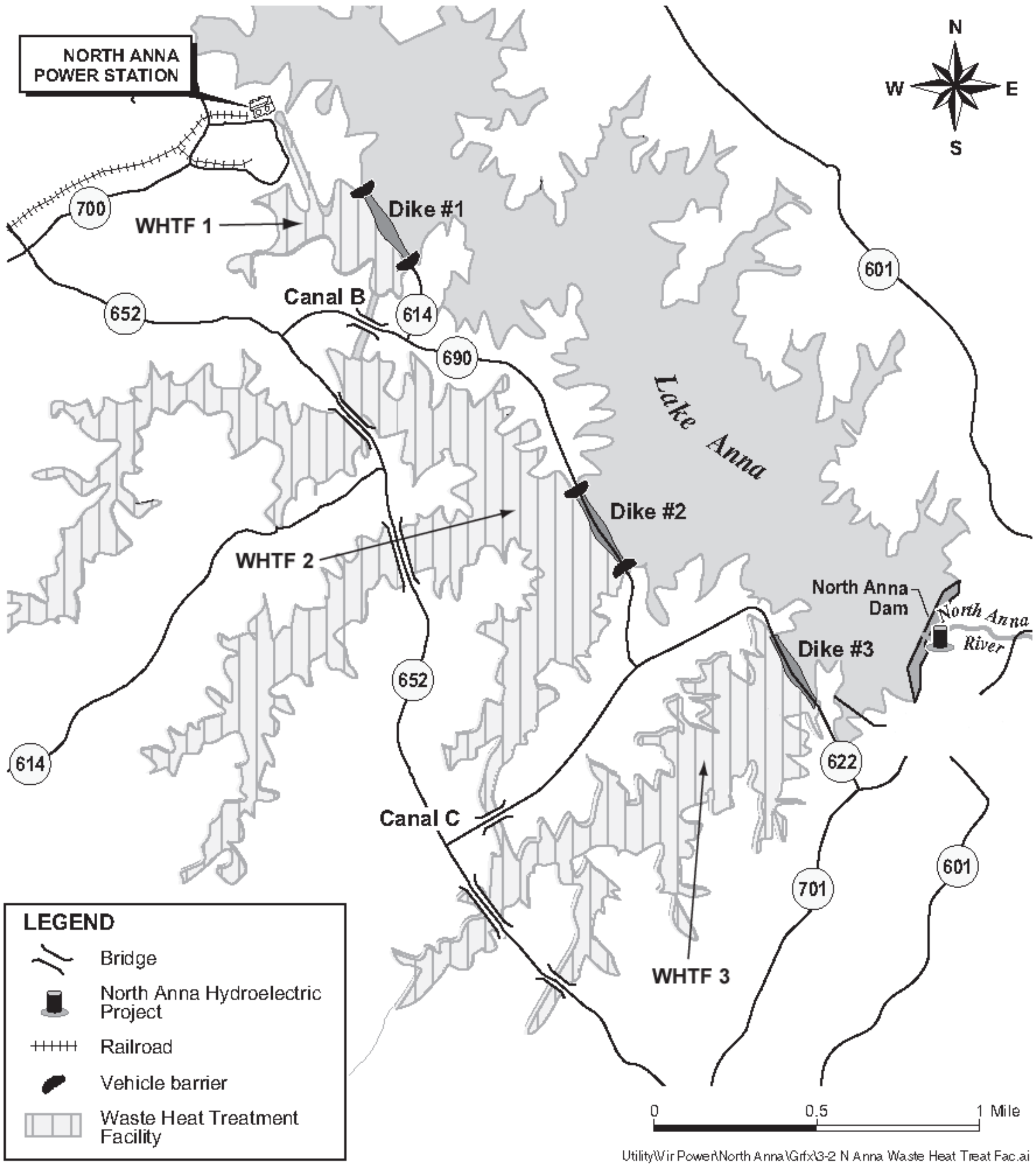

Figure 2-4. Lake Anna and the North Anna Power Station Waste Heat Treatment Facility

population density of about 43 people/mi^2. About 10 percent of the county is developed as urban, residential, or industrial; 71 percent is natural and planted forest lands; 16 percent is crop, pasture, and open land; and 3 percent is covered by water (Louisa County 2003).

Each Virginia county is required by Section 15.2-2223 of the Code of Virginia to have a comprehensive plan for the physical development of the territory within its jurisdiction. The comprehensive plan for Louisa County was issued in September 2001 (Louisa County 2001); the Spotsylvania County Plan was issued in February 2002 (Spotsylvania County 2002); and the Orange County comprehensive plan was issued September 1999 (Orange County Office of Planning and Zoning 1999). The Lake Anna Special Area Plan was issued in March 2000 (Lake Anna Special Area Plan Committee 2000).

Louisa County's comprehensive plan identifies two existing mining activities in the county (Louisa County 2001). Virginia Vermiculite Ltd. operates a vermiculite facility at the western end of the county (between the town of Louisa and the community of Boswells Tavern). A granite mining activity exists west of U.S. Highway 522 at the north end of the county. Various other mining activities have been proposed (Louisa County 2001).

Section 307(c)(3)(A) of the Coastal Zone Management Act (16 USC 1456(c)(3)(A)) requires an applicant seeking a Federal permit to conduct an activity that affects a coastal zone area to provide to the permitting agency a certification that the proposed activity complies with the enforceable policies of the state's coastal zone program. The Virginia Department of Environmental Quality (VDEQ) oversees this program for the Chesapeake Bay Coastal Zone Management Area. NAPS is not within Virginia's coastal zone for purposes of the Coastal Zone Management Act (VDEQ 2004a). However, Spotsylvania County and the associated portion of Lake Anna within Spotsylvania County are included within the Virginia coastal zone (VDEQ 2004a). Therefore, Dominion is required to provide a Coastal Zone Management Act certification to the Commonwealth of Virginia (VDEQ 2004b).

On November 22, 2006, Dominion provided certification from the Commonwealth of Virginia that its project complied with the enforceable policies of Virginia's Coastal Zone program (Dominion 2006d).

2.2.2 Transmission Line Rights-of-Way and Offsite Areas

One 230-kV transmission line and three 500-kV transmission lines leave the NAPS site switchyard. Each transmission line occupies a separate right-of-way, which ranges in width from 37 to 84 m (120 to 275 ft) and 24 to 66 km (15 to 41 mi) in length, covering a total of approximately 1174 ha (2900 ac) (Dominion 2006a). The transmission line 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, as shown in Figure 2-2.

The NAPS transmission line rights-of-way were constructed between 1973 and 1984, and pass through typical north-central Virginia land, such as row crops, pastures, forests and old fields, hardwood forests, and shrub bogs. No areas designated by the U.S. Fish and Wildlife Service (FWS) or VDEQ as "critical habitat" for endangered species exist at the ESP site or in any of the associated transmission line rights-of-way. The rights-of-way do not cross any State or Federal parks, wildlife refuges, or wildlife management areas.

Virginia Power maintains rights-of-way in timberlands and in the vicinity of road crossings on a 3-year mowing cycle. In areas inaccessible to mowers, non-restricted herbicides are used. In areas of dense vegetation or wetlands, maintenance by hand treatments may be used.

Areas of rare or sensitive plant species are identified and avoided, or modified treatment practices are used to avoid adverse impacts. Vegetation treatments have been developed in cooperation with the Virginia Department of Conservation and Recreation (VDCR) Natural Heritage Program.

Initial evaluations by Dominion show that any two of the 500-kV transmission lines together with the 230-kV line would have sufficient capacity to carry the total output of the proposed new units in addition to the existing units. If Dominion were to decide to proceed with development of the proposed ESP units, a system study (load flow) modeling these lines, including the additional power from the proposed new units, would be performed.

2.2.3 The Region

Regionally, NAPS is approximately 64 km (40 mi) north-northwest of Richmond, Virginia; 58 km (36 mi) east of Charlottesville, Virginia; 35 km (22 mi) southwest of Fredericksburg, Virginia; and 112 km (70 mi) southwest of Washington, D.C. I-95 and I-64 pass within 26 km (16 mi) to the east and 29 km (18 mi) to the south of the site, respectively. U.S. Route 1 is 24 km (15 mi) east of the site.

The region, defined as up to 80 km (50 mi) beyond the NAPS 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 the city of Fredericksburg and a portion of Charles County in Maryland. Major waterways, highways, roads, railroads, and other transportation routes in the region are shown in Figures 2-2 and 2-3.

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 I-95 and I-64 contain the highest density of residential, commercial, and industrial land-use. Land use in the immediate vicinity of NAPS and the areas outside the noted metropolitan areas and transportation corridors is primarily forest and agriculture. 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.

Land use information for the three counties that border on Lake Anna – Louisa, Orange, Spotsylvania and nearby Henrico County – is provided in Table 2-1.

Two major airports operate within the region: Richmond International Airport and Charlottesville-Albemarle County Airport, approximately 72 km (45 mi) southeast and 64 km (40 mi) west of NAPS, respectively. Three smaller airports are located within 24 km (15 mi) of NAPS: Lake Anna Airport, Louisa County Airport, and Cub Field. These smaller airports are located 11 km (7 mi) south-southwest, 18 km (11 mi) west-southwest, and 16 km (10 mi) southwest of the site, respectively.

2.3 Meteorology and Air Quality

Section 2.3 describes the general climate of the proposed ESP site and the regional meteorological conditions that were used as the basis for evaluating design and operational conditions for the prospective new units at the NAPS site, and to evaluate construction and operational impacts. General climate information was obtained from data published through the National Climatic Data Center in Asheville, North Carolina. Information for onsite meteorological conditions was obtained from the meteorological stations that serve NAPS.

The onsite primary meteorological tower is located about 530 m (1750 ft) east-northeast from the NAPS Unit 1 containment building (Dominion 2006a). The wind speed, wind direction, ambient and dew point temperatures, and atmospheric stability data are collected from sensors located on the tower. These data are considered representative of the ESP site.

2.3.1 Climate

The ESP site is located in the Piedmont region of Virginia. The climate in this region is considered continental. Summers are generally warm and humid, while winters are generally mild. Temperatures in the region rarely exceed 37.8°C (100°F) or fall below -18°C (0°F). The Blue Ridge Mountains located west of NAPS act as a partial barrier to episodes of cold, continental air in the winter. These mountains also tend to channel regional wind flow along a general north-south orientation.

Table 2-1. Land Use in Henrico, Louisa, Orange, and Spotsylvania Counties[a]

County and Land Use	Hectares	Acres	Percent of Total
Henrico			
Residential	14,865	36,732	23.5
Commercial	2094	5175	3.3
Industrial	1451	3586	2.3
Undeveloped[b]	27,744	68,554	43.9
Water	1757	4341	2.8
Other[c]	15,303	37,812	24.2
Total Henrico	63,214	156,200	100.0
Louisa			
Residential	7322	17,655	5.0
Agriculture	31,979	79,019	23.5
Forest	92,474	228,500	68.0
Water	3994	9868	3.0
Other[d]	649	1604	0.5
Total Louisa	136,418	336,646	100.0[e]
Orange			
Developed land[f]	4597	11,360	5.0
Agriculture	34,021	84,064	37.0
Forest	53,330	131,776	58.0
Water	N/A	N/A	
Total Orange	91,948	227,200	100.0[e]
Spotsylvania			
Residential	22,793	56,320	22.0
Developed land[g]	3108	7680	3.0
Agriculture	18,649	46,080	18.0
Forest	53,874	133,120	52.0
Other	5180	12,800	5.0
Total Spotsylvania	103,604	256,000	100.0

(a) The City of Richmond is heavily developed. For this reason, the land use of this jurisdiction is not discussed.
(b) Includes land being used for agricultural purposes.
(c) Includes public and semi-public (churches, schools, parks, etc.) and miscellaneous land classifications (rights-of-way, utilities, transportation and communications facilities).
(d) Includes commercial and industrial lands.
(e) Numbers have been adjusted to achieve a total of 100 percent.
(f) Developed land is defined to include residential, commercial, industrial, and public use.
(g) Developed land is defined to include industrial and commercial.
N/A not available
Source: NRC 2002.

Data from Richmond Airport are considered representative of long-term climate conditions at the site. Based on data presented in the ER (Dominion 2006a), Richmond receives an annual average rainfall of 109.6 cm (43.16 in.). Normal monthly rainfall is equally distributed throughout the year with maximum amounts of 12.8 cm (5.03 in.) and 11.2 cm (4.40 in.) occurring in July and August, respectively, and the minimum of 7.5 cm (2.96 in.) during April. The maximum monthly rainfall amounting to 47.9 cm (18.87 in.) occurred in July 1945, and the minimum amounting to 0.03 cm (0.01 in.) occurred in October 2000.

Richmond averages about 41.4 cm (16.3 in.) of snowfall annually with the majority occurring in January and February. The maximum monthly snowfall was 72.4 cm (28.5 in.), which occurred in January 1940. The maximum snow depth recorded from a single event was 51 cm (20 in.) in February 1922.

The annual average temperature for the Richmond airport is 14.3°C (57.7°F). July has the highest annual average monthly temperature of 25.6°C (78.0°F). The highest recorded temperature is 40.6°C (105.0°F), which occurred in July 1977, while the lowest recorded temperature is -24.4°C (-12°F), which occurred in January 1940 (NOAA 2001).

2.3.1.1 Wind

Based on data collected from the onsite meteorological station starting as early as 1974, the prevailing winds are from the south-southwest at both the 10- and 48.4-m (33- and 159-ft) levels (Dominion 2006a), although there is some seasonal variation. On a seasonal basis, the prevailing winds are from the south-southwest at both levels in the summer. During the winter, the prevailing winds are from the northwest for the lowest level, and north for the upper level. For the spring and fall, the prevailing winds at the two observation levels vary, with the lower-level winds from the north or northwest, while the upper-level winds are from the south-southwest. This information is consistent with local topography and regional climatic activities.

The mean annual wind speeds at the North Anna ESP site are 2.8 m/sec (6.3 mph) and 3.8 m/sec (8.6 mph) at the lower- and upper-tower levels, respectively (Dominion 2006a). The mean wind speed varies seasonally. For both levels, the highest wind speeds occur during the spring while the lowest occur during the summer. The annual frequency of calm wind speed conditions are 0.4 and 0.8 percent for the lower- and upper-tower levels, respectively (Dominion 2006a).

Wind persistence is defined as a continuous flow from a given direction or range of directions. This is determined by grouping continuous hourly wind direction readings into one of 16 22.5-degree cardinal range directions, such as north through north-northwest. The longest wind persistence event at the lowest level is 26 hours from the north. However, events of 25 and 24 hours have occurred from the northwest and the north-northwest, respectively (Dominion 2006a). For the upper level, the longest wind persistence occurrence was 33 hours from the west-northwest. At this level, three 30-hour wind persistence events have occurred from the north-northwest, north, and south-southwest directions (Dominion 2006a).

2.3.1.2 Atmospheric Stability

Atmospheric stability can be determined by the magnitude of change in the ambient temperature between vertical levels of the atmosphere, known as the delta-T method as defined by NRC. The two temperature measurement levels of the onsite meteorological station at NAPS are 10 and 48.4 m (33 and 159 ft).

On an annual basis, the highest frequency of stability class occurrence is neutral (30.7 percent) followed by slightly stable (26.1 percent). The mean wind speeds with these two stability classes are 3.1 m/sec (7.0 mph) and 2.3 m/sec (5.2 mph), respectively. Extremely unstable conditions occur 20 percent of the time with a mean wind speed of 3.2 m/sec (7.2 mph), while extremely stable conditions occur only 5.46 percent of the time with a mean wind speed of 1.3 m/sec (3.0 mph).

2.3.1.3 Temperature

Temperature measured at the lower level of the onsite meteorological station is considered representative of onsite conditions. The average temperature at this level is 13.2°C (55.8°F), while the normal temperature at the Richmond Airport is 14.3°C (57.7°F) (Dominion 2006a). A difference of several degrees is expected because the site is located in a rural area and onsite temperatures are moderated due to the presence of Lake Anna, while the Richmond Airport is located near a large city impacted by an urban heat-island effect. For comparison, annual average temperatures for the nearby towns of Louisa and Partlow in the vicinity of the NAPS site are 13.5°C (56.3°F) and 12.9°C (55.2°F), respectively.

2.3.1.4 Atmospheric Moisture

The moisture content of the atmosphere can be represented in a variety of ways. The most recognized is relative humidity. However, that parameter is not measured at the NAPS site; therefore data from Richmond is considered to be representative of the site. The normal annual relative humidity for Richmond is 70 percent, with the higher values expected to occur in the morning hours and lower values in the afternoon and evening (Dominion 2006a). Another measured parameter is wet-bulb temperature, which is used for cooling-system modeling studies. Based on a data record of 24 years (1973 to 1996), the 0.4 percent, 1 percent, and 2 percent wet-bulb temperatures measured in Richmond are 26.1°C (79°F), 25.6°C (78°F), and 25.0°C (77°F), respectively.

Fog is another relative indication of atmospheric moisture. Data collected at Richmond, based on 73 years of data, indicate heavy fog will occur on an average of 27.1 days per year (Dominion 2006a). Given the topography of the site compared to that of Richmond and locations near Lake Anna, a higher occurrence of heavy fog at the NAPS site is expected.

With the addition of combination wet and dry cooling towers at the site, the potential impacts from fogging, icing, and salt deposition might occur both within and outside the plant site boundary. The extent to which these events would occur depends on both the local meteorological conditions and the design of the wet and dry cooling towers. To determine the impact of the towers on the environment during operations (Chapter 5), Dominion used data collected onsite as well as data collected at nearby National Weather Service sites and an analytical computer code. The input data for this code included hourly wind speed and direction data and dry bulb and dew point temperature data collected at the 10-m (33-ft) level of the primary onsite meteorological tower during the years of 1998 through 2000, and sea-level pressure, cloud-cover, visibility, and mixing-height data obtained from the nearby National Weather Service Stations in Richmond and at Dulles Airport in Virginia. The information collected from these sources was input to an analytical code that estimated the potential impacts outlined in Chapter 5.

A general characterization of onsite humidity conditions and the potential for fogging resulting from increased emission of water vapor to the atmosphere can be expressed in terms of dew point depression, which is the difference between dry bulb and dew point temperature. In response to questions raised by the staff, summary onsite data were provided for the number of hours when the dew point depression was predicted to be five degrees or less as a function of season, time of day, and wind direction for the same period that was used to estimate the impacts from combination wet and dry cooling tower operation (Dominion 2006b). For the winter and spring seasons, the greatest occurrence when the dew point depression was five degrees or less occurred when winds were from the west-northwest. During the summer season, the greatest occurrence was with winds from the southwest, while in the fall the greatest occurrence was with winds from the west. In all cases, the greatest occurrence was during the early morning hours. For all seasons and all wind directions, the amount of time that the dew point depression was five degrees or less ranged from 37 percent (winter) to 28 percent (spring).

2.3.1.5 Severe Weather

The site can experience severe weather in the form of thunderstorms, hail, tornadoes, snow and ice, and hurricanes. Other significant weather events also are associated with several of these events, such as hail and lighting occurring with thunderstorms, and high winds associated with tornadoes. The probability of occurrence of impact from a tropical storm at the site is far greater than a hurricane, given the fact that hurricanes lose intensity and degrade into tropical storms soon after they make landfall.

The most representative long-term climatic data for thunderstorm occurrence at the site is data from the Richmond Airport (NOAA 2001). On average, 36 thunderstorms are expected per year. The maximum number (8 or more) is expected to occur in July with the minimum number (much less than 1) occurring during the period from November through February. The site has expected 100-year return periods for 1-hour and 24-hour rainfall totals of 9 cm (3.5 in.), and 20 cm (8.0 in.), respectively (NCDC 2003). For perspective, the highest recorded 24-hour precipitation amount near the site was 284 mm (11.2 in.). That occurred in Louisa in August 1969 in conjunction with the passage of the remnants of hurricane Camille through the region (Dominion 2006a). With the passage of tropical storm Gaston on August 30, 2004, there were reports of up to 330 mm (13 in.) of rainfall in the Richmond, Virginia area (NCDC 2004).

The occurrence of hail is typically associated with more organized thunderstorms. Recent data from the National Climatic Data Center indicated that 18 hail events have been reported for Louisa County during the period from January 1, 1955, to July 31, 2003 (NCDC 2003). Each occurrence was in either the afternoon or the early evening. In four occurrences, hailstones with diameters of 4.4 cm (1.8 in.) were observed, and in one occurrence, 3.8-cm (1.5-in.) diameter hailstones were reported. The other events produced hailstones typically around 2.5 cm (1.0 in.) in diameter.

For the period of January 1950 through July 31, 2003, the site was not on the path of either a hurricane or tropical storm. This is not unexpected given the inland location of the site and the fact that hurricanes making landfall along the Atlantic coast lose intensity and degrade into tropical storms and then into a system of heavy rainfall before they fully dissipate. However, the site area has experienced the impacts of tropical storms that have passed in its vicinity. The one with the largest impact was Tropical Storm Floyd in September 1999. Rainfall at or exceeding 15 cm (6 in.) from this storm was recorded at two locations near the site. This storm produced a maximum 2-minute wind speed of 18 m/sec (40 mph), which was recorded at the Richmond Airport.

The site area is also susceptible to the occurrence of tornadoes and associated high winds. During the period from January 1, 1950, to July 31, 2003, a total of seven tornado sightings were reported for Louisa County (NCDC 2003). The strongest winds were associated with the tornado that occurred on August 9, 1962. Maximum wind speeds were estimated to be between 51 m/sec (113 mph) and 70 m/sec (157 mph). The most recent tornado sighting in Louisa County was on February 17, 1998.

Based on a 30-year data set of tornado occurrences in the United States, on the average, only six tornadoes are expected to occur in Virginia annually (Ramsdell and Andrews 1986). The best estimate tornado strike probability and 10^{-7} probability design wind speed for the ESP site are 1.6×10^{-4} yr^{-1} and 110 m/sec (246 mph), respectively (Ramsdell 2004).

Louisa County has experienced 30 snow and ice events during the period from December 28, 1993, to July 31, 2003 (NCDC 2003). Of that total, two events are specifically listed as ice storms with the most devastating occurring on December 23, 1998. That storm resulted in $20 million in property damage in the county. The other events are listed as heavy snow, winter storm, and winter weather/mix. The latter two events could have included some degree of icing, but with a much smaller impact compared to those listed as ice storms.

2.3.1.6 Meteorological Monitoring

The meteorological monitoring for the proposed ESP site would consist of the current onsite monitoring program for NAPS provided that obstructions (including trees and the structures that would be constructed) are at a distance of at least 10 times their height. The primary meteorological monitoring system consists of a Rohn Model 80 guyed 48.8-m (160-ft) tower instrumented at the 10-m (33-ft) and the 48.4-m (159-ft) levels. Wind speed, wind direction, horizontal wind fluctuation, and ambient temperature are measured at both levels. In addition, at the 10-m (33-ft) level, dew point temperature data is measured. Temperature difference is measured between the two levels with a separate temperature system, and precipitation data are collected at ground level. Data are collected on a digital data recording system that is located in an insulated building at the base of the tower. This system is interfaced with the intelligent remote multiplex system so it can be transmitted into the control room for NAPS and to the utilities operations center in Richmond for processing. The primary system is located approximately 530 m (1750 ft) east of the NAPS Unit 1 containment building.

A backup monitoring system is also operational at the NAPS site. The system consists of a Rohn Model 25 tower, a freestanding 10-m (33-ft) tower located 396 m (1300 ft) northeast of the NAPS Unit 1 containment building. At the top of the tower, wind speed, wind direction, and horizontal wind direction fluctuation data are collected. Data from this system are also collected on a digital data recording system in the insulated building at the base of the tower and transmitted into the control room for NAPS and to the utilities operations center in Richmond for processing.

Data recovery rates for the period from January 1, 1996, to December 31, 2001, for the primary monitoring system, including reliable atmospheric stability information, ranged from 99.30 percent for the upper-level wind data in 1996 to 90.09 percent for the same data set in 1997. For each year in the data set the recovery rate exceeded 90 percent for both levels. The frequency of wind speed, class wind direction, and stability class are available in the updated Final Safety Analysis Report for NAPS Unit 1 and 2 (VEPCo 2002a).

The meteorological data for the period of January 1, 1996, to December 31, 1998, were used to generate atmospheric dispersion factors (χ/Q values) used to estimate radiological impacts in the areas surrounding the ESP site.

The NRC staff expects that the current monitoring systems would remain operational during the site preparation and construction phases as well as during the operational phase. Any anticipated modifications to the system would be limited to transmitting appropriate meteorological data to the additional control rooms.

The staff reviewed the available information relative to the onsite meteorological measurements program and the data collected by the program. The staff concludes that the system provides adequate data to represent onsite meteorological conditions as required by Title 10 of the Code of Federal Regulations (CFR) 100.20. The onsite data also provides an acceptable basis for making estimates of atmospheric dispersion for design-basis accidents and routine releases from the plant to meet the requirements of 10 CFR 50.34 and 10 CFR Part 50, Appendix I.

2.3.2 Air Quality

The county in which the ESP site is located, Louisa County, is within the Northeastern Virginia Intrastate Air Quality Control Region (AQCR). With the exception of Frederick County, the counties in this AQCR are designated as in attainment or unclassified for all criteria pollutants for which National Ambient Air Quality Standards have been established (40 CFR 81.347). Attainment areas are areas where the ambient air quality levels are better than designated by the U.S. Environmental Protection Agency (EPA). Frederick County is designated as in nonattainment for the new EPA 8-hr ozone standard. Louisa County and Spotsylvania County (70 FR 76165) are classified as in attainment of the ozone standard (40 CFR 81.347).

Within the Commonwealth of Virginia, the EPA has designated two Class 1 areas where visibility is an important issue (40 CFR 81.433) – James River Face Wilderness and Shenandoah National Park. The boundary of the closer of these areas, Shenandoah National Park, is within 76 km (42 mi) of NAPS (NRC 2002).

VDEQ would regulate airborne emissions at the North Anna ESP site during construction activities and for routine non-radiological emissions during operation. Currently, the applicant holds an Exclusionary General Permit from VDEQ under Title 9 of the Virginia Administrative Code for all non-radiological airborne emissions resulting from current plant operations. Under this permit, no air emission or air quality monitoring is performed at the site. Compliance is based on estimated emissions using fuel sulfur content and fuel consumption records with a limit on the hours of operation for boilers and diesel generators. If Dominion anticipates that the facility will exceed the emission limits specified as part of the permit, then it would be required to apply for a permit application under Title 5 of Virginia's Administrative Code and maintain more stringent recordkeeping and reporting requirements.

Under the air quality permit for the existing units, the site provides VDEQ with the necessary records and a compliance certification on an annual basis. Based on the 2000 emission statement filed by Dominion with VDEQ, estimated emissions were well below the limits established in the Exclusionary Permit. Any emissions from the operation of the proposed units are not expected to jeopardize compliance with requirements set forth under the current permit. However, additional records would have to be submitted along with a certification for all emission sources at the North Anna ESP site. The additional emissions are expected to be limited to a short test period.

2.4 Geology

A description of the geological, seismological, and geotechnical conditions at the proposed site is provided in Section 2.6 of the Environmental Report (ER) submitted by Dominion (Dominion 2006a). This description was based on earlier reports prepared for the two existing units at the site (VEPCo 2002a; Dames and Moore 1969), the two units proposed but never constructed (Dames and Moore 1971), and the independent spent fuel storage installation (ISFSI) constructed for the two existing units (VEPCo 2002b). Additionally, results of subsurface investigations performed in 2002 as part of the ESP application provided further basis for this description. The staff's description of site and vicinity geological features and the detailed analyses and evaluation of geological, seismological, and geotechnical data as required for an assessment of the site-safety issues related to the specific proposed ESP site are included in the staff's safety evaluation report (NRC 2006).

The North Anna ESP site lies within the Piedmont Physiographic Province (Trapp and Horn 2000). The Piedmont Province is bounded on the west by the Blue Ridge Province and on the east by the Coastal Province. The boundary between the Coastal Province and the Piedmont Province is the Fall Line. The Fall Line is a low east-facing cliff paralleling the Atlantic coastline from New Jersey to the Carolinas. It separates hard Paleozoic metamorphic rocks of the Appalachian Piedmont to the west from the softer, gently dipping Mesozoic and Tertiary sedimentary rocks of the Coastal Plain. This erosional scarp, the site of many waterfalls, often represents an obstruction to upstream passage of migratory fish.

The ESP site is underlain by rocks of the Ta River Metamorphic Suite, which extend thousands of feet below the surface. The crystalline metamorphic rocks near the surface have undergone extensive weathering to create a layer of saprolite about 30 m (100 ft) thick beneath the site. Unconfined aquifer systems exist in the saprolite and in fractures within the crystalline bedrock. The water table around the ESP site is a slightly subdued version of the topography, which is characterized by a gently undulating surface varying in elevation from about 60 to 150 m (200 to 500 ft) above MSL.

Sulfide and gold deposits have been mined in the vicinity of the NAPS ESP site. Mining operations have resulted in significant degradation of Contrary Creek, which drains into Lake Anna. The low pH and high metal concentrations in Contrary Creek are quickly buffered and diluted as Contrary Creek enters Lake Anna. Dominion states that the ESP site has not been, nor would be expected in the future to be, affected by such mining activities.

The geotechnical properties of the saprolite beneath the site are unsuitable for use as a structural fill material for plant construction. Therefore, structural fill material will need to be imported to the ESP site during construction and excavated material will have to be removed to another location.

Given Dominion's proposed use of best management construction practices, the gently rolling terrain and geotechnical properties of the saprolite render landslides in the region of the site unlikely. This conclusion is supported by a study of historical hillslope failures including field reconnaissance, air-photo interpretation, a literature search for available information on landslides, review of existing literature, and discussions with researchers familiar with the site region (Dominion 2004a).

2.5 Radiological Environment

A radiological environmental monitoring program (REMP) has been conducted around the NAPS site since 1976 (NRC 1976). The REMP includes monitoring of the airborne exposure pathway, direct exposure pathway, water exposure pathway, aquatic exposure pathway from Lake Anna and the North Anna River, and ingestion exposure pathway in a 40-km (25-mi) radius of NAPS. The preoperational environmental radiation monitoring program sampled various media in the environment to establish a baseline to determine the magnitude and fluctuation of radioactivity in the environment once the units began operation (AEC 1973). The preoperational monitoring program included collection and analysis of samples of air particulates, precipitation, milk, crops, soil, well water, surface water, fish, and silt as well as measurement of ambient gamma radiation. After operation of NAPS Units 1 and 2 began, the monitoring program continued to assess the radiological impacts to workers, the public, and the environment. Modifications to the monitoring program are made based on changes in the area, such as milk production, agricultural uses, and changes in lake use. Radiological releases are summarized in the reports entitled *Annual Radiological Environmental Operating Program* and *Annual Radioactive Effluent Release Report*; reports are issued annually. The 2005 Annual Environmental Operating Report for NAPS (VEPCo 2006a) reported the estimated maximum dose to a hypothetical individual at the station boundary because of liquid and gaseous effluents released during 2005 to be 0.0038 mSv (0.38 mrem) compared to the approximately 3.6 mSv (360 mrem) received from background radiation. The limits for all radiological releases for Units 1 and 2 are specified in the Offsite Dose Calculation Manual (ODCM) (VEPCo 2006b).

The NRC staff reviewed historical data on releases and estimated occupational and population doses. The data and analysis showed that doses to the maximally exposed individuals around NAPS were a small fraction of the limits specified in Federal environmental radiation standards, 10 CFR Part 20; 10 CFR Part 50, Appendix I; and 40 CFR Part 190.

2.6 Water

This section describes the hydrological processes governing the movement and distribution of water in the existing environment at the ESP site. The historic critical low-water period of the existing environment with the existing NAPS units in operation were used throughout this analysis.

2.6.1 Hydrology

This section describes the site-specific and regional hydrological features of the existing environment that could be altered by the construction or operation of the proposed Units 3 and 4. A description of the site's hydrological features was presented in Section 2.3.1 of the ER (Dominion 2006a). The hydrological features of the site related to site safety (e.g., probable maximum flood) are described by Dominion in the Site Safety Analysis Report (SSAR) portion (Part 2) of the application (Dominion 2006a).

2.6.1.1 Surface Water Hydrology

The dominant hydrological feature of the NAPS site is the Lake Anna reservoir. The Lake Anna reservoir was formed by impounding the North Anna River above the North Anna Dam. The Lake Anna reservoir is divided into two distinct bodies of water, Lake Anna and the WHTF. At the normal "full" elevation of 76.2 m (250 ft) above MSL, Lake Anna has a surface area of 3900 ha (9600 ac), whereas the WHTF has a surface area of 1400 ha (3400 ac).

The reservoir formed behind Lake Anna Dam has a volume of 3.76×10^8 m^3 (3.05×10^5 acre-ft) at the normal pool level elevation of 76.2 m (250 ft) above MSL. An additional 3.02×10^8 m^3 (2.45×10^5 acre-ft) are available for flood control storage up to the crest of the dam at elevation 80.8 m (265 ft) above MSL. A spillway with three radial gates is capable of regulating large releases from the pool and two skimmer gates are able to regulate small releases. Generally, the gates are operated to maintain a steady pool elevation of 76.2 m (250 ft) above MSL. The staff independently determined the stage-storage relationship of the reservoir using Geographic Information Systems (GIS) methods and determined that the values presented by Dominion agreed with the staff's stage and storage relationship to within 2 percent (Dominion 2004a, 2006a).

The WHTF receives the heated discharges from the existing units and, because of time of travel and exposure to the atmosphere, dissipates some of the excess heat to the atmosphere before the water is returned to Lake Anna. The WHTF is composed of three lagoons. Each lagoon is separated from Lake Anna by a dike. The three lagoons are interconnected via two canals. Water returns to Lake Anna through a submerged weir in the dike which forms the third and final lagoon of the WHTF. The submerged weir, with its various stop-log configurations, regulates the elevation of the WHTF. Additionally, the submerged weir causes the water entering Lake Anna from the WHTF to enter the lake as a high-velocity submerged jet, which increases the thermal mixing relative to a surface release.

The watershed above the reservoir drains 888 km^2 (343 mi^2) of the eastern slopes of the southwestern mountains in the Appalachian Range. Water released from North Anna Dam flows about 55 km (34 mi) down the North Anna River until it joins the South Anna River to form the Pamunkey River. After flowing about 146 km (91 mi) from its origin, the Pamunkey River joins the Mattaponi River to form the York River. The York River flows about 56 km (35 mi) before it enters Chesapeake Bay approximately 24 km (15 mi) north of Hampton, Virginia. Virginia currently requires a minimum release of 1.1 m^3/s (40 cfs) from the North Anna Dam, except under drought conditions. When the lake surface falls below elevation 75.6 m (248 ft) MSL, the release is incrementally decreased to a minimum release of 0.57 m^3/s (20 cfs) (VDEQ 2001).

In an average year at the site, precipitation exceeds evaporation. Evaporation from the surface area of the Lake Anna reservoir reduces the total amount of water available to flow downstream of the dam. An approximation of the natural mean monthly and annual evaporation rates was obtained from Van der Leeden et al. (1990) for an unnamed reservoir in nearby Richmond, Virginia (40 mi [64 km] south-southeast of the site) at which the climate would be similar. The Van der Leeden et al. report identified this reservoir as having an average evaporation rate of 99 cm (39 in.) per year with a maximum average monthly evaporation of 15 cm (5.9 in.) in July. In addition to this natural evaporation, the WHTF and Lake Anna experience induced evaporation resulting from the heat added to the lake from the once-through heat dissipation systems for NAPS Units 1 and 2. These two components (presence of the reservoir plus waste reactor heat) combine to produce evaporation rates that likely exceed the historical pre-impoundment evapotranspiration rates that would have occurred in the area that the reservoir has inundated. Therefore, the presence of the reservoir and the discharge of heat to the reservoir from Units 1 and 2 have increased evaporation and reduced the total quantity of water available for release downstream of the dam. In drought years, the decrease in precipitation is often paired with an increase in evaporation, resulting in significant water deficits. However, the dam provides a beneficial downstream flow stabilization impact. The historical pre-dam minimum flows of 0.28 m^3/s (10 cfs) or less were recorded by the USGS for eight of the years between 1930 and 1976. Current post-dam minimum discharges are 0.57 m^3/s (20 cfs).

Seasonal patterns of precipitation and evaporation also impact water availability. While monthly averages of precipitation are relatively constant, ranging from a maximum of 13.0 cm (5.14 in.) in July to a minimum of 7.4 cm (2.9 in.) in April, monthly averages of evaporation from Richmond, Virginia range from a maximum of 14 cm (5.6 in.) in July to a minimum of 3.3 cm (1.3 in.) in January. Over an annual cycle this seasonal variability tends to result in a water deficit during July, August, and September and a water surplus the rest of the year.

2.6.1.2 Groundwater Hydrology

The North Anna ESP site lies within the Piedmont Physiographic Province. Aquifers occur in both the shallow saprolite layer and the deeper fractured crystalline rocks. Recharge of the aquifers in this region is predominately from local infiltration. The water table is considered a subdued reflection of the ground surface; therefore, the groundwater generally flows from ridges to valleys.

The hydraulic connection between the reservoir and nearby aquifers results in a rise of the water table for those aquifers in proximity of the lake. Given the relatively small fluctuations of lake water surface elevation, the water table in these nearby aquifers does not vary significantly. No aquifers in the Piedmont Province of Virginia have been designated as sole source aquifers by the EPA (2006).

2.6.1.3 Hydrological Monitoring

This section describes the pre-application hydrological monitoring programs. Thermal and chemical monitoring programs are discussed in Sections 2.6.3.3 and 2.6.3.4, respectively.

As a result of ongoing monitoring associated with the two existing units, Dominion was able to consider this existing monitoring program as part of the pre-application monitoring program for the ESP site. If the new units were built, many of these same monitoring activities would likely be continued and would become part of the operational monitoring for the new units (Dominion 2006a). Dominion collects the existing flow measurements directly associated with the current site operation that are required under the terms of the applicant's existing VPDES permit. Dominion also records lake level elevations at the dam. At the site, Dominion records data from 19 groundwater wells. Nine of the groundwater wells are associated with NAPS Units 1 and 2; one was installed near the ISFSI, and nine pre-ESP-application wells were installed in 2002.

At various times in the past, the U.S. Geological Survey (USGS) has maintained four streamflow gauges in the vicinity of the plant. Two gauges measured streamflows of tributaries draining into Lake Anna and two measured streamflows downstream of the North Anna Dam. The longest streamflow record exists for the North Anna River gauge (USGS Gauge 0167100) near Doswell, Virginia. This gauge reflected the release from Lake Anna and runoff from an additional 250 km^2 (97 mi^2) of watershed downstream of the North Anna Dam. Flow rates were recorded from April 1929 through October 1988. A streamflow gauge immediately downstream from the North Anna Dam (North Anna River near Partlow, Virginia [USGS Gauge 01670400]) recorded data from October 1978 to October 1995. The gauge on Contrary Creek (USGS Gauge 01670300), which drains into Lake Anna, reflected only 14 km^2 (5.53 mi^2) of the watershed and has a record from October 1975 to January 1987. Another stream gauge upstream of Lake Anna (Pamunkey Creek at Lahore, Virginia, USGS Gauge 01670180) recorded runoff from 105 km^2 (40.5 mi^2) of the Pamunkey Creek drainage for the period from August 1989 to July 1993. The two upstream gauges on Contrary Creek and Pamunkey Creek, recorded flows representative of 120 km^2 (46 mi^2) or approximately 13 percent of the total upstream area contributing flow to the reservoir. Because of the limited inflow data, it is not possible to create a reliable historical water budget for Lake Anna from available inflow and discharge measurements only.

Dominion records sufficient information to calculate discharge released through the dam by providing lake elevation and release structure settings (e.g., skimmer gate and radial gate openings). Such records are the only available discharge measurements for the North Anna River immediately downstream of the North Anna Dam since the Partlow gauge was discontinued in 1995.

No water velocity measurements within Lake Anna have been recorded. Velocity measurements are important for both understanding of the hydrodynamics of the lake and calibrating spatially distributed numerical models of fluid and heat transport process in the reservoir.

2.6.2 Water Use

Consideration of water use requires estimating the magnitude and timing of consumptive and non-consumptive water uses. Non-consumptive water use does not result in a reduction in the water supply available. For instance, water used to rinse fish impinged on intake screens off the screens would result in no change in the water supply, as the same volume of water pumped from the reservoir would eventually be returned to the reservoir. Consumptive water use results in a reduction of the water supply available. For instance, reservoir evaporation results in a transfer of water from the reservoir to the atmosphere, thereby reducing the lake volume. The following two sections describe the existing consumptive and non-consumptive uses of surface water and groundwater.

2.6.2.1 Surface Water Use

The existing NAPS units are the largest users of water in the region. When both Units 1 and 2 are operating, eight circulating water pumps draw water from Lake Anna at a maximum rate of 120 m^3/s (4246 cfs). The large volume of water withdrawn from Lake Anna for condenser cooling is entirely returned to the WHTF. While there is no consumptive use of water between the intake and discharge, the elevated temperature of the discharged water does result in induced evaporative losses from the WHTF and Lake Anna.

In Section 2.3 of the ER, Dominion identifies surface water users within the North Anna River drainage whose average daily withdrawal during any single month exceeds 38,000 L/d (10,000 gpd). Dominion identified these users from the water-use database maintained by VDEQ. Users include the NAPS existing units, Bear Island Paper Company, the Doswell Water Treatment Plant, and St. Laurent Paper Products Corporation.

In Section 4.2.3 of the ER, Dominion discusses the upstream land-use changes that might alter the inflow to the reservoir and downstream development that may increase the downstream demand for water. These projections are based on comprehensive plans for the three upstream counties (Louisa, Spotsylvania, and Orange Counties) and the four downstream counties (Hanover, Caroline, New Kent, and King William Counties).

Increases in development generally result in increased areas of impervious surfaces. Impervious surfaces result in less groundwater recharge and higher fractions of surface water runoff. Because of the limited projected development in the three upstream counties and policies promoting the use of storm water management practices that limit the impact of impervious surfaces, upstream land-use changes are not expected to appreciably alter the patterns of inflow to the reservoir.

Growth in downstream demands for water withdrawals could result in increased water conflicts, particularly during drought periods. The Doswell Water Treatment Plant in Hanover County has a capacity of 15,000 m^3/d (4 MGD), which is the equivalent to a streamflow of 0.17 m^3/s (6.1 cfs). One of the alternatives proposed by Hanover County to meet its projected water supply needs would require an additional withdrawal of 1.3 m^3/s (46 cfs) from the North Anna River. The minimum release from Lake Anna prescribed by VDEQ for normal conditions is 1.1 m^3/s (40 cfs). During drought conditions the release prescribed by VDEQ can be reduced to 0.57 m^3/s (20 cfs). Three of the downstream counties are considering using the North Anna River or Pamunkey River as future water sources to meet projected growth.

The Virginia 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 levels during periods of drought, ensure assimilation of treated waste water, 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 1,100,000 L (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 November 2006, the Virginia State Water Control Board had not designated any surface water management areas in the Commonwealth.

2.6.2.2 Groundwater Use

Dominion describes groundwater use in the vicinity of the ESP site in Section 2.3.2.2 of the ER (Dominion 2006a). Groundwater in the vicinity of the ESP site is primarily 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 because of seasonal fluctuations in the water table. Drilled wells generally extend through the saprolite into the underlying bedrock. 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. The majority of groundwater development in the area is for domestic and agricultural use, with some public, light industrial, and commercial use.

2.6.3 Water Quality

The following sections describe the water quality of surface water and groundwater resources in the vicinity of the North Anna ESP site. Pre-application monitoring programs for thermal and chemical water quality are also described.

2.6.3.1 Surface Water Quality

This section describes the water quality of Lake Anna, the tributaries draining into Lake Anna, and the North Anna River downstream of the dam. Dominion presents a discussion of the water quality conditions in Section 2.3.3.1 of the ER (Dominion 2006a). The thermal load discharged into the lake from the two operating units results in localized elevated temperatures in the lake. These elevated temperatures are the most significant water-quality concern associated with both the existing and the proposed ESP units. Operational impacts of proposed Unit 3 on Lake Anna water quality are discussed in Section 5.2.2.3 of this EIS. Monitoring programs for thermal and chemical water quality are discussed in Sections 2.6.3.3 and 2.6.3.4, respectively.

Eight of the tributaries draining into Lake Anna are on the Virginia 2004 Clean Water Act Section 303(d) list as impaired for one or more of the following attributes: fecal coliform bacteria, pH, and dissolved oxygen. The source of impairment for pH in one of the tributaries, Contrary Creek, is known to be an abandoned mining operation (VDEQ 2004c). The specific source of the impairment for the other tributaries is unknown. The lower portion of Lake Anna is listed as impaired due to polychlorinated biphenyl (PCB) levels in fish tissues; a public health advisory has been issued regarding the consumption of certain fish. The source of the PCBs is unknown at this time. Downstream of Lake Anna, the discharge is not listed as impaired until it reaches the Chesapeake Bay estuary, after first entering the Pamunkey River and then the York River.

Iron pyrite mining was conducted on land adjacent to Contrary Creek during the late 19th and early 20th centuries (VDEQ 1986). When the mines were abandoned (circa 1920), mine shafts and tailings piles were left exposed. Runoff from the mine area was acidic and contained high concentrations of heavy metals. When NAPS Units 1 and 2 were under development, virtually no aquatic life was found in Contrary Creek downstream of the mine sites (AEC 1973). 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 24 km (15 mi) downstream, although water quality was generally satisfactory (VDEQ 1986).

In 1976, the Virginia State Water Control Board, in association with EPA, attempted to reclaim previously mined and disturbed areas along Contrary Creek to reduce the impacts of sedimentation and acid mine drainage (VDEQ 1986). The reclamation project reduced erosion and sedimentation in the area. The creation of the reservoir 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 onto clay particles and the subsequent settling of those particles. Chemical precipitation (and co-precipitation with iron) may also remove zinc and copper ions from Contrary Creek water when it mixes with reservoir water.

Units 1 and 2 have a Virginia Pollutant Discharge Elimination System (VPDES) permit from the VDEQ (VDEQ 2001). Before Units 3 and 4 could begin to operate, Dominion would be required to obtain a VPDES permit for discharges from these units. Dominion would also be required to demonstrate to VDEQ that the thermal effluent limitation for Unit 3 is adequate to ensure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife through a Clean Water Act Section 316(a) demonstration. If determined to be necessary, VDEQ may require additional monitoring prior to issuance of a VPDES permit. VDEQ may also require ongoing monitoring as a condition of the VPDES permit. Unit 4 would use dry cooling towers, which discharge the heat directly to the air, and would have no effect on surface water quality.

2.6.3.2 Groundwater Quality

There are no site-specific data available for the nonradiological chemistry of the groundwater underlying the ESP site. In Section 2.3.3.2 of the ER and in response to a request, Dominion provided a summary of published studies that characterize the water quality of crystalline aquifers in the Piedmont Province (Dominion 2004a, 2006a). The Piedmont region aquifers provide good quality water (USGS 2000). As with most crystalline rocks, the rocks of the Piedmont Province contribute relatively high levels of naturally occurring radioactivity to the groundwater. Groundwater sampling undertaken in 1992 as part of the Louisa County Water Testing Program has identified coliform contamination in aquifers near the ESP site. This coliform contamination is likely attributable to private septic systems in the area.

2.6.3.3 Thermal Monitoring

This section describes pre-application and pre-operational thermal monitoring programs. The applicant is able to consider an ongoing monitoring program associated with the existing Units 1 and 2 as part of the pre-application and pre-operational monitoring program at the ESP site. Many of the same monitoring activities would be continued if the proposed units were completed and would become part of the operational monitoring for the proposed units. In Section 6.1 of the ER, Dominion describes the existing lake temperature measurements directly associated with the current site operation that are required under terms of its existing VPDES permit (Dominion 2006a; VDEQ 2001a,b).

The current temperature monitoring program in Lake Anna reservoir includes both continuous fixed-location temperature stations and temperature profile locations that are sampled twice per year. Ten fixed-location temperature stations are located around Lake Anna, seven within the main body of the lake, one at the discharge canal, and two within the WHTF. An additional fixed-location station is located downstream of the North Anna Dam. The temperature profiling is conducted during at least two quarters per year, one measurement is always during the July-to-September quarter and the second is during one of the remaining quarters. All of the spot profile locations are located in the main body of the lake.

2.6.3.4 Chemical Monitoring

This section describes the pre-application and operational chemical monitoring programs. As a result of ongoing monitoring associated with the existing two units, the applicant is able to consider this operational monitoring program as part of the pre-application and pre-operational monitoring program for the ESP site. Many of these same monitoring activities would be continued if Units 3 and 4 were completed and would likely become part of the operational monitoring. In Section 6.6 of the ER, Dominion describes the chemical monitoring that is required under terms of the applicant's existing VPDES permit (Dominion 2006a).

The NAPS Units 1 and 2, VPDES permit establishes chemical discharge limits at a variety of locations internal to the NAPS facility and at the discharge from the WHTF into Lake Anna at Dike 3. Chemical monitoring of a variety of constituents is required including pH, chlorine, copper, nickel, chromium, zinc, suspended solids, oil and grease, and biological oxygen demand. While temperature is monitored both inside and outside the WHTF, no chemical monitoring is required outside the WHTF.

The Commonwealth of Virginia monitors Lake Anna, Lake Anna's tributaries, and the North Anna River downstream from Lake Anna. Results from this monitoring program provide the basis for the Virginia Clean Water Act Section 303(d) list of impaired waters. Recent sampling by the Commonwealth has resulted in a public health advisory regarding the consumption of certain fish in Lake Anna and its tributaries. The advisory was triggered because PCBs were detected in the tissues of certain fish.

Community-based monitoring of Lake Anna and WHTF water quality has been performed by volunteers from the Lake Anna Civic Association. Water samples are collected and analyzed for several standard water-quality metrics, such as the fecal coliform bacteria, *Escherichia coli*, and dissolved oxygen. Results from this monitoring program are provided to the Commonwealth of Virginia and EPA.

2.7 Ecology

Much of the proposed North Anna ESP site construction area consists of dirt roads, cleared areas, parking lots, buildings, and other areas recovering from prior disturbance. Because of past development or use, undisturbed habitats are absent from this area. 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, undisturbed habitats are absent from this area. Approximately 32 ha (80 ac) of the 729-ha (1803 ac) proposed site is currently forested; most of the forested portion of the site is within the area where cooling towers would be constructed. Generally, wildlife species found in the forested portions of the ESP site and surrounding areas are those typically found in the forested portions of the North Anna 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 line rights-of-way within the ESP site would include most of those found in the adjacent wooded areas. A few small wetland areas and two intermittent streams exist on the ESP site (Dominion 2006a).

Sections 2.7.1 and 2.7.2 provide general descriptions of the terrestrial and aquatic environments near the ESP site. They provide detailed descriptions, where needed, to support the analysis of potential environmental impacts of construction and operation of new nuclear power generating facilities. The descriptions are provided to support mitigation activities identified to avoid, minimize, rectify, reduce, or compensate for potential impacts identified during the assessment. Descriptions are provided to facilitate comparison of the alternatives identified to the North Anna ESP site. Also included are descriptions of monitoring programs for terrestrial and aquatic environments.

2.7.1 Terrestrial Ecology

The ESP site is located within the Piedmont Physiographic Province as described by Omernik (1987). Although forests in the Piedmont Province are nominally characterized by oak-hickory-pine forest (Woods et al. 1999), this portion of northeastern Virginia has been settled since the colonial era, and therefore no longer contains virgin forests. Vegetative cover 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 (Dominion 2006a). The Lake Anna reservoir is adjacent to the site, oriented from northwest to southeast.

2.7.1.1 Biological Communities of the North Anna Site

Approximately 30 percent of the North Anna site consists of generation and maintenance facilities, parking lots, roads, cleared areas, and mowed grass. Hardwood forests and planted pines 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 (*Quercus* spp.), yellow poplar (*Liriodendron tulipifera*), sweet gum

(*Liquidambar styraciflua*), and red maple (*Acer rubrum*) trees. Scattered loblolly pines (*Pinus taeda*), Virginia pines *(P. virginiana*), and short-leaf pines *(P. echinata*) exist in some wooded areas (Dominion 2006a).

The Piedmont region of Virginia is characterized as an irregular plain with low rounded ridges and shallow ravines (Woods et al. 1999). There are no steep ridges on 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 at the site. Hydrophytic vegetation, such as cattails (*Typha* spp.) and rushes (*Juncus* spp.), are typically absent or extend only to approximately 0.3 m to 1 m (1 to 3 ft) beyond the shoreline (Dominion 2006a). 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. Dominion has completed a wetland delineation that identified 2.7 hectares (6.68 acres) of wetlands in the construction footprint (Dominion 2006c). The delineation also identified approximately 1676 m (5500 linear feet) of streams that cover an area of approximately 0.19 hectares (0.46 acres), and approximately 1.0 hectares (2.49 acres) of open water within a beaver pond at the western edge of the ESP area near the end of the unnamed arm of Lake Anna. In a September 2006 letter, the ACE verified this delineation (ACE 2006).

Wildlife species found in the forested portions of the North Anna site are those typically found in upland Piedmont forests of northeastern Virginia. Frequently observed mammals, such as the white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), gray squirrel (*Sciurus carolinensis*), and gray fox (*Urocyon cinereoagenteus*), exist at the site, as do smaller mammals such as moles (Talpidae), shrews (Soricidae), and a variety of mice (Muridae) and voles (*Microtus* spp.). Woodchucks (*Marmota monax*) live in the grassy areas near forest edges at the site, and beavers (*Castor canadensis*) occur in Lake Anna and its tributaries. Various birds and herpifauna (e.g., snakes, turtles, lizards, and toads) live in the uplands and along the edge of Lake Anna (Dominion 2006a).

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 North Anna site during these surveys include the American crow (*Corvus brachyrhynchos*), blue jay (*Cyanocitta cristata*), Carolina chickadee (*Poecile carolinensis*), mourning dove (*Zenaida macroura*), black vulture (*Coragyps atratus*), turkey vulture (*Cathartes aura*), European starling (*Sturnus vulgaris*), song sparrow (*Melospiza melodia*), white-throated sparrow (*Zonotrichia albicollis*), dark-eyed junco (*Junco hyemalis*), northern cardinal (*Cardinalis cardinalis*), house finch (*Carpodacus mexicanus*), tufted titmouse (*Baeolophus bicolor*), red-bellied woodpecker (*Melanerpes carolinus*), downy woodpecker (*Picoides pubescens*), and northern flicker (*Colaptes auratus*) (Audubon Society 2006). Species known to nest within forested areas at the North Anna site, along forested edges, and in open areas (for example, northern cardinal, Carolina chickadee, blue jay) are those that commonly nest in upland Virginia habitats. Virginia Power has placed bluebird nest boxes in suitable habitats at the North Anna site and has constructed roofed structures for swallows in some locations. Eastern bluebirds (*Sialia sialis*) annually use the nest boxes, and barn swallows (*Hirundo rustica*) nest beneath the roofed structures (Dominion 2006a).

Several species of residential and migratory wading birds and waterfowl use Lake Anna. Numerous gulls, ducks, and geese were noted during Christmas Bird Counts (Audubon Society 2006), as were great blue herons (*Ardea herodias*). Virginia Power biologists have documented breeding at Lake Anna by mallards (*Anas platyrhynchos*), wood ducks (*Aix sponsa*), and Canada geese (*Branta canadensis*) (VEPCo 1986). 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 used several of these nest boxes (VEPCo 1986). Belted kingfishers (*Ceryle alcyon*), great blue herons, and green-backed herons (*Butorides virescens*) are present at Lake Anna throughout the year, and kingfishers and green-backed herons presumably nest on or near the Lake Anna shoreline. Great blue herons typically nest in rookeries, and because there are no known rookeries at Lake Anna (Dominion 2006a), 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 (*Anas rubripes*), bufflehead (*Bucephala albeola*), and greater scaup (*Aythya marila*) (VEPCo 1986). The Canada goose, American coot (*Fulica americana*), ringed-billed gull (*Larus delawarensis*), and herring gull (*L. argentatus*) are also abundant on Lake Anna during the winter (Audubon Society 2006; VEPCo 1986).

2.7.1.2 Threatened and Endangered Terrestrial Species

This section describes the threatened and endangered terrestrial animal and plant species that exist within the ESP site, vicinity, and corresponding transmission line rights-of-way. The U.S. Fish and Wildlife Service (FWS) maintains current lists of threatened or endangered species at its website (FWS 2004a). The Virginia Department of Game and Inland Fisheries (VDGIF) and Virginia Natural Heritage Program (VNHP) also maintain lists of State-protected species at their websites (VDGIF 2004a; VDCR 2004). Terrestrial species potentially occurring near the North Anna site that are listed as threatened or endangered by these agencies are listed in Table 2-2.

Animals

Bald eagles (*Haliaeetus leucocephalus*), a Federal- and State-threatened species, are occasionally observed along Lake Anna (six were observed during the 2006 Christmas Bird Count) (Audubon Society 2006). However, there are no known eagle nests at the ESP site (NRC 2002). The nearest known bald eagle nest is approximately 4.2 km (2.6 mi) to the west. Dominion is not aware of any eagle nests along North Anna-associated transmission line

Table 2-2. Terrestrial Species Known or Likely to Occur in Counties Adjacent to or Downstream from the Lake Anna Reservoir (Louisa, Orange, Spotsylvania, Caroline, and Hanover Counties)

Scientific Name	Species	Counties	Status*	Source
Birds				
Haliaeetus leucocephalus	bald eagle	Louisa, Orange, Spotsylvania, Caroline, Hanover	FT/ST	VDGIF 2004a, FWS 2004a, VDCR 2004, FWS 2004b
Picoides borealis	red-cockaded woodpecker	Caroline	FE/SE	VDGIF 2004a
Lanius ludovicianus	loggerhead shrike	Louisa, Orange, Spotsylvania, Caroline, Hanover	FS/ST	VDGIF 2004a
Dendroica cerulea	cerulean warbler	Louisa, Orange, Spotsylvania, Caroline, Hanover	FS	VDGIF 2004a
Aimophila aestivalis	Bachman's sparrow	Caroline	FS/ST	VDGIF 2004a, FWS 2004b, VDCR 2004
Bartramia longicauda	upland sandpiper	Louisa, Orange, Spotsylvania, Caroline, Hanover	ST	VDGIF 2004a
Mammals				
Plecotus rafinesquii macrotis	eastern big-eared bat	Hanover	SE	VDGIF 2004a
Sorex longirostris fisheri	Dismal Swamp southeastern shrew	Caroline	ST	VDGIF 2004a
Amphibians				
Ambystoma tigrinum	tiger salamander	Hanover	SE	VDCR 2004
Insects				
Speyeria idalia	regal fritillary	Orange, Spotsylvania	FS	FWS 2004a,b VDGIF 2004a
Vascular Plants				
Isotria medeoloides	small whorled pogonia	Spotsylvania, Hanover, Caroline	FT/SE	VDGIF 2004a, FWS 2004a,b VDCR 2004
Helonias bullata	swamp pink	Caroline, Hanover, Spotsylvania	FT/SE	VDGIF 2004a, VDCR 2004, FWS 2004b
Aeschynomene virginica	sensitive joint-vetch	Caroline	FT	FWS 2004a,b
Juncus caesariensis	New Jersey rush	Caroline	FS/ST	VDCR 2004

*FE = Federally endangered, FT = Federally threatened, FS = Federal species of concern, SE = State endangered, ST = State threatened.

(a) The migrant subspecies *L.l. migrans* is a Federal species of concern, all loggerhead shrikes in Virginia are State threatened.

rights-of-way. The loggerhead shrike (*Lanius ludoviciana*), a State threatened species occasionally has been observed in the vicinity of NAPS during Christmas Bird Counts (Audubon Society 2006). It is known to breed in central Virginia (VDGIF 2004a), but breeding loggerhead shrikes have not been recorded at the North Anna site or along the transmission line rights-of-way (Dominion 2006a). The loggerhead shrike inhabits mowed or grazed grassy areas and margins of wooded areas.

With the exception of the bald eagle and loggerhead shrike, no other Federally and/or State-listed endangered or threatened terrestrial animals are known to exist at the North Anna site or along the transmission line rights-of-way, although the upland sandpiper (*Bartramia longicauda*) and the cerulean warbler (*Dendroica cerulea*) may occasionally migrate through the area (VDGIF 2004a). The regal fritillary butterfly (*Speyeria idalia*) has been reported in Orange and Spotsylvania Counties, but has not been reported in Louisa County (VDGIF 2004a). The eastern big-eared bat (*Plecotus rafinesquii macrotis*) has been reported in Hanover County, downstream from Lake Anna. Several threatened or endangered species, including the red-cockaded woodpecker (*Picoides borealis*), Bachman's sparrow (*Aimophila aestivalis*), dismal swamp southeastern shrew (*Sorex longirostris fisheri*), and tiger salamander (*Ambystoma tigrinum*) have been reported in Caroline County (VDGIF 2004a), which is downstream from the North Anna site. However, the presence of these species at the NAPS site appears doubtful, and reported observation sites are well away from the transmission lines, or portions of the North Anna River potentially affected by construction and operation of new reactors at the North Anna site.

Plants

There are no known populations of any plants species listed as threatened or endangered by the FWS or the Commonwealth on the North Anna site (Dominion 2006a; NRC 2002). Additionally, there are no known populations of such species in Louisa County (VNHP 2004; FWS 2004a).

The supplemental environmental impact statement prepared for the license renewal of NAPS Units 1 and 2 (NRC 2002) described three Federally listed plant species that could potentially occur in the North Anna transmission line rights-of-way: the small whorled pogonia (*Isotria medeoloides*), swamp pink (*Helonias bullata*), and the sensitive joint-vetch (*Aeschynomene virginica*). The previous evaluation determined that continued operation and maintenance of the transmission line rights-of-way would have no effect on these species. Because the existing rights-of-way would not be altered, and no additional rights-of-way would be required to support the operation of the proposed additional units, no additional species are likely to be affected. The New Jersey rush (*Juncus caesariensis*), a State threatened species, occurs in shaded stream banks and other wet areas, and has been reported to occur in Caroline County (VDCR 2004).

The transmission line rights-of-way are managed to prevent woody growth from reaching the transmission lines. The removal of woody species can provide 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 line rights-of-way. 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 line rights-of-way, no endangered or threatened plants were noted along the rights-of-way associated with the North Anna ESP site (Dominion 2006a).

2.7.1.3 Terrestrial Ecological Monitoring

Dominion currently performs no terrestrial ecological monitoring (Dominion 2006a). However, Dominion does cooperate with private organizations such as the local chapter of the Audubon Society to allow informal monitoring of selected resources at and near NAPS, and has worked with the VDCR Natural Heritage Program to conduct rare plant surveys in transmission rights-of-way. The NRC expects Dominion to work with the Commonwealth on development and implementation of any required monitoring programs.

2.7.2 Aquatic Ecology

This section discusses the aquatic ecology in the vicinity of the North Anna ESP site. The information summarized here is extracted from summaries prepared for the license renewal of North Anna Power Station, Units 1 and 2 (NRC 2002) and Dominion's ER (Dominion 2006a). The information in these documents was reviewed by the staff. Where descriptions presented here are taken directly from the original documents, references are provided to direct the reader to the source documents.

The aquatic resources in the vicinity of the North Anna ESP site are associated with Lake Anna, the WHTF, and the North Anna River (VEPCo 2001). The reservoir was created to serve as the cooling water source for NAPS. The reservoir was made during 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 2-5) (NRC 2002).

The reservoir drains an area of 888 km^2 (343 mi^2) (VDEQ 1986). The dam is approximately 27 m (90 ft) high and 1500 m (5000 ft) long and contains 700,000 m^3 (900,000 yd^3) of earth and rock (AEC 1973). The reservoir began filling during January 1972 and reached full pool in December of that year (AEC 1973). The reservoir is approximately 27 km (17 mi) long, with 435 km (272 mi) of shoreline. The reservoir is relatively shallow (maximum depth 27 m [90 ft]; average depth approximately 8 m [25 ft] at full pool), with a surface area of 5300 ha (13,000 ac) (AEC 1973). The normal elevation of the reservoir is 76 m (250 ft) above MSL, at which stage it holds 376,000,000 m^3 (305,000 acre-feet) of water (AEC 1973). The reservoir is used

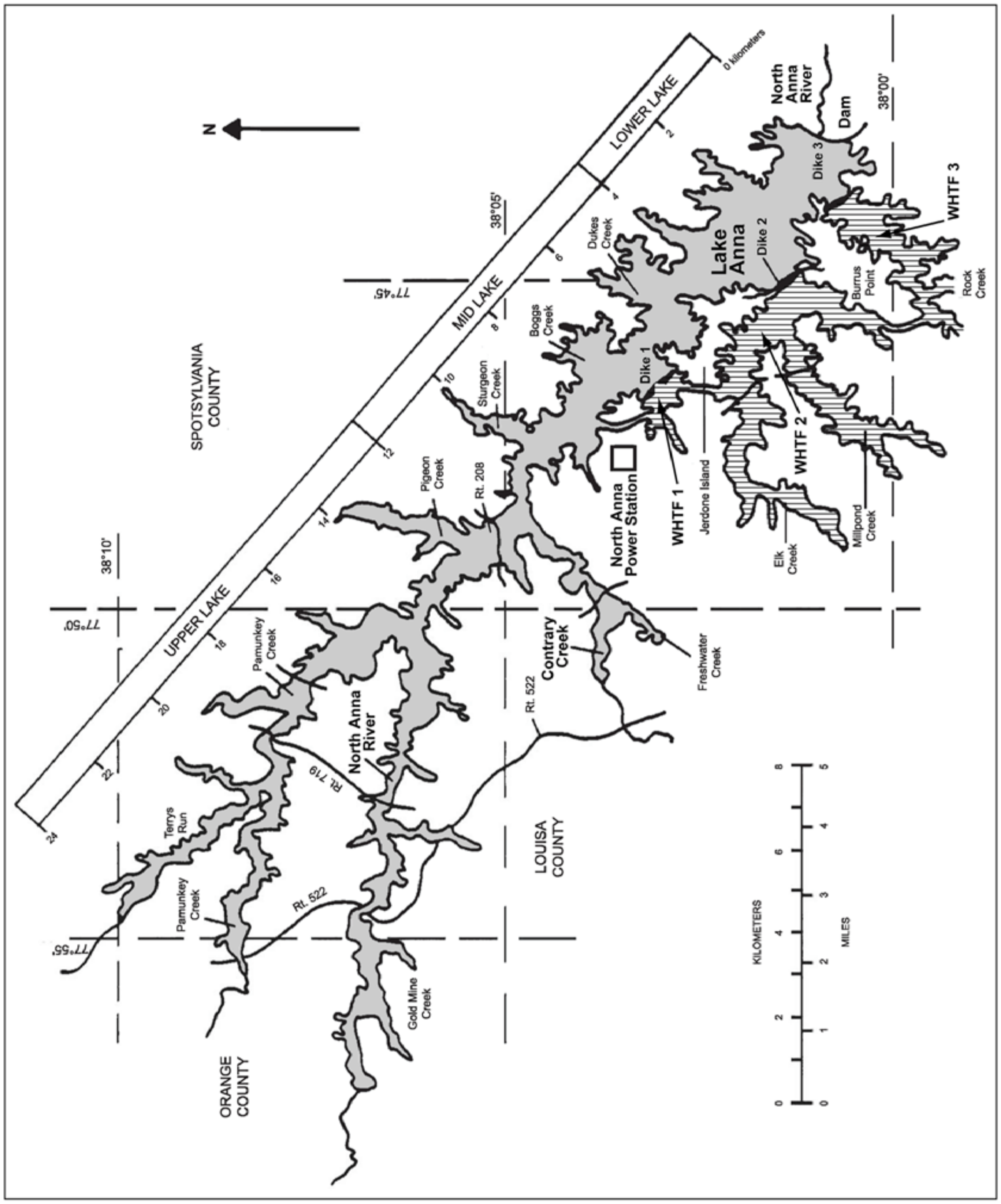

Figure 2-5. Lake Anna, the WHTF, and the Rivers and Creeks in the Vicinity of NAPS.

extensively for recreation and fishing. The aquatic resources of Lake Anna are managed cooperatively by Virginia Power, the Virginia Department of Game and Inland Fisheries (VDGIF) and VDCR (NRC 2002).

The reservoir is divided into two distinct bodies of water: the WHTF and Lake Anna. Lake Anna is the larger body of water and is physically separated from the WHTF by three dikes. The WHTF is the smaller body of water into which the waste heat from existing North Anna Units 1 and 2 is discharged via a discharge canal. The total surface area of the WHTF is 1400 ha (3400 ac). The surface area of Lake Anna is 3900 ha (9600 ac). The WHTF was formed by diking off the three southernmost arms of the reservoir. These arms are the three cooling lagoons of the WHTF; all three lagoons are interconnected by canals (NRC 2002). The third dike has a weir regulating outflow allowing water to exit the WHTF into Lake Anna (Section 3.2.2.2). Fish can move between the two bodies of water at the weir.

The North Anna River headwaters are in Louisa and Orange Counties, Virginia, and flow eastward for about 97 km (60 mi) before joining the South Anna River 55 km (34 mi) downstream of the North Anna Dam to form the Pamunkey River (Figure 2-2). The Pamunkey River flows about 146 km (91 mi) to the southeast, joining with the Mattaponi River to form the York River, which flows about 56 km (35 mi) into the Chesapeake Bay north of the Hampton Roads area of Virginia.

2.7.2.1 Biological Communities of Lake Anna

Lake Anna is typical of many shallow reservoirs found in the southern and mid-Atlantic states. Since impoundment, Lake Anna has gone through the typical ecological succession of reservoirs. The initial biotic community was highly productive because initial nutrient levels were high. Productivity subsequently decreased and ultimately stabilized (Paterson and Fernando 1970; Voshell and Simmons 1978). Aquatic communities in Lake Anna experienced gradual post-impoundment changes from riverine to lake communities. Some of these communities had stabilized in Lake Anna by 1975 (VEPCo 1986), and all have been relatively stable since 1985 (VEPCo 1986; VEPCo 2002b; NRC 2002).

Lake Anna contains numerous phytoplankton, zooplankton, and benthic macroinvertebrate communities. Seventy-seven genera of phytoplankton have been identified, and diatoms, green algae, blue-green algae (Cyanobacteria), and cryptomonads are the dominant forms. The zooplankton are dominated by small-bodied forms (rotifers and copepods). This has been attributed to selective predation upon larger-bodied zooplankton by landlocked schooling clupeids such as various shad species (Brooks and Dodson 1965). A total of 124 benthic taxa have been identified from Lake Anna (VEPCo 1986). Three bivalve species, *Elliptio complanatus*, *Ellipito productus*, and *Sphaerium striatum* (AEC 1973; NRC 2002) were collected in the North Anna basin prior to impoundment.

In more recent years, the introduced Asiatic clam (*Corbicula* spp.) has dominated collections from both Lake Anna and the lower North Anna River. The Asiatic clam has spread rapidly throughout the United States since its first discovery in 1938 (VEPCo 1986). Its populations expand rapidly when they invade a new habitat, and densities stabilize as the population reaches carrying capacity of the habitat. Asiatic clams are present throughout Lake Anna with the greatest population densities found at mid-lake (VEPCo 1989). After the Asiatic clam's initial invasion of Lake Anna, densities increased sharply from 1979 to 1981. Populations remained relatively stable between 1984 and 1988 (VEPCo 1989). Virginia Power received approval from VDEQ to discontinue Asiatic clam sampling in 1989 (NRC 2002).

Small numbers of unionid mussels (*Elliptio* spp.) and fingernail clams (family Sphaeriidae) have also been collected. Acid drainage and sediment from the Contrary Creek mine sites historically depressed freshwater mussel populations downstream from the Contrary Creek-North Anna River confluence. Prior to the impoundment of Lake Anna the first major mussel beds occurred 100 m (330 ft) downstream of the confluence of the North and South Anna Rivers (Reed and Simmons 1972). There are indications that mussel populations are recovering in the lower North Anna River (VEPCo 1986; NRC 2002).

Forty species of fish (representing 12 families) have been reported in Lake Anna (VEPCo 1986) (Table 2-3). Species include those historically found in the North Anna River, those that had been in local farm ponds inundated by the new reservoir, and those introduced by VDGIF.

Recreational species include largemouth bass (*Micropterus salmoides*), striped bass (*Morone saxatilis*), walleye (*Sander vitreus*), bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), black crappie (*Pomoxis nigromaculatus*), white perch (*M. americana*), pumpkinseed (*L. gibbosus*), redear sunfish (*L. microlophus*), redbreast (*L. auritus*), channel catfish (*Ictalurus punctatus*), and white catfish (*Ameiurus catus*). Forage species include threadfin shad (*Dorosoma petenense*), gizzard shad (*D. cepedianum)* and blueback herring (*Alosa aestivalis*). Striped bass and walleye are stocked annually by VDGIF. Sterile triploid herbivorous grass carp (*Ctenopharyngodon idella*) was stocked in the WHTF in 1994 by Virginia Power (NRC 2002). The sterile grass carp were stocked (with the approval of the VDGIF) in the WHTF to control the growth of the nuisance submersed aquatic plant hydrilla (*Hydrilla verticillata*).

Because of the importance of recreational fishing in Lake Anna, its fish community has been the subject of wide-ranging studies (VEPCo 1986). Abundance and distribution of fish were evaluated over a period from 1975 to 1985, using a variety of sampling methods. Larval fish studies, creel surveys, and a number of special studies focused on the reproduction and growth of important species, such as largemouth bass. Seasonal movement and habitat preferences of striped bass were investigated using ultrasonic tags (Dominion 2006a).

Table 2-3. Fish Reported from Lake Anna

Scientific Name		Common Name
Anguillidae		
	Anguilla rostrata	American eel
Clupeidae		
	Dorosoma cepedianum	gizzard shad
	D. petenense	threadfin shad
	Alosa aestivalis	blueback herring
Umbridae		
	Umbra pygmaea	eastern mudminnow
Poeciliidae		
	Gambusia affinis	mosquitofish
Catostomidae		
	Catostomus commersoni	white sucker
	Erimyzon oblongus	creek chubsucker
	Moxostoma macrolepidotum	shorthead redhorse
	Hypentelium nigricans	northern hog sucker
Esocidae		
	Esox niger	chain pickerel
	E. lucius	northern pike
Cyprinidae		
	Ctenopharyngodon idelle	grass carp
	Cyprinus carpio	common carp
	Nocomis leptocephalus	bluehead chub
	N. micropogon	river chub
	Notemigonus crysoleucas	golden shiner
	Notropis analostanus	satinfin shiner
	N. procne	swallowtail shiner
	N. hudsonius	spot tail shiner
Aphredoderidae		
	Aphredoderus sayanus	pirate perch
Ictaluridae		
	Ictalurus nebulosus	brown bullhead
	I. natalis	yellow bullhead
	I. punctatus	channel catfish
	Noturus insignis	margined madtom
	Ameiurus catus	white catfish
Centrarchidae		
	Enneacanthus gloriosus	bluespotted sunfish
	Lepomis auritus	redbreast sunfish
	L. gibbosus	pumpkinseed
	L. gulosus	warmouth
	L. macrochirus	bluegill
	L. microlophus	redear sunfish
	Acantharchus pomotis	mud sunfish
	Micropterus salmoides	largemouth bass
	Pomoxis nigromaculatus	black crappie
Percidae		
	Perca flavescens	yellow perch
	Sander vitreus	walleye
	Etheostoma olmstedi	tessellated darter
Moronidae		
	Morone americana	white perch
	M. saxatilis	striped bass

The community structure for fish in Lake Anna remained relatively stable during the 1975 to 1985 period, with some year-to-year variation in species composition. Post-1975 changes included (1) a decline in relative abundance of yellow perch and black crappie, (2) an increase in the relative abundance of white perch and threadfin shad, and (3) an increase in redear sunfish abundance, with a corresponding decrease in pumpkinseed (Dominion 2006a). 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 attraction structures and artificial habitat, and (5) the increase in Asiatic clam densities (VEPCo 1986).

Lake Anna appears to support a greater standing crop of fish than most U.S. reservoirs, with thriving populations of several forage species and game fish species. The mean standing crop for fish in Lake Anna ranged between 105 and 134 kg (232 and 296 lb) of fish per 0.4 ha (1 ac) during the 1975 to 1985 period, but it increased substantially in 1985 to 189 kg (417 lbs) per 0.4 ha (1 ac) because of a large increase in introduced threadfin shad and an increase in the abundance of gizzard shad. Both species provide forage for Lake Anna's game fish, which include largemouth bass, walleye, and striped bass. Standing stocks of largemouth bass, Lake Anna's most popular sport fish, remained stable during the 1975 to 1985 period. During 1985, Lake Anna produced more largemouth bass of citation size (3.6 kg [8 lb] or more) than any other lake or reservoir in Virginia. Life history studies of Lake Anna largemouth bass suggest that the reproductive success, feeding ecology, and growth of largemouth bass were similar before and after Units 1 and 2 commenced operation (VEPCo 1986; Dominion 2006a).

Non-native fish species, including striped bass, walleye, threadfin shad, and blueback herring, have been stocked in Lake Anna by VDGIF since 1972. Striped bass, introduced during 1973, have been stocked annually since 1975 to create and maintain a "put-grow-and-take" recreational fishery. A self-sustaining population is not expected in Lake Anna because the streams, including the North Anna River, that flow into Lake Anna lack the habitat to support striped bass reproduction. Studies show that striped bass grow and provide a substantial recreational fishery, but adults are subject to late-summer habitat restrictions (e.g., may be restricted to cooler-water refuge areas). As a consequence, they may lose weight and show a decline in condition. Walleye are also stocked annually by the VDGIF and are highly sought-after game fish (Dominion 2006a). Threadfin shad, introduced during 1983 to provide forage for striped bass and other species, are vulnerable to cold shock and winter kills, and would not be able to survive in Lake Anna if it were not for operation of NAPS. Threadfin shad appear to be thriving and are an important source of food for game fish. Blueback herring was stocked by VDGIF during 1980 also as a forage species (Dominion 2006a).

Commercially Important Fisheries of Lake Anna

There is no commercial fishing on Lake Anna or the North Anna River. Professional fishing guides regularly take clients fishing for largemouth, striped bass, black crappie, and walleye on

Lake Anna, but there is no commercial fishing in the lake. Professional fishing guides must adhere to Commonwealth fishing regulations, and are prohibited by law from selling their catch (Dominion 2006a).

Recreationally Important Fisheries of Lake Anna

Lake Anna is a popular destination for anglers from central and northern Virginia. Lake Anna's proximity to the cities of Washington, D.C., Richmond, Fredericksburg, and Charlottesville attracts many anglers. The heated effluent that flows into Lake Anna at Dike 3 creates conditions conducive to good fishing during the winter, making the reservoir a popular fishing spot when cold weather slows or shuts down fishing at other ponds and lakes in the region. VDGIF estimated that 42,731 anglers fished Lake Anna for combined total of 232,439 hours over a 12-month period during 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 (VDGIF 2003). Although not the most targeted species, 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 anglers (Dominion 2006a).

VDGIF manages the fisheries of Lake Anna, "...with particular emphasis on providing quality largemouth and striped bass fisheries within the capacity of available habitat" (Odenkirk 1999). Thus, the VDGIF focuses on these two species. Other species, such as black crappie and channel catfish, are monitored by the VDGIF but are not as actively managed (Dominion 2006a).

Electro-fishing catch rates for largemouth bass greater than 20 cm (8 in.) long in Lake Anna have been high in recent years (VDGIF 2003; Odenkirk 2001, 2002). 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 years old) largemouth bass is excellent; however, growth of older largemouth bass (5 years and older) is below the district average (Odenkirk 1999). On average (all age classes considered), largemouth bass in Lake Anna grow more rapidly than largemouth bass in other large Virginia impoundments (Odenkirk 2001). In summary, largemouth bass tend to grow rapidly in their first 4 years of life. Their growth rate levels out at age 5, and then slows. The population of Lake Anna contains a high proportion of harvestable individuals, and provides relatively high catch-per-unit-effort for anglers seeking larger, trophy-sized fish (Dominion 2006a).

Annual stockings of fry and fingerlings sustain the striped bass population in Lake Anna. Normally, between 100,000 and 200,000 fingerlings are stocked annually, which equates to about 25 and 50 fish per ha (10 and 20 fish per ac) (Odenkirk 1999). Striped bass growth patterns in Lake Anna 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). Young striped bass grow rapidly and reach harvestable size (51 cm [20 in.]) in about 30 months (Odenkirk 1999). Estimates of annual mortality range from 35 to 50 percent, depending on the cohort evaluated, with the lower percentage likely more typical (Odenkirk 1999, 2001, 2002; Dominion 2006a).

Based on experimental gill net catches, black crappie abundance in Lake Anna was very high during 1997 and 1998, but has declined in recent years (Odenkirk 1999, 2001, 2002). Growth of black crappie in Lake Anna is similar to growth observed in 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 black crappie (92 percent) caught in gill nets were caught in the upper lake (Odenkirk 1999; Dominion 2006a).

Channel catfish ranked fifth in abundance in gill nets during 1997 and fourth in abundance during 1998 (Odenkirk 1999). Much higher numbers of channel catfish and white catfish were captured in gill nets during 1998 than during 1997, but this was attributed to low reservoir levels (related to drought) rather than an actual increase in numbers of catfish (Dominion 2006a). Depending on the time of year, walleye are also sought by Lake Anna fishermen. Walleye are also stocked annually by the VDGIF. Walleye have been stocked in the lake since 1972 (McCotter 2005).

Gizzard shad are regarded by fisheries managers as a less-than-ideal forage species, because their rapid growth makes them unavailable to predators in 1 to 2 years. Threadfin shad, while the ideal size for forage, are subject to mass die-offs from low temperatures or sudden temperature changes. Because threadfin shad abundance is cyclic, gizzard shad serve in most years as Lake Anna's forage base (Odenkirk 1999). During 1997 and 1998, gizzard shad numbered second and first, respectively, in Lake Anna gill net catches. Threadfin shad were seventh in 1997 and eighth during 1998. Most shad (71 percent during 1997 and 76 percent during 1998) were caught in the upper reservoir (Odenkirk 1999; Dominion 2006a).

Nuisance Species of Lake Anna

Virginia Power first collected Asiatic clams in benthos samples during 1979. Densities increased sharply thereafter, as this species with its high reproductive potential quickly occupied suitable habitat in the reservoir (VEPCo 1986). The total numbers and densities of Asiatic clam at the various locations in Lake Anna and the WHTF show sizable fluctuations between years, mostly as a result of variations in spawning activity (Willis 1998, 1999a,b, 2000a,b, 2001; Dominion 2006a). Small clams less than 2 mm (0.08 in.) long are sometimes locally abundant immediately after spawning takes place and inflate numbers and densities found at a particular sampling location. Asiatic clam numbers in the WHTF near the cooling water discharge for Units 1 and 2 show the most dramatic fluctuations. For example, densities of clams at this location declined from 1619 clams per m^2 during spring 1992 to 11 clams per m^2 during fall 1992 (Willis 1992a,b). 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 (greater than 15 mm in length), older (1 to 3 years old) Asiatic clams are uncommon in Lake Anna samples, generally comprising less than 10 percent of the total collected (Odenkirk 2001; Willis 1998, 1999a,b, 2000a,b,c, 2001, 2002a,b). 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 in the third lagoon of the WHTF when sample sizes are small (Willis 1999b, 2000a,b).

When Virginia Power compared 1990 to 2002 Asiatic clam survey results to similar surveys conducted during the 1980s, data indicated a decline in the Lake Anna population. The greatest sample totals were recorded during the springs of 1985 and 1988, when 194 and 294 clams, respectively, were collected in replicate samples from a mid-lake location. The greatest sample totals collected during the fall occurred during 1986 and 1987, when 237 and 1227 clams, respectively, were collected from a mid-lake location. The greatest number of clams collected during the 1990 to 2002 period from the mid-lake location was 148, during spring 1994 sampling. Operational experience at Units 1 and 2 provides further evidence of a stable or declining Lake Anna Asiatic clam population; no condenser tube blockages have been reported since Asiatic clams first appeared in Lake Anna during the late 1970s (Dominion 2006a).

In the course of monitoring Asiatic clam populations, Virginia Power also looks for evidence that the zebra mussel (*Dreissena polymorpha*) has invaded Lake Anna. As of the end of 2002, Virginia Power biologists had observed no zebra mussels in Lake Anna or the WHTF. Dissolved calcium levels in Lake Anna and the WHTF are well below those known to promote shell growth in zebra mussels. Low dissolved calcium levels should limit its establishment in those waterbodies.

2.7.2.2 Biological Communities of the WHTF

The WHTF is the body of water into which waste heat from the existing units is discharged via the canal. It is separated from Lake Anna by a series of dikes. A weir at dike three allows water to flow from the WHTF to the lake. The same aquatic communities occur in the WHTF and Lake Anna. Fish can swim from Lake Anna into the WHTF and back.

2.7.2.3 Biological Communities of the North Anna River

The North Anna River joins the South Anna River 55 km (34 mi) downstream from the North Anna Dam (Figure 2-2), forming the Pamunkey River. Another 146 km (91 mi) downstream, the Pamunkey River joins the Mattaponi River to form the York River. The York River then flows east for 56 km (35 mi) emptying into Chesapeake Bay.

The lower North Anna River below the North Anna Dam is small, approximately 23 to 46 m (75 to 150 ft) wide, but supports a diverse assemblage of stream fishes. There is no commercial fishing in the North Anna River, but recreational fishing is popular. Unless stream flow is unusually high, powerboats are impractical, so most anglers fish from shore or from canoes and kayaks. Recreational fishermen generally seek largemouth and smallmouth bass (*Micropterus dolomieu*) or redbreast sunfish. Bluegill and redear sunfish are present as well, but receive less attention from anglers (Dominion 2006a).

In the North Anna River downstream of the dam, the periphyton community (single-celled, filamentous or colonial algae, and associated microfauna attached to underwater surfaces) is dominated by diatoms, as are many southeastern streams. Caddisflies (family Trichoptera) that feed on seston (living and dead plankton, plus particulate matter) from Lake Anna dominate the benthic macroinvertebrate community. Farther downstream, macroinvertebrate communities show more diversity and are similar to those of the South Anna River (VEPCo 2001; Dominion 2006a).

Before the North Anna River was impounded, the fish community of the river downstream of the Contrary Creek inflow was dominated by pollution-tolerant species. In the years following impoundment (and partial reclamation of the Contrary Creek mine sites), there was a steady increase in measures of abundance and diversity of fish in the river. During 1984 to 1985, 38 species from 10 families were found in the North Anna River, compared to 25 species from 8 families in the South Anna River (VEPCo 1986) control site. (Forty species have been reported from Lake Anna.) When species from Lake Anna were subtracted from the North Anna River totals, the two fish communities (North and South Anna River communities) showed similarities, indicating that the operation of the existing units had little or no effect on fish diversity downstream from the dam (Dominion 2006a).

During 2000, the number of fish collected at four stations downstream of the North Anna Dam was low but was similar to 1989, 1993, and 1996 collections. High spring flows and canceled surveys in the fall likely contributed to the low numbers of fish collected. 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 six species comprising 80 percent of the electrofishing catch by number and the same six 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 (Dominion 2006a).

There is anecdotal information of an anadromous shad run (anadromous meaning fish that begin their lives in freshwater and migrate into the open ocean where they mature and then return to freshwater) in the North Anna River up to the breached Anderson Mill Dam just upstream of the Virginia State route (SR) 738 road crossing. The North Anna River is a tributary of the Pamunkey River which has an annual run of American shad (*Alosa sapidissima*) (Jenkins and Burkhead 1994, Bilkovic et al. 2002a,b). The shad reported from the Anderson Mill site are likely American shad. The Pamunkey Fish Hatchery in King William County, Virginia, is approximately 121 km (75 mi) 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 and migrate into coastal rivers where they spend more of their lives in freshwater (Rohde et al. 1994). 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, and also are known as “yellow eels” (Dominion 2006a).

VDGIF periodically surveys all fish of the lower North Anna River and monitors the condition of the recreational fishery. The largemouth and smallmouth bass populations in the lower river 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 limited supply of forage in the river (Dominion 2006a).

Since 1987, Virginia Power biologists have gathered data on the abundance and distribution of bass species in the lower North Anna River (VEPCo 2001). Biologists 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 by the fish. Historically, largemouth bass have dominated the fish counts at upstream locations, while smallmouth bass have been more prevalent at downstream locations (VEPCo 2001). In recent years, both species have occupied the entire study area. Density estimates for both largemouth and smallmouth bass at all locations were lower during 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 the fish (Dominion 2006a).

Redbreast sunfish were most abundant in North Anna River electrofishing samples during 1998, 1999, and 2000, and are the most abundant species since 1981 (VEPCo 2001). The redbreast sunfish is found across the coastal plain and Piedmont of Virginia in warm-water creeks and rivers of low-to-moderate gradient (Jenkins and Burkhead 1994). It is an adaptable species and may also be found in ponds, lakes, reservoirs, and even slightly brackish waters near the coast. The lower North Anna River redbreast population is a typical stream-dwelling population, with unremarkable growth rates, food habits, and spawning habits (Dominion 2006a).

Native striped bass are known to spawn in the rivers of the Chesapeake Bay watershed, including the Pamunkey, upstream from the limits of brackish water from early April through the end of May (Setzler-Hamilton et al. 1981). Between 1997 and 1999, the furthest upstream Bilkovic et al. (2002b) collected striped bass eggs and larvae from the Pamunkey River was about river km 131 (81 mi) (number of km [mi] upstream from the mouth of the York River in

Chesapeake Bay). This location (river km 131 [81 mi]) is about 119 km (74 mi) downstream from the North Anna Dam and about 4.8 km (3.0 mi) downstream of the Route 360 bridge crossing. It is likely that in some years spawning occurs upstream of this location, but probably contributes little to annual striped bass recruitment in the York River system. The most upstream record of striped bass prior to the impoundment of Lake Anna is a record of a single specimen caught in 1971 and reported by Reed and Simmons (1972) from the Pamunkey River at the State Route 615 bridge crossing just north of Studley, Virginia some 29 km (18 mi) upstream of the Bilkovic et al. (2002b) record. This upstream record is some 90 km (56 mi) downstream of the Lake Anna Dam and 55 km (34 mi) downstream of the fall line on the North Anna River, thought to be the historic upstream range of the striped bass in the North Anna-Pamunkey River system. Since stocking of Lake Anna with young striped bass, movement of bass downstream of the reservoir has been observed. A single specimen was observed by Dominion biologists in 1989 during a snorkel survey at Dominion's Station NAR5 approximately 28 km (17 mi) downstream of the North Anna Dam. Anecdotal accounts from a reputable fishing guide on North Anna confirm the presence of striped bass in the North Anna River downstream of the dam and are likely pour-over fish from the Lake Anna population that get washed over or through the dam perhaps during periods of high water (NRC 2005).

2.7.2.4 Threatened and Endangered Aquatic Species

This section describes the threatened and endangered aquatic species that exist within the ESP site, vicinity, and corresponding transmission line rights-of-way, and examines the potential impacts of the construction and operation of the proposed new units upon these resources.

Animals

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 Federally or State-listed fish species' range includes Lake Anna or the North Anna River, and none are believed to occur in counties adjacent to Lake Anna or the North Anna River (i.e., Caroline, Hanover, Louisa, Orange, and Spotsylvania Counties). Two aquatic species listed by the FWS as Federally endangered do potentially occur in the counties adjacent to Lake Anna or the North Anna River (Table 2-4). They are dwarf wedge mussel (*Alasmidonta heterodon*) and the James River spiny mussel (*Pleurobema collina*), neither of which has been observed or collected in local streams.

The VDGIF ecological databases indicate that there is the potential for one State-listed mussel species, the James River spiny mussel to be present near the NAPS site. Although this species may occur in streams that border Lake Anna or the North Anna River, none have been observed or collected. None of the three Federally or State-listed species has been found in Lake Anna or the North Anna River.

Table 2-4. Federally Listed Threatened or Endangered Aquatic Species Known or Likely to Occur in Counties Adjacent to or Downstream from the Lake Anna Reservoir

Scientific Name	Common Name	Counties	Status
Alasmidonta heterodon	dwarf wedge mussel	Hanover, Louisa, and Spotsylvania	FE, SE
Pleurobema collina	James River spiny mussel	Orange, Hanover, Louisa, Caroline, and Sportsylvania	FE, SE
Fusconaia masoni	Atlantic pigtoe	Orange, Hanover, Louisa, Caroline, and Spotsylvania	SE

FE = Federal endangered (FWS 2004a, b)
SE = State endangered

The dwarf wedge mussel was historically found in Hanover, Louisa, and Spotsylvania Counties (VDCR 2004). It is listed as endangered by both the Commonwealth and FWS. The FWS Recovery Plan for the species, completed in 1993, indicated that one population survives in the South Anna River in Louisa County (Moser 1993). The VDGIF Fish and Wildlife Information Service database currently lists a relic population in the South Anna River in Louisa County, presumably the same population (VDGIF 2004b).

An additional mussel species, the fluted kidneyshell mussel (*Ptychobranchus subtentum*), a candidate for Federal listing, has been reported to have been observed in the vicinity of the North Anna ESP site (VDGIF 2006). However, these observations may be in error, because confirmed observations limit this species to more western mountain streams that drain to the Gulf of Mexico.

There are other bivalves listed as species of concern by the Federal and State governments. The VDGIF's Fish and Wildlife Information Service database lists these species as occurring in a stream or streams near NAPS. All confirmed accounts of these 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. None of the mussel species of concern were collected in pre-impoundment surveys of the North Anna River, and none have been collected in more recent years during routine monitoring surveys.

Plants

No Federally or State-listed aquatic plant species has been collected in any of the monitoring studies associated with the existing NAPS Units 1 and 2, nor has any listed species been observed in surveys or special studies conducted by Virginia Power biologists. No Federally or State-listed aquatic plant has a range that 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., Carolina, Hanover, Louisa, Orange, and Spotsylvania Counties).

2.7.2.5 Aquatic Monitoring

The NRC does not impose conditions of operation, including monitoring requirements, in the area of water quality. Regulation of water quality is implemented by a National Pollutant Discharge Elimination System (NPDES) permit under the EPA or the states (Virginia in the case of any new units at North Anna). The NRC's role in water quality is limited to assessing aquatic impacts as part of its National Environmental Policy Act of 1969 (NEPA) evaluation. To provide the information needed to assess potential aquatic impacts, previous monitoring programs and monitoring programs planned for construction and operation were reviewed. These programs are expected to support any required assessments of aquatic impacts associated with new units.

Virginia Power has monitored fish populations in Lake Anna since the early 1970s. Virginia Power conducts quarterly electro-fishing sampling at nine stations (five stations in Lake Anna, and four in the WHTF) and at six gill-netting stations (four in the lake and two in the WHTF). These surveys are designed to document (1) the types of fish species present in Lake Anna, (2) their relative numbers by species, and (3) their size class distribution. In the North Anna River below the dam, Virginia Power biologists have also gathered abundance and distribution data on largemouth and smallmouth bass by direct (snorkel) observation. The biologists sampled river segments, counted and categorized (by size) all bass that were observed, and noted the type of cover being used. Other fish abundance and distribution information in the North Anna River are collected three times per year by electro-fishing at four stations.

In response to NRC Generic Letter 89-13, Virginia Power initiated a semi-annual sampling program in the fall 1990 to monitor Asiatic clams in the reservoir. Virginia Power continues to collect replicate samples at two Lake Anna stations (i.e., intake and mid-lake) and two WHTF stations. They report the total number and density of clams at the stations and discuss population trends in semiannual reports. In the course of monitoring Asiatic clam populations, Virginia Power assesses the micro-fouling potential of Asiatic clams and looks for evidence that the exotic zebra mussel has invaded the reservoir. As of the end of 2002, Virginia Power had observed no zebra mussels in the reservoir.

Virginia Power biologists have also conducted studies in the North Anna River in response to reduced flow because of drought conditions. The studies included physical habitat measurements at different flows, dissolved oxygen concentrations and temperatures and collection of benthic macro-invertebrates.

Each fall, when warranted, an aerial and ground-based monitoring program that focuses on identifying the presence of a nuisance submerged aquatic macrophyte is conducted.

VDGIF also conducts aquatic ecology monitoring as part of their management responsibilities for the fisheries of Lake Anna. VDGIF district biologists monitor and research the fishes of Lake

Anna annually, focusing primarily on the largemouth and striped bass. Other species, such as black crappie, walleye, channel catfish, and gizzard and threadfin shad, are also monitored by VDGIF.

2.8 Socioeconomics

This section presents the socioeconomic resources that could be potentially impacted by the construction, operation, and decommissioning of two new nuclear power units. It is organized into two major subsections providing details on demographics and community characteristics. These subsections include discussions on spatial (e.g., regional, vicinity, and site) and temporal (e.g., 10-year increments of population growth) considerations, where appropriate, as referenced.

The potential impact area for the analysis discussed in this section was determined by where the majority of employees of the currently operating NAPS Units 1 and 2 reside. There are approximately 720 employees currently at NAPS. Approximately 79 percent of these employees live in Henrico, Louisa, Orange, and Spotsylvania Counties and the City of Richmond (NRC 2002). The staff assumes the operations workers for new units would likely settle in these same areas. The remaining 21 percent of the workers would be scattered across the remaining counties and cities and would not have a discernable impact. The applicant believes that 80 percent of the construction workforce is likely to come from the 80-km (50-mi) region surrounding the plant and impacts will not be noticeable except in the nearest counties. The remaining 20 percent of the construction workforce is likely to concentrate where both housing availability and commuting distance allow. These workers are likely to settle, where possible, in the same five closest jurisdictions. The staff's socioeconomic analysis, therefore, focuses on Henrico, Louisa, Orange, and Spotsylvania Counties and the City of Richmond.

2.8.1 Demographics

The analysis of the population distribution around the ESP site out to an 80-km (50-mi) radius is based on the 2000 census. Table 2-5 presents the population in the concentric rings starting at 16 km (10 mi), 16 to 40 km (10 to 25 mi), 40 to 60 km (25 to 37 mi), and 60 to 80 km (37 to 50 mi), and projected population increases in those rings from 2000 to 2065. Dominion used a formula adopted from the Weldon Cooper Center for Public Service (2004), with the 1990 and 2000 Census as the base. The Weldon Cooper Center for Public Service, located at the University of Virginia, Charlottesville, performed the 2001 provisional population estimates for Virginia. The percent annual growth in population ranges between 1.0 percent (2040 to 2065) and 1.9 percent (2000 to 2010). Total growth in population between 2000 and 2065 is projected at 135 percent. The ESP, if granted, would expire in 2027 assuming an issue date of 2007.

Table 2-5. Population Distribution from 2000 to 2065 Within 80 km (50 mi) of the ESP Site (Note: Through 2040, this is resident population. The year 2065 includes transient population.)

Year	0 to 16 km (0 to 10 mi)	16 to 40 km (10 to 24.9 mi)	40 to 60 km (24.9 to 37.3 mi)	60 to 80 km (37.3 to 50 mi)	Total	% Annual Growth
2000	15,511	185,456	487,482	849,347	1,537,796	
2010[(a)]	20,996	239,813	604,455	984,645	1,849,909	1.9
2020[(a)]	26,480	294,169	721,067	1,119,943	2,161,659	1.6
2030[(a)]	31,965	348,526	837,680	1,255,241	2,473,412	1.4
2040[(a)]	37,449	402,883	954,292	1,390,539	2,785,163	1.2
2065[(a)]	90,425	538,773	1,254,173	1,728,783	3,612,154	1.0

(a) Estimated population.
Source: Dominion (2006a).

All or parts of 32 counties and five major cities are located within 80 km (50 mi) of the proposed North Anna ESP site. The largest population center within 16 km (10 mi) of the site is the town of Mineral, which is southwest of NAPS. In 2000, the population of Mineral was 424 (USCB 2000a). Lake Anna State Park also lies within the 16-km (10-mi) radius to the northwest of the site.

The town of Louisa, located west of the ESP site, falls within the 32-km (20-mi) radius. In 2000, its population was 1401 (USCB 2000a). The City of Fredericksburg, population 19,279 (USCB 2000a), is northeast of the site, and the town of Culpeper, population 9664 (USCB 2000a), is north of the site. Fredericksburg and Culpeper fall within or on the edge of the 48-km (30-mi) radius. Charlottesville, population 45,049 (USCB 2000a), is located west of NAPS, and Richmond, population 197,790 (USCB 2000a), is east of the site. Charlottesville and Richmond lie within or on the edge of the 64-km (40-mi) radius.

Table 2-6 lists the age distribution of the population in the relevant jurisdictions – Henrico, Louisa, Orange, and Spotsylvania Counties and the City of Richmond in 2000 – and compares the city populations to the population of Virginia. The counties' age-distributed populations closely track within 2 to 3 percent of each other. The exceptions are Spotsylvania County's under-18 age group (30.0 percent versus 24.6 percent for Virginia), Orange County's 25-to-44 age group (27.8 percent versus 31.6 percent for Virginia), and Orange County's 65-and-over age group (17.1 percent versus 11.2 percent for Virginia).

Table 2-6. Estimated Age Distribution of Population in 2000

	Henrico County		Louisa County		Orange County		City of Richmond		Spotsylvania County		Virginia	
Age Group	**People**	**%**	**People**	**%**	**People**	**%**	**People**	**%**	**People**	**%**	**People**	**%**
Under 18	64,702	24.7	6255	24.4	5955	23.0	43,178	21.8	27,108	30.0	1,738,262	24.6
18 to 24	20,553	7.8	1691	6.6	1678	6.5	25,932	13.2	6626	7.3	679,398	9.6
25 to 44	86,166	32.9	7656	29.9	7184	27.8	62,712	31.7	29,062	32.2	2,237,655	31.6
45 to 64	58,278	22.2	6710	26.2	6620	25.6	39,839	20.1	20,073	22.2	1,630,867	23.0
65 and over	32,601	12.4	3315	12.9	4444	17.1	26,129	13.2	7526	8.3	792,333	11.2
Totals	262,300	100.0	25,627	100.0	25,881	100.0	197,790	100.0	90,395	100.0	7,078,515	100.0

Source: USCB (2000b).

Table 2-7 contains data on population, projected population, and annual growth rates for the area of potential impact. Among the counties included in the comparison, Spotsylvania County by far has the fastest growth rate, in terms of percentage growth from 1980 through 2000 (actual) and projected growth rate through 2030. Between 1990 and 2000, the population of Spotsylvania County increased by 57.4 percent. The population in Louisa County for the same 10-year period increased by 26.1 percent. During the same time period, population increases in Henrico and Orange Counties were 20.4 and 20.8 percent, respectively. The population of the City of Richmond decreased 2.6 percent during the same period (Virginia Statistical Abstract 2004). The City of Richmond consistently lost population over the 30-year period from 1970 through 2000 and is projected to continue to do so through 2020. Both Spotsylvania and Louisa Counties are ranked among the fastest growing counties in Virginia.

Table 2-7. Population Growth in Henrico, Louisa, Orange, and Spotsylvania Counties, and the City of Richmond – 1980 to 2030

	Henrico County		Louisa County		Orange County		City of Richmond		Spotsylvania County	
Year	**Population**	**Annual % Growth**	**Population**	**Annual % Growth**	**Population**	**Annual % Growth**	**Population**	**Annual % Growth**	**Population**	**Annual % Growth**
1970	154,465		14,004		13,792		249,431		16,424	
1980	180,735	1.6	17,825	2.4	18,063	2.7	219,214	-1.3	34,435	7.7
1990	217,880	1.9	20,325	1.3	21,421	1.7	203,056	-0.8	57,405	5.2
2000	262,300	1.9	25,627	2.3	25,881	1.9	197,790	-0.3	90,395	4.6
2010	301,000[(a)]	1.4	29,100	1.3	30,000	1.5	191,600	-0.3	125,000	3.3
2020	335,000	1.1	32,600	1.1	34,400	1.4	189,600	-0.1	153,000	2.0
2030	365,000	0.9	36,200	1.1	38,600	1.2	189,600	0.0	181,400	1.7

(a) Projected population for 2010-2030; values for 1970 through 2000 are actual census population numbers.
Sources: Weldon Cooper Center (2004); Virginia Employment Commission (2003); Virginia Statistical Abstract (2004, 2005).

2.8.1.1 Transient Population

The area within 16 km (10 mi) of the ESP site is predominately rural and characterized by farmland and wooded tracts. No significant industrial or commercial facilities are in the area, and none are anticipated. As a result, daily commuting is most likely to be out of, rather than into, the area.

Recreational use of Lake Anna, which is the cooling water source for NAPS, is the greatest contributor to a transient population. Numerous recreational sites, consisting of boat ramps, wet slips, camping sites, picnic areas, etc., are located around the reservoir. A central data collection site for recreational use of the lake does not exist. Dominion developed an estimate of lake use on a peak weekend day in mid-summer based on representative usage of recreational facilities (e.g., boating, picnicking, and camping) (Dominion 2006a). Data for the estimate were provided by the VDCR for the recreational facilities at Lake Anna. The estimate does not include use of the lake by local residents with their own private boat docks. Table 2-8 shows the estimated transient population in the vicinity attributed to the lake and to Paramount's Kings Dominion Amusement Park, located 32 km (20 mi) north of Richmond.

The resulting estimated total peak daily transient population on Lake Anna is 5900 for boating and other uses of the lake and 4370 for Lake Anna State Park. The use of the WHTF is limited to residents around the WHTF and their guests; thus, its peak use is less than 1000. Given the conservative assumptions and the potential for double-counting, these numbers may be high (Dominion 2006a).

The annual transient population is less certain because of the dramatic drop in boating during weekdays and the fall, winter, and spring seasons. Based on the Lake Anna State Park data and assuming 180 days of operation, the average daily attendance for the park is less than one quarter of the peak daily attendance. Assuming that the average attendance, excluding the park, is one-half the peak daily figure (Dominion 2006a), the total annual attendance in the vicinity of Lake Anna would be about 808,300, based on a 180-day use period.

An accurate count of the transient population between the 16-km (10-mi) and 80-km (50-mi) radii from the ESP site is difficult to estimate. There are colleges, schools, and hospitals within 80 km (50 mi). However, compared to the resident population within the same area, use of these facilities by the transient population is expected to be insignificant (Dominion 2006a).

Between 16 km (10 mi) and 80 km (50 mi) from the ESP site, Paramount's Kings Dominion Amusement Park is the only major recreational facility that draws a significant number of transient visitors. Paramount's Kings Dominion Amusement Park is 56 km (35 mi) southeast of the site. The park operates from March to November and hosts about 2 to 2.5 million visitors annually. According to the park's public relations manager, the park could experience slow

Table 2-8. Estimated Transient Population Recreating at Lake Anna Facilities and Paramount's Kings Dominion Amusement Park

Facility	Daily Peak Transient Population	Annual Usage	Comments/Assumptions
<u>Lake Anna – Recreational Facilities and State Park</u>			
Lake Anna	5900	531,000	Annual use based on 180 days at 2,950/average day.
Waste Heat Treatment Facility	<1000	90,000	Peak daily use based on doubling the resident population in cooling lagoon sectors (one guest per resident). Annual use based on 180 days at 500/average day.
Lake Anna State Park	4370	187,300	Annual use was 187,300 between July 1, 2001, and June 30, 2002. Park closes in winter. Usage includes occupants of boats launched at the park.
Total Estimated Annual Attendance	--	808,300	Assumed 180 days of operation. For Lake Anna State Park assumed 25 percent of the peak daily attendance. For Lake Anna (including the WHTF), assumed average attendance is one half the peak daily figure.[a]
<u>Paramount's Kings Dominion Amusement Park</u>			
Total estimated attendance	--	2,500,000	Annual use is estimated at between 2.0 to 2.5 million between March and November. Park closes in winter.
Attendance from outside 80-km (50-mi) radius	7246	999,948	Assumes that 40 percent of park visitors come from outside the 80-km (50-mi) radius.[b]
Total estimated transient population	18,516	--	Sum of Lake Anna and Paramount's Kings Dominion Amusement Park transient population

(a) Dominion calculated the annual attendance at 807,300 based on a 180-day season (Dominion 2006a). The NRC staff, using the same numbers and assumptions, derived an estimated annual attendance of 808,300.
(b) Dominion used the maximum capacity of 2.875 million visitors per year to estimate 20,830 average daily park visitors (Dominion 2006a). The NRC staff used the <u>current</u> estimated annual number of visitors at the park as a basis for calculations of the estimated transient population.
Source: Dominion (2006a).

growth in the future, until it reaches its current maximum capacity of 2.875 million visitors per year (i.e., an additional 15 percent above the current attendance) (Dominion 2006a). On average, the park is open for public use about 138 days per year (Paramount 2004).

Using the annual number of visitors to the park and the average number of days open, the current average daily park visitor count is conservatively estimated to be 18,115. While there is no official count of visitors that come from areas outside the 80-km (50-mi) radius of the ESP site, the majority of the park visitors are expected to come from the Richmond and Fredericksburg areas because of their proximity to the park. Dominion assumed that 40 percent of the daily park visitors (7246 visitors) come from areas outside the 80-km (50-mi) radius; or 999,948 visitors over the 138 days that the park is open. These park visitors are considered transient population (Dominion 2006a). The total estimated transient population within 80 km (50 mi), therefore, is the sum of Lake Anna recreational state park and King's Dominion out-of-area attendance, or 18,516 persons.

2.8.1.2 Migrant Labor

Migrant workers are typically members of minority or low-income populations. Because migrant workers travel and can temporarily spend a significant amount of time in an area without being an actual resident, they may be unavailable for counting by census takers. If this occurred, migrant workers would be under-represented in the U.S. Census Bureau's (USCB) minority and low-income population counts.

Agriculture in Louisa County is representative of the surrounding region, including Spotsylvania Henrico, and Orange Counties. In 1997, Louisa County had 385 individual farms. The main crops grown within the county are legumes, grass hay, corn for grain, soybeans, corn for silage, and wheat. Beef cattle production is also important, with 71 percent of the farms holding cattle and calf inventories and 71 percent of the farms selling cattle and livestock (Louisa County 2001). Migrant workers do not harvest agricultural crops in Louisa County; however, they do replant forestland that has been harvested (NRC 2002).

Over the past 5 years, most completely harvested forestland in Louisa County has been replanted or allowed to regenerate naturally. From July 1998 to June 2000, approximately 1465 ha (3560 ac) of forestland were thinned or cleared. In 1999, 877 ha (2130 ac) were reforested (Louisa County 2001). Planting takes place from late January through March and is often done under a Virginia Department of Forestry contract, even on private lands. Migrant laborers often plant the trees. Data on the number of migrant workers participating in the planting are not available, but the number is considered to be small. Given the expected small number of migrant workers, even if they were concentrated at a single location, they would remain only for a short time and would not materially change the population characteristics of any particular census tract within Louisa County.

2.8.2 Community Characteristics

2.8.2.1 Economy

The communities potentially most impacted socioeconomically by activities at the ESP site are Henrico, Louisa, Orange, Spotsylvania Counties, and the City of Richmond, all in central Virginia. The greatest impacts would be observed in Louisa County, where the NAPS site is located. All these counties, but not the City of Richmond, have experienced steady growth in population and economic activity during the 1990s. Brief discussions of the economy of each of the counties follow.

Some comparative economic statistics for the four counties and Virginia are presented in Tables 2-9, 2-10, 2-11, 2-12, and 2-13. Table 2-9 presents information on the unemployment rate (for December 2003), the percentage of individuals below the poverty line for 2000, and median household income. Table 2-10 presents the major employers in Louisa County. Table 2-11 presents information on regional employment trends for Henrico, Louisa, Orange, and Spotsylvania Counties; the City of Richmond; and the Commonwealth of Virginia. Table 2-12 contains county and city employment by proprietorship and industry (1990 and 2000) for the four counties and the City of Richmond. Table 2-13 is an aggregation of Table 2-12 and totals employment by industry or business type across the four counties and City of Richmond for 1990 and 2000.

The City of Richmond is part of the Richmond-Petersburg metropolitan statistical area, which is home to approximately 950,000 people. The Richmond-Petersburg area is the primary economic driving force within an 80-km (50-mi) radius of NAPS. The Richmond metropolitan statistical area is located approximately 160 km (100 mi) from Washington, D.C., and has a transportation network of trucking and railroad terminals and interstate highway access to main east-west and north-south routes. It also has an international airport and the western-most inland port in the Commonwealth of Virginia with direct access to the Atlantic Ocean, giving it access to both domestic and international markets (VEPCo 2001).

The unemployment rate for the City of Richmond at the end of December 2003 was 5.3 percent (Table 2-9), an increase from an annual unemployment rate of 2.9 percent for the year 2000 (Table 2-11). The workforce decreased from approximately 221,241 to 196,175 or about 11.3 percent between 1990 and 2000. Services, government, and manufacturing are the biggest employment sectors for 2000 (see Table 2-12). The City of Richmond has the highest poverty rate and lowest median household income of the five jurisdictions evaluated (Table 2-9).

Henrico County is also part of the Richmond-Petersburg metropolitan statistical area. The Richmond area is home to the headquarters of 35 major corporations, including eight Fortune 500 companies and 14 Fortune 1000 corporations. Of those numbers, three Fortune 500 and three Fortune 1000 companies are located in Henrico County (Henrico County 2004a). Services, retail trade and finance, insurance, and real estate are the largest employment sectors in the county (Table 2-12) (Henrico County 2004a). Capital One Financial Corporation is one of the largest private employers in the area (NRC 2002). The unemployment rate in Henrico County was 3.0 percent in December 2003 (Table 2-9) (Virginia Employment Commission 2004), essentially unchanged from 2000. Henrico County's employment increased from approximately 142,000 in 1990 to 195,000 in 2000, or about 37 percent (see Table 2-11).

Henrico County had the second highest median household income (at $49,185 in 2000) and the second lowest percentage individual poverty in 2000, 6.2 percent of the total population (Table 2-9). The median household income in Henrico County exceeded Virginia's median household income by approximately $2500.

Table 2-9. Percent Unemployment, Individual Poverty, and Median Household Income

	Unemployment (% December 2003)	Poverty (% Estimated 2000)	Median Household Income (2000 $)
Henrico County	3.0	6.2	49,185
Louisa County	4.8	10.2	39,402
Orange County	3.5	9.2	42,889
City of Richmond	5.3	21.4	31,121
Spotsylvania County	1.9	4.7	57,525
Virginia	3.3	9.6	46,677

Note: Low income was defined as being in a household having an income below the official poverty level.
Sources: USCB (2000c); Virginia Employment Commission (2004).

Table 2-10. Major Employers in Louisa County, Virginia

Employer	Product	Number of Employees
Dominion Virginia Power	Electric Utility	1318+
Kloeckner–Pentaplast	Rigid PVC Products	652
Wal-Mart, Inc.	Distribution Center	525
Louisa County Public Schools	Education	680
Louisa County	Government Services	250[a]
AGI Klearfold, Inc.	Plastic Packing	160
Tri-Dim	Filters	120

(a) Inclusive of full- and part-time employees (VEPCo 2001).
Sources: Louisa County Economic Development (2004), and NRC (2002).

Table 2-11. Regional Employment Trends – 1990 and 2000

County, City, and State	Workers Employed Full-Time and Part-Time 1990	Workers Employed Full-Time and Part-Time 2000	% Change in Workers Employed 1990 - 2000	Unemployment Rate 1990 %	Unemployment Rate 2000 %
Henrico	142,293	194,787	36.9	3.0	1.6
Louisa	8427	11,641	38.1	4.9	3.1
Orange	9955	10,558	6.1	2.5	2.2
Spotsylvania and Fredericksburg	40,402	59,872	48.2	3.8, 3.4	1.3, 2.3
City of Richmond	221,241	196,175	-11.3	6.4	2.9
Total for region	422,318	473,033	12.0	-	-
Virginia	3,727,194	4,424,791	18.7	4.5	2.2

Sources: BEA (2000) and County and City Data Books (1994, 2000).

Table 2-12. County and City Full-Time and Part-Time Employment by Type and by Industry

Industry	Henrico County		Louisa County		Orange County		Spotsylvania County and Fredericksburg		City of Richmond	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Total Employment	142,293	194,787	8427	11,641	9955	10,558	40,402	59,872	221,241	196,175
Wage and Salary Employment	126,504	178,082	6375	6359	7649	8466	33,500	50,699	206,804	182,142
Proprietors employment	15,789	16,705	2052	5282	2306	2092	6902	9173	14,437	14,033
• Nonfarm proprietor employment	15,628	16,529	1621	4827	1868	1613	6603	8871	14,437	14,033
• Farm proprietor employment	161	176	431	455	438	479	299	302	0	0
By Industry										
Farm employment	234	214	511	476	644	671	373	341	0	0
Agriculture services, fishing, and other	899	1352	146	191	126	164	294	D	539	639
Mining	200	187	76	D	L	D	10	D	161	195
Construction	10,539	12,092	1352	1227	972	913	3916	4497	8842	8513
Manufacturing	13,465	16,514	1548	1548	2058	1689	3215	3420	28,327	19,175
Transportation and public utilities	6313	8815	D	D	214	326	1271	2191	12,383	10,965
Wholesale trade	9771	11,757	116	227	212	558	1945	2678	11,697	9048
Retail trade	29,430	38,274	773	1310	1782	1903	10,606	15,513	22,744	18,830
Finance, insurance, and real estate	19,811	32,402	431	1222	601	D	3084	3754	24,320	16,601
Services	39,902	59,016	D	2949	1897	1768	10,424	19,237	61,122	61,735
Government and government enterprises	11,729	14,164	1040	1341	1446	2066	5264	7652	51,106	50,474

D - Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.
L - Fewer than 10 jobs, but the estimates for this item are included in the totals.
Source: BEA (2000).

Table 2-13 Aggregated Full-Time and Part-Time Employment by Industry or Business Type for Henrico, Louisa, Orange, and Spotsylvania Counties, Fredericksburg, and the City of Richmond

Industry or Business Type	1990 Employment	2000 Employment	% Increase (Decrease)
Total Employment	422,318	473,033	12.0
Wage and Salary Employment	380,832	425,748	11.8
Proprietors employment	41,486	47,285	14.0
• Nonfarm proprietor employment	40,157	45,873	14.2
• Farm proprietor employment	1329	1412	6.2
By Industry			
Farm employment	1762	1702	-3.4
Agriculture services, fishing, and other	2004	2346[a]	17.1[a]
Mining	447[a]	382[a]	-14.5[a]
Construction	25,621	27,242	6.3
Manufacturing	48,613	42,346	-12.9
Transportation and public utilities	20,181[a]	22,297[a]	10.5[a]
Wholesale trade	23,741	24,268	2.2
Retail trade	65,335	78,830	20.7
Finance, insurance, and real estate	48,247	53,979[a]	11.9[a]
Services	113,345[a]	144,705	27.7[a]
Government and government enterprises	70,585	75,697	7.2

(a) Summations and percentages are for numbers shown in Table 2-12 (i.e., as with Table 2-12, some county data are not reported because of confidentiality issues).
Source: BEA (2000).

Louisa County is located in the triangle between Richmond, Fredericksburg, and Charlottesville. I-64 runs east-west through the county, as does a CSX Corporation rail line. Because NAPS is located in Louisa County, that county has benefitted more economically from the existing Units 1 and 2 than have Henrico, Orange, and Spotsylvania Counties. Table 2-10 shows the top seven employers in Louisa County.

Until the 1990s, Louisa County had been rural and dominated by farming and forestry, which are still economically important. In the 1990s, the county population grew by 26 percent, without a comparable increase in industrial and commercial development (Louisa County 2001).

The number of full-time and part-time jobs in the county increased from 8427 in 1990 to 11,641 in 2000, an increase of 38.1 percent (see Table 2-11). During the 1990s, two clothing manufacturers that were located in the county closed (Louisa County 2001). A positive aspect of the county's economic development was the arrival of a Wal-Mart Regional Distribution Center at Zion Crossroads in the western part of the county. Wal-Mart currently employs approximately 525 people (see Table 2-10). In addition, since 1990 the unemployment rate in Louisa County dropped from 4.9 percent (see Table 2-11) to 3.1 percent in 2000. The unemployment rate has since increased to 4.8 percent for December 2003 (Table 2-9). Services, manufacturing, construction and finance, insurance, and real estate were the top employment sectors in the county in 2000 (Table 2-12). Louisa County had the second highest individual poverty rate and second lowest median household income (for 2000) of the five jurisdictions (see Table 2-9).

More than half the resident workers in Louisa County commute to jobs outside the county (Louisa County 2001; VEPCo 2001; Virginia Employment Commission 2005). In many respects, Louisa County is a bedroom community for the larger metropolitan regions, particularly Richmond, and to a lesser extent, Fredericksburg, Charlottesville, and Washington, D.C.

Operation of NAPS Units 1 and 2 in Louisa County has kept the property tax assessment rates significantly below those of neighboring counties. It also enabled the county to begin an economic development program in the 1970s with the construction of its industrial park (NRC 2002). In addition, NAPS represents a local source of high-wage employment. The average weekly wage in the nuclear electric power generation industry in the Richmond Metropolitan Statistical Area (which includes Louisa County) was $1551 in 2004, while the average wage for all industries was $762 in the Richmond MSA, $744 in Louisa County, and $779 in Virginia (Virginia Employment Commission 2005). While recognizing that NAPS has been economically beneficial, Louisa County would like to lessen its dependence on NAPS through diversification of the local economy. To achieve this diversification, the county hopes that it can attract technology and bio-research firms (NRC 2002) and that Wal-Mart will train and provide employment for workers at the lower end of the pay scale, which is defined as being substantially higher than minimum wage (currently the Federal minimum wage is $5.15 per hour), but generally less than $10 per hour.

The economy in Orange County is dominated by agribusiness, manufacturing, and commercial retail services. The towns of Orange and Gordonsville are the only two incorporated towns in the county. A planned, gated residential community exists at Lake of the Woods (VEPCo 2001).

Orange County's employment was approximately 10,560 in 2000 (see Table 2-11), but 55 percent of working adults commuted out of the county to work (Orange County 2004a; Virginia Employment Commission 2005). The existing employment base in Orange County represents an increase of 6.1 percent over the 1990 level (Table 2-11). The largest employer (600 people) is American Woodmark Corporation. The second largest employer (287 workers) is Von Holtzbrinck Publishing Services, a book distribution center (Orange County 2004b). The unemployment rate in Orange County was 3.5 percent in December 2003 (Table 2-9), an increase from the annual unemployment rate of 2.2 percent in 2000 (Table 2-11). Orange County had the third highest median household income and individual poverty rate of the five jurisdictions studied (Table 2-9). In percentage terms, the fastest growing employment sectors in Orange County during the decade of the 1990s were wholesale trade (163 percent), transportation and public utilities (52.3 percent), and government and government enterprises (42.9 percent) (Table 2-12).

Spotsylvania County is located halfway between Washington, D.C. and Richmond, Virginia. Economically, it is more associated with the Washington, D.C. metropolitan area through the commuting patterns of its residents (NRC 2002). It is estimated that approximately 63 percent of the county's workers commute to jobs outside the county (Virginia Employment Commission 2005). The county is a bedroom community to the Washington, D.C. area.

Historically, agriculture and forestry have been important components of the economy for Spotsylvania County. The economic slowdown of 2001 to 2002 did not materially impact Spotsylvania County, as can be seen by the unemployment and other economic factors. The continued building boom, particularly in residential construction, was the most important economic factor (Partridge et al. in Jaksch and Scott 2005). The relative economic importance of agricultural and forest activities has declined compared to the commercial base as the county has grown. The largest employer in Spotsylvania County is Spotsylvania County Schools (employment over 3000). Spotsylvania County government is the next largest employer (at over 650 workers), with CVS Pharmacy third (575 workers). CVS Pharmacy has a distribution warehouse located in the county (Spotsylvania County 2005a,b).

The unemployment rate in Spotsylvania County was 1.3 percent for the year 2000 (Table 2-11). This compares with an unemployment rate of 1.9 percent as of December 2003 (Table 2-9).

While there is exceptionally low unemployment in the county, Spotsylvania County lacks resident-based employers that pay higher wages. The prevalent wage paid by a number of resident based employers is under $10 per hour (Partridge et al. in Jaksch and Scott 2005). Workers employed full-time and part-time increased by approximately 48.2 percent between 1990 and 2000 (Table 2-11). In percentage terms, the fastest growing employment sectors in Spotsylvania County between 1990 and 2000 were services (84.5 percent); transportation and public utilities (72.4 percent); retail trade (46.3 percent); and government and government enterprises (45.4 percent) (Table 2-12).

There are no growth restrictions in Spotsylvania County, which had the second highest growth rate in Virginia and the thirteenth highest in the country (Partridge et al. in Jaksch and

Scott 2005). Attempts are being made to manage growth through the permit process. One such approach involves down-zoning housing density (for example, where housing density once was one house per acre, now it is one house per 2 acres). Attempts are being made to preserve agricultural land by limiting one house to approximately 10 acres. Also, market forces are limiting entry into the county's housing market. It is currently a seller's market, because houses in Spotsylvania County are more affordable than in Fairfax County and other Northern Virginia locations. The average price of a residential house in Spotsylvania is around $215,000, with more than that price often being offered by potential buyers. This is shifting growth that might have taken place in Spotsylvania County to Louisa and Caroline Counties and beyond (Goss 2003 in Jaksch and Scott 2005).

Table 2-13 aggregates employment by industry or employment type across Henrico, Louisa, Orange, and Spotsylvania Counties and the City of Richmond between 1990 and 2000. The fastest growing sector was services (27.7 percent). Next was retail trade at 20.7 percent, followed by agricultural services, fishing, and other at 17.1 percent. Proprietor employment increased by 14.0 percent, followed by finance, insurance, and real estate, which increased by 11.9 percent. The construction workforce increased from 25,621 in 1990 to 27,242 in 2000, or 6.3 percent. As can be seen from Table 2-11, the total number of workers increased from 422,318 in 1990 to 473,033 in 2000, or 12.0 percent.

2.8.2.2 Transportation

There are 32 counties within the 80-km (50-mi) radius of the ESP site. One county is in Maryland while the remaining counties are in Virginia. The 31-county Virginia area is served by two major freeways. I-95 runs north-south through the region and connects it with Washington, D.C., to the north and Richmond, Virginia, to the south. I-64 connects Richmond to Charlottesville on the west and Norfolk on the east. I-295 serves as a beltway around the City of Richmond.

The area is also traversed by several other State and Federal highways including U.S. Route 15 (U.S. 15) from the vicinity of Warrenton in the north, through Culpeper, and on south. U.S. 29 runs more northeast to southwest from the vicinity of Manassas, through Culpeper, to Charlottesville, and extends on to the southwest. U.S. 33 passes through Louisa and then southeast to Richmond. U.S. 250 runs between Charlottesville and Richmond. Numerous State routes (SRs) traverse the area including SRs 700, 652, 208, and 522.

Road access to North Anna is via SR 700, a narrow, two-lane, paved road. SR 700 intersects SR 652 approximately one-half mile from the North Anna site. The major commuting routes in the immediate vicinity of NAPS are SRs 700, 652, 208, 522, and 618. These roads all carry a level-of-service (LOS) designation "B" (stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished). See Table 2-14 for a description of LOS designations.

Table 2-14. Level-of-Service Designation Characteristics

Level-of-Service	Conditions
A	Free flow of the traffic stream; users are unaffected by the presence of others.
B	Stable flow in which the freedom to select speed is unaffected, but the freedom to maneuver is slightly diminished.
C	Stable flow that marks the beginning of the range of flow in which the operation of individual users is significantly affected by interactions with the traffic stream.
D	High-density stable flow, in which the freedom to maneuver is severely restricted; small increases in traffic will generally cause operational problems.
E	Operating conditions at or near capacity level, causing low but uniform speeds and extremely difficult maneuvering that is accomplished by forcing another vehicle to give way; small increases in flow or minor perturbation will cause breakdowns.
F	Defines forced or breakdown flow that occurs whenever the amount of traffic approaching a point exceeds the amount that can traverse the point. This situation causes the formation of queues characterized by stop-and-go waves and extreme instability.

Source: VEPCo 2001.

General transportation studies have been undertaken of highways in the region, and plans are in place to upgrade serveral highways, including those in areas around Lake Anna. The interchange for SR 606 and I-95 is congested, generally at a LOS D or better. A Virginia Department of Transportation (VDOT) I-95 interchange study has determined that this interchange will become more congested in the future (Dominion 2006a).

The VDOT I-95 study includes an analysis of traffic patterns for the SR 606/I-95 interchange out to year 2025. The study identifies an existing congestion issue and relates it to the ongoing rapid growth in western Spotsylvania County. Upgrading the access to I-95 has been delayed because of lack of funding, and is not yet included in VDOT's funded projects as of October 2006. The VDOT study also identifies the need for widening the western section of SR 606 to alleviate the existing congestion that affects traffic trying to access I-95 north and south.

I-95 north from Richmond is not as congested. I-64 west from Richmond has a LOS no worse than B (Dominion 2006a). During the December 2003 site visit, the staff noted that even during what would normally be considered rush hour, I-64 leaving Richmond westbound in the evening or returning to Richmond in the morning was moderately traveled, with traffic moving well. SRs 208 and 522 are well maintained, lightly traveled, two-lane roads.

The Louisa-Orange-Spotsylvania Advisory's three-county planning group, the Lake Anna Advisory Committee, has recommended that planners in each of the three counties upgrade their local roads around Lake Anna. The recommended upgrades would provide a circumferential roadway system around the lake with adequate lanes for towed boats and bicycles. Should the upgrade occur, it would alleviate congestion on local roads, such as SRs 608 and 522 (Lake Anna Special Area Plan Committee 2000). The Louisa County Comprehensive Plan of 2001 also recognizes the need to improve the roadways around Lake Anna. The plan recommends improvement to the roads within Louisa County, but provides no information on funding or the timing of the recommended road improvements (Louisa County 2001). No major upgrades are planned at this time (Coffey and Hatler in Jaksch and Scott 2005).

Spotsylvania County plans to widen SR 606 west of I-95 to four lanes and has included this project in their comprehensive plan (Spotsylvania County 2002). Construction of a SR 208 Bypass around the historic Courthouse District was originally planned to begin in 2006. Both projects have been delayed (Vogel and Goss 2005 in Jaksch and Scott 2005). When completed, the SR 208 Bypass will alleviate a potential bottleneck in the Spotsylvania Courthouse area. Construction is scheduled to be bid in 2007. SR 208 south is a two-lane road with a bridge over Lake Anna west of the ESP site. Spotsylvania County's long term plans are to upgrade the two-lane roads around Lake Anna by widening them to include shoulders, which should more easily accommodate larger vehicles such as motor homes. This upgrade is in line with the three-county planning group's plans for the Lake Anna area (Dominion 2006a).

In Hanover County, U.S. 33 links Richmond with Louisa and points to the north and west. This two-lane road in the northern part of the county is currently congested and needs to be widened (Dominion 2006a). A time frame for the widening has not been set because the source of funding has not been identified. Traffic congestion would be considered in developing a county traffic management plan (Hanover County 1998).

2.8.2.3 Property Taxes

Table 2-15 presents information on the total property tax revenues and the amount Dominion paid to Louisa County for NAPS from 1995 to 2003. In addition, the percentage of total property taxes paid and the county's budget is presented. For the period 1995 to 2003, property taxes for NAPS averaged about 46 percent of the total property tax revenue for Louisa County over the 9-year period and averaged approximately 22.5 percent of the county's total annual budget. Dominion projected annual property tax payments for NAPS would continue to increase slightly (absolute amount) through the license renewal term of Units 1 and 2 (VEPCo 2001). However, the percent such payments represent of the total county taxes paid will probably continue to decline. The potential effects of electric utility deregulation in Virginia on future property tax collections from the units is not fully known at this time.

The significance of this discussion on the economy is that the four-county area around the ESP site is in a state of change. Henrico and Spotsylvania Counties are more economically sound

Table 2-15. Property Tax Revenues Generated in Louisa County; Property Taxes Dominion Paid to Louisa County; and Operating Budgets for Louisa County – 1995 to 2003

Year	Total Property Tax Revenues	Property Tax Paid to County for NAPS	Percent of Total Property Taxes	Total County Operating Budget[(a)]
		Louisa County		
1995	19,244,309	10,683,585	56	36,120,116
1996	21,452,251	11,131,726	52	44,471,914
1997	22,783,690	11,361,154	50	37,600,195
1998	24,141,313	11,006,924	46	37,651,399
1999	24,094,105	11,145,065	46	43,562,452
2000	24,770,698	10,583,390	43	46,554,387
2001	24,343,887	10,987,610	45	51,944,200
2002	25,861,613	9,931,868	38	56,704,171
2003	26,098,535	10,171,340	39	54,514,969

(a) The total county budget is up in some years because of capital construction such as schools.
Source: McLeod in Jaksch and Scott 2005.

than Orange and Louisa Counties. Spotsylvania County, for at least the last two decades, has been influenced economically by the Washington, D.C., and northern Virginia economies, with many white-collar professionals choosing to live in Spotsylvania County (for the suburban-country lifestyle) and commute to jobs in Washington, D.C, and northern Virginia. Also, over the last two decades, the Richmond area has become economically diversified and has grown significantly. Some of this growth has impacted Spotsylvania County, to the north, and Henrico County, which abuts the City of Richmond.

Orange and Louisa Counties have also benefitted from the growth in neighboring Henrico and Spotsylvania Counties. In addition, both Louisa and Spotsylvania Counties have been impacted by Lake Anna and the economic development around Lake Anna. Orange County has been impacted to a lesser extent by this development because it has fewer miles of shoreline. Development around Lake Anna has been oriented toward upscale vacation and retirement homes. Lake Anna is becoming family oriented with more permanent year-round residences (Goss 2003 in Jaksch and Scott 2005). Land values around the lake have increased significantly. Starter homes are being built on Louisa County's eastern edge, closer to the City of Richmond. Homes and developments for residents with moderate incomes are scattered across Louisa County, and upscale neighborhoods are being built in the western end of the county closer to Charlottesville and around Lake Anna.

Dominion has a significant impact on the economic well-being of Louisa County, paying on average, about 46 percent of the total property taxes between 1995 and 2003. Louisa County schools have benefitted substantially from the taxes Dominion pays for NAPS by being able to upgrade their infrastructure. Over time, the percentage contribution of total NAPS property taxes payable to Louisa County for NAPS Units 1 and 2 will decline, assuming the current rate of economic growth in the county continues. Thus, while the economic importance of NAPS is expected to decline, it may decline even faster if Louisa County experiences substantial economic growth as did Spotsylvania and Henrico Counties during the 1990s.

2.8.2.4 Aesthetics and Recreation

Access to the North Anna site itself is provided by SR 700, a two-lane road leading up to the plant boundary. The terrain is gently undulating and wooded. Most of the site structures are screened from public view up to the proximity of the plant boundary. Noise from plant operations is not noticeable, particularly from points outside the NAPS plant boundary.

From October 2000 to September 2002,[a] the area around Lake Anna went through a severe drought, the worst in the 108-year history of data collection in the area. The drought had an impact on Lake Anna with the water level dropping to 245 feet above MSL. The normal operating pool level is 250 feet above MSL. As a result of the drop in water levels, most boat ramps could not support launches (Dominion 2004b,c), although commercial marinas continued to operate (Duke's Creek Marina, Anna Point Guide Service, McCotter's Guide Service, Gene Hord's Guide Service, and High Point Marina in Jaksch and Scott 2005).

The staff made an effort to determine how the drought affected park attendance and boat launches at Lake Anna State Park. The results are presented in Table 2-16.

Table 2-16. Visitor and Boat Launches at Lake Anna State Park – 1998 to 2003

Year	Annual Park Visitors	Annual Boat Launches
1998	145,500	2792
1999	111,000	2449
2000	158,200	2107
2001	178,300	2447
2002	185,900	2125
2003	159,700	2073

Note: For annual park visitors, the 2003 data are for 11 months of the year only, from January through November.
Source: Dominion 2004c.

(a) October through September is defined as a water year for purposes of measuring precipitation.

With respect to park attendance, it appears the drought had little impact. Annual attendance rates increased through the drought period (2000 to 2002) and then, based on annualizing the attendance from 11 months to 12 months for 2003, declined again.

The impact of the drought on boat launches from the park is more obvious. There was a general downturn in the number of boat launches between 1998 (at 2792 launches) and 2000 (at 2107 boat launches). During 2001, the number of launches increased to 2447 and then declined to 2125 in 2002 (the worst year of the drought), or 13.2 percent, although the ramps remained operational. The number of boat launches continued their decline into 2003, declining by 2.4 percent over 2003. The impact on Lake Anna's commercial marinas and guide services varied. All of the marinas remained operational, although some had problems with their wet slips and ramps and had to undertake modifications to keep operating. By changing launch points, the guides were also able to keep operating, although some noticed that fishing success was down for about a two-year period, and some reported that customer demand also fell off because of perceived poor conditions more than actual lack of success. Some guides reported that they had no trouble finding fish and that they were able to avoid navigation hazards that became more of a problem for private boaters (Wayne's World of Fishing, Anna Point Guide Service, McCotter's Guide Service, Gene Hord's Guide Service, Glenn Briggs Guide Service, and Teddy Carr in Jaksch and Scott 2005).

2.8.2.5 Housing

Approximately 850 permanent employees work at NAPS Units 1 and 2 (Dominion 2006a). Approximately 79 percent of these employees live in Henrico, Louisa, Orange, and Spotsylvania Counties and the City of Richmond; the rest live in other locations. Table 2-17 presents the county of residence for the 820 permanent employees for whom addresses were provided during the license renewal review (NRC 2002). The staff expects that the 850 employees currently employed at NAPS Units 1 and 2 are distributed throughout the counties in the same pattern as the 820 employees were at the time of license renewal.

Dominion refuels each nuclear unit at NAPS on an 18-month staggered schedule. During refueling outages, site employment increases by as many as 700 temporary workers for 30 to 40 days. The staff assumed that residences for these temporary workers are similarly dispersed throughout the region as are those of NAPS permanent employees.

Table 2-18 provides the number of housing units and housing unit vacancies for the area of potential impact for 1990 and 2000. Each county in the area of potential impact has a comprehensive land use plan. Louisa County updated its plan in September 2001 (Louisa County 2001). Louisa County is adding from 350 to 400 homes a year to its housing stock. This rate has been fairly constant over the last 3 to 4 years (NRC 2002).

Table 2-17. North Anna Power Station – Permanent Employee Residence Information by Four-County Area of Potential Impact

County	Number of Personnel	Percent of Total Personnel
Henrico, including the City of Richmond	104	12.7
Louisa	237	28.9
Orange	120	14.6
Spotsylvania	186	22.7
Other	173	21.1
Total	820	100.0

Source: NRC 2002.

The county showing the greatest increase in housing units over the decade of the 1990s is Spotsylvania County, which one would expect given its economic growth over the decade. The number of housing units increased by 62.7 percent, and the number of renter-occupied housing units increased by 62.5 percent. The number of vacant units increased by 31.4 percent. The City of Richmond had the largest number of vacant units at 7733 in 2000, representing a decrease of 12.2 percent from 1990.

Table 2-19 presents more detailed 2000 census data on vacant housing units for Henrico, Louisa, Orange, and Spotsylvania Counties and the City of Richmond. Of the total vacant housing units, the City of Richmond, as previously noted, had the highest number at 7733 vacancies of which 3113 (or 40.3 percent of vacant housing) were for rent and another 2659 (or 34.4 percent) were vacant. Henrico County was second with 4449 vacant units of which 1970 (or 44.3 percent of vacant housing) were for rent and another 818 units (or 18.4 percent of vacant housing) were vacant. Louisa and Orange Counties had the smallest number of units for rent at 73 and 116, respectively. Within the counties of interest and the City of Richmond, approximately 5630 units were available for rent.

Rental rates for reasonable housing in Louisa County are considered high for a small rural area, and the availability of rental apartments and housing is limited. Rents range from $750 to $800 per month for a moderately priced two-bedroom unit. The presence of the Wal-Mart distribution center at Zion Crossroads has pushed rents to these levels and they can be held there because of the shortage of housing. There is also shortage of rental housing in Orange and Culpeper Counties and nearby Charlottesville (Hayfield and Livingood in Jaksch and Scott 2005).

Table 2-18. Housing Units and Housing Units Vacant (Available) by County – 1990 and 2000

	1990	2000	Approximate Percentage Change
HENRICO COUNTY			
Total Housing Units	94,539	112,570	19.1
Occupied Units	89,138	108,121	21.3
Owner Occupied	56,848	71,089	25.1
Renter Occupied	32,290	37,032	14.7
Vacant Units	5401	4449	-17.6
LOUISA COUNTY			
Housing Units	9080	11,855	30.6
Occupied Units	7427	9945	33.9
Owner Occupied	5932	8110	36.7
Renter Occupied	1495	1835	22.7
Vacant Units	1653	1910	15.5
ORANGE COUNTY			
Housing Units	9038	11,354	25.6
Occupied Units	7930	10,150	28.0
Owner Occupied	6047	7822	29.4
Renter Occupied	1883	2328	23.6
Vacant Units	1108	1204	8.7
SPOTSYLVANIA COUNTY			
Housing Units	20,483	33,329	62.7
Occupied Units	18,945	31,308	65.3
Owner Occupied	15,516	25,735	65.9
Renter Occupied	3429	5573	62.5
Vacant Units	1538	2021	31.4
CITY OF RICHMOND			
Housing Units	94,141	92,282	-2.0
Occupied Units	85,337	84,549	-0.1
Owner Occupied	39,515	39,008	-1.3
Renter Occupied	45,822	45,541	-0.6
Vacant Units	8804	7733	-12.2
Sources: USCB 1990, 2000d.			

Table 2-19. Vacant Housing Units for Henrico, Louisa, and Spotsylvania Counties and the City of Richmond – 2000

	Number	Percent of Vacant Units
Henrico County		
Vacant Housing Units	4449	
For rent	1970	44.3
For sale only	806	18.1
Rented or sold, not occupied	395	8.9
For seasonal, recreational or occasional use	454	10.2
For migratory workers	6	0.1
Other vacant	818	18.4
Louisa County		
Vacant Housing Units	1910	
For rent	73	3.8
For sale only	124	6.5
Rented or sold, not occupied	84	4.4
For seasonal, recreational or occasional use	1226	64.2
For migratory workers	0	0.0
Other vacant	403	21.1
Orange County		
Vacant Housing Units	1204	
For rent	116	9.6
For sale only	170	14.1
Rented or sold, not occupied	66	5.5
For seasonal, recreational or occasional use	484	40.2
For migratory workers	1	0.1
Other vacant	367	30.5
Spotsylvania County		
Vacant Housing Units	2021	
For rent	359	17.8
For sale only	449	22.2
Rented or sold, not occupied	164	8.1
For seasonal, recreational or occasional use	564	27.9
For migratory workers	1	0.0
Other vacant	484	23.9
City of Richmond		
Vacant Housing Units	7733	
For rent	3113	40.3
For sale only	949	12.3
Rented or sold, not occupied	761	9.8
For seasonal, recreational or occasional use	249	3.2
For migratory workers	2	0.0
Other vacant	2659	34.4

Source: USCB 2000d.

2.8.2.6 Public Services

Water Supply

Table 2-20 summarizes the daily water consumption and areas served by each water system within the area of potential impact. Henrico County provides water to approximately 83,411 residential, commercial, and industrial customers (NRC 2002). Currently, the county purchases its water supply from the City of Richmond, which has no restrictions on the amount of water that can be purchased. Henrico County's average daily water use is 130,000 m^3/day (35 MGD). The county also has service agreements to supply limited amounts of water to Hanover and Goochland Counties (NRC 2002). Because of the rapid growth rate in Richmond and surrounding counties, a water supply treatment plant with a capacity of 210,000 m^3/day (55 MGD) was completed and placed in operation in May 2004 for Henrico County. Henrico County has a permit to withdraw 300,000 m^3/day (80 MGD) of water. The plant is expected to be expanded to accommodate the larger withdrawal rate by 2010 (Slater in Jaksch and Scott 2005).

Richmond's source of water is the James River, which supplies approximately 562,000 people in the City of Richmond and in Chesterfield, Hanover, and Henrico Counties. It has a maximum capacity of 484,000 m^3/day (128 MGD) and an average use of 310,000 m^3/day (83 MGD) (VEPCo 2001). Richmond is upgrading the plant to treat 570,000 m^3/day (150 MGD).

About 80 percent of the residential drinking water for Louisa County is from groundwater through private wells. Twelve small private water supply systems exist in the county. The major treatment plant in the county is the Northeast Creek water treatment plant that supplies the town of Louisa, part of the town of Mineral, and some county residents. The plant has a capacity of approximately 3800 m^3/day (1 MGD), and average use is 1100 m^3/day (0.3 MGD). To provide water for industrial and other users, five new groundwater wells and a new storage tank were also completed between 2001 and 2004 in the Zion Crossroads area in the western part of the county (Delk in Jaksch and Scott 2005). This is in addition to the existing storage tank.

Ninety percent of Orange County residents obtain their drinking water from private groundwater wells. The town of Orange draws its water directly from the Rapidan River in what is known as a "run-of-the-river" withdrawal.[a] The town of Orange also owns and operates a 7600 m^3/day (2 MGD) capacity water treatment plant that supplies the town (VEPCo 2001). Average daily use is around 5700 m^3/day (1.5 MGD) (VEPCo 2001).

(a) A "run of the river" means that there is little or no water storage behind the dam or structure being employed to withdraw water from the river.

Table 2-20. Major Public Water Supply Systems in Henrico, Louisa, Orange, and Spotsylvania Counties

Water System	Source	Daily Capacity m^3/day (MGD)	Average Daily Use m^3/day (MGD)	Area Served
Henrico County	James River	NA	130,000 (35)	Henrico, Hanover and Goochland Counties
City of Richmond	James River	484,000 (128)	310,000 (83)	Richmond, Chesterfield, Hanover, and Henrico Counties
Louisa County Water Authority	Groundwater/NE Creek Reservoir	3800 (1)	1100 (0.3)	Towns of Louisa, Mineral, and some County residents
Town of Orange	Rapidan River	7600 (2)	5700 (1.5)	Town of Orange
Rapidan Service Authority	Groundwater	NA	75 (0.02)	Town of Grodonsville, plus 50 to 60 homes on Route 20
Wilderness Treatment Plant	Rapidan River	6100 (1.6)	1500 (0.4)	Town of Wilderness/Lake of the Woods
Spotsylvania County	Ni River	23,000 (6)	17,000 (4.5)	Supplies most residential, commercial, and industrial areas in the county

NA = not available.

Source: NRC 2002.

Part of the town of Orange's treatment plant production, around 2000 m^3/day (0.5 MGD), is sold to the Rapidan Service Authority (RSA), which supplies the town of Gordonsville (VEPCo 2001). RSA operates two other Orange County facilities. The source of water for these plants is the Rapidan River and groundwater. RSA's Wilderness Treatment Plant has a 6100 m^3/day (1.6 MGD) treatment capacity and supplies, on average, approximately 1500 m^3/day (0.4 MGD) to Lake of the Woods and the town of Wilderness (VEPCo 2001).

Spotsylvania County has a public water system supplying most residential, commercial, and industrial areas within the county. Rural areas of the county are served by wells and springs (NRC 2002). The Ni River Treatment Plant, which draws water from the Ni River, has a capacity of 23,000 m^3/day (6 MGD) and average use of 17,000 m^3/day (4.5 MGD). Another larger treatment plant began operating during 2004 (Elam in Jaksch and Scott 2005).

Public water supply is not a constraint to growth in the vicinity of NAPS. There are supply concerns in some individual municipalities and in some of the impact counties. In Louisa County, water and sewer infrastructure are a concern now, particularly around the I-64 corridor in the vicinity of Gum Springs. The county is considering a separate system for this area. Water supply reservoirs are also a concern. The recent drought exacerbated a shortage in the availability of water supplies. Currently there are no growth restrictions in Louisa County (Williams and Buckler in Jaksch and Scott 2005).

In Orange County, the Rapidan River is the source of water for several public water supply systems. The Rapidan River is not normally a high flowing river; thus, during the 2000 to 2002 drought, there were some water supply problems. In the corridor that encompasses Gordonsville and the town of Orange, water and sewer services are operating at maximum capacity. Any new growth will require system upgrades. Location is also a problem. The existing water supply system at the eastern end of the county, where many current NAPS employees live, is operating at close to capacity. Shipping water from the west end of the county to the east end would be expensive. Currently there are no growth restrictions in Orange County (Livingood and Kendall in Jaksch and Scott 2005).

There are no limitations on new sources of water from groundwater, and many of the treatment plants located in the area of potential impact have reserve treatment capacity, especially in the larger metropolitan areas. In cases where municipal systems are approaching reserve-capacity limits, plans are in place to address those limitations by constructing new treatment systems or expanding existing facilities.

Police, Fire, and Medical Facilities

None of the nearest three counties has a hospital; however, there are major medical facilities in Henrico County and in Richmond, Fredericksburg, and Charlottesville.

In Orange County, there are two outpatient clinics and no hospitals. The fire departments are made up of volunteers, and rescue services are composed of both volunteer and paid employees. In the future, for new facilities, the county is considering hiring full-time paid staff (Livingood and Kendall in Jaksch and Scott 2005). An increase in construction workers locating to the county could put pressure on this infrastructure.

In the town of Louisa and Louisa County, there is no hospital. In Louisa County, general fire, police, and rescue services are considered adequate at present (Lintecum in Jaksch and Scott 2005).

Henrico County is home to three hospitals. In total, 12 acute-care hospitals and seven special-care facilities are located in the Richmond area representing nearly 5200 patient beds. Notable in this total is the Medical College of Virginia Hospital, a major research and teaching center (Henrico County 2004b). Spotsylvania County has no hospitals, but is served by hospitals in Fredericksburg, immediately to the north. The nearest general acute-care hospitals to the town of Mineral are Mary Washington Hospital in Fredericksburg, Henrico Doctor's Hospital in Henrico County, Martha Jefferson Hospital in Charlottesville, and Culpeper Regional Hospital in Culpeper, all between about 30 to 35 miles away (Switchboard 2005).

Social Services

Social services in the Commonwealth are provided in each county by the Virginia Department of Social Services (VDSS) with offices in each county. The department provides services to children (child care, protective services, foster care and child support enforcement, among other services) and adults (adult protective services, domestic violence prevention, etc.) and financial assistance such as food stamps and Medicaid. The department has 131 local departments located throughout Virginia (VDSS 2004).

2.8.2.7 Education

Louisa County has one high school, one middle school, and three elementary schools. For the school year 2000 to 2001, there were 4232 students in the school system (NRC 2002). All schools currently have higher enrollment than they were designed to accommodate (on the order of 100 to 150 students depending on the school), so overcrowding is a concern. Enrollment is growing at 2 percent a year. Tax rates in the county have not increased in 6 years, so while the schools are being maintained, there has been no new construction to accommodate the increased enrollment. Growth is occurring in the county because of its low tax rates when compared to the surrounding counties, in turn because Louisa County has NAPS in its tax base (see Table 2-15) (Melton in Jaksch and Scott 2005). Property was purchased for a new elementary school in 2004, with construction to start in 2007 (Green in Jaksch and Scott 2005). Property also has been purchased for construction of a new middle school. The growth areas in the county are around Lake Anna, Zion Crossroads, and the I-64 corridor (Lintecum in Jaksch and Scott 2005).

Orange County schools have a total enrollment of approximately 4200 students spread among five elementary schools, two middle schools, and one high school (Shifslett in Jaksch and Scott 2005). Orange County is expanding its school infrastructure. One new middle school has been added, and the high school has been renovated, adding an additional 26,000 square feet of space. Both middle schools currently have 600 students and could accommodate 800. The high school has a current enrollment of 1250 and could expand to 1500 pupils. Growth is taking place in the eastern end of the county, closer to NAPS and Lake Anna. There is one middle school in the eastern end of the county, and if growth continues, a new elementary school will need to be built (Baker in Jaksch and Scott 2005).

Spotsylvania County has 26 schools in its system (16 elementary schools, 6 middle schools, and 4 high schools). In addition, the county has one vocational school, and one special high school for intellectually gifted students (NRC 2002). Approximately 20,350 students are enrolled in the county school system, and an additional 350 are in the special high school (NRC 2002). A middle school is being constructed to accommodate growth around Lake Anna (Goss 2003 in Jaksch and Scott 2005).

Henrico County and the City of Richmond have 41 elementary schools, 10 middle schools, 9 high schools, and 2 technical centers (NRC 2002). Total school enrollment is more than 41,000.

2.9 Historic and Cultural Resources

This section discusses the cultural background and the known and potential historic and cultural resources at the North Anna ESP site and the immediate surrounding area.

2.9.1 Cultural Background

The area around the North Anna ESP site is rich in prehistoric and historic Native American and historic Euro-American resources. A number of recent documents provide adequate background detail for the area's cultural chronology and prehistoric and historic period contexts. Consequently, only a brief summary is provided here. For the ESP site, Ahlman and Mullin (2001) discuss the prehistoric and historic contexts. Another overview document discusses the cultural background at the nearby North Anna State Park (Goode and Dutton 1999), located upriver and north of the plant. Historic period overviews are available for both Louisa County (Thomas Jefferson Planning District 1995), in which the plant is located, and for Spotsylvania County (Traceries 1996), which is situated just across the North Anna River to the east of NAPS. Cooke (1997) also provides a historical overview of Louisa County. In addition, cultural information was obtained from the supplemental environmental impact statement prepared for the license renewal of NAPS, Units 1 and 2 (NRC 2002). The following cultural chronology summaries are extracted from these sources.

Prehistoric Period

The prehistoric Native American occupation of the region including the North Anna site includes three general periods: the Paleo-Indian period (about 10,000 to 8000 B.C.); the Archaic period (about 8000 to 1000 B.C.); and the Woodland period (about 1000 B.C. to A.D. 1600). Toward the end of the Woodland period (A.D. 1500 to 1675), a transitional episode known as the Protohistoric period occurred in which initial contacts with Europeans and cultural changes associated with subsequent white settlement of the area took place.

The prehistoric periods were marked by initial reliance on big game hunting subsistence, followed by increased use of smaller game animals and plant foods in the Archaic era. Major environmental changes in the Archaic period led to an increasingly more sedentary lifestyle, focused primarily in riverine settings. Late in the Archaic, more sedentary villages and an increasing reliance on cultivated crops became the norm and the subsequent Woodland period was characterized by larger base camps in the river valleys, with subsistence based on agriculture, hunting and gathering, and intergroup trade. The latter part of the Woodland period is primarily identified by the added presence of European trade goods (NRC 2002).

Historic Period Native American

At the time of European contact and subsequent intrusion into the area surrounding the North Anna site, the lands including the piedmont and mountains of western Virginia were occupied by several Siouan-speaking Indian groups.

One of the Monacan Indian groups, part of the larger Monacan Confederacy, is commonly associated with the area of present-day Louisa County. Between 1607 and 1720, the Monacan were gradually pushed from their homelands through a series of encounters with the encroaching settlers, and by the 1677 “Treaty Between Virginia and the Indians.” By 1700, the Monacan had left Louisa County (Cooke 1993). Although some of the Monacan left the area for good, going as far as Pennsylvania and Canada, a remnant group moved to the Bear Mountain area of Amherst County, Virginia, around 1720. Today, the Virginia Monacan Tribe numbers about 900 individuals (Hauck and Maxham 1993). In 1989, the Monacan Tribe was recognized by the Virginia General Assembly as one of the eight indigenous tribes in the Commonwealth, and became a member of the Virginia Council on Indians (Monacan Indian Nation Website).

Historic Period Euro-American

Similar to the prehistoric period, the historic period in Virginia can be subdivided into sequential time periods that are descriptive in terms of associated events. These include the European Settlement to Society Period (1607 to 1750); Colony to Nation Period (1750 to 1789); Early National Period (1789 to 1830); Antebellum Period (1830 to 1860); Civil War Period (1861 to 1865); Reconstruction and Growth Period (1865 to 1917); World War I to World War II Period (1917 to 1945); and the New Dominion Period (1945 to present).

European settlement of the area around the North Anna site began shortly after 1700, and Louisa County was formed in 1742. The earliest economy of the area was based on cultivation of tobacco in the fertile lands along the North and South Anna River valleys. In the early 1800s, production of tobacco resulted in severe soil exhaustion, and wheat and corn replaced it as staple crops. Although the area remained largely rural and agricultural in nature, at times mining and quarrying also became important to the economy of Louisa County in the 1800s, including mining of iron, copper, sulfur, gold and other ores, and quarrying of whetstone materials. The area just upriver from the North Anna site was the scene of intensive gold mining in the period from about 1830 to 1900 (NRC 2002).

2.9.2 Historic and Cultural Resources at the North Anna ESP Site

To assess both known and potential cultural resource sites at the North Anna ESP site, several existing literature and database sources were consulted, along with direct contacts to several organizations (Appendix B). Particularly useful in this regard was the recent cultural resource assessment for the plant site, commissioned by Dominion Resources (The Louis Berger Group 2001a,b). Additionally, Dominion Resources commissioned the Louis Berger Group to survey the area proposed for ten survey areas, totaling appropriately 2.4 ha (6.0 acres) within the area of Potential Effects for the proposed ESP site (Mullin 2006).

At the time of the 2001 cultural resource assessment, examination of historic and cultural resource files at the Virginia Department of Historic Resources Archives indicated that no previously recorded cultural resource sites were known to exist at NAPS (Ahlman and Mullen 2001). Similarly, a review of historical documentation at the Louisa County Historical Museum, including historic maps dating between 1751 and 1863, indicates few historic resources in the vicinity of the North Anna site, other than an early road paralleling the south side of the North Anna River that appears to be near the western boundary of the North Anna site. An unpublished map based on county deeds from 1765 to 1815 (Truce undated), shows the presence of the “Jerdones Mill” on the North Anna River bank, just upriver from the North Anna site, along with the associated “Jerdones Mill Road.” The same map shows an “Old Mine Road” within the North Anna site area.

Background research undertaken by Ahlman and Mullin (2001) indicate that on undisturbed lands within the larger plant boundary there is potential for both unrecorded prehistoric and historic cultural resources to occur. A field inspection of the proposed ESP project area was completed (Voigt 2003). This reconnaissance concluded that much of the proposed ESP site lies within previously disturbed areas, particularly in the eastern portion. However, some undisturbed areas in the western sector were identified that may have some potential for the presence of cultural resources. With the exception of the two cemetery sites discussed below, the 2006 survey of the ESP site found no artifacts, cultural features, or cultural deposits (Mullin 2006).

As a follow-up to the 2001 assessment, five known historic period cemeteries were recorded, three of which lie within the administrative boundary of the North Anna site and two that are located just down river from the North Anna Dam (Louis Berger Group 2001b). Two of these cemeteries have associated archaeological remains of former structures.

Two of the recorded historic period cemeteries, designated as 44LS221 and 44LS222 in the Virginia Department of Historic Resources site file system, are located in the vicinity of proposed ESP construction or laydown areas. Site 44LS221 is a small cemetery located in the area known as the Northwest Laydown Yard in a lightly wooded area. During construction of

NAPS, this area was marked and protected during construction activities. Site 44LS222 is located on the hilltop above the proposed construction area and is protected by a tall chain-link fence.

It should also be noted that reconnaissance-level historic and archaeological investigations completed in 1969 and 1970 for both the North Anna site area and the lake bed area yielded few results (AEC 1973). A few Archaic period artifacts were noted in the area, but the investigator did not deem them worthy of recording and evaluating. In addition, according to records in the Louisa County Historical Society files, a total of 33 historic period cemeteries were identified in the area along the river to be inundated. Many of these were avoided by adjusting project boundaries, although some were “removed” prior to inundation. This total apparently includes at least four of the cemeteries recorded recently at the North Anna site. Finally, cultural resource surveys along transmission line rights-of-way associated with NAPS have largely resulted in negative findings for cultural resources (Saunders 1976; MacCord 1981).

2.9.3 Native American Consultation

Today, there are eight Native American tribes that are recognized by the Commonwealth of Virginia. Six of these tribes have for several years been pursuing Federal recognition, but that status has not yet been achieved. Consultation letters were sent to the following tribes in conjunction with the North Anna ESP EIS:

- Chickahominy Indian Tribe
- Chickahominy Indians – Eastern Division
- Mattaponi Indian Tribe
- Monacan Indian Nation
- Nansemond Indian Tribe
- Pamunkey Indian Tribe
- Rappahannock Tribe
- Upper Mattaponi Indian Tribe

Based on information previously received from the Bureau of Indian Affairs, NRC also contacted the Tuscacora Nation concerning the ESP EIS for the proposed Units 3 and 4.

In addition, the Virginia Council on Indians was contacted regarding the project. The Council serves as an integrating office for Virginia’s Indian Tribes within the state government.

2.10 Environmental Justice

Environmental justice refers to a Federal policy under which each Federal agency identifies and addresses, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority[a] or low-income populations. The Council on Environmental Quality (CEQ) has provided guidance for addressing environmental justice (CEQ 1997). Although it is not subject to the Executive Order, the Commission has voluntarily committed to undertake environmental justice reviews (NRC 2004b). On August 24, 2004, the Commission issued its policy statement on the treatment of environmental justice matters in licensing actions (69 FR 52040).

The staff examined the geographic distribution of minority and low-income populations within 80 km (50 mi) of the North Anna site, employing the 2000 Census (USCB 2000e) for low-income populations and the 2000 Census (USCB 2000f) for minority populations. The radius within 80 km (50 mi) of NAPS encompasses counties in Virginia and Maryland. The analysis was also supplemented by field inquiries to the planning departments of Orange, Louisa, and Spotsylvania Counties (Livingood and Kendall 2003, Williams and Buckler 2003, and Goss 2003, respectively in Jaksch and Scott 2005); social service agencies in Louisa and Orange Counties (Lingo in Jaksch and Scott 2005), and other governmental officials in Spotsylvania County (Partridge et al. in Jaksch and Scott 2005).

For purposes of the staff's review, a minority population is defined to exist if the percentage of any minority or aggregated minority category within the census block groups[b] within an 80-km (50-mi) radius of the NAPS site exceeds the corresponding percentage of minorities in the entire Commonwealth of Virginia and State of Maryland (for Charles County, Maryland) by at least 20 percent, or if the corresponding percentage of minorities within the census block group is at least 50 percent. A low-income population is defined to exist if the percentage of low-income population within a census block group exceeds the corresponding percentage of low-income population in the entire Commonwealth of Virginia and State of Maryland by at least 20 percent, or if the corresponding percentage of low-income population within a census block group is at least 50 percent. For counties and census block groups within an 80-km (50-mi)

(a) Minority categories are defined as: American Indian or Alaskan Native; Asian; Native Hawaiian or other Pacific Islander; Black races; or Hispanic ethnicity; "other" may be considered a separate minority category. The 2000 Census included multi-racial data (NRC 2004b).

(b) A census block group is a combination of census blocks, which are statistical subdivisions of a census tract. A census block is the smallest geographic entity for which the Census Bureau collects and tabulates decennial census information. A census tract is a small, relatively permanent statistical subdivision of counties delineated by local committees of census data users in accordance with Census Bureau guidelines for the purpose of collecting and presenting decennial census data. Census block groups are subsets of census tracts (NRC 2002).

radius of the ESP site, the percentage of minority and low-income populations is compared to the percentage of minority and low-income populations in Virginia or Maryland, as applicable.[a]

Dominion followed the convention of including census tracts in its assessment. It included the census tracts where at least 50 percent of their area lay within 80 km (50 mi) of the ESP site (Dominion 2006a). The "at least 20 percentage points above the comparison area" criterion was used to determine whether a census tract should be counted as containing a minority or low-income population (Dominion 2006a). Because the 20 percentage points is a lower threshold, the 50 percent criteria was not needed.

The staff followed the convention of employing census block groups. Figure 2-6 shows the distribution of minority populations (cross-hatched) within the 80-km (50-mi) radius. All census tracts with at least 50 percent of their area within an 80-km (50-mile) radius of the North Anna ESP site are included in the analysis.

Within 32 km (20 mi) of NAPS, a minority population is concentrated to the southwest of the site in Louisa County. Black minority populations exist within approximately 24 km to 48 km (15 mi to 30 mi) east-southeast of the site on Caroline County's boundary with Hanover County and extending to King William County. Between approximately 64 km (40 mi) and 80 km (50 mi) east of the ESP site, minority populations exist in Essex and Westmoreland Counties.

A concentration of minority census block groups exists in Charles County (Maryland) and Prince William County (Virginia), east-northeast of the NAPS site. Between 64 km (40 mi) and 80 km (50 mi) southeast of NAPS, there is a concentration of minority census block groups in the Richmond area, and to the south-southwest a concentration in Buckingham, Fluvanna, Goochland, and Cumberland Counties. Minority populations also appear in Culpeper County northwest of the North Anna site. All minority block groups are more than 16 km (10 mi) from NAPS.

Data from the 2000 census characterize 9.6 percent of Virginia's and 8.5 percent of Maryland's populations as low-income (USCB 2000e). Applying the NRC criterion of "more than 20 percent greater," the census block groups were identified to contain low-income populations and are presented in Figure 2-7. Census block groups containing low-income populations are concentrated in the City of Richmond.

Also, Henrico and Chesterfield Counties, to the southeast between approximately 65 km and 80 km (40 mi and 50 mi) from the North Anna site, have low-income populations. Other areas of low-income populations include Buckingham County southwest of the site and Charlottesville. The staff assumed that these relationships would continue through 2065.

(a) Low-income households should be identified using the annual statistical poverty threshold from the Census Bureau.

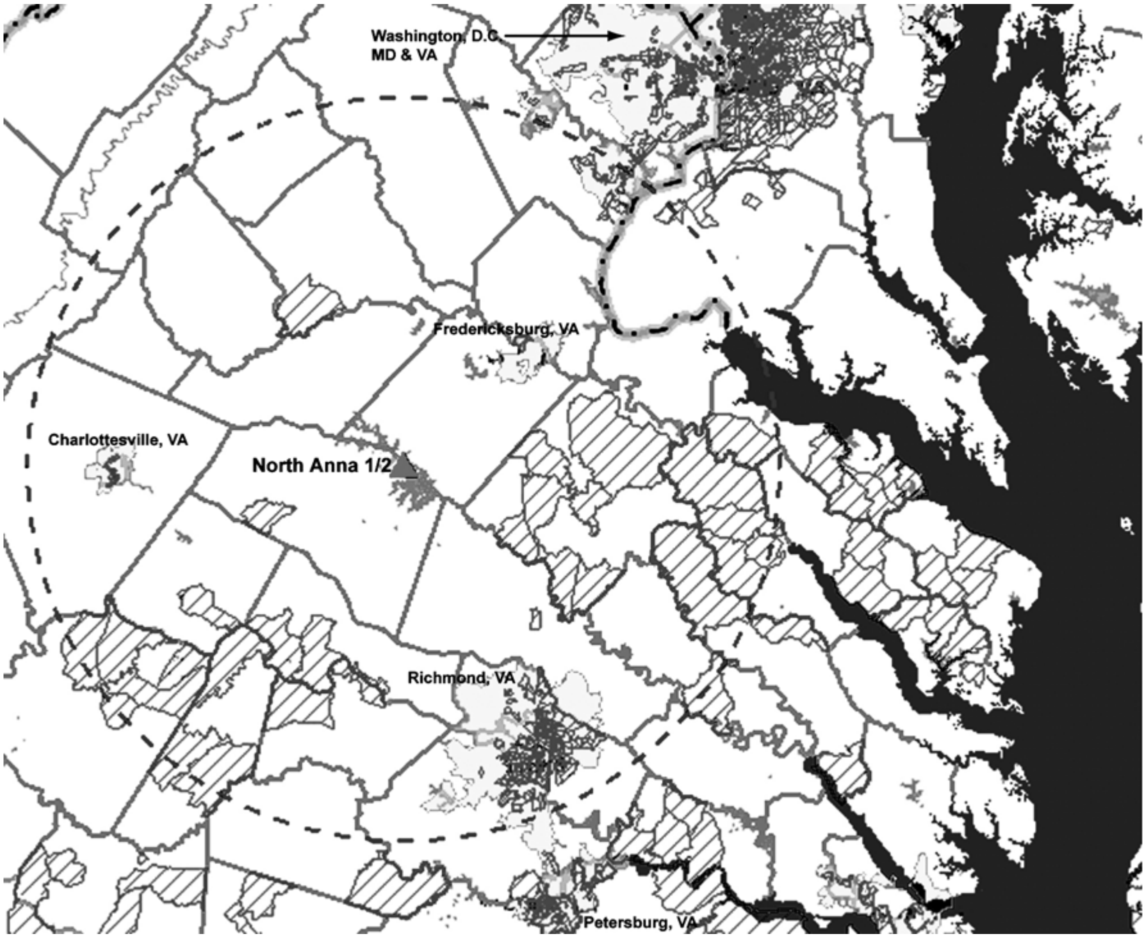

Figure 2-6. North Anna Census 2000 Environmental Justice Minority Populations (crosshatched areas) Within an 80-km (50-mi) Radius of the North Anna ESP Site

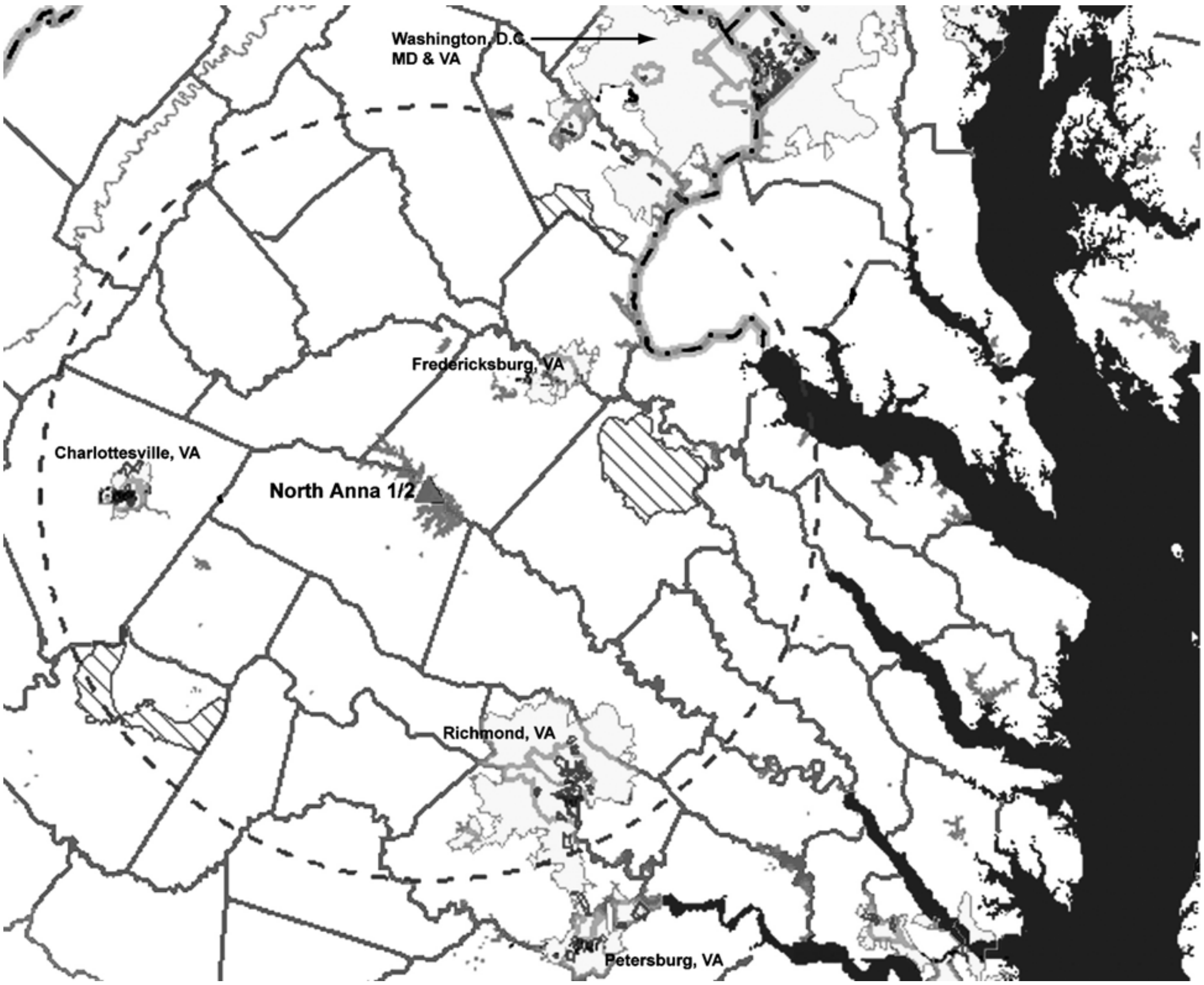

Figure 2-7. North Anna Census 2000 Environmental Justice Low Income Populations (crosshatched areas) Within an 80-km (50-mi) Radius of the North Anna ESP Site

2.11 Related Federal Projects

The staff reviewed the possibility that activities of other Federal agencies might impact the issuance of an ESP to Dominion. Any such activities could result in cumulative environmental impacts and the possible need for a Federal agency to become a cooperating agency for preparation of the EIS (10 CFR 51.10(b)(2)).

Federal lands within an 80-km (50-mi) radius of the NAPS site include the George Washington Birthplace National Monument, Fredericksburg and Spotsylvania National Military Park, Richmond National Battlefield, Shenandoah National Park, Featherstone and Rappahannock National Wildlife Refuges, Fort A.P. Hill Military Reservation, Marine Corps Base Quantico, and the Naval Surface Warfare Center, Dahlgren Division. There are no national forests, wilderness areas, or wild and scenic rivers within the region. Several Virginia State Parks exist within the region. The closest park, Lake Anna State Park, is approximately 8 km (5 mi) northwest of the NAPS site. The closest Native American reservations, the Mattaponi and the Pamunkey Tribes, are more than 80 km (50 mi) from the NAPS site. The hydroelectric project operated by Virginia Power at the North Anna Dam is not licensed by the Federal Energy Regulatory Commission because of its small size.

After reviewing the Federal activities in the vicinity of the NAPS site, the staff determined that there were no Federal project activities that would make it desirable for another Federal agency to become a cooperating agency for preparation of the EIS.

The NRC is required under Section 102(2)(C) of NEPA to consult with and obtain the comments of any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved in the subject matter of the EIS. During the course of preparing this EIS, NRC consulted with the FWS, the National Marine Fisheries Service (NOAA Fisheries), and the Army Corps of Engineers. Contact correspondence is included in Appendix F.

2.12 References

Note: Because the web pages cited in this document may become unavailable, the staff has entered the appropriate pages into ADAMS. The accession number of the package containing the websites used as references in Chapter 2 of the North Anna ESP EIS is ML051150299.

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10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, “Domestic Licensing of Production and Utilization Facilities.”

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions.”

10 CFR Part 100. Code of Federal Regulations, Title 10, *Energy*, Part 100, “Reactor Site Criteria.”

40 CFR Part 81. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 81, “Designation of Areas for Air Quality Planning Purposes.”

40 CFR Part 190. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

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3.0 Site Layout and Plant Parameter Envelope

The proposed North Anna early site permit (ESP) site is located in Louisa County in predominately rural northeastern Virginia, and is within the current North Anna Power Station (NAPS) boundaries. The site is situated approximately 64 km (40 mi) northwest of Richmond, Virginia. This chapter describes the approach Dominion Nuclear North Anna, LLC (Dominion) used to identify the key plant parameters and site characteristics needed to assess the environmental impacts of the proposed action (Dominion 2006). The site layout and existing facilities are discussed in Section 3.1. The plant parameters and power transmission system are discussed in Sections 3.2 and 3.3, respectively, and references for this chapter are documented in Section 3.4.

3.1 External Appearance and Site Layout

The proposed North Anna ESP site is located within the existing NAPS site in an area adjacent to the existing units (Figure 3-1). NAPS consists of two operational pressurized water reactors (PWRs) furnished by Westinghouse Electric Company, a shared turbine building, a switchyard, intake and discharge structures, and support buildings. NAPS is located on the shore of Lake Anna, an impoundment created in 1971 by constructing a dam on the main stem of the North Anna River to create a source of cooling water for NAPS. The Lake Anna reservoir is divided into Lake Anna, which serves as the cooling water source for NAPS Units 1 and 2, and the Waste Heat Treatment Facility (WHTF), which receives the heated discharge. The existing units use a spray pond for an ultimate heat sink. A radioactive waste disposal system, a fuel-handling system, an independent spent fuel storage installation, auxiliary structures, and other onsite facilities necessary for a complete operating nuclear power plant also exist on the NAPS site. With the exception of a few support buildings that may be relocated, existing structures at the NAPS site would remain unchanged with the addition of new units. The ESP site characteristics are listed in Appendix I, Table I-1 of this document.

For purposes of the ESP application, a specific plant design has not been selected for the proposed new Units 3 and 4; instead, a set of plant-parameter values was chosen for the staff's evaluation of the development of the North Anna ESP site. This plant parameter envelope (PPE) is based on the addition of two new power generating units, each of which would be a stand-alone unit with its own support systems. Appendix I, Table I-2 lists the PPE values used by the staff. Dominion states that the new units would share ancillary support structures such as maintenance facilities, office centers, and wastewater and water treatment plants. Each new unit would represent a portion of the total generation capacity to be added, and may 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 nuclear generating capacity to be added would not exceed 4500 megawatts-thermal (MW(t)) per unit, or up to a total of 9000 MW(t) for two units. For the

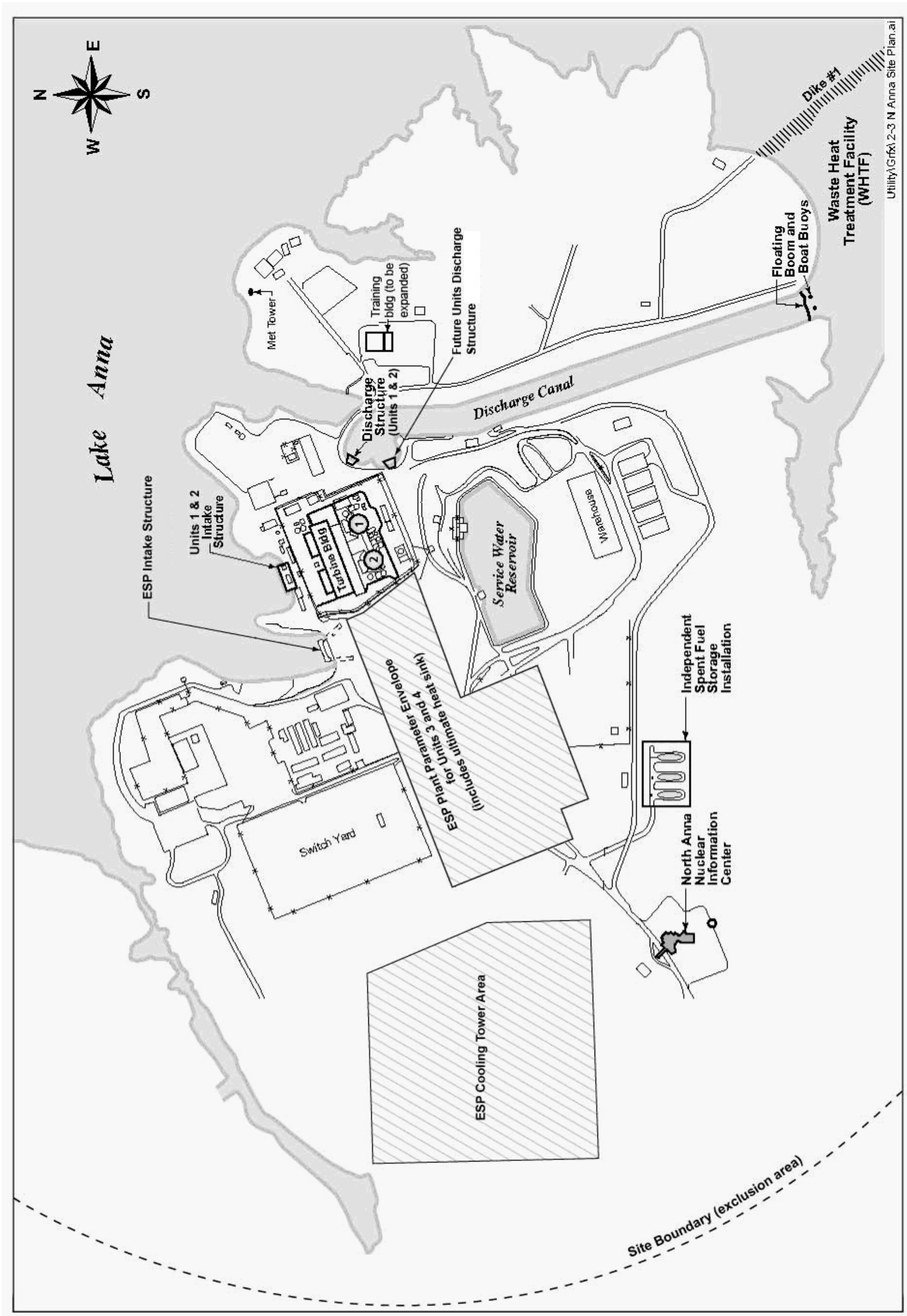

Figure 3-1. Proposed Major ESP Structures (Units 3 and 4) in Relation to Existing Units 1 and 2 Structures

cooling systems, Dominion has proposed using combination wet and dry cooling towers for Unit 3 and dry cooling towers for Unit 4. The proposed location for the cooling towers is illustrated in Figure 3-1.

3.2 Plant Parameter Envelope

An applicant for an ESP need not provide a detailed design of a reactor or reactors and the associated facilities, but should provide sufficient values for parameters for the reactor or reactors and the associated facilities so that an assessment of site suitability can be made. Consequently, the ESP application may refer to a PPE as a surrogate for a nuclear power plant and its associated facilities.

A PPE is a set of values of plant design parameters that an ESP applicant expects would bound the design characteristics of the reactor or reactors that might be constructed at a given site. The PPE values are surrogates for actual reactor design information. Analysis of environmental impacts based on a PPE approach permits an ESP applicant to defer the selection of a reactor design until the construction permit (CP) or combined construction and operating license (combined license or COL) stage. The PPE reflects the value of each parameter that it encompasses rather than the characteristics of any specific reactor design.

In its North Anna ESP application, Dominion used a composite of values from seven reactor designs to develop the PPE for the ESP application. The values in this EIS are not design-specific; rather, they are used to determine the environmental impacts of a reactor design that falls within the values used in this report. The reactor designs used to develop the PPE include the following five light-water reactor and two gas-cooled reactor types:

- Canada Deuterium Uranium Reactor (ACR-700) – This reactor, developed by Atomic Energy Canada Limited, is an evolutionary extension of the CANDU 6 plant using very slightly enriched uranium fuel and light-water cooling.

- Advanced Boiling Water Reactor (ABWR) – This reactor, developed by General Electric Company (GE), is a standardized plant that has been certified under the NRC requirements in Title 10 of the Code of Federal Regulations (CFR) Part 52, Appendix A. The ABWR is fueled with slightly enriched uranium and uses light-water cooling.

- Advanced Pressurized Water Reactor (AP1000) – This is an earlier version of the AP1000 reactor design developed by Westinghouse Electric Company, using slightly enriched uranium and light-water cooling. This design is not the standard AP1000 that has been certified by the NRC in 10 CFR Part 52, Appendix D; therefore, this design is referred to as the “surrogate AP1000.”

- Surrogate Economic Simplified Boiling Water Reactor (ESBWR) – This surrogate reactor design is based on a design developed by GE using slightly enriched uranium fuel and light-water cooling. Dominion revised its application to reflect a higher power level value of 4500 MW(t) (Dominion 2006). The ESBWR design certification application is currently under review by the NRC.

- International Reactor Innovative and Secure (IRIS) next generation PWR – This reactor is under development by a consortium led by Westinghouse Electric Company and is a modular light-water reactor.

- Gas Turbine Modular Helium Reactor (GT-MHR) – This reactor, developed by General Atomics, is a modular helium-cooled, graphite-moderated reactor.

- Pebble Bed Modular Reactor (PBMR) – This reactor, developed by PBMR (Pty) Ltd., is a modular graphite-moderated, helium-cooled gas turbine reactor.

Dominion would not be required to use any of these designs if it elects to proceed with a CP or COL application; however, a CP or COL applicant referencing an ESP would have to address whether the characteristics of the reactor ultimately selected fall within the values of the design parameters specified in the ESP.

Review Approach

NUREG-1555, *Environmental Standard Review Plan* (ESRP) (NRC 2000), and review standard RS-002, *Processing Applications for Early Site Permits* (NRC 2004), provide guidance to the NRC staff to help ensure a thorough, consistent, and disciplined review of any ESP application. The staff's June 23, 2003, response to comments received on draft RS-002 (NRC 2003) provide additional insights into the staff's approach to the review of an application employing the PPE approach.

Because PPE values were used as a surrogate for design-specific values, the staff expected Dominion to provide information sufficient for the staff to develop a reasonable independent assessment of potential impacts to specific environmental resources. In some cases, the design-specific information called for in the ESRP was not provided in the Dominion ESP application because it did not exist or was not available. Therefore, the NRC staff could not apply the ESRP guidance in those review areas. In such cases, the NRC staff used its experience and judgment to adapt the review guidance in the ESRP and to develop assumptions necessary to evaluate impacts to certain environmental resources to account for this missing information. These assumptions are discussed in the appropriate sections of this EIS.

Because the Dominion PPE values do not reflect a specific design, they were not reviewed by the NRC staff for correctness. However, the NRC staff made a determination that the application was sufficient to enable the staff to conduct its required environmental review and that the PPE values are not unreasonable for consideration by the staff when making its finding on the application in accordance with 10 CFR 52.18. During its environmental review, the staff used its judgment to determine whether Dominion provided information sufficient for the staff to perform its independent assessment of the environmental impacts of construction and operation of a new nuclear unit or units. Dominion expects that the PPE values will bound the design characteristics of a reactor or reactors that might be constructed at the North Anna ESP site. At the COL stage, as required by 10 CFR 52.79, the applicant must, in addition to the information and analysis otherwise required, submit information sufficient to demonstrate that the design of the facility falls within the parameters specified in the ESP. If actual reactor characteristics do not fall within the PPE values on which the staff based its estimate of the potential environmental impacts resulting from constructing and operating one or more new nuclear units at the ESP site, the staff will consider whether the difference between the actual characteristics and the PPE value is significant.

Table 3.1-1 in the ER provides information from various reactor designs that were used to develop the bounding site-specific PPE values contained in ER Table 3.1-9. The values in ER Table 3.1-1 are generic values and not site-specific values (Dominion 2006). Therefore, the site-specific values in ER Table 3.1-9 may differ from the generic values in ER Table 3.1-1. ER Tables 5.4-6 and 5.4-7 provide bounding PPE values for the radionuclide activities. Therefore, the PPE values provided in ER tables 3.1-9, 5.4-6, and 5.4-7 are used in the staff's analysis and are reproduced in Appendix I of the EIS unless specifically noted otherwise.

Throughout the North Anna ESP environmental report, Dominion (2006) provides:

(1) Statements of plans to address certain issues in the design, construction, and operation of the facility

(2) Statements of planned compliance with current laws, regulations, and requirements

(3) Statements of plans for future activities and actions that it will take should it decide to apply for a CP or COL

(4) Descriptions of Dominion's estimate of the environmental impacts resulting from the construction and operation of a new nuclear unit or units on the North Anna ESP site

(5) Descriptions of Dominion's estimates of future activities and actions of others and the likely environmental impacts of those activities and actions that would be expected should Dominion decide to apply for a CP or COL.

The activities described include, but are not limited to, such actions as:

- Considering the results of testing and monitoring during the development of a CP or COL application
- Complying with NRC regulations and those of other agencies, including obtaining appropriate permits from other agencies
- Taking actions to mitigate adverse environmental impacts (e.g., best management practices)
- Addressing certain issues at the CP or COL stage that were not addressed in the ESP application.

Some of these future actions are those that Dominion would be required to implement because they are currently required by law, and others are actions that Dominion has indicated that it would implement without the legal obligation to take such actions.

The staff performed its evaluation of the impacts of constructing and operating one or more new nuclear units at the ESP site assuming that these activities and actions would be undertaken by Dominion and others during future licensing activities. As discussed previously, the staff developed assumptions necessary to evaluate impacts to certain environmental resources to account for missing detailed information. In addition to other sources of information obtained independently, the staff considered future activities and actions, estimates of expected environmental impacts that were identified by Dominion in its ER, and the PPE values listed in Appendix I when developing the inputs and assumptions used in the NRC staff's independent review of the environmental impacts of constructing and operating one or more new units on the North Anna ESP site. The staff has identified missing information with respect to particular resources, the staff's assumptions in evaluating such resources, and any resulting limitations in the staff's conclusions or the environmental impacts to particular resources, where appropriate. In addition, as a result of the staff's environmental review of the Dominion ESP application, the staff determined that conditions or limitations on the ESP may be necessary in specific areas, in accordance with 10 CFR 52.24. Proposed permit conditions are set forth in Appendix J of this EIS.

3.2.1 Plant Water Use

This EIS assesses the impacts of plant water use based on the values of design parameters provided by Dominion in the ER. At the ESP stage, the staff's review of the design parameters is limited to an evaluation of whether the parameter values are not unreasonable. At the CP or COL stage, a CP or COL applicant referencing the ESP is required to demonstrate that the specific plant design would fall within the design parameters in the ESP. The following sections describe both the consumptive and non-consumptive water uses of proposed Units 3 and 4 and the associated plant water treatment systems.

The two proposed ESP units involve considerably different cooling systems with different water needs. The proposed Unit 3 would use a combined wet and dry cooling system. The proposed Unit 4 would use dry cooling towers. The proposed cooling systems are described in more detail in Section 3.2.2.

3.2.1.1 Plant Water Consumption

This section describes plant water consumption demands, excluding those demands that are part of the normal and ultimate heat sink cooling system. Consumptive water demands associated with the cooling systems are discussed in Section 3.2.2. Non-cooling system related water demands are relatively small compared to the consumptive cooling demands of Unit 3.

Units 3 and 4 would have identical demands for potable water, demineralized water, and fire protection water. In the ER (Table 3.3-1), Dominion states that the normal and maximum water demands for these systems are 41.3 L/s (655 gpm) and 210 L/s (3340 gpm), respectively. Potable water would be provided from groundwater wells, whereas the demineralized water and fire protection water would be supplied from Lake Anna.

3.2.1.2 Plant Water Treatment

Because no specific design has been selected, the water treatment systems for the proposed Units 3 and 4 are not specified. Currently, Lake Anna is the source for Units 1 and 2 condenser cooling and service water. This water is not treated. Makeup water for the proposed Units 3 and 4 and both ultimate heat sink systems would require treatment with biocides, antiscalants, and dispersants. Treatment of makeup water for ultra-pure water systems, such as the condensate and primary cooling systems, would employ technologies such as reverse osmosis and ultra-filtration. The water quality of effluents from any water treatment would be regulated by a Virginia Pollutant Discharge Elimination System (VPDES) permit for the units.

3.2.2 Cooling System

The following sections provide detailed descriptions of the operational modes and the components of the cooling water systems for the proposed Units 3 and 4. See Figure 3-2 for a conceptual drawing of the Unit 3 cooling system. Non-cooling system related water consumption, including potable, demineralized, and fire protection water demands are discussed in Section 3.2.1.

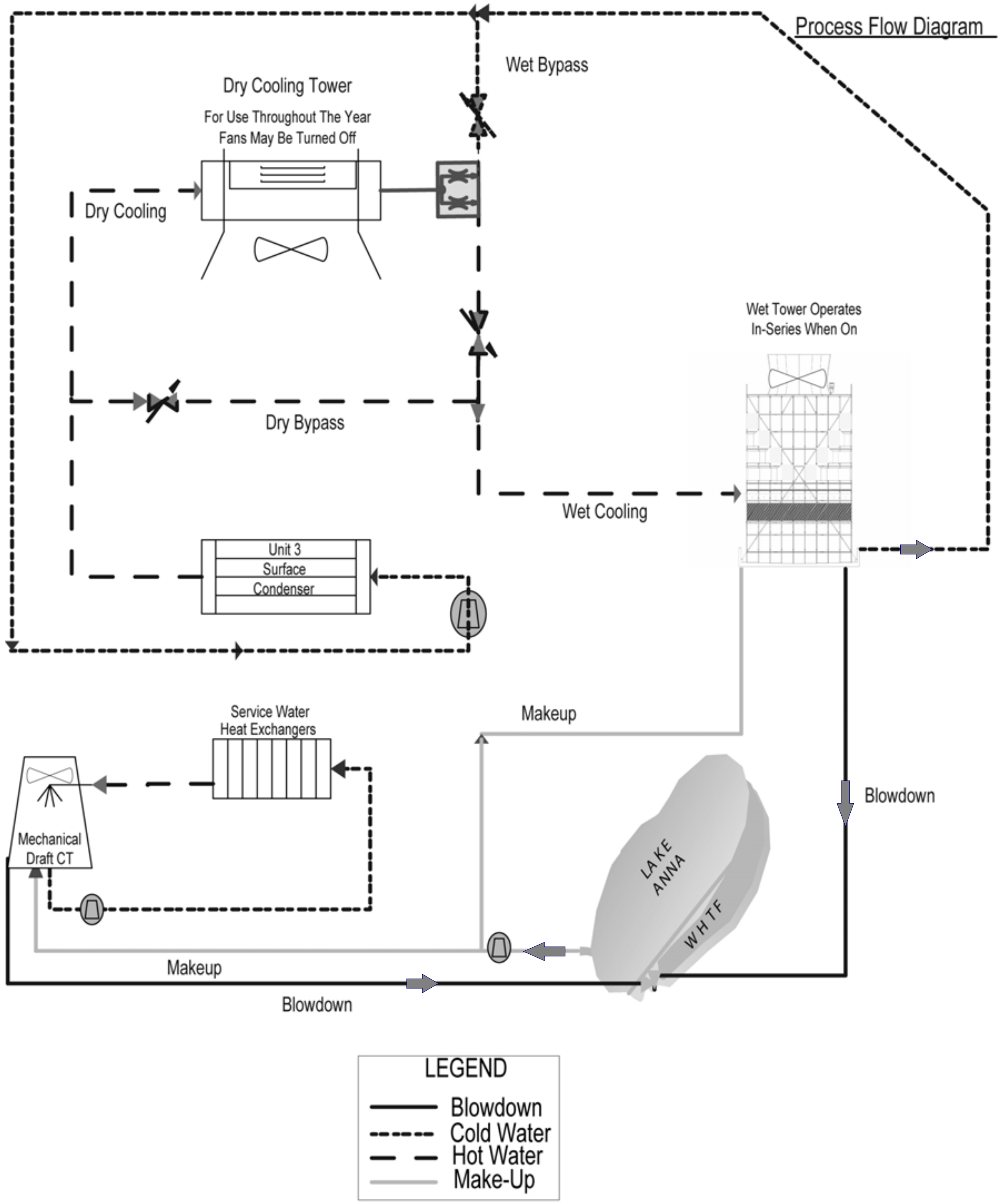

Figure 3-2. Conceptual Closed Loop Cooling Water Diagram for Unit 3

The two proposed units employ considerably different cooling systems with different water needs (Dominion 2006). The proposed Unit 3 would use a closed-cycle, combination wet and dry cooling tower system.

The plant would primarily use wet towers to cool Unit 3 during periods of relative water surplus, which are defined as periods when the water surface elevation of Lake Anna is at or above elevation 76.2 m (250 ft) above mean sea level (MSL). In the ER, this cooling mode for Unit 3 is termed the Energy Conservation (EC) mode.

During periods when the elevation of Lake Anna is below 76.2 m (250 ft) MSL for a period of seven or more consecutive days, Unit 3 would be cooled with a closed-cycle, combination wet and dry cooling tower system to limit consumptive water use. Dominion terms this cooling mode for Unit 3 as the Maximum Water Conservation (MWC) mode. In this mode, all or part of the excess heat generated by Unit 3 operation would be dissipated using a dry cooling tower. If atmospheric conditions were such that Unit 3 dry cooling towers could not completely cool the circulating water, Dominion would employ wet towers to dissipate the remaining excess heat. The heat from the turbine generator is transferred to the cooling water in the surface condenser. The cooling water passes through the dry cooling tower and, in the MWC mode, transfers a minimum of one-third of the heat to the atmosphere. The dry cooling towers would be designed to remove at least one-third of the excess heat from Unit 3 under worst-case atmospheric conditions. Cooling water leaving the dry towers would then pass through the wet towers to remove the balance of condenser/heat exchanger rejected heat by spraying the water into a forced or induced air stream. 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. Make-up water to the circulating water system and service water cooling system would be obtained from Lake Anna. Blowdown (recirculating water removed from the cooling system to reduce the buildup of contaminants, such as dissolved solids) from the cooling systems would be discharged to the existing plant WHTF discharge canal.

Unit 4 would use a dry cooling system that transfers heat directly from the condenser to an air cooled heat exchanger without the use of Lake Anna cooling water.

3.2.2.1 Description and Operational Modes

The operating modes for the proposed Units 3 and 4 under normal operating and emergency/shutdown conditions are described in the following paragraphs. In the ER, Dominion states that the minimum lake level for operation of the proposed units would be an elevation of 73.8 m (242 ft) MSL. The calculated minimum lake level under drought conditions is 74.74 m (243.5 ft) MSL.

Unit 3 Normal Cooling

Dominion states that the bounding thermal power generated by Unit 3 would be 4500 MW(t), and that the bounding heat rejection rate to the environment would be 3020 MW (1.03×10^{10} Btu/hr). Excess heat generated by the unit would be dissipated through the use of a series of closed-cycle cooling towers that can operate in two modes: EC and MWC modes.

The EC mode of rejecting excess heat generated by Unit 3 would be employed when surplus water is available from Lake Anna. Surplus water would be considered available when (1) the lake level elevation of Lake Anna is at or above 76.2 m (250 ft) MSL or (2) the lake level elevation is below elevation 76.2 m (250 ft) MSL for a period of less than seven consecutive days.

In the EC mode, excess heat generated by Unit 3 would be dissipated by closed-cycle wet cooling towers. Makeup water would be supplied from Lake Anna at a maximum flow rate of 1405 L/s (22,268 gpm). The blowdown flow rate and the related evaporation rate associated with the wet cooling towers would vary depending on thermal output from the unit and environmental conditions. In its PPE, Dominion states that the maximum evaporation rate would be 1053 L/s (16,695 gpm) and the maximum blowdown discharge would be 351 L/s (5565 gpm) in the EC mode.

The MWC mode of rejecting excess heat generated by Unit 3 would be employed when water levels in the lake drop below elevation 76.2 m (250 ft) MSL for a period of one week or more. Under favorable meteorological conditions, the entire excess heat load from Unit 3 would be dissipated using closed-cycle dry cooling towers. These towers would be sized so that under the worst-case conditions (i.e., full power operation and a hot and humid atmosphere at tower level), a minimum of one-third of excess heat from Unit 3 would be dissipated via the dry tower system. The remaining excess heat would be dissipated by the wet tower system. Therefore, although the MWC mode uses less water than the EC mode, it is possible that up to two-thirds of the total heat load would be dissipated by wet cooling.

In the MWC mode, the maximum makeup flow rate from Lake Anna to the wet tower system would be 971 L/s (15,384 gpm). The maximum blowdown discharge and evaporation rate from the wet towers are 245 L/s (3844 gpm), and 728 L/s (11,532 gpm), respectively.

Unit 4 Normal Cooling

During normal operation, the proposed Unit 4 would use a system of closed-loop dry cooling towers. The makeup water flow rate to the circulating water system would be negligible (on the order of 0.06 L/s [1 gpm]). No blowdown would be generated by these towers.

Ultimate Heat Sink

For safety-related cooling, an ultimate heat sink (UHS) would be constructed to provide water for reactor cooling and safety-related components of Units 3 and 4. The same UHS design would be used for each unit. Each UHS would be composed of a mechanical draft cooling tower with a 71.6 m wide by 107 m long by 15.2 m deep (235 ft wide by 350 ft long by 50 ft deep) engineered underground basin constructed beneath each tower (Dominion 2004). These basins would be large enough to store a water volume of 1.16×10^5 m^3 (3.06×10^7 gal), which is adequate to hold a 30-day supply of emergency cooling water (Dominion 2006). During periods when the ultimate heat sink cooling towers are in operation, the towers would withdraw a maximum makeup flow of 110 L/s (1700 gpm) from the two basins. The blowdown from the UHS towers would be discharged into the WHTF.

During periods of normal plant operation, a negligible volume of makeup water would be used to offset any water losses from the UHS basins. This water would originate from Lake Anna (Dominion 2006).

3.2.2.2 Component Descriptions

The following sections describe the intake, discharge, and heat dissipation systems for proposed Units 3 and 4. Pursuant to Sections 316(a) and 316(b) of the Clean Water Act, an applicant for a CP or COL referencing an ESP for the North Anna ESP site would be required to obtain approval from the Commonwealth of Virginia by documenting plant design and conducting site-specific analyses regarding the impacts of the thermal discharges and operation of the intake systems on the Lake Anna aquatic environment.

Intake System

The proposed location of the intake structure for Unit 3 is shown in Figure 3-1. Any makeup water required for Unit 4 could be obtained from the Unit 3 intake. The location of the intake would be in the same approximate location as the intakes planned for the two additional power reactor units proposed at the time that NAPS Units 1 and 2 were licensed. The size of the proposed intake structure to support Unit 3 operation is 21 m (70 ft) long and 21 m (70 ft) wide. The intake system for Unit 3 would consist of a structure next to the lake with trash racks, traveling screens, and pump bays, similar to the design currently in use by Units 1 and 2. Dominion expects no major modifications to the shoreline or the existing intake channel. The existing cofferdam would be modified to allow water access from Lake Anna.

Discharge System

Blowdown discharge from the wet towers associated with Unit 3 would enter the WHTF via the discharge canal currently used by the existing units. The PPE maximum blowdown discharge from Unit 3 would be 351 L/s (5565 gpm). There would be no blowdown discharge from Unit 4. The discharge canal and WHTF canal system were designed to convey approximately 230,000 L/s (8000 cfs), and the maximum flow rate from the existing units is approximately 120,000 L/s (4300 cfs). The discharge canal and WHTF system could therefore easily accommodate the extra water discharged by the proposed units. Dominion stated that it may combine the blowdown flow from Unit 3 with the discharge from the existing NAPS units and use the current Unit 1 and 2 discharge structure, or utilize the partially completed discharge structure planned for the two additional power reactors proposed at the time NAPS Units 1 and 2 were licensed (see Figure 3-1) (Dominion 2006).

Heat Dissipation Systems

The normal cooling needs of Unit 3 would be provided by a closed-cycle, combination wet and dry tower system. The percentage of excess heat dissipated by the dry towers would depend on the availability of water from Lake Anna and ambient environmental conditions. If excess water were available, Unit 3 would be cooled entirely by use of the wet towers. Under times of relative drought and favorable meteorological conditions, the majority of the Unit 3 waste heat would be dissipated by the dry towers.

The normal cooling needs of Unit 4 would be provided solely by a closed-cycle dry tower system. Unit 4 would have a negligible consumptive water demand on Lake Anna.

Wet cooling tower systems rely primarily on evaporative heat transfer to the atmosphere to dissipate the rejected thermal load. Dry cooling tower systems rely entirely on sensible heat transfer between the fluid circulating in the condenser loop and the ambient air. Dry towers are completely closed systems and therefore use negligible amounts of makeup water and produce negligible blowdown water. Dry cooling towers use large fans to keep air flowing over their radiators, so there is an associated high energy cost that significantly reduces plant efficiency. The efficiency penalty of dry cooling towers can exceed 12 percent (EPA 2001). Dominion's combination wet and dry cooling system would have an energy efficiency penalty of 1.7 to 4 percent (Dominion 2006).

For safety-related cooling, the UHS for each of the proposed Units 3 and 4 would provide water to the reactor cooling systems and safety-related components. As proposed, both plants would use the same UHS design, which would be composed of a mechanical draft cooling tower with an engineered basin constructed underground beneath it (Dominion 2006). The basin would have a storage capacity adequate to hold a 30-day supply of emergency cooling water.

3.2.3 Radioactive Waste Management System

Liquid, gaseous, and solid radioactive waste management systems would be used to collect and treat the radioactive materials that are produced as a by-product of operating the proposed Units 3 and 4 on the North Anna ESP site. These systems would process radioactive liquid, gaseous, and solid effluents to maintain releases within regulatory limits and to levels as low as reasonably achievable (ALARA) before being released to the environment. Waste processing systems would be designed to meet the design objectives of 10 CFR Part 50, Appendix I (Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as is Reasonably Achievable" for Radioactive Material in Light Water-Cooled Nuclear Power Reactor Effluents). Radioactive material in the reactor coolant would be the primary source of gaseous, liquid, and solid radioactive wastes in LWRs. Radioactive fission products build up within the fuel as a consequence of the fission process. These fission products would be contained in the sealed fuel rods, but small quantities could escape the fuel rods and contaminate the reactor coolant. Neutron activation of corrosion products in the primary coolant system would also contribute to coolant contamination.

Dominion did not identify specific radioactive waste management systems for the North Anna ESP site. The PPE concept was used to provide an upper bound on liquid radioactive effluents, gaseous radioactive effluents, and solid radioactive waste releases (Dominion 2006) (See Appendix I).

Adequate design information to estimate liquid and gaseous radioactive effluents was available for four of the seven reactor designs considered in establishing PPE values. The four reactors were LWRs and included the certified ABWR, the surrogate AP1000 PWR, the ACR-700 light-water-cooled, heavy-water moderated reactor, and the surrogate ESBWR. Limited information was available for liquid and gaseous effluent releases from the gas-cooled reactor designs.

In its FSER, the staff proposed permit condition number 4, which would require that any new unit's radioactive waste system design contain features to preclude any and all accidental releases of radionuclides into the liquid pathway (NRC 2006).

Solid radioactive wastes produced from operating the proposed Units 3 and 4 at the North Anna ESP site would be either dry or wet solids. The solid waste management system would receive, collect, and store solid wastes prior to onsite storage or shipment offsite. Dominion indicated that low-level waste storage for the ESP site would be coordinated with storage from the existing NAPS Units 1 and 2. The bounding solid radioactive waste activity was from one ABWR reactor or one ESBWR reactor (Dominion 2006).

3.2.4 Nonradioactive Waste Systems

Dominion describes the nonradioactive waste systems for the proposed Units 3 and 4 in Section 3.6 of its ER (Dominion 2006). Nonradioactive waste system parameters are not addressed by the PPE; however, effluents from liquid, gaseous, and solid nonradioactive waste systems are regulated by cognizant State and Federal agencies.

Chemicals and biocides may be employed in water treatment for various water uses at the proposed Units 3 and 4. Effluents containing chemicals and/or biocides would be regulated by the VPDES permit. Sanitary effluents would be expected to increase because of the increased workforce, and sanitary effluents would be regulated by the VPDES permit. Dominion states that the sanitary wastes would be treated onsite using a permanent, self-contained sanitary waste treatment system (Dominion 2006).

Dominion states that gaseous wastes (e.g., diesel backup generators) and solid wastes (e.g., sewage sludge, construction debris) would be handled in compliance with appropriate State and Federal regulations (Dominion 2006).

3.3 Power Transmission System

The existing NAPS Units 1 and 2 have 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. Table 3-1 presents the lengths, widths, and areas of the rights-of-way, which range from 37 to 84 m (120 to 275 ft) in width and from 24 to 66 km (15 to 41 mi) in length and cover a total of approximately 1174 ha (2900 ac) (AEC 1973; NRC 2002). The rights-of-way extend from the NAPS site to the north, south, east, and west terminating in Morrisville, Midlothian, Ladysmith, and at the South Anna non-utility generator (NUG) (Figure 3-3). The existing transmission lines and rights-of-way were constructed between 1973 and 1984, and no additional construction of transmission lines would be expected for Units 3 and 4 (Dominion 2006).

In the ER, Dominion indicates the existing transmission system (three 500-kV lines and one 230-kV line) has the capacity to handle the output from the existing Units 1 and 2 plus the anticipated output from the proposed Units 3 and 4 (Dominion 2006). Detailed system load studies for the proposed new units would be performed by Dominion once the in-service date for the units has been established, to confirm the current transmission system is capable of handling the output of all units.

Dominion owns approximately 1 percent of the rights-of-way and has easements for the remaining 99 percent (NRC 2002). Dominion has procedures to ensure that all chemical and mechanical vegetation controls are conducted in ways that minimize adverse impacts.

Vegetation in the rights-of-way is currently managed through a combination of mechanical and herbicide treatments conducted on a 3-year cycle. Mowing is the primary mechanical treatment, while Accord® and Garlon® are the primary herbicides used in the rights-of-way. In some areas, such as wetlands or dense vegetation, hand-trimming is used. Rare and sensitive plant species areas are identified and avoided, or modified treatment practices are used to avoid adverse impacts. These modified vegetation treatments are developed in cooperation with the Virginia Department of Conservation and Recreation's Natural Heritage Program (NRC 2002). In addition, wildlife food plots and Christmas tree plantations are located along the rights-of-way and are supported through cost sharing by Virginia Power (NRC 2002).

Table 3-1. North Anna Power Station Transmission Line Rights-of-Way

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

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

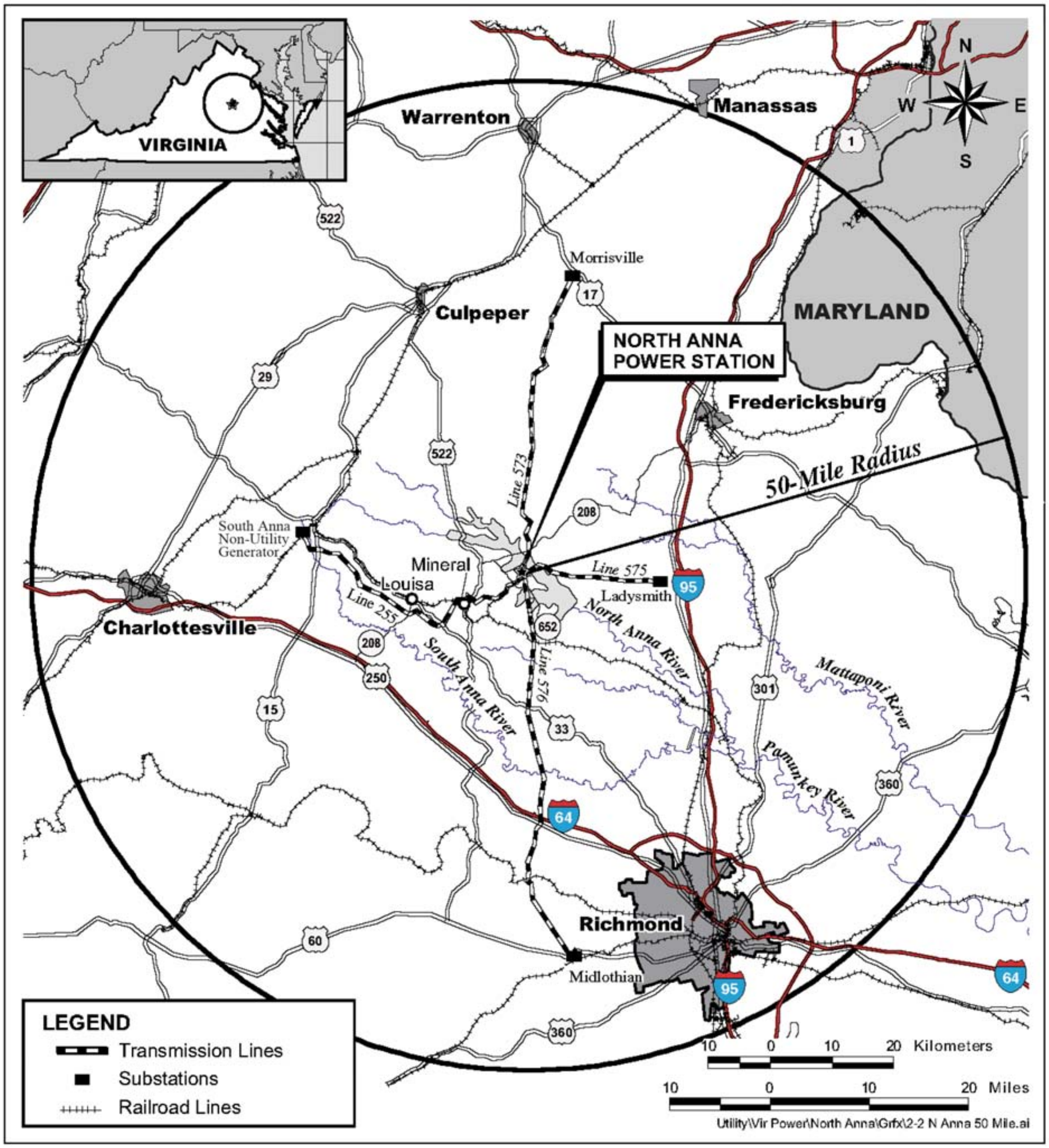

Figure 3-3. Location of Transmission Lines for North Anna Power Station, Units 1, 2, 3, and 4

3.4 References

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR Part 52. Code of Federal Regulations, Title 10, *Energy*, Part 52, "Early Site Permits, Standard Design Certifications, and Combined Licenses for Nuclear Power Plants."

Clean Water Act (also referred to as the Federal Water Pollution Control Act). PL 92-500. 33 USC 1251, et seq.

Dominion Nuclear North Anna, LLC (Dominion). 2004. Letter Response to Request for Additional Information Regarding Safety Portion of ESP Application, No. 04-318, Glen Allen, Virginia, August 2, 2004.

Dominion Nuclear North Anna, LLC (Dominion). 2006. *North Anna Early Site Permit Application – Part 3 – Environmental Report*. Revision 9, Glen Allen, Virginia, July 31, 2006.

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

U.S. Nuclear Regulatory Commission (NRC). 2000. *Standard Review Plans for Environmental Reviews for Nuclear Power Plants*. NUREG-1555, Office of Nuclear Reactor Regulation, Washington, D.C. Available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/.

U.S. Environmental Protection Agency (EPA). 2001. Technical Development Document for Regulations Addressing Cooling Water Intake Structures for New Facilities. EPA-821-R-01-036, Washington, D.C.

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

U.S. Nuclear Regulatory Commission (NRC). 2003. *Response to Comments on Draft RS-002, Processing Applications for Early Site Permits*. Available at http://www.nrc.gov/reading-rm/adams.html, Accession No. ML031710698.

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U.S. Nuclear Regulatory Commission (NRC). 2006. *Safety Evaluation Report for an Early Site Permit (ESP) at the North Anna ESP Site*. NUREG-1835, September 2006, Accession No. ML062210405.

4.0 Construction Impacts at the Proposed Site

This chapter examines the environmental impacts of construction associated with potential site preparation activities and construction of the proposed North Anna Power Station (NAPS) Units 3 and 4 as described in the application for an early site permit (ESP) submitted by Dominion Nuclear North Anna, LLC (Dominion). As part of its application, Dominion submitted an Environmental Report (ER)(Dominion 2006a) and a site redress plan (Dominion 2006b). The ER provided the plant parameter envelope (PPE) as the basis for the environmental review. The parameters included in the PPE and their values are listed in Appendix I. The site redress plan allows for specific site preparation activities to be conducted with approval of an ESP. These activities evaluated are those permitted by Title 10 of the Code of Federal Regulations (CFR) 52.25(a) and 10 CFR 50.10(e)(1). In the event the ESP application is approved and Dominion conducts site preparation activities but does not build the plant, Dominion would be required to implement its site redress plan.

This chapter is divided into 13 sections. Sections 4.1 through 4.9 discuss the potential impacts on land use, meteorology and air quality, water, terrestrial and aquatic ecosystems, socioeconomics, historic and cultural resources, environmental justice, nonradiological and radiological health effects, and applicable measures and controls that would limit the adverse impacts of station construction. In accordance with 10 CFR Part 51, impacts have been analyzed, and a significance level of potential adverse impacts (i.e., SMALL, MODERATE or LARGE) has been assigned to each analysis. Negligible impacts are listed as SMALL impacts. Possible mitigation of adverse impacts, where appropriate, is presented in Section 4.10, followed by a description of the site redress plan in Section 4.11. A summary of the construction impacts is presented in Section 4.12. Full citations for the references cited in this chapter are listed in Section 4.13. Cumulative impacts of construction and operation are discussed in Chapter 7. The technical analyses in this chapter support the results, conclusions, and recommendations in Chapters 9 and 10.

The staff relied on the mitigation measures and the required Federal, State, and local permits and authorizations presented in the ER in reaching its conclusion on the significance level of the adverse impacts. Appendix J was added to this Final Environmental Impact Statement (EIS) and includes representations made by Dominion that the staff relied on during the preparation of the EIS. With regard to the environmental impacts associated with construction of proposed Units 3 and 4, Dominion made a number of representations in its application. The staff's determinations of significance levels are based on the assumption that mitigation measures identified in the ER or activities planned by various State and County governments, such as infrastructure upgrades and school expansions, as discussed in this chapter are implemented. As listed in this appendix, the staff relied on these representations and staff-developed assumptions in assessing the environmental impacts associated with construction of Units 3 and 4. As such, fulfillment of these representations and assumptions provide part of the basis for the final impact assessment. Should an applicant for a construction permit (CP) or combined construction permit and operating license (COL) reference the ESP, and the staff ultimately determines that a representation or an assumption has not been satisfied at the CP/COL stage, that information would be considered new and potentially significant, and the affected impact area could be subject to re-examination.

4.1 Land-Use Impacts

This section provides information regarding land-use impacts associated with site preparation activities and construction of proposed Units 3 and 4 at the North Anna ESP site. Topics discussed include land-use impacts at the site, in the vicinity of the site, and in transmission line rights-of-way and offsite areas.

4.1.1 The Site and Vicinity

The ESP site is located entirely within the existing NAPS site, which is zoned for industrial use by Louisa County. All construction activities for proposed Units 3 and 4, including ground-disturbing activities, would occur within the existing NAPS site boundary. According to Dominion (2006a), approximately 52 ha (128 ac) would be affected on a long-term basis as a result of permanent facilities. An additional 27.5 ha (67.9 ac) would be disturbed on a short-term basis as a result of temporary activities and construction of temporary facilities and laydown areas. Dominion represented that it would conduct any ground-disturbing activities in accordance with Federal, State and local regulatory requirements (Dominion 2006a) (see Appendix J). The planned power block area is relatively level. Undulating surfaces in the area of the planned cooling towers would be leveled to accommodate the towers. Dominion has submitted a site redress plan, which is evaluated in Section 4.11 of this EIS.

No new highways or railroad lines would be needed to support the construction of Units 3 and 4. Clearing and removal of trees growing within the North Anna ESP site would be required. No agricultural lands would be directly affected by construction activities.

A few small wetland areas and two intermittent streams exist on the ESP site. Dominion represented that it would avoid watercourses and wetlands to the extent practicable during construction (Dominion 2006a) (see Appendix J). Any work that has the potential to impact a wetland would be performed in accordance with applicable regulatory requirements.

The floodplain along the Lake Anna shoreline was determined by Dominion using the Federal Emergency Management Agency Flood Insurance Rate Map (Dominion 2006a). Any flooding that might occur during construction of Units 3 and 4 would be limited to areas adjacent to the lake shoreline (i.e., below elevations of 255 feet above mean sea level). Preliminary construction activity would occur within the lake floodplain for the construction and installation of a new water intake structure.

Some offsite land-use changes as a result of construction activities would be expected. Likely changes are the conversion of some land in surrounding areas to housing developments (e.g., apartment buildings, single family condominiums and homes, manufactured home parks, and recreational vehicle parks) to accommodate construction workers and the addition of new retail developments. All counties surrounding the NAPS site have comprehensive land-use plans in place as required by Section 15.2-2223 of the Code of Virginia.

Based on the counties' comprehensive land-use plans for the surrounding vicinity, the site redress plan, Dominion's representations, and NRC's independent review, the staff concludes that the land-use impacts of construction would be SMALL, and mitigation is not warranted.

4.1.2 Transmission Line Rights-of-Way and Offsite Areas

In the evaluation provided in the ER, Dominion concluded that no additional electrical transmission lines or rights-of-way would be required to transmit the power generated by the proposed North Anna Units 3 and 4 to the regional power grid (Dominion 2006a). Construction would be limited to providing the new units' switchyards and interconnections with the existing operating units. All planned construction activities would occur on the NAPS site. Because Dominion represented that construction would be limited to onsite work, and no additional land would be needed to connect the new units to the grid, the staff concludes that land-use impacts resulting from construction in transmission line rights-of-way would be SMALL, and mitigation is not warranted.

4.2 Meteorological and Air Quality Impacts

During construction activities on the North Anna ESP site, some minor air quality impacts would be expected to occur. The likely sources of these air quality impacts would be fugitive dust emissions from general construction activities and the potential for elevated ambient air quality levels caused by transportation emissions from the vehicles and equipment used by the workforce used in construction. These impacts are discussed further in the following sections.

4.2.1 Construction Activities

The impact of construction activities on local air quality conditions would primarily be governed by the influence of additional building structures on the dispersion of normal effluent releases from either the existing NAPS Units 1 and 2 or from Units 3 and 4 during construction.

Equipment emissions and fugitive dust from operation of earth-moving and material-handling equipment are sources of air pollution from construction activities. Also, operation of other equipment for hauling debris, equipment, and supplies on unpaved roads would produce additional fugitive dust. The pollutant emission of concern would be PM_{10} particulate matter (less than 10 microns in diameter), reactive organic gases, and oxides of nitrogen and sulfur,

and carbon monoxide from construction equipment engines. All activities would be conducted in accordance with Virginia Administrative Codes 9 VAC 5-50 (Visible and Fugitive Dust Emissions) and 9 VAC 5-40-5680 (Emission Standard for Mobile Sources – Vehicles).
In addition, if construction activities include burning of construction materials, Dominion would need to obtain a permit from the Virginia Department of Environmental Quality (VDEQ) and contact Louisa County officials to determine if compliance with local ordinances is required (VDEQ 2004).

The ER identified additional mitigation including Dominion's representation that it would develop and implement a dust control plan to mitigate the impacts of emissions from construction activities (Dominion 2006a) (see Appendix J). Potential measures to be included in the plan would be the following:

- limit the speed of construction equipment on unpaved roads
- remove dirt spilled onto paved roads on the construction site
- cover haul trucks during unloading and loading activities
- cease grading and excavation activities during periods of high wind speeds or extreme air pollution episodes
- phase construction activities to minimize daily emissions
- phase grading to minimize the area of disturbed soils
- perform proper maintenance activities on construction vehicles to minimize emissions
- revegetate road medians and slopes in accordance with the site redress plan

Based on its independent evaluation of the requirements set forth in Virginia Administrative Codes, and Dominion's representation that it would develop and implement measures to control dust during construction, the staff concludes that air quality impacts from construction, both onsite and beyond the plant boundary, would be temporary and SMALL, and further mitigation beyond the actions stated above is not warranted.

4.2.2 Transportation

In its ER, Dominion represented that the 5000 construction workers would be divided between two 10-hour shifts (Dominion 2006a) (see Appendix J). Using an assumption of 1.8 workers per vehicle, 2800 additional vehicles per day would travel to and from the site (Dominion 2006a). Depending on the actual location of the workers, some of the roadways leading to the site would likely experience congestion unless upgrades recommended in the land-use plan are implemented. This situation would impact the local ambient air quality levels because of emissions from vehicles both during normal operation and during periods of traffic congestion when vehicles are stopped with their engines idling. The overall impact is difficult to estimate at this time because of the timing of construction activities and actual location of the workers that would be employed during construction, but five existing roads would be expected to be impacted.

In the ER, Dominion represented that it would develop and implement a traffic management plan to increase the number of construction workers per vehicle by developing methods for enhancing the use of multi-person vans (see Appendix J). Dominion represented that it would also attempt to schedule shift changes for operating personnel, outage workers, and construction workers to reduce the number of vehicles on the road at any given time. All of these techniques would mitigate the impact of vehicular traffic on air quality.

Based on Dominion's commitment to develop and implement a traffic management plan, and NRC's own independent review, the staff concludes that the impact on the local air quality from the increase in vehicular traffic related to construction activities would be temporary and SMALL, and additional mitigation beyond the actions stated above is not warranted.

4.3 Water-Related Impacts

Water-related impacts involved in the construction of a nuclear power plant would be similar to impacts that would be associated with any large industrial construction project. Prior to initiating construction, including any site preparation work, Dominion would be required to obtain the appropriate permits regulating alterations to the hydrological environment. These permits would likely include:

- Clean Water Act Section 404 Permit. This permit would be issued by the U.S. Army Corps of Engineers (ACE), which governs impacts of construction activities on wetlands or waters of the United States and management of dredged material.

- Clean Water Act Section 401 Certification. This certification would be issued by the Commonwealth of Virginia and would ensure that the project does not conflict with water quality management programs in the Commonwealth.

- Clean Water Act Section 402(p) National Pollutant Discharge Elimination System (NPDES) construction and industrial storm water permit. This permit would regulate point source storm water discharges. The U.S. Environmental Protection Agency's (EPA) 1990 Phase 1 Storm Water Regulation (40 CFR 122.26) established requirements for storm water discharges from various activities including construction activities disturbing an area of at least 2.0 ha (5.0 ac). EPA has delegated the authority for administering the NPDES program to the Commonwealth of Virginia.

- Coastal Zone Management Act (CZMA) Section 307 Consistency Determination (and 15 CFR Part 930). Section 307(c)(3)(A) of the CZMA [16 USC 1456(c)(3)(A)] requires that applicants for Federal licenses to conduct an activity in a coastal zone are to provide to the licensing agency a certification that the proposed activity is consistent with the enforceable policies of the State's coastal zone program. While the National Oceanic and Atmospheric Administration administers the CZMA, the authority to concur with or object to the consistency determination has been delegated to the VDEQ.

4.3.1 Hydrological Alterations

Excavation, fill, and grading operations at the North Anna ESP site would alter two ephemeral streams and possibly one or more wetlands. Many of the possible reactor designs considered in the PPE would require that dewatering systems be installed during construction of the foundation of the reactor and various other buildings. Dewatering systems used during construction would depress the water table in the vicinity. However, any drawdown in the water table would be limited by the proximity of Lake Anna and the discharge canal.

These impacts would be localized temporary construction impacts. Wetland delineations and jurisdictional determinations of the upland landscape and submerged lake areas that would be impacted by construction would be required in order to submit an application for a Section 404 Permit application to ACE. The ACE permitting process ensures that impacts of construction are limited by requiring the appropriate construction best management practices (BMPs).[a] Dominion currently has not obtained a Section 401 certification from Virginia for construction activities at the North Anna ESP site.

Dominion proposed a 21 m (70 ft) long and 21 m (70 ft) wide intake structure to support the combination wet and dry cooling tower for Unit 3 (Dominion 2006a). Dominion expects no major modifications to the shoreline or the existing intake channel. The existing cofferdam would be completely or partially removed or tunneled through to allow water access from Lake Anna. Implementing BMPs for dredging would minimize the sediment that would enter the lake during modification of the cofferdam. Any impacts of dredging would be localized and temporary. Before initiation of any shoreline modification or dredging activities, Dominion would be required to obtain a 404 Permit from the ACE.

Because the impacts of hydrologic alterations resulting from construction activities would be localized and temporary, and the NPDES storm-water permits, 401 Certification and ACE Section 404 Permit processes would minimize impacts, the staff concludes that the impacts of hydrologic alterations would be SMALL, and further mitigation beyond the actions stated would not be warranted.

4.3.2 Water-Use Impacts

Water-use requirements for construction activities would be similar to other large industrial construction projects. Additional potable water supplies for the construction workforce would be required. Water for various standard construction activities, such as dust abatement, would

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(a) Best management practices are recommended site management, maintenance or monitoring activities that have been shown to work effectively to mitigate impacts. Government agencies sometimes use BMPs to specify standards of practice where a regulation may not be sufficiently descriptive.

be provided from Lake Anna. Groundwater dewatering systems may preclude existing onsite wells from supplying water during construction, particularly potable water needs. If additional water is required, water could be imported from offsite during periods when the dewatering system is active.

Based on these considerations, and because they would be localized and temporary, the staff concludes that water-use impacts caused by construction activities would be SMALL, and mitigation is not warranted.

4.3.3 Water-Quality Impacts

Water-quality impacts for the construction activities would be similar to those associated with other large industrial construction projects. Construction BMPs are generally used to ensure that accidental spills and storm water runoff will have minimal impact on surface water and groundwater quality. Even if Dominion were to apply for and receive a construction permit (CP) or a combined license (COL) referencing an ESP for the NAPS site, or if it were to conduct site preparation activities under such an ESP, an NPDES permit would be required from the Commonwealth of Virginia before construction activities could commence. In view of the ability of standard engineering construction practices to limit water quality impacts and the localized and temporary nature of any impacts, the staff concludes that water-quality impacts caused by construction activities would be SMALL, and further mitigation is not warranted.

4.4 Ecological Impacts

This section describes the potential impacts of construction on the ecological resources at the North Anna ESP site and discusses terrestrial ecosystems impacts, aquatic ecosystem impacts, and threatened and endangered species.

4.4.1 Terrestrial Ecosystem Impacts

The total area of the North Anna ESP site is approximately 81 ha (200 ac) of which approximately 49 ha (120 ac) have been developed for industrial use. Construction activities are not expected to have noticeable impacts on ecological resources within the developed portions of the North Anna ESP site. Construction of Units 3 and 4 would result in the removal of approximately 32 ha (80 ac) of forested habitat within the site. The North Anna ESP site does not contain any old growth timber or unique or sensitive plant species or communities. Therefore, construction activities would not noticeably reduce the local or regional diversity of plants or plant communities.

There are no important terrestrial animal species or habitats (as previously evaluated by the NRC [NRC 2002]) on the North Anna ESP site. A few small wetland areas and two intermittent streams exist on the North Anna ESP site (Dominion 2006a). Dominion has completed a wetland delineation that identified 2.7 hectares (6.68 acres) of wetlands within the vicinity of the ESP site (Dominion 2006c). The delineation also identified approximately 1676 m (5500 linear feet) of streams that cover an area of approximately 0.19 hectares (0.46 acres), and approximately 1.0 hectares (2.49 acres) of open water within a beaver pond at the western edge of the ESP area near the end of the unnamed arm of Lake Anna. In a September 2006 letter, ACE verified this delineation (ACE 2006). Neither ACE or the VDEQ can determine the type of permit(s) required (e.g., CWA Section 404 Permit, Virginia Water Protection Permit, or NPDES construction site storm water permit) or limitations or requirements, if any, that would be attached to the permit(s) until a more detailed site design and development plan is available. Dominion represented that it would avoid watercourses and wetlands to the extent practicable during construction, and Dominion would be required to comply with any wetland protection or mitigation measures attached to any permits issued by ACE or the VDEQ (see Appendix J). To minimize construction-related impacts to wildlife, Dominion represented that it would adhere to Commonwealth of Virginia permit conditions, which could restrict the timing of certain construction activities (Dominion 2006a).

In anticipation of construction, topsoil would be removed from the construction site footprint, stored, rolled, and seeded, if necessary, to minimize erosion. Some disturbed areas may be graveled, paved, or compacted to prevent erosion. These and other soil preparation activities would minimize impacts to the aquatic environment from earth-moving activities. For areas that had been temporarily disturbed during construction, Dominion represented that it would grade and contour the land, cover it with topsoil, and seed it with native vegetation (Dominion 2006a) (see Appendix J).

Land clearing associated with construction would be conducted according to Federal and State regulations, permit conditions, existing procedures, and construction and other established BMPs (e.g., directed drainage ditches and silt fencing would be employed). Fugitive dust emissions would be minimized by watering the access roads and construction site as necessary. Therefore, impacts from dust on terrestrial ecosystems would be minimal.

To minimize construction-related impacts to wildlife, Dominion represented that it would adhere to State permit conditions that may restrict the timing of certain construction activities (Dominion 2006a). As the site undergoes clearing and grading, disturbance and loss of forested habitat would displace mobile animals such as birds and larger mammals. Species that can adapt to disturbed or developed areas (e.g., raccoon [*Procyon lotor*], opossum [*Didelphis virginiana*], mockingbird [*Mimus polyglottus*], northern cardinal [*Cardinalis cardinalis*]) may recolonize portions of the site where suitable habitat remains or is replanted following construction activities. Species more dependent on forested habitat may be permanently displaced. Clearing and grading activities may directly result in the loss of some individuals, particularly less mobile animals such as toads, lizards, turtles, snakes, moles, voles, and mice.

The construction-related impacts of forested habitat loss to local wildlife populations cannot be quantified because population data for species on and adjacent to the NAPS site are not available. However, relatively large tracts of forest to the north, west, and south of the North Anna ESP site are available to displaced wildlife. The approximately 32 ha (80 ac) of forested habitat at the ESP site represents a small portion of the available undeveloped land in the site vicinity; therefore, the impacts of construction-related mortality and temporary displacement of wildlife are expected to be minimal. In addition, construction activities likely would not reduce the local or regional diversity of plants or plant communities.

The loggerhead shrike (*Lanius ludoviciana*), which appears as a threatened species on the State list, has been observed near the North Anna ESP site, but has not been reported to nest in the vicinity (Dominion 2006a). Site preparation and construction could result in some habitat loss for this species, but it usually does not use forested areas, preferring forest edges and open areas. Several other State-listed species may occasionally pass through the vicinity, but do not rely on habitat at the North Anna ESP site.

Movement of construction workers, materials, and equipment, and the operation of construction equipment (e.g., earth-moving equipment, portable generators, pile drivers, pneumatic equipment, and hand tools) would generate noise. Noise from human activities can affect wildlife by inducing physiological changes, nest or habitat abandonment, and behavioral modifications, or it may disrupt communications required for breeding or defense (Larkin 1996). However, it is not unusual for wildlife to adapt to noise from human activities (Larkin 1996). Although short-term noise levels from construction activities could be as high as approximately 110 decibels (e.g., impulse noise during pile-driving activities), these noise levels would not extend far beyond the boundaries of the ESP site. At a distance of 120 m (400 ft) from the construction site, noise levels would range from approximately 60 to 80 decibels from these activities. These noise levels are below the 80-to-85-decibel level at which birds and small mammals are startled or frightened (Golden et al. 1980). Thus, noise from construction activities would not be likely to disturb wildlife beyond 120 m (400 ft) from the construction site. Additionally, construction of Units 3 and 4 would occur adjacent to the existing operating Units 1 and 2, where wildlife have presumably become accustomed to typical existing operating facility noise levels of approximately 50 to 60 decibels at the NAPS security fence (Dominion 2006a). Therefore, noise-related impacts during construction would be minor.

The use of the closed-cycle, combination wet and dry cooling systems for Unit 3 and the dry cooling system for Unit 4 introduces additional structures and, therefore, the potential for avian collisions. Collisions with utility structures are not a biologically significant source of mortality for thriving populations of birds with good reproductive potential (EPRI 1993). The staff previously reviewed monitoring data concerning avian collisions at nuclear power plants with large cooling towers and determined that the overall avian mortality is low (NRC 1996). No avian collisions with existing structures at the NAPS site have been reported (Dominion 2006a). The number of construction-related bird collisions with onsite structures is expected to be inconsequential.

In the ER, Dominion represented that it would implement construction mitigation measures including instituting construction BMPs for erosion and dust control, noise abatement, proper equipment maintenance, restricting the timing of activities to minimize impacts to resources such as breeding birds, and adherence to applicable permit conditions (see Appendix J). Dominion delineated the wetlands and streams on the ESP site and would adhere to any permit conditions or mitigation requirements developed by the ACE or VDEQ. The staff reviewed the potential impacts of constructing Units 3 and 4 on terrestrial ecological resources, including loss of habitat, loss of wetlands, noise, dust emissions, and avian collisions. Based on NRC's independent review, and Dominion's representation that it would implement mitigation measures, the staff concludes that the overall impact of construction-related activities on terrestrial ecological resources would be SMALL, and further mitigation beyond the actions stated above is not warranted.

4.4.2 Aquatic Ecosystem Impacts

This section discusses the potential impacts to the aquatic ecology in the vicinity of the North Anna ESP site during construction. The information summarized here is extracted from summaries prepared for the license renewal of NAPS Units 1 and 2 (NRC 2002) and Dominion's ER (Dominion 2006a). The information in these documents was reviewed by NRC staff and NRC consultants.

Construction of the new cooling water intake structure and channel for Units 3 and 4 would be the primary source of construction impacts on the aquatic environment in the reservoir. Construction would involve modifications to an existing partially completed intake structure constructed in the 1970s for two additional power reactor units that were proposed at the time the existing NAPS Units 1 and 2 were licensed. Section 3.2.2 provides a description of the proposed plant cooling water use and structures, including a flow diagram in Figure 3-2.

The cooling water intake structure would be approximately 21 m (70 ft) long and 21 m (70 ft) wide and would house the trash racks, traveling screens, and intake pumps (Figures 4-1 and 4-2). Dominion expects no major modifications to the shoreline or short intake channel. The existing cofferdam would be modified (completely removed, partially removed, or tunneled through) to allow water access from Lake Anna. Any dredged material would be disposed of in accordance with regulatory requirements and permit conditions.

In anticipation of construction, topsoil would be removed from the construction site footprint, stored, rolled, and seeded, if necessary, to minimize erosion. Some disturbed areas may be graveled, paved, or compacted to prevent erosion. These and other soil preparation activities would minimize impacts to the aquatic environment from earth-moving activities. For areas that have been temporarily disturbed during construction, Dominion represented that it would grade and contour the land, cover it with topsoil, and seed it with native vegetation (Dominion 2006a) (see Appendix J).

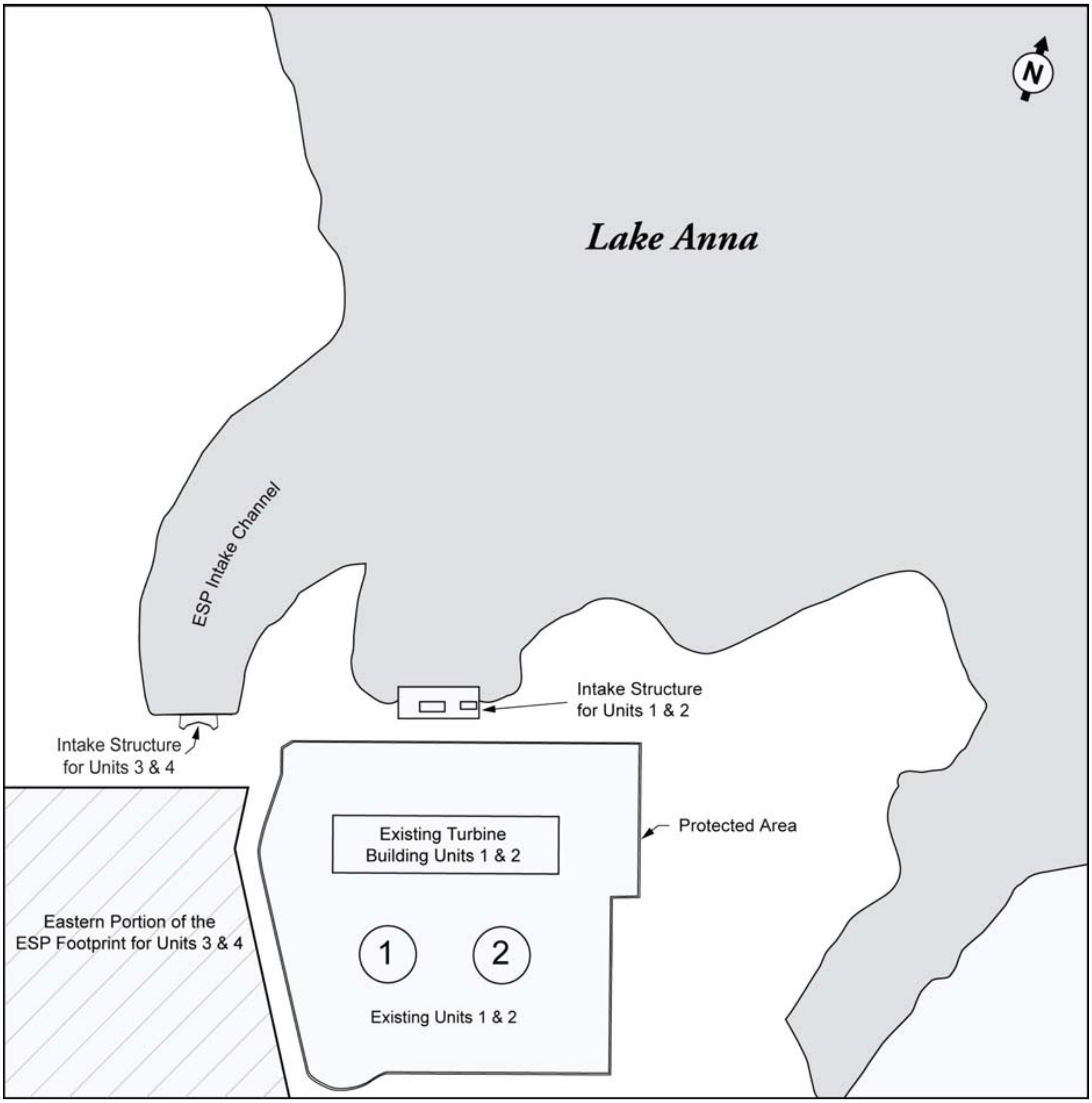

Figure 4-1. Layout of Screenwell/Pump Intake for the North Anna ESP Site

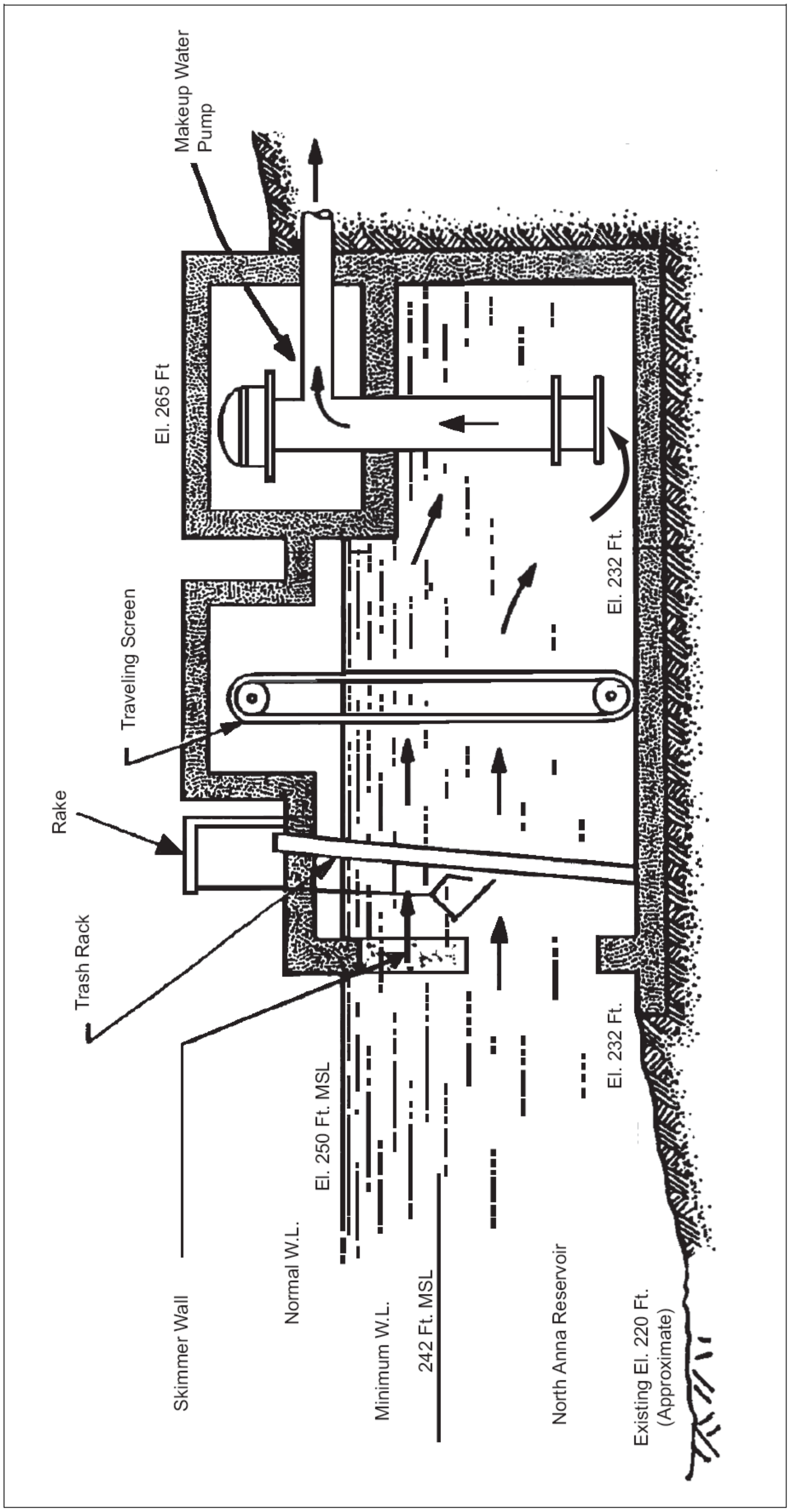

Figure 4-2. Schematic View of Pump Intake for the North Anna ESP Site

A temporary loss of benthic habitat and the displacement or loss of benthic organisms would be expected as a result of construction activities (Dominion 2006a). Fish and benthic organisms inhabiting the intake channel and the lake near the intake channel may temporarily migrate from the area during cofferdam modification. To minimize the impacts to benthic and fish populations in Lake Anna, Dominion represented that it would conduct facility construction and environmental protection activities in accordance with State regulations and permit requirements (Dominion 2006a) (see Appendix J). Prior to any in-water activities associated with the construction of the intake structure, Dominion would be required to obtain a Clean Water Act Section 404 Permit from ACE. The permit could place restrictions on any activities conducted in Lake Anna during the proposed construction. These restrictions would further lessen any impact to benthic or aquatic communities.

Dredging could also cause increased turbidity, thus leading to a temporary reduction in primary productivity caused by reduced light penetration and the smothering of periphyton and aquatic macrophytes in the intake channel. After construction, primary productivity would be expected to return to previous levels, and macrophyte recolonization would occur (Dominion 2006a). Dominion represented that it would install a barrier (e.g., a turbidity curtain or sheet piling), or some form of protection between the intake bay for Units 3 and 4 and the lake, to reduce the potential for sediment entrainment through the existing units to the Waste Heat Treatment Facility (WHTF) (Dominion 2006a) (see Appendix J). This mitigation measure is expected to reduce the possibility for adversely impacting primary production in the WHTF.

As a matter of practice, VDEQ would likely require that sedimentation and erosion-control BMPs or effective storm-water management practices or both would be used to maintain water quality and protect aquatic resources in Lake Anna and the WHTF. After construction is completed, benthic and aquatic organisms would be expected to repopulate the area. Prior to any construction activities that could result in discharges from the site that might effect the aquatic environment, Dominion would be required to obtain a Commonwealth VPDES Construction Site Stormwater Permit.

Because Dominion may use the existing discharge canal for Units 1 and 2 or the partially completed canal originally intended for two additional units proposed at the time NAPS Units 1 and 2 were licensed, construction impacts would be minimal.

If dredging were performed to improve access to the water intake for Units 3 and 4, the dredging could cause heavy metals in sediment from Contrary Creek to be resuspended and potentially impact aquatic biota. Potential impacts would be considered in the Clean Water Act Section 404 Permit and the Section 401 Certification process.

The staff assessed the potential impacts of construction of Units 3 and 4 on aquatic ecological resources including modifying the existing partially competed intake structure, constructing a new intake structure, and modifying the cofferdam. The applicant is expected to follow sedimentation and erosion control BMPs and to comply with the VDEQ stormwater management plan as well as any restrictions or requirements contained in the ACE Section 404 Permit. No planned construction activities would be expected to impact the fisheries or any of the biological communities of the North Anna River. Any impacts to the aquatic resources in Lake Anna in the vicinity of the intake channel would be minor and temporary.

Dominion stated that the potential for fuel or other fluid spills could exist throughout the construction phase and that the State agencies would likely require that controls to prevent contaminants from entering the aquatic system from spills would be handled according to an approved Spill Prevention Control and Countermeasure Plan (Dominion 2006a).

The cooling towers for Units 3 and 4 could be located near an intermittent stream on the NAPS site. If so, construction of these towers could result in temporary soil erosion and silt entry into the stream. Renovation of an existing rail spur or the construction of a new spur also could occur near the stream. Intermittent streams in this area are not known to provide habitat for any important fish species.

The staff reviewed the potential impacts of construction of Units 3 and 4 on aquatic ecological resources including constructing a new intake structure and channel, the construction of a new discharge structure, or the modification of the existing discharge canal originally designated for two new units during the licensing of Units 1 and 2. The impacts are expected to be localized and temporary. Additionally, no planned construction activities would be expected to impact the fisheries or any of the biological communities of the North Anna River. Based on its independent review and Dominion's representation to implement mitigation measures, the staff concludes that the overall impact of construction-related activities on aquatic ecological resources would be SMALL, and further mitigation beyond the actions stated above is not warranted.

4.4.3 Threatened and Endangered Species

As described in Sections 2.7.2 and 2.7.4, no Federally listed threatened or endangered species are known to occur at or near the North Anna ESP site except the bald eagle (*Haliaeetus leucocephalus*), which is occasionally observed perching or foraging on the shore of Lake Anna. The closest known bald eagle nesting site is located more than 4 km (2.5 mile) from the North Anna ESP site. In the Commonwealth of Virginia, a 0.25-mile (0.4-km) buffer zone is usually preserved to limit construction activities (FWS and VDGIF 2000). Dominion follows the bald eagle nesting guidelines (Dominion 2006c). Site preparation and construction for Units 3 and 4 would have no effect on existing bald eagle nests, and are not likely to alter eagle foraging behavior on Lake Anna. There are no areas designated as critical habitat for threatened or endangered species located near the NAPS site.

Virginia Power has monitored fish populations in Lake Anna and the North Anna River since the early 1970s to evaluate the response of these populations to the operation of NAPS Units 1 and 2. No Federally listed fish species have been collected in any of these monitoring studies, nor have any listed species been observed in creel surveys or occasional special studies conducted by Virginia Power biologists and affiliated researchers. Lake Anna and the North Anna River are not in the range of any Federally listed fish species. No listed fish species are believed to occur in counties adjacent to Lake Anna or the North Anna River (i.e., Caroline, Hanover, Louisa, Orange, and Spotsylvania Counties).

According to the Virginia Department of Conservation and Recreation (VDCR) and the Virginia Department of Game and Inland Fisheries (VDGIF) (Division of Natural Heritage) databases, two Federally listed mussel species occur in counties that border Lake Anna or the North Anna River. Neither of these species has been found in Lake Anna, the North Anna River, or other local streams.

The staff reviewed the potential impacts of construction of Units 3 and 4 on threatened and endangered species. It is unlikely that any aquatic or terrestrial Federally listed threatened or endangered species exist on the North Anna ESP site. Based on its independent review, and because there are no records of Federally listed species, except for an occasional bald eagle, in the proposed project area, the staff concludes that the effect of construction on threatened and endangered species would be SMALL, and mitigation is not warranted.

4.5 Socioeconomic Impacts

This section evaluates the social and economic impacts to the surrounding region as a result of constructing Units 3 and 4 at the North Anna ESP site. The evaluation assesses impacts of construction and demands on the surrounding region that could result from the larger workforce. Construction activities are assumed to last up to 5 years and need up to 5000 workers. The evaluation also assesses the visual impacts of constructing the new plant structures.

Dominion expects the workforce to be maintained for most of the construction period. This construction workforce would be in addition to the 850 personnel currently employed at the site (Dominion 2006a) and intermittent outage crews.

4.5.1 Physical Impacts

Construction activities at the North Anna ESP site could cause temporary and localized physical impacts including, but not limited to, noise, odor, vehicle exhaust emissions, and fugitive dust. Dominion does not expect significant vibration and shock impacts during construction because of the strict restriction or control of such activities onsite (Dominion 2006a). This section qualitatively addresses those potential impacts that may affect people, buildings, roads, and recreational facilities (such as Lake Anna).

4.5.1.1 Workers and the Local Public

The NAPS site is located in an area zoned for industrial use. The site is bounded by light industrial and commercial zones to the north and west, a recreational area (Lake Anna) to the east, and residential housing to the south. All construction activities are expected to be located within the NAPS site boundary (Dominion 2006a). Offsite areas supporting construction activities (e.g., borrow pits, quarries, disposal sites) are assumed to be permitted and operational. As such, impacts by those offsite facilities from constructing Units 3 and 4 at NAPS are considered small incremental impacts associated with their normal operation.

The estimated population within 16 km (10 mi) of the North Anna ESP site is 15,500 people (Dominion 2006a). The area surrounding the site is predominately rural and is characterized by farmland and wooded tracts. The exception is the residential development surrounding Lake Anna. No other significant industrial or commercial facilities exist around the site, and it is the goal of the Louisa County Board of Supervisors to preserve the rural character of Louisa County (Louisa County 2001).

People who work or live around the NAPS site could be subjected to noise, fugitive dust, and gaseous emissions resulting from construction activities. The staff expects that the construction workforce and the NAPS Unit 1 and 2 workforce would be the most impacted, followed by individuals working or living immediately adjacent to the site. Least impacted would be transient populations, such as temporary employees, recreational visitors to Lake Anna, and tourists passing through the area.

Onsite impacts to construction workers would be mitigated through adequate training and use of personal protective equipment to minimize the risk of potentially harmful exposures (Dominion 2006a). Emergency first-aid care and regular health and safety monitoring of construction personnel could also be undertaken to reduce onsite impacts of construction activities.

Dominion expects that individuals working onsite or living near the North Anna ESP site would not experience physical impacts greater than those considered to be an annoyance or a nuisance. In the event of atypical or noisy construction activities (e.g., pile driving), prior public announcements or notifications of such activities or both would be provided. In the ER, Dominion represented that these activities would be performed in compliance with Federal, State, and local regulations, and the site-specific permit conditions specified in its ER (Dominion 2006a) (see Appendix J).

Fugitive dust and odors could be generated from normal construction activities. Various mitigation measures, such as paving disturbed areas, using water to suppress dust, and reducing material-handling activities, as stated in Section 4.4.1 of the ER, could be undertaken to minimize these impacts. Dominion represented that it would undertake additional mitigation control measures to address any nuisance issues on a case-by-case basis (Dominion 2006a) (see Appendix J).

Dominion stated that noise and exhaust emissions from construction equipment would have no discernable impact on the local noise level and air quality (Dominion 2006a). All equipment would be operated in accordance with Federal, State, and local emission requirements (Dominion 2006a).

In the ER, Dominion identified mitigation measures such as training workers, developing a fugitive dust plan, and complying with the conditions specified in State and local permits.

Based on NRC's independent review and Dominion's represented that it would undertake mitigation measures, the staff concludes that the overall physical impacts to workers and the local population are SMALL, and further mitigation beyond the mitigation actions stated above is not warranted.

4.5.1.2 Buildings

Construction activities are not expected to impact any offsite structures. The building(s) most exposed to shock and vibration from pile driving are those located on the NAPS site; however, Dominion has constructed the onsite buildings to safely withstand shock and vibration impacts resulting from construction activities (Dominion 2006a).

Because the nearest offsite building is about 910 m (3000 ft) from the North Anna ESP site, the staff concluded that the overall physical impacts to offsite buildings would be SMALL, and mitigation is not warranted.

4.5.1.3 Roads

The transportation network in Louisa County and at the ESP site is well developed. In 2001, most of the roadways within Louisa County were operating at acceptable levels-of-service (LOS) (see Table 2-14 for relevant definitions of LOS). As shown in Table 2-7, the population in Louisa County, the county most impacted by the presence of the proposed Units 3 and 4, is projected to increase from approximately 25,627 to 29,100 or approximately 13.6 percent between 2000 and 2010 (VEC 2003). It is expected to increase by another 15 percent between 2010 and 2020 (Louisa County 2001) even without the influx of construction workers for Units 3 and 4. While such growth would put pressure on the local road system, it is not expected to overwhelm the system. An adequate transportation system exists, and a number of improvements are planned in Louisa County over the next 15 years for primary and secondary roads to maintain a level of service "C" rating (Louisa County 2001). Many of these improvements have been delayed because of insufficient funding for new construction (Coffey and Hatter in Jaksch and Scott 2005).

Dominion stated that no new public roads would be required as a result of construction activities, nor would public roads be altered (e.g., widened) as a result of construction activities. Dominion indicated that some minor road repairs and improvements (e.g., patching cracks and potholes, adding turn lanes, reinforcing soft shoulders) would be necessary to enable equipment accessibility and minimize safety risks (Dominion 2006a). Construction site exits onto public roads would be marked clearly with signs and maintained. Damage to public roads, markings, or signs caused by construction activities would be repaired to pre-existing conditions or better by Dominion (Dominion 2006a).

Dominion stated that a new access road on the NAPS site would support construction activities and would be private and fully contained within the existing NAPS site boundary. The road would be maintained by Virginia Power personnel as needed (Dominion 2006a). However, the staff evaluation found that State Route (SR) 700 leading into NAPS from SR 618 to SR 652 is very narrow and paved (SR 700 has been upgraded from SR 652 to the plant site). It is unlikely that this road could accept heavy construction traffic and the transportation of construction materials without substantial upgrading. There could be congestion at shift changes at the intersection of SR 700 and SR 652, particularly if the construction, operating, and outage personnel leave and enter the plant site at the same time. In addition, construction at the North Anna ESP site could increase traffic loads in and around Lake Anna itself. The roads around Lake Anna are already congested.

In the ER, Dominion represented that it would develop and implement a traffic management plan to increase the number of construction workers per vehicle by developing methods for enhancing the use of multi-person vans (see Appendix J). Dominion also represented that it would attempt to schedule shift changes for operating personnel, outage workers, and construction workers to reduce the number of vehicles on the road at any given time.

SR 618 through the town of Mineral would need to be evaluated with respect to potential construction at the NAPS site. Also, the existing rail spur into the site could be employed to bring in heavier equipment and construction materials, thereby reducing some of the burden on the local roads. The rail spur may require upgrading to accommodate the heavier loads.

Dominion stated that no public roads would need to be altered because of construction of new facilities; however, local officials believe this would need to be evaluated prior to the start of construction. Based on the Dominion's representation that it would develop and implement a traffic management plan, and its independent review, the staff concludes that the overall physical impacts to local roadways would be temporary and SMALL, and additional mitigation beyond the actions stated above is not warranted.

4.5.1.4 Aesthetics

Created in 1971, Lake Anna is the main source of cooling water for NAPS Units 1 and 2. Significant residential development has occurred around the lake with many permanent year-round and part-time residences being built. The lake is a major economic development resource for Louisa and Spotsylvania counties and, to a lesser extent, Orange County. The lake has public access and its use by the public includes recreational boating, fishing, camping, and picnicking. Virginia Power and Old Dominion Electric Cooperative own, and Virginia Power controls, the land that forms Lake Anna, both above and beneath the water surface, up to the expected high-water marks. The aquatic resources of Lake Anna are managed cooperatively by Virginia Power and State natural resource agencies, including the VDGIF and VDCR.

From a visual perspective, the closed-cycle, combination wet and dry cooling system for Unit 3 and the dry cooling system for Unit 4 are expected to be approximately 46 m (150 ft) tall, which is less than the 71 m (234 ft) PPE height value for the containment building. As these structures reach completion, they likely will be visible above the treeline by offsite viewers. The current North Anna structures are already visible from Lake Anna and from other selected locations; it is not expected that the visual impact would be appreciably different than the current visible structures in those locations. Recreational users of Lake Anna would be able to observe construction activities occurring on the NAPS site; however, such activities would take place on a site zoned "industrial" and already containing NAPS Units 1 and 2.

Because visual impacts of construction, such as water turbidity from localized dredging and fugitive dust, would be temporary and would be controlled pursuant to State regulations and Dominion's representation that it would develop and implement a dust control plan (see Section 4.2.1), and the points from which they could be observed from the lake would be limited, the staff concludes that the visual impacts of construction on Lake Anna and the surrounding area would be SMALL, and further mitigation is not warranted.

4.5.2 Demography

The population in the region within 80 km (50 mi) of the ESP site is projected to grow at an average annual rate of 1.75 percent between 2000 and 2020 (i.e., from 1,538,156 in 2000 to 2,160,921 in 2020), as shown in Table 2-5. The economy in the region is considered strong and growing.

In the ER, Dominion stated that 80 percent of the peak 5000-person construction workforce for Units 3 and 4 would come from within the region and commute to the NAPS site. The remaining 1000 workers could commute from outside the region to the site or move into the region. Thus, increases in population directly attributable to the construction workforce for Units 3 and 4 would be minimal.

Some new jobs may result from the multiplier effect[a] attributable to the construction workforce. But these increases, when compared to the total population base in the region, would be minimal as well.

(a) The multiplier effect describes the situation in which each dollar spent on goods and services by a construction worker becomes income to the recipient who saves some but spends the rest on consumption. This spending becomes income to someone else, who in turn saves part and spends the rest. The number of times the final increase in consumption exceeds the initial dollar spent is called the "multiplier."

Should a larger than expected number of construction workers decide to relocate to Louisa or Orange Counties, there could be a noticeable, but not excessive, increase in population. Based on 2000 census data, a 1000-person increase caused by the relocation of construction workers would only represent a 3.9 percent increase in total population (in either county). Any multiplier effects resulting from construction worker expenditures would most likely mean that residents of the two counties could obtain new or higher paying jobs as a result of the increased economic activity.

Based on its representation that (1) most construction workers would be expected to come from within the region and (2) the number of construction workers who might relocate to the region would be a small percentage of the larger population base, the staff concludes that the impacts of construction on increases in population within the region would be SMALL, and mitigation is not warranted.

4.5.3 Community Characteristics

This section evaluates the social and economic impacts to the surrounding region as a result of constructing Units 3 and 4 at the North Anna ESP site. The evaluation assesses impacts of construction and demands placed by the larger workforce on the surrounding region. Construction activities are assumed to last up to 5 years and employ up to 5000 workers. Dominion expects this size workforce to be maintained for most of the construction period (Dominion 2006a). This construction workforce would be in addition to the 850 personnel currently employed at the site (Dominion 2006a).

4.5.3.1 Economy

The impacts of construction of Units 3 and 4 on the local and regional economy are dependent on the region's current and projected economy and population. The impacts on the economy of constructing Units 3 and 4 would generally be positive within the region. The degree of this beneficial impact would vary throughout the region, with Louisa County receiving the greater benefit.

Some insight can be obtained on the projected economy and population by consulting county comprehensive plans and data from the U.S. Census Bureau. The North Anna ESP, if granted, could be in effect for up to 20 years after approval. Safety-related construction activities would be authorized by a CP or a COL. Before a CP or COL is issued, limited construction activities and site preparation activities authorized under the site redress plan could start at any time. Therefore, the positive economic benefits of construction could begin before the start of major construction activities. The economic impacts, given the 20-year time horizon, are qualitatively discussed.

Dominion projects that up to 5000 workers would be needed to construct Units 3 and 4. The employment of this large workforce for an extended period of time would have economic and social impacts on the surrounding region. Louisa County would be impacted the greatest. The impacts on Orange County are expected to be less, and the impacts become more diffuse as a result of interacting with the larger economic base of the surrounding counties and the City of Richmond. Impacts would affect transportation, taxes, aesthetics and recreation, housing, public services, and education, all of which are discussed separately below. The magnitude of the impacts depends on the percentage of the workforce that would come from within the 80-km (50-mi) region around the NAPS site and, thus, would commute to the site. In addition, the magnitude depends on the percentage of the workforce that might relocate to the area and whether workers relocate to Louisa and Orange Counties or Henrico County and the City of Richmond.

The staff assumed that about 1000 new workers would move into the region for construction and more jobs would be created in the region because of the multiplier effect of direct employment as a result of the expenditures of the construction workforce and Dominion in the region for products and services.

Another consideration is whether there would be a sufficient number of construction workers to supply the estimated 5000-person workforce and whether the available workers would have the requisite skills, especially in light of a tight labor market as evidenced by the very low unemployment rates in the area (see Tables 2-9 and 2-11). In its ER (Dominion 2006a), Dominion refers to a labor study that showed there would be sufficient construction labor from the greater Richmond area to meet its demands.

Relying on information obtained from the interviews conducted during the December 2003 site visit, the staff confirmed that a sufficient number of construction workers would be available to meet the expected demand (Jaksch and Scott 2005). Many construction workers commute from the Fredericksburg area to jobs in Northern Virginia and Washington, D.C.; for example, for the Fredericksburg region, it is estimated that out of a workforce of 122,000, 48,300 workers (almost 40 percent) commute from the Fredericksburg region to their jobs (Fredericksburg 2003). Also, if workers were given the opportunity to reduce or eliminate their commute by working closer to home, they would be expected to do so. As a result, the staff concludes that there would be few impediments to recruiting the requisite construction workforce (from the local labor pool and with regional imports) to support the construction of Units 3 and 4 at the North Anna ESP site.

The staff reviewed the impacts of construction of the proposed Units 3 and 4 on the economy of the region and concludes that the magnitude of the economic impacts would be diffused in the larger economic bases of Henrico and Spotsylvania Counties and the City of Richmond. The economic impacts would be more noticeable for the smaller economic bases of Orange and Louisa Counties. Based on the positive aspects of the proposed construction on the regional economies and the workforce availability, the staff concludes that the impacts on the economy are mostly positive. In terms of representing adverse effects, the staff concludes that the impact would be SMALL BENEFICIAL to up to MODERATE BENEFICIAL for Louisa and Orange Counties, and mitigation is not warranted.

4.5.3.2 Transportation

Current transportation patterns, existing road traffic congestion, and planned road upgrades in the region were examined in Section 2.8.2.2 of this EIS. This section summarizes the potential impacts of construction on the transportation system as a whole.

The main impacts to the transportation system resulting from construction of Units 3 and 4 would be on the roads leading to and from the NAPS site. Several impacts could occur. First, there could be the potential congestion on some of the major Federal highways and SRs leading to the NAPS site. Second, there could be the crowding and congestion at the entrance to NAPS during shift changes. SR 700 between SR 652 and NAPS has been upgraded to accommodate heavier vehicles, thus reducing the potential damage to roads from heavy haul traffic (Jaksch and Scott 2005) This impact could be alleviated by using the existing rail spur to bring in supplies and construction equipment. The rail spur itself may need to be upgraded to accommodate the increased traffic and weight of some of the material being hauled. However, the transport of heavy construction equipment into the site is expected to be an occasional-to-rare occurrence.

Depending on the routes used, a peak workforce of 5000 construction workers commuting to and from the NAPS site could potentially impact other parts of the transportation system. Not all 5000 workers would commute to the site at the same time, and their arrival and departure times would most likely be spread throughout the 24-hour period in two shifts.

SR 700 (LOS B) (see Table 2-14 for relevant definitions of LOS) is the only road that leads directly to the North Anna ESP site, and the traffic east of the intersection on SR 652 is normally related to activities at NAPS. This would also be the case during the construction of Units 3 and 4. Construction worker access to the ESP site would be via an access road that Dominion would build on the north side of SR 700 on Virginia Power property. This new access road would intersect with SR 700 several hundred yards west of the access road to the existing units (Dominion 2006a). Dominion indicated that the potential for congestion exists at SRs 700 and 652 if construction and plant shift changes are not managed. To mitigate this potential problem, Dominion represented that it would develop, in cooperation with the Virginia Department of Transportation, and implement a traffic management plan as a construction mitigation measure (see Appendix J). However, this action may not fully alleviate the congestion. Beginning at the intersection of SR 700 and SR 652, the increased construction traffic would begin to disperse onto local roads; however, congestion could develop at the intersection of SRs 700 and 652 during construction shift changes even if the shift changes for construction and operation are staggered (Dominion 2006a). Both SRs 700 and 618 into Mineral are of concern to Louisa County officials in light of the additional vehicular traffic placed on the roads as a result of construction (Williams and Buckler, and Coffey in Jaksch and Scott 2005).

Accounting for the current permanent workforce of 850 employees, the planned outages that double the workforce (at least four outages would occur during the construction of Units 3 and 4 with workers divided over three shifts), and 5000 construction workers working two 10-hour shifts per day would place a total of approximately 3900 vehicles per day on the roads (Dominion 2006a). This represents a major increase in traffic at the intersection of SRs 700 and 652, which historically has been able to handle a peak of around 2000 workers without creating a major traffic problem on the local roads (Dominion 2006a). The potential cumulative increase in the number of vehicles during a combined outage, construction, and permanent workforce egress and ingress into the site would require the traffic management plan and other improvements to mitigate impacts.

In its ER, Dominion identified several mitigating measures that could be undertaken to partially mitigate congestion at the intersection of SRs 700 and 652 and on the local road systems, particularly SR 700 between US 522 and SR 652, which is a paved country lane (Dominion 2006a). These mitigating actions include:

- Develop a traffic management plan for the local road system prior to construction startup to alleviate congestion at the intersection of SRs 700 and 652.

- Encourage the use of car and van pooling to reduce the number of vehicles on the roads leading to the plant.

- Schedule shift changes for all employees so arrivals and departures are staggered over a 24-hour period. Dominion states it plans to do this, but recognizes the need to hand off work from the outgoing to the incoming shift workers may complicate this scheduling effort for construction and when an outage occurs.

- Upgrade the intersection of SRs 700 and 652 by installing turn lanes and traffic lights at the intersection.

Another alternative would be for the Virginia Department of Transportation to widen SR 700 at U.S. 522 near the town of Mineral. As previously mentioned, SR 700 is paved, but is not designed to handle large amounts of vehicular traffic or the transport of heavy loads.

The Lake Anna Advisory Committee, a three-county planning group composed of representatives from Louisa, Orange, and Spotsylvania Counties, already recommended that planners in each of the three counties upgrade their local roads around Lake Anna (Lake Anna Special Area Plan Committee 2000). The recommended upgrades would provide a circumferential roadway system around the lake with lanes for towed boats and bicycles. Should the upgrades occur, they would alleviate congestion on local roads, such as SR 608 and U.S. 522, caused by the influx of construction workers. Many of the roads around the upper end of Lake Anna have not been upgraded since the 1970s. Transportation choke points in the area now are SRs 700 and 652 at the NAPS site entrance and SR 208 to Fredericksburg.

Currently, in Orange County, the transportation system is adequate; however, with new development, the system would become constrained.

Spotsylvania County contemplates planning to widen SR 606 west of I-95 to four lanes and has included this project in its comprehensive plan (Spotsylvania County 2002), but there are no active plans to do so. This project, if completed, should reduce the additional impacts of a large number of construction workers commuting on SR 606 to the NAPS site. SR 208 currently is being widened to just north of the historic Courthouse District. Although much of the right-of-way has been purchased, extending this construction south to SR 606 has been delayed. When completed, this new road would bypass the Courthouse District with a through road (Vogel and Goss 2005 in Jaksch and Scott 2005). SR 208 south is a two-lane road with a bridge over Lake Anna west of the North Anna ESP site. Spotsylvania County eventually plans to upgrade the smaller two-lane roads around Lake Anna by widening them and including shoulders (Dominion 2006a). In Louisa County, SR 700 from SR 652 to NAPS and parts of SR 652 have been upgraded and can accommodate heavy construction traffic. Part of SR 208 south of Louisa is undergoing improvement, but there are no other active plans to improve the other roads near the North Anna ESP site, either immediately or in the near future, because most of the local roads currently carry comparatively light traffic and highway funds are limited (Coffey and Hatter in Jaksch and Scott 2005).

In Hanover County, U.S. 33 currently carries modest volumes of traffic and needs to be widened (Hanover County 2003). A schedule for widening U.S. 33 has not been established because the source of funding has not been identified. If U.S. 33 is not widened before the start of construction of Units 3 and 4, construction workers commuting from the City of Richmond would cause increased congestion (Dominion 2006a). The magnitude of the congestion impacts would depend, to some extent, on the shift schedule for the construction of Units 3 and 4, relative to the normal commuting schedule of other road users (Dominion 2006a).

The most likely commuting routes taken by the construction workers from Richmond would be U.S. 33 through Hanover County or I-64 through northwest Henrico County and along the southern boundary of Louisa County. I-64 west from Richmond has a LOS no worse than B (Dominion 2006a). Dominion represented that commuting construction workers from the greater Richmond area using SR 208 or U.S. 522 would not cause congestion problems (Dominion 2006a). While these are well-maintained, lightly traveled, two-lane roads at present, adding up to 3900 vehicles per day could result in congestion. These impacts could be mitigated by staggering the shift changes, encouraging car pooling, etc., or by upgrading the roads in the future.

Construction workers traveling south on I-95 from Spotsylvania County or points further north toward Washington, D.C., would most likely take SR 606 west or the U.S. 1 exit (exit 126) to Route 208, and then south on SR 208 (Courthouse Road) to reach the NAPS site (Dominion 2006a). The SR 606/Interstate 95 interchange is already congested, generally at LOS D or worse. I-95 is not the most direct route to the NAPS site from Richmond; therefore, I-95 north from Richmond through Hanover County would not be as adversely impacted by construction workers commuting from the greater Richmond area. The capacity of I-95 is generally adequate to serve current and projected needs; however, there are periods of extreme congestion during morning and afternoon weekday hours and during peak weekend travel times (Hanover County 2003). There are active plans to upgrade Route 208 with a bypass of the Spotsylvania Courthouse area (construction to be bid in 2007).

In conclusion, traffic congestion would be a problem if the road systems are not updated or properly maintained. Ongoing growth in the area and recreation at Lake Anna is currently putting pressure on the roads around Lake Anna. Increased congestion could impact the recreational use of Lake Anna with consequential economic impacts to the area. Adding a construction workforce to an existing permanent workforce, plus workers associated with planned outages, would further exacerbate traffic congestion unless mitigation measures, as described above, are undertaken. Even then, these mitigation measures may not fully alleviate the congestion, especially on SR 700 leading to the NAPS site and at the intersection of SRs 700 and 652.

Based on its independent review and Dominion's representation that it would develop and implement a traffic management plan, the staff concludes that if the planned upgrades and improvements to the road systems in the region are implemented, then the temporary impacts of construction on transportation in the region would be SMALL to MODERATE, and further mitigation beyond the actions stated above is not warranted.

4.5.3.3 Taxes

The type of reactor selected would impact the size of the required workforce and, thus, the amount of taxes paid. Because reactor selection would only occur if Dominion decides to proceed with a CP or a COL, only a qualitative assessment of the impacts to the surrounding area and region can be provided at this time.

Construction Impacts at the Proposed Site

Tax revenues from several types of taxes would be generated by the construction of Units 3 and 4 and its workforce: income taxes on wages and salaries paid and corporate profits, sales and use taxes on purchases, and property taxes on the physical facility itself. Each of these tax types is briefly discussed below.

Income Taxes

Virginia has a personal income tax with a 5.75 percent top marginal rate for taxable income exceeding $17,000. It also has a corporate income tax, which is 6 percent of corporate taxable income. Both the corporate and personal tax return is based on the Federal return, so generally, income that is taxable at the Federal level is also taxed by Virginia Department of Taxation (VTAX) (2003). Therefore, construction workers and employees of Dominion would pay taxes on their wages and salaries to Virginia, if their residence is in Virginia, as would corporations based in or doing business in Virginia. While the exact amount of tax payable to Virginia is not known, the absolute amount could be substantial over a 5-year construction period, but small when considered in relation to total amount of income taxes Virginia would collect over that period.

Sales and Use Taxes

Virginia has two types of sales and use taxes. A 4 percent tax is levied on selected food items with 3 percent of the revenue paid to the Commonwealth and 1 percent to the local jurisdiction where it is collected (VTAX 2000). In addition, a 4.5 percent sales tax is levied on other goods and services sold, with the Commonwealth receiving 3.5 percent of the revenue and the local jurisdictions receiving 1 percent (VTAX 1987). The current combined sales and use tax rate for Louisa County is 4.5 percent: 3.5 percent of the revenue is paid to the Commonwealth and 1 percent to the local jurisdiction where it is collected (Dominion 2006a).

Virginia and the counties surrounding the North Anna ESP site would experience an increase in the amount of sales and use taxes collected from construction materials and supplies purchased for the project. Additional sales and use taxes would be generated by retail expenditures of construction workers.

Dominion estimates that about half of the day-to-day expenditures during construction would occur in the region (Dominion 2006a). At this point it is difficult to assess which counties and local jurisdictions would be most affected by the expenditures and resultant sales and use taxes collected. But, as with income taxes, the total amount of sales and use taxes collected, while large, would be small when compared to the total amount of taxes collected by the Commonwealth and local governments. The exception might be Louisa County where a larger percentage of expenditures that generate sales and use taxes could be expected to take place. In sum, the taxes collected would benefit the Commonwealth and local jurisdictions.

Because the absolute amount of sales and use taxes paid to the Commonwealth and to local entities would be small when compared to the total amount of sales and use taxes collected, the staff concludes that the overall impacts of construction on sales and use taxes collected would be small and beneficial. In the case of Louisa County, the impacts might be moderate and beneficial because of the preponderance of construction activities in the county.

Property Taxes

Louisa County would benefit from additional property tax revenue associated with the construction of Units 3 and 4. The first source of revenue would be the tangible personal property taxes paid by contractors during construction of the additional units. This tax is based on the value of property owned by the contractors that acquire taxable status in Louisa County during the construction period. Currently, the county calculates the assessed value of the property at 10 percent of the original cost, which is then taxed at the rate of $1.90 per $100 of value (Dominion 2006a).

The second source of revenue would be from the real property taxes levied for the incremental increase in value to the entire site from the additional units. While under construction, the tax would be levied only on the value of the tangible personal property to become part of the additional units. Currently, the Virginia State Corporation Commission is responsible for the valuation of the property both during construction and following completion of the additional units. The current tax rate for this property is $0.67 per $100 of value (Dominion 2006a).

Louisa County is expected to be the primary beneficiary of the property taxes paid by Dominion during the construction period. For the period 1995 to 2003, property taxes paid by Dominion for NAPS averaged about 46 percent of the total property revenue of Louisa County, and approximately 22.5 percent of the county’s total annual budget (see Section 2.8.2.3 for a more detailed discussion).

The staff considers the overall impacts from real and personal property taxes resulting from construction of Units 3 and 4 to be moderate and beneficial for Louisa County. Construction would take place at the North Anna ESP site, which is in Louisa County. Louisa County receives the preponderance of property tax revenue collected on the existing NAPS Units 1 and 2, which represents a significant portion of the total property tax revenues collected by the county. This would be expected to continue with the construction of Units 3 and 4.

Summary of Impacts on Taxes

The staff reviewed the income taxes generated on wages and salaries of Units 3 and 4 construction workers and Dominion corporate profits as well as sales and use taxes, most of which represent beneficial sources of income for the Commonwealth and some of which would benefit the counties in the region. Property tax paid by contractors and by Dominion would directly benefit Louisa County. The overall impacts from real and personal property taxes, on the region would be SMALL BENEFICIAL to MODERATE BENEFICIAL for Louisa County, and mitigation is not warranted.

4.5.3.4 Recreation

As discussed previously under physical impacts, construction at the North Anna ESP site would have limited visual impacts on users of Lake Anna or from points outside the site boundaries. Water-quality impacts of construction of a new water intake structure would be subject to applicable Federal and State regulations, and any noticeable effects would be transitory. Impacts on recreational users of Lake Anna as a result of these activities would be minimal.

Congestion on roads around Lake Anna could be exacerbated with the addition of the construction workforce, and recreational use of Lake Anna would increase as a result of expected increased use by the construction workforce, potentially causing temporary overcrowding. The increased congestion on the roads and use of the lake could lessen the recreational experience of current users of the lake and could discourage some recreational users of the lake, particularly those users visiting from outside the region such as Northern Virginia. Reduction in the number of visitors from outside the area would most likely reduce recreational spending on items such as gas for boats, food, and lodging, resulting in negative economic impacts to local merchants around the lake.

Based on the expectation that the mitigative measures discussed earlier (e.g., traffic management, road improvements, and best construction management practices to minimize water quality impacts) are implemented, the staff concludes that the impacts of construction on the recreational use of Lake Anna would be SMALL to MODERATE, and further mitigation is not warranted.

4.5.3.5 Housing

Impacts on housing from the construction workforce are dependent on how many workers come from within the region (80 km [50 mi]) and, therefore, already have housing, and how many workers might need to relocate to the area and would require housing. Dominion states in its ER that the majority of the construction workforce would come from within the region (Dominion 2006a). Interviews with local county and economic development officials and data from the U.S. Bureau of Economic Analysis support this assumption. In 2000, there were 473,033 full- and part-time workers in Henrico, Louisa, Orange and Spotsylvania Counties and the City of Richmond, or 10.7 percent of the Virginia workforce (see Table 2-11). Of the total, 27,242 workers were employed in construction across the four counties and the City of Richmond (see Table 2-13). This number does not include construction workers who may commute to jobs outside the area of their residence.

Dominion estimates it would need a construction workforce of up to 5000 over a 5-year period to construct Units 3 and 4 (Dominion 2006a). If the entire workforce is derived from within the 80-km (50-mi) radius, there would be no or little impact on housing. However, Dominion's prior experience on projects of similar size indicates that up to 20 percent of the workforce would come from beyond the 80-km (50-mi) radius (Dominion 2006a). It is not unusual for construction workers to drive 80 km (50 mi) or more from their place of residence to a job site. Even if 1000 or more workers came from outside the region, all 1000 would not necessarily require housing within the region.

Nevertheless, if current trends hold into the future, it appears that adequate rental housing is available within the 80-km (50-mi) radius of NAPS, particularly in Henrico County and the City of Richmond (see Tables 2-18 and 2-19) and to a lesser extent Spotsylvania County, assuming that approximately 1000 workers would come from outside the region, may need housing in the region, and would be willing to live in Henrico or Spotsylvania Counties or the City of Richmond and commute to the NAPS site. However, if these assumptions are not fully realized, housing availability could be impacted, particularly in Orange and Louisa Counties where there is a shortage of rental housing (see Table 2-19). If too many workers attempt to move into these two counties, there would likely be an increase in rental fees. The staff concludes that impacts to Orange and Louisa Counties could be moderate if significantly more workers than expected locate to these counties where a shortage of rental housing currently exists. The building of a significant number of new rental units in anticipation of construction activities at the North Anna ESP site is not expected because of the short duration of construction. If rents increase, some low-income populations could find it more difficult to secure rental housing.

Such upward pressures on rental fees is less likely to occur in a larger metropolitan area where there is a greater supply of rental housing. In addition, if a number of construction workers were to utilize modular or mobile trailer units during their period of employment, they would likely compete with recreational users of Lake Anna for spaces at existing recreational vehicle/trailer parks, resulting in upward pressure on the prices or rents charged for such spaces.

Increased demand for recreational vehicle/trailer spaces could lead to an increase in the number of spaces being made available. During the construction of NAPS Units 1 and 2, temporary recreational vehicle parks were established in Louisa to accommodate some of the workers. Discussions with Louisa County officials indicated that they would consider establishing such temporary recreational vehicle parks again, if needed (Lintecum and Williams and Buckler in Jaksch and Scott 2005). The availability of adequate water and sewer services would have to be addressed (discussed in the next section).

Because of the overall availability of housing in Henrico and Spotsylvania Counties and the City of Richmond and assuming that the housing pattern follows past experience, the staff concludes that the overall impacts of construction on housing in these areas would be SMALL, and mitigation is not warranted.

The staff further concludes that housing impacts to Orange and Louisa Counties could be MODERATE if significantly more workers than expected move to these counties where a shortage of rental housing currently exists. Increased housing construction to meet this potential need is not likely because of the short duration of construction of Units 3 and 4 would take place.

4.5.3.6 Public Services

Water Supply and Waste Treatment Facilities

Even without the construction of Units 3 and 4 at the North Anna ESP site, the water and sewer infrastructure is now a concern in Louisa County, particularly around the I-64 corridor, in the vicinity of Gum Springs because of current growth and demand. The county is considering a separate system for this area. Water supply reservoirs are also a concern because a recent drought has exacerbated a shortage in the availability of water supplies. An influx of construction workers to the county could further exacerbate the current situation. According to the Director of Planning and Community Development and the Director of Planning and Zoning, there are currently no growth restrictions in Louisa County (Williams and Buckler in Jaksch and Scott 2005).

There were some water supply problems in Orange County during the recent drought. Also, in the Gordonsville to town of Orange corridor, water and sewer services are near or at capacity; therefore, any new population growth would require upgrades of both systems. Moreover, the water and sewer systems at the eastern end of the county, where many current NAPS employees live, are close to capacity. In the event of an influx of construction workers to the eastern end of the county, shipping water from the west end of the county to the east end would be a possible, albeit expensive, solution. Currently, there are no growth restrictions in Orange County (Livengood and Kendall in Jaksch and Scott 2005).

In its ER, Dominion stated that there are no public water or sewer systems in the vicinity of the North Anna ESP site except those of incorporated towns, where it is unlikely that new recreational vehicle/trailer courts would be allowed (Dominion 2006a). This would require extending services from the incorporated areas to such facilities or locating them closer to Henrico County and the City of Richmond, where public water and sewer systems are available.

As previously discussed, Dominion expected that 80 percent, or approximately 4000, of the construction workers to live within an 80-km (50-mi) radius of the NAPS site, with the remaining 1000 workers commuting from outside the area or moving into the area. Given the shortage of rental units in Orange and Louisa Counties, Dominion expected that most of those workers moving into the region would locate in the larger population centers of Henrico and Spotsylvania Counties and the City of Richmond. Existing or planned expansions to the infrastructure would mitigate the impacts to Orange and Louisa Counties. However, during an interview on December 8, 2003, officials in Orange and Louisa Counties expressed the view that the existing water supply and sewer infrastructure are nearly at capacity (Jaksch and Scott 2005).

Because of the overall availability of water supply and treatment facilities in Henrico and Spotsylvania Counties and the City of Richmond, the staff concludes that the overall impacts of construction on water supply and waste treatment facilities for these areas would be small. These governments have either added capacity to the infrastructure recently, or are planning additional upgrades or expansion or both. The staff further concludes that the impacts to Orange and Louisa Counties could be moderate if significantly more workers than expected locate in these counties where there is little available capacity in both water supply and waste treatment facilities.

Police, Fire, and Medical Facilities

In Orange County, there are two outpatient clinics but no hospitals. The fire departments are made up of volunteers, and rescue services are composed of both volunteer and paid employees. In the future, as new facilities are established, the county is considering hiring full-time paid staff. An increase in the number of construction workers locating to the county could put pressure on the police, fire, and medical infrastructure (Kube in Jaksch and Scott 2005).

There is no hospital in the town of Louisa or in Louisa County. In Louisa County, general fire, police, and rescue services are considered adequate to meet current needs. Louisa County staff periodically evaluate the adequacy of services based on growth and would include growth as a result of the construction of Units 3 and 4. It is possible that such growth would require expansion of the police department and the fire department (currently a volunteer service) in the town of Louisa. The fire department may have to transition to a fully paid, full-time status (Hayfield in Jaksch and Scott 2005).

A population increase caused by the construction workforce working at the North Anna ESP site, with some workers potentially relocating to Louisa and Orange Counties, would require some upgrades to existing services in these counties. In part, these needs are expected to be offset to some degree because of the additional tax dollars available from additional taxpayers and economic activity (Lingo, Kube, Melton, Candeto, Williams and Buckler, Gibson, and Hayfield in Jaksch and Scott 2005).

In the larger metropolitan areas of the City of Richmond and in Henrico and Spotsylvania Counties, police, fire, and medical facilities would not be significantly affected by any new construction workers relocating to the area.

Social Services

This section focuses on the potential impacts of construction on the social and related services provided to disadvantaged segments of the population in Louisa and Orange Counties, and is distinguished from issues surrounding environmental justice (discussed in Section 4.7).

Generally, construction of Units 3 and 4 at NAPS is viewed as economically beneficial to the disadvantaged population segments served by the Department of Social Services for Louisa and Orange Counties. Construction of the new units may enable the disadvantaged population to improve their social and economic position by taking better-paid construction and non-construction jobs, potentially lessening the demand for social services by this segment of the population. At a minimum, the expenditures of the construction workforce in the counties for goods and services would have a positive effect on the number of jobs that could be filled by the disadvantaged population (Lingo, Oswell and McLaughlin in Jaksch and Scott 2005).

There may be an initial increase in demand for social services by construction and other workers moving to the area until they establish employment, but this is considered manageable (Oswell and McLaughlin in Jaksch and Scott 2005).

Summary of Public Services

Based on the current availability of services and additional taxes that would affect the financial demand for additional services, the staff concludes that the impact on the demand for public and related services as a result of construction would be SMALL, and mitigation is not warranted.

4.5.3.7 Education

Orange County is currently in the process of expanding its school infrastructure and, as a result, could accommodate modest growth increases in student population. Growth is taking place in the eastern end of the county closer to the NAPS site and Lake Anna. One middle school is located in the eastern end of the county and, if growth continues in this area, a new elementary school would be needed. Construction of the two proposed units at the NAPS site would require additional investment in the public school system, particularly given the ongoing growth in the eastern end of the county. At issue is how to accommodate any increased enrollment resulting from construction laborers locating to the county – whether through permanent construction or the use of modular trailer units (Baker in Jaksch and Scott 2005).

In an interview on December 10, 2003, the Superintendent for Louisa County schools indicated that the county schools are currently overcrowded, with enrollment growing at 2 percent a year (Melton in Jaksch and Scott 2005). Tax rates in the county have not been increased in 6 years; therefore, while the schools are being maintained, there has been no new construction to accommodate the increased enrollment. Growth is occurring in the county as a result of its lower taxes as compared to the surrounding counties (Louisa County has the NAPS facility in its tax base [see Table 2-15]). Increases in student population resulting from construction workers and their families relocating to the county would most likely be handled with modular units. Louisa County purchased property to build a new elementary school in 2004, and construction is scheduled to begin in 2007 (Lintecum in Jaksch and Scott 2005). Property has also been purchased for a new middle school.

It is expected that a maximum of 1000 workers would establish new residences within an 80-km (50-mi) radius of the NAPS site and that most of these would locate in the larger population centers because of the existing shortage of available housing in Louisa and Orange Counties. Given that the workers would be scattered throughout the metropolitan region of Henrico and Spotsylvania Counties and the City of Richmond, the effects of increased enrollment of students as a result of their relocation on school infrastructure in those areas is expected to be minimal.

Housing is more widely available in Henrico and Spotsylvania Counties and the City of Richmond than the other counties in the vicinity of the North Anna ESP site. Most construction workers are expected to already be located in these areas, and the majority of new construction workers from outside the region would most likely to locate to these areas as well. Under these assumptions, the staff concludes that the impacts of construction on school infrastructure are considered small in Orange County, which has expanded its school infrastructure and currently has excess capacity. The schools in Louisa County currently are overcrowded. Property has been purchased for a new elementary school, with construction to begin in 2007. The county is planning to build new schools, which will alleviate the current crowded conditions. However, if the numbers of construction workers locating in Louisa County is significantly greater than suggested by previous trends, the new capacity would not be sufficient to provide services, and the impact could rise to MODERATE.

Based on the overall availability of educational facilities in Henrico, Spotsylvania, Orange, and Louisa Counties and the City of Richmond and assuming that the housing pattern follows past experience, the staff concludes that the impacts of construction on educational resources would be SMALL to MODERATE, and mitigation is not warranted.

4.6 Historic and Cultural Resources

The National Historic Preservation Act (NHPA) requires Federal agencies to take into account the potential effects of their undertakings on historic properties. The review process mandated by Section 106 of the NHPA is outlined in regulations promulgated by the Advisory Council on Historic Preservation and codified in 36 CFR Part 800. Evaluating the suitability of a potential ESP site within the existing NAPS site for construction, operation, and decommissioning of new power units is an undertaking that could possibly affect either known or potential historic properties that may be located at the North Anna ESP site. Therefore, in accordance with the provisions of NHPA, NRC is required to make a reasonable effort to identify historic properties in the area of potential effects. If no historic properties are present or affected, NRC is required to notify the State Historic Preservation Officer of this finding before proceeding. If it is determined that historic properties are present, NRC is required to assess and resolve possible adverse effects of the undertaking.

In the case of the North Anna ESP site, Dominion has indicated that construction of additional units would involve land disturbance within a designated ESP plant construction area (currently a mostly disturbed area), the ESP cooling tower area, and in a spoils and overflow storage area. Both the cooling tower area and spoils storage areas exhibit less previous ground disturbance than the area where Units 3 and 4 would be constructed. Additionally, temporary parking, module fabrication areas, and laydown area would involve some ground disturbance. Following construction activities, disturbed support areas would be landscaped and replanted to match the overall site appearance.

Dominion commissioned studies to assist in recording and protecting known cultural resource sites, as in the case of the five historic period cemeteries located on the NAPS site. As part of the cultural resource assessment effort, the entire NAPS site has been classified into one of three categories, based on the potential for presently undiscovered historic properties to be present, including recommendations for responding to inadvertent discovery and preventing possible adverse effects to resources (Voigt 2003). These three categories are:

- *Areas with No Potential for Historic or Cultural Resources*. These areas include lands where past disturbances related to construction of the power station and appurtenant (associated) facilities have taken place to such an extent that any once-extant cultural resources are no longer present. No further archaeological investigations are recommended for these areas.

- *Areas with Low Potential for Historic or Cultural Resources*. Lands within the ESP site that fall into this category are those that are relatively undisturbed but that possess characteristics that would normally indicate a low possibility for most types of cultural resources to occur. For the most part, these lands have a degree of slope greater than 15 percent. For most of these areas, further archaeological work would not be necessary, although there could be smaller areas within the larger zone where specific ground conditions could require investigation.

- *Areas with Moderate-to-High Potential for Historic or Cultural Resources*. These areas are classified as those that are relatively undisturbed by past activities and have a likelihood for prehistoric and historic archaeological sites according to local models of prehistoric and historic land-use and settlement patterning. Archaeological investigation is recommended prior to undertaking any ground-disturbing activities in these areas.

The eastern part of the proposed project area, where proposed Units 3 and 4 are expected to be located, was extensively altered during ground-disturbing activities related to the original construction of the power plant and associated facilities. Therefore, it is classified as having No Potential for Historic and Cultural Resources (Voigt 2003).

The western sector of the proposed project area includes the cooling tower area, spoils and overflow storage areas, and parking and laydown areas. It includes lands that have been designated as Low and Moderate-to-High Potential for historical and cultural resources (Voigt 2003).

Two known historic cemeteries are located in proximity to the proposed project area. Site 44LS221 is situated in a wooded area near the proposed cooling tower area. The site was marked and avoided during original site construction activities. It would be protected by similar measures during any future site preparation and construction activities and would not be impacted. Site 44LS222 is located near the cooling tower area, but outside the ESP construction boundary. This cemetery is a known site and would be avoided to prevent construction activities from impacting the site.

As a result of recently completed consultation between NRC and VDHR, Dominion conducted an archaeological survey for ten individual survey areas, including approximately 6.0 acres (2.4 hectares) within the western sector of the North Anna ESP APE that fell into one of two categories: (1) acreage that has not been previously disturbed during construction of the original power station and (2) areas that required subsurface testing and pedestrian survey based on the results of the previous field inspection of the ESP APE (Voigt 2003). With the exception of the two previously recorded historic period cemeteries mentioned above, no artifacts, cultural features, or cultural deposits were identified during the field survey (Mullin 2006).

To date, literature reviews and consultations with regional Native American tribes have not identified any traditional cultural properties or other culturally significant resources that might occur in the vicinity of the proposed construction area.

Based on the findings of the field survey for the ESP APE, NRC concludes that construction would have no adverse effect upon historic properties. The VDHR stated that if the sites are avoided, there would be no negative impact on the resources (VDHR 2006). Although field studies to date have not revealed any historic properties that would be adversely impacted, Dominion would include the NAPS cultural resource-specific written directions in its site-wide Excavation and Backfill Work Procedures (North Anna Power Station NSS Work Procedure WP-C01) involving an immediate stop work order should archaeological, historic, or other cultural resources be discovered during excavation (Dominion 2006a). The construction supervisor is responsible for ensuring the work stoppage and for notifying the Environmental Compliance Coordinator of an inadvertent discovery. Dominion would then consult with VDHR regarding the need for and types of necessary cultural resources investigations.

Based on the results of previous cultural resources field investigations at the North Anna ESP site and the presence of a well-managed cultural resources program at the NAPS site, which includes the existence of written procedures to provide immediate reaction and notification in the event of inadvertent discovery of historic and cultural resources, and its cultural resource analysis and consultation, the staff concludes that the potential impacts on historic and cultural resources would be SMALL, and mitigation is not warranted.

4.7 Environmental Justice Impacts

Environmental justice refers to a Federal policy under which each Federal agency identifies and addresses, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority[(a)] or low-income populations. On August 24, 2004, the Commission issued its policy statement on the treatment of environmental justice matters in licensing actions (69 FR 52040). Figures 2-6 and 2-7 (Section 2.8.4) show the locations of minority and low-income populations around the NAPS site and within an 80-km (50-mi) radius.

The staff identified the pathways through which the environmental impacts associated with the construction of Units 3 and 4 at the NAPS site could affect human populations. The staff then evaluated whether minority and low-income populations could be disproportionately affected by these impacts. In its December 2003 site audit, the staff interviewed local government officials and the staff of social welfare agencies concerning potentially disproportionate impacts to low income and minority populations (Jaksch and Scott 2005). The staff found no unusual resource dependencies or practices, such as subsistence agriculture, hunting, or fishing, through which the populations could be disproportionately impacted by construction of Units 3 and 4 at the North Anna ESP site and that would result in those populations being adversely affected. In addition, the staff did not identify any health-related or location-dependent disproportionately high and adverse impacts affecting these minority and low-income populations. In addition, no disproportionately high and adverse impacts on minority or low-income groups were identified during the scoping process, from comments on the DEIS or SDEIS, or from other public outreach activities.

Based on information provided by Dominion, and NRC's independent review, the staff concludes that offsite impacts of construction of Units 3 and 4 at the NAPS site to minority and low-income populations would be SMALL, and mitigation is not warranted.

(a) The NRC Guidance for performing environmental justice reviews defines "minority" as American Indian or Alaskan Native; Asian; Native Hawaiian or other Pacific Islander; or Black races; or Hispanic ethnicity ("other" may be considered a separate minority category.) The 2000 census included multi-racial data (NRC 2004).

4.8 Nonradiological Health Impacts

In its ER, Dominion (2006a) indicated that the physical impacts of construction, including public health, occupational health, and noise, would be small. The impacts were discussed qualitatively. The area around the North Anna ESP site is predominantly rural with a population of approximately 15,500 people within 16 km (10 mi) of the site. No significant industrial or commercial facilities are currently located or planned in this area.

4.8.1 Public Health

Dominion indicated that individuals living near the North Anna ESP site should not experience any physical impacts greater than those that would be considered an annoyance or nuisance. In the event of atypical or noisy construction activities (e.g., pile driving), prior public announcements or notifications of these activities would be provided or both. Dominion has stated that these activities would be performed in compliance with Federal, State, and local regulations, and conditions specified in site-specific permits (Dominion 2006a).

Fugitive dust emissions and odors could be generated as a result of normal construction activities. As discussed in Section 4.2.1, Dominion represented that it would develop and implement a dust control plan to minimize fugitive dust. Dominion indicated that noise and exhaust emissions from construction equipment should have no discernable impact on the local noise level and air quality (Dominion 2006a). All equipment would be operated in accordance with Federal, State, and local emission requirements (Dominion 2006a).

Based on Dominion's representation that it would develop and implement measures to control dust during construction, the required permits and authorization, and NRC's own independent review, the staff concludes that the nonradiological health impacts to the local population would be SMALL, and additional mitigation beyond the actions stated above is not warranted.

4.8.2 Occupational Health

In general, human health risks for construction workers and personnel working onsite would be expected to be dominated by occupational injuries (e.g., falls, electrocution, asphyxiation) to workers engaged in activities such as construction, maintenance, and excavation. Historically, actual injury and fatality rates at nuclear reactor facilities have been lower than the average U.S. industrial rates. Occupational injury and fatality risks are reduced by strict adherence to NRC and Occupational Safety and Health Administration (OSHA) safety standards, practices, and procedures. Appropriate State and local statutes must also be considered when assessing the occupational hazards and health risks associated with construction. The staff assumes strict adherence to NRC, OSHA, and State safety standards, practices, and procedures during construction activities.

Other nonradiological impacts to construction workers and personnel working onsite include noise, fugitive dust, and gaseous emissions resulting from construction activities. Onsite impacts to construction workers would be mitigated through training and using personal protective equipment to minimize the risk of potentially harmful exposures. Emergency first-aid care and regular health and safety monitoring of construction personnel could also be undertaken.

Dominion stated that atypical or noisy construction activities should be performed in compliance with applicable Federal, State, and local regulations, and conditions specified in site-specific permits (Dominion 2006a).

Fugitive dust emissions and odors could also be generated during normal construction activities. Various measures could be undertaken to mitigate these impacts such as paving disturbed areas, using water to suppress dusts, and reducing material-handling activities. Dominion represented that it would undertake additional mitigation control measures to address any nuisance issues on a case-by-case basis.

Dominion stated that noise and exhaust emissions from construction equipment should have no discernable impact on the local noise level and air quality (Dominion 2006a). All equipment would be operated in accordance with applicable Federal, State, and local emission requirements (Dominion 2006a).

Based on Dominion's representation that it would develop and implement measures to address nuisances during construction, the required permits and authorizations, and its own independent review, the staff concludes that the overall nonradiological impacts to workers from construction activities would be SMALL, and additional mitigation beyond the actions stated above is not warranted.

4.8.3 Noise Impacts

Large construction projects involve many noise-generating activities. Regulations governing noise from construction activities are generally limited to worker health and safety. Federal regulations governing construction noise are found in 29 CFR Part 1910 and 40 CFR Part 204. The regulations in 40 CFR Part 204 generally govern the noise levels of air compressors, while the regulations in 29 CFR 1910.95 deal with noise exposure in the construction environment. The Commonwealth of Virginia does not have noise regulations or guidelines.

The North Anna ESP site is zoned industrial. Louisa County has a noise ordinance that limits daytime noise levels in industrial zones to 75 dBA and nighttime noise levels to 65 dBA (Louisa County 2006). Spotsylvania County has only a general prohibition of "Unreasonably loud, disturbing and unnecessary noise." Noise customarily emitted from construction activities and industrial establishments is exempt from this prohibition during daytime hours (6:00 a.m. to 10:00 p.m.) (Spotsylvania County 2006).

Activities associated with construction of Units 3 and 4 at the North Anna ESP site would generate noise levels typical of larger construction projects. Noise levels for common construction activities are typically about 90 decibels at a distance of 3.5 m (10 ft). At 35 m (100 ft), the noise level would be about 70 decibels, and at a distance of 350 m (1000 ft), the noise level would be 50 decibels. A 10-decibel decrease in noise level is generally perceived as a halving the loudness. A few activities (e.g., jack hammers) have noise levels of about 110 decibels.

Many of the construction activities at the North Anna ESP site would take place near the existing Units 1 and 2. It is unlikely that noise from the location would be discernible at the exclusion area boundary or offsite. Construction activities may take place within 21 m (70 ft) of the western edge of the exclusion area boundary. The land to the west of the site is zoned for light industrial use; however, no uses for it have been established.

The following mitigation measures could be undertaken by Dominion, if necessary to reduce the noise during construction of Units 3 and 4:

- routinely inspecting and maintaining equipment to include noise aspects
- restricting loud noise-related activities, such as pile driving or blasting, to daylight hours
- developing and implementing a plan to manage and respond to citizen concerns about noise.

Considering the temporary nature of construction activities and the remote location of the North Anna ESP site, the staff concludes that the noise impacts from construction would be SMALL, and additional mitigation beyond the action stated above is not warranted.

4.8.4 Summary of Nonradiological Health Impacts

The staff evaluated health impacts to the public and construction workers. It is expected that health risks to workers would be dominated by occupational injuries at rates below the average U.S. industrial rates.

Based on Dominion's representation that it would operate the construction equipment within local noise and air quality limits and implement dust and nuisance control plans, and its own independent review, the staff concludes that the impacts of construction on nonradiological health would be SMALL, and further mitigation beyond the above actions is not warranted.

4.9 Radiological Health Impacts

The sources of radiation exposure to site preparation workers (i.e., construction workers) include direct radiation exposure, exposure from gaseous radioactive effluents, and exposure from liquid radioactive waste discharges from routine operations at NAPS Units 1 and 2 during the site preparation and construction phase of additional units. Dominion (2006a) noted that all major construction activities are expected to occur outside of the NAPS Units 1 and 2 protected area boundary but inside the restricted site boundary (exclusion area as shown in Figure 2-1).

4.9.1 Direct Radiation Exposures

Dominion identified two principal sources of direct radiation exposure from NAPS Units 1 and 2. These sources are (1) the boron recovery tank and (2) the low-level contaminated storage area, both located directly south of the two operating units. Another source of direct radiation is the independent spent fuel storage installation (ISFSI), which is located south of the construction site. The staff did not identify any additional sources of direct radiation.

Dominion estimated direct radiation exposure to site preparation workers by using thermoluminescent dosimeters (TLDs) that measure direct radiation levels at locations in and around the NAPS protected area and by dose rate surveys (Dominion 2006a). The TLDs used for this evaluation are the same ones used for evaluating public dose in controlled areas; the TLDs were read quarterly. The TLD located closest to the proposed site for Units 3 and 4 at the protected area boundary was on the west protected area fence for Units 1 and 2. Dominion used the measurements from this TLD to estimate one component (from the boron recovery tank and the low-level contaminated storage area) of the direct radiation exposure to site preparation workers. The maximum measured dose rate for the 7-year period from 1996 through 2002 at this TLD location was 0.74 mSv/yr (74 mrem/yr) and the average annual dose rate for all the TLD readings at this location for the 7-year period was 0.56 mSv/yr (56 mrem/yr) (these dose rates are for continuous exposure at the TLD location). The staff assumes that workers involved in site preparations would be west of this protected area fence, several hundred feet farther away from the operating Units 1 and 2 than where the TLDs were located. Using the average annual TLD reading of 0.56 mSv/yr (56 mrem/yr) over the 7-year period, and adjusting the TLD exposure time to 2080 hr/yr, which is the estimated maximum time a worker would be exposed, Dominion calculated an annual worker whole body or total effective dose equivalent (TEDE) dose of 0.13 mSv/yr (13 mrem/yr) from this component of direct radiation. Adjustments for background dose were not made for the assessment of dose to the site preparation workers.

The TLD reading at the west protected area fence of the existing Units 1 and 2 included the ISFSI dose contribution based on the ISFSI loading at the time of the measurements. However, to provide a more conservative dose estimate, Dominion calculated an additional dose component to the site preparation workers assuming a fully loaded ISFSI. Dominion calculated this additional dose to be 4.7 x 10^{-5} mSv/hr (4.7 x 10^{-3} mrem/hr). With an occupancy rate of 2080 hr/yr, this is equivalent to an annual worker whole body or TEDE dose of 9.8 x 10^{-2} mSv/yr (9.8 mrem/yr). When this ISFSI dose of 9.8 x 10^{-2} mSv/yr (9.8 mrem/yr) is added to the estimated dose from the boron recovery tank and the contaminated storage area of 0.13 mSv/yr (13 mrem/yr), Dominion calculated a total dose to the site preparation workers of 0.23 mSv/yr (23 mrem/yr).

The staff reviewed the potential locations for exposures and recent records of dose rates, the locations of the TLDs, the method to estimate doses to members of the public in controlled areas, and other recent data. The staff determined that the method used to estimate the dose from direct exposure was acceptable.

4.9.2 Radiation Exposures from Gaseous Effluents

Dominion used data from the Annual Radioactive Effluent Report for 2001 (VEPCo 2002) to estimate the whole body dose and dose to the critical organ for a site preparation worker from gaseous effluents. Dominion stated that the annual releases for 2001 are typical for the existing units (Dominion 2006a). For the year 2001, Dominion calculated the whole body dose of 4.6 x 10^{-4} mSv/yr (4.6 x 10^{-2} mrem/yr) and 1.5 x 10^{-3} mSv/yr (1.5 x 10^{-1} mrem/yr) to the critical organ for the maximally exposed member of the public from release of gaseous effluents from the operating units. These doses are based on continuous occupancy; therefore, for estimating doses to the site preparation worker, the doses were adjusted to an occupational exposure time of 2080 hr/yr. These doses are calculated for the maximally exposed member of the public located at or beyond the plant site boundary.

Because the workers involved in site preparation are located inside the plant boundary and are, therefore, closer to the effluent release point, Dominion assumed that the gaseous effluent dose to these workers would be higher than the dose to the maximally exposed member of the public at or beyond the site boundary. To arrive at a factor of how much larger these doses would be, Dominion took a ratio of the atmospheric dispersion factors (χ/Q) for routine releases from the existing units at the exclusion distance and at a point 0.40 km (0.25 mi) to the west of the existing units (approximately the same distance from the existing units as the construction site).

On this basis, Dominion conservatively assumed that the gaseous effluent dose to the site preparation worker would be no more than 10 times higher than the dose to the maximally exposed member of the public. Therefore, Dominion multiplied the gaseous effluent dose to the maximally exposed member of the public by a factor of 10 to arrive at the estimated dose to the site preparation worker from gaseous effluents. The resulting doses are 1.1 x 10^{-3} mSv/yr (1.1 x 10^{-1} mrem/yr) for the whole body dose and 3.5 x 10^{-3} mSv/yr (3.5 x 10^{-1} mrem/yr) for the critical organ. From International Commission on Radiological Protection (ICRP) Publication 30 (ICRP 1979), applying a weighting factor of 0.3 to the organ dose and adding the whole body dose provided a TEDE of 2.1×10^{-3} mSv/yr (2.1×10^{-1} mrem/yr) for the site preparation worker from gaseous effluents (ICRP 1979).

The staff reviewed the data from the Annual Radioactive Effluent Report for 2001 (VEPCo 2002) and for more recent years and determined that the method to estimate dose from gaseous effluents was acceptable.

4.9.3 Radiation Exposures from Liquid Effluents

Dominion used data from the Annual Radioactive Effluent Report for 2001 to estimate the whole body dose and dose to the critical organ for a site preparation worker from liquid effluents (Dominion 2006a). Dominion stated that the annual releases for 2001 are representative of the typical releases for the existing units. For the year 2001, Dominion calculated a whole body dose of 3.1×10^{-3} mSv/yr (3.1×10^{-1} mrem/yr) and 3.5×10^{-3} mSv/yr (3.5×10^{-1} mrem/yr) to the critical organ for the maximally exposed member of the public from release of liquid effluents from the operating units. These doses are based on continuous occupancy; therefore, for estimating doses to the site preparation worker, the doses were adjusted to an occupational exposure time of 2080 hr/yr. Dominion also multiplied this dose by a factor of 10 to account for uncertainty regarding the location of the worker compared to the maximally exposed member of the public. The resulting doses are 7.3×10^{-3} mSv/yr (7.3×10^{-1} mrem/yr) for the whole body dose and 8.4×10^{-3} mSv/yr (8.4×10^{-1} mrem/yr) for the critical organ. From ICRP Publication 30, applying a weighting factor of 0.3 to the organ dose and adding the whole body dose provided a TEDE of 9.8×10^{-3} mSv/yr (9.8×10^{-1} mrem/yr) for the site preparation worker from liquid effluents (ICRP 1979).

The staff reviewed the data from the Annual Radioactive Effluent Report for 2001 and for more recent years and determined that the method to estimate dose from liquid effluents was acceptable.

4.9.4 Total Dose to the Site Preparation Workers

To obtain the dose per year to the site preparation workers, Dominion added the annual dose from the three pathways – direct radiation, gaseous effluents, and liquid effluents – and multiplied the total by the estimated number of workers (5000) to determine an estimated maximum annual collective dose to site preparation workers of 1.20 person-Sv (120 person-rem). This compares to the approximately 15 person-Sv (1500 person-rem) the site preparation workers would receive from natural background radiation (i.e., 5000 workers times 300 mrem/yr [NCRP 1987]).

In summary, Dominion estimated an annual dose to a site preparation worker of 0.24 mSv (24 mrem). The dose is primarily from the direct exposure pathway, with the doses from liquid and gaseous effluents being small. This estimate is well within both the dose limits to individual members of the public found in 10 CFR 20.1301 and occupational dose limits to workers found in 10 CFR 20.1201. The annual dose limit to an individual member of the public is 1 mSv (100 mrem) TEDE. The annual occupational dose limit to workers is 0.05 Sv (5 rems) TEDE.

4.9.5 Summary of Radiological Health Impacts

Based on the Dominion estimate of dose to site preparation workers and NRC's independent review, the staff found the doses to be well within NRC exposure limits designed to protect the public health, even if workers exceed the 2080 hrs/yr occupancy factor, and concludes that the impacts of radiological exposures to site preparation workers would be SMALL, and mitigation is not warranted.

4.10 Measures and Controls to Limit Adverse Impacts During Construction Activities

In its evaluation of environmental impacts during construction activities for the proposed new North Anna units, the staff relied on Dominion's compliance with the following regulatory requirements:

- Compliance with applicable Federal, State, and local laws, ordinances, and regulations intended to prevent or minimize adverse environmental impacts (e.g., solid waste management, ground-disturbing activities including erosion and sediment control and threatened and endangered species, air emissions, noise control, storm-water management, spill response and cleanup, hazardous material management). This includes testing any soil suspected of contamination from radioactive waste or other contaminants

- Compliance with applicable requirements of existing permits and licenses (e.g., VPDES permit, operating license) for the existing units and other permits or licenses required for construction of the new units (for example, Clean Water Act Section 404 Permit, VDEQ wetlands permit)

- A permit from VDEQ and compliance with county ordinances if burning of construction materials is required

- A VPDES permit related to accidental spills and storm-water runoff

In the ER, Dominion tabulated its representation of "feasible and adequate measures/controls" in Table 4.6-1, "Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Construction" (Dominion 2006a). This tabulation includes measures and controls that Dominion would be required to implement by applicable Federal, Commonwealth, local statutes

| and regulations, and permit requirements, terms, and conditions. The staff relied on these
| measures and controls in its evaluation of environmental impacts during construction of the
| proposed new units and th North Anna ESP site; for those issues where Dominion indicated that
| a study, process, or capability "would be considered," the staff relied upon the study, process,
| or capability as implemented or conducted.

| In addition to the foregoing measures and controls tabulated in the ER Table 4.6-1, the staff
| also relied on the following general plans or specific mitigation measures:

- Incorporation of environmental requirements into construction contracts (ER Section 4.6)
- Avoid watercourses and wetlands to the extent possible during any construction (ER Sections 4.1.1.6.2, 4.3.1.2)
- Develop a dust control plan to mitigate the impacts of emissions from construction activities (ER Section 4.4.1.4)
- Develop a construction traffic management plan to include several traffic mitigating measures (ER Section 4.4.2.2.1)
- Mitigate potential impacts for materials delivery. Methods include (1) avoiding routes that could adversely affect sensitive areas (e.g., housing, hospitals, schools, retirement communities, businesses) to the extent possible and (2) restricting delivery times activities to daylight hours. (ER Section 4.4.1.1.3)
- Repair any damage to public roads, markings, or signs caused by construction activities to pre-existing condition or better (ER Section 4.4.1.1.3)
- Build and maintain new access road on the NAPS site to support construction activities (by Virginia Power personnel as needed). (ER Section 4.4.1.1.3)
- Minimize emissions from heavy construction equipment by scheduled equipment maintenance procedures (ER Section 4.3.1.2)
- Prevent contaminants from entering the aquatic system through use of a Spill Prevention Control and Countermeasure Plan (ER Section 4.3.2)
- Manage nuisances and concerns from adjacent residents, business owners, or landowners on a case-by-case basis through a Dominion prepared concern resolution process (ER Section 4.4.1)

- Coordinate with the VDHR regarding the potential presence of historic and cultural resources within planned disturbed areas and notify VDHR in the event of any unanticipated discovery (ER Section 4.1.3)

In addition, the staff relied upon the following Dominion statements:

- Dominion stated it could construct/modify the intake structure in accordance with State and permit regulations. It noted that it may install a barrier between the ESP site and the lake to reduce the potential for silt and soil entrainment through the existing units to the WHTF (ER Section 4.3.2)

- Dominion stated it could institute controls to minimize potential noise impacts including inspection and maintenance of equipment and restrict noise-related activities to daylight hours. (ER Section 4.4.1.3)

- Dominion stated it would provide safety training and personal protective equipment to construction workers to minimize the risk of potentially harmful exposures; provide regular health and safety monitoring (ER Section 4.4.1.1.1)

- Dominion stated it would follow construction best management practices for erosion control in Lake Anna, the WHTF, and potentially impacted streams (ER Section 4.2.1).

4.11 Site Redress Plan

Site Preparation and Preliminary Construction Activities

In its ESP application, Dominion requested that it be allowed to conduct site preparation activities at the North Anna ESP site as authorized by 10 CFR 52.17(c) and 10 CFR 52.25, and enumerated in 10 CFR 50.10(e)(1). In its application, as provided by 10 CFR 52.17(c), Dominion included a site redress plan that would be implemented if site preparation activities were performed, but the ESP expired before the issuance of a CP or COL by the NRC (Dominion 2006b). The objective of the site redress plan is to ensure that the ESP site would be returned to an environmentally stable and aesthetically acceptable condition suitable for non-nuclear uses consistent with Louisa County zoning requirements. Under the site redress plan, locations that are permanently disturbed would be stabilized and contoured to conform with surrounding areas. Revegetation of disturbed lands would be conducted.

In a letter dated October 6, 2005, Dominion requested that the ESP be conditioned to prohibit activities that could result in a discharge to navigable waters until a Section 401 Certification is either obtained or waived by the Commonwealth of Virginia (Dominion 2005). In a letter dated June 16, 2006, the Commonwealth agreed on the need for this permit condition (VDEQ 2006). The staff included this as a recommended permit condition in Table J-3.

In its site redress plan, Dominion committed to:

- Create a record of the existing site conditions within the proposed ESP site by way of photographs, surveys, listings of existing facilities and structures, or other documentation. This record would establish the baseline for redressing the site in the event that ESP site preparation activities were undertaken, but the ESP was not referenced in a CP or COL while the ESP remained valid.

- Obtain Commonwealth and local permits and authorizations necessary to perform the site preparation activities.

- Obtain the appropriate regulatory approvals of an agreement between Virginia Power and Dominion. This agreement would authorize Dominion to conduct the pre-construction activities subject to Dominion's obligation to perform such site redress as may be required to comply with the Site Redress Plan approved by the NRC.

- Provide to the NRC a guaranty by Dominion Resources, Inc. of $10 million as a financial assurance for Dominion's obligation to comply with the Site Redress Plan. Dominion is an indirect, wholly-owned subsidiary of Dominion Resources, Inc.

When these prerequisites have been achieved, planned site preparation and preliminary construction activities may proceed and may include none, some, or all of the activities discussed below pursuant to 10 CFR 52.25 and 10 CFR 50.10(e)(1). If the ESP is approved, Dominion may perform the following site preparation activities for the proposed Units 3 and 4 at the North Anna ESP site:

- Prepare the site for construction of the facilities (including such activities as clearing, grading, construction of temporary access roads, and preparation of borrow areas

- Install temporary construction support facilities (including items such as warehouses, shop facilities, utilities, concrete mixing plants, docking and unloading facilities, and construction support buildings)

- Excavate for facility structures

- Construct service facilities (including items such as roadways, paving, railroad spurs, fencing, exterior utility and lighting systems, switchyard interconnects, and sanitary sewage treatment facilities)

- Construct structures, systems, and components that do not prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public, including but not limited to:

  - cooling towers
  - intake and discharge structures
  - circulating water lines
  - fire protection equipment
  - switchyard and onsite interconnections
  - microwave towers
  - underground utilities.

The environmental impacts of site preparation activities enumerated in 10 CFR 50.10(e)(1) are bounded by environmental impacts for construction of the entire facility. In many cases, the impacts of both the site preparation activities and construction may be similar, but the impacts resulting solely from site preparation activities would be of a shorter duration. In the preceding sections in this chapter, the staff presented impacts of construction that bound the impacts of site preparation. Should the ESP expire before an application for a CP or COL referencing the ESP is received under 10 CFR 52, Subpart C, and site preparation and preliminary construction activities have occurred, then the site redress plan would be implemented to return the ESP site to an environmentally stable and aesthetically acceptable condition suitable for future alternative use (presumably non-nuclear) that conforms with local zoning laws, thus minimizing the long-term environmental impacts.

Site Redress Plan

Dominion provided a site redress plan as part of its ESP application in the event that site preparation and preliminary construction work did not proceed to full construction (Dominion 2006b). The plan identifies the overall objective as providing "an environmentally stable, self-draining, self-maintaining, aesthetically acceptable site that can be left unattended." In its plan, Dominion states that redress activities would reflect applicable land use and zoning requirements and identifies the following general redress activities for consideration:

- recontouring, revegetation, and replanting of cleared areas

- restoration of sensitive water resource features disturbed for intake and/or discharge structures

- habitat replacement

- use of constructed facilities for alternative purposes, or their removal

- remediation of contamination resulting from site preparation and preliminary construction or site redress activities.

The staff reviewed the list of allowed site preparation and preliminary construction activities in the event that the ESP is granted for the North Anna site and reviewed the full site redress plan submitted by Dominion. As a result of its own independent review, the staff, in accordance with 10 CFR 52.25(a), concludes that the potential site preparation and preliminary construction activities described in Dominion's site redress plan would not result in any significant adverse environmental impacts that could not be redressed. In addition, consistent with 10 CFR 52.25(a), the staff recommended the inclusion of the site redress plan as an ESP condition in Table J-3.

4.12 Summary of Construction Impacts

Impact level categories denoted in Table 4-1 as SMALL, MODERATE, or LARGE were assigned to each resource area based on the staff's evaluation and conclusions regarding expected adverse environmental impacts, if any. A brief statement explains the basis for the impact level. Some impacts, such as the addition of tax revenue from Dominion for the local economies, are likely to be beneficial impacts to the community, and are noted as such.

Table 4-1. Characterization of Impacts from Construction of the Closed-Cycle Cooling System for Unit 3 at the North Anna ESP Site

Category	Comments	Impact Level
Land-use impacts		--
The site and vicinity	Construction activities would take place within existing site boundaries.	SMALL
Transmission line rights-of-way	No new transmission line rights-of-way would be needed.	SMALL
Air quality impacts	Construction activities would be conducted in accordance with applicable Virginia administrative codes, and dust and emissions would be minimized through a dust control plan.	SMALL

Table 4-1. (contd)

Category	Comments	Impact Level
Water-related impacts		--
Hydrological alterations	Impacts would be localized and temporary. Construction activities would be conducted in accordance with applicable Virginia administrative codes and ACE permit processes; hydrological impacts would be minimized though application of best management practices.	SMALL
Water use	Minimal water usage during construction.	SMALL
Water quality	Construction would be conducted using best management practices to control spills and storm water runoff.	SMALL
Ecological impacts		--
Terrestrial ecosystems	No important terrestrial species would be affected by construction at the NAPS site.	SMALL
Aquatic ecosystems	Construction impacts to benthic habitats would be temporary.	SMALL
Threatened and endangered species	There are no Federally listed species in the vicinity.	SMALL
Socioeconomic impacts		--
Physical impacts		
Workers/local public	Construction takes place within existing plant boundaries, so impacts to the public would be minimal. Impacts to workers would be mitigated with training and protective equipment.	SMALL
Buildings	Construction would not affect any offsite buildings, and onsite buildings were constructed to withstand vibration from construction activities.	SMALL
Roads	Growth would put pressure on local road systems, but traffic control and management measures would protect any local roads during construction.	SMALL
Aesthetics	Construction activities would be temporary, and observation points would be limited because of site location.	SMALL
Demography	Percentage of construction workers relocating to the region would be small. Most would already live within the region.	SMALL
Community characteristics		

Table 4-1. (contd)

Category	Comments	Impact Level
Economy	Economic impacts of construction overall are beneficial to local economies, in this case ranging from small to moderately beneficial.	SMALL BENEFICIAL to MODERATE BENEFICIAL
Transportation	Planned upgrades and traffic management plans would reduce temporary construction transportation impacts. Impacts could be moderate in some areas without planned upgrades.	SMALL to MODERATE
Taxes	Depends on residence location; generally, impacts are beneficial, especially for property taxes and employment, ranging from small to moderate (Louisa County).	SMALL BENEFICIAL to MODERATE BENEFICIAL
Recreation	Visual impacts of construction would be limited and temporary. Recreational use of Lake Anna would be expected to increase, and traffic mitigation would keep impacts small. Impacts could be moderate if mitigation measures are not undertaken.	SMALL to MODERATE
Housing	Adequate housing is available in Henrico and Spotsylvania Counties and in the City of Richmond to handle construction workers. If more construction workers than expected locate in Orange and Louisa Counties, the impact could be moderate.	SMALL to MODERATE
Public services	Public services are adequate for any temporary influx of workers resulting from construction at the NAPS site.	SMALL
Education	If no additional school capacity is added, then the impact in Louisa County could be moderate. If Louisa County builds new schools to accommodate the temporary influx of construction workers, then all counties would have room for additional students.	SMALL to MODERATE
Historic and cultural resources	Most of the proposed construction area is previously disturbed, and Dominion has a well-managed cultural resource program in place at NAPS.	SMALL
Environmental justice	No unusual resource dependencies in the area.	SMALL

Table 4-1. (contd)

Category	Comments	Impact Level
Nonradiological health impacts	Emission controls and remote location of the NAPS site would keep nonradiological health impact small.	SMALL
Radiological health impacts	Exposures to site preparation workers would be below annual occupational and public dose limits.	SMALL

4.13 References

Note: Because the web pages cited in this document may become unavailable, the staff has entered the appropriate pages into ADAMS. The accession number of the package containing the websites used as references in Chapter 4 of the North Anna ESP EIS is ML051150091.

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10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 52. Code of Federal Regulations, Title 10, *Energy*, Part 52, "Early Site Permits, Standard Design Certifications, and Combined Licenses for Nuclear Power Plants."

15 CFR Part 930. Code of Federal Regulations, Title 15, *Commerce and Foreign Trade,* Part 930, "Federal Consistency with Approved Coastal Management Programs."

29 CFR Part 1910. Code of Federal Regulations, Title 29, *Labor,* "Occupational Safety and Health Standards," Subpart G, "Occupational Health and Environmental Control."

36 CFR Part 800. Code of Federal Regulations, Title 36, *Parks, Forests, and Public Property*, Part 800, "Protection of Historic Properties."

40 CFR Part 122. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 122, "EPA Administered Permit Programs: The National Pollutant Discharge Elimination System."

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5.0 Operational Impacts at the Proposed Site

This chapter examines environmental issues associated with operation of the proposed Units 3 and 4 at the North Anna ESP site, for a 40-year period as described in the early site permit (ESP) application submitted by Dominion Nuclear North Anna, LLC (Dominion). As part of this application, Dominion submitted an Environmental Report (ER) that discusses the environmental impacts of station operation (Dominion 2006a). The ER provided the plant parameter envelope (PPE) as the basis for the environmental review.

This chapter is divided into 13 sections. Sections 5.1 through 5.11 discuss the potential operational impacts on land use, meteorology and air quality, water, terrestrial and aquatic ecosystems, socioeconomics, historic and cultural resources, environmental justice, nonradiological and radiological health effects, postulated accidents, and applicable measures and controls that would limit the adverse impacts of station operation during the 40-year operating period. In accordance with Title 10 of the Code of Federal Regulations (CFR) Part 51, impacts have been analyzed, and a significance level of potential adverse impacts (i.e., SMALL, MODERATE or LARGE) has been assigned to each analysis. Appendix J was added to this Final Environmental Impact Statement (Final EIS) and includes representations made by Dominion that the staff relied on during the preparations of the EIS. With regard to the environmental impacts associated with operation of proposed Units 3 and 4, Dominion made a number of representations in its application. The staff's determination of significance levels is based on the assumption that the mitigation measures identified in the ER or activities planned by various Commonwealth and county governments, such as infrastructure upgrades, as discussed throughout this chapter are implemented. As listed in Appendix J, the staff relied on Dominion's representations and staff-developed assumptions in assessing the environmental impacts associated with operation of the units. As such, fulfillment of these representations and assumptions provide part of the basis for the final impact assessment. Should a construction permit (CP) or combined construction permit and operating license (COL) applicant reference the ESP, and the staff ultimately determines that a representation of assumption has not been satisfied at the CP/COL stage, that information would be considered new, and potentially significant, and the affected impact area could be subject to re-examination. Failure to implement these upgrades may result in a change in significance level. Possible mitigation of adverse impacts is also presented, where appropriate. A summary of these impacts is presented in Section 5.12. The references cited in this chapter are listed in Section 5.13. The technical analyses in this chapter support the results, conclusions, and recommendations in Chapters 9 and 10.

5.1 Land-Use Impacts

Sections 5.1.1 and 5.1.2 contain information regarding land-use impacts associated with operation of the proposed Units 3 and 4 at the North Anna ESP site. Section 5.1.1 discusses land-use impacts at the site and in the vicinity of the site. Section 5.1.2 discusses land-use impacts with respect to transmission line rights-of-way and offsite areas.

5.1.1 The Site and Vicinity

Some offsite land-use changes can be expected as a result of operational activities. Possible changes include the conversion of some land in surrounding areas to housing developments (e.g., apartment buildings, single family condominiums and homes, and manufactured home parks) and retail development to serve plant workers. Property tax revenue from the new plants could also lead to additional growth and land conversions in Louisa County as a result of infrastructure improvements (e.g., new roads and utility services). However, any growth could be managed because all counties surrounding the North Anna ESP site have comprehensive land-use plans in place as required by Virginia Code Section 15.2-2223, Comprehensive Plan. Based on the existence and projected implementation of land-use plans, the information provided by Dominion, and its own independent review, the staff concludes that the land-use impacts of operation would be SMALL, and further mitigation is not warranted.

5.1.2 Transmission Line Rights-of-Way and Offsite Areas

In its ER, Dominion stated that any two of the three existing 500-kV transmission lines along with the existing 230 kV line are expected to have sufficient capacity to carry the total output of the existing units and two additional units (Dominion 2006a). Dominion represented that it would perform a system study (load flow) modeling these lines with the new units' power contribution at the COL stage (Dominion 2006a) (see Appendix J). The staff based its evaluation on the assumption that the existing transmission lines are adequate and that new transmission lines would not be needed. If Dominion decides to build new transmission lines at the COL stage, then it will be considered new information.

In Supplement 7 to the Generic Environmental Impact Statement for License Renewal Regarding North Anna Units 1 and 2, the Nuclear Regulatory Commission (NRC) determined that the impact of transmission lines was SMALL, and no mitigation was warranted (NRC 2002b). This conclusion would not change with the additional new units at the North Anna ESP site because the existing transmission lines would be used. Based on the information provided in the ER, that no additional electrical transmission lines or rights-of-way would be needed, and on the staff's evaluation, land-use impacts to other offsite areas would be SMALL, and mitigation is not warranted.

5.2 Meteorological and Air Quality Impacts

The proposed cooling systems for North Anna include a closed-cycle, combination wet and a dry cooling system for Unit 3 and dry cooling towers for Unit 4. The meteorological and air quality impacts from operation of the new units would be limited to those resulting from cooling of Unit 3 and periodic pollutant emissions from auxiliary boilers and generators supporting both units.

Lake Anna would provide the makeup water to the wet cooling towers. Because warm, moist air would be emitted to the atmosphere from the operation of the wet cooling towers, elevated plumes would at times extend above the cooling towers and be visible off site. There would also be the potential for fogging and icing at ground level as the plume loses buoyancy and for drift deposition on the local surroundings. In addition, there is the potential for ice buildup on the transmission lines and other structures within the plant boundary. The greatest impacts would occur during conditions of high humidity and low ambient temperature when the Unit 3 circulating water system is operating in the Energy Conservation (EC) mode. Microclimatic impacts would include an increase in humidity in the vicinity of the towers as well as a slightly reduced level of solar radiation in areas in the shadow of the plume, consistent with wind direction frequency.

The SACTI (Seasonal and Annual Cooling Tower Impacts) system of computer programs, initially compiled by Argonne National Laboratory (ANL) (ANL 1984) for the Electric Power Research Institute was used to estimate the impact of operating the cooling towers. The version used by Dominion is dated November 1, 1990. A brief description of the application and limitations of the SACTI code regarding aesthetic aspects of the cooling tower plume is included Section 5.5.1.4. The input meteorological data used to estimate the impacts encompassed the period of 1998 through 2000. It included data collected onsite as well as site representative data collected at the National Weather Service sites in Richmond, Virginia, and Dulles Airport in Northern Virginia. For this analysis, the cooling towers were assumed to be operating in the EC mode, which results in the greatest evaporation rates from the wet cooling towers and, therefore, the greatest level of impacts (Dominion 2006a).

The results of the staff's independent analysis indicated that for all seasons, the plume would extend to a maximum height of 980 m (3200 ft) and to a length of 4900 m (16,000 ft) from the tower. The annual duration of plume fogging (i.e., the plume remaining at the ground level) would be about 70 hr (excluding hours of natural fog), with a majority of fogging occurring at about 300 m (1000 ft) to the south-southeast from the cooling towers. Fogging would, however, occur as far as 1600 m (5200 ft) from the tower. Fogging is estimated to occur during all seasons except summer. Dominion and the staff's analyses indicates that icing is unlikely to occur in conjunction with ground-level fogging (Dominion 2006a; NRC 2006a).

Deposition of salts from cooling tower drift would occur in all directions from the towers out to 1525 m (5000 ft), but would occur predominately in the areas to the north through northeast as well as to the south through southeast of the towers. The maximum estimated amount of deposition would be 12.6 kg/km^2/month at 175 m (575 ft) north-northeast of the cooling towers. The vast majority of the drift deposition would occur within 300 m (1000 ft) of the towers.

Significant chemical interaction of the cooling tower plume and pollutants emitted onsite or in the vicinity of the plant is not anticipated. Generally, the approach to minimize the potential for contact with cooling tower drift is to limit parking or work activities in the vicinity of the cooling towers. The impacts of salt deposition on terrestrial resources are discussed in Section 5.4.1.1.

Air quality impacts from routine releases other than the cooling system would be limited to nonradiological pollutants emitted during the operation of auxiliary boilers and emergency generators, and emissions from onsite service vehicles. Impacts of transmission lines on air quality were reviewed elsewhere by the NRC in the *Generic Environmental Impact Statement of License Renewal at Nuclear Plants* (NUREG-1437) (NRC 1996). With regard to air quality impacts for criteria pollutants, given the distance from the Prevention of Significant Deterioration Class I areas (see the Clean Air Act, Section 169A, and 40 CFR Part 51, Subpart P) and the short time duration of emissions, the resulting impacts on local ambient air quality levels or visibility in the Class I areas are estimated to be negligible.

Impacts of existing transmission lines on air quality were reviewed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NUREG-1437) (NRC 1996). Small amounts of ozone and smaller amounts of oxides of nitrogen are produced by transmission lines. The analysis found the small amounts of these gases to be insignificant for 745-kV lines (the largest lines in operation) and for a prototype 1200-kV line. In addition, the staff determined that potential mitigation measures would not be warranted given any small benefit that could be accrued at great cost. The largest existing line in the transmission and distribution system servicing the North Anna ESP site is a 500-kV line, which is well within the range of lines considered in NUREG-1437. Given the distance from Class I areas and the small amount and duration of emissions, the resulting impact on local ambient air quality levels or visibility in the Class I areas is estimated to be insignificant. Based on these factors, the staff concludes that the potential impacts of releases from vehicles, auxiliary boilers, emergency generators, cooling systems, and energized transmission lines would be SMALL, and mitigation beyond those normally taken in the operation of plant equipment is not warranted.

5.3 Water-Related Impacts

This section discusses the water-related impacts on Lake Anna and the Waste Heat Treatment Facility (WHTF) from the closed-cycle, combination wet and dry cooling system proposed for Unit 3. The proposed Unit 4 dry cooling system would have negligible impacts on the water supply. Therefore, only Unit 3 is considered in relation to water-related operational impacts.

The Lake Anna reservoir is divided into two distinct bodies of water, Lake Anna and the WHTF, which is composed of three waste heat treatment lagoons (Figure 2-4). The lagoons have a total surface area of approximately 1400 ha (3400 ac) and are separated from the rest of Lake Anna by a series of dikes. The main body of the lake is approximately 27 km (17 mi) long with 435 km (272 mi) of irregular shoreline and approximately 3900 ha (9600 ac) of water surface.

During normal operation at full power, and based on Dominion's PPE values, the primary cooling system for Unit 3 would reject 3020 MW (1.03×10^{10} Btu/hr) to the environment. Unit 3 would reject this heat load to the atmosphere through its closed-cycle, combination wet and dry cooling system. Unit 3 would employ a cooling tower system that can function in different modes which consume different amounts of water depending on the meteorological and water supply conditions. During times of relative water abundance, the Unit 3 cooling system would operate in the EC mode, which increases water consumption while decreasing energy consumption. During times of limited water availability (i.e., whenever the lake level elevation of Lake Anna falls below 76.2 m (250 ft) mean sea level (MSL) for a period of seven or more consecutive days), the Unit 3 cooling system would operate in the Maximum Water Conservation (MWC) mode, which reduces water consumption while increasing energy consumption. The maximum water withdrawal rates in EC and MWC modes are 1405 and 971 L/s (22,268 and 15,384 gpm), respectively. During full load operation, the maximum blowdown rates in EC and MWC modes are 351 and 245 L/s (5565 and 3844 gpm), respectively. (Blowdown is the removal of recirculating water from the cooling system to reduce the buildup of contaminants, such as dissolved solids.)

Management of water resources involves balancing the tradeoffs among various and often conflicting uses. The water uses at Lake Anna and the North Anna River downstream of Lake Anna include recreation, visual aesthetics, fishery management, and a variety of consumptive uses of water, such as municipal water supplies and industrial uses (e.g., cooling water for power generation). The U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (ACE), and the Commonwealth of Virginia have jurisdiction for regulating water use and water quality through Federal and State laws; some authorities have been delegated from Federal agencies to the Commonwealth. Water resource management incorporates the uncertainty of projections of the future supply and demand for water that results from natural climate variability and man-made demands. The ability to manage the water supply to balance periods of excess supply with periods of excess demand is limited by the available water infrastructure. While the water supply is regularly being replenished by precipitation, conflicts over water resources typically grow along with population.

Both Dominion and the staff independently analyzed changes in the water supply available from Lake Anna that would result from operating proposed Unit 3 at the North Anna ESP site. In performing their respective analyses, Dominion and the staff employed different approaches and relied on different data sources. These approaches are briefly described below; however, a more complete description of the Dominion analysis can be found in Sections 5.2.2 and 5.3.2 of the ER (Dominion 2006a). A more complete description of the staff's analysis (NRC 2006b) can be found in Appendix K of this EIS.

The staff has reviewed long-term precipitation and evaporation data from Richmond, Virginia, to characterize typical-year and critical-year conditions. Based on annual values, precipitation exceeds evaporation during typical-year conditions. Using average monthly estimates, however, evaporation exceeds precipitation by more than 20 percent in June. Over a typical 12-month period, runoff from areas draining into Lake Anna offset any decreases in the lake level elevation resulting from natural evaporation. However, even minimum releases of 1.1 m^3/s (40 cfs) from Lake Anna would result in decreases in lake level elevation during the months of July, August, and September. Therefore, Lake Anna lake level elevations would decline during both typical- and critical-years during those months. Historical summer flows in the North Anna River near Partlow, Virginia, before construction of North Anna Dam were occasionally much smaller than even the minimum release of 0.57 m^3/s (20 cfs) established under the Lake Level Contingency Plan. Because the inflows typically exceed the regulated outflows to Lake Anna, the staff concludes that it is reasonable to expect that Lake Anna would experience lake level elevation decreases during the late summer months for most years.

During the period from October 2001 through December 2002, an extreme drought occurred in the region extending from Georgia to northern Virginia. As a result of this climatic anomaly, Lake Anna experienced the lowest lake level elevations and lowest estimated inflows in its history. During this period of drought, Dominion implemented the Lake Level Contingency Plan (a condition of the North Anna Power Station [NAPS] Virginia Pollutant Discharge Elimination System [VPDES] permit issued by Virginia Department of Environmental Quality [VDEQ 2001]), and releases from North Anna Dam were reduced from the normal minimum of 1.1 m^3/s (40 cfs) to 0.57 m^3/s (20 cfs). Low water conditions were quickly alleviated when normal precipitation levels returned to the region. This period of extreme drought was determined to be the critical period in the analyses of both the applicant and the staff.

Both the staff's assessment and Dominion's water budget model of Lake Anna are based on a simplified representation of the conservation of mass for the lake. The principle of conservation of mass can be stated specifically for water as the change in storage of water at any time is equal to the water inflow less the water outflow. In both water budget assessments, changes in lake storage over time were equal to the differences between the inflows and the outflows. Inflows included the drainage from the basin upstream of the lake and the precipitation occurring directly on the lake. Outflows included both natural and induced (i.e., forced because of the combined operation of Units 1 and 2, plus Unit 3) evaporation and releases from the dam. Groundwater can either flow from the aquifer into Lake Anna, or Lake Anna water can recharge the aquifer. Based on groundwater elevation measurements, the only time Lake Anna is expected to recharge the adjacent aquifer would be after refilling the lake following an extended period of low lake elevations. The change in storage is reflected by a change in the pool elevation.

Dominion's representation and the staff assumptions to estimate the inflow to Lake Anna were different. Because of the limited record of tributary flow measurements, there is no direct means to estimate the total inflow into Lake Anna from its tributaries. The outflow from North Anna Dam was estimated by Dominion from the U.S. Geological Survey (USGS) gauge downstream from the dam at Partlow, Virginia, and from the gate settings at the dam after the

Partlow gauge was discontinued in 1995. Dominion did not use precipitation data in its water budget analysis; it used the sum of precipitation, groundwater, and tributary inflows to offset the imbalance between the estimated evaporative losses and dam releases and the changes in lake water volume. The change in lake water volume was based directly on observed records of lake level elevation.

The staff found that relatively small departures in the pool elevation measurements using Dominion's model can result in significant variations in the precipitation, groundwater, and tributary inflow estimates. For example, an adjustment of only 2.5 cm (1 in.) between daily lake elevation measurements translates into a change of about 14 m^3/s (500 cfs); this can also result in negative inflow estimates that are inconsistent with conservation of mass principles. Dominion reduced the frequency of occurrence of negative inflow estimates by smoothing (i.e., using weekly averages instead of daily values). Dominion's historical evaporation estimates were based on calculations using a lake temperature model developed by Massachusetts Institute of Technology (Ho and Adams 1984). Dominion's discussions and conclusions were based on the weekly averaged results.

The staff estimated inflows from the watershed upstream of Lake Anna by using data from the adjacent Little River drainage basin adjusted for differences in the size of the drainage areas. The rationale for using an adjacent drainage basin is that too few of the tributaries flowing into Lake Anna are gauged for the observed data set to be useful in constructing an inflow sequence. The Little River drainage is 277 km^2 (107 mi^2) and is adjacent to the North Anna drainage; measurements from Little River span from October 1961 to the present. Based on a review of streamflow records from USGS Gauge 01671100 (Little River near Doswell, Virginia), the staff selected the period from June 2000 through April 2003 as the critical water period. The direct precipitation to the lake was based on precipitation records from the National Weather Service meteorological station at the Richmond, Virginia, airport.

The staff estimated lake outflows based on the current operating rules for North Anna Dam. Releases were generally performed to maintain a lake level elevation of 76.2 m (250 ft) MSL. Under this condition, the staff calculated flow over the dam based on lake level. When the lake level elevation dropped below 76.2 m (250 ft) MSL, the release was maintained at the normal minimum flow of 1.1 m^3/s (40 cfs). If the lake level elevation declined below 75.6 m (248 ft) MSL, releases were assumed to decrease to 0.57 m^3/s (20 cfs) immediately. Once inflows and outflows were calculated, the staff calculated the rate of evaporation from the Lake Anna reservoir, factoring in the difference between the flows.

Because makeup water for ultimate heat sink (UHS) cooling towers for Units 3 and 4 would be stored in an engineered basin and is much less than the water demand for the circulating water system during normal operation, the water demand when operating in UHS mode was considered to be bounded by the water demand for normal operations.

5.3.1 Hydrological Alterations

The Unit 3 operational activity identified by the staff that would result in a detectable hydrological alteration in Lake Anna occurs when the lake elevation would be below 76.2 m (250 ft) MSL and the wet cooling towers are operating. Discharges to the North Anna River downstream of the North Anna Dam could also be affected by operation of the wet cooling towers, which would increase the duration of reduced discharges, that is 1.1 m^3/s (40 cfs) when the lake elevation is between 75.6 m (248 ft) and 76.2 m (250 ft) MSL, and 0.57 m^3/s (20 cfs) when the lake is below 75.6 m (248 ft) MSL).

When the lake elevation is above 76.2 m (250 ft) MSL, no hydrological effect would be detectable in the lake because water available for the Unit 3 cooling system would have otherwise been discharged from the North Anna Dam. The operation of Unit 3 would also result in a net decrease of water available to the North Anna River equal to the consumptive water loss (see also Section 5.3.2).

The staff's independent water budget analysis assumed the NAPS Units 1 and 2 and the proposed Unit 3 would operate continuously. In non-drought years, the projected incremental decline of the lake level attributable to Unit 3 was relatively minor. The staff determined that the operation of Unit 3 would decrease the fraction of time that the lake level elevation was above 75.6 m (248 ft) MSL by 5 percent, from 94 percent to 89 percent of the time. With the operation of Unit 3, the percentage of time the lake would be at or below elevation 75.0 m (246 ft) MSL would increase by 0.9 percent, from 1.1 percent to 2.0 percent. The staff also analyzed the differences in lake level elevation between the baseline (Units 1 and 2 in operation) and proposed (addition of Unit 3) scenarios to examine the impacts of Unit 3 on downstream flows. Considering the entire simulation period, including the critical drought period, the incremental decline in lake level elevation resulting from the operation of Unit 3 was less than 7.6 cm (3 in.) 70 percent of the time, less than 15 cm (6 in.) 86 percent of the time, and less than 30 cm (1 ft) 94 percent of the time.

The staff projected that the lowest lake level elevations and greatest incremental decrease would occur during the month of October. When modeling lake level elevations during the critical period of record, specifically targeting the minimum elevation occurring during early October 2002, the staff analyzed the minimum lake level elevations for the following scenarios:

- Units 1 and 2 (baseline conditions): 74.74 m (245.2 ft)
- Units 1 and 2 plus Unit 3 (proposed conditions): 74.22 m (243.5 ft)

While the addition of Unit 3 would cause further declines in the level of Lake Anna, the staff's analysis of long-term conditions using the water budget model indicates that the lake level elevation would not drop below 75.6 m (248 ft) MSL during periods of normal or above average precipitation. During low-water conditions, the existing NAPS Units 1 and 2 and the proposed

Unit 3 would be allowed to operate until the elevation of the lake reaches 73.8 m (242 ft) MSL. Both the staff and Dominion estimate that during the critical period (June 2000 through April 2003), the elevation of the lake would have remained above 73.8 m (242 ft) MSL assuming that Unit 3 had been operating.

At the request of VDEQ (referenced in VDEQ 2006), Dominion also evaluated the impacts of raising normal operating lake level 15 to 30 cm (6 to 12 in.) above 76.2 m (250 ft) MSL on shoreline areas. VDEQ could elect to require such actions to mitigate impacts on down-river flows. Increasing the lake level by approximately 18 cm (7 in.) would eliminate changes in the frequency of the 0.57 m^3/s (20 cfs) minimum instream flow (Dominion 2006a). The staff's independent assessment (described in Appendix K) estimated that the frequency of 0.75 m^3/s (20 cfs) flows would be unchanged if the normal lake level were raised 25 cm (10 in.). Dominion conducted map reconnaissance, helicopter flyovers, and ground-truthing from boats and concluded that there would be some shifting of wetland areas, particularly in gradually sloping uplake tributary areas, if lake levels were raised. In addition, Dominion concluded that raising the lake level could increase localized flooding potential and downstream flows, and would likely affect use of some residential and marina boat ramps and docks, including those at Lake Anna State Park. On May 3, 2006, the staff conducted a field visit by boat on Lake Anna and independently verified that there would be a shifting of wetlands with changes in water levels, but there would be an insignificant affect on the docks and their availability for recreational purposes (NRC 2006c)

Information on operational practices and procedures was not provided in the ESP application. The operation of the cooling system presented in the application was not unreasonable for analysis purposes to assess hydrologic impacts. The actual procedures controlling the operation of the cooling system will be determined by the Commonwealth of Virginia in the Clean Water Act, National Pollution Discharge Elimination System (NPDES) permit, which is not needed until the CP or COL stage. Based on the staff's independent assessment described above and detailed in Appendix K, the staff concludes that the impacts of operation on hydrological effects would be SMALL, and that mitigation is not warranted.

5.3.2 Water-Use Impacts

Lake Anna, which was created as a source of cooling water for NAPS, has become a popular recreation area, and the dam provides downstream flood control. The lake is not used as a source of potable or industrial water, except for NAPS Units 1 and 2. The existing NAPS units are the largest users of water in the region, and the addition of a third unit would add to this use. Most of the water used at NAPS for Units 1 and 2 is drawn directly from Lake Anna for condenser cooling. This use is non-consumptive, and the water is entirely returned to the lake, albeit at a warmer temperature. Although there is no consumptive use of water between the intake and discharge, the elevated discharge temperature induces increased evaporative losses from the remainder of the WHTF and Lake Anna resulting in a consumptive use of water.

Operational Impacts at the Proposed Site

Unlike the existing NAPS units, the majority of the water withdrawn from Lake Anna for Unit 3 condenser cooling would be consumed by the wet cooling towers. Although there is some blowdown from the wet cooling towers, the discharge rate to the WHTF would be small (the full load maximum would be 351 L/s [5565 gpm]). Consumption of water by the wet cooling towers would reduce the overall volume of water in the lake, thereby impacting the quantity of water released at North Anna Dam. Unit 4 would use dry cooling towers and, therefore, would have no impact on Lake Anna level or the North Anna River downstream of the dam.

Because the North Anna Dam discharge rate is related to the Lake Anna surface level elevation, the lake level elevation analysis discussed above was used to estimate the impact on downstream flows in the North Anna River. The net total discharge from North Anna Dam would be reduced if Unit 3 operates as proposed. If water conditions become severe, then the Commonwealth of Virginia has the regulatory authority to require Dominion to derate or terminate operation of one or more of the North Anna units. The staff determined that the percent of time the dam would discharge 0.57 m^3/s (20 cfs) increased from approximately 6 percent (Units 1 and 2 only) to 11 percent. The separate analyses performed by the staff and Dominion resulted in different estimates of the frequency that the level of Lake Anna would drop below 75.6 m (248 ft) with Unit 3 operating. Without Unit 3, the staff and Dominion estimated that Lake Anna would drop below 75.6 m (248 ft) 5.7 percent of the time and 5.2 percent of the time, respectively. However, with Unit 3 operating the staff and Dominion estimated that Lake Anna would drop below 75.6 m (248 ft) 11 percent of the time and 7.3 percent of the time, respectively. The staff has concluded that there are two primary causes for this difference in the frequency estimates with Unit 3 operating. First, the staff used an evaporation rate of 47,462 m^3/day (8707 gpm) over any 365 day period compared to Dominion's representation of 47,462 m^3/day (8707 gpm) at a 96 percent capacity factor. Second, the staff applied the average evaporation rate of 47,462 m^3/day (8707 gpm) throughout the period, while Dominion applied an evaporation rate that varied depending on temperature.

The staff's analysis relied exclusively on the specific consumptive water use (evaporation) estimates that Dominion committed to in its plant parameter envelope (PPE). The PPE provides the bounding parameters used by the staff to analyze the impacts. However, in its analysis, Dominion made additional representations that were not in its PPE. For instance, as mentioned above, Dominion considered the relationship between the weather and the estimated consumptive water use for Unit 3. In its analysis, Dominion indicated that Unit 3 would use no water for condenser cooling (i.e., the condenser heat load for Unit 3 would be serviced entirely by the dry tower) if the air temperature was below 67°F. This temperature value is not a parameter that Dominion committed to in the PPE. Also, Dominion estimated the daily consumptive water losses for both the condenser and service water cooling systems based on air temperature and relative humidity. The staff concluded that the consumptive water use estimates used by Dominion are not unreasonable if the representations described above are fulfilled. However, because the bases for these values were not included in Dominion's PPE, the staff performed an independent analysis relying on average and maximum consumptive water use values reported by Dominion in its PPE.

In the PPE, Dominion stated that the average evaporation rate for Unit 3 was 8707 gpm with a 96 percent capacity factor. However, Unit 3 has the potential to operate at a capacity factor greater than 96 percent for extended periods. Therefore, the staff used the PPE definition described in Appendix I of the EIS that drops the 96 percent capacity factor and states that "...the average evaporation rate over any 365 day period will not exceed 8707 gpm". The definition of the PPE instantaneous maximum evaporation rate parameters for the MWC and EC modes was unchanged.

Because water supply generally exceeds demand, as indicated above, the staff concludes that the water supply afforded by Lake Anna is adequate to meet Unit 3 and current downstream water demands except during periods of severe drought. Operation of Unit 3 would approximately double the duration of periods during drought conditions when the Lake Level Contingency Plan would be applied (i.e., when the lake level elevation would be below 75.6 m [248 ft] MSL).

The forced evaporation from proposed Unit 3 would reduce the volume of water released from North Anna Dam, thereby impacting downstream water users. To characterize this impact, the staff estimated the change in the reliability of a hypothetical off-stream storage reservoir used to service a steady water demand. The capacity of a reservoir adequate to provide releases of a steady flow of 20 cfs from the North Anna Dam from the operation of NAPS Units 1 and 2 was calculated to provide 95 percent reliability. The staff estimated that the reliability of the same hypothetical reservoir would decrease from 95 to 90 percent with the addition of Unit 3's additional consumptive water loss.

Hanover County, one of four downstream counties, has identified a need for additional water (Hanover County Department of Public Utilities 2004). The downstream users identified by Hanover County are the county itself, the Doswell Limited Partnership Power Plant, Paramount's King's Dominion Amusement Park, and the Bear Island Paper Company. This potential conflict over water use, which exists regardless of whether Unit 3 is constructed, falls within the regulatory authority of the Commonwealth of Virginia.

Based on the foregoing, including Dominion's commitment to be bounded by the PPE values for consumptive water use, the staff concludes that during normal water years the water use impacts, including impacts on downstream users, would be SMALL, and mitigation is not warranted. During severe droughts, however, the impact to the water level could be temporarily MODERATE. Although the staff concludes that the impact of proposed Unit 3 operation on downstream water users would be SMALL for most years and MODERATE during drought years, the staff considered the interest expressed by the Commonwealth about mitigating the impacts by increasing the reservoir storage capacity.

The staff did evaluate changing the normal elevation of Lake Anna to mitigate the impact of consumptive water use associated with operation of Unit 3 on downstream flows during drought periods. The staff determined that raising the normal lake level by 25 cm (10 in.) would result in the same frequency of occurrence of 0.57 m^3/s (20 cfs) discharge flows from the North Anna Dam as the current normal lake elevation of 76.2 m (250 ft) MSL with only NAPS Units 1 and 2 operating. Any decisions to change the normal lake elevation would be made by VDEQ.

Given the infrequent and temporary nature of the severe drought conditions, the fact that the minimum operational lake level elevation is 73.8 m (242 ft) MSL, and that lake level would return to normal with normal precipitation, further mitigation other than ceasing or derating operation is not warranted.

5.3.3 Water Quality Impacts

The discharged waste heat from operation of Unit 3 is not expected to appreciably change the water temperature of Lake Anna because the maximum blowdown flow rate (i.e., 351 L/s [5565 gpm] in EC mode and 245 L/s [3844 gpm] in MWC mode) is insignificant (i.e., less than 0.3 percent) relative to the combined discharges from Units 1 and 2 of 123,000 L/s (1,934,300 gpm). Because the Unit 3 cooling tower would consume water, the volume of water in Lake Anna would be reduced (compared to operation of only Units 1 and 2 alone) when the lake level elevation is below 76.2 m (250 ft) MSL. However, assuming the heat rejection rate from operations of Units 1 and 2 remains constant, the reduced volume of water in the lake caused by Unit 3 operations would result in an increase of average lake water temperature. Dominion considered the rise in lake temperatures caused by Unit 3 operations in section 5.2.2.1.3 of the ER, and found that the average temperature rise in Lake Anna would be less than 0.06°C (0.1°F). The staff independently reviewed the analyses and agrees with the assessment.

The thermal impacts of Units 3 and 4 would be negligible because a temperature increase of 0.06°C (0.1°F) is insignificant. Based on the foregoing, the staff concludes that the thermal impacts of the proposed new units is SMALL, and that mitigation is not warranted.

Because a specific design has not been selected, the ultimate water treatment systems for proposed Units 3 and 4 have not been specified. Currently, raw cooling water from Lake Anna used for condenser cooling and service water at NAPS Units 1 and 2 is not treated. Makeup water for Unit 3, and the UHS systems for both Units 3 and 4 would be treated with biocides, antiscalants, and dispersants. Treatment of makeup water for ultrapure water systems, such as the condensate and primary cooling systems, would employ technologies such as reverse osmosis and ultrafiltration.

The agency responsible for regulating the impacts on water quality of discharges into Lake Anna is VDEQ. The water quality impact of effluents from Units 1 and 2 is regulated by a VPDES permit that minimizes the impact on Lake Anna's water quality. Although Dominion provided a chemical composition of Unit 3 blowdown in its PPE (see Appendix I), the concentrations of other waste streams that would discharge to the WHTF from operation of Unit 3 were not defined.

An applicant for a CP or COL referencing an ESP for the North Anna ESP site would need to provide information on the chemical effluents to the NRC. Based on its review, the staff concludes that the issue of water quality impacts at the North Anna ESP site is not resolved (see Appendix J), but is likely to be SMALL.

5.4 Ecological Impacts

Section 5.4 describes the potential impacts to ecological resources from operation of the proposed Units 3 and 4. This description focuses on the habitats, wildlife, and fish that could be affected by operation of the proposed new units, in addition to transmission line rights-of-way and offsite facilities. Dominion has proposed that Unit 3 would be cooled using a closed-cycle, combination wet and dry cooling system, and Unit 4 would be cooled using a dry cooling system. The potential impacts of new operating units on the hydrology of Lake Anna, shoreline vegetation, habitats, and the associated terrestrial and aquatic ecology both of Lake Anna and downstream are addressed in the following subsections.

5.4.1 Terrestrial Ecosystems

This section discusses the impacts to the terrestrial ecosystems in the ESP site vicinity and along the NAPS transmission line rights-of-way from the cooling systems associated with operating the proposed new units at the North Anna ESP site. Closed-cycle heat dissipation systems associated with nuclear power plants have the potential to impact terrestrial ecosystem resources through salt drift, vapor plumes, icing, noise, and avian collisions with tall structures (e.g., cooling towers). Each of these topics is discussed below.

5.4.1.1 Cooling Tower Impacts on Terrestrial Ecological Resources

Salt Drift

Salt deposition can cause vegetation stress, either directly by deposition of salts onto foliage or indirectly from accumulation of salts in the soil. An order-of-magnitude approach is typically used to evaluate salt deposition on plants, because plant species sensitivities vary and tolerance levels are not well documented. In this approach, deposition of sodium chloride at rates up to 1 to 2 kg/ha/mo is not considered to be damaging to plants, while deposition rates approaching or exceeding 10 kg/ha/mo during the growing season could cause leaf damage in many species (NRC 1996). All of the predicted deposition rates, both within and beyond the site boundaries, are less than 1 kg/ha/mo (see Section 5.2).

No important terrestrial species or habitats are known to exist within the vicinity of the proposed cooling towers. Important species as defined by the NRC (2000a) include Federally or State-listed threatened or endangered species, commercially or recreationally valuable species, species essential to the maintenance and survival of rare or commercially valuable species, and those that perform critical ecological functions or are biological indicators of ecosystem health. Important habitats include any wildlife sanctuaries, refuges, preserves, or habitats identified by State or Federal agencies as unique, rare, or of priority for protection; wetlands and floodplains; and land areas identified as critical habitat for species listed by the U.S. Fish and Wildlife Service (FWS) as threatened or endangered.

Because salt deposition rates are estimated to be less than 1 kg/ha/mo at all directions and distances from the towers and there are no important terrestrial species or habitats likely to be affected by salt deposition, the staff concludes that salt deposition impacts would be SMALL, and mitigation is not warranted.

Vapor Plumes and Icing

The environmental impact of the operation of the wet cooling towers was evaluated by Dominion using the SACTI computer model (ANL 1984), a suite of analytical tools developed by Argonne National Laboratory to describe fogging, icing, salt deposition, and visible plumes from traditional (e.g., non plume-abated) wet cooling towers. The model was developed specifically for the Electric Power Research Institute (EPRI) for use in licensing power plants with mechanical- or natural-draft cooling tower systems, has been verified with field data, and has been used for many years. The SACTI program calculates the fogging, icing, salt deposition, and plume height and length without consideration of water-saving techniques or features that could be part of the design of the towers and result in a reduction of the size of the vapor plume. Using a combination of atmospheric data from the NAPS site and National Weather Service data from Richmond, Virginia, for the period 1998 to 2000, Dominion used the SACTI model to calculate seasonal cooling tower plume characteristics (Dominion 2006b).

The SACTI model predicted that operation of the new cooling towers would result in approximately 70 additional hours of fogging per year and no additional icing. Vapor plumes (i.e., fog) produced by the cooling system would have a minimal impact on the vision of flying birds, and would be unlikely to adversely affect vegetation. The staff performed a confirmatory calculation that showed similar results (NRC 2006a). Based on the foregoing, the staff concludes that the impacts of vapor plumes on terrestrial resources would be SMALL, and mitigation is not warranted. Similarly, because no icing was predicted by the model, the staff concludes that the impacts of icing would be SMALL, and mitigation is not warranted.

5.4.1.2 Noise

Maximum noise levels from the operation of the reactors and dry cooling towers would be similar to current noise levels to which local species are adapted. Current noise levels at NAPS are occasionally as high as 100 decibels (measured at the security fence during outages), but they are typically less than 80 to 85 decibels, which is the level at which birds and small mammals are startled or frightened (Golden et al. 1980), and more likely to be 65 dBa or lower. Even with all combinations of wet and dry cooling towers in operation, noise levels from the cooling towers would be less than 65 decibels at the exclusion area boundary (Dominion 2006a). There are no important terrestrial species or important habitats in the vicinity of the site. Based on the foregoing, the staff concludes that the noise impacts to terrestrial ecological resources would be SMALL, and no mitigation is warranted.

5.4.1.3 Avian Collisions

The dry cooling towers proposed for Unit 4 heat dissipation are expected to be approximately 46 m (150 ft) tall, which is considerably less than the 71 m (234 ft) maximum height for the tallest building in the power block. The mechanical draft towers that may be used in the combination wet and dry cooling system for Unit 3 would be approximately 24 m (80 ft) tall. Nevertheless, for purposes of analyzing environmental impacts, Dominion's evaluation of avian collisions were based on a maximum structure height of 55 m (180 ft) for the cooling tower and 70 m (230 ft) for the tallest structure. No avian collisions with existing NAPS structures have been recorded, and the cooling towers would produce operational noise and air movements that would further decrease the likelihood of bird collisions. In view of the above, it is likely that bird collisions with the new towers would be rare. The North Anna ESP site is not within a major migratory bird concentration area along the Atlantic flyway (VDCR 2004). Dominion maintains a migratory bird protection program, including protection of nests and reporting of bird (especially raptor) strikes and other events (Dominion 2001a). Based on the foregoing, the staff concludes that impacts to birds from collisions with heat dissipation and other facility structures would be SMALL, and mitigation is not warranted.

5.4.1.4 Shoreline and Riparian Habitat

The increased water use and evaporation resulting from the addition of one new unit using wet cooling towers could increase the amount of shoreline exposed along Lake Anna or affect the length of time that the additional shoreline is exposed, as discussed in Section 5.3, above. This increased shoreline exposure could lead to alterations of the shoreline vegetation or enhance the introduction or spread of undesirable vegetation.

The staff evaluated the potential impacts of station operation on wetlands along the shoreline and upper reaches of Lake Anna using a hydrological assessment as discussed in Section 5.3.2, above, and in Appendix K. The maximum annual drawdown in most years would not differ greatly from that resulting from the operation of the existing units alone. The fraction of time that lake level would be at or below 75.0 m (246 ft) MSL would increase from 1 percent with two units operating to approximately 2 percent of the time with the addition of Unit 3. The surface elevation would be above 75.6 m (248 ft) MSL approximately 89 percent of the time with three operating units compared with approximately 94 percent of the time with the existing two operating units. The normal pool elevation is 76.2 (250 ft) MSL. The staff determined that the difference between the lake level with and without Unit 3 would be less than 7.6 cm (3 in.) approximately 69 percent of the time, less than 15 cm (6 in.) approximately 85 percent of the time, and less than 30 cm (1 ft) approximately 94 percent of the time. All of the periods for which the difference in the lake surface elevation with and without Unit 3 was predicted to be greater than 30 cm (1 ft) would have occurred during the two major drought events of 1980 to 1981 and 2001 to 2002.

Differences in surface elevations that fluctuate between 0 and 15 cm (0 and 6 in.) are likely to have no discernable effect on shoreline vegetation or wetlands. During the occasional periods when there are greater differences in the surface elevation, there could be noticeable temporary changes in the shoreline and wetland vegetation. Higher areas may dry out, and lower, normally inundated areas may develop stands of wetland vegetation over time. However, the increased drawdown is expected to be temporary, and even if the additional drawdown lasts for a year or more, any observable changes would not be detectable within a relatively short time after the water level returns to normal. Riparian and wetland vegetation is adapted to survive fluctuating water levels and periodic drought conditions without detectable long-term effects. Therefore, the staff concludes that the impacts to shoreline vegetation and habitats would be SMALL, and mitigation is not warranted.

The VDEQ identified the possibility of raising the lake level 15 to 30 cm (6 to 12 in.) to mitigate the impact on North Anna River downstream flows (Dominion 2006a). Dominion evaluated this potential option in the ER, stating:

> Dominion evaluated shoreline areas in an effort to assess, in general, various impacts of potentially raising normal operating lake level 6 inches to 12 inches above 250 ft. MSL, in the event a Virginia permitting agency process determined the need for such an action. [Note: Raising normal operating lake level is not being proposed to demonstrate site suitability. And though not currently proposed, Virginia DEQ could require an increase in lake level to mitigate impacts on down-river flows. Increasing the lake level by approximately 7 inches would eliminate changes in the frequency and duration of the 20 cfs minimum instream flow.]

On May 3, 2006, the staff toured Lake Anna with the applicant (NRC 2006c) and discussed the option of raising the lake level between 15 to 30 cm (6 to 12 in.) to mitigate the impacts on downstream flows. If the lake level were raised 15 to 30 cm (6 to 12 in.), it could impact dock owners and could affect near-shore wetlands, especially the upper reaches of the lake where the tributary streams enter the North Anna River and in the areas uplake of the North Anna Dam. In areas of relatively steep banks, there would be little effect on wetlands. In the area above the State Road 208 bridge, the change to the wetlands would be most evident due to the gradual slope of the shoreline. The net effect of raising the lake level would be to shift the wetlands, but it would not result in a significant gain or loss of wetlands. The authority to require that the lake level be raised resides with the Commonwealth of Virginia.

Evaporative losses resulting from the operation of the wet cooling system for Unit 3 could cause decreased flows downriver. Reduced flows could alter the riparian vegetation and habitat for riparian and wetland species along the North Anna River. The staff's hydrological analysis demonstrates that the fraction of time that weekly average outflow from the North Anna Dam would be at or below 1.1 m^3/s (40 cfs) would increase from approximately 63 percent of the time with NAPS Units 1 and 2 operating to 66 percent with the addition of Unit 3 (see Appendix K). The analysis also predicted that the fraction of time that the outflow would be at 0.57 m^3/s (20 cfs) would increase from 6 percent under current two-unit operations to approximately 11 percent of the time with the addition of Unit 3. Under the scenario with just NAPS Units 1 and 2 operating, the model predicted two periods (1998, and 2001 to 2002) when the weekly average outflow would have dropped to 0.57 m^3/s (20 cfs). With the addition of Unit 3, the model predicted an additional seven such periods during the 1978 to 2003 modeling period. In almost all cases, the 0.57 m^3/s (20 cfs) average weekly outflow conditions commenced in October, lasted for approximately two weeks to several months, and then returned to higher outflow levels by the end of January.

In 1981 and 1999, the low outflow period would have commenced in early to mid-August. There would have been low flow 0.57 m^3/s (20 cfs) conditions for over 14 months during the 2002 drought under both of the modeled conditions (i.e., the baseline with NAPS Units 1 and 2 operating and the proposal with Unit 3 operating as well). Low flow would have commenced in early October 2001 with three units operating rather than in late October with two units operating, and would have lasted until mid- to late December 2002 with three units operating rather than early December with just two units. Therefore, although low outflow conditions in the North Anna River were modeled to occur at a noticeably higher fraction of the time with the addition of Unit 3 compared to current conditions, in all but two cases these low-flow periods occurred during portions of the year when the riparian vegetation would have either stopped growing or would already be dormant and is, therefore, not likely to adversely affect growth or reproduction.

Therefore, it is not likely that a period of reduced outflow every few years would noticeably affect the riparian vegetation downstream. The staff's analysis identified 2 out of 25 years when the 0.57 m^3/s (20 cfs) outflow conditions would have commenced during August. Low outflow during the growing season could have short-term effects on riparian vegetation; however, riparian vegetation is adapted to survive periodic fluctuations in water level and drought conditions without detectable long-term effects. The staff's analysis determined that there would be periods of reduced (i.e., 0.57 m^3/s [20 cfs]) outflow during the growing season approximately once a decade. Therefore, the changes in the flow regime are not expected to noticeably change the quantity, distribution, or characteristics of the riparian or wetland vegetation and habitats along the North Anna River between the North Anna Dam and the confluence with the South Anna River. Therefore, the staff concludes that impacts of the additional units on downstream riparian habitats would be SMALL, and mitigation is not warranted.

5.4.1.5 Transmission Line Rights-of-Way

The vegetation in the transmission line rights-of-way is managed through a combination of mechanical and herbicide treatments conducted on a 3-year cycle. Mowing is the primary mechanical treatment, while Accord® and Garlon® are the primary herbicides used in the rights-of-way. In some areas (e.g., wetlands, dense vegetation), hand-cutting is used. Although no rare or sensitive plant species are known to occur within the NAPS transmission line rights-of-way, Dominion has procedures in place to ensure that such species are identified and avoided, or modified treatment practices used to avoid adverse impacts. These modified vegetation treatments are developed in cooperation with the Virginia Department of Conservation and Recreation (VDCR) Natural Heritage Program (NRC 2002b). In addition, wildlife food plots and Christmas tree plantations located along the rights-of-way are supported through cost sharing by the Virginia Electric and Power Company (also referred to as Virginia Power or VEPCo) (NRC 2002b).

In its analysis of the application to renew the operating licenses for NAPS Units 1 and 2, the staff determined that continued operation and maintenance of the transmission lines rights-of-way would not adversely impact terrestrial resources (NRC 2002b). Because there would be no new lines or alterations of the existing rights-of-way, no changes to this impact would be expected to occur if additional power from Units 3 and 4 were transmitted through this system.

5.4.1.6 Summary of Terrestrial Ecosystems Impacts

The staff considered potential impacts to terrestrial ecological resources of operating the proposed Units 3 and 4, including salt drift; fogging; icing; noise; avian collisions; changes to shoreline, riparian, and wetland habitat; and transmission line rights-of-way. Based on its analysis and independent review, the staff concludes that the operational impacts of Units 3 and 4 operations on terrestrial ecological resources would be SMALL, and mitigation is not warranted.

5.4.2 Aquatic Impacts

This section discusses the potential impacts of the operation of the proposed Units 3 and 4 on Lake Anna and the North Anna River aquatic ecosystems from the cooling systems. The potential impacts to the aquatic environment are expected to be related solely to the operation of Unit 3. Unit 4 is expected to use a closed-cycle, dry cooling system that uses almost no cooling water. Therefore, this analysis focuses on Unit 3 operational impacts, along with the impacts of the existing Units 1 and 2.

5.4.2.1 Intake System

The existing cooling water system for NAPS Units 1 and 2 is a once-through design that withdraws water from the Lake Anna reservoir. At maximum capacity, Units 1 and 2 withdraw and return 122,000 L/s (1,934,300 gpm), or about 2.8 percent of the total Lake Anna volume per day (3.76×10^8 m^3 at 76.2 m MSL [305,000 ac ft at 250 ft MSL]). Each unit uses four circulating water pumps to withdraw condenser cooling water from Lake Anna, and the water flows through screens located in a cove north of the station. Each screen well contains four individual bays, and each bay is equipped with a trash rack, a traveling screen, and a vertical, motor-driven, circulating water pump. The trash racks consist of 1.3-cm (0.5-in.) wide by 8.9-cm (3.5-in.) thick vertical bars spaced 10.2 cm (4.0 in.) on center. Water flows through the trash racks at about 0.2 m/s (0.69 ft/s) (VEPCo 1985). Traveling screens in the front of the cooling water pumps filter the water and protect the pumps from damage and clogging. The traveling screens, constructed of 14-gauge wire with 9.5-mm (0.37-in.) square openings are designed to rotate once every 24 hr or whenever a predetermined differential pressure exists across the screens. Debris collected at the trash racks is removed by mechanical rakes. Debris and fish collected in the wire baskets associated with the traveling screens are disposed of as solid waste (VEPCo 1985). After passing through the plant, water is returned to the WHTF, which is separated from the main part of the lake by a series of dikes.

The cooling water intake system can affect aquatic communities by either impingement or entrainment. Impingement occurs when swimming organisms are not strong enough to escape the cooling water intake current and are caught or stuck on the screens (i.e., impinged). Impinged organisms are generally fish, but can occasionally include other semi-aquatic animals such as amphibians (e.g., frogs, turtles, and salamanders), waterfowl (e.g., ducks and coots), or mammals (e.g., muskrats). The screens are periodically cleaned using a spray wash system to remove impinged organisms. Impingement mortality varies with species, but is considered to be 100 percent because NAPS Units 1 and 2 do not have a fish return system.

Entrainment is the passage of organisms through the traveling screens into the cooling water system. Entrained organisms are generally small and include phytoplankton, zooplankton, and fish eggs and larvae. As these entrained organisms pass through the cooling water system, they are subjected to a variety of stresses that may result in mortality. Impacts to the entrained organisms include physical damage from contact with pumps, pipes, and condensers; pressure-related damage from passage through pumps; damage from shear associated with complex water flows; damage from exposure to elevated temperatures in the condenser passage; and potential exposure to toxic chemicals added to the cooling water system. Entrainment mortality varies by species, but is considered to be 100 percent for closed-cycle cooling systems similar to the one proposed for Unit 3.

Dominion proposes a 21 m (70 ft) long and 21 m (70 ft) wide intake structure to support the Unit 3 closed-cycle, combination wet and dry cooling system. The maximum water withdrawal associated with Unit 3 would be 1400 L/s (49.6 cfs). This represents a 1 percent increase in water withdrawal from Lake Anna compared to the current water withdrawal of about 120,000 L/s (4300 cfs) to support Units 1 and 2. Because Unit 4 would use a dry cooling system, water use is negligible compared to the other three units and is not considered in this impact assessment.

5.4.2.2 Impingement

In 1985, Virginia Power (VEPCo) published *Impingement and Entrainment Studies for North Anna Power Station*, *1978-1983* (VEPCo 1985). This document described the study design and results associated with work conducted under Section 316(b) of the Clean Water Act in compliance with the NAPS Environmental Technical Specifications and the then-existing VPDES permit under Special Conditions: Environmental Studies (“the Section 316(b) study”). The objective of the Section 316(b) study was to examine the effects of impingement and entrainment associated with the cooling water intake system supplying Units 1 and 2 to determine whether NAPS operations adversely affect fish populations in the Lake Anna reservoir.

During the study years (1979 to 1983), an average of just over 47,400 fish representing 34 species were collected annually for each full year. Results for 1978 were not included in the analysis because sampling occurred only from April to December. During each sampling episode, traveling screens were washed to ensure that all fish were collected, and that decayed fish or fish that had been dead for more than 24 h were discarded. The remaining fish were identified by species and counted, and up to 50 individuals of each species were weighed and measured. By relating the number of fish impinged to the sampling duration and measured intake flow, it was possible to estimate daily, monthly, and yearly impingement values.

The Section 316(b) study results were based on the operating conditions that existed at that time and the intake configurations and specifications described in ER Revision 6 (Dominion 2006a) and the Draft EIS (NRC 2004a). The study found that six fish species accounted for 99 percent of all fish impingements (Table 5-1). The gizzard shad, *Dorosoma cepedianum,* was the species most commonly impinged, and accounted for 61 percent of the observed impingements during the study period (Table 5-1). More than 80 percent of the total impingements occurred from January to April (Table 5-2).

Concurrent with the study, cove rotenone sampling in Lake Anna was conducted from 1979 to 1983 to determine the impact of the estimated impingements on species biomass. This cove rotenone sampling determined that gizzard shad impingements associated with the once-through cooling system used for Units 1 and 2 represented 0.32 percent of the total lake biomass of that species. Impingement impacts for the other representative important fish species (RIS) expressed as the biomass lost to impingement ranged from 0.02 percent for the bluegill *Lepomis macrochirus*, to 3.8 percent for the black crappie, *Pomoxis nigromaculatus,* (Table 5-1).

The staff compared estimates of impingement associated with existing Units 1 and 2 derived from the Section 316(b) study to assess the impacts of impingement associated with the closed-cycle, combination wet and dry cooling system proposed for Unit 3 (Dominion 2006a). Dominion used an intake flow rate of 1723 L/s (60.8 cfs) in its calculations to assess impingement losses for Unit 3. This represents a maximum flow rate through the intake and results in a greater-than-expected estimate of losses. Typically, normal plant cooling tower makeup water needs are expected to be 971 L/s (34.3 cfs). In developing its estimate of impingement losses for Unit 3, Dominion represented that the current fish distribution and composition would be the same as observed during the Section 316(b) study, that a new cooling water system would operate at 100 percent pumping capacity, and that the intake screen mesh size and approach velocity for Unit 3 would be the same as that of the existing units.

Because the water use associated with the closed-cycle, combination wet and dry cooling system would be much less than that of NAPS Units 1 and 2, impingement rates resulting from Unit 3 would be significantly less than current impingement rates (Table 5-2). Based on the information provided by Dominion in the ER, the addition of the Unit 3 closed-cycle cooling system to the existing once-through cooling system for Units 1 and 2 would increase average yearly impingement from Lake Anna from 182,440 to 187,880 individuals, or approximately 3 percent. These estimates are likely conservative because of the high intake flow estimates used for Unit 3. Accordingly, the staff concludes that there would be a negligible decrease in fish biomass in Lake Anna under Unit 3 operation.

The Section 316(b) study conducted at NAPS from 1978 to 1983 concluded that impingement associated with the once-through cooling system employed by Units 1 and 2 had not resulted in significant impacts to the fish communities of Lake Anna. Subsequent monitoring (VEPCo 2002) has shown that fish populations in the reservoir are healthy and diverse. Because the closed-cycle, combination wet and dry cooling system proposed for Unit 3 increases the total cooling water withdrawal from Lake Anna by approximately 1 percent and would result in a minimal increase in impingement and fish biomass loss relative to the current

Table 5-1. Fish Species Most Commonly Impinged at Existing Units 1 and 2 (1979 to 1983) (Dominion 2006a)

Scientific Name	Common Name	Percent of Total Impingement	Estimated Percent of Lake Anna Total Biomass by Species
Dorosoma cepedianum	Gizzard shad	61	0.32
Pomoxis nigromaculatus	Black crappie	16	3.8
Perca flavescens	Yellow perch	16	1.4
Lepomis macrochirus	Bluegill	4	0.02
Morone americana	White perch	1	0.1
Morone saxatilis	Striped bass	1	no data

Table 5-2. Estimated Mean Monthly Impingement of RIS

	Estimated Mean Impingement per Month (all species)	
Month	Existing Units[(a)] (1979-1983)	Unit 3 Combination Wet and Dry Cooling System[(a)]
January	16,012	310
February	30,873	811
March	93,955	3258
April	15,702	480
May	4364	117
June	1560	37
July	1034	20
August	1680	30
September	2166	37
October	4454	101
November	5360	123
December	5280	116
Yearly Total	182,440	5440

(a) ER (Dominion 2006a)

Unit 1 and 2 operations, the staff concludes that the impacts of impingement would be SMALL. Although the staff concludes that the impacts of impingement to the Lake Anna fishery would be small, further mitigation could reduce losses if the intake through screen flow velocity were designed to be less than 0.15 m/s (0.5 ft/s), as recommended in the Section 316(b) study.

5.4.2.3 Entrainment

The Section 316(b) study described above also considered entrainment. Entrainment samples were collected once a week in front of the intake forebays from 1979 to 1983. Sampling was conducted from March through July of each year, which encompassed the spawning periods of certain reservoir fish species (e.g., the bluegill, the yellow perch, *Perca flavescens*; the black crappie, the white perch, *Morone americana*; and the largemouth bass, *Micropterus salmoides* (VEPCo 1985). Entrainment samples did not contain fish eggs because most of the species in the reservoir produce demersal (i.e., negatively buoyant) adhesive eggs that are not generally entrained. For purposes of the Section 316(b) study, and as a conservative estimate of impact, Dominion applied 100 percent mortality for all larval fish entrained (VEPCo 1985).

As previously described in Section 5.4.2.2, the staff analysis was based on the Section 316(b) study results and the intake configurations and specifications described in the ER. The Section 316(b) study results determined that the larvae of five species accounted for the majority of larval entrainment losses, with the largest entrainment abundances associated with the larvae of gizzard shad at 65 percent (Table 5-3). Larvae of white perch accounted for 15 percent of the entrainment abundances during the study, and larvae of sunfish (family Centrarchidae) accounted for 13.3 percent of the entrainment abundances. Larvae of the yellow perch and black crappie accounted for less than 6 percent of entrainment abundances (Table 5-3). Based on the duration of entrainment sampling, sampling gear used, and the measured flow, total larval entrainment was calculated for the months that spawning occurs in the reservoir (March to July) for each species.

Because larval abundance in Lake Anna is not known, it was not possible to determine the percentage of larvae entrained based on the actual abundance in the lake. The adult equivalent model of Goodyear (1978) was used to assess the population impacts caused by the loss of fish larvae from entrainment by the existing NAPS units with the following conditions:
(1) 100 percent mortality of entrained larvae; (2) stock populations are at equilibrium, and the total lifetime fecundity produces two adults; (3) no compensatory mechanisms are operating; and (4) 75 percent of the eggs produced by the entrained species survive to the larval stage. The model estimated the number of adult fish that would have resulted from the larvae had they not been lost to entrainment, and also provided an estimate of the potential percent reduction in the adult fish population as a consequence of entrainment. Predicted reductions in fish populations ranged from 0.01 percent for black crappie in 1978 and 1979 and sunfish in 1982, to 4.13 percent for gizzard shad in 1980. Dominion concluded that reductions of this magnitude would not be expected to have a significant adverse effect on the reservoir fish populations for those species, especially when viewed in concert with other population mechanisms such as natural compensation (VEPCo 1985). The analysis from the adult equivalent model provided a conservative estimate of entrainment impact by the existing units, primarily as a result of assumptions used in the analysis (VEPCo 1985).

Table 5-3. Larval Fish Species Most Commonly Entrained at Existing Units (1978 to 1983) (Dominion 2006a)

Common Name	Scientific Name	Estimated Percent of Total Entrainment
Gizzard shad	*Dorosoma cepedianum*	65.7
White perch	*Morone americana*	15.0
Sunfishes	*Lepomis* spp.	13.3
Yellow perch	*Perca flavescens*	4.9
Black crappie	*Pomoxis nigromaculatus*	1.0

The staff compared estimates of entrainment from the Section 316(b) study for the existing units to calculate entrainment losses predicted for Unit 3. As described above, Dominion used an intake flow rate of 1723 L/s (60.8 cfs) to estimate entrainment for Unit 3. This represents a maximum flow rate through the intake and results in a conservative (environmentally protective) estimate of losses. Typically, normal plant cooling tower makeup water needs would be 971 L/s (34.3 cfs). Dominion applied the fish larvae distribution and composition as though it were the same as in the Section 316(b) study, and indicated that the new cooling system would operate at 100 percent pumping efficiency and that the intake screen mesh size and flow velocity for the new unit would be the same as that of the existing units.

Because the water use associated with the closed-cycle, combination wet and dry cooling system would be much less than that of the once-through cooling system for Units 1 and 2, entrainment at Unit 3 would be significantly less than at the existing units (Table 5-4). Based on the information provided by Dominion in ER (Dominion 2006a), the addition of the Unit 3 cooling system to the existing once-through cooling system for Units 1 and 2 would increase yearly entrainment during spawning months from about 149 million larvae to about 153 million, or approximately 2 percent. These estimates are probably conservative because of the high intake flow estimates used for Unit 3. Accordingly, the staff concludes that there would be a negligible loss of larval fish in the Lake Anna fish communities.

Based on the results of the Section 316(b) study and a comparison of entrainment abundances expected to occur using the Unit 3 closed-cycle, combination wet and dry cooling system, as described above, the staff concludes that the impacts of entrainment of Unit 3 operations in addition to the losses from Units 1 and 2 would be negligible. The fish populations most susceptible to larval entrainment represent a balanced community in Lake Anna. Over the years fishery management of the reservoir has matured and changed to meet the demands for public fishing through species additions (i.e., threadfin shad, *Dorosoma petenense*, and annual stockings of striped bass, *Morone saxatilis*, and walleye, *Sander vitreous*). Overall, the abundance and quality of the fisheries have remained healthy and balanced despite increased

Table 5-4. Estimated Mean Monthly Entrainment of Larvae of Common Fish Species

	Estimated Mean Entrainment per Month (all species)	
Month	**Existing Units[a] (1978-1983)**	**Unit 3 Combination Wet and Dry[a]**
March	223,513	5251
April	10,600,874	272,335
May	71,160,116	1,644,107
June	55,855,069	1,204,313
July	11,521,058	230,416
Total	149,390,630	3,354,224

(a) ER (Dominion 2006a)

fishing pressure and shoreline property development. Because of the thriving populations of game fish and the forage species that support them, the staff concludes that the additional entrainment resulting from the operation of the Unit 3 closed-cycle, combination wet and dry cooling system would represent a minor increase in entrainment, and the impacts on aquatic species in Lake Anna would be SMALL.

Although the staff concludes the impacts of entrainment for Unit 3 would be SMALL, it considered further mitigation by employing 1.0-mm (0.04-in.) mesh screening on the traveling screen intakes associated with Unit 3. Replacing the existing 9.5-mm (0.37-in.) mesh screening with 1.0-mm (0.04-in.) mesh would significantly reduce the entrainment of most larvae and eggs from Lake Anna. However, these organisms would be impinged on the screens because they have little or no motility and cannot avoid the intake. These life forms would still experience mortality rates of close to 100 percent because they are fragile and are unable to escape from the surface of the screens. The use of fine mesh screen technology to reduce entrainment is typically employed in riverine environments where a sweeping current is present because of downstream flow. A sweeping current naturally removes surface debris and impinged organisms. Such sweeping flows are not present in the North Anna reservoir. The replacement of the existing 9.5-mm mesh screen panels with 1-mm mesh would not increase entrainment survival unless the intake had a fish return system. Additionally, the size of the intake would need to be sufficiently larger to maintain low approach velocities. Therefore, the staff concludes that the use of fine-mesh screening would not significantly reduce the already small entrainment losses predicted for Unit 3 operation, and mitigation is not warranted.

5.4.2.4 Aquatic Thermal Impacts

This section discusses the potential thermal impacts to the aquatic resources of Lake Anna from the discharge of heated blowdown water from the proposed Unit 3 combination wet and dry cooling system. This water would enter the existing discharge canal, mix with the water released from the NAPS Units 1 and 2 cooling system, pass into the WHTF, and ultimately flow back into Lake Anna and the North Anna River. Fish and other aquatic flora and fauna could be affected if there are rapid changes in water temperatures above or below their tolerance range. The staff evaluated the thermal impacts on the lake's ecosystem and described the water-use impacts of the cooling system for an additional unit. Except where more detailed data were available, the design parameter values from the PPE (see Appendix I) were used as the basis for the analysis and evaluation of the Unit 3 discharge system. The staff described the physical attributes of the discharge system in Section 3.2.2.

Currently, cooling water from NAPS Units 1 and 2 is discharged at a rate of 120 m^3/s (4246 cfs) into the WHTF at a temperature of approximately 8°C (14°F) above intake ambient conditions. The water flows through the WHTF, which is a series of lagoons and connecting canals, and returns to Lake Anna at Dike 3, which is just above the North Anna Dam. Waste heat is transferred to the atmosphere mostly by evaporation, conduction, and back radiation, and only a small fraction of waste heat is transported downstream via the North Anna Dam. Dominion estimates that with both NAPS Units 1 and 2 operating, the cooling water residence time in the WHTF is approximately 7 days, and would not change significantly with the additional flow from proposed Unit 3. About one-half of the waste heat is dissipated in that time. Virtually all of the remaining heat is dissipated to the atmosphere from the surface of Lake Anna either by evaporation or radiation. The general characteristics of Lake Anna include a more riverine environment upstream to a lacustrine environment downstream. Thus, the middle and lower portions of the lake are generally stratified during the summer and mixed or weakly stratified in winter. This would not change with the operation of proposed Unit 3.

Cold Shock

Cold shock occurs when aquatic organisms that have been acclimated to warm water, such as fish in a power plant's discharge canal, are exposed to a sudden temperature decrease. This is more likely to occur if a single-unit power plant shuts down suddenly in winter. It is less likely to occur at a multiple-unit plant, because a sudden temperature decrease is moderated by the heated discharge from the remaining unit or units that continue to operate. Cold shock mortalities at U.S. nuclear power plants are relatively rare and typically involve small numbers of fish (NRC 1996).

Winter kills of fish have occurred in Lake Anna associated with cold weather and unusually cold water temperatures, but plant operations were not a factor (NRC 2004b). During February and March 1979, large numbers of gizzard shad were killed or stunned when Lake Anna water temperatures fell below 2.2°C (36°F) (VEPCo 1985). These fish drifted into the existing units' intake and were observed in impingement samples. The susceptibility of gizzard shad and threadfin shad to winter kills is well known, and limited threadfin shad kills have occurred during severe winters. The threadfin shad is native to the Gulf slope of the United States, peninsular Florida, and Central America, and was introduced as a forage fish to a number of Virginia impoundments in the 1950s, 1960s, and 1970s (Jenkins and Burkhead 1994). Because this species is subject to cold kills when water temperatures drop below 8.9°C (48°F), it is able to overwinter in northern latitude impoundments only when waters are heated by power plant effluents (Olmsted and Clugston 1986).

As noted above, incidents of cold shock in receiving waters of nuclear power plants are infrequent, and even more infrequent at multiple-unit plants. Because the maximum blowdown discharge temperature is 37.8°C (100°F), and the maximum blowdown flow rate is 351 L/s (12.4 cfs), the addition of the Unit 3 closed-cycle, combination wet and dry cooling system represents a minor contribution of water and heat to the existing discharges associated with NAPS Units 1 and 2. Thus, the presence of the Unit 3 cooling system would have little or no impact on increasing the number of fish acclimated to elevated water temperature. Moreover, the presence of multiple units at a site reduces the effect of cold shock because it is unlikely that all units would abruptly cease operation simultaneously. Based on the foregoing, the staff concludes that the impacts of operation from cold shock on aquatic resources would be SMALL, and mitigation is not warranted.

Heat Stress

The thermal tolerance for aquatic organisms is defined in different ways. Some definitions relate to the temperature that causes fish to avoid the thermal plume, other definitions relate to the temperature that fish prefer for spawning, and others relate to the temperatures (upper and lower) that may kill individual fishes. Some of these tolerances are termed preferred temperatures, upper avoidance temperatures, and lethal temperatures. A list of these tolerances for several important species found in the reservoir was compiled in the ER (Dominion 2006a) and is presented in Table 5-5. While study objectives, methods, and definitions vary among the temperatures cited, patterns of temperature preference and tolerance are generally evident for a given species. Critical thermal maxima and chronic lethal maxima values are arrived at experimentally, and are based on different endpoints and acclimation schemes.

In Section 5.3, the staff describes its independent assessment of the incremental impacts of the proposed Unit 3 on the water temperatures within Lake Anna. The negligible increase in flow and heat load from Unit 3 relative to the existing flow and heat load from Units 1 and 2 would result in a negligible increase in the temperature and associated heat stress that fish in Lake Anna would experience. Although temperature-related fish kills have been reported in the lake and may continue to occur, it is unlikely that the operation of the Unit 3 closed-cycle,

Table 5-5. Temperature Requirements of Important Fish Species of Lake Anna

Species	Preferred Temperature Range		Upper Avoidance		Lethal (Undefined Experimental Method)		Critical Thermal Maximum (Lethal)		Chronic Lethal Maximum (Lethal)	
	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
gizzard shad	19-23[a]	69-73[a]	30[a]	86[a]	37[b]	98[b]	–[c]	--	--	--
channel catfish	25-36[a]	77-87[a]	30-35[a]	90-95[a]	33-35[b]	92-95[b]	35.9-42.1[d]	95.9-107.8[a,d]	--	--
striped bass	18-21[e]	65-70[e]	25-27[e]	77-81[e]	--	--	31.6[d]	88.9[d]	--	--
bluegill	28-33[f]	82-91[f]	--	--	--	--	--	--	--	--
	27-32[a]	81-90[a]	30-35[a]	90-95[a]	--	--	36.1-41.4[d]	97-106.5[d,g]	35.9[d]	95.9[d]
largemouth bass	27-32[a]	81-90[a]	29-34[a]	84-93[a]	--	--	--	--	--	--
	27-32[a]	81-90[f]	31-33[f]	88-91[f]	--	--	32.3-40.2[d]	97.3-104.4[d,h]	--	--

(a) Coutant 1977.
(b) Carlander 1969.
(c) Blank entries indicate no data were found.
(d) Beitinger et al. 2000.
(e) Coutant and Carroll 1980; Moss 1985; Dudley et al. 1977.
(f) Carlander 1977.
(g) Acclimation temperatures >28°C (82°F).
(h) Acclimation temperatures >20°C (68°F).

combination wet and dry cooling system would result in increased mortality beyond that observed during two unit operation, given the minor flow and thermal inputs to the WHTF and lake. Additionally, many fish found in the lake are prolific, exhibit a high reproductive potential, and a compensatory mechanism to offset losses. Fish are mobile and will seek out a thermal regime that is optimal for its growth and reproduction. Based on the foregoing, the staff concludes the thermal impacts on the fish populations of the discharge of waste heat from Unit 3 into Lake Anna would be SMALL, and mitigation is not warranted.

5.4.2.5 Striped Bass

Striped bass, *Morone saxatilis*, are well adapted to residence in fresh water, and are often chosen for the development of a recreational fishery in inland reservoirs. Considered a cool-water species, striped bass become less mobile as the water warms and seek out thermal refugia where water temperature is less than 26°C (79°F) and dissolved oxygen levels are at least 3 or 4 mg/L (Cheek et al. 1985). Because striped bass are sensitive to changes in temperature and vulnerable to thermal stress, some reservoir populations are susceptible to summer die-offs because of elevated lake temperatures and diminished dissolved oxygen levels. In reservoirs similar to Lake Anna in the southern United States, striped bass are generally found in deeper, colder water during the summer months, and tend to congregate near the thermocline. The striped bass fishery in Lake Anna is supported by stocking; there is no evidence that this species spawns in Lake Anna or the North Anna River. Spawning has been documented in the Pamunkey River during the months of April and May.

Impacts to Striped Bass Populations in Lake Anna

Evidence suggests that unusually high air temperatures and low rainfall in summer (e.g., the drought conditions that occurred in central Virginia from 2001 to 2002) can reduce striped bass habitat in some portions of Lake Anna. The closed-cycle, combination wet and dry cooling system proposed for Unit 3 would contribute less than 1 percent to the current discharge flow of heated water to the discharge canal and WHTF, and the maximum temperature of the blowdown water (38°C [100°F]) would be within the range of temperatures currently observed in the discharge canal in July and August of 37.0° to 39.1°C (98.6° to 102.4°F) (Dominion 2006a). Dominion determined the operation of Unit 3 would result in an average increase in Lake Anna water temperature of 0.1°F under normal climactic conditions, and of 0.3°F during extended drought events. The staff independently reviewed the analyses and agrees with the assessment. These projections assume full mixing and an average rise in temperature. The elevated temperature would actually vary throughout the reservoir, providing thermal refugia to highly mobile species.

Based on the above, the staff determined that waste heat input to Lake Anna from the Unit 3 closed-cycle, combination wet and dry cooling system would not appreciably contribute to the thermal heating that already occurs in Lake Anna because of natural and anthropogenic (derived from human activities) inputs. Lake Anna currently is stratified during the summer and is mixed or weakly stratified in winter; this pattern would not change with the operation of Unit 3. Although NAPS Units 1 and 2 operations during extended drought periods decrease striped bass habitat, there is no evidence indicating that suitable habitat would be eliminated in the mid-lake and upper-lake areas. Because Unit 3 would not significantly contribute to the current thermal inputs to Lake Anna, the staff concludes that the thermal impacts to striped bass from the operation of the Unit 3 cooling system would be negligible.

Impacts to Striped Bass Below the North Anna Dam

Striped bass are known to occur in the North Anna River downstream of the dam, but these fish are believed to have passed through or over the dam from Lake Anna. Striped bass are known to occur and spawn successfully in the Pamunkey River, but they are unlikely to venture above the fall line during their spawning migrations (Jenkins and Burkhead 1994). The most upstream record of striped bass prior to the impoundment of the reservoir was 90 km (56 mi) downstream of the North Anna Dam (Reed and Simmons 1972). Bilkovic et al. (2002) collected striped bass eggs and larvae no further upstream than 119 km (74 mi) below the North Anna Dam. Because of the distances, the waste heat discharged from Units 1 and 2 is not detectable and does not affect anadromous striped bass populations or known spawning habitat downstream of the dam. Because the Unit 3 closed-cycle, combination wet and dry cooling system and the Unit 4 dry cooling system would not significantly contribute to the current thermal inputs to the WHTF or the lake from the operation of NAPS Units 1 and 2, the staff concludes that the thermal impacts to striped bass in the North Anna/Pamunkey Rivers would be negligible.

Lake Anna Striped Bass Recreational Fishery

The staff distinguishes between the striped bass fishery and the population of striped bass inhabiting the reservoir: the striped bass fishery encompasses all aspects of the activity, business, or practice of catching striped bass in the reservoir and includes the fish, the anglers, and all related activities, such as boating, tackle sales, and guide services. There are three major factors affecting the striped bass population in the reservoir: (1) the VDGIF stocking strategy, (2) Unit 1 and 2 operations and their effect on water temperatures, and (3) recreational fishing pressure. As described above, the effects of NAPS Units 1 and 2 operations would not noticeably change with the addition of Unit 3. Based on the expected blowdown flow and temperature, operation of the Unit 3 closed-cycle, combination wet and dry cooling system would not contribute to the existing thermal inputs occurring from the operation of Units 1 and 2. Because the Lake Anna striped bass population is sustained through stocking, and suitable striped bass habitat is expected to continue to exist in Lake Anna, and in view of the minimal heat input to the WHTF or the lake from Unit 3, the staff concludes that the heat stress impact on the striped bass and associated fishery from Unit 3 operations would be minimal.

5.4.2.6 Downstream Impacts

The streamflow in the North Anna River downstream of the North Anna Dam is influenced by the flow attenuation impact of the lake and policies governing the release from the dam. Based on streamflow data collected downstream from Doswell, Virginia (approximately 32 km [20 mi] downstream of the North Anna Dam), for the period of October 1979 through September 2003, the monthly mean streamflows vary from a maximum of about 23 m^3/s (804 cfs) during March to a minimum of 4 m^3/s (149 cfs) during August (USGS 2006).

Because of the large surface area of the lake, small increases in lake elevations can quickly accommodate significant upstream flood flows. The downstream flow from the dam is less variable than it was prior to impoundment. Under normal operating conditions, release gates on the dam are operated to maintain a steady lake level elevation of 76.2 m (250 ft) MSL. For lake levels less than 76.2 m (250 ft) MSL, the Lake Level Contingency Plan is followed in accordance with Part I.F of the VPDES permit (VDEQ 2001). This plan requires a normal minimum water release rate from the North Anna Dam of 1.1 m^3/s (40 cfs). If the lake level drops to 75.6 m (248 ft) MSL, releases are incrementally reduced to a minimum of 0.57 m^3/s (20 cfs). These minimum flow requirements are established to maintain instream flows and water quality in the North Anna River downstream of the dam, and in the Pamunkey and York Rivers further downstream. Steady low-flow releases from the dam can persist for several months, particularly in the drier summer period, and under conditions of extreme drought (e.g., the drought occurring from October 2001 to December 2002). Low-water conditions are quickly reversed when normal precipitation rates resume in the region, and the water release rate of at least 1.1 m^3/s (40 cfs) would be reestablished. Raising the lake level 25.4 cm (10 in.) would keep the frequency of the low flow conditions with the addition of Unit 3 the same as current conditions with Units 1 and 2.

The VDEQ identified the possibility of raising the lake level 15 to 30 cm (6 to 12 in.) to mitigate the impact on North Anna River downstream flows (Dominion 2006a). The authority to require that the lake level be raised resides with the Commonwealth of Virginia.

While the staff concludes that the incremental heat load from Unit 3 would cause undetectable changes in lake temperature, the evaporative losses from the cooling towers could result in consumptive water losses that may noticeably impact lake levels and downstream flows. The staff performed an independent review of water budget impacts of the operation of Unit 3 to assess incremental declines in reservoir water levels and downstream discharges. The results in Table 5-6 indicate that the percentage of time that the lake would be below 75.6 m (248 ft) would increase from about 6 percent for NAPS Units 1 and 2 (baseline) to 11 percent for NAPS Units 1 and 2 plus Unit 3 (proposal). Because the Lake Level Contingency Plan requires the lake discharges to be incrementally reduced from the normal minimum water release rate of 1.1 m^3/s (40 cfs) to 0.57 m^3/s (20 cfs) as the lake level declines below 75.6 m (248 ft), the percentage of time that the lake level is between 76.2 m (250 ft) and 75.6 m (248 ft) is essentially the same between the baseline (57 percent) and the proposed (55 percent).

As discussed below, the impacts to aquatic ecology during low-flow conditions would likely be greatest in the reach of the North Anna River extending from the dam to the confluence with the South Anna River. To quantify the impacts to instream flows in the North Anna River, Dominion calculated Indicators of Hydrologic Alteration (IHA) using a standard methodology described in ER (Dominion 2006a). The IHA analysis concluded that the Pamunkey River flow downstream of the North Anna River would be reduced by 0.5 to 5 percent for all flow regimes, but that river flow during the months of April and May would be sufficient to support striped bass spawning. Dominion concluded that the biological impacts of the Unit 3 closed cycle, combination wet and dry cooling system to the general aquatic community of the North Anna River and striped bass spawning and rearing areas in the Pamunkey would be indistinguishable from the effects of operations of NAPS Units 1 and 2.

The existing biological communities in the North Anna River and the waters downstream of the North Anna River experience a wide variation in seasonal and even daily water temperatures, and most resident species are able to tolerate potentially stressful conditions because of

Table 5-6. Fraction of Time at Various Lake Level Elevation (with associated downstream releases)

Lake level Elevation (ft)	North Anna Dam Discharge (cfs)	NAPS Existing Units 1 and 2	NAPS Existing Units 1 and 2 plus Unit 3
At or above 250 ft	Follows rating curve (>40 cfs)	37%	33%
Between 250 and 248 ft	40 cfs	57%	55%
At or below 248 ft	20 cfs	6%	11%
At or below 246 ft	20 cfs	1%	2%
Minimum elevation		245.2 ft	243.5 ft

low-flow conditions, anthropogenic impacts, and other physical or chemical stressors. Although the blowdown water from Unit 3 would contain biocides, antiscalants, and dispersals, the concentrations of these chemicals in the blowdown water would not be expected to be sufficiently high to affect species downstream of the dam. Moreover, the use and concentrations of anti-fouling chemicals would be regulated by Dominion's NPDES permit, which establishes discharge criteria to protect sensitive aquatic communities. Because the incremental waste heat transported to the North Anna River would be small, it is not expected to adversely affect the aquatic communities of the North Anna River nor is it expected to influence the temperatures of the Pamunkey or York Rivers or the Chesapeake Bay. As described above, although flow over the North Anna Dam would be reduced to 0.55 m^3/s (20 cfs) an additional 5 percent of the time, sufficient water is expected to be available in the North Anna River to support downstream spawning of striped bass in the Pamunkey River. The lowest flow regimes are likely to occur during the months from June to December when striped bass are not spawning and are less likely to be adversely affected by lower water levels.

A preliminary analysis of American shad, *Alosa sapidissima,* data by VDGIF suggests that a correlation may exist between flow and year class strength. Additionally, the VDGIF has expressed concern over maintaining adequate flows in the North Anna River during March through October for a variety of species and life stages, including herring (*Alosa aestivalis)*, shad, smallmouth bass, striped bass, and resident minnows and suckers. Based on the life-history information described in Jenkins and Burkhead (1994), these species typically spawn in the spring and early summer (March to July) when low-flow conditions are unlikely. This could result in the need to modify the water releases at the North Anna Dam during certain periods of the year.

Operation of Unit 3 could result in consumptive water use resulting from evaporative loss from the cooling towers. Based on the water budget modeling conducted by the staff, the loss of water from Lake Anna reservoir for the operation of Unit 3 would increase the percentage of time that the reservoir would be at or below 75.6 m (248 ft) from 6 percent for the baseline (i.e., operation of NAPS Units 1 and 2) to 11 percent for the operation of Units 1, 2, and 3. This would extend the period of time when releases over North Anna Dam are reduced to 0.57 m^3/s (20 cfs) and result in reduced downstream flow during the summer months or extended periods of drought.

Although the staff concluded that impacts associated with operation of NAPS and proposed Unit 3 on downstream aquatic communities would not be significant, the staff also considered the effects of varying the North Anna Dam release rate during late summer and fall to more closely emulate natural variations in stream flow. The staff determined that varying water release rates might be preferable to a constant release rate in late summer and early fall because most organisms in small rivers are adapted to a varying flow regime and steady flows may result in a change in community structure. Modifications to the water release regime from the North Anna Dam to mitigate impacts would be under the jurisdiction of VDEQ.

5.4.2.7 Shoreline Erosion and Other Physical Impacts

Because low-flow velocities in Lake Anna predominate, increased shoreline erosion, lake-bed scouring, and increased turbidity levels caused by the operation of Unit 3 would not be detectable or destabilizing to the aquatic resources of Lake Anna. The flow velocity in the discharge channel, the connecting canals, and the main ponds of the WHTF would be slightly higher than in Lake Anna because of their smaller dimensions. The proposed Unit 3 closed-cycle, combination wet and dry cooling system would release a maximum of 351 L/s (12.4 cfs) of blowdown water into the existing discharge canal. This represents an increase in the velocity of water in the discharge canal and WHTF of about 0.3 percent. Because the banks of the canals are currently protected by rip-rap from 73.8 to 76.2 m (242 to 250 ft) MSL, the small contribution to flow and velocity from Unit 3 would not result in scouring or erosion in the canal. During the operation of NAPS Units 1 and 2, the flow velocity in the WHTF is generally less than 0.3 m/s (1 ft/s) and has not caused any noticeable scouring or erosion. This would not change based on the small contribution to the overall flow and velocity resulting from the operation of Unit 3.

Physical impacts resulting from increased turbidity or siltation are unlikely, based on the small changes in discharge flow and velocity expected from Unit 3. Siltation is expected to be minimal because any medium or coarse sediment that was suspended would settle before reaching the intake approach channel during normal lake conditions. Sediment entering the new intake channel from floods or storm events would not present a siltation problem because the channel is 3.7 m (12 ft) deeper than required by the design for the new intake, allowing room for occasional sediment deposition. Fine-grained sediment entering the intakes would either be removed during the water treatment process or returned to Lake Anna via the WHTF at Dike 3.

There is no evidence of scouring, erosion, or excessive turbidity from the operation of NAPS Units 1 and 2, and no evidence to suggest that this would change with the addition of Unit 3 given the proportionally small amounts of blowdown water that would be released during normal operations. Based on the foregoing, the staff concludes that the impacts to aquatic ecological resources from physical changes to Lake Anna from operation of Unit 3 closed-cycle, combination wet and dry cooling would be SMALL, and mitigation is not warranted.

5.4.2.8 Summary of Aquatic Impacts

The aquatic plants and animals in Lake Anna represent a balanced aquatic community. Over the years, these populations have changed as the reservoir's ecosystem has matured. Because of the demand for public fishing, the fish community has been changed through species additions (e.g., threadfin shad) and annual stockings of striped bass and walleye. Overall, the fisheries have remained healthy and balanced despite shoreline development, NAPS operations, and increased fishing pressure.

Based on the information provided in the ER (Dominion 2006a), the staff evaluated the impacts to aquatic communities in Lake Anna, the North Anna River, and the downstream river systems to which the North Anna is a tributary. Because Unit 4 would use dry cooling towers, water use would be minimal and would not result in detectible impacts to the aquatic environment. The closed-cycle, combination wet and dry cooling system proposed for Unit 3 would result in significantly less impingement and entrainment than a once-through cooling system, and would contribute minimally to the thermal load currently experienced by the lake from the operations of the NAPS Units 1 and 2. Based on the impingement and entrainment modeling conducted by Dominion and data from the Section 316(b) demonstration study for NAPS Units 1 and 2, as discussed above, the operation of Unit 3 would increase the overall yearly impingement and entrainment losses by approximately 1 percent. These losses are not expected to result in noticeable changes to the fish communities in Lake Anna.

The proposed Unit 3 closed-cycle, combination wet and dry cooling system for would discharge a maximum of 351 L/s (12.4 cfs) at a maximum temperature of 38°C (100°F). This flow rate represents 0.3 percent of the about 120,000 L/s (4246 cfs) flow discharged by NAPS Units 1 and 2, and the discharge temperature of Unit 3 blowdown water is within the range currently observed in the discharge canal during July and August (37.0° to 39.1°C [98.6° to 102.4°F]). Thus, the operation of Unit 3 would result in a negligible change in the volume and temperature of the water entering the discharge canal, the WHTF, Lake Anna, or the North Anna River.

Operation of the Unit 3 cooling system would result in consumptive water use from evaporative losses. Based on the water budget modeling conducted by the staff, Lake Anna reservoir water losses resulting from the operation of Unit 3 would increase the fraction of time that the reservoir would be at or below 75.6 m (248 ft) from 6 percent for the baseline (i.e., operation of NAPS Units 1 and 2) to 11 percent for the operation of Units 1, 2, and 3. This would extend the period of time when releases over North Anna Dam are reduced to 0.57 m^3/s (20 cfs) and result in reduced downstream flow during the summer months or extended periods of drought. Based on the staff's independent review of the IHA analysis conducted by Dominion, sufficient water should be available during the spring and early summer to support striped bass spawning and rearing requirements in the Pamunkey River downstream of NAPS. Based on the foregoing, the staff concludes that the aquatic impacts to Lake Anna and the downstream communities from the operation of Units 3 and 4 would be SMALL, and mitigation is not warranted.

5.4.3 Threatened and Endangered Species

This section describes the potential impacts that operation of the proposed Units 3 and 4 could have on threatened or endangered species at and in the vicinity of the North Anna ESP site. The terrestrial species potentially occurring in the vicinity of the North Anna ESP site are described in Section 2.7.1, and the potential impacts of operating the new units to terrestrial species are examined in Section 5.4.3.1. The threatened and endangered aquatic species potentially occurring near the ESP site are described in Section 2.7.4, and potential impacts of operating the new units to aquatic species are considered in Section 5.4.3.2.

On May 20, 2005, the FWS concurred with the staff's biological assessment that the proposed action would have no effect on the dwarf wedge mussel, small whorled pogonia, sensitive joint-vetch, or swamp pink, and may affect, but is not likely to adversely affect the bald eagle (NRC 2005). On May 17, 2006, the staff informed FWS that it had become aware of two new eagle's nests located approximately 5 and 8 km (2.5 and 5 mi), from the North Anna ESP site (NRC 2006d). The staff concluded that because no ESP activities are proposed within the normal restriction buffer distances 0.4 to 0.8 km (0.25 to 0.5 mi) used for bald eagle management and protection, the proposed actions at the North Anna ESP site are not likely to adversely affect the bald eagle (NRC 2006d).

5.4.3.1 Terrestrial Species

Except for the bald eagle (*Haliaeetus leucocephalus*), no Federally listed threatened or endangered species are known to occur at or near the North Anna ESP site. The closest known bald eagle nesting site is located more than 4 km (2.5 mi) from the North Anna ESP site. In the Commonwealth of Virginia, a 0.25-mile (0.4-km) buffer zone is usually preserved to limit construction activities (FWS and VDGIF 2000). Dominion stated in its May 24, 2006, RAI response that it follows nesting guidelines referenced by the Virginia Department of Game and Inland Fisheries and the U.S. Fish and Wildlife Service (Dominion 2006b). There are no Federally listed terrestrial threatened or endangered animal species that are known to occur along the North Anna River downstream from Lake Anna. Therefore, if any changes to the flow regimes in this portion of the river were made, there would not be an effect on Federally listed threatened or endangered terrestrial species.

Three Federally listed threatened or endangered plant species have been identified as potentially occurring within the NAPS transmission line rights-of-way. These include the small whorled pogonia (*Isotria medeoloides*), swamp pink (*Helonias bullata*), and the sensitive joint-vetch (*Aeschynomene virginica*). In its assessment of the potential impacts of continued operation of the existing NAPS Units 1 and 2, the staff concluded that continued operation and maintenance of the transmission lines and rights-of-way would not adversely impact these plant species (NRC 2002b). Because no changes to the transmission lines and rights-of-way are anticipated to result if the proposed Units 3 and 4 are built, there would be no change to the potential impact of operation and maintenance of the transmission lines or rights-of-way on these threatened or endangered plant species.

The staff evaluated the potential impacts of operation of the proposed Units 3 and 4, including operation of the plants, cooling systems, and transmission systems, as well as potential changes to the flows in the North Anna River on terrestrial threatened and endangered species. Based on this evaluation, the staff concludes that the impacts of operating the proposed new units on terrestrial threatened and endangered species would be SMALL, and mitigation is not warranted.

5.4.3.2 Aquatic Species

Virginia Power has monitored fish populations in Lake Anna and the North Anna River for more than 25 years. No Federally 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. No range of any Federally or State-listed fish species 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).

According to VDGIF and VDCR (Division of Natural Heritage) databases, one Federally listed mussel species (dwarf wedge mussel [*Alasmidonta heterodon*]), and one mussel species (fluted kidneyshell [*Ptychobranchus subtentum*]) that is a candidate for Federal listing, occur in counties that border Lake Anna or the North Anna River. Neither species has been found in Lake Anna or the North Anna River. Neither of the two Federal species nor the State-listed Atlantic pigtoe (*Fusconaia masoni*) has been found in Lake Anna, the North Anna River, or their tributaries.

The staff evaluated the potential impacts of operating the proposed new Units 3 and 4, including operating the plants, cooling systems, and transmission systems, as well as potential changes to the flows in the North Anna River, on aquatic threatened and endangered species. Based on this evaluation, the staff concludes that the impacts of operation on threatened or endangered aquatic species would be SMALL, and mitigation is not warranted.

5.5 Socioeconomic Impacts

This section describes the socioeconomic impacts from operating Units 3 and 4 at the North Anna ESP site, and from the activities and demands of the operating workforce on the surrounding region. Socioeconomic impacts include potential impacts on individual communities, the surrounding region, and minority and low-income populations.

5.5.1 Physical Impacts

This section assesses the potential physical impacts on the nearby communities that could result from the operation of new nuclear units at the North Anna ESP site. Potential impacts discussed include noise, odors, exhausts, thermal emissions, and visual intrusions. Dominion plans to manage these physical impacts to comply with applicable Federal, State, and local environmental regulations (Dominion 2006a). Dominion does not expect operation of the new units to significantly affect the North Anna ESP site and its vicinity (Dominion 2006a). The staff's evaluation is discussed in the following subsections.

5.5.1.1 Workers and the Local Public

Access to the North Anna ESP site is provided by State Route (SR) 700. The terrain around and into the plant site is undulating and wooded. Most of the site structures are screened from public view up to the proximity of the plant boundary. There are no residential areas located within the North Anna ESP site boundary.

Offsite, the region surrounding Lake Anna and the North Anna ESP site is covered with forest and brushwood interspersed with occasional farmland. The population immediately surrounding the lake ranges from about 980 and 2940 within 4 and 8 km (2.5 and 5 mi), respectively, from the ESP site (Dominion 2006a). The town of Mineral, located about 10 km (6 mi) from the North Anna ESP site, has a population of 424 (USCB 2000).

Because of its distance from the ESP site, residents of Mineral would experience minimal physical impacts from operation of the new units. Depending on meteorological conditions (e.g., wind direction), people who work or live close to the North Anna ESP site (the nearest residence is about 1000 m [3000 ft] away) could experience some noise (particularly from the Unit 3 and 4 cooling systems), fugitive dust, and gaseous emissions resulting from operation activities. Those least impacted by station operations would be transient populations, such as temporary employees, recreational visitors to Lake Anna, and tourists passing through the area. Such effects should be transient and have minimal impact.

Personnel working onsite are most likely to be impacted by station operation. The number of employees at the North Anna site would double to approximately 1600-plus employees if both Units 3 and 4 were in operation. Onsite impacts to permanent workers from station operations could be mitigated through adequate training and use of personal protective equipment to minimize the risk of potentially harmful exposures. Standard management practices should minimize such exposures. Emergency first-aid care and regular health and safety monitoring of permanent operating personnel could also be undertaken.

The staff evaluated the information provided by Dominion and notes that most of the local public is located well away from the North Anna ESP site and onsite impacts to North Anna ESP workers can be mitigated. Based on these considerations and its own independent review, the staff concludes that the overall physical impacts of station operation to workers and the local public are SMALL, and additional mitigation beyond the actions discussed above is not warranted.

5.5.1.2 Buildings

Because operational activities are not expected to impact any offsite buildings, most of which are located well away from the North Anna ESP site boundaries, the staff concludes that any offsite physical impacts from station operation to buildings would be SMALL, and mitigation is not warranted.

5.5.1.3 Roads

In its analysis, the staff assumed that by the time North Anna Units 3 and 4 would begin operation, improvements to the road systems around the North Anna ESP site, if any, (as discussed in Sections 4.5.1.3 and 4.5.3.2) would have been completed. Construction of Units 3 and 4 would require up to 5000 workers while the operating workforce would number approximately 720, in addition to the 850 permanent workforce at the existing units. Thus, any impacts to the road system by the operating workforce would most likely be significantly less than impacts incurred with the addition of the construction workforce.

There may be some congestion at the entrances to the North Anna ESP site at shift changes. There may also be some ambient dust levels from commuter traffic into and out of the North Anna ESP site, but this is expected to be minimal because commuters to and from the site would be using paved roads.

Based on the staff assumption that any needed upgrades to the regional road system would have been made in conjunction with, or as a result of, the construction of Units 3 and 4, and that the number of operating personnel would be significantly fewer than the number of construction personnel, the staff concludes that the physical impacts of station operation on the road system would be SMALL, and mitigation is not warranted.

5.5.1.4 Aesthetics

The turbine building for Units 1 and 2 is about 30 m (100 ft) above grade and the containment buildings are about 40 m (130 ft) above grade. The tallest building for Units 3 and 4 could be 71 m (234 ft) above grade, the Unit 3 closed-cycle, combination wet and dry towers would be less than 55 m (180 ft) tall, and the Unit 4 dry towers would be about 48 m (150 ft) tall (Dominion 2006a). The ESP and cooling tower site grade would be lower than the surrounding terrain, except in the direction of Lake Anna. Given a distance of about 900 m (3000 ft) to the nearest residence, screening by trees and other vegetation on the wooded ESP site, and relative elevations, most residents near the site would not have a clear view of Units 3 and 4. However, recreational users on the Lake Anna Reservoir and some residents along the lake would be able to see the new units in addition to the other developed areas of the NAPS site already visible. The tallest building at least would rise above the treeline, but would be largely screened by trees on the south, north, and west.

The Unit 3 closed-cycle, combination wet and dry cooling system would generate a vapor plume that could be visible above the height of the plant buildings and that could extend beyond the site boundary. The plume would be most prevalent during times when the ambient temperature is low and when the dry bulb and wet bulb temperatures are nearly equal. Typically this would be between late autumn and early spring.

The environmental impact of the operation of the wet towers portion of the cooling system was evaluated by Dominion using the SACTI (Seasonal and Annual Cooling Tower Impacts) system of computer programs, initially written and assembled by the Argonne National Laboratory (ANL) (ANL 1984) for the Electric Power Research Institute, and was used to estimate the impact of operating the cooling towers. The version used by Dominion is dated November 1, 1990. The input meteorological data used to estimate the impacts encompassed the period of 1998 through 2000. It included data collected onsite as well as site representative data collected at the National Weather Service sites in Richmond, Virginia, and Dulles Airport in northern Virginia. For the calculations, the cooling towers were analyzed operating in the EC mode, which results in the greatest evaporation rates from the towers, and therefore, resulted in the greatest level of impacts (Dominion 2006a).

The results of the staff's independent analysis indicated that for all seasons, the plume would extend to a maximum height of 980 m (3200 ft) and to a length of 4900 m (16,000 ft) from the tower. The annual duration of plume fogging (i.e., the plume remaining at the ground level) would be about 70 hr (excluding hours of natural fog), with a majority of fogging occurring at about 300 m (1000 ft) to the south-southeast from the cooling towers. Fogging would, however, occur as far as 1600 m (5200 ft) from the tower. Fogging is estimated to occur during all seasons except summer. The analysis indicates that icing is unlikely to occur in conjunction with ground-level fogging (Dominion 2006a).

Operational Impacts at the Proposed Site

Table 5-6 presents estimates, by season, of the approximate percentage of time that the plume would extend above the tallest structure in the PPE (71 m [234 ft]) or would extend more than 800 m (about 2600 ft) from the towers.

In Dominion's plume model, the top of the tallest structure in the PPE is approximately 50 m (160 ft) above the top of traditional mechanical-draft wet cooling towers, which are only 22 m (74 ft) tall. The shorter traditional wet cooling tower was used in the analysis to provide an upper bound for nearby plume effects such as fogging or salt drift. The Unit 3 closed-cycle, combination wet and dry cooling system described in the ER would be 55 m (180 ft) tall. Dominion suggests that the cooling towers could be plume-abated, which would significantly reduce the visual impact below that shown in Table 5-7. The frequency results reported below are for a release point between 40 m (130 ft) and 50 m (160 ft) below the height of the tallest structure on the North Anna ESP site. The evaluation indicates that on an annual average basis, the plume would extend more than 200 m (650 ft) above the tower or extend more than 400 m (1300 ft) in length approximately 10 percent of the time the wet towers are operating. These results are based on the wet cooling towers operating 100 percent of the time in the EC mode, which results in the most fogging.

Deposition of salts from cooling tower drift would occur in all directions from the towers out to 1525 m (5000 ft), but would occur predominately in the areas to the north through northeast as well as to the south through southeast of the towers. The maximum estimated amount of deposition is calculated to be 12.6 kg/km^2/month at 175 m (575 ft) north-northeast of the cooling towers. The vast majority of the drift deposition would occur within 300 m (1000 ft) of the towers. Significant chemical interaction of the cooling tower plume and pollutants emitted onsite or in the vicinity of the plant is not anticipated.

In its May 24, 2006, response to the NRC's Request for Additional Information (Dominion 2006b), Dominion represented that the fogging and salt-deposition analysis conducted as a part of this ESP application remains bounding (see Appendix J).

In Appendix K, the staff evaluated the impacts of Unit 3 operation on water use in relation to water levels within Lake Anna over a 35-year period; the analysis is also applicable to the aesthetics impacts as well. Lake levels would be above 75.6 m (248 ft) about 89 percent of the time with Units 1 and 2 and Unit 3 operating versus about 94 percent with only NAPS Units 1 and 2 operating. Levels below 75 m (246 ft) (just above the lowest level experienced during the 2001 to 2002 drought) could occur about 2 percent of the time with Unit 3 operating, versus 1 percent with only NAPS Units 1 and 2 operating. The minimum water level with Unit 3 operating was estimated at 74.22 m (243.5 ft), versus 74.74 m (245.2 ft) with only NAPS Units 1 and 2. Under severe drought conditions, Unit 3 could have an exacerbating effect on the drawdown of Lake Anna, potentially adding to the duration of low water levels, which would affect the visual impact of the amount of shoreline exposed.

Table 5-7. Fraction of Time by Season That Water Vapor Plume from the Proposed Unit 3 Wet and Dry Cooling Towers Would Exceed the Height of the Tallest Structure in the PPE or Would Extend More than 800 m (2625 ft) from the Towers

Season	Plume height >40 m (131 ft) above top of towers	Plume height >50 m (164 ft) above top of towers	Plume length > 800 m (2625 ft) from towers
Winter	89	49	20
Spring	77	29	11
Summer	78	20	4
Fall	79	27	7

Source: Dominion 2006a

Because the new units would be located in the existing power station complex and the visual aspects of the site to offsite viewers would be limited by screening and topography, and based on information provided by Dominion (2006a) and its independent review, as discussed above, the staff concludes that the aesthetic impacts from the operation of Units 3 and 4 would be SMALL. There would be an elevated steam plume from the operation of the Unit 3 cooling towers; the staff concludes that the visual impacts would be quite noticeable at times, especially during the winter (periodic MODERATE visual impact). On an annual basis, however, this impact would be limited to about 10 percent of the time and would be the least from mid-spring to early fall when outdoor recreation is most likely to occur. In addition, the staff identified that during severe drought conditions, the operation of Unit 3 would have an impact on the water levels by slightly adding to the duration and extent of shoreline mud flats that could be exposed; the staff concludes that these visual aesthetic impacts would temporarily be MODERATE. Mitigation is not warranted because of the temporary and infrequent nature of the impacts.

5.5.2 Demography

Population in the region within a 80-km (50-mi) radius of the North Anna ESP site is projected to grow at an average annual rate of 1.7 percent between 2000 and 2020 (i.e., from 1,538,156 in 2000 to 2,161,660 in 2020; see Table 2-5). The economy in the region is considered to be strong and is growing.

There are currently 850 personnel employed at NAPS for Units 1 and 2 (Dominion 2006a). Approximately 720 additional permanent workers would be required for the operation of the proposed Units 3 and 4 (Dominion 2006a). As an upper-bound estimate, the staff assumed that these 720 workers would relocate into the area with their families (i.e., none of the new workers already lived in the area). The 720 additional employees would translate into an increase in population of about 2900 to the region, assuming each new employee represents a family of four (Dominion 2006a). Assuming that the geographic distribution of new employees would be the same as for the existing units when it was evaluated for license renewal (NRC 2002b) (see

Table 2-17), about 208 new employees would settle in Louisa County, 163 in Spotsylvania County, 105 in Orange County, 91 in Henrico County and the City of Richmond, and 153 in the other counties within an 80-km (50-mi) radius of North Anna ESP site.

The addition of the new employees and their families would equate to the following percentage increase in population (using 2000 census data, see Table 2-7): Louisa County, 3.2 percent; Orange County, 1.6 percent; and Spotsylvania County, 0.7 percent. The potential percentage increase for Henrico County and the City of Richmond would be substantially less than 0.1 percent. Overall, the potential increases in population do not represent a large percentage increase in the total population, even for Louisa County, which is expected to gain the highest percentage of new employees.

Some new jobs may result from employment of the new operating personnel through the multiplier effect attributable to the operations workforce. But these increases, when compared to the total population base in the region, would be expected to be minimal as well. And many of these new jobs would be filled by workers who already reside in the region.

The staff evaluated the impacts of station operation on increases in population and determined that while the new operating personnel are expected to come from outside the region, their small numbers, when considering the population base of each jurisdiction, would not significantly increase the base population within each jurisdiction. Most new jobs created through the multiplier effect are expected to go to workers who already reside in the region. Based on these considerations, the staff concludes that the impacts of station operation on increases in the regional population would be SMALL, and mitigation is not warranted.

5.5.3 Community Characteristics

This section evaluates the social and economic impacts to the surrounding region as a result of operation of Units 3 and 4 at North Anna ESP site. The evaluation assesses impacts of operation and of those demands placed by the workforce on the surrounding region during a 40-year operating license period. Dominion expects to employ up to an additional 720 workers to operate the new units (Dominion 2006a). This is in addition to the 850 personnel currently employed at the site (Dominion 2006a).

5.5.3.1 Economy

The impacts of station operation on the local and regional economy are dependent on the region’s current and projected economy and population. Some insight can be obtained on the projected economy and population by consulting county comprehensive plans and data from the U.S. Census Bureau. The economic impacts over a 40-year period of station operation are qualitatively discussed.

Dominion stated that most new operating personnel are expected to come from outside the region (Dominion 2006a). Their employment for such an extended period of time would have economic and social impacts on the surrounding region. Louisa County (site of the operating plants) would be the most impacted. Orange County may be the second most impacted. Outside of these areas, the impacts become diffuse as a result of interacting with the larger economic base of the surrounding counties and the City of Richmond. Impacts would affect areas such as transportation, taxes, aesthetics and recreation, housing, public services, and education, which are discussed separately in the following sections. The magnitude of the impacts hinge on (1) the percentage of the workforce that would come from within the region of interest (80 km [50 mi]) and thus commute to the site and (2) those workers who might relocate to the area and whether they relocate to Louisa and Orange Counties or Henrico County and the City of Richmond.

The new jobs, as with the construction workforce, would also create new jobs in the region through the multiplier effect. Any multiplier effect resulting from the operating personnel expenditures in the region would most likely mean that some residents would obtain new or higher paying jobs as a result of the increased economic activity.

The staff reviewed the generally positive impacts of station operation on the economy of the region and concludes that the impacts (including tax receipts; see Section 5.5.3.3) would be small everywhere except potentially in Louisa and Orange Counties, where the impacts could be moderate. The magnitude of the economic impacts would be diffused in the larger economic bases of Henrico and Spotsylvania Counties and the City of Richmond; whereas, within the smaller economic bases of Orange and Louisa Counties, the economic impacts would be more noticeable. Based on the effects of station operation on the regional economies, the staff concludes that the impacts would be SMALL BENEFICIAL to MODERATE BENEFICIAL (Louisa and Orange Counties).

5.5.3.2 Transportation

Section 4.5.3.2 discusses a number of permanent changes to the regional and local transportation network that could be made to reduce potential adverse impacts generated by the influx of 5000 construction workers during construction of the new units. These include improvements planned for I-95, U.S. 33, and State roads in Spotsylvania and Louisa Counties, among others. These permanent changes, if implemented, would reduce or eliminate any potential adverse impacts that could be generated by the additional operating workforce of about 720 workers and their families.

Impacts that might occur include potential congestion on some of the Federal and State routes leading to the North Anna ESP site. In addition, there could be crowding and congestion at the entrance to the plant site during shift changes, as previously discussed. Not all of the additional 720 permanent workers for Units 3 and 4 and existing operating labor force for Units 1 and 2 would be commuting to and from the site at the same time and would mostly likely be spread throughout the 24-hour period in three shifts. Outage workers would add to this total periodically on a temporary basis.

Should transportation difficulties arise during the period of operation, the staff expects that Dominion would cooperate with local jurisdictions and would implement some of the mitigation practices undertaken during the construction phase as part of its traffic management plan, such as promoting car and van pools to reduce the number of vehicles on the roads leading to the plant (see Appendix J).

Based on the staff's assumption that transportation network improvements would be made during the construction phase to accommodate the much-larger construction work force and that Dominion would implement a traffic management plan, as needed, the staff concludes that the overall impacts of station operation on transportation would be SMALL, and further mitigation would not be warranted.

5.5.3.3 Taxes

Several types of taxes would be applicable to the permanent workforce at North Anna ESP site. These include income taxes on wages and salaries paid and corporate profits, sales and use taxes on purchases, and property taxes on owned, real property. Each is briefly discussed in turn.

Income Taxes

Virginia has both personal and corporate income taxes. Wages and salaries of permanent employees of Dominion's new operating units would pay taxes to Virginia if they reside in Virginia. Dominion would pay a corporate income tax to the Commonwealth on the profits received from the new units. While the exact amount of tax payable to Virginia is not known, it could be substantial over the 40-year life of the operating units. The taxes collected through personal income and corporate tax, while substantial, are nevertheless a small sum when compared to the total amount of income taxes Virginia would collect over that period.

Sales and Use Taxes

Virginia has two types of sales and use taxes. Four percent is levied on certain food items with 3 percent going to the Commonwealth and 1 percent going to the local jurisdiction in which the tax is collected (VTAX 2000). In addition, Virginia has a 4.5 percent sales tax levied on other goods and services sold, with the Commonwealth receiving 3.5 percent and local jurisdictions receiving the remaining 1 percent (VTAX 1987). The current combined sales and use tax rate for Louisa County is 4.5 percent; 3.5 percent would be paid to the Commonwealth of Virginia and 1 percent to the locality, such as Louisa County (Dominion 2006a).

The Commonwealth and the counties surrounding the North Anna ESP site would experience an increase in the amount of sales and use taxes collected from purchases made by the employees of the site. Additional sales and use taxes would be generated by expenditures by the workers at restaurants, hotels, and retail outlets. The taxes paid to any one jurisdiction are a small sum when compared to the total sales and use taxes collected by the region as a whole.

Property Taxes

The counties surrounding the ESP site and the City of Richmond would benefit from additional revenue generated by property taxes collected from new North Anna employees who purchase houses.

Property taxes would be levied on Dominion by Louisa County for the increase in value of the NAPS property because of the new units, as well as continued levies on the existing Units 1 and 2. An average of 46 percent of the property taxes collected in Louisa County between 1995 and 2003 came from Dominion for NAPS (Section 2.8.2.3). The addition of the new units at the North Anna ESP site could substantially increase the property tax payments. The existing units have enabled the property tax rate assessments in Louisa County to remain substantially below those of neighboring counties (Section 2.8.2.1). Operation of the new units would help offset the depreciation of the existing units; thus, NAPS could continue to be a major benefit to Louisa County when the new units start operating.

The potential effects of electric utility deregulation within Virginia on Units 3 and 4 are not known at this time (NRC 2002b). However, it is reasonable to conclude that the operation of new units should result in an increase in, or at least the maintenance of, the existing amounts paid in property taxes to Louisa County.

It is not possible to estimate either the real property taxes on housing that would be paid to the regional governments by the new employees locating to the area, or expenditures that the regional governments would incur as a result of the need to provide increased services (e.g., school, recreational, medical, fire, and police, and transportation systems) for the new employees at North Anna site. The expenditures by the regional governments would, in part, be related to the number, size, and age distribution of the families of the new employees.

The staff considers the overall impacts of the property taxes collected to be beneficially large for Louisa County and small for the other counties in the vicinity of NAPS. The amount of property taxes collected on the operation of the new units could represent a significant portion of the total property taxes collected by Louisa County.

Operational Impacts at the Proposed Site

Summary of the Impact of Taxes

The staff independently evaluated the effect of taxes from income on wages and salaries of Units 3 and 4 operational workers, and sales, use, and property taxes on these employees and on Dominion's corporate profits, most of which represent beneficial sources of income for the Commonwealth, some of which would benefit the counties in the region. Property tax paid by Dominion would directly benefit Louisa County. Based on its independent review of the overall impacts from income, sales and use, and property taxes, the staff concludes that the beneficial impact level would be SMALL on the region to LARGE for Louisa County.

5.5.3.4 Recreation

Most of the 43,000 anglers visiting Lake Anna every year launch their boats at Lake Anna State Park and at commercial marinas. Pleasure boat traffic on the lake exceeds angler traffic by as much as 10 to 15 times. Use of stationary boat docks would be impacted when the lake level drops below 76 m (248 ft) MSL. At and below this level, many of the stationary docks become unusable. However, boat ramps would be usable for launching boats until the water level receded below the end of the ramp. During the 2001 to 2002 drought, most private boat ramps could not support launches at lake levels below 74.7 m (245.1 ft) MSL (Dominion 2004c). Even though they were adversely affected because of lower traffic and costs incurred to extend ramps, adjust docks, and move boats, most of the marina operations and fishing guides were able to adjust their operations and continue to operate profitably (Jaksch and Scott 2005). The staff does not expect adverse impacts from NAPS on marinas and guides in normal water years. Because of the adjustments already made in 2001 and 2002, the staff concludes that impacts on marina operators and fishing guides from operations of four units (even in drought years) would be SMALL to MODERATE and temporary, and additional mitigation is not warranted.

Visitors to the State park actually increased during 2002 above the previous years, while the number of boat launches at the park in 2002 was fewer than launches in 2001 by 13.2 percent. The number of boat launches declined by an additional 2.4 percent in 2003, which was not a drought year.[a] Thus, there appears to have been a decline in boating during the drought years, but an increase in the use of the park itself. As discussed in Section 5.5.1.4, operation of the Unit 3 closed-cycle, combination wet and dry cooling system would slightly exacerbate conditions at the lake during times of drought.

These impacts could have economic consequences for the three counties surrounding the lake. The more immediate impacts would be to the marinas and commercial businesses that earn revenue on a seasonal basis from recreational users of the lake. If drought conditions persist over a long enough time period, property values around the lake could be affected as well.

(a) Note that these numbers do not include boat launches from private marinas.

Owners of lake-front homes with preferred water views would be particularly impacted. However, larger market forces such as general economic conditions, population trends, and interest rates are expected to dominate property values in almost all circumstances. Minimal recreational impacts to Lake Anna from operation of the units are expected to occur during non-drought conditions. Based on data from the Federal Financial Institution Examination Council, the average dollar value of loans to buy houses in census tracts touching Lake Anna continued to increase from 2000 to 2002, indicating that property values were not likely to have suffered significant reduction as a result of the 2000 to 2002 drought (FFIEC 2001, 2002, 2003).

As discussed in Section 5.3.2, the staff also evaluated changing the normal elevation of Lake Anna and the impacts of raising normal operating lake level 15 to 30 cm (6 to 12 in.) above 76.2 m (250 ft) MSL. Raising the lake level could increase localized flooding potential and downstream flows, and would likely affect use of some residential and marina boat ramps and docks, including those at Lake Anna State Park. These facilities might need some modification to avoid impacting the year-round and seasonal recreational usage of the lake. The staff concludes that the recreational impacts of raising the lake level would be MODERATE.

Although the WHTF is considered by Virginia Power to be part of the nuclear facility and is operated as a private industrial facility, homeowners on the shoreline of the WHTF have access to it, with Virginia Power's permission, for recreational use (e.g., boating, fishing, swimming). This limited access and use would remain unchanged following the addition of the cooling systems for Units 3 and 4. Dominion evaluated the potential thermal and chemical impacts of Unit 3 and 4 operations on the ability of homeowners to continue their recreation activities. Dominion determined that there would be virtually no change in temperature of the WHTF as a result of the operation of Units 3 and 4, and there would likely be no impact on thermophilic organisms. While Dominion has not identified which chemicals would be added to the proposed cooling towers to manage water chemistry, it also committed to evaluate potential additives in accordance with "applicable EPA human health and aquatic life criteria to demonstrate that the concentrations of these chemicals in the WHTF would not exceed the criteria, and thus would not pose any risks to human health" (Dominion 2006a). Based on the foregoing, the staff concludes that the thermal and chemical impacts from the operation of Units 3 and 4 on recreation would be SMALL, and mitigation is not warranted.

Based on the individual aspects of recreational activities in the North Anna ESP site area, if the normal operating level of Lake Anna remains at 76.2 m (250 ft), the staff concludes that the recreational impacts of Unit 3 and 4 operations would be SMALL most of the time, but could be MODERATE during the infrequent extreme droughts. Therefore, mitigation is not warranted. The staff concludes that if the normal operating level of the lake is raised 15 to 30 cm (6 to 12 in.), then modification of residential and marina boat ramps and docks may be necessary; this action could result in a MODERATE impact.

5.5.3.5 Housing

Section 2.8.2.5 reviewed the availability of housing in the region and presented tables specifically showing that the availability of housing units for sale and rent in the region could easily accommodate the expected permanent workforce of 720 new employees. Further, the counties in the vicinity of the North Anna ESP site and within the region are addressing the needs of the projected increases in population in their comprehensive plans (Louisa County 2001; Spotsylvania County 2002; Orange County 1999).

Spotsylvania, Louisa, and Orange Counties do not have growth moratoriums (Hayfield, Kube, Martyn et al. Williams and Buckler, Gross and Taylor in Jaksch and Scott 2005). The incomes of the new workforce would generally be expected to be higher than the average incomes in Orange and Louisa Counties and the City of Richmond. The staff also anticipates that the new operating personnel would buy housing in the region rather than renting. It can be expected that the prices paid for housing by these employees would be on the high end of the price range within these counties and the City of Richmond. However, the new workers and their families are a small percentage of the existing and projected populations for the counties and the City of Richmond over the next 10 years (see Table 2-11). Therefore, the staff expects the impact on housing prices of workers locating to the counties within the larger population areas (Henrico County and the City of Richmond) to be minimal.

In Spotsylvania County, housing prices are high relative to the surrounding counties. In Orange and Louisa Counties there could be upward pressure on housing prices at the upper end of the range because there are fewer units available in that range and some new construction may need to take place to meet demand. The staff would expect many of the new employees to locate into existing upscale areas of development in these counties, such as Lake Anna (Orange, Louisa, and Spotsylvania Counties) and Lake of the Woods (Orange County). Should that be the case, there are enough home builders available to meet an increase in demand (Ryan, Waugh in Jaksch and Scott 2005), although there are some shortages in the specialty skills such as stone or brick masons (Ryan in Jaksch and Scott 2005).

Based on the existence of a sufficient supply of houses in all price ranges within Henrico and Spotsylvania Counties and the City of Richmond, the staff concludes that the impacts of station operation on housing would be SMALL in these areas, and mitigation is not warranted. Because of their proximity to the North Anna ESP site, the housing market within Orange and Louisa Counties could experience a temporary shortage that would increase housing prices that could create a moderate impact in the short-term. However, eventually over the 40-year operating life, the supply of housing would increase to meet demand. Therefore, the staff concludes the long-term impacts of station operation in Orange and Louisa Counties would be SMALL, and no mitigation is warranted.

5.5.3.6 Public Services

Water Supply and Waste Treatment Facilities

As discussed in Section 2.8.2.6, Louisa and Orange Counties, in light of current growth, have some concern about water and sewer infrastructure in certain parts of their respective counties, which are currently experiencing growth or are expected to grow. The incorporated areas of the two counties appear to have excess capacity in their sewer treatment facilities, but the recent drought revealed a water-supply issue. Wells and septic tanks are the methods of managing water supply and sewage disposal in residential developments outside the incorporated areas. Louisa County addresses the issue of water supply in its comprehensive plan (Louisa County 2001). Orange County is encouraging development in the existing growth areas to lessen the impact on the rural character of the county (Orange 1999). Spotsylvania and Henrico Counties and the City of Richmond appear to have adequate infrastructure and excess capacities for both water and sewage disposal.

The current water supply and sewage disposal issues in Orange and Louisa Counties would exist whether the two new nuclear units were operated or not, and could be exacerbated with normal, projected population growth. The potential impacts associated with hiring new permanent employees would be contingent on where in the counties the employees locate, whether there are water and sewer issues in those locations, and the extent to which they have been previously addressed.

Police, Fire, and Medical Facilities

As discussed in Section 2.8.2.6, there are no hospitals in Orange and Louisa Counties. Most patients requiring hospitalization travel to Charlottesville, Culpeper, Fredericksburg, or to the Henrico County/Richmond area. In Orange County, the fire departments are made up of volunteers, and rescue services are composed of both volunteer and paid employees. Services may need upgrading to account for normal population growth and, if upgraded, could account for any population growth caused by the new employees. In Louisa County, general fire, police, and rescue services are considered presently adequate. In the larger metropolitan area of Richmond/Henrico County and Fredericksburg/Spotsylvania County, police, fire, and medical facilities would not be materially impacted by an increase in the permanent workforce at the North Anna ESP site. This is because the 720 new employees would be a small fraction of the expected population growth in these areas.

Social Services

This section focuses on the potential impacts of station operation on the social and related services provided to segments of the disadvantaged population in Louisa and Orange Counties. Issues surrounding environmental justice are discussed in Section 5.7.

Operational Impacts at the Proposed Site

Operation of the new units at the North Anna ESP site is viewed as beneficial to the economically disadvantaged population segments served by the Departments of Social Services for Louisa and Orange Counties. Operation of the new units may enable members of the disadvantaged population to improve their social and economic position by advancing to higher paying jobs created by the multiplier effect of station operation jobs. Based on where the current operating workforce for Units 1 and 2 lives and with the expectation that the new employees would follow similar location patterns, many of these benefits could accrue to Louisa County.

The expected benefits of station operation to Orange County would be, as in Louisa County, the secondary jobs provided by expenditures of the operations workforce in the county. Many of the jobs created through the multiplier effect could be of the type that would go to members of the disadvantaged population.

Summary of Public Services

Based on the information provided by Dominion and the staff's independent review of the local and regional water and wastewater treatment capacities; the police, fire, and medical facilities; and the demand for social and related services, the staff concludes that any increase in demand for these services by an increase in the operations workforce would be SMALL, and mitigation is not warranted. The increase in employment associated with station operation could have beneficial impacts, which could reduce the demand for social services, while the increase in tax revenue could help with the infrastructure and resource requirements from potential increase in demand for other services (e.g., police and fire).

5.5.3.7 Education

As discussed in Section 2.8.2.7, Orange County is currently expanding its school infrastructure and, as a result, could accommodate modest growth in student population. Louisa County schools are currently overcrowded. Enrollment is growing at 2 percent a year. Tax rates in the county have not been increased in six years, so that while the schools are being maintained, there has been no new construction to accommodate the increased enrollment. Property was purchased to build a new elementary school in 2004 with construction to start in 2007. Property has also been purchased for a new middle school (Lintecum in Jaksch and Scott 2005). Any increase in student population caused by the newly hired permanent workers relocating to the county could exacerbate the existing situation if the additions to the educational infrastructure do not take place.

A majority of the new workers would be expected to establish residences in the larger population areas such as Henrico, Hanover, and Spotsylvania Counties and the City of Richmond; the staff assumes that the new workers would follow the same location patterns as the current permanent workforce at the NAPS site. Given that the workers would be distributed throughout the metropolitan region, the effects of increased enrollment of students on school infrastructure in those areas is expected to be minimal. It is also possible, should crowding continue to exist in Louisa County at the time the new workers are hired, that such conditions could cause fewer new workers to locate in Louisa County than might otherwise.

Orange County currently has excess capacity (Baker in Jaksch and Scott 2005). Louisa County is addressing its current overcrowding problem through the planned building of new schools (Melton, Lintecum in Jaksch and Scott 2005). Any new construction undertaken to meet the demands placed on the system by the construction workforce would be available to accommodate the demands of the operation workforce. The staff considers the infrastructure in Spotsylvania and Henrico Counties and the City of Richmond to be adequate given the size of the base population vis-a-vis the small increase in that population caused by the new employees relocating to these jurisdictions. Based on the information provided by Dominion and the staff's independent review of the local and regional educational facilities, the staff concludes that the impact on education as a result of station operation would be SMALL, and mitigation is not warranted.

5.6 Historic and Cultural Resource Impacts

The National Historic Preservation Act (NHPA), as amended through 2000, requires Federal agencies to take into account the potential effects of their undertakings on historic properties. The review process mandated by Section 106 of the NHPA is outlined in regulations promulgated by the Advisory Council on Historic Preservation codified at 36 CFR Part 800. Evaluating the suitability of potential ESP sites for construction, operation, and decommissioning of new power units is an undertaking that could possibly affect either known or potential historic properties that may be located at the site. Therefore, in accordance with the provisions of NHPA, the NRC is required to make a reasonable effort to identify historic properties in the area of potential effects. If no historic properties are present or affected, NRC is required to notify the State Historic Preservation Officer before proceeding. If it is determined that historic properties are present, NRC is required to assess and resolve possible adverse effects of the undertaking. Should an alternate site be selected for an ESP, NRC would also undertake consultation with all potentially affected Native American tribes regarding the possible presence of traditional cultural properties or other culturally sensitive resources at the site. For more specific historic and cultural information on North Anna, see Section 2.9.

In that all ground-disturbing activities that could have an impact on historic or cultural resources would probably occur during the construction phase, there would be limited potential for impacts during operation of additional power units at North Anna. Should archaeological, historic, or other cultural resources be uncovered during site excavation, Dominion would implement the NAPS site-wide Excavation and Backfill Work Procedures (NAPS NSS Work Procedure WP-C01) involving an immediate stop work order and contact the appropriate organization and/or regulatory agency for proper evaluation and designation, in accordance with the existing procedures (Dominion 2006a). Based on the limited potential for historic or cultural resources on site and NAPS existing mitigation plan should such items be discovered, the staff concludes that the historic and cultural impacts from operations would be SMALL, and mitigation is not warranted.

5.7 Environmental Justice Impacts

Environmental justice refers to a Federal policy under which each Federal agency identifies and addresses, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority[a] or low-income populations. On August 24, 2004, the Commission issued its policy statement on the treatment of environmental justice matters in licensing actions (69 FR 52040). Figures 5-1 and 5-2 show the locations of minority and low-income populations around the NAPS site and within an 80-km (50-mi) radius that meet the NRC guidance criteria for potentially affected areas (NRC 2004c).

The staff identified the pathways through which the environmental impacts associated with the construction of Units 3 and 4 at the NAPS site could affect human populations. The staff then evaluated whether minority and low-income populations could be disproportionately affected by these impacts. In its December 2003 onsite review, the staff interviewed local government officials and the staff of social welfare agencies concerning potentially disproportionate impacts to low income and minority populations (Jaksch and Scott 2005). The staff found no unusual resource dependencies or practices, such as subsistence agriculture, hunting, or fishing through which the populations could be disproportionately impacted by construction of Units 3 and 4 at the NAPS site that would result in those populations being adversely affected. In addition, the staff did not identify any health-related or location-dependent disproportionately high and adverse impacts affecting these minority and low-income populations.

Based on information provided by Dominion and its own independent review, the staff concludes that offsite impacts of operation of Units 3 and 4 at the North Anna ESP site to minority and low-income populations would be SMALL, and mitigation is not warranted.

(a) The NRC Guidance for performing environmental justice reviews defines “minority” as American Indian or Alaskan Native; Asian; Native Hawaiian or other Pacific Islander; Black races, or Hispanic ethnicity (“other” may be considered a separate minority category.) The 2000 census included multi-racial data. The staff should consider multi-racial individuals in a separate minority category, in addition to the aggregate minority category (NRC 2004c).

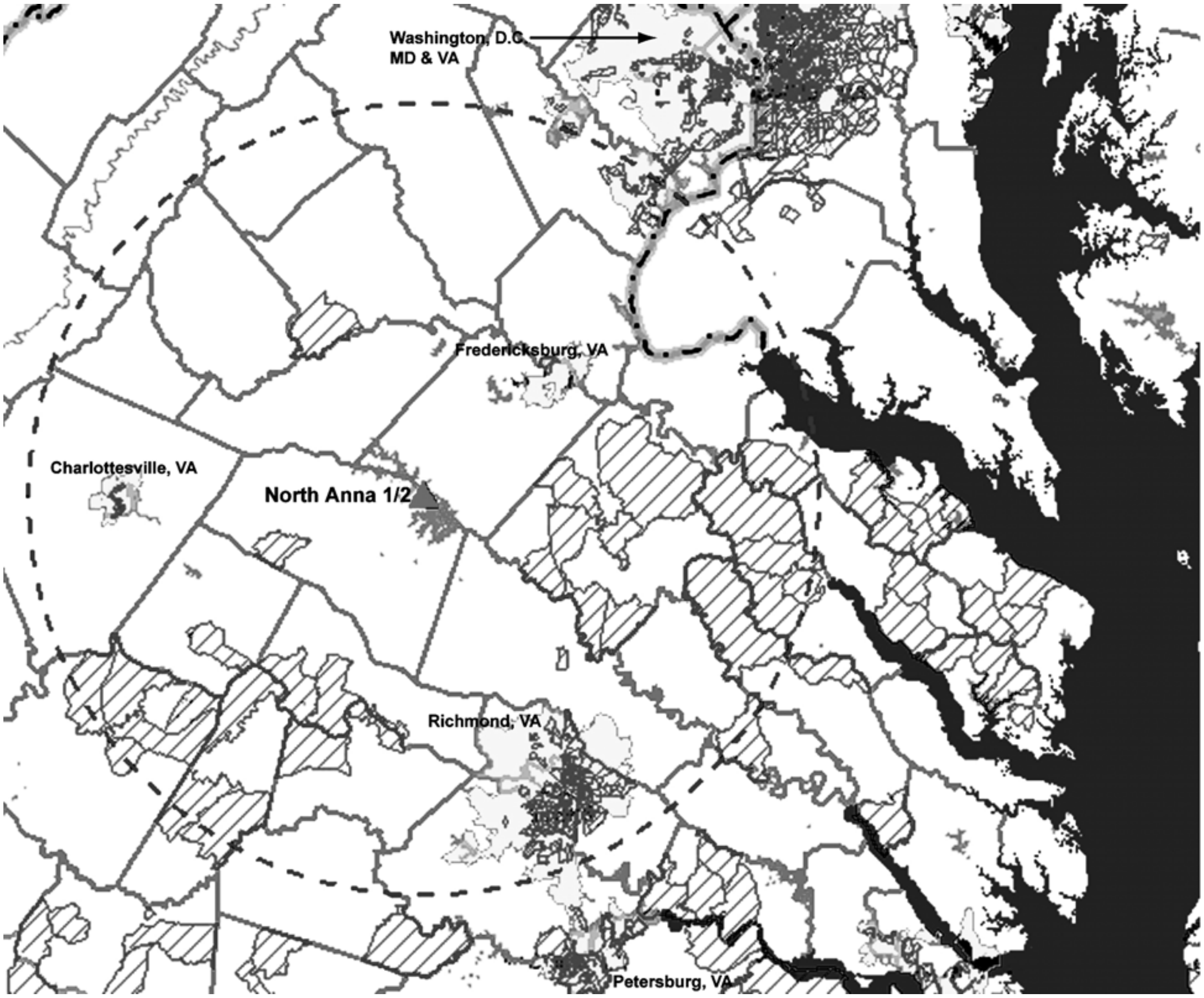

Figure 5-1. North Anna Census 2000 Environmental Justice Minority Populations (Crosshatched Areas) Within an 80-km (50-mi) Radius of the North Anna ESP Site

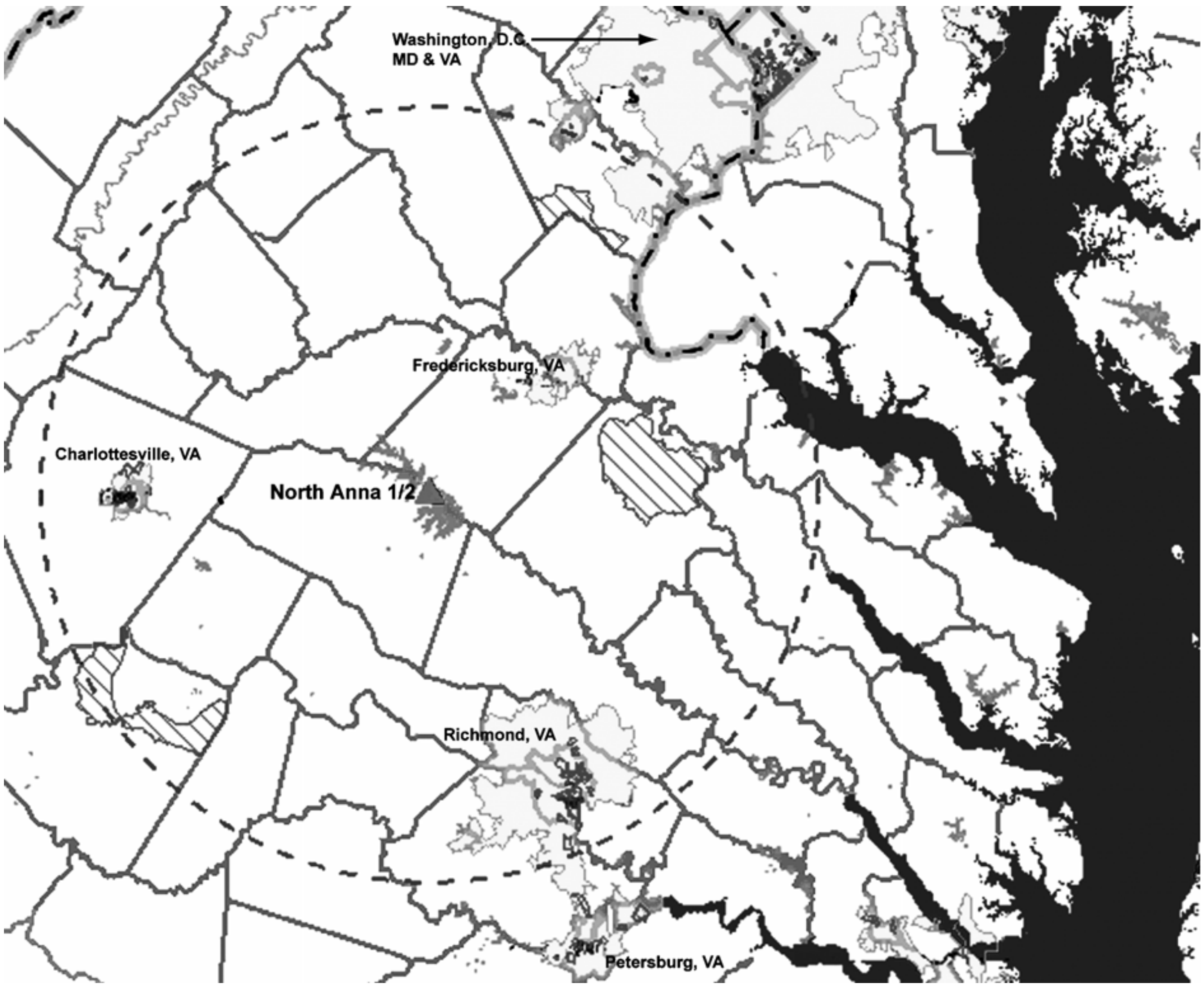

Figure 5-2. North Anna Census 2000 Environmental Justice Low Income Populations (Crosshatched Areas) Within an 80-km (50-mi) Radius of the North Anna ESP Site

5.8 Nonradiological Health Impacts

This section addresses the nonradiological health impacts of operating the proposed new units at the North Anna ESP site. Health impacts to the public from the cooling system, noise generated by unit operations, and electromagnetic fields are discussed. Nonradiological health impacts are also evaluated for workers at the new units. Health impacts from radiological sources during operations are discussed in Section 5.9.

5.8.1 Public Health

The potential health impacts of thermophilic organisms have been investigated in the power industry since the 1970s; the existing Units 1 and 2 have open-cycle cooling systems that discharge heated cooling water into the WHTF and then into the North Anna Reservoir and the North Anna River (Dominion 2006a). Thermophilic microorganisms (e.g., *Naegleria fowleri*) generally exist in water bodies with ambient temperatures between 25 and 80°C (77 and 176°F) with maximum growth of such organisms generally occurring when ambient temperatures are maintained between 50 and 60°C (122 and 140°F) (Dominion 2001b). Correspondence from the Virginia Department of Health (VDH) states that *N. fowleri* begins to proliferate around 30°C (86°F) and thrives at temperatures of 35 and 45°C (95 and 113°F) when compared to competing organisms (VDH 2005).

Since 1975, Virginia Power has monitored water temperatures at various locations in Lake Anna, the WHTF, and the discharge canal. The highest temperatures recorded in (1) the discharge canal was 39°C (102.4°F) in August 2002, (2) the WHTF was 35°C (95.0°F) in July 1993, and (3) Lake Anna was 34°C (92.7°F) in July 1977. These temperatures were hourly average values. While ambient summer water temperatures in the sampled locations were found to be within the range conducive to reproduction and growth of pathogenic micro-organisms, the temperatures measured were below those considered optimal for the growth of thermophilic forms.

Thermophilic microorganisms can cause primary amoebic meningo-encephalitis in humans. No cases of primary amoebic encephalitis have been documented in NAPS workers or area residents during the operating history of the plants (Dominion 2006a). The review performed by Dominion in Section 5.3.4.1 of the ER (Dominion 2006a) concluded that the closed-cycle, combination wet and dry cooling system for the proposed Unit 3 would not significantly increase the temperature of the WHTF and Lake Anna and, therefore, would not create an environment conducive to the optimal growth of thermophilic organisms.

The Commonwealth of Virginia considers the WHTF a private pond and does not regulate the discharge temperature of Units 1 and 2 into the WHTF. The point of compliance for the NPDES permit is Dike 3 where the water from the WHTF is discharged into the reservoir. While the WHTF is a private pond, VEPCo has allowed private homeowners on the WHTF access for recreational purposes, including swimming. In a letter dated September 15, 2005 (VDH 2005), VDH recommended that swimmers avoid recreational activities in water bodies exceeding 40°C (104°F). In the ER, Dominion stated that it is exploring options with VDEQ and VDH to communicate information related to existing risks to local residents (Dominion 2006a). Based on the use of a closed-cycle, combination wet and dry cooling system for Unit 3 and dry cooling system for Unit 4 and the evaluation of thermophilic organisms, the staff considers the public health impacts from the operation of Unit 3 to be SMALL, and mitigation beyond informing the local residents of the risk associated with recreational activities on the lake is not warranted.

5.8.2 Occupational Health

In general, human health risks for a new nuclear unit are expected to be dominated by occupational injuries (e.g., falls, electric shock, asphyxiation) to workers engaged in activities such as maintenance, testing, and plant modifications. Historically, actual injury and fatality rates at nuclear reactor facilities have been lower than the average U.S. industrial rates. Occupational injury and fatality risks are reduced by strict adherence to NRC and OSHA safety standards, practices, and procedures. Appropriate State and local statutes must also be considered when assessing the occupational hazards and health risks for new nuclear unit operation. The staff assumes adherence to NRC, OSHA, and State safety standards, practice, and procedures during new nuclear unit operations.

Occupational health impacts from thermophilic micro-organisms would be the same as those discussed above for the public. Health impacts to workers from nonradiological emissions, noise, and electromagnetic fields would be monitored and controlled in accordance with the applicable Occupational Safety and Health Administration regulations.

5.8.3 Noise Impacts

The effects of noise were considered by the NRC in NUREG-1437 in its evaluation of license renewal issues (NRC 1996). In that generic EIS, noise levels below 60 to 65 decibels were considered to be of small significance. More recently, the impacts of noise were considered by the NRC in Supplement 1 of NUREG-0586 (NRC 2002a) in its evaluation of decommissioning issues. In the decommissioning EIS, the criterion for assessing the level of significance was not expressed in terms of sound levels. Rather, the level of significance was based on the effect of noise on human activities and threatened and endangered species. The criterion in NUREG-0586, Supplement 1 is:

> ...noise impacts ... are considered detectable if sound levels are sufficiently high to disrupt normal human activities on a regular basis. ... noise impacts ... are considered destabilizing if sound levels are sufficiently high that the affected area is essentially unsuitable for normal human activities, or if the behavior or breeding of a threatened or endangered species is affected.

The noise level for the Unit 3 cooling towers given in the PPE is 65 dBA at a distance of 300 m (1000 ft), which is 5 dBA higher than the noise level for the Unit 4 cooling towers. Based on the information provided by Dominion and the NRC insights from the assessments in NUREG-1437 and NUREG-0586 Supplement 1, the staff concludes that the potential impacts of noise resulting from operation of two additional nuclear power plants with cooling systems meeting the noise criteria of the PPE as defined in the ER would be SMALL, and mitigation is not warranted.

5.8.4 Acute Effects of Electromagnetic Fields

The current transmission lines that originate from the NAPS site are capable of handling the output from two additional units. These lines consist of three 500-kV lines that were erected in the late-1970s and one 230-kV line erected in 1984. Both sets of transmission lines were designed and constructed according to National Electrical Safety Code (NESC) requirements and industry guidance that was current at that time (Dominion 2006a).

The current NESC requirements for preventing electric shock from induced current were met; therefore, the staff concludes that the impact to the public from acute effects of electromagnetic fields would be SMALL, and mitigation is not warranted. The conclusion of SMALL impact by the NRC staff is predicated on the assumption made by the staff that the transmission lines carrying the additional power of the two new units would not exceed the NESC criteria for electric shock (see Appendix J).

5.8.5 Chronic Effects of Electromagnetic Fields

Research on the potential for chronic effects from 60-Hz electromagnetic fields from energized transmission lines was reviewed and addressed elsewhere by the NRC in NUREG-1437 (NRC 1996). At that time, research results were not conclusive. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy. An NIEHS report (1999) contains the following conclusion:

> The NIEHS concludes that ELF-EMF (extremely low frequency-electromagnetic field) exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement is not sufficient to cause the staff to consider the potential impact as significant to the public. However, because conclusive information is not available, this issue is not resolved (see Appendix J).

5.8.6 Summary of Nonradiological Health Impacts

The staff evaluated health impacts to the public and the workers from the cooling systems, noise generated by unit operations, and acute and chronic impacts of electromagnetic fields at the higher power levels from the two additional units. Based on the information provided by Dominion and its independent review, the staff concludes that the potential impacts of nonradiological effects resulting from the operation of two additional units with closed-cycle cooling systems meeting the noise criteria of the PPE would be SMALL, and mitigation is not warranted.

5.9 Radiological Health Impacts

This section addresses the radiological impacts of normal operations of the proposed new Units 3 and 4 including a discussion of the estimated radiation dose to a member of the public and to the biota present in the proximity of the new units. Estimated doses to workers at the proposed units are also discussed. Radiological impacts were determined using the PPE approach for liquid and gaseous radiological effluents.

5.9.1 Exposure Pathways

During normal operation, small quantities of radiological materials are released to the environment through gaseous and liquid effluents from the plant. Dominion stated in its ER that the contribution to direct radiation exposure from new reactor designs would be negligible (Dominion 2006a).

Using the PPE, the ER submitted by Dominion provided a list of fission and activation products that may be released as liquid and gaseous effluents from the proposed Units 3 and 4 (Dominion 2006a). A listing of liquid and gaseous effluent isotopes and annual releases are presented in Appendix H (i.e., Tables H-2 and H-5, respectively). The impacts from releases and direct radiation were evaluated by considering the probable pathways to individuals, populations, and biota near the proposed new units. The highest doses from the major exposure pathways were evaluated for a given receptor.

The proposed units at the North Anna ESP site would release liquid effluents into the WHTF through the discharge canals used for the operating units. The liquid pathways considered are ingestion of aquatic food, ingestion of drinking water, exposure to shoreline sediment, and exposure to water through boating, swimming, and other activities (Dominion 2006a).

The gaseous pathways considered by Dominion in its ER were external exposure to the airborne plume, external exposure to contaminated ground, inhalation of airborne activity, and ingestion of contaminated agricultural products (Dominion 2006a). In its review, the staff identified another airborne release pathway, the release of tritium to the atmosphere, incorporated in water vapor, from evaporation of cooling water from the Unit 3 closed-cycle, combination wet and dry cooling system. Units 1 and 2 routinely release tritium into Lake Anna and the Unit 3 cooling system would draw water from Lake Anna. According to the annual environmental operating reports for NAPS, tritium has concentrated in Lake Anna; for example, the average tritium concentration in the lake for 2005 was reported as 116 Bq/L (3137 pCi/L) (VEPCo 2006). This concentration level is well below the EPA drinking water standard of 741 Bq/L (20,000 pCi/L) found in 40 CFR Part 141. The dose to the public from these pathways were evaluated by the staff in Appendix H and are discussed in the following sections.

5.9.2 Radiation Doses to Members of the Public

The exposure pathways to humans as described in Regulatory Guides 1.109 and 1.111 (NRC 1977a, b) are illustrated in Figure 5.3. The dose to a maximally exposed individual was calculated from both the liquid and gaseous effluent release pathways (Dominion 2006a), and a collective whole body dose was calculated for the population within 80 km (50 mi) of the North Anna ESP site.

5.9.2.1 Liquid Effluent Pathway

Liquid pathway doses were calculated on a per unit basis by Dominion using the LADTAP II computer program (Strenge et al. 1986) for the following activities: eating fish and invertebrates caught near the discharge point, drinking water from Lake Anna, and boating, swimming, and using the shoreline for recreational purposes. The liquid effluent releases for one new unit used to estimate the dose to the maximally exposed individual are found in Table 5.4-6 of the ER submitted by Dominion (Dominion 2006a). This table is repeated in Appendix H, Table H-2. In Dominion ER Revision 9 (Dominion 2006a), the tritium release was revised from 115 TBq/yr (3100 Ci/yr) per unit to 31.5 TBq/yr (850 Ci/yr) per unit. This value was reduced to ensure concentrations in Lake Anna would not exceed the EPA drinking water standard of 741 Bq/L (20,000 pCi/L) found in 40 CFR Part 141. As discussed in Appendix H (Section H.3.3), the revised tritium release rate of 31.5 TBq/yr (850 Ci/yr) per unit would result in estimated tritium concentrations in Lake Anna of 350 Bq/L (9400 pCi/L), which is well below EPA's drinking water standard for tritium.

Other parameters used as input to the LADTAP II program, including effluent discharge rate, dilution factor for discharge, transit time to receptor, and impoundment concentration, are found in Tables 5.4-1 and 5.4-2 of the Dominion ER (Dominion 2006a).

Liquid pathway doses to the maximally exposed individuals calculated on a per unit basis by Dominion (2006a) are presented in Table 5-8. The maximum annual total body dose was

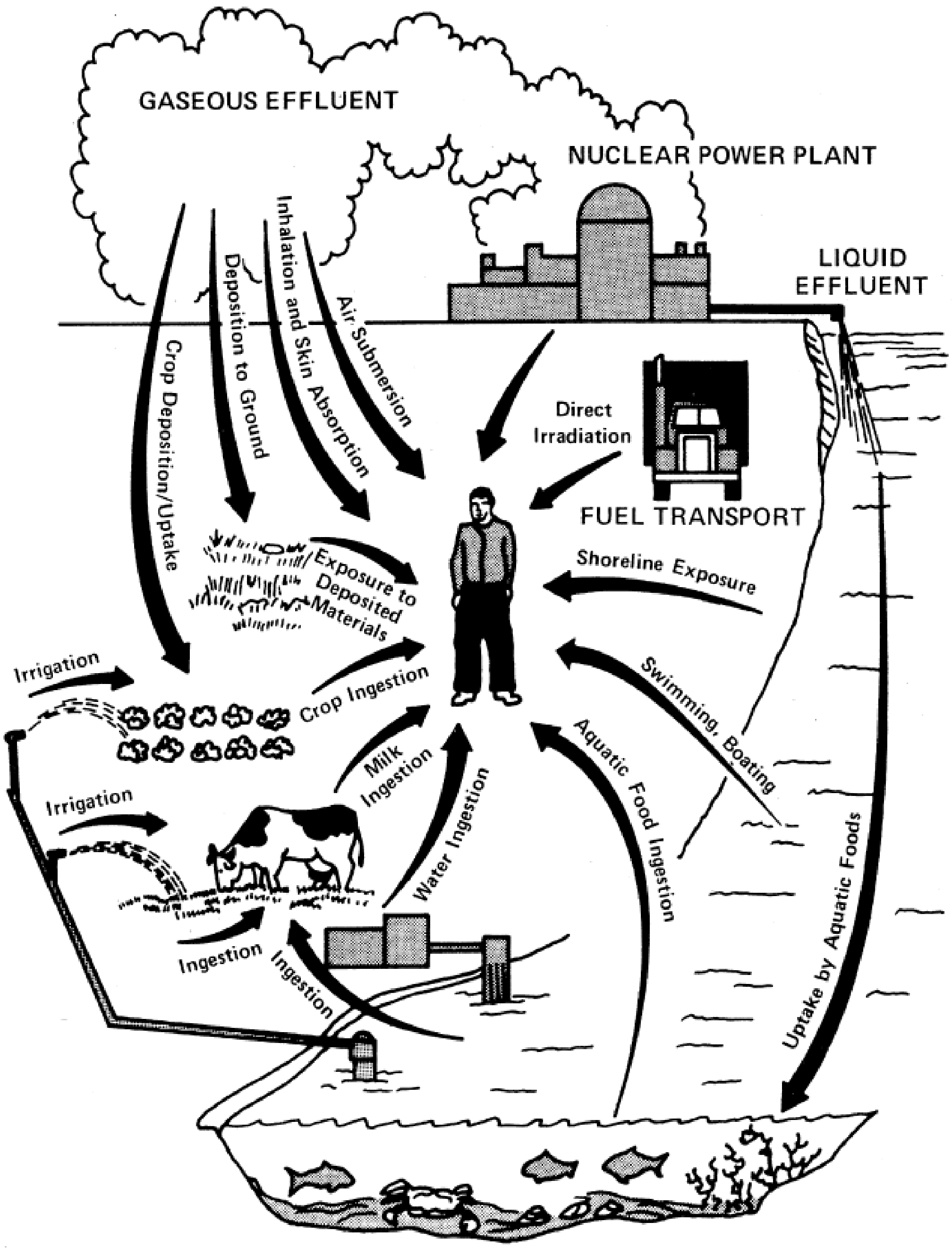

Figure 5-3. Exposure Pathways to Humans

8.10x10^{-3} mSv (0.81 mrem) to the adult. The maximum annual thyroid dose was 6.8x10^{-3} mSv (0.68 mrem) to the infant. The maximum annual bone dose was 0.025 mSv (2.5 mrem) to the child. The staff performed an independent evaluation of liquid pathway doses, including the information about tritium concentrations in Lake Anna, and found similar results. The information on tritium resulted in minor changes to the estimates in Table 5-8 for the drinking water pathway and essentially no change to the estimates for the other pathways. The staff determined that all input parameters used in Dominion's calculations were appropriate. Results of the staff's independent evaluation are presented in Appendix H.

5.9.2.2 Gaseous Effluent Pathway

Gaseous pathway doses to the maximally exposed individual were calculated on a per unit basis by Dominion using the GASPAR II computer program (Strenge et al. 1987) at the following locations: the nearest site boundary, nearest vegetable garden, nearest residence, and nearest meat cow. Doses from the milk pathway were not calculated as there were no milk cows or goats located within a 8-km (5-mi) radius of the ESP site (Dominion 2006a). The gaseous effluent releases used in the estimate of dose to the maximally exposed individual are found in Table 5.4-7 of the Dominion ER (Dominion 2006a). This table is repeated in Appendix H, Table H-5. Other inputs to the GASPAR II program, including meat and vegetable production rates, atmospheric dispersion factors, ground deposition factors, receptor locations, and consumption factors, are found in Tables 5.4-3 through 5.4-5 of the Dominion ER (Dominion 2006a).

Dominion (2006a) did not calculate an infant dose for the vegetable or meat pathway. The staff believes this is a reasonable approach as it is unlikely that infants would consume meats, fruits, and vegetables from the livestock and gardens near the ESP site. In addition to their mother's breast milk and formula, infants will consume cereal, cow's milk (no milk cows are within 8 km [5 mi] of the ESP site), and canned baby food products such as fruits, vegetables, and meat, but these products generally would have been grown in areas away from the ESP site. In the unlikely event that an infant does ingest vegetables or meats grown near the ESP site, the dose to an infant would be bounded by the dose to a child from the same pathways. Although infant ingestion dose factors (i.e., mrem per pCi ingested) will be higher for most radionuclides compared to child ingestion dose factors, the dose to the infant from ingestion of vegetables and fruits would still be bounded by the dose to a child. This is because the infant's annual consumption of vegetables and meats is expected to be far less than a child's annual consumption.

As discussed in Section 5.9.1, the staff identified another atmospheric release pathway from the proposed units, the release of tritium to the atmosphere from the evaporation of cooling water from the Unit 3 closed-cycle, combination wet and dry cooling system. The dose to the public from this pathway is presented in Appendix H. Doses were estimated to be less than 10 percent of the contribution from all of the radionuclides in the PPE gaseous effluent release.

Table 5-8. Liquid Pathway Doses for Maximally Exposed Individuals at Lake Anna

Pathway	Total Body Dose (mSv/yr)[a]	Thyroid Dose (mSv/yr)[a]	Bone Dose (mSv/yr)[a]
Fish Consumption	5.1×10^{-3}	0[b]	2.3×10^{-2}
Invertebrate Consumption	6.6×10^{-4}	0[b]	1.5×10^{-3}
Drinking Water	2.0×10^{-3}	6.5×10^{-3}	2.7×10^{-4}
Shoreline Recreation	3.0×10^{-4}	3.0×10^{-4}	3.0×10^{-4}
Swimming	3.2×10^{-6}	3.2×10^{-6}	3.2×10^{-6}
Boating	4.0×10^{-6}	4.0×10^{-6}	4.0×10^{-6}
Total	8.1×10^{-3}	6.8×10^{-3}	2.5×10^{-2}
Age group receiving maximum dose	Adult	Infant	Child

(a) Multiply mSv/yr times 100 to obtain mrem/yr.
(b) Thyroid dose is not applicable because infants are assumed not to consume fish and invertebrates.
Source: Dominion 2006a, Table 5.4-8. Doses were estimated on a per unit basis.

Gaseous pathway doses to the maximally exposed individual calculated by Dominion (2006a) were on a per unit basis and are presented in Table 5-9. The staff performed an independent evaluation of gaseous pathway doses and found similar results. All input parameters used in Dominion's calculations were judged by the staff to be appropriate. Results of the staff's independent evaluation are presented in Appendix H.

5.9.3 Impacts to Members of the Public

This section describes the staff's evaluation of the estimated impacts from radiological releases and direct radiation of the proposed units at the North Anna ESP site. The evaluation addresses doses from operations to the maximally exposed individual located at the ESP site boundary and the population dose (collective dose to the population within 80 km [50 mi]) around the ESP site.

5.9.3.1 Maximally Exposed Individual

Dominion (2006a) stated that whole body and organ dose estimates to the maximally exposed individual from liquid and gaseous effluents for one unit were within the design objectives of 10 CFR Part 50, Appendix I. The design objectives of 10 CFR Part 50, Appendix I are applicable to each reactor unit. Doses to whole body and maximum organ at Lake Anna from liquid effluents were well within the 0.03 mSv/yr (3 mrem/yr) and 0.1 mSv/yr (10 mrem/yr) Appendix I design objectives, respectively. Doses at the site boundary from gaseous effluents were well within the Appendix I design objectives of 0.1 mGy/yr (10 mrad/yr) gamma in air,

Table 5-9. Gaseous Pathway Doses for Maximally Exposed Individual

Location	Pathway	Total Body Dose (mSv/yr)[a]	Thyroid Dose (mSv/yr)[a]	Skin Dose (mSv/yr)[a]
Nearest Site Boundary (1.4 km [0.88 mi] ESE)	Plume	2.1×10^{-2}	(b)	6.2×10^{-2}
Nearest Site Boundary (1.4 km [0.88 mi] ESE)	Inhalation			
	Adult	3.0×10^{-3}	1.6×10^{-2}	(c)
	Teen	3.1×10^{-3}	2.0×10^{-2}	(c)
	Child	2.7×10^{-3}	2.3×10^{-2}	(c)
	Infant	1.6×10^{-3}	2.0×10^{-2}	(c)
Nearest Garden (1.5 km [0.94 mi] NE)	Vegetable			
	Adult	4.4×10^{-3}	4.9×10^{-2}	(c)
	Teen	5.7×10^{-3}	6.6×10^{-2}	(c)
	Child	1.1×10^{-2}	1.3×10^{-1}	(c)
Nearest Residence (1.5 km [0.96 mi] NNE)	Plume	1.4×10^{-2}	(b)	4.0×10^{-2}
Nearest Residence (1.5 km [0.96 mi] NNE)	Inhalation			
	Adult	2.0×10^{-3}	1.0×10^{-2}	(c)
	Teen	2.0×10^{-3}	1.3×10^{-2}	(c)
	Child	1.8×10^{-3}	1.5×10^{-2}	(c)
	Infant	1.0×10^{-3}	1.3×10^{-2}	(c)
Nearest Meat Cow (2.22 km [1.37 mi] SE)	Meat			
	Adult	6.7×10^{-4}	1.5×10^{-3}	(c)
	Teen	4.9×10^{-4}	1.1×10^{-3}	(c)
	Child	7.9×10^{-4}	1.7×10^{-3}	(c)

(a) Multiply mSv/yr times 100 to obtain mrem/yr.
(b) Thyroid dose is not applicable for the plume pathway.
(c) Skin dose is not applicable for the ingestion and inhalation pathways.
Source: Dominion (2006a), Table 5.4-9. Doses were calculated on a per unit basis. There were no milk cows or goats within 8 km (5 mi) (Dominion 2006a). No infant doses were calculated for the vegetable or meat pathway because the doses that infants receive from their diet would be bounded by the dose calculated for the child.

0.2 mGy/yr (20 mrad/yr) beta in air, 0.05 mSv/yr (5 mrem/yr) dose to the whole body, and 0.15 mSv/yr (15 mrem/yr) dose to the skin. In addition, dose to the thyroid was within the 0.15 mSv/yr (15 mrem/yr) Appendix I design objectives. A comparison of dose estimates for one unit to the Appendix I design objectives is presented in Table 5-10.

Dominion (2006a) stated that doses from liquid and gaseous effluents to the maximally exposed individual at the site boundary from the existing Units 1 and 2 and the two proposed Units 3 and 4 combined were well within the regulatory standards of 40 CFR Part 190. As discussed in Appendix H, the dose contribution from liquid effluents considered the concentration of tritium in Lake Anna. Doses from direct radiation were determined to be negligible (Dominion 2006a).

Table 5-10. Comparison of Maximally Exposed Individual Dose Estimates from Liquid and Gaseous Effluents to 10 CFR Part 50, Appendix I, Design Objectives

Pathway/Type of Dose	Dominion (2006a)[a,b]	Appendix I Design Objectives[c]
Liquid Effluents		
Whole body dose	0.0081 mSv/yr	0.03 mSv/yr
Maximum organ dose	0.025 mSv/yr	0.1 mSv/yr
Gaseous Effluents (Noble gases only)		
Gamma air dose	0.032 mGy/yr	0.1 mGy/yr
Beta air dose	0.048 mGy/yr	0.2 mGy/yr
Whole body dose	0.024 mSv/yr	0.05 mSv/yr
Skin dose	0.062 mSv/yr	0.15 mSv/yr
Gaseous Effluents (Radioiodines and particulates)		
Organ dose	0.12 mSv/yr (thyroid)	0.15 mSv/yr

(a) Doses were estimated on a per unit basis.
(b) Multiply mSv/yr (or mGy/yr) times 100 to obtain mrem/yr (or mrad/yr)
(c) Design objectives are for each light-water-cooled nuclear power reactor (10 CFR Part 50, Appendix I)
Source: Dominion 2006a, Table 5.4-10

Although doses from direct radiation were estimated to be approximately 0.23 mSv (23 mrem) to a construction worker (see Section 4.9.1), the direct radiation dose to the maximally exposed individual at the site boundary was determined to be negligible due to the additional distance that attenuates the direct radiation. For calculation purposes, the construction worker would be located at the west protected area fence for Units 1 and 2 while the maximally exposed individual would be located 1.4 km (0.88 mi) from Units 1 and 2.

Adherence to the 40 CFR Part 190 dose standards, ensures compliance with 10 CFR 20.1301, which states that the total effective dose equivalent to individual members of the public from licensed operations shall not exceed 1 mSv (100 mrem) in a year. The dose standards from 40 CFR Part 190 are 0.25 mSv/yr (25 mrem/yr) to the whole body, 0.75 mSv/yr (75 mrem/yr) to the thyroid, and 0.25 mSv/yr (25 mrem/yr) to any other organ from the entire fuel cycle. The combined estimated doses from the existing units and the proposed new units were 0.068 mSv/yr (6.8 mrem/yr) to the whole body, 0.27 mSv/yr (27 mrem/yr) to the thyroid, and 0.12 mSv/yr (12 mrem/yr) to the bone for the maximally exposed individual at the site boundary (Dominion 2006a). These data are summarized in Table 5-11. The staff performed an independent evaluation of cumulative dose as described in Appendix H and found similar results (NRC 2006e).

Table 5-11. Comparison of Maximally Exposed Individual Dose Estimates from Liquid and Gaseous Effluents to 40 CFR Part 190 Standards

Dose	Dominion (2006a) Estimate[a,b,c]	40 CFR 190 Standards
Whole body dose equivalent	0.068 mSv/yr	0.25 mSv/yr
Thyroid dose	0.27 mSv/yr	0.75 mSv/yr
Dose to another organ	0.12 mSv/yr (bone)	0.25 mSv/yr

(a) Doses from direct radiation were determined to be negligible (Dominion 2006a).
(b) Sum of dose from liquid and gaseous effluent releases for the two existing NAPS units and the proposed units (Dominion 2006a)
(c) Multiply mSv/yr times 100 to obtain mrem/yr.
Source: Dominion 2006a, Table 5.4-11

5.9.3.2 Population Dose

Dominion (2006a) estimated a collective whole body dose within 80 km (50 mi) of each unit to be 0.28 person-Sv/yr (28 person-rem/yr). A collective dose of 0.086 person-Sv/yr (8.6 person-rem/yr) was calculated for the liquid effluent pathway using the LADTAP II computer code. A collective dose of 0.19 person-Sv/yr (19 person-rem/yr) was calculated for the gaseous effluent pathway using the GASPAR II computer code. The staff performed an independent evaluation of population doses and found the applicant's estimates to be conservative (see Appendix H). Dominion estimated collective dose to the same population from natural background radiation was 9200 person-Sv/yr (920,000 person-rem/yr) (Dominion 2006a).

The collective dose from natural background radiation was calculated by using the 80-km (50-mi) population data of 2.8 million and a dose rate of 3.25 mSv/person/yr (325 mrem/person/yr) (Dominion 2006a).

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses, and at low dose rates, below about 100 mSv (10,000 mrem). However, considering the scientific work in the field, radiation protection experts conservatively assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2006), the BEIR VII report, supports the linear, no-threshold dose response theory. Simply stated, the assumption is that any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably overestimates those risks.

The staff conservatively estimated the risks to the population living within 80 km (50 mi) of the new Units 3 and 4 using the International Commission on Radiological Protection (ICRP) Publication 60 nominal probability coefficients for total detriment (730 fatal cancers, non-fatal cancers, and severe hereditary effects per 10,000 person Sv (1 million person-rem) (ICRP 1991). In this context, detriment is defined as a measure of the total harm that would eventually be experienced by an exposed group and its descendants as a result of the group's exposure to a radiation source (ICRP 1977). Harm includes fatal cancers, non-fatal cancers, and severe hereditary defects. This coefficient was multiplied by the estimated collective whole body dose of 0.28 person-Sv/yr (28 person-rem/yr) to obtain an estimated number of fatal cancers, non-fatal cancer, and severe hereditary effects of less than 0.02 annually for a single new unit at the North Anna ESP site. This was compared to an estimated 672 fatal cancers, non-fatal cancers, and severe hereditary effects from natural background radiation exposure annually. The cumulative effects of operating two new units at the ESP site in addition to the currently operating Units 1 and 2 would be less than 1 cancer or hereditary effect annually. These cumulative effects are well below the estimated effects from natural background radiation. In addition, at the request of the U.S. Congress, the National Cancer Institute (NCI) conducted a study and published *Cancer in Populations Living Near Nuclear Facilities* in 1990 (NCI 1990). This report included an evaluation of health statistics around all nuclear power plants, as well as several other nuclear fuel cycle facilities, in operation in the United States in 1981 and found "no evidence that an excess occurrence of cancer has resulted from living near nuclear facilities" (NCI 1990).

5.9.3.3 Summary of Radiological Impacts to Members of the Public

The staff evaluated the health impacts from routine gaseous and liquid radiological effluent releases from the proposed nuclear units at the North Anna ESP site. Based on the information provided by Dominion and on its own independent evaluation, the staff concludes there would be no observable health impacts to the public from normal operation of the proposed nuclear units, and the radiological health impacts would be SMALL, and mitigation is not warranted.

5.9.4 Occupational Doses to Workers

On the basis of information contained in NUREG-0713 (NRC 2002c), the average annual collective dose per operating reactor was 1.72 person-Sv/yr (172 person-rem/yr) for the time period from 1992 to 2001. Limited information was available on occupational dose estimates from the advanced reactor designs. Dominion reported annual occupational dose estimates of 1.5 person-Sv (150 person-rem) for the AP1000, international reactor innovative and secure (IRIS), and gas turbine-modular helium reactor (GT-MHR) reactor designs (Dominion and Bechtel 2002). The estimated occupational doses for the advanced reactor designs were slightly lower than annual occupational doses for current light-water reactors. The operator of a new plant would need to ensure that individual doses to workers are less than 0.05 Sv (5 rem) annually as specified in 10 CFR 20.1201 and apply the 10 CFR Part 50, Appendix I, as low as reasonably achievable (ALARA) process to maintain doses below this limit.

The staff concludes that the health impacts from occupational radiation exposure would be SMALL based on individual workers receiving less than the 10 CFR 20.1201 dose limit and the collective occupational dose being typical of that experienced in current LWR reactors. Mitigation is not warranted.

5.9.5 Impacts to Biota

The exposure pathways to biota other than humans described in Regulatory Guides 1.109 and 1.111 are illustrated in Figure 5-4. Dominion (2006a) estimated doses to fish, invertebrates, algae, muskrat, raccoon, heron, and duck, which are referred to as surrogate species. Surrogate species are well defined and provide an acceptable method for judging doses to the biota (Dominion 2006a). Important biota species for the North Anna ESP site and the corresponding surrogate species are (1) bald eagle and loggerhead shrike (heron) and (2) dwarf wedge mussel, slippershell mussel, and fluted kidneyshell mussel (invertebrate).

5.9.5.1 Liquid Effluent Pathway

Dominion (2006a) used the LADTAP II computer code to calculate doses to biota from the liquid effluent pathway. The following exposure pathways were evaluated for the different surrogate biota:

- Fish and invertebrates – internal exposure from bioaccumulation of radionuclides and external exposure from swimming and shoreline activities

- Algae – internal exposure from bioaccumulation of radionuclides and external exposure from immersion in water

- Muskrat and duck – internal exposure from ingestion of aquatic plants and external exposure from swimming and shoreline activities

- Raccoon – internal exposure from ingestion of invertebrates and external exposure from shoreline activities

- Heron – internal exposure from ingestion of fish and external exposure from swimming and shoreline activities.

These pathways are illustrated in Figure 5-4.

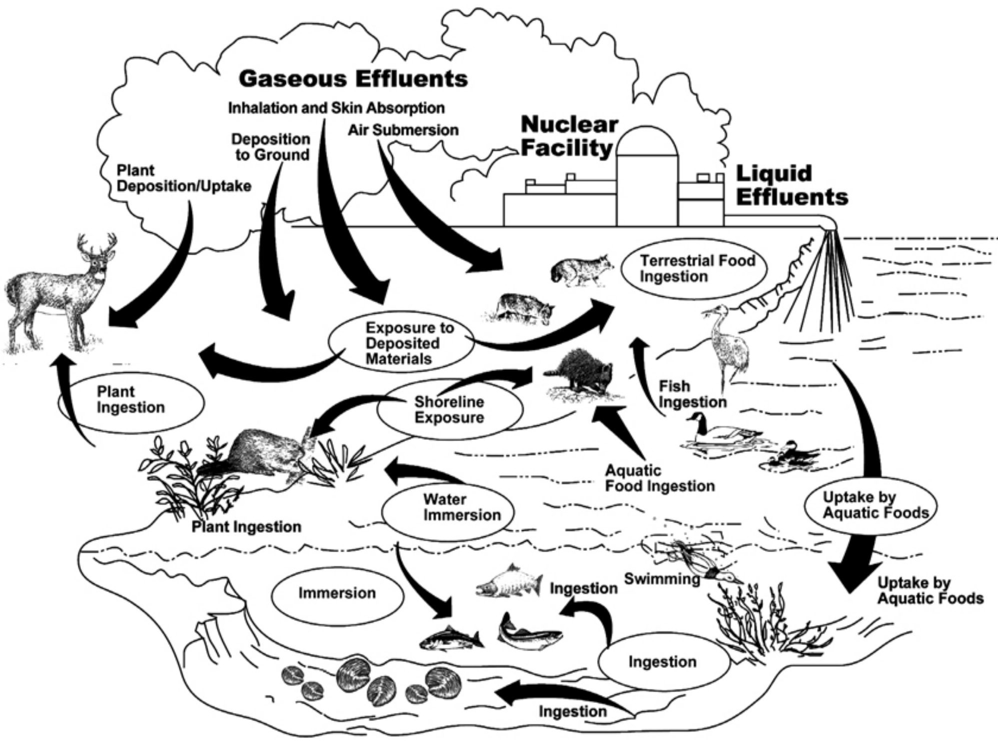

Figure 5-4. Exposure Pathways to Biota Other than Humans

Input parameters used in the dose calculation included food consumption rates, body masses, and effective body radii. These parameters were taken from NUREG/CR-4013 (Strenge et al. 1986) and Regulatory Guide 1.109 (NRC 1977a). These parameters are shown in Tables 5.4-14 and 5.4-15 of the Dominion ER (Dominion 2006a).

5.9.5.2 Gaseous Effluent Pathway

Dominion used the doses calculated for the maximally exposed individual from the gaseous effluent pathway (described earlier in this section) as a basis for the doses to the biota (Dominion 2006a). External doses from ground deposition were increased by a factor of two to account for the terrestrial organisms being closer to the ground (Dominion 2006a).

5.9.5.3 Impact of Estimated Biota Doses

Table 5-12 compares the estimated whole body dose to the biota from the liquid and gaseous effluent pathways calculated by Dominion (2006a) from one proposed new unit at the ESP site to the regulatory standard for humans in 40 CFR Part 190. Although the 40 CFR Part 190 standards apply to members of the public in unrestricted areas but not to biota, they are provided here for comparative purposes. The biota doses for all surrogate species except fish

Table 5-12. Comparison of Biota Doses from Proposed Units 3 and 4 to 40 CFR Part 190

Biota	Dose from Liquid Effluent/Unit (mGy/yr)(a,b)	Dose from Gaseous Effluent/Unit (mGy/yr)(a,b)	Total Dose/Unit (mGy/yr)(a,b)	Total Dose for Two Units (mGy/yr)(a)	40 CFR 190 Total Body Dose Limit (mSv/yr)
Fish	0.097	0(c)	0.097	0.19	0.25
Invertebrates	0.46	0(c)	0.46	0.92	0.25
Algae	0.54	0(c)	0.54	1.08	0.25
Muskrat	0.43	0.34	0.77	1.54	0.25
Raccoon	0.049	0.34	0.39	0.78	0.25
Heron	0.54	0.34	0.88	1.76	0.25
Duck	0.43	0.34	0.77	1.54	0.25

(a) Multiply mGy/yr or mSv/yr times 100 to obtain mrad/yr or mrem/yr.
(b) From Dominion (2006a), Table 5.4-16.
(c) Negligible contribution from material deposited in water bodies.

exceed the regulatory standard in 40 CFR Part 190 of 0.25 mSv/yr (25 mrem/yr) to the total body. This assumes mrem and mrad are approximately equivalent. The staff performed an independent evaluation of biota doses and found similar results.

The ICRP (1977, 1991) states that if man is adequately protected, then other living things are also likely to be sufficiently protected. The International Atomic Energy Agency (IAEA 1992) and the National Council on Radiation Protection and Measurements (NCRP 1991) reported that a chronic dose rate of no greater than 10 mGy/day (1 rad/day) to the maximally exposed individual in a population of aquatic organisms would ensure protection for the population. IAEA (1992) also concluded that chronic dose rates of 1 mGy/day (0.1 rad/day) or less do not appear to cause observable changes in terrestrial animal populations. Table 5-13 compares the estimated whole body dose to the biota for the proposed Units 3 and 4 to the IAEA chronic dose rate values for aquatic organisms and terrestrial animals. The cumulative effects of current operating units and proposed Units 3 and 4 would result in dose rates significantly less than the NCRP and IAEA studies.

The staff performed an independent evaluation of doses to biota and found similar results; these results are presented in Appendix H.

The staff reviewed the available information relative to the radiological impact on biota from the routine operation of the proposed Units 3 and 4 and concludes the impacts would be SMALL, and mitigation is not warranted.

Table 5-13. Comparison of Biota Doses from Proposed Units 3 and 4 to NCRP and IAEA Studies

Biota	Estimated Dose for Two Units (mGy/day)[(a)]	Chronic Dose Rate Values from NCRP and IAEA Studies (mGy/day)[(a)]
Fish	5.2×10^{-4}	10
Invertebrates	2.5×10^{-3}	10
Algae	3.0×10^{-3}	10
Muskrat	4.2×10^{-3}	1
Raccoon	2.1×10^{-3}	1
Heron	4.8×10^{-3}	1
Duck	4.2×10^{-3}	1

(a) Multiply mGy/day times 100 to obtain mrad/day.

5.9.6 Radiological Monitoring

A radiological environmental monitoring program (REMP) has been in place for the NAPS site since 1976 (NRC 1976). The REMP includes monitoring of the airborne exposure pathway, direct exposure pathway, water exposure pathway, aquatic exposure pathway from Lake Anna and the North Anna River, and the ingestion exposure pathway in a 40-km (25-mi) radius of the station. The pre-operational environmental radiation monitoring program sampled various media in the environment to determine a baseline to observe the magnitude and fluctuation of radioactivity in the environment once the units began operation (AEC 1973). The pre-operational program included collection and analysis of samples of air particulates, precipitation, milk, crops, soil, well water, surface water, fish, and silt as well as measurement of ambient gamma radiation. After operation of NAPS Units 1 and 2 began, the monitoring program continued to assess the radiological impacts to workers, the public, and the environment. Radiological releases are summarized in the two annual reports: *Radiological Environmental Operating Program* and *Annual Radioactive Effluent Release Report*. The limits for all radiological releases are specified in the *North Anna Offsite Dose Calculation Manual* (ODCM) (Dominion 2003). No additional monitoring program has been proposed for the new units. The staff reviewed the documentation for the REMP, the ODCM, and recent monitoring reports and determined that the current operational monitoring program is adequate to establish the radiological impacts to the environment related to the construction and operation of proposed Units 3 and 4 at the North Anna ESP site.

5.10 Environmental Impacts of Postulated Accidents

The staff considered the radiological consequences on the human environment of potential accidents at the proposed new nuclear units at the North Anna ESP site. Consequence estimates are based on the General Electric ABWR standard reactor design, which has been certified by the NRC, a surrogate Westinghouse AP1000, and an ESBWR design, for which

General Electric submitted an application for certification in August 2005. The NRC accepted the application for docketing in December 2005. In this analysis, the ESBWR source terms were increased by 25 percent to account for uncertainty and potential changes to the design as the staff performs the design certification review. Consequently, this design is referred to as the "surrogate" ESBWR design.

The term "accident," as used in this section, refers to any off normal event, not addressed in Section 5.9, which results in the release of radioactive material into the environment. The focus of this review is on events that could lead to releases substantially in excess of permissible limits for normal operations. Normal release limits are specified in 10 CFR Part 20, Appendix B, Table 2.

Numerous features combine to reduce the risk associated with accidents at nuclear power plants. Safety features in the design, construction, and operation of the plants, which comprise the first line of defense, are intended to prevent the release of radioactive material from the plant. The design objectives and the measures for keeping levels of radioactive material in effluents to unrestricted areas ALARA are specified in 10 CFR Part 50, Appendix I. There are additional measures that are designed to mitigate the consequences of failures in the first line of defense. These include the NRC reactor site criteria rule in 10 CFR Part 100, which require the site to have certain characteristics that reduce the risk to the public and the potential impacts of an accident, and emergency preparedness plans and protective action measures for the site and environs as set forth in 10 CFR 50.47; 10 CFR Part 50, Appendix E; and NUREG-0654/FEMA-REP-1 (NRC 1980). All of these safety features, measures, and plans make up the defense-in-depth philosophy to protect the health and safety of the public and the environment.

This section discusses (1) types of radioactive material that might be released, (2) paths to the environment, (3) the relationship between radiation dose and health effects, and (4) the environmental impacts of postulated reactor accidents, both design basis accidents (DBAs) and severe accidents. The environmental impacts of postulated accidents during the transportation of spent fuel are discussed in Chapter 6.

The potential for dispersion of radioactive material in the environment depends on the mechanical forces that physically transport the material and on the physical and chemical forms of the materials. Radioactive material exists in a variety of physical and chemical forms. The majority of the material is in the form of nonvolatile solids. However, there is a significant amount of material that is in the form of volatile solids or gases. Gaseous radioactive material includes the chemically inert noble gases krypton and xenon. Radioactive forms of iodine, which are created in substantial quantities in the fuel by fission, are volatile. Other radioactive material formed during the routine operation of a nuclear power plant have lower volatilities, and therefore, have less tendency to escape from the fuel than the noble gases and iodines.

Radiation exposure is determined by the proximity of individuals to radioactive material, the duration of exposure, and factors that shield the individuals from the radiation. Pathways that lead to radiation exposure include (1) external radiation from radioactive material in the air, on the ground, and in the water, (2) the inhalation of radioactive material, and (3) ingestion of food or water containing material initially deposited on the ground and in water.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 100 mSv (10,000 mrem) and at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2005), the BEIR VII report, supports the linear, no-threshold dose response theory. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks.

Physiological effects are clinically detectable should individuals receive radiation exposure resulting in a dose greater than about 0.25 Sv (25 rem) over a short period of time (hours). Doses of about 2.5 to 5.0 Sv (250 to 500 rem) received over a relatively short period (hours to a few days) can be expected to cause some fatalities.

5.10.1 Design Basis Accidents

Dominion has evaluated the potential consequences of postulated accidents to demonstrate that Units 3 and 4 could be constructed and operated at the North Anna ESP site without undue risk to the health and safety of the public. These evaluations use a set of surrogate DBAs that are representative for the range of reactor designs being considered for the ESP site and site-specific meteorological data. The set of accidents covers events that range from relatively high probability of occurrence with relatively low consequences to relatively low probability with high consequences.

The DBA review focuses on three light-water reactor designs: the ABWR, the surrogate AP1000 and the surrogate ESBWR. The bases for analyses of postulated accidents for these designs are well established because they have been considered as part of the design certification process under 10 CFR Part 52, Subpart B. Accidents for the other reactor designs listed in the application are not as well defined as those for the ABWR, the surrogate AP1000, and the surrogate ESBWR; acceptable assumptions and methodologies for the evaluation of postulated accidents for the other reactor designs have not been fully established. Because the source terms for accident analyses are generally proportional to the power level, for the purposes of this site suitability evaluation, the potential consequences of accidents for the other reactor designs are expected to be bounded by those for the ABWR, surrogate AP1000, and surrogate ESBWR designs. For example, preliminary information on source terms for the IRIS and ACR-700 reactor designs indicates that the source term for the surrogate AP1000 loss-of-coolant accident (LOCA) is expected to bound the worst case accidental releases for these advanced reactor designs. The advanced gas reactor designs (GT-MHR and PBMR) postulate relatively small releases to the environment compared to water reactor technologies (Dominion 2006b).

Should an application be made to build and operate one of the other designs that references an ESP for the North Anna ESP site, the applicant would be required to show and the staff would verify that the radiological consequences of DBAs for the proposed reactor or reactors are bounded by the consequences of DBAs evaluated here.

Potential consequences of DBAs are evaluated following procedures outlined in regulatory guides and standard review plans. The potential consequences of accidental releases depend on the specific radionuclides released, the activity released for each radionuclide, and meteorological conditions. The source term for the ABWR reactor design is based on TID-14844 (AEC 1962) guidance, and guidance on methods for evaluating potential accidents for the ABWR are set forth in NUREG-0800 (NRC 1987), Regulatory Guide 1.3 (NRC 1974a), and Regulatory Guide 1.25 (NRC 1974b). The source terms for the surrogate AP1000 reactor and surrogate ESBWR reactor and methods for evaluating potential accidents are based on guidance in Regulatory Guide 1.183 (NRC 2000b).

For environmental reviews, consequences are evaluated assuming realistic meteorological conditions. Meteorological conditions are represented in these consequence analyses by an atmospheric dispersion factor, which is also referred to as χ/Q. Acceptable methods of calculating χ/Q for DBAs from meteorological data are set forth in Regulatory Guide 1.145 (NRC 1983).

Dominion has provided the staff with meteorological data for 1996, 1997, and 1998 for the North Anna ESP site. These data have been reviewed by the staff and found to be representative of the meteorological conditions at the site. The meteorological instrumentation and its maintenance are consistent with staff guidance (i.e., Regulatory Guide 1.23 (Safety Guide 23) [AEC 1972]), and the data quality is consistent with standards set forth in that guidance. Therefore, the data are considered acceptable for use in evaluation of the consequences of DBAs.

Table 3.1-9 of the PPE referenced in Section 3.1.3 of the ER, lists χ/Q values. These values are not appropriate for environmental reviews. Realistic (50^{th} percentile) χ/Q values for use in the environmental review of DBAs are provided in ER Section 7.1.4. However, Dominion only provides one χ/Q for the low population zone (LPZ). NRC guidance (e.g., Regulatory Guides 1.145 and 1.183) indicates that LPZ χ/Qs should be calculated for each of the four time periods that comprise the "course of the accident" (i.e., 30 days [720 hours]). Therefore, the staff calculated χ/Q values for the four periods using data provided by the applicant.

Table 5-14 presents the atmospheric dispersion factors that the staff used to calculate doses for DBAs. The first column lists the time periods and boundaries for which χ/Q values and dose estimates are needed. For the exclusion area boundary (EAB), the postulated DBA dose and its atmospheric dispersion factor are calculated for a short-term (i.e., 2 hours) and for the LPZ, they are calculated for the "course of the accident" (i.e., 30 days [720 hours]). For the LPZ, there is a χ/Q for each of the four time periods. The second column lists the χ/Q values. The χ/Q values for the EAB and the first LPZ time period are the same as those calculated by Dominion. The χ/Q values for the last three LPZ time periods are those estimated by the staff.

The staff concludes that the atmospheric dispersion characteristics of the North Anna ESP site are acceptable for estimating the potential consequences of postulated DBAs for reactor designs with postulated design χ/Q values falling within the site χ/Q values. The staff intends to verify that the χ/Q values used in analyzing the reactor design proposed at the CP/COL stage are equal to or greater than the χ/Q values specified in the ESP if an applicant for a CP or COL references any North Anna ESP.

Tables 5-15, 5-16, and 5-17 list the set of surrogate DBAs considered by Dominion and present the staff's estimate of the environmental consequences of each DBA in terms of total effective dose equivalent (TEDE). TEDE is the sum of the committed effective dose equivalent (CEDE) from inhalation and the deep dose equivalent from external exposure. Dose conversion factors from Federal Guidance Report 11 (Eckerman et al. 1988) were used by the staff to calculate the CEDE. Similarly, dose conversion factors from Federal Guidance Report 12 (Eckerman and Ryman 1993) were used to calculate the deep dose equivalent.

The Commission has determined (10 CFR Part 52, Appendix A) that the ABWR design meets the TEDE dose criteria of 10 CFR 50.34. Equivalent TEDE values have been estimated for the ABWR from doses in the design certification document by multiplying the thyroid dose by a factor 0.03 (the organ weighting factor for the thyroid) and adding the product to the whole body dose. In addition, the ABWR doses have been scaled to a power level of 4386 MW(t), 102 percent of the power proposed for an ABWR unit at the North Anna ESP site (Dominion 2006a). The scaling was done by multiplying the North Anna site specific doses for the design certification power level of 3926 MW(t) by a factor of 1.1 (Dominion 2006a).

The review criteria used in the staff's safety review of DBA doses are included in Tables 5-15, 5-16, and 5-17 to illustrate how small the calculated environmental consequences (TEDE doses) are. In all cases, the calculated TEDEs are a small fraction of the review criterion. Considering the magnitude of the doses in Tables 5-15, 5-16, and 5-17 and the relationship between low doses and health effects such as fatal and non-fatal cancers and severe hereditary effects described in Section 5.10, the staff concludes that the potential environmental impacts of design basis accidents are small.

Table 5-14. Atmospheric Dispersion Factors (χ/Q, s/m^3) for the North Anna ESP Site Design-Basis Accident Calculations

Time Period[(a)] and Boundary	Site
0 to 2 hr, Exclusion Area Boundary	3.34×10^{-5}
0 to 8 hr, Low Population Zone	2.17×10^{-6}
8 to 24 hr, Low Population Zone	1.5×10^{-6}
1 to 4 day, Low Population Zone	1.2×10^{-6}
4 to 30 day, Low Population Zone	9.0×10^{-7}

(a) Times are relative to the beginning of the release to the environment.

Table 5-15. Design Basis Accident Doses for an ABWR Reactor

		TEDE in Sv[(a)]		
Accident	**Standard Review Plan Section[(b)]**	**EAB**	**LPZ**	**Review Criterion**
Main Steam Line Break	15.6.4			
Pre-Existing Iodine Spike		7.6×10^{-4}	4.9×10^{-5}	2.5×10^{-1}[(c)]
Accident-Initiated Iodine Spike		3.7×10^{-5}	2.4×10^{-6}	2.5×10^{-2}[(d)]
Loss-of-Coolant Accident	15.6.5	2.6×10^{-3}	7.5×10^{-3}	2.5×10^{-1}[(c)]
Failure of Small Lines Carrying Primary Coolant Outside Containment	15.6.2	6.4×10^{-5}	4.1×10^{-6}	2.5×10^{-2}[(d)]
Fuel Handling	15.7.4	9.2×10^{-4}	6.0×10^{-5}	6.3×10^{-2}[(d)]
Cleanup Water Line Break[(e)]		4.7×10^{-6}	3.0×10^{-7}	2.5×10^{-2}[(c)]

(a) To convert Sv to rem, multiply Sv by 100.
(b) NUREG-0800 (NRC 1987).
(c) 10 CFR 50.34(a)(1) and 10 CFR 100.11 criterion.
(d) Standard Review Plan criterion.
(e) The doses for Cleanup Water Line Break bound the doses for a Feedwater System Pipe Break (Dominion 2006a)

Summary of Design Basis Accident Impacts

Although Dominion chose the PPE approach in the overall ESP application, it based its evaluation of the environmental impacts of design basis accidents on characteristics of the ABWR, the surrogate AP1000, and the surrogate ESBWR reactor designs with the explicit representation that these impacts would bound the impacts of other ALWRs designs (Dominion 2006a). The NRC staff reviewed these analyses, which are based on analyses performed for design certification of these reactor designs. The results of the Dominion and staff analyses indicate that the environmental risks associated with DBAs, if an ALWR were to be located at the North Anna ESP site, would be small, compared to the TEDE doses used as safety review criteria. In all cases, the calculated TEDEs are a small fraction of the review

Table 5-16. Design Basis Accident Doses for the Surrogate AP1000 Reactor

Accident	Standard Review Plan Section[b]	TEDE in Sv[a] EAB	LPZ	Review Criterion
Main Steam Line Break	15.1.5			
Pre-Existing Iodine Spike		3.9×10^{-4}	7.9×10^{-5}	2.5×10^{-1}[c]
Accident-Initiated Iodine Spike		4.5×10^{-4}	3.1×10^{-4}	2.5×10^{-2}[d]
Steam Generator Rupture	15.6.3			
Pre-Existing Iodine Spike		1.7×10^{-3}	5.5×10^{-5}	2.5×10^{-1}[c]
Accident-Initiated Iodine Spike		8.4×10^{-4}	4.0×10^{-5}	2.5×10^{-2}[d]
Loss-of-Coolant Accident	15.6.5	1.4×10^{-2}	1.7×10^{-3}	2.5×10^{-1}[c]
Feedwater System Pipe Break	15.2.8	4.5×10^{-4}	3.1×10^{-4}	2.5×10^{-2}[d]
Rod Ejection	15.4.8	1.7×10^{-3}	2.8×10^{-4}	6.3×10^{-2}[d]
Reactor Coolant Pump Rotor Seizure (Locked Rotor)	15.3.3	1.4×10^{-3}	9.6×10^{-5}	2.5×10^{-2}[d]
Reactor Coolant Pump Shaft Break	15.3.4	1.4×10^{-3}	9.6×10^{-5}	2.5×10^{-2}[d]
Failure of Small Lines Carrying Primary Coolant Outside Containment	15.6.2	7.2×10^{-4}	4.8×10^{-5}	2.5×10^{-2}[d]
Fuel Handling	15.7.4	1.3×10^{-3}	9.6×10^{-5}	6.3×10^{-2}[d]

(a) To convert Sv to rem, multiply Sv by 100.
(b) NUREG-0800 (NRC 1987).
(c) 10 CFR 50.34(a)(1) and 10 CFR 100.11 criterion.
(d) Standard Review Plan criterion.

Table 5-17. Design Basis Accident Doses for the Surrogate ESBWR Reactor

Accident	Standard Review Plan Section[b]	TEDE in Sv[a] EAB	LPZ	Review Criterion
Main Steam Line Break	15.6.4			
Pre-Existing Iodine Spike		3.1×10^{-3}	2.0×10^{-4}	2.5×10^{-1}[c]
Accident-Initiated Iodine Spike		1.6×10^{-4}	1.0×10^{-5}	2.5×10^{-2}[d]
Loss-of-Coolant Accident	15.6.5	2.1×10^{-3}	1.3×10^{-3}	2.5×10^{-1}[c]
Feedwater System Pipe Break	15.2.8	6.8×10^{-8}	4.4×10^{-9}	2.5×10^{-2}[d]
Cleanup Water Line Break		2.6×10^{-4}	1.7×10^{-5}	2.5×10^{-2}[d]
Failure of Small Lines Carrying Primary Coolant Outside Containment	15.6.2	4.5×10^{-5}	6.8×10^{-6}	2.5×10^{-2}[d]
Fuel Handling	15.7.4	1.8×10^{-3}	1.2×10^{-4}	6.3×10^{-2}[d]

(a) To convert Sv to rem, multiply Sv by 100.
(b) NUREG-0800 (NRC 1987).
(c) 10 CFR 50.34(a)(1) and 10 CFR 100.21 criteria.
(d) Standard Review Plan criterion.

criterion. Considering the magnitude of the doses in Tables 5-15, 5-16, and 5-17, and the relationship between low doses and health effects such as fatal and non-fatal cancers and severe hereditary effects described in Section 5.10, the staff concludes that the potential environmental impacts of design basis accidents would be SMALL, and further mitigation is not warranted.

The environmental impacts of design basis accidents have not been explicitly evaluated for gas-cooled reactors and will need to be evaluated at the CP/COL stage if an applicant referencing the ESP selects a gas-cooled design. For this evaluation to bound the reactor design selected at the CP/COL stage, the applicant and the staff will need to verify that the environmental impacts of design basis accidents at the North Anna ESP site remain bounded by the environmental impacts from the surrogate designs considered here.

5.10.2 Severe Accidents

For the ABWR and AP1000 reactor designs, Dominion based its evaluation of the potential environmental consequences of severe accidents in the ER on the evaluation of potential consequences of severe accidents for current generation reactors presented in NUREG-1437 (NRC 1996). Three pathways were considered: (1) the atmospheric pathway in which radioactive material is released to the air, (2) the surface water pathway in which airborne radioactive material falls out on open bodies of water, and (3) the groundwater pathway in which groundwater is contaminated by a basemat melt-through with subsequent contamination of surface water by the groundwater.

In response to an NRC request for additional information dated March 12, 2004 (NRC 2004a), the applicant performed a site-specific analysis of the potential environmental consequences of postulated severe accidents at the North Anna ESP site. The PPE does not include source terms for severe accidents; therefore, the applicant used source terms for the ABWR and the surrogate AP1000 reactors. The applicant used the MACCS2 computer code (Chanin et al. 1990; Jow et al. 1990) for the analysis. A summary of the results of the analysis was submitted to the NRC in a letter dated May 17, 2004 (Dominion 2004b), and detailed computer output was submitted by letter dated July 12, 2004 (Dominion 2004d). In addition, in Revision 6 of the ER, Dominion performed a site-specific analysis of the potential consequences of postulated severe accidents for the surrogate ESBWR at the North Anna ESP site. Dominion used the MACCS2 computer code (Chanin et al. 1990; Jow et al. 1990) for the analysis. Along with Revision 6 to the North Anna ESP application, Dominion provided the MACCS2 input and output files to the NRC.

The MACCS computer code was developed to evaluate the potential offsite consequences of severe accidents for the sites covered by NUREG-1150 (NRC 1990). MACCS2 (Chanin and Young 1997) is the current version of MACCS. The MACCS and MACCS2 codes evaluate the consequences of atmospheric releases of radioactive material following a severe accident. The pathways modeled include external exposure to the passing plume, external exposure to material deposited on the ground and skin, inhalation of material in the passing plume and resuspended from the ground, and ingestion of contaminated food and surface water. The primary enhancements in MACCS2 are that MACCS2 has (1) an improved emergency response model, (2) an expanded library of radionuclides, and (3) an improved food-chain model (Chanin and Young 1997).

Three types of severe accident consequences are assessed in MACCS2: (1) human health, (2) economic costs, and (3) land area affected by contamination. Human-health effects are expressed in terms of the number of cancers that might be expected if a severe accident were to occur. These effects are directly related to the cumulative radiation dose received by the general population. MACCS2 estimates both early cancer fatalities and latent fatalities. Early fatalities are related to high doses or dose rates and can be expected to occur within a year of exposure (Jow et al. 1990). Latent fatalities are related to exposure of a large number of people to low doses and dose rates and could occur after a latent period of several (e.g., 2 to 15) years. Population health risk estimates are based on the population distribution within an 80-km (50-mi) radius of the plant, whereas average individual health risks are based on the distribution of population close to the plant. Economic costs of a severe accident include the costs associated with short-term relocation of people, decontamination of property and equipment, interdiction of food supplies, land, and equipment use, and condemnation of property. The affected land area is a measure of the areal extent of the residual contamination following a severe accident.

Risk is the product of the frequency of an accident, also called the core damage frequency, and the consequence of the accident. For example, a severe accident without loss of containment for an ABWR is estimated to have a core damage frequency of 1.34×10^{-7} per reactor year (Ryr^{-1}); and the cumulative population dose associated with a severe accident without loss of containment at the North Anna ESP site is calculated to be 7.86×10^{1} person-Sv (7.86×10^{3} person-rem). The population dose risk for this class of accidents is the product of 1.34×10^{-7} Ryr^{-1} and 7.86×10^{1} person-Sv, or 1.05×10^{-5} person-Sv Ryr^{-1} (1.05×10^{-3} person-rem Ryr^{-1}).

Core damage frequency estimates are made using well developed methods that have been updated based on investigation of the accident at Three Mile Island, Unit 2 and research following the accident. Core damage frequency estimation methods used to generate the estimates presented in this EIS are described in NUREG-1150, *Severe Accident Risk: An Assessment for Five U.S. Nuclear Power Plants* (NRC 1990). These methods explicitly consider both pre-accident and post-accident human errors. The core damage frequencies listed in this EIS are core damage frequencies estimated for the ABWR, AP1000, and ESBWR reactor designs as part of the design certification process. The following sections discuss the estimated risks associated with the air, surface water, and groundwater pathways.

5.10.2.1 Air Pathway

The MACCS2 code directly estimates consequences associated with releases to the air pathway. The results of the MACCS2 runs are presented in Tables 5-18, 5-19, and 5-20. The core damage frequencies given in these tables are for internally initiated accident sequences while the plant is at power. Internally initiated accident sequences include those sequences initiated by human error, equipment failures, and loss of offsite power. Based on insights from the review of the ALWR probabilistic risk assessments, completed prior to the ESP application, the core damage frequencies for externally initiated events and during shutdown would be comparable to or lower than those for internally initiated events.

Tables 5-18, 5-19, and 5-20 show that the probability weighted consequences (i.e., the risks) of severe accidents for the ABWR, the surrogate AP1000, or the surrogate ESBWR reactor located on the North Anna ESP site are small for all risk categories considered. For perspective, Tables 5-21 and 5-22 compare the health risks from severe accidents for the ABWR, surrogate AP1000, and surrogate ESBWR reactors at the North Anna ESP site with the risks for current generation of operating reactors at various sites.

In Table 5-21, the health risks estimated for the ABWR, surrogate AP1000, and surrogate ESBWR reactors at the North Anna ESP site are compared with health risk estimates for the five reactors considered in NUREG-1150 (NRC 1990). Although risks associated with both internally and externally-initiated events were considered for the Peach Bottom and Surry reactors in NUREG-1150, only risks associated with internally initiated events are presented in Table 5-20. The health risks shown for the ABWR, surrogate AP1000, and surrogate ESBWR reactors at the North Anna ESP site are significantly lower than the risks associated with current generation of operating reactors presented in NUREG-1150.

In addition, the last two columns of Table 5-21 provide average individual fatality risk estimates for comparison to the Commission's safety goals. The Commission has set safety goals for average individual early fatality and latent cancer fatality risks from reactor accidents in the Safety Goal Policy Statement (NRC 1986). The Policy Statement expressed the Commission's policy regarding the acceptance level of radiological risk from nuclear power plant operation as follows:

- Individual members of the public should be provided a level of protection from the consequences of nuclear power plant operation such that individuals bear no significant additional risk to life and health.

- Societal risks to life and health from nuclear power plant operation should be comparable to or less than the risks of generating electricity by viable competing technologies and should not be a significant addition to other societal risks.

Table 5-18. Mean Environmental Risks from ABWR Severe Accidents at the North Anna ESP Site

Release Category Description (Accident Class)		Core Damage Frequency (Ryr^{-1})	Environmental Risk					
			Population Dose (person- Sv Ryr^{-1})[a]	Fatalities (Ry^{-1})		Cost[d] (\$ Ryr^{-1})	Land Requiring Decontamination[e] (ha Ryr^{-1})	Population Dose from Water Ingestion (person-Sv Ryr^{-1})[a]
				Early[b]	Latent[c]			
0	No loss of containment	1.34×10^{-7}	1.05×10^{-5}	(f)	4.66×10^{-7}	(f)	7.34×10^{-7}	1.93×10^{-8}
1	Transients followed by failure of high-pressure coolant makeup water and failure to depressurize in timely fashion	2.08×10^{-8}	2.16×10^{-6}	(f)	9.86×10^{-8}	(f)	(f)	(f)
2	Short-term station blackout with reactor core isolation cooling (RCIC) failure, onsite power recovery in 8 hr	1.00×10^{-10}	(f)	(f)	(f)	(f)	(f)	(f)
3	Station blackout with RCIC available for about 8 hr	1.00×10^{-10}	(f)	(f)	(f)	(f)	(f)	(f)
4	Station blackout (more than 8 hr) with RCIC failure	1.00×10^{-10}	(f)	(f)	(f)	(f)	(f)	(f)
5	Transients followed by failure of high pressure coolant makeup water, successful depressurization of reactor, failure of low-pressure coolant makeup water	1.00×10^{-10}	(f)	(f)	(f)	(f)	(f)	(f)

Table 5-18. (contd)

Release Category Description (Accident Class)		Core Damage Frequency (Ryr^{-1})	Population Dose (person- Sv Ryr^{-1})[a]	Fatalities (Ry^{-1}) Early[b]	Fatalities (Ry^{-1}) Latent[c]	Cost[d] ($ Ryr^{-1})	Land Requiring Decontamination[e] (ha Ryr^{-1})	Population Dose from Water Ingestion (person-Sv Ryr^{-1})[a]
6	Transient, loss-of-coolant accident (LOCA), and anticipated transient without scram (ATWS) events with successful coolant makeup water, but potential prior failure of containment	1.00×10^{-10}	2.81×10^{-6}	(f)	1.25×10^{-7}	6.04×10^{-1}	4.75×10^{-6}	4.81×10^{-8}
7	Small/medium LOCA followed by failure of high-pressure coolant makeup water and failure to depressurize	3.91×10^{-10}	1.26×10^{-5}	(f)	5.55×10^{-7}	$2.70 \times 10^{+0}$	1.96×10^{-5}	2.42×10^{-7}
8	LOCA followed by failure of high-pressure coolant makeup water	4.05×10^{-10}	1.96×10^{-5}	2.17×10^{-11}	8.63×10^{-7}	$5.06 \times 10^{+0}$	2.88×10^{-5}	5.63×10^{-7}
9	ATWS followed by boron injection failure and successful high-pressure coolant makeup water	1.70×10^{-10}	1.06×10^{-5}	2.41×10^{-12}	5.00×10^{-7}	$2.69 \times 10^{+0}$	1.39×10^{-5}	4.00×10^{-7}
Total		1.56×10^{-7}	5.93×10^{-5}	2.41×10^{-11}	2.65×10^{-6}	$1.11 \times 10^{+1}$	6.83×10^{-5}	1.28×10^{-6}

(a) To convert Sv to rem, multiply Sv by 100.
(b) Early fatalities are fatalities related to high doses or dose rates that generally can be expected to occur within a year of the exposure (Jow et al. 1990).
(c) Latent fatalities are fatalities related to low doses or dose rates that could occur after a latent period of several (2 to 15) years.
(d) Cost risk includes costs associated with short-term relocation of people, decontamination, interdiction, and condemnation. It does not include costs associated with health effects (Jow et al. 1990)
(e) Land risk is farm land requiring decontamination prior to resumption of agricultural usage. To convert hectares to acres, multiply by 2.47.
(f) Less than 1% of total

Table 5-19. Mean Environmental Risks from the Surrogate AP1000 Severe Accidents at the North Anna ESP Site

			Environmental Risk					
				Fatalities (Ry^{-1})				
Release Category Description (Accident Class)		Core Damage Frequency (Ryr^{-1})	Population Dose (person- Sv Ryr^{-1})[(a)]	Early[(b)]	Latent[(c)]	Cost[(d)] (\$ Ryr^{-1})	Land Requiring Decontamination[(e)] (ha Ryr^{-1})	Population Dose from Water Ingestion (person Sv Ryr^{-1})[(a)]
CFI	Intermediate containment failure, after core relocation but before 24 h	1.89×10^{-10}	(f)	(f)	(f)	(f)	(f)	(f)
CFE	Early containment failure, after onset of core damage but before core relocation	7.47×10^{-9}	1.88×10^{-4}	5.15×10^{-11}	8.89×10^{-6}	$3.76 \times 10^{+1}$	3.12×10^{-4}	2.52×10^{-6}
IC	Intact containment	2.21×10^{-7}	1.05×10^{-5}	0	4.84×10^{-7}	(f)	(f)	(f)
BP	Containment bypass, fission products released directly to environment	1.05×10^{-8}	5.96×10^{-4}	7.07×10^{-11}	2.90×10^{-5}	$1.42 \times 10^{+2}$	8.98×10^{-4}	1.66×10^{-5}
CI	Containment isolation failure occurs prior to onset of core damage	1.33×10^{-9}	2.97×10^{-5}	1.31×10^{-12}	1.65×10^{-6}	$5.49 \times 10^{+0}$	4.79×10^{-5}	3.87×10^{-7}
CFL	Late containment failure occurring after 24 h	3.45×10^{-13}	(f)	(f)	(f)	(f)	(f)	(f)
Total		2.40×10^{-7}	8.28×10^{-4}	1.24×10^{-10}	4.02×10^{-5}	$1.85 \times 10^{+2}$	1.27×10^{-3}	1.96×10^{-5}

(a) To convert Sv to rem, multiply Sv by 100.
(b) Early fatalities are fatalities related to high doses or dose rates that generally can be expected to occur within a year of the exposure (Jow et al. 1990).
(c) Latent fatalities are fatalities related to low doses or dose rates that could occur after a latent period of several (2 to 15) years.
(d) Cost risk includes costs associated with short-term relocation of people, decontamination, interdiction, and condemnation. It does not include costs associated with health effects (Jow et al. 1990).
(e) Land risk is farm land requiring decontamination prior to resumption of agricultural usage. To convert hectares (ha) to acres, multiply by 2.47.
(f) Less than 1% of total

Table 5-20. Mean Environmental Risks from Surrogate ESBWR Severe Accidents at the North Anna ESP Site

Release Category Description (Accident Class)		Core Damage Frequency (Ryr^{-1})	Environmental Risk					
			Population Dose (person- Sv Ryr^{-1})[a]	Fatalities (Ry^{-1}) Early[b]	Fatalities (Ry^{-1}) Latent[c]	Cost[d] (\$ Ryr^{-1})	Land Requiring Decontamination[e] (ha Ryr^{-1})	Population Dose from Water Ingestion (person-Sv Ryr^{-1})[a]
TSL	Containment leakage at Technical Specification Limit	2.8×10^{-8}	6.80×10^{-6}	[f]	3.05×10^{-7}	0.05	1.30×10^{-6}	1.06×10^{-8}
CCIW	Containment fails due to core concrete interaction; lower drywell debris bed covered	2.9×10^{-10}	3.60×10^{-6}	[f]	1.61×10^{-7}	0.24	3.48×10^{-6}	1.48×10^{-8}
EVE	Ex-vessel steam explosion fails containment	[f]	1.93×10^{-5}	2.68×10^{-10}	9.75×10^{-7}	3.98	2.03×10^{-5}	5.85×10^{-7}
FR	Release through controlled (filtered) venting from suppression chamber	[f]	[f]	[f]	[f]	[f]	[f]	[f]
CCID	Containment fails due to core concrete interaction; lower drywell debris bed uncovered	[f]	2.08×10^{-6}	2.41×10^{-11}	9.31×10^{-8}	0.44	2.32×10^{-6}	5.97×10^{-8}
OPW2	Containment fails due to late (>24 hours) loss of containment heat removal	[f]	4.02×10^{-7}	[f]	1.81×10^{-8}	0.06	5.47×10^{-7}	[f]

Table 5-20. (contd)

Release Category Description (Accident Class)		Core Damage Frequency (Ryr^{-1})	Population Dose (person- Sv Ryr^{-1})[a]	Fatalities (Ry^{-1}) Early[b]	Fatalities (Ry^{-1}) Latent[c]	Cost[d] ($ Ryr^{-1})	Land Requiring Decontamination[e] (ha Ryr^{-1})	Population Dose from Water Ingestion (person-Sv Ryr^{-1})[a]
BOC	Break outside of containment	[f]	3.73×10^{-7}	2.22×10^{-10}	2.26×10^{-8}	0.05	[f]	1.04×10^{-8}
BYP	Containment bypassed because of CIS failure with large (>12" hole) opening. Lower drywell debris bed covered.	[f]	[f]	4.65×10^{-11}	[f]	[f]	[f]	[f]
DCH	Direct containment heating (high pressure RPV failure) event damages containment	[f]	[f]	[f]	[f]	[f]	[f]	[f]
OPVB	Containment fails due to failure of vapor suppression system (vacuum breaker) function.	[f]	[f]	[f]	[f]	[f]	[f]	[f]
OPW1	Containment fails due to early (<24 hours) loss of containment heat removal	[f]	[f]	[f]	[f]	[f]	[f]	[f]
Total		2.88×10^{-8}	3.29×10^{-5}	5.62×10^{-10}	1.59×10^{-6}	4.85	2.84×10^{-5}	6.89×10^{-7}

(a) To convert Sv to rem, multiply Sv by 100.
(b) Early fatalities are fatalities related to high doses or dose rates that generally can be expected to occur within a year of the exposure (Jow et al. 1990).
(c) Latent fatalities are fatalities related to low doses or dose rates that could occur after a latent period of several (2 to 15) years.
(d) Cost risk includes costs associated with short-term relocation of people, decontamination, interdiction, and condemnation. It does not include costs associated with health effects (Jow et al. 1990)
(e) Land risk is farm land requiring decontamination prior to resumption of agricultural usage. To convert hectares to acres, multiply by 2.47.
(f) Less than 1 percent of the total

Table 5-21. Comparison of Environmental Risk for New Surrogate ESBWR Units at the North Anna ESP Site with Risks for Five Sites Evaluated in NUREG-1150

Reactor Site	Core Damage Frequency (Ryr^{-1})	50-mi (80-km) Population Dose Risk (person-Sv Ryr^{-1})[a]	Fatalities Ryr^{-1}		Average Individual Fatality Ryr^{-1}	
			Early	Latent	Early	Latent Cancer
Grand Gulf[b]	4.0×10^{-6}	5×10^{-1}	8×10^{-9}	9×10^{-4}	3×10^{-11}	3×10^{-10}
Peach Bottom[b]	4.5×10^{-6}	$7 \times 10^{+0}$	2×10^{-8}	5×10^{-3}	5×10^{-11}	4×10^{-10}
Sequoyah[b]	5.7×10^{-5}	$1 \times 10^{+1}$	3×10^{-5}	1×10^{-2}	1×10^{-8}	1×10^{-8}
Surry[b]	4.0×10^{-5}	$5 \times 10^{+0}$	2×10^{-6}	5×10^{-3}	2×10^{-8}	2×10^{-9}
Zion[b]	3.4×10^{-4}	$5 \times 10^{+1}$	1×10^{-4}	2×10^{-2}	9×10^{-9}	8×10^{-9}
ABWR at North Anna ESP Site[c]	1.6×10^{-7}	5.9×10^{-5}	2.4×10^{-11}	2.7×10^{-6}	4.6×10^{-14}	4.4×10^{-12}
AP1000 at North Anna ESP Site[c]	2.4×10^{-7}	8.3×10^{-4}	1.2×10^{-10}	4.0×10^{-5}	2.6×10^{-13}	4.9×10^{-11}
Surrogate ESBWR at North Anna ESP Site[c]	2.9×10^{-8}	3.3×10^{-5}	5.6×10^{-10}	1.6×10^{-6}	5.5×10^{-13}	3.4×10^{-12}

(a) To convert Sv to rem, multiply Sv by 100.
(b) Risks were calculated using the MACCS code and presented in NUREG-1150 (NRC 1990).
(c) Calculated with MACCS2 code using North Anna site-specific input.

Table 5-22. Comparison of Environmental Risks from Severe Accidents Initiated by Internal Events for an ABWR, a Surrogate AP1000, and a Surrogate ESBWR at the North Anna ESP Site with Risks Initiated by Internal Events for 28 Current Operating Plants Undergoing License Renewal

Reactor Site	Core Damage Frequency (yr^{-1})	50-mi (80-km) Population Dose Risk (person-Sv Ryr^{-1})[a]
Current Reactor Maximum[b]	2.4×10^{-4}	6.9×10^{-1}
Current Reactor Mean[b]	3.6×10^{-5}	1.5×10^{-1}
Current Reactor Median[b]	2.8×10^{-5}	1.4×10^{-1}
Current Reactor Minimum[b]	1.9×10^{-6}	5.5×10^{-3}
North Anna Units 1 and 2	3.5×10^{-5}	2.5×10^{-1}
ABWR at North Anna ESP Site[c]	1.6×10^{-7}	5.9×10^{-5}
AP1000 at North Anna ESP Site[c]	2.4×10^{-7}	8.3×10^{-4}
ESBWR at North Anna ESP Site[c]	2.9×10^{-8}	3.3×10^{-5}

(a) To convert Sv to rem, multiply Sv by 100.
(b) Based on MACCS and MACCS2 calculations for current plants undergoing operating license renewal.
(c) Calculated with MACCS2 code using North Anna site-specific input.

The following quantitative health objectives are used in determining achievement of the safety goals:

- The risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities that might result from reactor accidents should not exceed one-tenth of 1 percent (0.1 percent) of the sum of prompt fatality risks resulting from other accidents to which members of the U.S. population are generally exposed.

- The risk to the population in the area near a nuclear power plant of cancer fatalities that might result from nuclear power plant operation should not exceed one-tenth of 1 percent (0.1 percent) of the sum of cancer fatality risks resulting from all other causes.

These quantitative health objectives are translated into two numerical objectives as follows:

- The individual risk of a prompt fatality from all “other accidents to which members of the U.S. population are generally exposed,” such as fatal automobile accidents, is about 5×10^{-4} per year. One-tenth of one percent of this figure implies that the individual risk of prompt fatality from a reactor accident should be less than 5×10^{-7} per reactor year.

- "The sum of cancer fatality risks resulting from all other causes" for an individual is taken to be the cancer fatality rate in the U.S. which is about 1 in 500 or 2×10^{-3} per year. One-tenth of 1 percent of this implies that the risk of cancer to the population in the area near a nuclear power plant because of its operation should be limited to 2×10^{-6} per reactor year.

MACCS2 calculates average individual early and latent cancer fatality risks. The average individual early fatality risk is calculated using the population distribution within 1.6 km (1 mi) of the plant boundary. The average individual latent cancer fatality risk is calculated using the population distribution within 16 km (10 mi) of the plant. For the plants considered in NUREG-1150, these risks were well below the Commission's safety goals. Risks calculated for the ABWR, the surrogate AP1000, and the surrogate ESBWR designs at the North Anna ESP site are lower than the risks associated with the current generation reactors considered in NUREG-1150 and are well below the Commission's safety goals.

The staff compared the core damage frequencies and population dose risk estimates for the ABWR, surrogate AP1000, and surrogate ESBWR reactors at the North Anna ESP site with statistics summarizing the results if contemporary severe accident analyses performed for 28 current generation operating reactors at 23 sites. The results of these analyses are included in the final site-specific Supplements 1 through 20 to the Generic Environmental Impact Statement for License Renewal (GEIS), NUREG-1437, and in the ERs included with license renewal applications for those plants for which supplements have not been published. All of the analyses were completed after publication of NUREG-1150, and the 23 analyses used MACCS2, which was released in 1997. Table 5-22 shows that the core damage frequencies estimated for the ABWR, AP1000, and ESBWR reactors are significantly lower than those of current generation reactors. Similarly, the population doses estimated for the advanced reactors at the North Anna ESP site are well below the mean and median values for current generation reactors undergoing license renewal.

Population dose and risk estimates for the North Anna site in Tables 5-18 through 5-22 were estimated using population projections for 2030 based on 1990 census data that were made for renewal of the North Anna Unit 1 and 2 operating licenses (NRC 2002b). Population growth estimates presented in Chapter 2 of the ER (Dominion 2006a) indicate that between 2030 and 2065 the population in the region is expected to increase by factors of 1.0 to 1.7 depending on distance and direction from the site (Dominion 2006a). Even if the projected growth from 2030 to 2065 were as large as a factor of 2, the risks would still be well below the Commission's safety goals.

5.10.2.2 Surface Water Pathways

Surface water pathways are an extension of the air pathway. These pathways cover the effects of radioactive material deposited on open bodies of water. The surface water pathways of interest include exposure to external radiation from submersion in water and activities near the water, ingestion of water, and ingestion of fish and other aquatic creatures. Of these pathways, the MACCS2 code only evaluates the ingestion of contaminated water. The risks associated with this surface water pathway calculated for the North Anna ESP site are included in the last columns of Tables 5-18, 5-19, and 5-20. For each accident class, the population dose risk from ingestion of water is a small fraction of the dose risk from the air pathway.

Lake Anna is used for recreational activities including swimming and fishing. Doses from these surface water pathways are not modeled in MACCS or MACCS2. NUREG-1437 (NRC 1996) provides an estimate of typical population exposure risk for the aquatic food pathway for plants located on small rivers. The North Anna ESP site is classified as being on a small river. For these plants, the risk associated with the aquatic food pathway is about 4×10^{-3} person-Sv Ryr^{-1} (4×10^{-1} person-rem Ryr^{-1}). The total risk for the existing NAPS Units 1 and 2 is about 2.5×10^{-1} person-Sv Ryr^{-1} (2.5×10^{1} person-rem Ryr^{-1}) (NRC 2002b). Thus, the generic aquatic pathway risk is less than 2 percent of the total risk. Analysis of water-related exposure pathways at the Fermi reactor (NRC 1981) suggests that population exposures from swimming are significantly lower than exposures from the aquatic ingestion pathway.

Virginia Power controls the land to the high water mark of Lake Anna within the NAPS site (Dominion 2006a). In the event of a large release of radioactive material, Virginia Power and the Commonwealth of Virginia could control access to the lake, which is the major surface water body in the vicinity of the North Anna ESP site. By exercising that control, Virginia Power could reduce exposures through the surface water pathways.

In a similar fashion to the air pathway, the environmental impacts of the surface water pathway for other advanced LWRs are expected to be bounded by the ABWR, surrogate AP1000, and surrogate ESBWR. The environmental impacts of severe accidents have not been evaluated for gas-cooled reactors. The PPE does not contain specific parameters related to severe accidents for gas-cooled reactors, and the consequences of severe accidents have not been evaluated for gas-cooled reactors and will need to be evaluated at the CP/COL stage if a gas-cooled design is selected. For this evaluation to bound the reactor design selected at the CP/COL stage, the applicant and the staff will need to verify that the environmental impacts of the surface water pathway releases for severe accidents at the North Anna ESP site remain bounded by the environmental impacts from the surrogate designs.

5.10.2.3 Groundwater Pathway

Neither MACCS nor MACCS2 evaluates the environmental risks associated with severe accident releases of radioactive material to groundwater. However, this pathway has been addressed in NUREG-1437 in the context of renewal of licenses for the current generation reactors. NUREG-1437 assumes a 1×10^{-4} Ryr^{-1} probability of occurrence of a severe accident with a basemat melt-through leading to potential groundwater contamination, and the staff concluded that groundwater generally contributed a small fraction of the risk attributable to the atmospheric pathway. Although the staff assumed that the probability of occurrence of a release via the groundwater pathway is significantly larger than a release via the atmospheric pathway for the ABWR, the surrogate AP1000, or the surrogate ESBWR, the groundwater pathway is more tortuous and affords a greater time for implementing protective actions and therefore results in a lower risk to the public. As a result, the staff concludes that the risks associated with releases to groundwater are small for the North Anna ESP site.

5.10.2.4 Summary of Severe Accident Impacts

Although Dominion chose the PPE approach in the overall ESP application, it based its evaluation of the environmental impacts of severe accidents on characteristics of the ABWR, the surrogate AP1000, and the surrogate ESBWR reactor designs with the explicit representation that these impacts would bound the impacts of other ALWR designs (Dominion 2006a). The NRC staff reviewed the analysis in the ER and conducted its own confirmatory analysis using the MACCS2 code (NRC 2006f). The results of both the Dominion and NRC analyses indicate that the environmental risks associated with severe accidents if an ALWR were to be located at the North Anna ESP site would be small compared to risks associated with operation of current generation reactors at the North Anna site and other sites. These risks are well below the NRC safety goals. On these bases, the staff concludes that the probability weighted consequences of severe accidents at the North Anna ESP site are of SMALL significance for ALWR. The environmental impacts of severe accidents for designs not evaluated in this EIS, including gas-cooled designs are not resolved because necessary design information is lacking. Consequently these impacts would need to be evaluated at the CP/COL stage. For this evaluation to bound a LWR reactor design selected at the CP/COL stage, the staff would need to verify that the environmental impacts of severe accidents at the North Anna ESP site remain bounded by the environmental impacts from the surrogate designs.

5.10.3 Summary of Postulated Accident Impacts

The staff evaluated the environmental impacts from design basis accidents and severe accidents using the ABWR, the surrogate AP1000, and the surrogate ESBWR to characterize the environmental impacts from ALWR. As described previously, preliminary information on the IRIS and the ACR-700 reactor designs indicate that the surrogate AP1000 is expected to bound the source term, doses, and probability weighted consequences of design and severe accidents.

Based on the information provided by Dominion, and its own independent review, the staff concludes that the potential environmental impacts of a postulated accident from the operation of two additional nuclear power plants would be SMALL, for the operation of advanced LWRs. The staff did not explicitly evaluate the design basis or severe accident impacts for gas-cooled reactors because of the lack of necessary design information. Consequently, the impacts involving gas-cooled reactor designs are not resolved.

5.11 Measures and Controls to Limit Adverse Impacts During Operation

In the ER, Dominion tabulated its representation of "feasible and adequate measures/controls" in Table 5.10-1, "Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations" (Dominion 2006a). This tabulation includes measures and controls that Dominion would be required to implant by applicable Federal, Commonwealth, local statutes and regulations, and permit requirements, terms, and conditions. The staff relied upon these measures and controls in its evaluation of environmental impacts during operation of the proposed new units at the North Anna ESP site; for those issues where Dominion indicated that a study, process, or capability "would be considered," the staff relied upon the study, process, or capabilities as being implemented or conducted.

In addition to the foregoing measures and controls tabulated in ER Table 5.10-1, the staff also relied on the following general plans or specific mitigation measures:

- Current transmission line maintenance practices would continue if two new units were built at the ESP site (ER Section 5.6.1.1).
- A system study modeling the transmission lines with new units' contribution would be conducted (ER Section 5.1.2).
- Locations of rare or sensitive plant species within transmission line corridors would be identified so modified treatment practices can be used in these areas to avoid adverse impacts (ER Section 5.6.1.1).

- Demonstrate that the fogging and salt deposition analysis of the cooling system remains bounding (May 24, 2006, response to RAI).

- The intake structure for the proposed new units at the ESP site would meet Section 316(b) of the Clean Water Act and the implementing regulations, as applicable (ER Section 5.3.1.2).

- Vegetative shielding would block a clear view of the new units from most nearby residences (ER Section 5.8.1.5, Table 5.10-1).

- Noise levels would be controlled in accordance with applicable local county regulations (ER Section 5.8.1.2).

- Although the operation of the new units are not expected to require changes in land use (ER Section 5.1), any ground-disturbing activities necessary for operations would be conducted in coordination with the VDHR and professional archaeological practices consistent with the process established for construction activities (ER Section 4.1.3).

Dominion evaluated the measures and controls shown in Table 5.10-1 of the ER (Dominion 2006a) and considered them feasible from both a technical and economic standpoint. In addition, Dominion expects these measures and controls to be adequate for avoiding or mitigating potential adverse impacts associated with operation of the proposed new units. The staff considered these measures and controls in its evaluation of station operation impacts. The staff has included the measures and controls in Appendix J, Table J-1.

5.12 Summary of Operational Impacts

Impact level categories denoted in Table 5-22 as SMALL, MODERATE, or LARGE were assigned to each resource area based on the staff's evaluations and conclusions regarding expected adverse environmental impacts, if any. A brief statement explains the basis for the impact level. Some impacts, such as the addition of tax revenue from Dominion for the local economies, are likely to be beneficial impacts to the community, and are noted as such.

Table 5-22. Characterization of Operational Impacts at the North Anna ESP Site

Category	Comments	Impact Level
Land use impacts		--
The site and vicinity	Operation of new units within existing site. Possible new housing and retail space added in vicinity due to potential growth.	SMALL
Transmission line rights-of-way	No new transmission line rights-of-way would be needed.	SMALL
Air quality impacts	Impacts are expected to be negligible. Pollutants emitted during operations considered insignificant and limits could be incorporated under existing Exclusionary Permit.	SMALL
Water-related impacts		--
Hydrological alterations	Changes in the quantity and distribution of heat in the lake are expected to be negligible.	SMALL
Water use		
Normal years	During normal water years, the impact would be small.	SMALL
Drought years	During critical low-water years, the impacts could be temporarily moderate.	MODERATE
Water quality	Water effluents would be regulated by the VPDES permit, but their exact composition would depend on information not yet available.	Not Resolved
Ecological impacts		--
Terrestrial ecosystems	No detectable impacts expected; no important species in area.	SMALL
Aquatic ecosystems	The fish community is balanced. Proportion of resources subject to impingement and entrainment would be small. The impact on striped bass would be minimal even during drought years or late summer. Refugia would be available.	SMALL
Threatened and Endangered Species		--
Terrestrial Species	No threatened or endangered species known to inhabit area.	SMALL
Aquatic Species	No threatened or endangered species known to inhabit area.	SMALL

Table 5-22. (contd)

Category	Comments	Impact Level
Socioeconomic impacts		--
Physical Impacts		--
Workers/Public	Workers would use protective equipment and receive training to mitigate any possible impact. North Anna location is relatively remote, so the public would not be impacted.	SMALL
Buildings	No impact to onsite or offsite buildings.	SMALL
Roads	Upgrades and other mitigation before or during construction would cover the lesser impact of operational work forces.	SMALL
Aesthetics	Lower water levels, and their effect on shoreline exposure during severe drought could temporarily impact area. Elevated steam plume for the Unit 3 cooling towers, especially in the winter. These impacts are expected to be temporarily at the moderate level.	SMALL TO MODERATE
Demography	Number of new employees small in proportion to population base.	SMALL
Community Characteristics		
Economy	Increased jobs would benefit the area economically, up to a moderate beneficial impact (Louisa and Orange Counties) is possible.	SMALL BENEFICIAL TO MODERATE BENEFICIAL
Transportation	Improvements made for construction would be sufficient to cover any adverse impact from small number of additional operational workers.	SMALL
Taxes	Depends on residence location; generally impacts are beneficial, especially for property taxes and employment. Beneficial impacts of additional taxes would be large for Louisa County.	SMALL BENEFICIAL TO LARGE BENEFICIAL
Recreation	Lower water levels, and their effect on shoreline exposure and recreational usage during severe drought could temporarily impact area.	SMALL TO MODERATE

Table 5-22. (contd)

Category	Comments	Impact Level
Housing	Adequate housing is available in Henrico and Spotsylvania Counties and in Richmond to handle operational workers. Orange and Louisa Counties could experience a temporary shortage of upscale housing, possibly at the moderate impact level.	SMALL
Public Services	Adequate in all counties for any population increase due to operation workforce.	SMALL
Education	Current schools and planned additions would handle additional students.	SMALL
Historic and cultural resources	A cultural resource program is in place for minimizing impacts from routine land disturbances.	SMALL
Environmental justice	No unusual resource dependence in the area.	SMALL
Nonradiological health impacts	Health impacts monitored and controlled in accordance with Occupational Safety and Health Administration regulations.	SMALL
	Chronic health impacts of electromagnetic fields	Not Resolved
Radiological health impacts	Doses to public and occupational workers are monitored and controlled in accordance with NRC limits. Doses to biota other than humans were found to be protective when compared to guidance in ICRP and NCRP studies.	SMALL
Impacts of postulated accidents		--
Design basis accidents	Doses for advanced light water reactors are expected to be a small fraction of the regulatory dose limits. Staff would verify that source terms for postulated DBAs on chosen reactor designs are within those considered in the ESP EIS.	SMALL
Severe accidents	Risks for ALWRs would be small. If gas-cooled reactor is selected at the CP/COL stage then the staff will evaluate the severe accident impacts for gas-cooled reactors. Severe accident mitigation alternatives are unresolved.	SMALL

5.13 References

Note: Because the web pages cited in this document may become unavailable, the staff has entered the appropriate pages into ADAMS. The accession number of the package containing the websites used as references in Chapter 5 of the North Anna ESP EIS is ML051150148.

10 CFR Part 20. Code of Federal Regulations, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 52. Code of Federal Regulations, Title 10, *Energy*, Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

10 CFR Part 100. Code of Federal Regulations, Title 10, *Energy*, Part 100, "Reactor Site Criteria."

36 CFR Part 800. Code of Federal Regulations, Title 36, *Parks, Forests, and Public Property*, Part 800, "Protection of Historic Properties."

40 CFR Part 51. Code of Federal Regulations, Title 40, *Protection of the Environment*, Part 51, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans."

40 CFR Part 141. Code of Federal Regulations, Title 40, *Protection of the Environment*, Part 141, "National Primary Drinking Water Regulations."

40 CFR 190. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

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6.0 Fuel Cycle, Transportation, and Decommissioning

This chapter addresses the environmental impacts from (1) the uranium fuel cycle and solid waste management, (2) transportation of radioactive material, and (3) decommissioning for the postulated Units 3 and 4 at the North Anna early site permit (ESP) site. The environmental impacts were assessed for the North Anna ESP site and the alternative sites. Distinctions between the impacts of light-water reactor (LWR) designs and the gas-cooled reactor designs are discussed.

In its evaluation of uranium fuel cycle impacts for the North Anna ESP site, Dominion Nuclear North Anna, LLC (Dominion) used the plant parameter envelope (PPE) approach for the LWR designs but not for the two gas-cooled reactors. In its evaluation of the impacts from transportation of radioactive materials, Dominion did not use the PPE approach but rather evaluated each reactor design individually. Therefore, an applicant referencing any North Anna ESP would have to perform a new evaluation if a different design is proposed at the construction permit (CP) or combined license (COL) stage.

6.1 Fuel Cycle Impacts and Solid Waste Management

This section discusses the environmental impacts from the uranium fuel cycle and solid waste management for both the LWR designs and gas-cooled reactor designs. The impacts of the two types of design are presented separately because Title 10 of the Code of Federal Regulations (CFR), Section 51.51 provides specific criteria for evaluating the environmental impacts only for LWR designs. Issues related to fuel cycle impacts and solid waste management are not resolved because data to validate impacts from gas-cooled designs were not available.

6.1.1 Light-Water Reactors

The regulations in 10 CFR 51.51(a) state that

> Every environmental report prepared for the construction permit stage of a light-water-cooled nuclear power reactor, and submitted on or after September 4, 1979, shall take Table S–3, *Table of Uranium Fuel Cycle Environmental Data*, as the basis for evaluating the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low level wastes and high level wastes related to uranium fuel cycle activities to the environmental costs of licensing the nuclear power plant. Table S–3 shall be included in the environmental report and may be supplemented by a discussion of the environmental significance of the data set forth in the table as weighed in the analysis for the proposed facility.

The PPE for the North Anna ESP site used input parameters from the following LWR designs:

- Advanced Canada Deuterium Uranium Reactor (ACR-700) – This reactor, developed by Atomic Energy Canada Limited, is an evolutionary extension of the CANDU 6 plant using very slightly enriched uranium fuel and light-water cooling.

- Advanced Boiling Water Reactor (ABWR) – This reactor, developed by General Electric Company (GE), is a standardized plant that has been certified under the NRC requirements in 10 CFR Part 52, Appendix A. The ABWR is fueled with slightly enriched uranium and has light-water cooling.

- Advanced Pressurized Water Reactor (AP1000) – This earlier version of the AP1000, a reactor design developed by Westinghouse Electric Company, using slightly enriched uranium and light-water cooling. This design is not the standard AP1000 design that was certified by the NRC in 10 CFR Part 52, Appendix D; therefore, this design is referred to as the “surrogate AP1000.”

- Surrogate Economic Simplified Boiling Water Reactor (ESBWR) – This surrogate reactor design is based on a design developed by GE using slightly enriched uranium fuel and has light-water cooling. Dominion revised its application to reflect a higher power level volume of 4500 MW(t) (Dominion 2006a). The ESBWR design certification application is currently under review by the NRC.

- International Reactor Innovative and Secure (IRIS) Next-Generation Pressurized Water Reactor (PWR) – This reactor, under development by a consortium led by Westinghouse Electric Company, is a modular light-water reactor.

These light-water designs use uranium dioxide fuel; therefore, the values in Table S–3 can be used to assess environmental impacts. Table S–3 values are normalized for a reference 1000-MW(e) LWR at an 80 percent capacity factor. The PPE power level for the North Anna ESP site is 9000 MW(t), assuming two ESBWR units would be located on the ESP site or at any of the alternative sites, with a PPE capacity factor of 96 percent (Dominion 2006). This corresponds to 3040 MW(e). The 10 CFR 51.51(a) Table S–3 values are reproduced in Table 6-1, which follows.

Specific categories of natural resource use are included in Table S–3 (see Table 6-1). These categories relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic and high-level and low-level wastes, and radiation doses from transportation and occupational exposures. In developing Table S–3, the staff considered two fuel cycle options – no recycle and uranium-only recycle – that differed in the treatment of spent fuel removed from a reactor. “No recycle” treats all spent fuel as waste to be stored at a Federal waste repository; “uranium-only recycle” involves reprocessing spent fuel to recover unused uranium and return it to the system. Neither cycle involves the recovery of plutonium.

Table 6-1. Table of Uranium Fuel Cycle Environmental Data[(a)] – Taken From Table S–3 (Normalized to Model LWR Annual Fuel Requirement [WASH-1248; AEC 1974] or Reference Reactor Year [NUREG-0116; NRC 1976])

Environmental Considerations	Total	Maximum Effect per Annual Fuel Requirement or Reference Reactor Year of Model 1000 MW(e) LWR
Natural Resource Use		
Land (acres):		
Temporarily committed[(b)]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to a 100 MW(e) coal-fired power plant.
Permanently committed	13	
Overburden moved (millions of MT)	2.8	Equivalent to 95 MW(e) coal-fired power plant.
Water (millions of gallons):		
Discharged to air	160	= 2 percent of model 1000 MW(e) LWR with cooling tower.
Discharged to water bodies	11,090	
Discharged to ground	127	
Total	11,377	<4 percent of model 1000 MW(e) LWR with once-through
Fossil fuel:		
Electrical energy (thousands of MW-hr)	323	<5 percent of model 1000 MW(e) LWR output.
Equivalent coal (thousands of MT)	118	Equivalent to the consumption of a 45 MW(e) coal-fired power plant.
Natural gas (millions of standard cubic feet)	135	<0.4 percent of model 1000 MW(e) energy output.
Effluents--Chemical (MT)		
Gases (including entrainment):[(c)]		
SO_x	4400	
NO_x[(d)]	1190	Equivalent to emissions from 45 MW(e) coal-fired plant for a year.
Hydrocarbons	14	
CO	29.6	
Particulates	1154	
Other gases:		
F	0.67	Principally from uranium hexafluoride (UF_6) production, enrichment, and reprocessing. The concentration is within the range of state standards–below level that has effects on human health.
HCl	0.014	

Table 6-1. (contd)

Environmental Considerations	Total	Maximum Effect per Annual Fuel Requirement or Reference Reactor Year of Model 1000 MW(e) LWR
Liquids:		
SO_4	9.9	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3-600 cfs, NO_3-20 cfs, Fluoride-70 cfs.
NO_3	25.8	
Fluoride	12.9	
Ca^{++}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10	
Fe	0.4	
Tailings solutions (thousands of MT)	240	From mills only–no significant effluents to environment.
Solids	91,000	Principally from mills–no significant effluents to environment.
Effluents--Radiological (curies)		
Gases (including entrainment):		
Rn-222	. . . .	Presently under reconsideration by the Commission.
Ra-226	0.02	
Th-230	0.02	
Uranium	0.034	
Tritium (thousands)	18.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	0.14	Principally from fuel reprocessing plants.
I-129	1.3	
I-131	0.83	
Tc-99	. . . .	Presently under consideration by the Commission.
Fission products and transuranics	0.203	
Liquids:		
Uranium and daughters	2.1	Principally from milling–included tailings liquor and returned to ground–no effluents; therefore, no effect on environment.
Ra-226	0.0034	From UF_6 production.
Th-230	0.0015	
Th-234	0.01	From fuel fabrication plants–concentration 10 percent of 10 CFR Part 20 for total processing 26 annual fuel requirements for model LWR.
Fission and activation products	5.9×10^{-6}	
Solids (buried on site):		
Other than high level (shallow)	11,300	9100 Ci comes from low level reactor wastes and 1500 Ci comes from reactor decontamination and decommissioning—buried at land burial facilities. 600 Ci comes from mills—included in tailings returned to ground. Approximately 60 Ci comes from conversion and spent fuel storage. No significant effluent to the environment.
TRU and HLW (deep)	1.1×10^7	Buried at Federal Repository.

Table 6-1. (contd)

Environmental Considerations	Total	Maximum Effect per Annual Fuel Requirement or Reference Reactor Year of Model 1000 MW(e) LWR
Effluents—thermal (billions of British thermal units)	4063	<5 percent of model 1000 MW(e) LWR
Transportation (person-rem):		
Exposure of workers and general public	2.5	
Occupational exposure (person-rem)	22.6	From reprocessing and waste management.

(a) In some cases where no entry appears it is clear from the background documents that the matter was addressed and that, in effect, the table should be read as if a specific zero entry had been made. However, there are other areas that are not addressed at all in the table. Table S–3 does not include health effects from the effluents described in the table, or estimates of releases of radon-222 from the uranium fuel cycle or estimates of technetium-99 released from waste management or reprocessing activities. These issues may be the subject of litigation in the individual licensing proceedings.

Data supporting this table are given in the “Environmental Survey of the Uranium Fuel Cycle,” WASH-1248, April 1974; the “Environmental Survey of the Reprocessing and Waste Management Portion of the LWR Fuel Cycle,” NUREG-0116 (Supp.1 to WASH-1248, NRC 1976); the “Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle,” NUREG-0216 (Supp. 2 to WASH-1248) (NRC 1977b); and in the record of the final rulemaking pertaining to Uranium Fuel Cycle Impacts from Spent Fuel Reprocessing and Radioactive Waste Management, Docket RM-50-3. The contributions from reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle). The contribution from transportation excludes transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in Table S–4 of Sec. 51.20(g). The contributions from the other steps of the fuel cycle are given in columns A-E of Table S–3A of WASH-1248.

(b) The contributions to temporarily committed land from reprocessing are not prorated over 30 years, because the complete temporary impact accrues regardless of whether the plant services one reactor for one year or 57 reactors for 30 years.

(c) Estimated effluents based upon combustion of equivalent coal for power generation.

(d) 1.2 percent from natural gas use and process.

The contributions in Table S–3 resulting from reprocessing, waste management, and transportation are maximized for both of the two fuel cycles (uranium only and no recycle); that is, the identified environmental impacts are based on the cycle that results in the greater impact. The uranium fuel cycle is defined as the total of those options and processes associated with provision, utilization, and ultimate disposition of fuel for nuclear power reactors.

During the Carter administration, the Nuclear Nonproliferation Act of 1978, Pub. L. No. 95-242 (22 USC 3201 et seq.), was enacted; it significantly impacted the disposition of spent nuclear fuel by deferring indefinitely the commercial reprocessing and recycling of spent fuel produced in the U.S. commercial nuclear power program. While the ban on the reprocessing of spent fuel was lifted during the Reagan administration, economic circumstances changed, reserves of uranium ore increased, and the stagnation of the nuclear power industry provided little incentive for industry to resume reprocessing. During the 109th Congress, the Energy Policy Act of 2005, Pub. L. No. 109-58 (119 Stat. 594 [2005]), was enacted. It authorized DOE to conduct an advanced fuel recycling technology research and development program to evaluate proliferation-resistant fuel recycling and transmutation technologies that minimize environmental or public health and safety impacts. Consequently, while Federal policy does not prohibit reprocessing, additional DOE efforts would be required before commercial reprocessing and recycling of spent fuel produced in the U.S. commercial nuclear power plants could commence.

The no-recycle option is presented schematically in Figure 6-1. Natural uranium is mined in either open-pit or underground mines or by an in situ leach solution mining process. In situ leach mining, the primary form of mining in the United States today, involves injecting a lixiviant solution into the uranium ore body to dissolve uranium and then pumping the solution to the surface for further processing. The ore or in situ leach solution is transferred to mills where it is processed to produce "yellowcake" (U_3O_8). A conversion facility prepares the uranium oxide by converting it to uranium hexafluoride, which is then processed by an enrichment facility to increase the percentage of the more fissile isotope uranium-235 and decrease the percentage of the non-fissile isotope uranium-238. At a fuel-fabrication facility, the enriched uranium, which is approximately 5 percent uranium-235, is then converted to UO_2. The UO_2 is pelletized, sintered, and inserted into tubes to form fuel assemblies. The fuel assemblies are placed in the reactor to produce power. When the content of the uranium-235 reaches a point where the nuclear reactor has become inefficient with respect to neutron economy, the fuel assemblies are withdrawn from the reactor. After onsite storage for sufficient time to allow for short-lived fission product decay and to reduce the heat generation rate, the fuel assemblies would be transferred to a waste repository for internment. Disposal of spent fuel elements in a repository constitutes the final step in the no-recycle option.

The following assessment of the environmental impacts of the fuel cycle as related to the operation of the proposed project is based on the values given in Table S–3 (see Table 6-1) and the staff's analysis of the radiological impact from radon-222 and technetium-99. In NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996),[(a)] the staff provides a detailed analysis of the environmental impacts from the uranium fuel cycle. Although NUREG-1437 is specific to the impacts related to license renewal, the information is relevant to this review because the advanced LWR designs considered here use the same type of fuel; the staff's analyses in Section 6.2.3 of NUREG-1437 are summarized and set forth here.

The fuel cycle impacts in Table S-3 are based on a reference 1000-MW(e) LWR operating at an annual capacity factor of 80 percent for a net electric output of 800 MW(e). In the following review and evaluation of the environmental impacts of the fuel cycle, the staff assumed that the

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

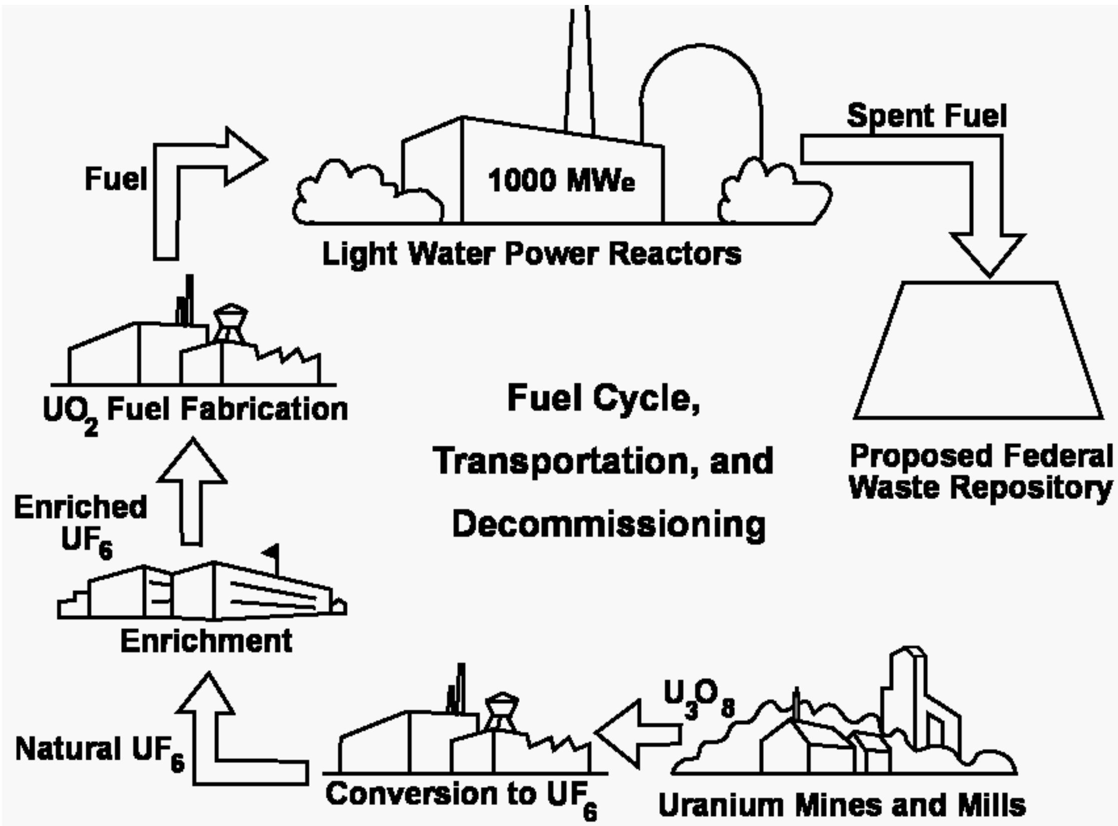

Figure 6-1. The Uranium Fuel Cycle: No-Recycle Option (derived from NRC 1999)

site-wide fuel cycle impacts associated with the additional LWRs would be based on a total net electric output of 3200 MW(e). This was termed the 1000 MW(e) LWR scaled model and resulted in a factor approximately four times (i.e., 3200/800) the impacts in Table S-3 (see Table 6-1). The 3200 MW(e) bounds the 3040 MW(e) which is the total net electric output equivalent to the PPE power level of 9000 MW(t) for the ESP site.

Recent changes in the fuel cycle may have some bearing on environmental impacts; however, as discussed below, the staff is confident that the contemporary fuel cycle impacts are less than those identified in Table S-3.

The values in Table S–3 were calculated from industry averages for the performance of each type of facility or operation within the fuel cycle. Recognizing that this approach would result in a range of reasonable values for each estimate, the staff followed the policy of choosing the assumptions or factors to be applied so the calculated values would not be underestimated. This approach was intended to ensure that the actual environmental impacts would be less than the quantities shown in Tables S–3 for all LWR nuclear power plants within the widest range of operating conditions. Many subtle fuel cycle parameters and interactions were recognized by the staff as being less precise than the estimates and were not considered or were considered but had no effect on the Table S–3 calculations. For example, to determine the quantity of fuel required for a year's operation of a nuclear power plant in Table S–3, the staff defined the model reactor as a 1000-MW(e) light-water-cooled reactor operating at 80 percent capacity with a 12-month fuel reloading cycle and an average fuel burnup of 33,000 MWd/MTU. This is a "reactor reference year" or "reference reactor year" depending on the source document (either Table S–3 or NUREG-1437), but it has the same meaning. The sum of the initial fuel loading plus all of the reloads for the lifetime of the reactor can be divided by the now more likely 60-year (40-year initial license term and 20-year renewal license term) lifetime to obtain an average annual fuel requirement. The quantity of fuel was determined in NUREG-1437 for both boiling-water reactors (BWRs) and pressurized-water reactors (PWRs); the higher annual requirement, 35 metric tonnes (MT) of uranium made into fuel for a BWR, was chosen in NUREG-1437 as the basis for the reference reactor year. A number of fuel management improvements have been adopted by nuclear power plants to achieve higher performance and to reduce fuel and separative work (enrichment) requirements. Since Table S–3 was promulgated, these improvements have reduced the annual fuel requirement.

Another change considered is the elimination of the U.S. restrictions on importation of foreign uranium. The economic conditions of the uranium market currently favor utilization of foreign uranium at the expense of the domestic uranium industry. These market conditions have led to the closing of most U.S. uranium mines and mills, substantially reducing the environmental impacts in the United States from these activities. Factoring in changes to the fuel cycle suggests that the environmental impacts of mining and milling could drop levels below those given in Table S–3; however, for the purposes of this analysis, Table S–3 estimates have not been reduced.

Section 6.2 of NUREG-1437 discusses the sensitivity to recent changes in the fuel cycle on the environmental impacts in greater detail.

6.1.1.1 Land Use

The total annual land requirement for the fuel cycle supporting the 1000-MW(e) LWR scaled model is about 184 ha (452 ac). Approximately 20 ha (52 ac) are permanently committed land, and 164 ha (400 ac) are temporarily committed. A "temporary" land commitment is a commitment for the life of the specific fuel cycle plant (e.g., a mill, enrichment plant, or succeeding plants). Following completion of decommissioning, such land can be released for unrestricted use. "Permanent" commitments represent land that may not be released for use after plant shutdown and/or decommissioning because decommissioning activities do not result in removal of sufficient radioactive material to meet the limits in 10 CFR Part 20, Subpart E, for release of land for unrestricted use. Of the 164 ha (400 ac) of temporarily committed land, 128 ha (316 ac) are undisturbed and 36 ha (88 ac) are disturbed. In comparison, a coal-fired power plant with the same MW(e) output as the LWR scaled model and that uses strip-mined coal requires the disturbance of about 324 ha (800 ac) per year for fuel alone. The staff concludes that the impacts on land use to support the 1000-MW(e) LWR scaled model would be SMALL.

6.1.1.2 Water Use

Principal water use for the fuel cycle supporting a 1000-MW(e) LWR scaled model is that required to remove waste heat from the power stations supplying electrical energy to the enrichment step of this cycle. Scaling from Table S–3, of the total annual water use of 1.72×10^8 m^3 (4.55×10^{10} gal), about 1.60×10^8 m^3 (4.44×10^{10} gal) are required for the removal of waste heat, assuming that these plants use once-through cooling. Other water uses involve the discharge to air (e.g., evaporation losses in process cooling) of about 2.42×10^6 m^3/yr (6.40×10^8 gal/yr) and water discharged to ground (e.g., mine drainage) of about 1.92×10^6 m^3/yr (5.08×10^8 gal/yr).

Regarding thermal effluents, annual discharges from the nuclear fuel cycle are about 4 percent of the 1000-MW(e) LWR scaled model using once-through cooling. The consumptive water use of 2.42×10^6 m^3/yr (6.40×10^8 gal/yr) is about 2 percent of the 1000-MW(e) LWR scaled model using cooling towers. The maximum consumptive water use (assuming that all plants supplying electrical energy to the nuclear fuel cycle used cooling towers) would be about 6 percent of the 1000-MW(e) LWR scaled model using cooling towers. Under this condition, thermal effluents would be negligible. The staff concludes that the impacts on water use for these combinations of thermal loadings and water consumption would be SMALL relative to the water use and thermal discharges of the proposed project.

6.1.1.3 Fossil Fuel Impacts

Electrical energy and process heat are required during various phases of the fuel cycle process. The electrical energy is usually produced by the combustion of fossil fuel at conventional power plants. Electrical energy associated with the fuel cycle represents about 5 percent of the annual electrical power production of the reference 1000-MW(e) LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, would be less than 0.4 percent of the electrical output from the model plant. The staff concludes that the fossil fuel impacts from the direct and indirect consumption of electrical energy for fuel cycle operations would be SMALL relative to the net power production of the proposed project.

6.1.1.4 Chemical Effluents

The quantities of chemical, gaseous, and particulate effluents with fuel cycle processes are given in Table S–3 (see Table 6-1) for the reference 1000-MW(e) LWR. The site-wide quantities of effluents would be approximately four times that of the reference 1000-MW(e) LWR scaled model. The principal effluents are SO_x, NO_x, and particulates. Based on data in the *Seventh Annual Report of the Council on Environmental Quality*, these emissions constitute a SMALL additional atmospheric loading in comparison with these emissions from the stationary fuel combustion and transportation sectors in the United States; that is, about 0.08 percent of the annual national releases for each of these effluents (CEQ 1976).

Liquid chemical effluents produced in fuel cycle processes are related to fuel enrichment and fabrication, and may be released to receiving waters. These effluents are usually present in such dilute concentrations that only small amounts of dilution water are required to reach levels of concentration that are within established standards. Table S–3 (see Table 6-1) specifies the amount of dilution water required for specific constituents. Additionally, all liquid discharges into the navigable waters of the United States from plants associated with the fuel cycle operations will be subject to requirements and limitations set by an appropriate Federal, State, regional, local, or affected Native American tribal regulatory agency.

Tailings solutions and solids are generated during the milling process. These solutions and solids are not released in quantities sufficient to have a significant impact on the environment.

The staff determined that the impacts of these chemical effluents would be SMALL.

6.1.1.5 Radioactive Effluents

Radioactive effluents estimated to be released to the environment from waste management activities and certain other phases of the fuel cycle process are set forth in Table S–3 (see Table 6-1). Using these effluents in NUREG-1437 (NRC 1996) data, the staff has calculated the 100-year involuntary environmental dose commitment to the U.S. population from the LWR-supporting fuel cycle for one year of operation of the 1000-MW(e) LWR scaled model. These calculations estimate that the overall whole body gaseous dose commitment to the U.S. population from the fuel cycle (excluding reactor releases and the dose commitment from radon-222 and technetium-99) would be approximately 16 person-Sv (1600 person-rem) per year of operation of the 1000-MW(e) LWR scaled model; this reference reactor year is scaled to reflect the total electric power rating for the site for a year.

The additional whole body dose commitment to the U.S. population from radioactive liquid effluents due to all fuel cycle operations other than reactor operation would be approximately 8 person-Sv (800 person-rem) per year of operation. Thus, the estimated 100-year environmental dose commitment to the U.S. population from radioactive gaseous and liquid releases resulting from these portions of the fuel cycle is approximately 24 person-Sv (2400 person-rem) (whole body) for the 1000-MW(e) LWR scaled model.

Currently, the radiological impacts associated with radon-222 and technetium-99 release are not addressed in Table S–3. Principal radon releases occur during mining and milling operations and as emissions from mill tailings, whereas principal technetium-99 releases occur from gaseous diffusion enrichment facilities. Dominion (2006) provided an assessment of radon-222 and technetium-99 based on information from NUREG-1437.

In Section 6.2 of NUREG-1437, the staff estimated the radon-222 releases from mining and milling operation, and from mill tailings for each year of operations of the reference 1000-MW(e) LWR. The estimated releases of radon-222 for the reference reactor year for the 1000-MW(e) LWR scaled model, or for the total electric power rating for the site for a year, is approximately 7.7×10^{14} Bq (20,800 Ci). Of this total, about 78 percent would be from mining, 15 percent from milling operations, 7 percent from inactive tails prior to stabilization. For radon releases from stabilized tailings, the staff assumed that the scaled model would result in an emission of 1.5×10^{11} Bq (4 Ci) per site year (i.e., four times the NUREG-1437 estimate for the reference reactor year). The major risks from radon-222 are from exposure to the bone and the lung, although there is a small risk from exposure to the whole body. The organ-specific dose weighting factors from 10 CFR Part 20 were applied to the bone and lung doses to estimate the 100-year dose commitment from radon-222 to the whole body. The estimated population dose commitment from mining, milling, and tailings before stabilization for each year of operation for the 1000 MW(e) LWR scaled model (assuming the 1000 MW(e) LWR scaled model) would be approximately 37 person-Sv (3700 person-rem) to the whole body. From stabilized tailings piles, the estimated 100-year environmental dose commitment would be approximately 0.71 person-Sv (71 person-rem) to the whole body. Additional insights regarding national policy/resource perspectives regarding institutional controls comparisons with routine radon-222 exposure and risk, and long-term releases from stabilized tailings piles are discussed in NUREG-1437.

Also in NUREG-1437, the staff considered the potential health effects associated with the releases of technetium-99. The estimated releases of technetium-99 for the reference reactor year for the 1000 MW(e) LWR scaled model, or the total electric power rating for the site for a year is 1.1×10^9 Bq (0.03 Ci) from chemical processing of recycled UF_6 before it enters the isotope enrichment cascade and 7.4×10^8 Bq (0.02 Ci) into the groundwater from a candidate repository. The major risks from technetium-99 are from exposure of the gastrointestinal tract and kidney, although there is a small risk from exposure to the whole body. Applying the organ-specific dose weighting factors from 10 CFR Part 20 to the gastrointestinal tract and kidney doses, the total-body 100-year dose commitment from technetium-99 was estimated to be 4 person-Sv (400 person-rem) for the 1000-MW(e) LWR scaled model.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses and dose rates, below about 100 mSv (10,000 mrem). However, radiation protection experts conservatively assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2006), the BEIR VII report, supports the linear, no-threshold dose response model. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably overestimates those risks.

Based on this model, the staff estimated the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv [1,000,000 person-rem]) from International Commission on Radiation Protection (ICRP) Publication 60 (ICRP 1991). This coefficient was multiplied by the sum of the estimated whole body population doses discussed above, approximately 66 person-Sv/yr (6600 person-rem/yr), to calculate that the U.S. population would incur a total of approximately 4.8 fatal cancers, nonfatal cancers, and severe hereditary effects annually. This risk is quite small compared to the number of fatal cancers, nonfatal cancers, and severe hereditary effects that would be estimated to the U.S. population annually from exposure to natural sources of radiation using the same risk estimation method.

Radon releases from tailings are indistinguishable from background radiation levels at a few kilometers from the tailings pile (at less than 1 km in some cases) (NRC Docket 50-488 1986). The public dose limit specified by U.S. Environmental Protection Agency's (EPA) regulation in 40 CFR Part 190, is 0.25 mSv/yr (25 mrem/yr) to the whole body from the entire fuel cycle, but most NRC licensees have airborne effluents resulting in doses of less than 0.01 mSv/yr (1 mrem/yr) (61 FR 65120).

In addition, at the request of the U.S. Congress, the National Cancer Institute (NCI) conducted a study and published *Cancer in Populations Living Near Nuclear Facilities* in 1990 (NCI 1990). This report included an evaluation of health statistics around all nuclear power plants, as well as several other nuclear fuel cycle facilities, in operation in the U.S. in 1981 and found "no evidence that an excess occurrence of cancer has resulted from living near nuclear facilities" (NCI 1990). The contribution to the annual average dose received by an individual from the fuel cycle-related radiation and other sources as reported in National Council on Radiation Protection and Measurements (NCRP) Report 93 (NCRP 1987) is listed in Table 6-2. The nuclear fuel cycle contribution to an individual's annual average radiation dose is extremely small (less than 0.01 mSv [1 mrem] per year).

Based on the analyses presented above, the staff concludes that the environmental impacts of radioactive effluents from the fuel cycle are SMALL.

6.1.1.6 Radioactive Wastes

The quantities of buried radioactive waste material (low-level, high-level, and transuranic wastes) are specified in Table S–3 (see Table 6-1). For low-level waste disposal at land burial facilities, the Commission notes in Table S–3 that there will be no significant radioactive releases to the environment. For high-level and transuranic wastes, the Commission notes that these are expected to be buried at a repository and that no release to the environment is expected to be associated with such disposal, because the gaseous and volatile radionuclides contained in the spent fuel would have been released and monitored before disposal. In NUREG-0116 (NRC 1976), which provides background and context for the high-level and transuranic Table S–3 values established by the Commission, the staff indicates that these high-level and transuranic wastes will be buried and will not be released to the environment.

On February 15, 2002, subsequent to receipt of a recommendation by the Secretary of Energy, the President recommended the Yucca Mountain site for the development of a repository for the geologic disposal of spent nuclear fuel and high-level nuclear waste (White House Press Release 2002).

Table 6-2. Comparison of Annual Average Dose Received by an Individual from All Sources

Source		Dose (mSv/yr)[(a)]	Percent of Total
Natural			
	Radon	2	55
	Cosmic	0.27	8
	Terrestrial	0.28	8
	Internal (body)	0.39	11
	Total natural sources	3	82
Artificial			
	Medical x-ray	0.39	11
	Nuclear medicine	0.14	4
	Consumer products	0.10	3
	Total artificial sources	0.63	18
Other			
	Occupational	0.009	<0.30
	Nuclear fuel cycle	<0.01	<0.03
	Fallout	<0.01	<0.03
	Miscellaneous sources	<0.01	<0.03

(a) To convert mSv/yr to mrem/yr, multiply by 100.
Source: NCRP Report 93, Ionizing Radiation Exposure of the Population in the United States (NCRP 1987)

The EPA developed Yucca Mountain-specific repository standards, which were subsequently adopted by the NRC in 10 CFR Part 63. In an opinion, issued July 9, 2004, the U.S. Court of Appeals for the District of Columbia Circuit (the Court) vacated EPA's radiation protection standards for the candidate repository, which required compliance with certain dose limits over a 10,000 year period (U.S. Courts of Appeals 2004). The Court's decision also vacated the compliance period in NRC's licensing criteria for the candidate repository in 10 CFR Part 63. In response to the Court's decision, EPA issued proposed revised standards on August 22, 2005, that would revise the radiation protection standards for the candidate repository (70 FR 49014). As required by the Nuclear Waste Policy Act of 1982 (42 USC 10101 et seq.) in order to be consistent with EPA's revised standards, NRC proposed revisions to 10 CFR Part 63 on September 8, 2005 (70 FR 53313). The proposed standards are 0.15 mSv (15 mrem) per year for 10,000 years following disposal and 3.5 mSv (350 mrem) per year, after 10,000 years through 1 million years after disposal. The NRC's Part 63 rulemaking will not be completed by the time this EIS is issued.

Therefore, for the high-level waste and spent-fuel disposal component of the fuel cycle, there is some uncertainty with respect to regulatory limits for offsite releases of radioactive nuclides for the current candidate repository site. However, before promulgation of the affected provisions of the Commission's regulations, the staff assumed that limits would be developed along the lines of the 1995 National Academy of Sciences report, *Technical Bases for Yucca Mountain Standards*, and that in accordance with the Commission's Waste Confidence Decision, 10 CFR 51.23, a repository can and likely will be developed at some site that will comply with such limits, with peak doses to virtually all individuals of 100 mrem (1 mSv) per year or less (NAS 1995; NRC 1996).

Despite the current uncertainty with respect to these rules, some judgment as to the National Environmental Policy Act of 1969 (NEPA) implications of offsite radiological impacts of spent fuel and high-level waste disposal should be made. The staff concludes that these impacts are acceptable because the impacts would not be sufficiently great to require the NEPA conclusion that the construction and operation of new units at the North Anna ESP site should be denied. For the reasons stated above, the staff concludes that the environmental impacts of radioactive waste disposal are SMALL.

6.1.1.7 Occupational Dose

In the review and evaluation of the environmental impacts of the fuel cycle, the staff considered a total net electrical output of 3200 MW(e) for the ESP site. This case is referred to as the 1000-MW(e) LWR scaled model. The annual occupational dose attributable to all phases of the fuel cycle for the 1000-MW(e) LWR scaled model is about 24 person-Sv (2400 person-rem). This is based on the 6 person-Sv (600 person-rem) occupational dose estimate attributed to all phases of the fuel cycle for the model 1000 MW(e) LWR (NRC 1996). Occupational doses would be maintained to meet the dose limits in 10 CFR Part 20, which is 0.05 Sv/yr (5 rem/yr). On this basis, the staff concludes that environmental impacts from this occupational dose would be SMALL.

6.1.1.8 Transportation

The transportation dose to workers and the public totals about 0.025 person-Sv (2.5 person-rem) annually for the reference 1000-MW(e) LWR per Table S–3 (see Table 6-1). This corresponds to dose of 0.1 person-Sv (10 person-rem) for the 1000-MW(e) LWR scaled model. For comparative purposes, the estimated collective dose from natural background radiation to the population within 80 km (50 mi) of the ESP site is 9200 person-Sv/yr (920,000 person-rem/yr) (Dominion 2006). On this basis, the staff concludes that environmental impacts of transportation would be SMALL.

6.1.1.9 Conclusion

The staff evaluated the environmental impacts of the uranium fuel cycle as given in Table S–3 (see Table 6-1); considered the effects of radon-222 and technetium-99; and appropriately scaled for the 1000-MW(e) LWR scaled model. On the basis of this comparison, the staff concludes that the impacts would be SMALL, and mitigation is not warranted.

6.1.2 Gas-Cooled Reactors

As noted earlier, issues related to reactors based on other-than LWR designs are not resolved because of the lack of information to validate values and impacts. However, the following analyses were performed using data from Dominion for the purposes of estimation only.

The gas-cooled reactors analyzed for the uranium fuel cycle are:

- Gas Turbine Modular Helium Reactor (GT-MHR) – This reactor, developed by General Atomics, is a modular helium-cooled graphite-moderated reactor.

- Pebble Bed Modular Reactor (PBMR) – This reactor, developed by PBMR (Pty), Ltd., is a modular graphite-moderated helium-cooled turbine reactor.

Table S–3 from 10 CFR 51.51(a) can be used as a basis for bounding the environmental impacts from the uranium fuel cycle only for LWRs. Dominion performed an assessment of the environmental impacts of the fuel cycle for gas-cooled reactor designs by comparing key parameters for these reactor designs to those used to generate the impacts in Table S–3 (Dominion 2006a). Key parameters are energy usage, material involved, and number of shipments for each major fuel cycle activity (i.e., mining, milling, conversion, enrichment, fuel fabrication, and radioactive waste disposal). Dominion sought to demonstrate in the ER that the impacts for the gas-cooled reactor designs were comparable to the environmental impacts identified for LWRs in the technical basis document, WASH-1248, “Environmental Summary of the Uranium Fuel Cycle,” and its Supplement 1 (NUREG-0116) for Table S–3 (NRC 1976).

As discussed in Section 6.1.1, the fuel cycle impacts in Table S–3 were based on a reference 1000 MW(e) LWR operating at an annual capacity factor of 80 percent for a net electric output of 800 MW(e). This is termed the “reference reactor year.” For the purposes of evaluating fuel cycle impacts for the North Anna ESP site or for any of the alternative sites, the staff assumed that the additional LWR’s site-wide fuel impacts would be based on a total net electric output of 3200 MW(e). This was termed the 1000 MW(e) LWR scaled model and resulted in a factor approximately four times (i.e., 3200/800) the impacts in Table S–3 for the North Anna ESP site.

One of the other-than-LWRs considered by Dominion, the Gas Turbine-Modular Helium Reactor (GT-MHR), is a four module 2400-MW(t), nominal 1140-MW(e) unit assumed to operate at an annual capacity factor of 88 percent for a net electric output of 1003 MW(e). Therefore, the maximum number of GT-MHR units that could be sited at the North Anna ESP site or at any of the alternative sites and remain below the 3200 MW(e) total net electric output for the site is three (i.e., 3 x 1003).

The second other-than-LWR reactor considered by Dominion, the pebble bed modular reactor (PBMR), is an eight module, 3200 MW(t), nominal 1320 MW(e) unit assumed to operate at an annual capacity factor of 95 percent for a net electric output of 1253 MW(e). Therefore, the comparable number of PBMR units to remain below the 3200 MW(e) total net electric output for the site is two (i.e., 2 x 1253).

Dominion (2006a) compared the impacts between the Table S–3 LWR to the gas-cooled reactor designs. The comparison used an annual fuel loading as a starting point and then proceeded in reverse direction through the fuel cycle (i.e., fuel fabrication, enrichment, conversion, milling, mining, radioactive waste). Table 6-3, derived from Table 5.7-1 of the ER (Dominion 2006), provides an estimate of the impacts for each phase of the uranium fuel cycle assuming that the North Anna ESP site or any of the alternative sites would host three four-module GT-MHR units or two eight-module PBMR units.

6.1.2.1 Fuel Fabrication

The quantity of UO_2 required for reactor fuel is a key parameter. The more UO_2 required, the greater the environmental impacts (i.e., more energy, greater emissions, and increased water usage). The 1000-MW(e) LWR scaled model described in Section 6.1.1 would require the equivalent of 160 MT of enriched UO_2 annually. This compares to 18 to 19 MT of enriched UO_2 annually for the gas-cooled reactor technologies.

Table 6-3. Fuel Cycle Environmental Impacts from Gas-Cooled Reactor Designs for the North Anna ESP Site[(a)]

Reactor Technology Facility/Activity	GT-MHR (4 Modules) (2400 MW(t) total) (≈1140 MW(e) total) 88 percent Capacity: Multiplier=3	PBMR (8 Modules) (3200 MW(t) total) (~1320 MW(e) total) 95 percent Capacity: Multiplier=2
Mining Operations		
Annual ore supply (Million MT)	1.01	0.67
Milling Operations		
Annual yellowcake (MT)	909	606
UF_6 Production		
Annual UF_6 (MT)	1137	758
Enrichment Operations		
Enriched UF_6 (MT)	24	25
Annual separative work unit (SWU) (MT)	612	388
Fuel Fabrication Plant Operations		
Enriched UO_2 (MT)	18	19
Annual fuel loading (MTU)	16	17
Solid Radioactive Waste		
Annual LLW from reactor operations (Ci)	3300 Ci;[(b)] 400 m^3	131 Ci;[(b)] 2400 drums
LLW from reactor decontamination and decommissioning Ci per reference reactor-year	Data not available	Data not available

(a) Values calculated by multiplying annual values from Table 5.7-1 of the ER (Dominion 2006) by a multiplier of 3 for the GT-MHR and a multiplier of 2 for the PBMR.
(b) To convert from curies to becquerels, multiply by 3.7×10^{10} Bq/Ci.

References: 10 CFR 51.51(a), Table S–3 Table of Uranium Fuel Cycle Environmental Data
Notes:
1. The enrichment SWU calculation was performed using the United States Enrichment Corporation, Inc. (USEC) SWU calculator and assumes a 0.30 percent tails assay.
2. The information on the reference reactor (mining, milling, UF_6, enrichment, fuel fabrication values) taken from NUREG-0116, Table 3.2, no recycling (NRC 1976).
3. The information on the reference reactor (solid radioactive waste) taken from 10 CFR 51.51, Table S–3.
4. The calculated information on the reference reactor uses the same methodology as for the reactor technologies.
5. The normalized information is based on 1000 MW(e) and the reactor vendor-supplied unit capacity factor.
6. For the new reactor technologies, the annual fuel loading was provided by the reactor vendor.
7. The USEC SWU calculator also calculated the kilograms of uranium feed. This number was multiplied by 1.48 to get the necessary amount of UF_6.
8. The annual yellowcake number was generated using the relationship 2.61285 lb. of U_3O_8 to 1 kg U of UF_6; 1.185 kgs of U_3O_8 to 1.48 kg.
9. The annual ore supply was generated assuming an 0.1% ore body and a 90% recovery efficiency.
10. Cobalt-60 with a 5.26 year half-life and iron-55 with a 2.73 year half-life are the main nuclides listed for the PBMR decontamination and decommissioning waste.

GT-MHR fuel consists of microspheres of uranium oxycarbide (UCO) coated with multiple layers of pyrocarbon and silicon carbide referred to as TRISO coating. Two types of microspheres are used in the GT-MHR fuel, one enriched to 19.8 percent uranium-235 and one with natural uranium. The microspheres and graphite shims are bound together into a rod-shaped compact, which is stacked into graphite blocks referred to as fuel elements. A reactor core consists of 1020 fuel elements.

PBMR fuel consists of UO_2 kernels (enriched to 12.9 percent uranium-235) that are TRISO coated, similar to the GT-MHR fuel. The TRISO-coated particles are imbedded into a graphite matrix to form a fuel sphere that is 60 mm in diameter. Each fuel sphere contains approximately 15,000 TRISO-coated particles. Approximately 260,000 fuel spheres make up a core of a single reactor module.

The fuel described above for gas-cooled reactors are fabricated differently than fuel for LWRs. Currently, there are no operating large-scale fuel fabrication facilities producing gas-cooled reactor fuels in the United States, so a direct comparison of environmental impacts is not possible. Based on some environmental impacts from a small-scale fuel fabrication facility producing gas-cooled reactor fuel, Dominion concluded that the environmental impacts from producing gas-cooled reactor fuel would be “not inconsistent” with those of LWRs (Dominion 2006). By comparison with the fuel fabrication impacts for LWR technologies, the staff expects that the environmental impacts from producing gas-cooled reactor fuel likely would be SMALL, but these impacts will need to be assessed at the CP or COL stage when the staff will consider the environmental data that become available on a large-scale, fuel fabrication facility for gas-cooled reactors.

6.1.2.2 Enrichment

Dominion (2006) identified two quantities of interest for enrichment. These were (1) the amount of energy required to enrich the fuel measured in SWUs and (2) the amount of UF_6 needed. A SWU is a measure of energy required to enrich the fuel. The major environmental impacts for the entire uranium fuel cycle are from the emissions of the fossil fuel plants used to supply energy for the gaseous diffusion plants that enrich the uranium. An enrichment technology developed since the impacts in Table S–3 (see Table 6-1) were developed and evaluated includes the gas centrifuge process that uses 90 percent less energy than the gaseous diffusion process (NRC 1996).

To produce 160 MT of enriched UO_2 for the 1000-MW(e) LWR scaled model, the enrichment plant would need to produce about 208 MT of UF_6, which requires over 500 MT of SWUs. For gas-cooled reactor technologies, the needed enriched UF_6 ranges from 24 to 25 MT of UF_6. The amount of energy to produce these quantities of enriched UF_6 for the gas-cooled reactor designs ranges from 388 to 612 MT of SWU. The upper range is approximately 20 percent higher than the energy required for the reference LWR. Dominion (2006) concluded that the large reduction in energy associated with using an alternate enrichment technology (e.g., centrifuge) and its associated environmental impacts would more than offset the increase in SWUs. The staff expects that, on balance, the environmental impacts of enriching gas-cooled fuels by comparison with the impacts of enriching LWR fuel would likely be SMALL, but these impacts will need to be assessed at the CP or COL stage, when the staff will consider impacts from the enrichment technology in use at that time.

6.1.2.3 Uranium Hexafluoride Production – Conversion

There are two uranium conversion processes: a wet process and a dry process. In NUREG-1437 (NRC 1996), the NRC stated that environmental releases are small from the conversion facilities compared to the overall fuel cycle impacts and that changing from 100 percent use of one process to 100 percent use of the other would make no significant difference in the overall impacts. Conversion technologies that would be used today to produce UF_6 are similar to those considered when determining the environmental impacts that were part of Table S–3 of 10 CFR 51.51(a) (see Table 6-1).

The conversion facility would need to produce 1440 MT of UF_6 annually for the reference 1000-MW(e) LWR scaled model compared to 758 to 1137 MT of UF_6 for the gas-cooled reactors based on the USEC SWU calculator (see Table 6-3, footnote (a)). The other-than-LWR values are less than the amount of UF_6 required for the LWR; therefore, the associated environmental impacts are expected to be less. On this basis, the staff concludes that the environmental impacts from producing UF_6 for gas-cooled reactors would be SMALL.

6.1.2.4 Uranium Milling

Annual yellowcake production is the metric of interest for uranium milling. Plants required to produce less yellowcake than the reference plant would require less energy, have fewer emissions, and use less water.

The uranium mill for the 1000-MW(e) LWR scaled model would produce about 1200 MT of yellowcake. The uranium mill for the gas-cooled reactor technologies would need to produce 606 to 909 MT of yellowcake, which is less than the amount of yellowcake needed for the scaled LWR. On this basis, the staff concludes that the environmental impacts from uranium milling for the gas-cooled reactors would be SMALL.

6.1.2.5 Uranium Mining

Annual ore supply is the metric of interest for uranium mining. The less ore mined, the smaller the environmental impacts (i.e., less energy used, fewer emissions, less water usage). For the 1000-MW(e) LWR scaled model, 1.09 Million MT of raw ore would be required to produce 1200 MT of yellowcake. For the gas-cooled reactor technologies, the scaled ore requirements ranged from 0.67 to 1.01 Million MT of ore, a range that is less than the amount of ore required for the reference 1000-MW(e) scaled-model LWR. On this basis, the staff concludes that the environmental impacts from uranium mining for gas-cooled reactors would be SMALL.

6.1.2.6 Solid Low-Level Radioactive Waste – Operations

Table S–3 (see Table 6-1) of 10 CFR 51.51(a) states that there are 3.4 x 10^{14} Bq (9100 Ci) of low-level waste generated annually from operations of the reference LWR; the 1000-MW(e) LWR scaled model would result in 1.3 x 10^{15} Bq (36,400 Ci) of low-level waste annually. Gas-cooled reactor technologies are projected to generate 4.8 x 10^{12} Bq to 1.2 x 10^{14} Bq (131 to 3300 Ci) of low-level waste scaled annually, well below the amounts generated by the reference LWR. For this reason, the staff concludes that the environmental impacts from low-level radioactive waste operations for gas-cooled reactors would be SMALL.

6.1.2.7 Solid Low-Level Radioactive Waste – Decontamination and Decommissioning

In Table S–3 (see Table 6-1) the Commission states 5.6 x 10^{7} MBq (1500 Ci) per Reference-Reactor Year "...comes from reactor decontamination and decommissioning - buried at land burial facilities." Dominion (2006) noted that gas-cooled reactor technologies would (1) operate much cleaner than the reference 1000-MW(e) LWR, as evidenced by lower estimates of low-level waste generated and (2) produce less heavy metal radioactive waste because of the higher thermal efficiency and higher fuel burnup. The gas-cooled reactor designs are also more compact than the reference LWR design, which would be expected to result in less decontamination and decommissioning waste (Dominion 2006). Dominion concluded that low-level waste impact from decontamination and decommissioning are expected to be comparable to or less than that of the reference LWR (Dominion 2006). On this basis, the staff expects that the environmental impacts from solid low-level radioactive waste generated during decontamination and decommissioning for gas-cooled reactors would likely be SMALL, but these impacts will need to be assessed at the CP or COL stage.

6.1.2.8 Conclusions

The staff expects that the environmental impacts from the uranium fuel cycle activities and solid waste management activities for the proposed gas-cooled reactors would be SMALL. However, because of the uncertainty in the final design of the gas-cooled reactors and the change in technology that could be applied to uranium fuel cycle activities, this issue is not resolved. Should an applicant reference one of these designs, additional reviews would be needed at the CP or COL stage in the following areas: fuel fabrication, enrichment, and solid low-level waste operation during decontamination and decommissioning.

6.2 Transportation of Radioactive Materials

This section addresses both the radiological and nonradiological environmental impacts from normal operating and accident conditions resulting from (1) shipment of unirradiated fuel to the North Anna ESP site, (2) shipment of spent fuel to a monitored retrievable storage facility or a permanent repository, and (3) shipment of low-level radioactive waste and mixed waste to offsite disposal facilities. Distinctions between transportation impacts of advanced LWR designs and gas-cooled reactor designs are discussed.

The NRC evaluated the environmental effects of transportation of fuel and waste for light-water-cooled nuclear power reactors in WASH-1238 (AEC 1972) and NUREG-75/038 (NRC 1975) and found the impact to be small. These documents provided the basis for Table S–4 in 10 CFR 51.52 that summarizes the environmental impacts of transportation of fuel and waste to and from one LWR of 3000 to 5000 MW(t) (1000 to 1500 MW(e)). Impacts are provided for normal conditions of transport and accidents in transport for a reference 1100-MW(e) LWR[a]. Dose to transportation workers during normal transportation operations was estimated to result in a collective dose of 0.04 person-Sv (4 person-rem) per reference reactor-year. The combined dose to the public along the route and dose to onlookers were estimated to result in a collective dose of 0.03 person-Sv (3 person-rem) per reference reactor-year.

Environmental risks (radiological) during accident conditions were determined to be SMALL. Nonradiological impacts from postulated accidents were estimated as one fatal injury in 100 reactor years and one nonfatal injury in 10 reference reactor-years. Subsequent reviews of transportation impacts in NUREG-0170 (NRC 1977a) and Sprung et al. (2000) concluded that impacts were bounded by Table S–4 in 10 CFR 51.52.

In accordance with 10 CFR 51.52(a), a full description and detailed analysis of transportation impacts is not required when licensing an LWR (i.e., impacts are assumed bounded by Table S–4) if the reactor meets the following criteria:

- The reactor has a core thermal power level not exceeding 3800 MW(t).
- Fuel is in the form of sintered UO_2 pellets having a uranium-235 enrichment not exceeding 4 percent by weight; and pellets are encapsulated in zirconium-clad fuel rods.
- Average level of irradiation of the fuel from the reactor does not exceed 33,000 MWd/MTU, and no irradiated fuel assembly is shipped until at least 90 days after it is discharged from the reactor.

(a) The transportation impacts associated with advanced reactors were normalized for a reference 1100 MW(e) LWR at an 80 percent capacity factor for comparisons to Table 5-4.

- With the exception of irradiated fuel, all radioactive waste shipped from the reactor is packaged and in solid form.

- Unirradiated fuel is shipped to the reactor by truck; irradiated fuel is shipped from the reactor by truck, rail, or barge; and radioactive waste other than irradiated fuel is shipped from the reactor by truck or rail.

The environmental impacts of the transportation of fuel and radioactive wastes to and from nuclear power facilities were resolved generically in 10 CFR 51.52, provided that the specific conditions in the rule (see above) are met; if not, then a full description and detailed analysis is required for initial licensing. The NRC may consider requests for licensed plants to operate at conditions above those in the facility's licensing basis; for example, higher burnups (above 33,000 MWd/MTU), enrichments (above 4 percent uranium-235), or thermal power levels (above 3800 MW(t)). Departures from the conditions itemized in 10 CFR 51.52(a) must be supported by a full description and detailed analysis of the environmental effects, as specified in 10 CFR 51.52 (b). Departures found to be acceptable for licensed facilities cannot serve as the basis for initial licensing for new reactors.

In its application, Dominion did not identify a specific reactor design, rather it used bounding parameters from seven reactor designs. Five of the designs are LWRs, and include the ACR-700 (3964 MW(t)/unit); the ABWR (4300 MW(t)/unit); the AP1000 (3400 MW(t)/unit); the ESBWR (4500 MW(t)/unit), and the IRIS (3000 MW(t)/unit). For the ACR-700 reactor design, two reactors make up a unit. For the IRIS design, three reactors (modules) make up a unit. For the remaining LWR designs, one reactor makes up a unit. None of the proposed LWR designs meets all the conditions in 10 CFR 51.52(a); therefore, a full description and detailed analysis are required for each LWR design. This conclusion is based on the following:

- The ACR-700, ABWR, and surrogate ESBWR designs exceed the 3800 MW(t) core thermal power level.

- The ABWR, AP1000, surrogate ESBWR, and IRIS designs require fuel that exceeds the U-235 enrichment of 4 percent.

- The ABWR, surrogate AP1000, surrogate ESBWR, and IRIS designs are expected to exceed the average irradiation level of 33,000 MWd/MTU.

The remaining two designs, the GT-MHR and the PBMR, are gas-cooled reactors. Each GT-MHR unit is a four-module, 2400-MW(t), 1140-MW(e) gas-cooled reactor designed to operate at a unit capacity factor of 88 percent. Each PBMR unit is an eight-module, 3200-MW(t), 1320-MW(e) gas-cooled reactor designed to operate at a unit capacity factor of 95 percent. This compares to the reference reactor in WASH-1238 (AEC 1972), which is a single-unit, 1100-MW(e) LWR with a unit capacity factor of 80 percent. The gas-cooled reactor designs do not meet the conditions in 10 CFR 51.52 because these reactors are not LWR designs upon which Table S–4 impacts were based. Therefore, a full description and detailed analysis was required for each gas-cooled reactor design. This was provided by Dominion in its response to a request for additional information on July 12, 2004 (Dominion 2004).

Dominion used a sensitivity analysis to show that transportation impacts from advanced LWR designs would be bounded by the criteria identified in Table S–4 (Dominion 2006a). NUREG-1437, Addendum 1, (NRC 1999) was referenced as the basis for exceeding 4 percent uranium-235 enrichment and 33,000 MWd/MTU. However, NUREG-1437, Addendum 1, applies to reactor designs and locations that are listed in NUREG-1437, Appendix A; it does not address advanced reactors.

Dominion also used a sensitivity analysis to show that transportation impacts from the advanced gas-cooled reactor designs would be bounded by the criteria identified in Table S–4 (Dominion 2006a); however, as discussed previously, this type of analysis does not meet the requirements of 10 CFR 51.52. Dominion (2006a) identified the major contributors to transportation risk to be the number and type of shipments (shipment risk) and the kind of material being shipped (material risk). Its evaluation of shipment risk showed fewer shipments of unirradiated fuel, spent fuel, and low-level waste would be required for the advanced gas-cooled reactors compared to the reference LWR when averaged over 40 years of operation. Regarding material risk, Dominion (2006a) stated the following:

- The estimated total spent fuel radioactive inventory and fission product inventory was less for the gas-cooled reactors when compared to the reference LWR.

- Actinide inventories would be greater for the gas-cooled reactors (59 to 64 percent greater) because of the increased burnup rate for these types of reactors; however, because the GT-MHR was assumed to ship about one-third less spent fuel on a MTU basis, Dominion (2006a) determined the actinide inventory per shipment would be about one-half of that in the reference LWR shipment. The PBMR is assumed to ship the same amount of spent fuel in a spent fuel shipping cask as the reference LWR; consequently, there is about a 60 percent increase in per-shipment actinide inventories from PBMR spent fuel shipments relative to the reference LWR.

- Gas-cooled reactors would generate fewer kilowatts of decay heat per MTU and fewer kilowatts of decay heat per truck cask than the reference LWR at the time of shipment.

6.2.1 Transportation of Unirradiated Fuel

The staff performed an independent review of the environmental impacts of transporting unirradiated (fresh) fuel to the proposed North Anna ESP site. Environmental impacts of normal operating conditions and transportation accidents are discussed in this section. Appendix G provides the details of the analysis.

6.2.1.1 Normal Conditions

Normal conditions, sometimes referred to as "incident-free" transportation, are transportation activities in which shipments reach their destination without releasing any radioactive material to the environment. Impacts from these shipments would be from the low levels of radiation that penetrate the unirradiated fuel shipping casks.

Truck Shipments

Table 6-4 provides an estimate of the number of truck shipments of unirradiated fuel for each advanced reactor design compared to those of the reference 1100-MW(e) reactor specified in WASH-1238 (AEC 1972). Estimates are normalized to an equivalent 1100-MW(e) electric generating capacity. The basis for the shipment estimates can be found in Appendix G of this EIS. Only the ACR-700, PBMR, and GT-MHR reactor designs exceeded the number of truck shipments of unirradiated fuel estimated for the reference LWR in WASH-1238. The largest number of shipments, in excess of 700 shipments over 40 years, is for the GT-MHR. However, the combined annual shipments of unirradiated fuel, spent fuel, and radioactive waste equate to far less than the one truck shipment per day condition specified in Table S–4 of 10 CFR 51.52 for all reactor types.

Shipping Mode and Weight Limits

In 10 CFR 51.52, a condition is identified that states all unirradiated fuel is shipped to the reactor by truck. In information provided by Dominion, the applicant specifies that unirradiated fuel will be shipped to the reactor site by truck for all reactor designs that it references (INEEL 2003). Section 10 CFR 51.52 includes a condition that the truck shipments not exceed 33,100 kg (73,000 lbs) as governed by Federal or State gross vehicle weight restrictions. All the advanced reactor designs would meet this weight restriction for unirradiated fuel (INEEL 2003).

Radiological Doses to Transport Workers and The Public

Section 10 CFR 51.52, Table S–4, includes conditions related to radiological dose to transport workers and members of the public along transport routes. These doses are a function of many variables, including the radiation dose rate emitted from the unirradiated fuel shipments, the number of exposed individuals and their locations relative to the shipment, the time in transit (including travel and stop times), and number of shipments to which the individuals are exposed. For this EIS, the radiological dose impacts of the transportation of unirradiated fuel

Table 6-4. Numbers of Truck Shipments of Unirradiated Fuel for Each Advanced Reactor Type

Reactor Type	Number of Shipments per Reactor Unit			Unit Electric Generation, MW(e)[c]	Capacity Factor[c]	Normalized, Shipments per 1100 MW(e)[d,e]
	Initial Core[a]	Annual Reload	Total[b]			
Reference LWR (WASH-1238)	18	6	252	1100	0.8	252
ABWR[e]	30	6.1	267	1500	0.95	165
Surrogate ESBWR[e]	30	6.1	267	1520[f]	0.96[f]	162
Surrogate AP1000	14	3.8	161	1150	0.95	130
ACR-700	30	15.3	628	1462[g]	0.9	420
IRIS	34	4.3	201	1005[h]	0.96	184
GT-MHR	51	20	831	1140[I]	0.88	729
PBMR	44	20	824	1320[j]	0.95	579

NOTE: The reference LWR shipment values have all been normalized to 880 MW(e) net electrical generation.
(a) Shipments of the initial core have been rounded up to the next highest whole number.
(b) Total shipments of unirradiated fuel over a 40-year plant lifetime (i.e., initial core load plus 39 years of average annual reload quantities).
(c) Unit capacities and capacity factors were taken from INEEL (2003) except where indicated otherwise.
(d) Normalized to net electric output for WASH-1238 reference LWR (i.e., 1100 MW(e) plant at 80 percent or net electrical output of 880 MW(e)).
(e) Ranges of capacities are given in INEEL (2003) for these reactor unirradiated fuel shipments. The unirradiated fuel shipment data for these reactors were derived using the upper limit of the ranges.
(f) Values taken from ER Revision 9 (Dominion 2006a).
(g) The ACR-700 unit includes two reactors at 731 MW(e) each.
(h) The IRIS unit includes three reactors at 335 MW(e) each.
(I) The GT-MHR unit includes four reactors (modules) at 285 MW(e) each.
(j) The PBMR unit includes eight reactors (modules) at 165 MW(e) each.

were calculated for the worker and the public using the RADTRAN 5 computer code (Neuhauser et al. 2003). Details of the calculations are found in Appendix G.

Table 6-5 presents the radiological impacts to workers, public onlookers (persons at stops and sharing the road), and members of the public along the route (i.e., residents within 800 m [0.5 mi] of the highway) for transporting unirradiated fuels to sites. The cumulative annual dose estimates in Table 6-5 were normalized to 1100 MW(e) (880 MW(e) net electrical output). The staff performed an independent review and determined that all dose estimates are bounded by the Table S–4 conditions of 0.04 person-Sv/yr (4 person-rem/yr) to transportation workers, 0.03 person-Sv/yr (3 person-rem/yr) to onlookers, and 0.03 person-Sv/yr (3 person-rem/yr) to onlookers and members of the public along the route.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 100 mSv (10,000 mrem) and at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2005), the BEIR VII report, supports the linear, no-threshold dose response theory. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over estimates those risks.

Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv [1,000,000 person-rem]) from ICRP Publication 60 (ICRP 1991). All the public doses presented in Table 6-5 are less than or equal to 1.2×10^{-3} person-Sv/yr (1.2×10^{-1} person-rem/yr); therefore, the total detriment estimates associated with these doses would all be less than 1×10^{-4} fatal cancers, nonfatal cancers, and severe heredity effects per year. These risks are very small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would be expected to occur annually in the same population from exposure to natural sources of radiation. However, these impacts are not resolved for other-than-LWR designs and would need to be assessed at the CP or COL stage when specific information is available regarding other-than-LWR fuel performance and shipping containers, if the applicant selects such a design.

Maximally-Exposed Individuals Under Normal Transport Conditions

A scenario-based analysis was conducted to develop estimates of incident-free radiation doses to maximally exposed individuals (MEIs) for fuel and waste shipments to and from advanced reactors. The discussion in the following paragraphs apply to unirradiated fuel shipments to and spent fuel and radioactive shipments from advanced reactors. The analysis is based on information in DOE (2002) and incorporates information about exposure times, dose rates, and the number of times an individual may be exposed to an offsite shipment. Adjustments were made where necessary to reflect the fuel and waste shipments addressed in this EIS. In all cases, the staff assumed that the dose rate emitted from the shipping containers is 0.1 mSv/hr (10 mrem/hr) at 2 m (6.6 ft) from the side of the transport vehicle, the maximum dose rate

Table 6-5. Radiological Impacts of Transporting Unirradiated Fuel to Advanced Reactor Sites

Plant Type	Normalized Average Annual Shipments	Cumulative Annual Dose; person-Sv/yr per 1100 MW(e)[(a)] (880 MW(e) net) Workers	Public - Onlookers	Public - Along Route
Reference LWR (WASH-1238)	6.3	1.1×10^{-4}	4.2×10^{-4}	1.0×10^{-5}
ABWR	4.1	7.1×10^{-5}	2.7×10^{-4}	6.6×10^{-6}
Surrogate ESBWR	4.1	6.9×10^{-5}	2.7×10^{-4}	6.5×10^{-6}
Surrogate AP1000	3.3	5.6×10^{-5}	2.2×10^{-4}	5.2×10^{-6}
ACR-700	10.5	1.8×10^{-4}	7.0×10^{-4}	1.7×10^{-5}
IRIS	4.6	7.9×10^{-5}	3.1×10^{-4}	7.4×10^{-6}
GT-MHR	18.2	3.1×10^{-4}	1.2×10^{-3}	2.9×10^{-5}
PBMR	14.5	2.5×10^{-4}	9.6×10^{-4}	2.3×10^{-5}
10 CFR 51.52, Table S–4 Condition	<1 per day	4.0×10^{-2}	3.0×10^{-2}	3.0×10^{-2}

(a) Multiply person-Sv/yr times 100 to obtain doses in person-rem/yr.

allowed by U.S. Department of Transportation (DOT) regulations, even though unirradiated fuel and radioactive waste would have much lower dose rates than the regulations allow. An MEI is a person who may receive the highest radiation dose from a shipment to and/or from the advanced reactor site. The analysis is described below.

<u>Truck crew member</u>. Truck crew members would receive the highest radiation doses during incident-free transport because of their proximity to the loaded shipping container for an extended period of time. The analysis assumed that crew member doses are limited to 0.02 Sv (2 rem) per year, which is the DOE administrative control level presented in DOE-STD-1098-99, DOE Standard, Radiological Control, Chapter 2, Article 211 (DOE 2005). This limit is anticipated to apply to spent nuclear fuel shipments to a disposal facility, as DOE will take title to the spent fuel at the reactor site. Spent nuclear fuel represents the bulk of the fuel and waste shipments to and from reactor sites, and those with the highest radiation dose rates; consequently crew doses from unirradiated fuel and radioactive waste shipments will be lower than the spent nuclear fuel shipments. The NRC limit for occupational exposures is 0.05 Sv/yr (5 rem/yr).

The U.S. Department of Transportation (DOT) does not regulate annual occupational exposures, but recommends limits to air crew members that are a 5-year effective dose of 0.02 Sv/yr (2 rem/yr) with no more than 0.05 Sv (5 rem) in a single year (DOT 2003). As a result, a 0.02 Sv/yr (2 rem/yr) MEI dose to truck crews is a reasonable estimate.

<u>Inspectors</u>. Radioactive shipments are inspected by Federal or State vehicle inspectors, for example, at State ports of entry. DOE (2002) assumed that inspectors would be exposed for 1 hour at a distance of 1 m (3.3 ft) from the shipping containers. The dose rate at 1 m (3.3 ft) is

about 0.14 mSv/hr (14 mrem/hr); therefore, the dose per shipment is about 0.14 Sv (14 mrem). This is independent of the location of the reactor site. Based on this conservative value, the annual doses to vehicle inspectors were calculated to be in the range 9 to 18 mSv/yr (900 to 1800 mrem/yr), assuming the same person inspects all shipments of fuel and waste to and from the reactor sites. The high end of the range is the ACR-700 and the low end is the surrogate AP1000. All of the values are less than the 20 mSv/yr (2000 mrem/yr) DOE administrative control level on individual doses.

Resident. The analysis assumed that a resident lives 30 m (100 ft) from the point where a shipment would pass and would be exposed to all shipments along a particular route. Exposures to residents on a per-shipment basis were extracted from RADTRAN 5 output files. These dose estimates are based on an individual located 30 m (100 ft) from the shipments that are traveling 24 km/hr (15 mph). The potential radiation doses to maximally-exposed residents, which are independent of the location of the reactor site, ranged from about 0.00027 mSv/yr (0.027 mrem/yr) for the surrogate AP1000 to 0.00055 mSv/yr (0.055 mrem/yr) for the ACR-700.

Individual stuck in traffic. This scenario addresses potential traffic interruptions that could lead to a person being exposed to a loaded shipment for one hour at a distance of 1.2 m (4 ft). The analysis assumed this exposure scenario would occur only one time to any individual, and the dose rate was at the regulatory limit of 0.1 mSv (10 mrem/hr) at 2 m (6 ft) from the shipment. The dose to the MEI was calculated in DOE (2002) to be 0.016 mSv (1.6 mrem).

Person at a truck service station. This scenario estimates doses to an employee at a service station where all truck shipments to and from the reactors would stop. DOE (2002) assumed this person is exposed for 49 minutes at a distance of 16 m (52 ft) from the loaded shipping container. This results in a dose of about 0.0007 mSv/shipment (0.07 mrem/shipment) and an annual dose in the range from 0.044 mSv (4.4 mrem) for the surrogate AP1000 to 0.09 mSv/yr (9 mrem/yr) for the ACR-700, assuming that a single individual services all unirradiated fuel, spent fuel, and radioactive waste shipments to and from the advanced reactors.

6.2.1.2 Accidents

Accident risks are a combination of accident frequency and consequence. Accident frequencies for transportation of fuel to and from reactors sites are expected to be lower than those used in the analysis in WASH-1238 (AEC 1972), which forms the basis for Table S–4 of 10 CFR 51.52, because of improvements in highway safety and security, and an expected decrease in traffic accident, injury, and fatality rates. There is no significant difference in consequences of accidents severe enough to result in a release of unirradiated fuel particles to the environment between advanced LWRs and current-generation LWRs because the fuel form, cladding, and packaging are similar to those analyzed in WASH-1238. Consequently, the impacts of accidents during transport of unirradiated fuel for advanced LWRs to the North Anna ESP site are expected to be smaller than the impacts listed in Table S–4 for current generation LWRs.

With respect to the advanced gas-cooled reactors, accident rates (accidents per unit distance) and associated accident frequencies (accidents per year) would be expected to follow the same trends as for LWRs (i.e., overall reduction relative to the accident rates used in the WASH-1238 analysis). The consequences of accidents involving gas-cooled reactor unirradiated fuel, however, are more uncertain. The staff assumed that the gas-cooled reactor unirradiated fuel shipments would have the same capabilities as LWR unirradiated fuel to maintain functional integrity following a traffic accident. This assumption is considered to be conservative because gas-cooled reactor fuel operates at significantly higher temperatures, and thus maintains integrity under more severe thermal conditions than LWR fuel. Detailed information about the behavior of the gas-cooled reactor fuel under accident impact conditions was not available. However, packaging systems for unirradiated gas-cooled reactor fuel will be required to meet the same performance requirements as unirradiated LWR fuel packages including fissile material controls to prevent criticality during normal and accident conditions. Consequently, it is expected that packaging systems for unirradiated gas-cooled reactor fuels would provide equivalent protection as those packages designed for unirradiated LWR fuels. In addition, the fuel forms for the gas-cooled reactors are similar to LWRs (i.e., UO_2 for the PBMR and uranium oxycarbide for the GT-MHR versus UO_2 for LWRs); therefore, the inherent failure resistance provided by unirradiated gas-cooled reactor fuels should be similar to that provided by LWR fuel. Based on the assumption that unirradiated gas-cooled and LWR fuels and associated packaging systems would provide similar resistance to various environmental conditions, the staff concludes that the impacts of accidents involving unirradiated gas-cooled reactor fuel would likely not be significantly different than for unirradiated LWR fuel and will be within the impacts listed in Table S–4 for current generation LWRs. However, for other-than-LWR fuel performance ,these impacts are not considered to be resolved, and would need to be assessed at the CP or COL stage when specific information becomes available.

6.2.2 Transportation of Spent Fuel

The staff performed an independent review of the environmental impacts of transporting spent fuel from the proposed North Anna ESP site to a spent fuel disposal repository. For the purposes of these analyses, the staff considered the Yucca Mountain, Nevada, site as a surrogate destination. The staff considers that an estimate of the impacts of the transportation of spent fuel to a possible repository in Nevada to be a reasonable bounding estimate of the transportation impacts to a storage or disposal facility because of the distances involved and the representativeness of the distribution of members of the public in urban, suburban, and rural areas (i.e., population distributions) along the shipping routes. Environmental impacts of normal operating conditions and transportation accidents are discussed in this section.

This analysis is based on shipment of spent fuel by legal-weight trucks in casks with characteristics similar to casks currently available (i.e., massive, heavily shielded, cylindrical metal pressure vessels). Each shipment is assumed to consist of a single shipping cask loaded on a modified trailer. These assumptions are consistent with assumptions made in the evaluation of the environmental impacts of transportation of spent fuel in Addendum 1 to NUREG-1437 (NRC 1999). These assumptions are conservative because the alternative assumptions involve rail transportation or heavy-haul trucks, which would reduce the overall number of spent fuel shipments (NRC 1999), thus reducing impacts.

Environmental impacts of transportation of spent fuel were calculated using the RADTRAN 5 computer code (Neuhauser et al. 2003). Routing and population data used in the RADTRAN 5 for truck shipments were obtained from the TRAGIS routing code (Johnson and Michelhaugh 2000). The population data in the TRAGIS code are based on the 2000 census.

The staff's evaluation reviewed the impacts of spent fuel shipments originating from the North Anna ESP site and the alternative sites (Surry Power Station [Surry], Portsmouth Gaseous Diffusion Plant [Portsmouth], and Savannah River Site). Appendix G provides the details of the analysis.

6.2.2.1 Normal Conditions

Normal conditions, sometimes referred to as “incident-free” transportation, are transportation activities in which shipments reach their destination without an accident occurring en route. Impacts from these shipments would be from the low levels of radiation that penetrate the heavily shielded spent fuel shipping cask. Radiation exposures will occur to (1) persons residing along the transportation corridors between the North Anna ESP site and the proposed repository location; (2) persons in vehicles traveling on the same route as a spent-fuel shipment; (3) persons at vehicle stops for refueling, rest, and vehicle inspections; and (4) transportation crew workers.

| Shipping casks have not been designed for the spent fuel from advanced reactor designs. Information in INEEL (2003) indicated that advanced LWR fuel designs would not be significantly different from existing LWR designs; therefore, current shipping cask designs were used for the analysis for advanced LWR designs. No information is available on spent fuel shipping cask designs for the gas-cooled reactor designs. For purposes of this analysis, their design was assumed to be the same as those for the existing LWRs. Spent fuel shipping cask designs for gas-cooled reactor designs will be evaluated at the CP or COL stage if the applicant references such designs.

Radiation doses are a function of many parameters, including vehicle speed, traffic count, dose rate, packaging dimensions, number in the truck crew, stop time, and population density at stops. A listing of the values for these and other parameters, is provided in Appendix G. Table 6-6 presents radiation dose estimates to the transport workers and the public for the ESP and alternative sites. Doses are presented on a per-shipment basis. The per-shipment dose estimates are independent of reactor technology because they were calculated based on an assumed external radiation dose rate emitted from the cask, which was fixed at the regulatory maximum limit for the advanced reactor designs (i.e., 0.10 mSv/h [10 mrem/h] at 2 m).

Population dose estimates per reactor-year are presented in Table 6-7 for specific advanced reactor designs. Population doses were calculated by multiplying the number of spent fuel shipments per year for each advanced reactor design and the dose per shipment from Table 6-6. Population doses were normalized to the reference LWR design in WASH-1238 (880 net MW(e)). This corresponds to an 1100-MW(e) LWR operating at 80 percent capacity. Appendix G provides the basis for the number of spent fuel shipments for each advanced reactor design.

The bounding cumulative doses to the exposed population given in Table S–4 are

- 0.04 person-Sv/reactor-year (4 person-rem/reactor-year) to transport workers
- 0.03 person-Sv/reactor-year (3 person-rem/reactor-year) to general public (onlookers), and members of the public along the route.

Population doses to the crew and the onlookers for all the reactor types including the reference reactor found in Table 6-7, exceed Table S–4 values. Two key reasons for the higher population doses relative to Table S–4 are the higher number of spent fuel shipments estimated for some of the reactor technologies and the longer shipping distances assumed for the analyses (i.e., to a possible repository in Nevada) than were used in WASH-1238. WASH-1238 used a "typical" distance for a spent fuel shipment of 1600 km (1000 mi), whereas the shipping distances used in this assessment ranged from about 3000 km (1800 mi) to 4700 km (2900 mi). The higher numbers of shipments are based on spent fuel shipping casks designed to transport shorter-cooled fuel (i.e., 150 removed from the reactor). It was assumed in this analysis that the shipping cask capacities are 0.5 MTU/shipment, roughly equivalent to one PWR or two BWR spent fuel assemblies per shipment.

Newer designs are based on longer-cooled spent fuel (i.e., 5 years removed from the reactor) and have larger capacities than those used in this assessment. DOE (2002) spent fuel shipping cask capacities were approximately 1.8 MTU/shipment, or up to four PWR or nine BWR fuel assemblies per shipment. Use of the newer shipping cask designs will reduce the number of spent fuel shipments and the associated environmental impacts.

Other conservative assumptions in the staff's calculation include:

- <u>Use of the regulatory maximum dose rate (0.1 mSv/hr [10 mrem/hr] at 2 m) in the RADTRAN5 calculations</u>. The shipping casks assumed in the EIS prepared by DOE in support of the application for a geologic repository at the proposed Yucca Mountain repository (DOE 2002) were designed to transport spent fuel that has cooled for 5 years. Most spent fuel will have cooled for much longer than 5 years before it is shipped to a possible geologic repository. Based on this, shipments from the North Anna and alternative sites are also expected to be cooled for longer than 5 years. Consequently,

Table 6-6. Routine (Incident-Free) Radiation Doses to Transport Workers and the Public from Shipping Spent Fuel from Potential Early Site Permit Sites to a Spent Fuel Disposal Facility

ESP Site	Population Dose, person-Sv/shipment[a] Crew	Onlookers	Along Route
North Anna	1.0×10^{-3}	3.5×10^{-3}	9.2×10^{-5}
Portsmouth	9.1×10^{-4}	3.2×10^{-3}	7.3×10^{-5}
Savannah River Site	9.9×10^{-4}	3.5×10^{-3}	1.0×10^{-4}
Surry	1.1×10^{-3}	3.5×10^{-3}	9.7×10^{-5}

(a) Multiply person-Sv/yr times 100 to obtain doses in person-rem/yr.

Table 6-7. Routine (Incident-Free) Population Doses from Spent Fuel Transportation, Normalized to Reference Light-Water Reactors

Reactor Type	Reference LWR (WASH-1238)			ABWR			Surrogate AP1000			ACR-700		
Shipments per Year	60			41			40			90		
	Environmental Effects, person-Sv per reactor-year[a]											
Reactor Site	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route
North Anna	0.06	0.21	<0.01	0.04	0.14	<0.01	0.04	0.14	<0.01	0.09	0.32	<0.01
Portsmouth	0.06	0.19	<0.01	0.04	0.13	<0.01	0.04	0.12	<0.01	0.08	0.28	<0.01
Savannah River Site	0.06	0.21	<0.01	0.04	0.14	<0.01	0.04	0.14	<0.01	0.09	0.32	<0.01
Surry	0.06	0.21	<0.01	0.04	0.14	<0.01	0.04	0.14	<0.01	0.10	0.32	<0.01

Reactor Type	Surrogate ESBWR			IRIS			GT MHR			PBMR		
Shipments per Year	40			35			34			12		
	Environmental Effects, person-Sv per reactor-year[a]											
Reactor Site	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route
North Anna	0.04	0.14	<0.01	0.04	0.12	<0.01	0.03	0.12	<0.01	0.01	0.04	<0.01
Portsmouth	0.04	0.13	<0.01	0.03	0.11	<0.01	0.03	0.11	<0.01	0.01	0.04	<0.01
Savannah River Site	0.04	0.14	<0.01	0.03	0.12	<0.01	0.03	0.12	<0.01	0.01	0.04	<0.01
Surry	0.04	0.14	<0.01	0.04	0.12	<0.01	0.04	0.12	<0.01	0.10	0.04	<0.01

(a) Multiply person-Sv/yr times 100 to obtain doses in person-rem/yr.

the estimated population doses in Table 6-7 could be further reduced if more realistic dose rate projections are used.

- Use of 30 minutes as the average time at a truck stop in the calculations. Many stops made for actual spent fuel shipments are of short duration (i.e., 10 minutes) for brief visual inspections of the cargo (e.g., checking the cask tie-downs). These stops typically occur in minimally populated areas, such as an overpass or freeway ramp in an unpopulated area. Furthermore, empirical data provided in Griego et al. (1996) indicate that a 30-minute duration is toward the high end of the stop time distribution. Average stop times observed by Griego et al. (1996) are on the order of 18 minutes. Based on these observations, the stop model assumptions used in this study overestimate public doses at stops by at least a factor of two. Consequently, the doses to onlookers given in Table 6-7 could be further reduced to reflect more realistic truck shipping conditions.

Dominion performed its own RADTRAN 5 calculations to determine the impact of “incident-free” transport of spent fuel to a spent fuel disposal facility. The assumed transport of spent fuel originated from the Maine Yankee Nuclear Plant (a distance further than North Anna site) and terminated at the proposed repository at Yucca Mountain, Nevada. Dose estimates per shipment were similar to those calculated by the staff.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 100 mSv (10,000 mrem) and at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2005), the BEIR VII report, supports the linear, no-threshold dose response theory. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks.

Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv [1,000,000 mrem]) from ICRP Publication 60 (ICRP 1991). All the population doses presented in Table 6-7 are less than 1 person-Sv/yr (100 person-rem/yr); therefore, the total detriment estimates associated with these population doses would all be less than 1×10^{-1} fatal cancers, nonfatal cancers, and severe hereditary effects per year. These risks are quite small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that the same population would incur annually from exposure to natural sources of radiation.

Dose estimates to the MEI from transport of unirradiated fuel, spent fuel, and wastes under normal conditions are presented in Section 6.2.1.1.

6.2.2.2 Accidents

As discussed previously, the staff used the RADTRAN 5 computer code to estimate impacts of transportation accidents involving spent fuel shipments. RADTRAN 5 considers a spectrum of postulated transportation accidents, ranging from those with high frequencies and low consequences (e.g., "fender benders") to those with low frequencies and high consequences (i.e., accidents in which the shipping container is exposed to severe mechanical and thermal conditions). Details of the analysis are discussed in Appendix G.

Radionuclide inventories are important parameters in the calculation of accident risks. The radionuclide inventories used in this analysis were from *Early Site Permit Environmental Report Sections and Supporting Documentation* (INEEL 2003). This report includes hundreds of radionuclides for each reactor type. A screening analysis was conducted to select the dominant contributors to accident risks to simplify the RADTRAN 5 calculations. The screening identified the radionuclides that would contribute more than 99.999 percent of the dose from inhalation of radionuclides released following a transportation accident. The dominant radionuclides are similar regardless of the fuel type (i.e., advanced LWR fuel or gas-cooled reactor fuel). Spent fuel inventories used in the staff analysis are presented in Table 6-8. The list of radionuclides set forth in the table includes all of the radionuclides that were included in the analysis conducted by Sprung et al. (2000). However, INEEL (2003) did not provide radionuclide source terms for radioactive material deposited on the external surfaces of LWR spent fuel rods (commonly called "crud"). In addition, data on activation products was provided for only the advanced BWR. The advanced BWR spent fuel transportation risks were calculated assuming the entire cobalt-60 inventory is in the form of crud. Therefore, the source term assumed for this analysis is about two orders of magnitude greater than that given in Sprung et al. (2000). Because crud is deposited from corrosion products generated elsewhere in the reactor cooling system and the complete reactor design and operating parameters are uncertain, the quantities and characteristics of crud deposited on advanced reactor spent fuel are unknown at this time. Consequently, the impacts of crud and activation products on spent fuel transportation accident risks will need to be examined at the CP/COL stage. No radionuclide inventory data were presented in INEEL (2003) for the ACR-700 and IRIS advanced reactors; therefore, transportation accident risks were not quantified for these reactor types and would need to be assessed at the CP/COL stage.

Robust shipping casks are used to transport spent fuel because of the radiation shielding and accident resistance required by 10 CFR Part 71. Spent fuel shipping casks must be certified Type B packaging systems, meaning they must withstand a series of severe postulated accident conditions with essentially no loss of containment or shielding capability. These casks

Table 6-8. Radionuclide Inventories Used in Transportation Accident Risk Calculations for Each Advanced Reactor Type, Bq/MTU[(a)(b)]

Radionuclide	ABWR Inventory, Bq/MTU	Surrogate ESBWR Inventory, Bq/MTU	Surrogate AP1000 Inventory, Bq/MTU	GT-MHR Inventory, Bq/MTU	PBMR Inventory, Bq/MTU
Am-241	4.96×10^{13}	4.81×10^{13}	2.69×10^{13}	8.18×10^{13}	7.55×10^{13}
Am-242m	1.24×10^{12}	1.02×10^{12}	4.85×10^{11}	5.03×10^{11}	8.51×10^{11}
Am-243	1.20×10^{12}	1.21×10^{12}	1.24×10^{12}	5.14×10^{11}	4.77×10^{12}
Ce-144	4.22×10^{14}	5.00×10^{14}	3.28×10^{14}	2.15×10^{15}	1.19×10^{15}
Cm-242	2.04×10^{12}	1.80×10^{12}	1.05×10^{12}	1.51×10^{12}	2.78×10^{12}
Cm-243	1.37×10^{12}	1.28×10^{12}	1.14×10^{12}	2.02×10^{11}	1.96×10^{12}
Cm-244	1.80×10^{14}	1.84×10^{14}	2.87×10^{14}	2.83×10^{13}	5.48×10^{14}
Cm-245	2.43×10^{10}	2.50×10^{10}	4.48×10^{10}	1.65×10^{8}	5.29×10^{10}
Co-60[(c)]	1.01×10^{14}	1.06×10^{14}	(c)	(c)	(c)
Cs-134	1.78×10^{15}	1.92×10^{15}	1.78×10^{15}	2.21×10^{15}	4.03×10^{15}
Cs-137	4.59×10^{15}	4.70×10^{15}	3.44×10^{15}	1.08×10^{16}	1.41×10^{16}
Eu-154	3.81×10^{14}	3.90×10^{14}	3.38×10^{14}	3.23×10^{14}	3.74×10^{14}
Eu-155	1.93×10^{14}	2.00×10^{14}	1.71×10^{14}	8.77×10^{13}	1.08×10^{14}
Pm-147	1.25×10^{15}	1.31×10^{15}	6.51×10^{14}	6.92×10^{15}	5.07×10^{15}
Pu-238	2.27×10^{14}	2.28×10^{14}	2.25×10^{14}	1.17×10^{14}	4.55×10^{14}
Pu-239	1.43×10^{13}	1.43×10^{13}	9.44×10^{12}	2.25×10^{13}	1.11×10^{13}
Pu-240	2.28×10^{13}	2.30×10^{13}	2.01×10^{13}	3.96×10^{13}	3.32×10^{13}
Pu-241	4.51×10^{15}	4.51×10^{15}	2.58×10^{15}	8.33×10^{15}	7.18×10^{15}
Pu-242	8.29×10^{10}	8.29×10^{10}	6.73×10^{10}	1.56×10^{11}	4.51×10^{11}
Ru-106	6.07×10^{14}	6.88×10^{14}	5.74×10^{14}	1.48×10^{15}	1.68×10^{15}
Sb-125	1.99×10^{14}	2.14×10^{14}	1.42×10^{14}	2.21×10^{14}	2.51×10^{14}
Sr-90	3.27×10^{15}	3.36×10^{15}	2.29×10^{15}	8.95×10^{15}	1.08×10^{16}
Y-90	3.27×10^{15}	3.36×10^{15}	2.29×10^{15}	8.95×10^{15}	1.08×10^{16}

(a) Divide becquerel/metric ton Uranium (Bq/MTU) by 3.7×10^{10} to obtain curies/MTU
(b) The source of the spent fuel inventories is INEEL (2003) except for the surrogate ESBWR inventories, which were taken from Dominion (2006b). The surrogate ESBWR inventories reflect the increased core thermal power assumed in Dominion (2006a).
(c) Cobalt-60 is an activation product. Only the ABWR/ESBWR submittal in INEEL (2003) provided inventory data for activation products; it was scaled up for the surrogate ESBWR.

are also designed with fissile material controls to ensure the spent fuel remains subcritical under normal and accident conditions. According to Sprung et al. (2000), the probability of encountering accident conditions that would lead to shipping cask failure is less than

0.01 percent (i.e., more than 99.99 percent of all accidents would result in no release of radioactive material from the shipping cask). The staff assumed that shipping casks for advanced reactor spent fuels will provide equivalent mechanical and thermal protection of the spent fuel cargo.

The RADTRAN 5 accident risk calculations were performed using unit-specific radionuclide inventories (Bq/MTU) for the spent fuel shipments from the various reactor types. The resulting risk estimates were then multiplied by assumed annual spent fuel shipments (MTU/yr) to derive estimates of the annual accident risks associated with spent fuel shipments from each potential advanced reactor site. As was done for routine exposures, the staff assumed that the numbers of shipments of spent fuel per year are equivalent to the annual discharge quantities.

For this assessment, release fractions for current generation LWR fuel designs (Sprung et al. 2000) were used to approximate the impacts from the advanced reactor spent fuel shipments. This assumes that the fuel materials and containment systems (i.e., cladding, fuel coatings) behave similarly to current LWR fuel under reactor mechanical and thermal conditions. Because of the lack of experimental data on gas-cooled reactor fuels, the staff could not determine whether this approach is bounding. However, gas-cooled reactors operate at much higher temperatures than LWRs; therefore, high temperature conditions anticipated in transportation accident fires should have less of an effect on radionuclide releases than they do for LWR fuels. Thus, smaller release fractions are anticipated for advanced gas-cooled reactor fuels than for LWR fuels subjected to thermal transients.

The NRC staff used RADTRAN 5 to calculate the population dose from the released radioactive material from four of five[(a)] possible exposure pathways. These pathways are:

- External dose from exposure to the passing cloud of radioactive material (cloudshine).

- External dose from the radionuclides deposited on the ground by the passing plume (groundshine). The staff's analysis included the radiation exposure from this pathway even though the area surrounding a potential accidental release would be evacuated and decontaminated, thus preventing long-term exposures from this pathway.

- Internal dose from inhalation of airborne radioactive contaminants (inhalation).

- Internal dose from resuspension of radioactive materials that were deposited on the ground (resuspension). The staff's analysis included the radiation exposures from this

(a) Internal dose from ingestion of contaminated food was not considered as the staff assumed evacuation and subsequent interdiction of foodstuffs following a postulated transportation accident.

pathway even though evacuation and decontamination of the area surrounding a potential accidental release would prevent long-term exposures.

Table 6-9 presents the environmental consequences of transportation accidents when shipping spent fuel from the North Anna ESP site and alternative sites to the proposed Yucca Mountain repository. The shipping distances and population distribution information for the routes were the same as those used for the normal “incident-free” conditions (for details, see Appendix G). The table presents estimates of population dose (person-Sv/reactor year) for several of the advanced reactor designs. These values are normalized to the WASH-1238 reference reactor (880-MW(e) net electrical generation, 1100-MW(e) reactor operating at 80 percent capacity).

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 100 mSv (10,000 mrem) and at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2005), the BEIR VII report, supports the linear, no-threshold dose response theory. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks.

Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv [1,000,000 person-rem]) from ICRP Publication 60 (ICRP 1991). All the population doses presented in Table 6-9 are less than 1×10^{-5} person-Sv/yr (1×10^{-3} person-rem/yr); therefore, the total detriment estimates associated with these population doses would all be less than 1×10^{-6} fatal cancers, nonfatal cancers, and severe hereditary effects per year. These risks are quite small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would be expected to occur annually in the same population from exposure to natural sources of radiation.

6.2.2.3 Conclusion

The values determined by this analysis represent the contribution of such effects to the environmental costs of licensing the reactor. Because of the conservative approaches and data used to calculate doses, actual environmental effects are not likely to exceed those calculated in the EIS. Thus, the staff concludes that the overall transportation accident risks associated with advanced reactor spent fuel shipments are likely to be SMALL and are consistent with the risks associated with transportation of spent fuel from current generation reactors presented in

Table 6-9. Annual Spent Fuel Transportation Accident Impacts for Advanced Reactors, Normalized to Reference 1100-MW(e) LWR Net Electrical Generation

	Advanced Reactor Type				
	ABWR	**Surrogate ESBWR**	**Surrogate AP1000**	**GT-MHR**	**PBMR**
MTU/yr	**20.3**	**20.3**	**19.7**	**6**	**5.8**
Population Dose, person-Sv/yr[(a)]					
North Anna	4.7×10^{-6}	5.0×10^{-6}	4.2×10^{-7}	1.9×10^{-7}	3.1×10^{-7}
Portsmouth	5.2×10^{-6}	5.5×10^{-6}	4.0×10^{-7}	1.8×10^{-7}	3.0×10^{-7}
Savannah River Site	5.3×10^{-6}	5.6×10^{-6}	4.7×10^{-7}	2.2×10^{-7}	3.5×10^{-7}
Surry	4.9×10^{-6}	5.1×10^{-6}	4.3×10^{-7}	2.0×10^{-7}	3.2×10^{-7}

(a) Multiply person-Sv/yr times 100 to obtain person-rem/yr.

Table S–4 of 10 CFR 51.52. The fuel performance characteristics, shipping casks, and accident risks for other-than-LWR designs would need to be assessed at the CP or COL stage if the applicant references such designs.

6.2.3 Transportation of Radioactive Waste

This section discusses the environmental effects of transporting waste from advanced reactor sites. The environmental conditions listed in 10 CFR 51.52 that apply to shipments of radioactive waste are as follows:

- Radioactive waste (except spent fuel) would be packaged and in solid form.
- Radioactive waste (except spent fuel) would be shipped from the reactor by truck or rail.
- The weight limitation of 33,100 kg (73,000 lb) per truck and 90,700 kg (100 tons) per cask per railcar would be met.
- Traffic density would be less than the one truck shipment per day or three railcars per month condition.

Dominion (2006), states that all the radioactive waste will be transported by truck, and Dominion plans to solidify and package its waste regardless of which advanced reactor technology is chosen. In addition, waste from any of the advanced reactor technologies will be subject to NRC (10 CFR Part 71) and DOT (49 CFR Parts 171, 172, 173, and 178) regulations for the shipment of radioactive material.

Radioactive waste from any of the advanced reactor technologies are expected to be capable of being shipped in compliance with Federal or State weight restrictions.

Table 6-10 presents estimates of annual waste volumes and annual waste shipment numbers for the advanced reactor types normalized to the reference 1100-MW(e) LWR defined in WASH-1238 (AEC 1972). Annual waste volumes and waste shipments for the advanced reactor technologies were less than the 1100-MW(e) reference reactor that was the basis for Table S–4 for all designs except the PBMR. As shown in the table, only the PBMR would be expected to generate a larger volume of radioactive waste than the reference LWR in WASH-1238. However, the GT-MHR and PBMR information in INEEL (2003) assumed the applicant would ship their wastes using two different packaging systems: one that hauls 28.3 m^3/shipment (1000 ft^3/shipment) and one that hauls 5.7 m^3/shipment (200 ft^3/shipment). Under those conditions, the number of shipments of radioactive waste per year, normalized to 1100 MW(e) electric generation capacity (880 MW(e) net electrical output), would be about six shipments/year per 1100 MW(e) (880 net MW(e)) for the GT-MHR and seven shipments/year per 1100 MW(e) for the PBMR. These estimates are well below the reference LWR (46 shipments/yr per 1100 MW(e)). However, impacts from other-than-LWR designs are not resolved because of the lack of verifiable information.

The sum of the daily shipments of unirradiated fuel, spent fuel, and radioactive waste is well below the one truck shipment per day condition given in 10 CFR 51.52, Table S–4 for all reactor types. Doubling the shipment estimates to account for empty return shipments of fuel and waste is still well below the one-shipment-per-day-condition.

Dose estimates to the MEI from transport of unirradiated fuel, spent fuel, and waste under normal conditions are presented in Section 6.2.1.1.

6.2.4 Conclusions

An analysis was conducted of the impacts under normal operating and accident conditions of transporting unirradiated fuel to advanced reactor sites and spent fuel and wastes from advanced reactor sites to disposal facilities. To make comparisons to Table S–4, the environmental impacts are normalized to a reference reactor year. The reference reactor is an 1100-MW(e) reactor that has an 80-percent capacity factor, for a total electrical output of 880 MW(e) per year. The environmental impacts can be adjusted to calculate impacts per site by multiplying the normalized impacts by the ratio of the total electric output for the advanced reactor sites to the electric output of the reference reactor.

Because of the conservative approaches and data used to calculate doses, actual environmental effects are not likely to exceed those calculated in the EIS. Thus, the staff concludes that the environmental impacts of transportation of fuel and radioactive wastes to and from advanced LWR designs would be SMALL, and would be consistent with the risks associated with transportation of fuel and radioactive wastes from current-generation reactors presented in Table S–4 of 10 CFR 51.52. For gas-cooled designs, the impacts are likely to be

Table 6-10. Summary of Radioactive Waste Shipments for Advanced Reactors

Reactor Type	INEEL (2003) Waste Generation Information	Annual Waste Volume, m^3/yr per Unit	Electrical Output, MW(e) per Unit	Normalized Rate, m^3/1100 MW(e) Unit (880 MW(e) Net)[(a)]	Shipments/ 1100 MW(e) (880 MW(e) Net) Electrical Output[(b)]
Reference LWR (WASH-1238)	100 m^3/yr per unit	108	1100	108	46
ABWR	100 m^3/yr per unit	100	1500	62	27
Surrogate ESBWR	100 m^3/yr per unit	100	1520[(c)]	60	26
Surrogate AP1000	55 m^3/yr per unit	56	1150	45	20
ACR-700	47.5 m^3/yr per unit	47.5	731	64	28
IRIS	25 m^3/yr per module	74 (3 modules)	1005 (3 modules)	67	29
GT-MHR	98 m^3/yr (4 module plant)	98 (4 modules)	1140 (4 modules)	86	37[(d)]
PBMR	100 drums/yr per module	168 (8 modules)	1320 (8 modules)	118	51[(d)]

Conversions: 1 m^3 = 35.31 ft^3. Drum volume = 210 liters (0.21 m^3).

(a) Capacity factors used to normalize the waste generation rates to an equivalent electrical generation output are given in Table 6-3 for each reactor type. All are normalized to 880 MW(e) net electrical output (1100-MW(e) unit with an 80 percent capacity factor).

(b) The number of shipments per 1100 MW(e) was calculated assuming the WASH-1238 average waste shipment capacity of 2.34 m^3 per shipment (108 m^3/yr divided by 46 shipments/yr).

(c) This value was taken from the ER, Revision 9 (Domion 2006a)

(d) The applicant states in INEEL (2003) that 90 percent of the waste could be shipped on trucks carrying 28 m^3 (1000 ft^3) of waste and the remaining 10 percent in shipments carrying 5.7 m^3 (200 ft^3) of radioactive waste. This would result in six to seven shipments per year after normalization to the reference LWR electrical output.

small, but this issue is not resolved because of the lack of verifiable information on these designs. At the CP or COL stage, an applicant referencing such designs would need to provide the necessary data and the staff would need to validate the assumptions used in this transportation analysis.

Assumptions that will need validation if a gas-cooled design is selected include:

- Verifying that unirradiated and spent fuel from gas-cooled reactors have the same abilities as LWR unirradiated and spent fuel to maintain fuel and cladding integrity following a traffic accident.

- Verifying that shipping cask design assumptions (for example, cask capacities) are equal to or bounded by the assumptions in this analysis.

- Verifying that unirradiated fuel initial core/refueling requirement, spent fuel generation rates, and radioactive waste generation rate assumptions are equal to or bounded by the assumptions in this analysis.

- Verifying that shipping cask capacities and accident source terms, including spent fuel inventories, severity fractions, and release fractions, are equal to or bounded by the assumptions in this analysis.

Should the ACR-700 or IRIS reactors be chosen for the ESP site, a transportation accident analysis will be performed as spent fuel inventories were not available for this analysis.

6.3 Decommissioning Impacts

At the end of the operating life of a power reactor, the NRC regulations require that the facility undergo decommissioning. Decommissioning is the removal of a facility safely from service and the reduction of residual radioactivity to a level that permits termination of the NRC license. The regulations governing decommissioning of power reactors are found in 10 CFR 50.75 and 50.82.

Environmental impacts from the activities associated with the decommissioning of any LWR before or at the end of an initial or renewed license are evaluated in the *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, *Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors*, NUREG-0586, (NRC 2002). If an applicant for a CP or COL referencing the North Anna ESP applies for a license to operate one or more additional units at the North Anna ESP site, there is a requirement to certify that sufficient funds will be available to assure radiological decommissioning at the end of power operations. At the time an application is submitted, the requirements in 10 CFR 50.33, 50.75, and 52.77 (and any other applicable requirements) would have to be met.

At the ESP stage, applicants are not required to submit information regarding the process of decommissioning, such as the method chosen for decommissioning, the schedule, or any other aspect of planning for decommissioning. Dominion did not provide this information in its application. For the new nuclear unit or units, if LWR designs are chosen or if other-than-LWRs that were considered in NUREG-0586, Supplement 1 are chosen, the impacts from decommissioning are expected to be within the bounds described in NUREG-0586, Supplement 1 for both the North Anna ESP site and the alternative sites. In such cases, the staff expects the impact from decommissioning are likely to be small. However, for whatever design that is selected, the impacts from decommissioning are not resolved and would have to be assessed at the CP or COL stage.

6.4 References

Note: Because the web pages cited in this document may become unavailable, the staff has entered the appropriate pages into ADAMS. The accession number of the package containing the Web-sites used as references in Chapter 6 of the North Anna ESP EIS is ML051150239.

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7.0 Cumulative Impacts

The U.S. Nuclear Regulatory Commission (NRC) staff considered potential cumulative impacts during its evaluation of information applicable to each of the impact categories of constructing and operating reactors at the proposed North Anna Power Station (NAPS) early site permit (ESP) site for reactor designs that fall within the plant parameter envelope (PPE) (Dominion 2006). For the purpose of this analysis, past actions are those occurring after Lake Anna was created, but prior to operation of the existing NAPS Units 1 and 2. Present actions are those from the start of operation of existing NAPS Units 1 and 2 until the start of construction of the proposed Units 3 and 4 (hereafter referred to as Units 3 and 4). Future actions are those that are reasonably foreseeable through construction and operation of Units 3 and 4, including decommissioning. The geographical area over which past, present, and future actions could contribute to cumulative impacts depends on the type of impact evaluated.

The impacts of the proposed action, as described in Chapters 4 and 5, are combined with other past, present, and reasonably foreseeable future actions in the vicinity of the NAPS site that would affect the same resources impacted by NAPS Units 1 and 2 regardless of what entity (Federal or non-Federal) or person undertakes such other actions. These combined impacts are defined as "cumulative" in Title 40 of the Code of Federal Regulations (CFR) Part 1508.7 and include individually minor but collectively significant actions taking place over a period of time. It is possible that an impact that may be SMALL by itself could result in a MODERATE or LARGE impact when considered in combination with the impacts of other actions on the affected resource. Likewise, if a resource is regionally declining or imperiled, even a SMALL individual impact could be important if it contributes to or accelerates the overall resource decline.

7.1 Land Use

For purposes of this analysis, the geographic area considered for cumulative impacts resulting from construction and operation of Units 3 and 4 includes the three-county area of Louisa, Orange, and Spotsylvania Counties, Virginia, because the impacts to land use are insignificant outside the three-county area. The staff reviewed the available information on land-use impacts of constructing two additional nuclear units at the North Anna ESP site. Accordingly, the staff concludes that, while lower tax rates or better services could encourage development, the comprehensive land-use plans would control development. As a result, cumulative land-use impacts would be SMALL, and mitigation is not warranted.

7.2 Air Quality

The NAPS site is located in an area that is in attainment for criteria pollutants. In Section 5.2 of this EIS the staff evaluates the impacts of the discharge of warm moist air from the wet cooling tower portion of the closed-cycle, combination wet and dry cooling system. The existing units use a once-through cooling system, and Unit 4 would use a dry cooling system, neither of which discharges warm moist air. Therefore, the cumulative impacts of the cooling system are the same as the impact analyzed in Section 5.2. The discharge from the Unit 3 wet cooling tower portion of the wet and dry cooling system would have a SMALL impact. In addition, the Commonwealth of Virginia regulates emissions to the atmosphere. The air quality impacts of construction and operations are estimated to be small. No other significant impacts from other actions were identified. Based on its evaluation, the staff concludes that the cumulative air quality impacts would be SMALL, and mitigation is not warranted.

7.3 Water Use and Quality

There would be two primary surface water resource parameters affected by the operation of Unit 3 on the Lake Anna reservoir: (1) the lake level and (2) the downstream flow. Variations in these parameters impact water use, aquatic ecosystems, and socioeconomics. The cumulative effects on those parameters are discussed in each category in this chapter.

The staff, while preparing this assessment, did not identify other currently planned industrial, commercial, or public installations that would consume water within the general vicinity of the North Anna ESP site. The intake of water from, and the discharge of water to, Lake Anna from the new units would be regulated by the Virginia Department of Environmental Quality (VDEQ) just as the existing NAPS Units 1 and 2 are currently regulated by the VDEQ. The intake and discharge limits for each installation are established considering the overall or cumulative impact of all of the other regulated activities in the area. The staff expects that compliance with Clean Water Act and regulations of the Commonwealth of Virginia are adequate to minimize the cumulative effects on water resources. Operation of Units 3 and 4 would require National Pollutant Discharge Elimination System (NPDES) permits from the Commonwealth. NPDES permits must be renewed every 5 years, which will ensure that the Commonwealth of Virginia addresses changes in water quality during the operating life of the facility. The Commonwealth has the authority to designate the North Anna drainage as a surface water management area, which would ensure that water supply changes during the operating life of the facility are addressed. Unit 4 would use dry cooling towers and would not consume water from Lake Anna for cooling; therefore, its operation would have little operational impact on Lake Anna.

In Chapter 5, the staff evaluated the combined impacts of the existing Units 1 and 2 and the effects of adding the proposed Units 3 and 4 on Lake Anna. A cumulative evaluation of the effects of Units 3 and 4 on Lake Anna begins with the existing lake conditions and adds the effects of construction and operation of Units 3 and 4 to derive a cumulative impact assessment. Based on the fact that the Lake Anna drainage is largely rural and the shoreline is largely residential, the staff concludes that it is unlikely that future development will appreciably alter the hydrology of Lake Anna. In non-drought years, the projected incremental decline of the lake level attributable to Unit 3 using the closed-cycle, combination wet and dry cooling tower system is relatively minor. The lowest pool elevation and greatest incremental decline would most likely occur during the month of October.

The operation of Unit 3 would increase the frequency and duration of periods of low lake level during drought conditions when the Lake Level Contingency Plan would be applied. Implementation of the Lake Level Contingency Plan reduces flow from Lake Anna should the level in the lake declines to a minimum flow of 0.57 m^3/s (20 cfs) (Louisa County 2001). Hanover County, one of four downstream counties, has identified a need for additional water for future development (Hanover County Department of Public Utilities 2004). Resolution of any future conflicts over water use would fall within the regulatory authority of the Commonwealth of Virginia. There are three basic approaches considered by the staff to mitigate water conflicts including (1) alternative design of the Unit 3 cooling system, (2) alternative operation of the proposed Unit 3, and (3) alternative operating procedures for the North Anna Dam. Alternative cooling system designs are discussed in Section 8.2 of this Final Environmental Impact Statement (FEIS). Dry cooling eliminates the consumptive water loss associated with Unit 4. If water conditions become severe, then the Commonwealth of Virginia has the regulatory authority to require Dominion to derate or terminate operation of one or more of the North Anna units. Finally, the release of water from Lake Anna is regulated by the Commonwealth of Virginia. The Lake Level Contingency Plan is an explicit statement of the Commonwealth's policy to balance the demands of lake and downstream water needs. The Commonwealth can alter the normal pool elevation and the trigger elevation at which releases are reduced, and can specify the timing, duration, and magnitude of discharge flows from the North Anna Dam.

Based on the staff's independent water budget assessment, which includes the cumulative impact of the existing NAPS Units 1 and 2 and the proposed Units 3 and 4, the staff concludes that the water use impacts would be SMALL except in drought years when the impacts would be MODERATE. In drought years, the Commonwealth of Virginia may determine that Dominion must derate or cease operation. Water quality impacts are anticipated to be small. However, because specific bounding water quality parameters were not provided in the PPE for all discharge streams, the cumulative water quality impact is not resolved.

7.4 Terrestrial Ecosystem

For purposes of this analysis, the geographic area in which adverse cumulative effects on terrestrial resources, such as wildlife populations and habitat areas could occur, includes the areas around Lake Anna, within the North Anna ESP site, and within the existing transmission line rights-of-way.

Although the rate of housing and recreational development around Lake Anna has been relatively high, the habitats at the North Anna ESP site and in the vicinity of Lake Anna are common in central Virginia, and are not considered critical for the survival of Federally listed threatened or endangered species. Therefore, the staff concludes that the development of the North Anna ESP site on the cumulative habitat loss in the region would be SMALL.

There are no important terrestrial species (e.g., threatened or endangered species) or important habitats (e.g., critical habitats, wildlife sanctuaries) in the vicinity of the site or transmission line rights-of-way, and wildlife has adapted to the noise levels from the existing Units 1 and 2. The nearest bald eagle *(Haliaeetus leucocephalus*) nest is more than 4 km (2.5 mi) from of the site and would not be affected by noise from the NAPS site. Therefore, cumulative noise effects on wildlife are expected to be minimal.

The closed-cycle, combination wet and dry cooling system, as proposed for Unit 3, and dry cooling towers, as proposed for Unit 4, include elevated structures that could pose a risk of avian collisions. In NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, the staff reviewed the issue of avian collisions with elevated structures at nuclear power plants in the United States and concluded that cooling towers pose a very small hazard for birds (NRC 1996). Therefore, impacts to birds from collisions with heat dissipation structures of the kind proposed for Unit 3 and Unit 4 cooling systems and existing facilities at the NAPS site are expected to be minimal. The North Anna ESP site is in an area with relatively few tall facilities or features that would pose collision hazards to birds and additional industrial development involving tall physical structures is not likely in the foreseeable future. Therefore, cumulative effects on birds resulting from collisions would be expected to be minimal.

Because there would be no new transmission lines, no changes expected in transmission line operation and maintenance, and no alterations of rights-of-way, no changes to the level of impact on terrestrial resources are expected to occur if additional power is transmitted through this system. Also, the addition of the closed-cycle, combination wet and dry cooling system for Unit 3 and the dry cooling towers for Unit 4 are not expected to adversely impact avian populations in the vicinity of the North Anna ESP site. The staff concludes that the potential regional cumulative impacts on terrestrial ecology contributed by the construction and operation of Units 3 and 4 would be SMALL, and mitigation is not warranted.

7.5 Aquatic Ecosystem

The construction and operation of Units 3 and 4 were evaluated to determine whether interactions with past, present, and future actions could contribute to adverse cumulative impacts to aquatic resources. For the purpose of this analysis, the geographic area of interest is the Lake Anna reservoir, the Waste Heat Treatment Facility (WHTF), and the portion of the North Anna River downstream of North Anna Dam. Factors contributing to cumulative aquatic impacts include the operations of NAPS (with or without the addition of Units 3 and 4), anthropogenic activities not directly related to NAPS (e.g., increased urban development and recreational activity in or near the lake and river), and natural environmental stressors (e.g., short- or long-term changes in precipitation or temperature, and the resulting response of the aquatic community). The staff considered these potential sources of impacts in its evaluation of the cumulative aquatic ecology impacts of Dominion's ESP application.

The studies conducted by Dominion have demonstrated that operation of Units 1 and 2 are in compliance with sections 316(a) and 316(b) of the Clean Water Act. Thermal discharges from Units 1 and 2 have increased the overall temperature of the WHTF and Lake Anna; however, heat-sensitive species are able to find refuge in deeper parts of the lake and uplake area, and heat shock or cold shock events have not resulted in detectible changes to resident or stocked fish populations. Biocide releases from Units 1 and 2 currently comply with the Commonwealth of Virginia NPDES permit requirements, and will continue to be monitored in the future.

The cooling towers proposed for Unit 4 would not result in measurable impingement, entrainment, or discharge-related impacts. The closed-cycle, combination wet and dry cooling system proposed for Unit 3 would increase overall impingement and entrainment at NAPS by approximately 2 to 3 percent. This is not expected to result in detectible changes in the resident and introduced fish communities in Lake Anna.

The thermal impacts of Unit 3 to the WHTF, Lake Anna, and the North Anna River are expected to be minor because the temperature of the small volume of blowdown water released to the WHTF is within the temperature range currently observed in the discharge canal. Without changes to the discharge from the North Anna Dam, operation of Unit 3 would result in a decrease in the level in Lake Anna that would affect the downstream release of water over the North Anna Dam, especially during the summer months and drought years. The decreases in lake level would not be expected to adversely impact aquatic organisms in the lake. The consumptive water use by Unit 3 could have some adverse impact on aquatic communities downstream of the North Anna Dam during summer months or drought years. However, the aquatic communities of the North Anna River have adapted to changes in stream flow over time, and it is expected that the overall impacts associated with Units 3 and 4 would be negligible.

Anthropogenic stressors not directly associated with NAPS activities may contribute to the cumulative impacts to the lake and river. These impacts include habitat loss and nonpoint pollution related to increased urbanization along the shores of the reservoir and river, increased recreational use of the North Anna reservoir, impacts to the lake fishery from changes in VDGIF management practices or increased fishing pressure, and downstream impacts from increased consumptive water use for human needs. Because the Lake Anna reservoir is essentially a closed system that is regulated by Federal, State, and local resource agencies, the staff assumes the cumulative impacts to the lake and river associated with urbanization and increased resource use would be managed within the existing system of rules and guidelines to ensure the aquatic communities are protected and the fishery resources continue to be sustainable.

The presence of natural environmental stressors (e.g., short- or long-term changes in precipitation or temperature) would contribute to the cumulative environmental impacts to Lake Anna and the North Anna River. These impacts are not related to NAPS activities and are difficult to predict. At certain times of the year, NAPS operations, other anthropogenic stressors, and climactic events could combine to adversely impact the aquatic populations of Lake Anna and the North Anna River. The staff expects that these events would be of short duration and that the impacted resources would quickly recover after normal patterns resume.

At present, Lake Anna represents a balanced community and supports a thriving population of game fish and the forage species that support them. A diverse community is also present in the North Anna River below the dam. Long-term monitoring has shown that the lake and river communities are capable of adapting to changing environmental conditions resulting from natural or anthropogenic sources of impact, and this adaptation is expected to continue to occur with or without the addition of Units 3 and 4. Accordingly, the construction and operation of proposed Units 3 and 4 is not expected to change the overall aquatic impacts of NAPS.

Based on 25 years of aquatic monitoring data conducted by Virginia Power, there is no evidence that Federally listed threatened or endangered aquatic species are present in Lake Anna or the North Anna River. Although aquatic species listed could occur in counties adjacent to NAPS, there is no evidence that they have been observed in those locations. Based on this assessment, the staff concludes the cumulative impacts to threatened or endangered aquatic species from the construction and operation of Units 3 and 4 are SMALL, and mitigation is not warranted.

Consumptive water use for Unit 3 may exacerbate low-water conditions in Lake Anna and the North Anna River during the summer months or droughts, but the overall impacts of Units 3 and 4 are not expected to be environmentally detectible or to contribute significantly to the cumulative aquatic impacts that currently exist. The presence of anthropogenic or natural stressors unrelated to NAPS operations currently influence the aquatic resources of Lake Anna, the WHTF, and the North Anna River, and will continue to do so. These impacts would be considered by Federal, State, and local regulatory agencies, and the various management plans for the lake would be modified, as necessary. Based on the foregoing, the staff concludes that the cumulative aquatic impacts of the construction and operation of Units 3 and 4 would be SMALL, and mitigation is not warranted.

7.6 Socioeconomic, Historic and Cultural Resources, Environmental Justice

Much of the analyses of the socioeconomic impacts presented in Sections 4.5 and 5.5 incorporate cumulative impact analysis because the metrics used for analysis are placed in the total or cumulative context. The geographical area of the cumulative analysis varies depending on the particular impact considered, and may depend on specific boundaries, such as taxation jurisdictions, or distance, as in the case of environmental justice. The construction and operation of Units 3 and 4 would not add any cumulative socioeconomic impacts beyond those already evaluated in Sections 4.5 and 5.5. The staff concludes that construction impacts would generally be SMALL, but there could be greater impacts if more workers than expected settle in Louisa and Orange Counties, in which case MODERATE impacts may be reached for physical impacts on roads, housing, and some public services. In addition, during times of severe drought, the impacts to aesthetics and recreation during operations may also reach MODERATE levels and there could be periodic MODERATE aesthetic impacts from cooling tower plumes. In terms of cumulative effects, the impact on regional economies and tax revenues would be beneficially SMALL to LARGE.

With regard to historic and cultural resources, construction and operation of Units 3 and 4 would not add to any cumulative impacts to these resources beyond those identified in Sections 4.6 and 5.6. Dominion would implement the existing NAPS procedures to ensure that either known or newly discovered potential historic and cultural sites would not be inadvertently impacted during onsite activities that involve land disturbances (Dominion 2006). The staff concludes that the cumulative impacts of construction and operation on historic and cultural resources would be SMALL, and mitigation is not warranted.

The staff found no unusual resource dependencies or practices through which minority or low-income populations would be disproportionately affected. As a result, cumulative impacts of environmental justice would be SMALL.

Based on the above considerations, the staff concludes that under some circumstances, construction and operation of Units 3 and 4 could make a detectable adverse contribution to the cumulative effects associated with some socioeconomic issues under certain circumstances, including aesthetics and recreation. The individual impacts range from MODERATE ADVERSE to LARGE BENEFICIAL.

7.7 Nonradiological Health

The cumulative impacts of construction and operation of the existing NAPS Units 1 and 2 and the proposed North Anna Units 3 and 4 on the ambient temperature of Lake Anna with regard to potential formation of thermophilic microorganisms was evaluated in Section 5.8.1. The evaluation indicated that the addition of two new units would not significantly increase the temperature in Lake Anna, and existing temperatures are not sufficiently high to create an environment conducive to the optimal growth of thermophilic organisms. Further, health risks to workers can be expected to be dominated by occupational injuries at rates below the average U.S. industrial rates. Noise, dust emissions, and acute effects from electromagnetic fields were also evaluated and found to have small impacts. Based on the foregoing, the staff concludes that the cumulative impacts resulting from construction and operation of Units 3 and 4 on nonradiological health would be SMALL, and mitigation is not warranted. Chronic effects from electromagnetic fields are not resolved.

7.8 Radiological Impacts of Normal Operation

The radiological exposure limits and standards for the protection of the public and for occupational exposures have been developed assuming long-term exposures, and therefore incorporate cumulative impacts. As described in Section 5.9, the public and occupational doses predicted from the operation of Units 3 and 4 would be well below regulatory limits and standards. Specifically, the site boundary dose to the maximally exposed individual from the existing Units 1 and 2 and the proposed Units 3 and 4 combined would be well within the regulatory standard of 40 CFR Part 190. For purposes of this analysis, the geographical area is the area included within an 80-km (50-mi) radius of the North Anna ESP site.

As stated in Section 2.5, Dominion has conducted a radiological environmental monitoring program (REMP) around NAPS since 1976. The REMP measures radiation and radioactive materials from all sources, including NAPS. The Commission would regulate any reasonably foreseeable future actions that could contribute to cumulative radiological impacts. Therefore, the staff concludes that the cumulative radiological impacts of operation of the proposed Units 3 and 4 and the existing operating NAPS Units 1 and 2 would be SMALL, and mitigation is not warranted.

7.9 Fuel Cycle, Transportation, and Decommissioning

The addition of the Units 3 and 4 on the North Anna ESP site would result in the need for additional fuel. The impacts of producing this fuel include mining of the uranium ore, milling of the ore, conversion of the uranium oxide to uranium hexafluoride, enrichment of the uranium hexafluoride, fuel fabrication where the uranium hexafluoride in converted into uranium oxide fuel pellets, and disposition of the spent fuel in a Federal waste repository. As discussed in Section 6.1 of this EIS, the environmental impacts of fuel cycle activities for the proposed units would be a maximum of four times those presented in Table S–3 of 10 CFR 51.51. Table S–3 provides the environmental impacts from uranium fuel cycle operations for a model 1000-MW(e) LWR operating at 80 percent capacity with a 12-month fuel loading cycle and an average fuel burnup of 33,000 MWd/MTU. Per 10 CFR 51.51(a), the staff considers the impacts in

Table S–3 to be acceptable for the 1000-MW(e) reference reactor. As discussed in Section 6.1.1, advances in reactors since the development of Table S–3 impacts will have the effect of reducing environmental impacts of the operating reference reactor. For example, a number of fuel management improvements have been adopted by nuclear power plants to achieve higher performance and to reduce fuel and separative work (enrichment) requirements. Fuel cycle impacts would occur not only at the North Anna ESP site but would also be scattered through other locations in the United States or, in the case of foreign-purchased uranium, in other countries. The staff considers the cumulative fuel cycle impacts of operating NAPS Units 1 and 2 and the proposed Units 3 and 4 for the 1000-MW(e) light-water scale model to be SMALL. Cumulative impacts for other than light-water reactor designs are not resolved.

The addition of Units 3 and 4 would result in additional shipments of unirradiated fuel to the site and additional shipments of spent fuel and waste from the site. Cumulative impacts would be approximately twice that of the existing operating plants. Environmental impacts from transportation of unirradiated fuel, spent fuel, and waste are discussed in Section 6.2 of this EIS based on specific reactor types proposed for Units 3 and 4. The following conclusions were derived from the staff's analysis of unirradiated fuel shipments:

- The number of unirradiated fuel shipments equates to less than one truck shipment per day within criteria specified in Table S–4 of 10 CFR 51.52.

- Annual dose to workers and the public would be less than dose specified in Table S–4.

- Health impacts are projected to be small (i.e., less than 1×10^{-4} detriment/yr, where detriment includes fatal cancer, non-fatal cancers, and severe hereditary effects).

The following conclusions were derived from the staff's analysis of spent fuel: (1) after accounting for conservative assumptions in the staff's evaluation, doses to the worker and the public would be within criteria specified in Table S–4, and (2) health impacts from normal conditions and accident conditions would be small (i.e., less than 0.1 detriment/yr). Regarding transportation of waste shipments, the staff concluded that the normalized number of waste shipments would be within the value specified in Table S–4 for the 1100-MW(e) reference reactor. Cumulative impacts of transportation for operating both NAPS Units 1 and 2 and the proposed Units 3 and 4 would be SMALL. Cumulative impacts for other than light-water reactor designs are not resolved.

As discussed in Section 6.3 of this EIS, environmental impacts from decommissioning are expected to be small as the licensee would have to comply with decommissioning regulatory requirements. In Supplement 1 to NUREG-0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, the NRC found the impacts on radiation dose to workers and the public, waste management, water quality, air quality, ecological resources, and socioeconomics to be small (NRC 2002). However, because Dominion was not required to (and did not) submit information regarding decommissioning in its ESP application, this issue is not resolved.

7.10 Staff Conclusions and Recommendations

The staff considered and evaluated the potential impacts resulting from construction and operation of proposed Units 3 and 4 together with past, present, and future actions at the proposed North Anna ESP site and surrounding area. For several impact areas, the staff concludes that the potential cumulative impacts resulting from construction and operation are SMALL, and mitigation beyond the actions discussed in Sections 4.10 and 5.10 is not warranted. However, some areas have the potential for MODERATE impacts, most of which would occur under temporary circumstances such as drought conditions or as the result of a larger than expected concentration of construction workers settling near the NAPS site. Further mitigation is not warranted because of the temporary nature of the impacts.

7.11 References

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

40 CFR Part 190. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

40 CFR Part 1508. Code of Federal Regulations. Title 40, *Protection of Environment*, Part 1508, "Council on Environmental Quality, Terminology and Index."

Clean Water Act (also known as the Federal Water Pollution Control Act). 33 USC 1251 et seq.

Dominion Nuclear North Anna, LLC (Dominion). 2006. *North Anna Early Site Permit Application – Part 3 – Environmental Report*. Revision 8, Richmond, Virginia.

Hanover County Department of Public Utilities. 2004. Letter to Chief, Rules and Directives Branch, NRC., regarding Dominion's ESP application, January 7, 2004, Hanover, Virginia.

Louisa County. 2001. *The County of Louisa, Virginia Comprehensive Plan*. Comprehensive Plan, Chapter V, September 4, 2001, Louisa, Virginia.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437, Volumes 1 and 2, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2002. *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, Supplement 1 Regarding the Decommissioning of Nuclear Power Reactors.* NUREG-0586, Washington, D.C.

8.0 Impacts of the Alternatives

The purpose of this chapter of this Environmental Impact Statement (EIS) is to examine the environmental impacts of alternatives to constructing and operating the proposed two nuclear units at the proposed North Anna early site permit (ESP) site. The U.S. Nuclear Regulatory Commission (NRC) staff considered the no-action alternative, system design alternatives, and alternative sites. For the purposes of this EIS, the staff considered the alternative sites selected by Dominion North Anna LLC (Dominion) in its ESP application (Dominion 2006). The results of the analysis described in this chapter were used and analyzed in Chapter 9 to determine whether any alternative site considered is obviously superior to the proposed site.

Consideration of alternative sites involves a two-part examination as set forth in NUREG-1555, Section 9.3 (NRC 2000), in accordance with an NRC decision related to licensing the Seabrook Nuclear Power Plant (Public Service Company 1977). The first stage evaluates a full suite of environmental issues to determine whether any of the alternative sites is environmentally preferable to the proposed site. If not, then the evaluation of alternative sites ends at the first stage. If an alternative site appears environmentally preferable to the proposed site, the analysis proceeds to the second stage. The second stage of the test considers economic, technological, and institutional factors among the environmentally preferred sites to determine whether any alternative site that was considered is "obviously superior" to the proposed site. If there is no such obviously superior site, then the proposed site prevails; a staff conclusion that an alternative site is obviously superior to the proposed site would normally lead to a recommendation that the ESP application be denied.

Section 8.1 discusses the no-action alternative. Section 8.2 examines the station design alternatives. Section 8.3 reviews Dominion's region of interest (ROI) and examines the suitability of the ROI and Dominion's alternative site selection process, describing the method Dominion used to select the candidate and alternative sites. Section 8.4 examines issues that are common to all the sites, and addresses them collectively. Sections 8.5 through 8.7 individually evaluate the selected alternative sites. Section 8.8 provides a summary of alternative site impacts, and Section 8.9 cites the references relevant to this chapter.

8.1 No-Action Alternative

For this ESP application, the no-action alternative refers to a scenario in which the NRC would deny the ESP request. Upon such a denial, the construction and operation of new nuclear power reactors at the proposed North Anna ESP site in accordance with Title 10 of the Code of Federal Regulations (CFR) Part 52 process would not occur.

The no-action alternative consists of two parts. First, the no-action alternative would include a scenario in which the NRC would not issue the ESP. There are no environmental impacts associated with not issuing the ESP except that the impacts associated with site preparation and preliminary construction activities, allowed pursuant to 10 CFR 52.17(c) and 10 CFR 52.25(a), would be avoided. Second, given that the EIS addresses the environmental impacts of construction and operation as directed by the Commission (10 CFR 52.18(a)(2)), the no-action alternative would result in no such construction and operation. Therefore, the impacts predicted in this EIS would not occur. Nonetheless, Part 52 does not require an ER or EIS prepared in conjunction with an ESP application to include consideration of the benefits of construction and operation of a reactor or reactors at the ESP site (see 10 CFR 52.18), nor does it require that such an ER or EIS include consideration of alternative energy sources (see Exelon Generation Co., LLC et al., CLI-05-17, 62 NRC 5 [2005]). Dominion did not include these matters in its ER, and this EIS did not consider them. Accordingly, should the NRC ultimately determine to issue an ESP for the North Anna ESP site, and a CP or COL application that references such an ESP is docketed, these matters will be considered in the EIS prepared in connection with the review of that CP or COL application.

However, the no-action alternative would not achieve the benefits intended by the ESP process, which would include (1) early resolution of siting issues prior to large investments of financial capital and human resources in new plant design and construction, (2) early resolution of issues on the environmental impacts of construction and operation of reactors that fall within the site parameters, (3) the ability to bank sites on which nuclear plants may be located, and (4) facilitation of future decisions on whether to build new nuclear plants.

The no action alternative to the proposed action of issuing an ESP for the North Anna ESP site would avoid the environmental impacts associated with site preparation and preliminary work allowed pursuant to 10 CFR 52.17(c) and 52.25. Because this site preparation and preliminary work could in any event be redressed by the site redress plan described in Section 4.11 of this EIS, the impacts of the proposed action and the no action alterative are similar.

8.2 System Design Alternatives

Sections 8.2.1 through 8.2.3 contain information regarding alternative plant cooling systems for the proposed Unit 3 at the North Anna ESP site. Section 8.2.1 discusses once-through cooling systems; Section 8.2.2 discusses wet cooling heat-dissipation systems; and Section 8.2.3 discusses dry cooling heat dissipation systems for Unit 3. A dry cooling tower has been proposed for Unit 4 at the North Anna ESP site. Water and energy balance studies of Lake Anna suggest that it would be difficult for the lake to support a once-through cooling system, a wet cooling tower heat dissipation system, or a combination wet and dry cooling system for Unit 4. (Refer to Appendix K for more detail on the water budget analysis.) Therefore, none of these alternatives is considered for Unit 4 at the North Anna ESP site.

The purpose of the plant cooling system is to dissipate heat to the environment. The various cooling system options differ in how and where the heat transfer takes place and, therefore, have different environmental impacts. In the closed-cycle, combination wet and dry cooling system proposed for Unit 3, heat is transferred to the atmosphere through evaporation, long-wave radiation, and conduction. With the wet tower portion of the system, only a fraction of the water withdrawn from the lake is returned as blowdown, with the majority being evaporated. The dry tower portion of the system consumes a negligible amount of water.

8.2.1 Plant Cooling System: Unit 3 Once-Through Cooling System

A once-through cooling system for Unit 3 would transfer heat to the atmosphere and aquatic environment of the Waste Heat Treatment Facility (WHTF), Lake Anna, and the North Anna River downstream of the dam by convection, evaporation, long-wave radiation, and conduction. As described below, when compared to the proposed design, increased impingement, entrainment, circulation changes in the WHTF and Lake Anna, temperature in the aquatic environment, and consumptive use of water would result from the once-through design.

A once-through cooling system design would withdraw a larger volume of water from Lake Anna through the intakes, and more than double the impingement and entrainment losses currently occurring from the operation of Units 1 and 2. The once-through design for Unit 3 was estimated to withdraw 71,900 L/s (1,140,000 gpm) compared to the maximum of 1405 L/s (22,269 gpm) for the proposed Unit 3 closed-cycle design operating in Energy Conservation (EC) mode. The additional recirculation from this flow combined with the existing recirculation in Lake Anna could further erode the limited water volume below the lake thermocline that may be an important refugium for certain fish populations in Lake Anna.

A once-through design would initially transfer all the reject heat to the aquatic environment. The increased heat load would dispense warm water out of the WHTF further into Lake Anna. The staff estimated that WHTF-type conditions would be extended into about 19 percent of the volume of Lake Anna. This could reduce the productivity of certain fish populations in Lake Anna that are sensitive to temperature. Some of the heat entering the WHTF and Lake Anna would be lost to the atmosphere through evaporation. This additional evaporation resulting from the increased lake surface temperatures would reduce the total water supply. Dominion estimated that induced evaporation from once-through cooling could result in water loss at an average annual rate of 0.79 m^3/s (28 cfs), whereas the combined-cycle, wet and dry cooling system proposed in the Environmental Report (ER) (Dominion 2006) would induce evaporative losses at a lesser average annual rate of about 0.57 m^3/s (20 cfs).

The staff evaluated mitigation for the once-through cooling system to reduce cooling water discharge temperatures into Lake Anna. Wet mechanical draft cooling towers could be employed as helper towers along with the once-through cooling design on an as-needed basis during the late summer and early fall. Use of these towers in a helper mode would reduce the station discharge temperature to Lake Anna but would result in an increase in consumptive water use that would be greater than the combination wet and dry cooling system. Based on the combination wet and dry cooling tower system's expected smaller impact on the aquatic environment, the staff concludes that a combination wet and dry cooling system for Unit 3 would be preferable to a once-through cooling system.

8.2.2 Plant Cooling System: Unit 3 Wet Cooling System

Wet, mechanical and natural draft cooling towers transfer heat to the atmosphere through evaporation and conduction. Assuming all the heat transfer is through evaporation, a wet cooling design would consume more water than either the once-through design or the combination wet and dry cooling system proposed in the ER (Dominion 2006). The increased use of makeup water requirements for a wet cooling design would increase impingement and entrainment slightly over the proposed design.

The use of a wet cooling tower design versus the proposed combination wet and dry cooling system design for Unit 3 would increase water withdrawals from Lake Anna. The impact of the increased evaporative losses of a wet cooling tower design would be particularly noticeable during drought years. The results of water balance calculations suggest that the use of a wet cooling tower system for the 2001 through 2003 critical water period would have resulted in an additional 1.0 m (3.4 ft) drawdown of the lake in September 2002. In comparison, use of the proposed combination wet and dry cooling system would only have drawn the lake down by an additional 0.5 m (1.6 ft). The use of a wet cooling tower design would also prolong the duration of low-flow conditions downstream of the dam. The staff concludes that based on the expected smaller impact on the lake level and downstream flows, a combination wet and dry cooling system design for Unit 3 is preferable to a wet cooling tower design.

8.2.3 Plant Cooling System: Unit 3 Dry Cooling System

The use of a dry cooling design versus the proposed combination wet and dry cooling system design for Unit 3 would largely eliminate the impacts on aquatic biota in Lake Anna and the North Anna River downstream. The lake would not be heated by rejected heat from Unit 3, and there would be no additional consumptive water use.

A dry cooling tower designed to dissipate heat may reduce water-related impacts of operating Unit 3, but it also has some disadvantages. In particular, dry cooling systems are more expensive to build and are not as efficient as wet cooling systems. To achieve the necessary cooling, dry systems move a large amount of air through a heat exchanger, and the fans that force the air through the heat exchanger use a significant amount of power. Dominion estimates that the power needed to operate dry cooling towers would be 8.5 to 11 percent of the plant power output (Dominion 2006). The power needed to operate a dry tower for Unit 3 would be about 150 MW(e). This power demand reduces the net power output of the plant. The power needed for operating the combination wet and dry cooling system would be 1.7 to 4 percent. This, in turn, would increase the environmental impacts of fuel use and spent fuel transport and storage. The fans and the large volume of air required for cooling also result in elevated noise levels. The dry cooling tower would also occupy more land than a once-through or wet tower cooling system.

The staff concludes that based on its analysis that Lake Anna could support Unit 3 using a combination wet and dry cooling system and given the environmental impact of increased use of resources needed by using a less efficient dry cooling system, a combination wet and dry cooling system is preferable to a dry cooling system for Unit 3.

8.3 Alternative Sites, Region of Interest, and Selection and Evaluation Process

NRC regulations require that the ER submitted in conjunction with an application for an ESP include an evaluation of alternative sites to determine whether there is an "obviously superior" alternative to the site proposed (10 CFR 52.17(a)(2)). An ESP applicant has the option to provide as much or as little information regarding the impacts of constructing and operating the proposed unit(s); however, the ER must address all environmental impacts of construction and operation necessary to make the comparison and determination regarding alternative sites. For the North Anna ESP review, the staff concluded that it had sufficient information on the relevant environmental issues to determine that none of the alternative sites was environmentally preferable to the proposed site. This is the minimum determination that must be made; otherwise the staff would recommend that the ESP request be denied. At the CP/COL stage of the process, the applicant will be required to provide sufficient information to resolve environmental issues not considered in the ESP proceeding as well as any new and significant information regarding issues that were resolved in the ESP proceeding.

In the discussion that follows, based on the approach used by the staff to estimate environmental impacts and on the staff's expert judgment, the staff believes that the impact levels that were assigned for the resource areas are defined sufficiently to be used for the purposes of a comparison between the proposed and the alternative sites. While these impact determinations are estimates, the staff relied on higher level information (i.e., reconnaissance-level information) was informed by the provisions of state and local regulations, by extensive institutional experience with the licensing of existing reactors (including analyses developed during recent license renewal reviews, such as those in the associated License Renewal GEIS), and by the judgment and professional experience of individual staff reviewers with respect to their areas of expertise. The staff applied the same methodology to the North Anna ESP site and the alternative sites review. Therefore, although the comparisons in the alternatives analysis described in the following sections are based on reconnaissance-level information, the staff considers them to be informed comparisons, and has concluded that they are sufficient for making the determination concerning the existence of an obviously superior site. For certain environmental issues, there may not have been sufficient site-specific generated information to resolve an issue for the purpose of utilizing the site for a specific design (and therefore, the issue is "not resolved"), but was sufficient for comparative purposes to resolve whether there was an "obviously superior" site. With respect to unresolved issues, the staff will determine and disclose the environmental impacts of plant construction and operation in its environmental review of a CP or COL application.

This section includes subsections discussing Dominion's Region of Interest (ROI) for selecting alternative sites and its alternative site-selection process. The three alternative sites examined in detail in this EIS are Dominion's Surry Power Station (Surry) site in Surry County, Virginia; the U.S. Department of Energy's (DOE) Portsmouth Gaseous Diffusion Plant (Portsmouth) site in Pike County, Ohio; and DOE's Savannah River Site, located in Aiken and Barnwell Counties, South Carolina.

Dominion stated that the two DOE sites were selected as candidate sites because:

- The sites represent valuable national assets with prior or existing nuclear energy potential.
- New nuclear power facilities would represent potentially promising new missions for these sites.
- The sites have the potential to support reactor demonstrations and/or commercial reactor development.
- There is extensive site information and an available infrastructure that could help to reduce site development costs.
- The partially or fully developed site environment and the available infrastructure reduces the incremental environmental impacts associated with the new plant construction and operation on land use, ecological resources, aesthetics, and local transportation networks.
- The sites are not in proximity to major population centers (Dominion 2006).

The Surry site was selected by Dominion as an ESP candidate site because:

- The existing environmental conditions and the environmental impacts are known from data collected during years of monitoring air, water, ecological, and other parameters.
- Construction of new transmission line rights-of-way may potentially be avoided if the existing transmission system (lines and rights-of-way) can accommodate the increased power generation.

- No additional land acquisitions would be necessary if a new transmission line can be avoided, and the resulting land-use impacts of the new plant would be small.

- The Surry site was recently subjected to an environmental review process during its license renewal review.

- The Surry site had extensive environmental studies performed during the original site-selection process, which could be updated and used for new units.

- Site physical criteria, including primarily geologic/seismic suitability, have been characterized.

- Plant construction, operation, and maintenance costs would be reduced because of existing site infrastructure (e.g., roads, transmission line rights-of-way, water source, and intake/discharge system).

- The Surry site has nearby power markets.

- The Surry site has local community acceptance and support (Dominion 2006).

NRC's environmental review guidance for alternative nuclear plant sites recognizes that there will be special cases in which the proposed site was not selected on the basis of a systematic site-selection process, but was selected on the basis of environmentally acceptable operating experience at the site or because the site was previously found acceptable on the basis of a National Environmental Policy Act of 1969 (NEPA) review. In such cases the NRC will analyze the applicant's site-selection process only as it applies to the alternative sites. The site comparison may then be restricted to a site-by-site comparison of the alternative sites with the proposed site (NRC 2000).

8.3.1 Dominion's Region of Interest

The ROI is the geographic area considered in searching for candidate ESP sites. More specifically, the ROI is:

> The geographical area initially considered in the site selection process. This area may represent the applicant's system, the power pool or area within which the applicant's planning studies are based, or the regional reliability council or the appropriate subregion or area of the reliability council (NRC 2000).

In its ESP application, Dominion selected its ROI for examining potential sites as the Mid-Atlantic, Northeast, and Midwest regions of the United States. These regions were selected because of Dominion's interest in continuing to grow and operate deregulated marketplaces in the region (Dominion 2006). Within this ROI, Dominion used the candidate site criteria identified by NRC (NRC 2000) to identify candidate sites (Dominion 2006). The staff concludes that the ROI used by Dominion in its ESP application is appropriate for consideration and analysis of potential ESP sites because it is consistent with the major load centers to be supplied by the proposed plant and desirable candidate areas have not been excluded on the basis of an arbitrarily defined ROI. The staff determined that Dominion's basis for defining its ROI did not arbitrarily exclude desirable candidate areas.

8.3.2 Dominion's Alternative Site Selection Process

Dominion evaluated its proposed North Anna ESP site and the three alternative sites using 45 site suitability/screening criteria (Dominion 2006). The criteria were grouped into four major categories: (1) economic, (2) engineering, (3) environmental, and (4) socioeconomic (see Table 8-1). The economic category was given a relative weight of 40 percent by Dominion, and the other three categories were weighted 20 percent each. A ranking or score for each of the 45 criteria was assigned by Dominion (from 0 to 5, with 5 being the most favorable). The relative importance of each criterion to the overall evaluation was established by assigning weights that reflected the collective judgment of Dominion's experts involved in the process. The sum of the weighted scores for all criteria represented a total site merit score. The preferred site was chosen based on the highest site merit score. Based on its study, Dominion found the North Anna site to be the preferred ESP site followed by the Savannah River, Portsmouth, and Surry sites, respectively (Dominion and Bechtel 2002). Accordingly, Dominion submitted its ESP application for the North Anna site. However, Dominion concluded that all four sites are suitable locations for deployment of new nuclear power plants.

Among the issues reviewed by Dominion in its site selection process were cooling water use, ground water, aquatic and terrestrial resources, transmission lines, socioeconomic, land use, air quality, and population density. The range of issues evaluated by Dominion in its site selection process was sufficient for the staff to determine that Dominion had employed a reasonable site selection process that resulted in identifying reasonable alternative sites within Dominion's ROI.

8.3.3 NRC's Evaluation of Alternative Sites

The staff independently performed an evaluation of the alternative sites identified by Dominion, i.e., the Surry, Portsmouth, and Savannah River sites. Because the sites were evaluated at an overview level using readily available information rather than using the more detailed approach applied to the North Anna ESP site, which included independent analysis and modeling as necessary, this evaluation is viewed as a "reconnaissance" level evaluation. All three alternative sites previously had been characterized by their operators, but the basis for these characterizations was not specific to an ESP action. In the *Study of Potential Sites for the*

Table 8-1. Dominion Site Screening Criteria

Economic	Engineering	Environmental	Socioeconomic
Electricity Projections	Site Size	Terrestrial Habitat	Present/Planned Land Use
Transmission System	Site Topography	Terrestrial Vegetation	Demography
Stakeholder Support	Environmentally Sensitive Areas	Aquatic Habitat/ Organisms	Socioeconomic Benefits
Site Development Costs	Emergency Planning	Groundwater	Agricultural/Industrial
	Labor Supply	Surface Water	Aesthetics
	Transportation Access	Population	Historic/Archaeological
	Security		Transportation Network
	Hazardous Land Use		Environmental Justice
	Ease for Decommissioning		
	Water Rights and Air Quality Permits		
	Regulatory		
	Schedule		
	Geologic Hazards		
	Site-Specific Safe Shutdown Earthquake		
	Capable Faults		
	Liquefaction Potential		
	Bearing Material		
	Near-Surface Material		
	Groundwater		
	Flooding Potential		
	Ice Formation		
	Cooling Water Source		
	Temperature and Moisture		
	Winds		
	Rainfall		
	Snow		
	Atmospheric Dispersion		

Deployment of New Nuclear Plants in the United States, Dominion and Bechtel evaluated DOE sites at Portsmouth, Savannah River, and Idaho Falls along with the Dominion Surry site with relation to economic, engineering, environmental, and sociological factors using preliminary advanced reactor design information (Dominion and Bechtel 2002). This report, funded by DOE, concluded that the three DOE sites and the two Dominion sites (North Anna and Surry) were suitable for potentially siting new nuclear power plants. This report also concluded that the North Anna site ranked highest overall of the sites evaluated and scored slightly higher with regard to environmental issues than the Surry, Portsmouth, and Savannah River sites.

In its evaluation of the alternative sites, the staff toured each of the sites and discussed topics specifically relevant to the ESP evaluation process including potential sources of cooling water, transmission line access, local ecology, and socioeconomics with site experts. The staff relied primarily on direct observation, information provided by the site experts, DOE environmental reviews on the Portsmouth and Savannah River Federal sites, and site-specific information provided in the Dominion and Bechtel report for DOE (Dominion and Bechtel 2002). In the case of the Surry alternative site, the staff relied on the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 6 Regarding Surry Power Station, Units 1 and 2* for much of the site background documentation (NRC 2002). The staff also reviewed reports from relevant State and Federal agencies and other regional information sources in evaluating the alternative sites.

8.3.4 Greenfield and Brownfield Alternative Sites

Dominion also considered other existing nuclear power plant, greenfield, and brownfield sites within the ROI. In as much as sites of current nuclear facilities have space for additional units, the greenfield and brownfield sites were determined not to be environmentally preferable because of the large land area that would need to be disturbed to build a new plant and to support necessary transmission line rights-of-way. The associated land use, ecological resource impacts, and the aesthetic impacts were determined to be large in comparison to impacts at alternative sites with existing nuclear power plants.

The staff reviewed Dominion's alternative site-selection process as it applies to greenfield and brownfield sites and concludes that the approach used and the findings of impacts are reasonable.

8.4 Generic Issues Consistent Among Alternative Sites

In evaluating the alternative sites, the NRC staff found that certain impact areas would not vary significantly among sites, and as a result, would not affect the evaluation of whether an alternative site is environmentally preferable to the proposed site. These impact areas include air quality, nonradiological health, radiological health during construction and operations for members of the public and workers, radiological health during construction and operations for biota, and postulated accidents.

The staff evaluated the fuel cycle and solid waste management impacts for the proposed site in Section 6.1 of this EIS and found the impacts to be SMALL. The impacts from the fuel cycle and solid waste management are likely to affect the alternate sites equally as no site-specific differences among the alternate sites related to the fuel cycle and solid waste management were identified by the staff. The staff evaluated the transportation impacts of radioactive materials for the proposed and alternate sites in Section 6.2 and Appendix G of this EIS and found the impacts to be SMALL at all sites.

Decommissioning impacts were analyzed in Section 6.3 for all sites and were determined to be unresolved, because the reactor design has not been selected at the ESP stage. The impacts from decommissioning are likely to affect all sites equally. In Chapter 5 the staff concluded that severe accident mitigation alternatives (SAMAs) are unresolved for North Anna ESP site, because the reactor design is not known at the ESP stage. SAMAs are also unresolved at all the alternative sites for the same reason. The analysis of SAMAs is likely to show the same result at all sites. In addition, the impacts to public service facilities (e.g., schools, water supply, and wastewater treatment) would not materially impact whether an alternative site is selected or not. As a result, the impacts of these various impact areas are not evaluated as part of the site-specific alternatives analysis. However, the impacts on air quality and health, and radiation exposures are discussed generically in the following sections.

8.4.1 Air Quality Impacts

During construction at any of the alternative sites, it is expected that some minor air quality impacts would occur in terms of fugitive dust emissions from general construction activities and the potential for elevated ambient levels of criteria pollutants caused by automotive emissions from the workforce traffic and emissions from construction equipment. The criteria pollutants of concern would be particulate matter less than 10 microns in diameter (PM_{10}), reactive organic gases, oxides of nitrogen, carbon monoxide, and sulfur dioxide from combustion engines of the construction equipment.

Air pollutants and fugitive dust would be emitted from operations of construction equipment and earth-moving and material-handling activities, respectively. In addition, operation of other equipment for hauling debris, equipment, and supplies on unpaved roads will produce fugitive dust emissions. Estimation of direct and indirect emissions is beyond the scope of the reconnaissance-level information. However, all activities would be conducted in accordance with State air quality agency requirements for visible and fugitive dust emissions as well as emission standards for mobile sources. If the Surry site were chosen as the alternative site, the same requirements set forth for the North Anna ESP site would apply because both are in the Commonwealth of Virginia. If the Savannah River Site were chosen, then requirements established by the South Carolina Department of Health and Environmental Control would apply. The Ohio Environmental Protection Agency would be consulted if the Portsmouth site were chosen. In addition, if construction activities include burning of construction materials, a permit would need to be secured from the State, and Dominion would need to contact local county officials to determine which local ordinances, if any, must be followed.

Dominion estimated that during construction activities, approximately 5000 workers would be divided between two 10-hour shifts (Dominion 2006). Using an assumption of 1.8 workers per vehicle, this would represent 2800 additional vehicles per day traveling on roads into and out of the proposed site (Dominion 2006). For any of the alternative sites, the estimate of work is similar to that proposed for the North Anna ESP site. Some roadways leading into the site chosen may or may not experience congestion. This situation will impact the local ambient air quality because of emissions from vehicles both during normal operation and during congestion periods when vehicles are idling. However, because the current ambient air quality pollutant levels at the alternative sites are well below current national standards, the resulting impact is estimated to be insignificant and would not create an air quality impact. Therefore, the staff concludes that air quality impacts from construction at any of the alternative sites would be SMALL, temporary and similar to those at the proposed site.

The meteorological and air quality impacts would be limited to additional nonradiological pollutants during the operation of the wet cooling portion of the combination wet and dry cooling system, auxiliary boilers, emergency generators, and emissions from onsite service vehicles. The amount of pollutants emitted to the atmosphere is anticipated to be less than 91 MT/yr (100 tons/yr) for any alternative site (Dominion and Bechtel 2002) and is considered insignificant. However, Dominion would require approval under the existing Federal, State, or local air quality laws and regulations on new sources for any activities undertaken.

The current status of compliance regarding criteria pollutants in the regions surrounding the alternative sites is the following (EPA 2005; 70 FR 30396, 70 FR 33771):

- Various areas around the Surry site have been designated as non-attainment areas regarding the new U.S. Environmental Protection Agency (EPA) 8-hour ozone level requirements. This includes James City and Isle of Wight Counties along with the City of Williamsburg.

- No non-attainment areas were identified in the counties near the Portsmouth site.

- None of the counties around the Savannah River Site have been designated as non-attainment. However, an Early Action Compact (EAC) was developed among the counties in the region called the Lower Savannah Area; this includes Aiken, Allendale, and Barnwell Counties that surround the Savannah River Site as well as Columbia and Richmond counties in Georgia. The concept of EACs was developed by the EPA for those areas that were classified as non-attainment with regard to the new 8-hour ozone criteria pollutant level, to delay official designation as non-attainment and allow the areas to develop their own means to achieve attainment. Some EACs, such as the Lower Savannah Area EAC, were established and are participating in the EAC review and evaluation process to demonstrate their support of cleaner air statewide including ozone pollutant levels.

Although there are some existing air quality issues near the Surry and Savannah River alternative sites, the issues would not be expected to be a limiting factor in considering these sites, and the staff concludes that the air quality impacts from operation at any of the alternative sites would be SMALL and similar to those at the proposed site.

8.4.2 Nonradiological Health Impacts

Nonradiological health impacts from construction of new nuclear power plants on the construction workers at all the alternative sites would be similar to those evaluated in Section 4.8. They would include occupational injuries, noise, odor, vehicle exhaust, and dust emissions. During the plant construction phase, activities would comply with applicable State regulations regarding fugitive dust emissions and air pollution control. The alternative sites considered by Dominion are in rural areas, and construction impacts on the surrounding population would be minimal. Accordingly, the staff concludes that health impacts to construction workers and the public resulting from the construction of two new units at any of the alternative sites would be SMALL.

Health impacts to operational employees and the public would be expected to be the same for all the alternative sites. Thermophilic microorganisms would not be a concern at alternative sites for any facilities using either a wet or a combination wet and dry cooling process because the temperatures in the water bodies receiving the cooling system discharges are below those known to be conducive to the optimal growth and survival of thermophilic pathogens. Health impacts to workers from occupational injuries, noise, and electromagnetic fields would be similar among the sites. Noise and electromagnetic fields would be monitored and controlled in accordance with applicable Occupational Safety and Health Administration regulations. Based on the foregoing, the staff concludes that the health impacts to employees and the public from the proposed units at any of the alternative sites would be SMALL.

With respect to transmission systems, the potential exists for impacts to members of the public from operation of the transmission system in terms of electrical shock, electromagnetic field exposure, noise, and aesthetics. The impacts at the alternative sites are expected to be similar to those evaluated in Section 5.8.

8.4.2.1 Acute Effects of Electromagnetic Fields

All transmission lines, either constructed or used as part of an existing nuclear site, are designed to standards established by the most current version of the National Electrical Safety Code (NESC) (IEEE 2001), which is the standard that is applicable to the systems and equipment operated by utilities. The areas of particular concern are (1) the potential to create an electric shock that could disrupt the operation of pacemakers and health assistance devices and (2) the potential for chronic exposure to electromagnetic fields associated with the transport of electric current through large conductors, such as high-voltage transmission lines.

Currently, to limit the potential for electric shock, NESC requires transmission lines to be designed so that electrostatic effects from operation do not create a steady-state current that exceeds 5 mA root mean square. For the alternative sites considered, it is likely that NESC requirements for preventing electric shock from induced current would be met, and the impact to the public would be insignificant.

8.4.2.2 Chronic Effects of Electromagnetic Fields

There has been considerable debate in scientific circles regarding the potential impact from exposure to 60-Hz electromagnetic fields resulting from energized transmission lines. The potential for chronic effects from these fields continues to be studied and consensus results are still outstanding. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the DOE. A 1999 NIEHS report contains the following conclusion (NIEHS 1999):

> The NIEHS concludes that ELF-EMF (extremely low frequency-electromagnetic field) exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and is exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposure. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement is not sufficient to cause the staff to consider the potential impact as significant to the public. In any event, the impacts would be similar at the proposed site and any of the alternative sites.

8.4.3 Radiological Health Impacts

Exposure pathways for gaseous and liquid effluents from the proposed new Units 3 and 4 at the North Anna ESP site would be similar for the alternative locations. Gaseous effluent pathways would include external exposure to the airborne plume, external exposure to contaminated soil, inhalation of airborne activity, and ingestion of contaminated agricultural products. Liquid effluent pathways would include ingestion of aquatic foods, ingestion of drinking water, external exposure to shoreline sediments, and external exposure to water through boating and swimming.

8.4.3.1 Radiation Doses and Health Impacts to Members of the Public

Section 5.9 provides an estimate of doses to the maximally exposed individual and the general population at the North Anna ESP site for both the liquid effluent and gaseous effluent pathways during operation. The same bounding liquid and gaseous effluent releases would be used to evaluate doses to the maximally exposed individual and the population at each alternative site. However, there would be differences in the estimated doses at each of the sites. The differences would result from the use of site-specific atmospheric and water dispersion data, different exposure pathways, and site-specific population data for the dose calculations.

Section 5.9 shows that the estimated dose to the maximally exposed individual at the North Anna ESP site would be well within the design objectives (10 CFR Part 50, Appendix I). Considering the differences in pathways analyzed, atmospheric and water dispersion factors and population, doses estimated to the maximally exposed individual for the alternative sites would also be expected to be well within the 10 CFR Part 50, Appendix I design objectives. Population dose within 80 km (50 mi) of these alternative sites would be expected to be small compared to the population dose from natural background radiation.

Based on the foregoing, the staff concludes that the proposed system would likely result in annual doses to the public well within regulatory limits, and there would be no observable health impact to the public from construction or normal operation of the proposed North Anna ESP facility or from any of the alternative sites. Therefore, the staff concludes that radiation doses and resultant health impacts from construction or operation of new nuclear units at the alternative sites would be SMALL.

8.4.3.2 Occupational Doses to Workers

Doses to construction workers during construction of the two proposed units were estimated and compared against the requirements in 10 CFR Part 20. These doses were well below limits for members of the public. In addition, annual collective doses were estimated and appeared realistic and reasonable. Occupational doses to workers during construction would be expected to be approximately the same for the alternative sites as for the proposed North Anna ESP site.

Therefore, the staff concludes that health impacts from radiological doses to construction workers would be SMALL.

Occupational doses to workers during operations would be expected to be approximately the same for facilities at the alternative sites as for the North Anna ESP site. The same (accumulated) annual occupational dose estimates of 1.5 person-Sv (150 person-rem) would be expected for units regardless of the site location. The staff concludes that the occupational radiation doses from operation of units at the alternative sites would be SMALL.

8.4.3.3 Impacts to Biota

Table 5-12 provides the annual whole body dose estimates to surrogate biota species for the two proposed units at the North Anna ESP site. The staff reviewed the available information relative to the radiological impact on biota, other than humans, and performed an independent estimate of dose to the biota. The staff concludes that no measurable radiological impact on populations of biota would be expected from the radiation and radioactive material released to the environment as a result of the construction or routine operation of the proposed units, or of operation at any of the alternative sites. The staff concludes that the impacts to biota of radiation doses from the construction or operation of units at the alternative sites would be SMALL.

8.4.4 Postulated Accidents

A suite of design basis accidents (DBAs) has been considered for the new nuclear units at the North Anna ESP site. The evaluation involved calculation of doses for specified periods at the exclusion area and low population zone boundaries, and comparison of those doses with doses based on regulatory limits and guidelines. Similar analyses have not been conducted for the alternative sites. Had such evaluations been conducted, differences in the results would be expected to be caused by differences in meteorological conditions and distances to the site boundaries. The release characteristics would be similar at all sites because the reactor designs are the same.

For the North Anna ESP site meteorology, the doses for each accident sequence considered were well below the corresponding regulatory limits and guidelines. Because the general climatological conditions at the North Anna ESP site are sufficiently similar to the conditions at the alternative sites, it is highly unlikely that differences in local meteorological conditions would be sufficient to cause doses from DBAs for new nuclear units at any of the alternative sites to exceed regulatory limits or guidelines. Similarly, because each of the alternative sites is located at a nuclear facility (although not necessarily a nuclear reactor site), it is unlikely that differences in distances to the exclusion area and low population boundaries would be sufficient to cause doses from DBAs for new nuclear units at any of the alternative sites to exceed regulatory limits or guidelines. Similarly, doses at the alternative site are unlikely to be significantly lower than doses estimated at the North Anna ESP site. Therefore, the staff concludes that for the purposes of consideration of alternative sites, the impact of DBAs at each of the alternative sites would be SMALL.

A detailed analysis of the potential consequences of severe accidents for the postulated plants has been conducted for the North Anna ESP site. Similar analyses have not been conducted for the alternative sites. Had such evaluations been conducted, the differences in the results would likely have been limited to site-specific factors such as meteorological conditions, population distribution, and land-use distribution. The release characteristics would be similar at all sites because the reactor designs would be the same.

The probability-weighted consequences estimated for severe accidents for the proposed units at the North Anna ESP site would be well below the consequences estimated for severe accidents at current generation reactors (see Section 5.10). This result suggests that, as at the North Anna ESP site, the consequences of severe accidents at any of the alternative sites would be less than the consequences of a severe accident for a current-generation operating plant at each site. These risks are well below the NRC safety goals. In addition, the Commission has determined that the probability-weighted consequences of severe accidents is SMALL for all existing plants (10 CFR Part 51, Subpart B, Table B-1). On this basis, the staff concludes that for the purposes of consideration of alternative sites, the impact of severe accidents at each of the alternative sites would be SMALL.

8.5 Evaluation of Surry Power Station Site

The Surry site, operated by Dominion, was recently evaluated in a supplemental EIS prepared by NRC in connection with an operating license renewal application (NRC 2002). The analysis of environmental impacts for this section draws from the data and conclusions gathered in the licence renewal process, the analysis provided by Dominion and Bechtel (2002), and the staff's independent review.

The following assumptions were made by the staff in the review of the Surry site as an alternative to the proposed North Anna ESP site.

- The units would use closed-cycle cooling.

- Mechanical draft towers would most likely be employed to avoid visual aspects of natural draft towers.

- The existing intake structures would be used with possible modifications to accommodate two additional units.

- The existing discharge canal would be used for cooling-water discharge.
- The land for additional reactors would be within the existing Surry site.

No additional transmission lines are assumed to be needed for power transmission for alternative units.

The station is on the Gravel Neck Peninsula on the south side of the James River, in an unincorporated portion of Surry County, Virginia. The station is approximately 40 km (25 mi) upstream of the point where the James River enters Chesapeake Bay. The James River is about 4 km (2.5 mi) wide at the Surry site. The Surry site, shown in Figure 8-1, occupies approximately 340 ha (840 ac).

The Surry site is 10 km (7 mi) south of Colonial Williamsburg and 13 km (8 mi) east-northeast of the town of Surry. Jamestown Island, part of the Colonial National Historic Park, is to the northwest on the northern shore of the James River. The area within 16 km (10 mi) of the site includes Surry, Isle of Wight, York, and James City Counties, and parts of the cities of Newport News and Williamsburg. The counties surrounding the Surry site are predominantly rural, characterized by farmland, woods, and marshy wetlands. East and south of the site, at distances between 16 and 48 km (10 and 30 mi), are the urban areas of Hampton, Newport News, Norfolk, and Portsmouth, Virginia, and others, collectively known as Hampton Roads.

The site has two Westinghouse-designed light-water reactors, each with a design rating for a gross electrical power output of 855 megawatts-electric (MW(e)). The Surry site was originally planned for four units. Construction permits were issued for Units 3 and 4; however, the units were never built. Cooling for the existing Surry site reactors is provided by a once-through cooling system to remove waste heat from the reactor-steam electric system. Cooling water is withdrawn from and returned to the James River.

Distinctive features of the Surry site include the 40-m (135-ft)-diameter cylindrical containment buildings with hemispherical domes and the cooling canal. When the plant was designed, there was a concern about the containment structures being visible from historic Jamestown Island; consequently, the containment buildings were designed so the elevation would be sufficiently low so as to blend with the surrounding forested lands. In addition to the two nuclear reactors and their turbine building, intake and discharge canals, and auxiliary buildings, the Surry site is the location of Dominion’s Gravel Neck Combustion Turbine Station, a switchyard, and an independent spent fuel storage installation (ISFSI).

Gravel Neck Peninsula is at the upstream limit of saltwater incursion to the James River; upstream of Gravel Neck is tidal river and downstream is an estuary. Surry extends as a band across the peninsula. Steep bluffs drop to the river on either side and to the tip of the

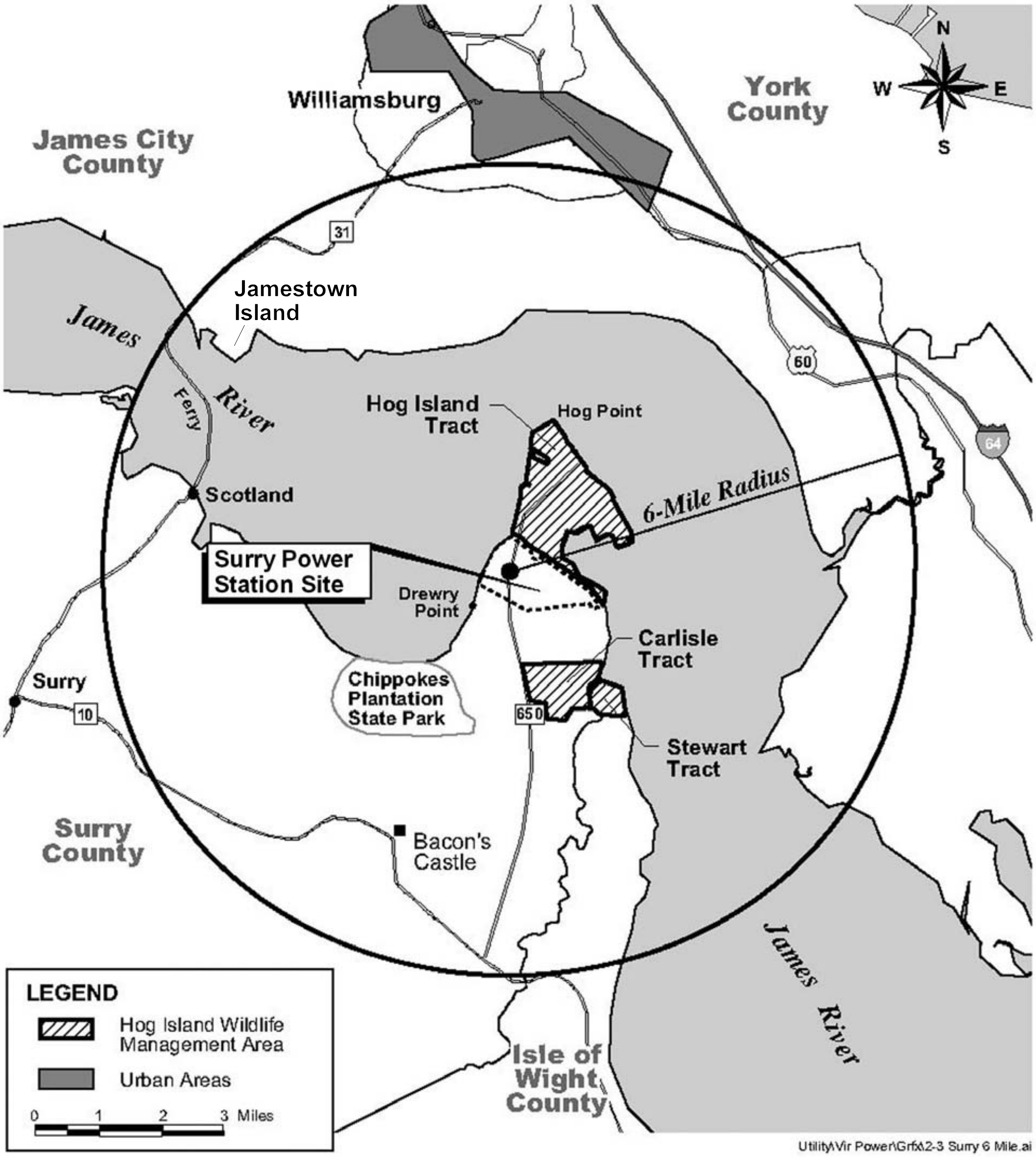

Figure 8-1. Surry Vicinity Map

peninsula. Hog Island Wildlife Management Area, a Commonwealth of Virginia wildlife management area, is located on the tip of the Gravel Neck Peninsula, and contains primarily tidal marshes. Areas within 16 km (10 mi) of the site to the west, south, and east are predominantly rural, characterized by farmland, forests, and marshy wetlands. The tidal flats and marshes of Hog Island State Wildlife Management Area provide habitat for large numbers and numerous species of migratory shorebirds, wading birds, and waterfowl. It also provides habitat for numerous amphibians, reptiles, mammals, and upland game birds.

The terrestrial community at the Surry site consists of remnants of mixed pine-hardwood forests interspersed with early succession fields and developed areas. Wildlife species, found primarily in the forested portions of the site, are those typically found in upland forests of coastal Virginia. With the exception of the bald eagle (*Haliaeetus leucocephalus*) (Federally and State-listed as threatened), terrestrial species that are Federally and/or State-listed as endangered or threatened are not known to exist at the Surry site or along the rights-of-way of its associated transmission lines (NRC 2002). The barking tree frog (*Hyla gratiosa*), State-listed as threatened, is believed to be in the general vicinity but has not been observed at the Surry site.

The Surry site is located in one of the strongest economic areas in Virginia, and Dominion is the major employer in Surry County (NRC 2002). At present, because of the location of the Surry Power Station in Surry County, Dominion has a significant impact on the economic well-being of the county.

The following sections examine the major environmental issues reviewed by the staff. Section 8.5.1 evaluates land-use issues, including the site and transmission lines. Section 8.5.2 examines hydrology, water use, and water quality. Sections 8.5.3 and 8.5.4 evaluate the terrestrial and aquatic resources including endangered species, and Section 8.5.5 evaluates socioeconomics, historic and cultural resources and environmental justice issues.

8.5.1 Land Use Including Site and Transmission Lines

Similar to the North Anna ESP site, the Surry site was originally designed for the construction of four reactor units. Surry Units 3 and 4 were to be constructed to the east of Unit 2 where the existing construction building and parking area are now situated. The original plans called for Units 3 and 4 to be offset from Units 1 and 2, with the turbine building roughly in line with the Units 1 and 2 containment buildings. The containment buildings for Units 3 and 4 were originally to be located farther north of the intake canal than the existing Units 1 and 2 containment buildings.

For purposes of its ESP application, Dominion determined that the originally planned location for Units 3 and 4 continues to be the best choice for two new nuclear units at the Surry site (Dominion and Bechtel 2002). The potential location for new nuclear generating units at the Surry site is shown in Figure 8-2 (Dominion and Bechtel 2002). This location is east of the

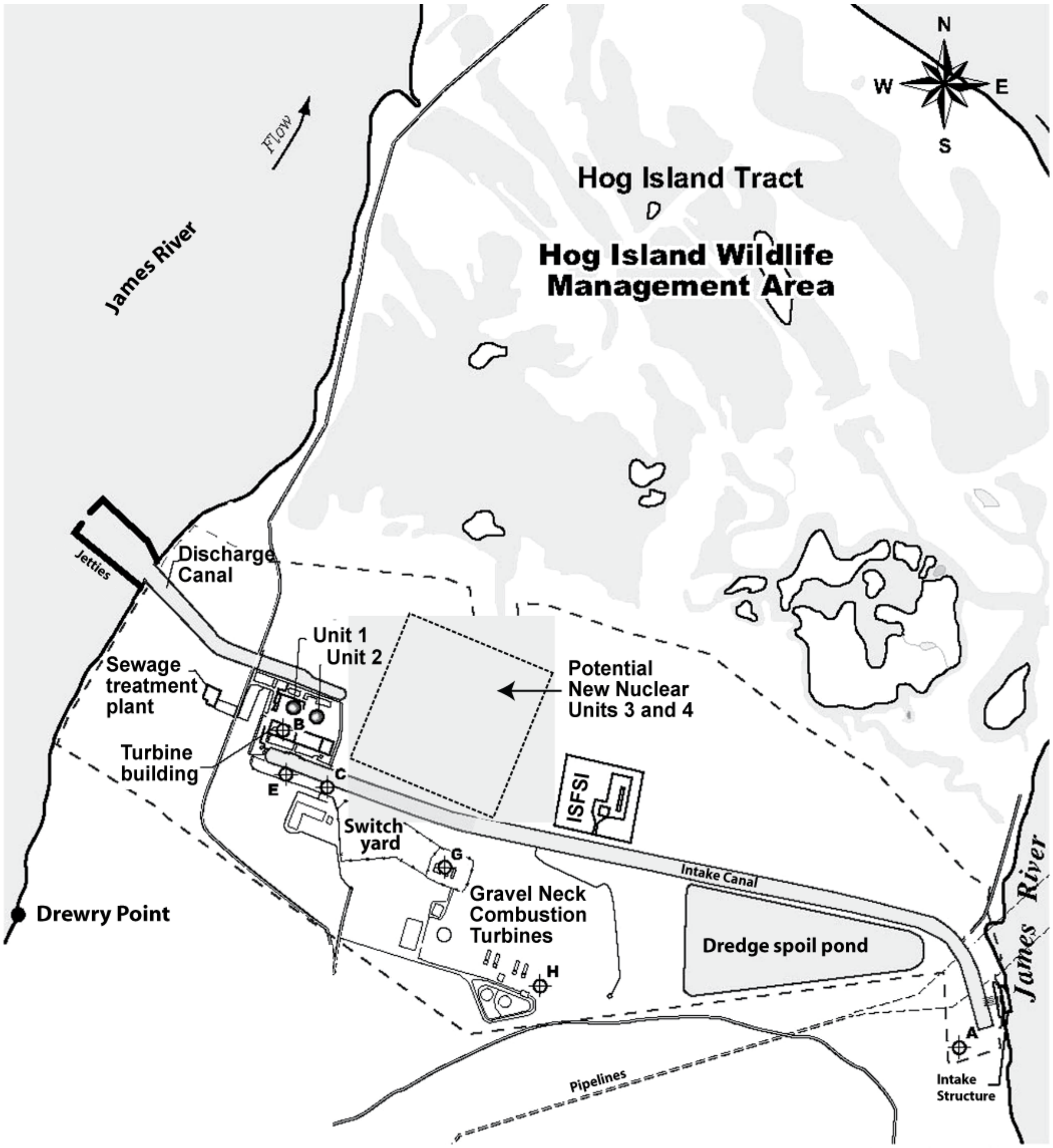

Figure 8-2. Surry Power Station Site

radwaste facility and includes construction, maintenance, and miscellaneous buildings and the uncleared area west of the ISFSI. Relocation of these existing buildings to another onsite location would therefore be necessary. The existing cleared area measures approximately 300 m (900 ft) in the east-west direction. According to Dominion and Bechtel (2002), an additional 300 m (900 ft) could be cleared to the east, while still maintaining approximately 150 m (500 ft) to the ISFSI outer fence. An earthen berm around the ISFSI would likely be constructed to reduce construction and occupational radiation doses. Any expansion of the ISFSI would be to the east, away from the nuclear power units. In the north-south direction, the cleared area measures approximately 350 m (1100 ft), including the contractor parking area. An additional 30 to 45 m (100 to 150 ft) could be cleared without encroaching too close to the north site boundary. The areas to the north and east of the ISFSI could also be used, if needed.

The Surry site is in a district classified as M-2 General Industrial District by Surry County (Surry County 1975). Location of nuclear power plants and associated radioactive waste-handling facilities is permitted as a conditional use in this district upon approval by the County Board of Supervisors. Dominion has received such approval for Surry Units 1 and 2, but would need additional approval for new units.

The Surry site has an existing exclusion area that is consistent with NRC regulations. New nuclear units sited at the Surry site would likely have the same exclusion area as the existing units.

The residential locations of employees currently working at Surry are shown in Table 8-2 (NRC 2002). Approximately 60 percent of the employees live in Isle of Wight, James City, or Surry Counties, or the City of Newport News, Virginia. The remaining 40 percent of employees reside in other counties and cities within Virginia and adjacent states. The staff assumes that the residences of the workforce needed to construct two units at the Surry site would be similarly dispersed. Offsite land-use impacts associated with construction of new units would likely be relatively limited, given the temporary nature of the construction (about 5 years). Construction of new rental housing and/or manufactured home and recreational vehicle parks could be expected to accommodate construction workers.

Section 307(c)(3)(A) of the Coastal Zone Management Act (16 USC 1456(c)(3)(A)) requires that applicants seeking a Federal permit to conduct an activity that affects a coastal zone area provide to the permitting agency a certification that the proposed activity complies with the enforceable policies of the State's coastal zone program. Surry is within the Virginia coastal resources management area (VDEQ 2004). If construction of new nuclear units at Surry were planned, Dominion would need to submit a certification to the Virginia Department of

Table 8-2. Surry Power Station, Units 1 and 2, Permanent Employee Residence by County/City

County/Independent City	Number of Personnel	Percentage of Total Personnel	Cumulative Percentage
Isle of Wight County	212	24	24
James City County	98	11	35
Newport News (city)	97	11	46
Surry County	90	10	57
Hampton (city)	71	8	65
Suffolk (city)	52	6	71
Chesapeake (city)	42	5	75
Chesterfield County	25	3	78
Portsmouth (city)	23	3	81
Virginia Beach (city)	21	2	83
York County	20	2	85
Prince George County	19	2	88
Sussex County	18	2	90
Southampton County	11	1	91
Others	79	9	100
Total	878	100	

Source: NRC 2002.

Environmental Quality (VDEQ) stating that construction of the new units is consistent with the Virginia Coastal Management Program. This submission would be reviewed by VDEQ.

New land-use impacts associated with operation of new nuclear generating units at the Surry site would be expected to be limited. Some new housing in surrounding communities would likely be constructed to accommodate permanent workers at the new units. The incremental property tax revenue from the new units could affect future land use in Surry County as a result of infrastructure improvements made possible by the tax revenue. In the supplemental EIS related to renewal of the operating licenses for Surry Units 1 and 2, the staff determined that tax revenue impacts on land use during the 20-year license renewal term would be small (NRC 2002). The staff concludes that although new units would be licensed for 40 years, the incremental land-use impacts would be minor. Based on the foregoing, the staff concludes that the land-use impacts on the site and vicinity of construction and operation would be SMALL.

The transmission line rights-of-way from the Surry site consist of three 500-kV transmission lines from the breaker, a 500-kV switchyard, and six 230-kV transmission lines from the 230-kV switchyard. The lines are not at or near capacity (Dominion and Bechtel 2002). For the addition of two advanced boiling water reactor-size units, it appears that the 500-kV transmission line rights-of-way would be able to transmit the new load; however, system-study (load-flow) modeling of the transmission lines and the new nuclear units would need to be performed to be certain whether any additional lines are required from the site. Based on the evaluation conducted by Dominion and Bechtel (2002), it is likely that no additional electrical transmission line rights-of-way would be needed to transmit the power generated by additional units at the Surry site to the regional power grid. This impact would be similar to land-use impacts for construction and operation in the transmission line rights-of-way and offsite areas associated with the North Anna ESP site. Therefore, based on the foregoing, the staff concludes that the land-use impacts of transmission system construction and operation would be SMALL.

8.5.2 Water Use and Quality

The Surry site is located adjacent to the James River estuary. The consumptive use of water to support mechanical-draft cooling towers for new units would be undetectable relative to the supply available in the estuary. Discharges to the James River could contain water treatment chemicals that would be subject to regulation by the VDEQ to ensure protection of the environment. The additional small amount of heat from blowdown water would likely be undetectable if commingled with the once-through discharge of Surry Units 1 and 2. Therefore, based on the foregoing, the staff concludes that the impacts to water use and water supply at the Surry site from construction and operation of two new units would be SMALL. Discharge of thermal and chemical effluents would be regulated by Commonwealth of Virginia's Pollutant Discharge Elimination System (VPDES) permitting process to limit water quality impacts to the James River. Therefore, the staff concludes that water quality impacts during construction and operation would be SMALL.

8.5.3 Terrestrial Resources Including Endangered Species

A maximum of approximately 200 ha (500 ac) of land would be disturbed to develop two additional units with cooling towers at the Surry site (Dominion and Bechtel 2002). Much of this area has been previously disturbed during development of the existing nuclear units and associated facilities. Habitats in the area are a mixture of industrial areas, early successional grasslands, and remnant mixed pine-hardwood forests. There are no threatened, endangered, or other important terrestrial species known to exist within the Surry alternative site, although Federally threatened bald eagles are known to nest near the Surry site. Federally and State-listed threatened or endangered species reported to occur in Surry County are listed in Table 8-3.

Potential construction impacts include erosion, dust generation, and noise which are typical of large construction projects. These impacts could be mitigated using standard industrial

Table 8-3. Federally and State-Listed Threatened or Endangered Terrestrial Species Reported Within Surry County, Virginia

Scientific Name	Species	Federal Status	State Status
Birds			
Haliaeetus leucocephalus	bald eagle	T	T
Lanius ludovicianus[(a)]	loggerhead shrike	SC	
Falco peregrinus	peregrine falcon		T
Mammals			
Plecotus rafinesquii macrotis	eastern big-eared bat		E
Amphibians			
Hyla gratiosa	barking tree frog		T
Ambystoma mabeei	Mabee's salamander		T
Insects			
Speyeria diana	Diana fritillary	SC	
Vascular Plants			
Aeschynomene virginica	sensitive joint-vetch	T	T

T = threatened, E= endangered, SC = species of concern.
Sources: VDGIF 2004; VDCR 2004.
(a) The migrant subspecies *L.l. migrans* is a Federal species of concern; all loggerhead shrikes in Virginia are State threatened.

procedures or best management practices. Standard practices to limit potential construction impacts including silt fences to control sedimentation and water sprays to limit dust generation should protect wetlands and other ecological resources in the site vicinity.

Construction noise could affect bald eagles nesting in the vicinity of the site. Prior to initiation of major construction activities, the presence and distribution of bald eagle nests in relation to the location of planned facilities would need to be determined. If eagle nests are in the area, mitigation measures would need to be developed. According to the Bald Eagle Protection Guidelines for Virginia (FWS and VDGIF 2000), no major construction activities should occur within 400 m (1300 ft) of an active eagle nest, and loud noises (such as blasting) should not occur during the nesting/breeding season. No active nests currently exist within 400 m (1300 ft) of the Surry construction site.

The staff evaluated the potential impacts of operation of new nuclear units, including operation of the plants, cooling systems, and transmission systems on terrestrial threatened or endangered species as follows. If new reactor units are constructed, very little usable habitat would remain within the development area at the Surry site. Operation of additional units would typically result in some noise generation, salt drift, icing, fogging, and bird collisions. Noise would likely be typical of operating reactor units and cooling towers, which have been found to be a SMALL impact (NRC 1996). However, it is possible that such noise could deter bald eagles from nesting near the site. There are no sensitive habitat areas adjacent to the site that would be adversely affected by noise from plant operations. The terrestrial vegetation in the immediate vicinity of the Surry site is not believed to be unusually sensitive to salt drift, fogging, or icing (Dominion and Bechtel 2002). However, because the cooling tower makeup water from the James River estuary is brackish (up to 17 parts per thousand of salt), the cooling tower drift could have higher salt content than at freshwater sites. Because it is likely that mechanical-draft towers with their much shorter towers would be used rather than natural-draft towers, bird collisions would not be likely (NRC 1996). Based on the above evaluation, the staff concludes that the impacts of operating two new units on terrestrial resources, including threatened and endangered species, would be SMALL.

According to the analysis performed by Dominion and Bechtel (2002), no additional transmission lines would be needed to transmit electrical power generated by new units at the Surry site to the regional distribution grid. The staff based its evaluation on the assumption that new transmission lines would not be required to support two new units. Therefore, maintenance and operation of the existing transmission line rights-of-way would likely not be affected by two new nuclear units at the Surry site. NRC determined that the impacts of continued operation of these transmission lines and maintenance of the rights-of-way would have a small impact on terrestrial ecosystems (NRC 2002). However, some monitoring and mitigation for nesting bald eagles might be warranted.

Based on the foregoing, the staff concludes that the overall impact to terrestrial ecological resources of both construction and operation of two new units and associated cooling systems and transmission line rights-of-way at the Surry site would be SMALL. However, some monitoring and mitigation for nesting bald eagles might be warranted.

8.5.4 Aquatic Resources Including Endangered Species

The aquatic environment near the Surry site is associated with the James River. The James River rises in the Allegheny Mountains near the Virginia/West Virginia border and flows in a southeasterly direction to Hampton Roads (that area of Virginia that includes Newport News, Norfolk, Portsmouth, Hampton, and surrounding cities and towns), where it enters Chesapeake Bay. The James River flows 692 km (430 mi) from its headwaters (the confluence of the Cowpasture and Jackson Rivers) to Chesapeake Bay, crossing portions of the Blue Ridge, Valley and Ridge, Piedmont, and Coastal Plain physiographic regions. The river drains an area of 25,900 km^2 (10,000 mi^2), which is just over 25 percent of the total land area of Virginia. Overall, about 71 percent of the basin is forested, 23 percent is agricultural, and 6 percent is urban. The lower James River flows through the Coastal Plain of Virginia, which is virtually flat in tidewater areas, generally ranging from 0 to 30 m (0 to 100 ft) above mean sea level (MSL).

Two major tributaries enter the river between Richmond and Hampton Roads. The Appomattox River enters the James River from the south, in the stretch of river between Richmond and Petersburg. The Chickahominy River enters from the north, just west of Williamsburg. Although the James River downstream of Richmond was severely polluted for many years, the passage of the Clean Water Act in 1972 and implementation of associated regulations, such as the National Pollutant Discharge Elimination System, have reduced the flow of point-source pollutants into the James River watershed. Pollution prevention measures and programs carried out by industrial entities in the area have further reduced chemical discharges to the James River. At present, nutrients from sewage treatment facilities, agricultural operations, and urban runoff and bacteria from combined sewer systems (those that combine storm water and sewage) are considered the chief threats to the water quality of the lower James River.

In the vicinity of the Surry site, the James River is approximately 4 km (2.5 mi) wide. Cobham Bay lies west (just upstream) of the Gravel Neck Peninsula and represents the approximate limit of saltwater incursion, effectively dividing the James River into a tidally influenced freshwater river upstream (to the fall line at Richmond) and an estuary downstream. The U.S. Army Corps of Engineers historically has dredged the main channel of the lower James River so ocean-going vessels can proceed upriver as far as Hopewell, approximately 80 river km (50 river mi) northwest of the Surry site.

The lower James River supports a diverse assemblage of finfish species, ranging from exclusively marine species near Chesapeake Bay to exclusively freshwater species at the fall line in Richmond. Approximately 80 fish species are known from the brackish portion of the James River downstream of Surry, with another 40 or so species recorded from the tidally influenced freshwater portion of the river upstream of the Surry site. Distributions and abundances of particular species vary between seasons and years, depending on salinity differences and natural fluctuations in fish populations.

Dominion's predecessors conducted extensive surveys of James River aquatic biota in the 1970s. While preparing its ER for the ESP application, Dominion contacted the Virginia Institute of Marine Sciences for more recent information (Virginia Institute of Marine Sciences 2001). The following paragraphs describe the historic Virginia Electric and Power Company (Virginia Power) data and the more recent data collected by the Virginia Institute of Marine Sciences.

From 1970 to 1978, Virginia Power collected 63 fish species in monthly haul seine surveys conducted to characterize fish populations of the shore zone in the vicinity of the Surry site. Five species made up more than 75 percent of fish collected. These were the Atlantic menhaden (*Brevoortia tyrannus*), blueback herring (*Alosa aestivalis*), inland silverside (*Menidia beryllina*), bay anchovy (*Anchoa mitchilli*), and spottail shiner (*Notropis hudsonius*). Over the same period, 42 fish species were collected in otter trawl samples that were intended to characterize fish populations in deeper waters (the shelf zone) adjacent to the main river channel. Five species comprised more than 80 percent of fish collected in trawl samples: the hogchoker (*Trinectes maculatus*), spot (*Leiostomus xanthurus*), channel catfish (*Ictalurus punctatus*), Atlantic croaker (*Micropogonias undulatus*), and bay anchovy.

Between 1996 and 2000, the Virginia Institute of Marine Sciences conducted approximately 350 deep-water ichthyoplankton trawl surveys in the James River in the vicinity of Hog Island. In those collections, four species comprised more than 80 percent of the catch: hogchoker, white perch (*Morone americana*), Atlantic croaker, and bay anchovy. Spot was the fifth most abundant species. Salinity appears to be the most important factor influencing the relative abundances of fishes between the two sampling periods.

In addition to finfish, several invertebrate aquatic species were found in the vicinity of the Surry site. These include zooplankton (dominated by copepods), amphipods (notably the scud [*Gammarus* spp.]), and a variety of benthic organisms (e.g., polychaetes and shellfish). Shellfish formed the bulk of the benthic biomass from the transition zone in the vicinity of the Surry site to Chesapeake Bay. The brackish water clam (*Rangia cuneata*), a species capable of tolerating a wide range of salinities, dominated the benthic community in the vicinity of the Surry site. Larval American oysters (*Crassostrea virginica*) occurred in the area as meroplankton, but adults were uncommon. The more recent trawl survey collected American oysters, blue crabs (*Callinectes sapidus*), spider crabs (*Libinia emarginata*), eight species of shrimp (Penaeidae), and five species of clams (Bivalvia). The diversity of benthic macroinvertebrate is usually low in a transition zone, increasing downstream to seawater and upstream (moderately) to freshwater. A combination of physical, chemical, and biological factors influence the distribution of benthic organisms, but as with the finfish, salinity appears to exert the greatest influence.

No areas designated by the U.S. Fish and Wildlife Service (FWS) as critical habitat for endangered species exist in the James River (Virginia Natural Heritage Program 2003). Virginia Power and its contractors conducted extensive surveys of fish and aquatic invertebrates in the lower James River in the vicinity of the Surry site in the 1970s. Based on these historical surveys and a review of the scientific literature, no Federally listed aquatic species is found in the lower James River. On Virginia’s endangered species list, Jenkins and Burkhead (1994) identify only one threatened or endangered fish species in the entire James River drainage, the orangefin madtom (*Noturus gilberti*), which occurs in the headwaters of the river, several hundred miles upstream of the Surry site.

The Atlantic sturgeon (*Acipenser oxyrhynchus*), a candidate for Federal listing, was reported in the vicinity of the Surry site in the early 1970s and was subsequently collected in research and monitoring studies conducted by Virginia Power and Virginia Power-funded entities in the mid-to-late 1970s. A number of authorities on the fishes of Virginia and the mid-Atlantic coast also list this species as occurring in the lower reaches of the James River. The blackbanded sunfish (*Enneacanthus chaetodon*), listed as endangered by the Commonwealth of Virginia, is reported to occur in Prince George, Surry, and Sussex Counties west of the Surry site. However, this sunfish primarily inhabits thickly vegetated ponds, swamps, and pools and is not reported to occur in the James River Drainage (Jenkins and Burkhead 1994.)

Although not recorded in Virginia for more than 100 years, the shortnose sturgeon (*Acipenser brevirostrum*) is on the Commonwealth's list of rare animal species. This listing is based on the fact that the species occurs in major river systems north and south of the Chesapeake Bay, is presumed to have spawned in the four major estuarine drainages of the Chesapeake Bay (including the James River) in Virginia as late as the 19th century, and may reappear in the future if restoration efforts are successful. At present, the shortnose sturgeon is listed as endangered by the National Marine Fisheries Service and by Virginia. The Virginia Department of Conservation and Recreation lists the shortnose sturgeon "LE" or "Listed as Endangered" in their Natural Heritage Program, Rare Animal Species.

The staff evaluated the potential impacts of operating new nuclear units, including operating the plants, cooling systems, and transmission systems on aquatic threatened and endangered species. Based on this evaluation, the staff concludes that the impacts of constructing and operating new units on aquatic threatened and endangered species at the Surry site would be SMALL.

The potential for impingement and entrainment of aquatic resources is expected to be minimal because of closed-cycle cooling. The potential impacts of heated water would be expected to be mitigated by the placement of the discharge structures. The overall impact on aquatic ecological resources of construction and operation of two new units and associated cooling towers and transmission facilities at the Surry site would be SMALL.

8.5.5 Socioeconomics, Historic and Cultural Resources, Environmental Justice

In evaluating the socioeconomic impacts of construction at the Surry site, the staff used the license renewal supplemental EIS information (NRC 2002) and Dominion and Bechtel's (2002) analysis of potential sites. The staff also conducted a reconnaissance survey of the site using readily obtainable data from the Internet or published sources and a one-day audit trip to confirm various aesthetic and cultural issues. No new data were collected. The socioeconomic sections follow the organizational structure of the socioeconomic discussions in Sections 2.8, 4.5, and 5.5. Both construction and station operation impacts are addressed.

8.5.5.1 Physical Impacts

Construction activities can cause temporary and localized physical impacts such as noise, odor, vehicle exhaust, vibration, shock from blasting, and dust emissions. The use of public roadways, railways, and barges would be necessary to transport construction materials and equipment. Dominion anticipates that the roadways could need some minor repairs or upgrading, such as patching and filling potholes, to allow safe transport of these materials and equipment. However, no extensive work is planned to the existing roads or railways, and no new routes would be needed (Dominion and Bechtel 2002). All construction activities would occur within the existing Surry site. Offsite areas that would support construction activities (e.g., borrow pits, quarries, and disposal sites) are expected to be already permitted and operational. Impacts on those facilities from construction of the new units would be small incremental impacts associated with their normal operation.

Potential impacts from station operation include noise, odors, exhausts, thermal emissions, and visual intrusions. Noise would be produced by the operation of pumps, cooling fans, transformers, turbines, generators, switchyard equipment, and traffic. Dominion states in its ER that any noise coming from the North Anna ESP site would be controlled in accordance with applicable local county regulations. By inference, this is also expected to apply to the Surry site. Virginia has no regulations or guidelines regarding noise limits. Commuter traffic would be controlled by speed limits. Good road conditions and appropriate speed limits would minimize the noise level generated by the workforce commuting to the Surry site (Dominion 2006).

The new units would have standby diesel generators and auxiliary power systems. Permits obtained for these generators would ensure that air emissions comply with regulations. In addition, the generators would be operated on a limited short-term basis. During normal plant operation, the new units would not use a significant quantity of chemicals that could generate odors exceeding odor threshold values. Good access roads and appropriate speed limits would minimize the dust generated by the commuting workforce (Dominion and Bechtel 2002).

Construction activities would be temporary and would occur mainly within the boundaries of the Surry site. Offsite impacts would represent small incremental changes to offsite services supporting the construction activities. During station operations, noise levels would be managed in accordance with local ordinances. Air quality permits would be required for the diesel generators, and chemical use would be limited, which should limit odors. Visual aesthetics in areas across the James River would be affected. Except for culturally significant areas, these impacts would be SMALL to MODERATE. (See Section 8.5.5.3 for additional details.) Based on the foregoing, the staff concludes that the physical impacts of construction and operation would be SMALL to MODERATE.

8.5.5.2 Demography

The population base is considered to be the population of significant population centers within a 80-km (50-mi) radius of the Surry site. The combined population of the Richmond-Petersburg and Norfolk-Virginia Beach and Newport News, Virginia Metropolitan Statistical Area is 2,566,050 (USCB 2000a). The estimated population within an 80-km (50-mi) radius of the Surry site is 2,387,353 and is projected to grow by approximately 41 percent to 3,365,040 by 2030 (NRC 2002).

Most of the construction workforce is expected to come from within the region, and those who might relocate to the region would represent a small percentage of the larger population base. While the station operation workforce is expected to relocate into the region, their numbers are small (720 new operating employees and their families) when compared to the total base population and their locations of residence would probably be scattered throughout the region. Based on the foregoing, the staff concludes that any environmental impacts caused by population increases within an 80-km (50-mi) radius of the site would be SMALL.

8.5.5.3 Community Characteristics

Economy

The Surry site is located in one of the strongest economic areas in Virginia. The Richmond-Petersburg area is the primary economic driving force in the area within an 80-km (50-mi) radius of the Surry site. The Norfolk-Virginia Beach-Newport News area is characterized by the U.S. Navy's significant presence in the area (NRC 2002). Hampton Roads relies heavily on defense-related industry, particularly shipbuilding. In recent years, the regional economy has become more diversified with major businesses, financial and health care components, and a growing "high-tech" sector. Regionally, the service sector now offers the most employment opportunities. The construction and operation of two new nuclear units at the Surry site would be expected to benefit the economy of the region, especially Surry County.

Dominion estimates it would take approximately 5000 construction workers more than 5 years to build two new nuclear units at the Surry site (Dominion 2006). Dominion is expected to be able to attract the necessary workforce for construction activities at the Surry site because of its proximity to the major population centers of Richmond-Petersburg and Norfolk-Virginia Beach Newport News. While the availability of craft workers for outages at Surry is reported as very limited, this can be attributed to the short duration of the projects. However, the availability of craft workers for regular construction projects of longer duration is reported to be good (Dominion and Bechtel 2002). The construction workforce within 80 km (50 mi) of the site was estimated to number approximately 98,000 (Dominion and Bechtel 2002).

Approximately 990 employees work at Surry Units 1 and 2, (about 110 contract employees and 880 permanent employees). The addition of new units would result in an increase in the operations workforce of 720 employees. In its ER, Dominion stated that it expected most of the operations workforce for the new units to relocate from outside the region. The ER does not address from where these employees would come (Dominion 2006). Some nuclear defense sites are reducing their workforces as they change missions (such as the Portsmouth and the Savannah River sites), and workers from these sites could be potential pools of labor for the operating workforce at Surry.

The staff concludes that construction labor would be available from within the region, and there would be little problem recruiting the required labor skills to enable the construction of the nuclear units at the Surry site and the operations workforce would relocate to the region.

Based on the foregoing, the staff reviewed the impacts of station construction and operation on the economy of the region and concludes that the impacts would be SMALL BENEFICIAL everywhere in the region except Surry County, where the impacts could be MODERATE BENEFICIAL. The magnitude of the economic impacts would be diffused in the larger economic bases of the Norfolk-Virginia Beach-Newport News area, including Isle of Wight, Surry, York, and James City Counties. With Surry County's smaller economic base, the economic impacts would be more noticeable.

Taxes

Construction and operations workers would pay income, sales, and use taxes to Virginia and the local governments in the region where sales take place and property taxes to the counties in which they own a residence. Sales and use taxes would be paid from the sales of construction materials and supplies purchased for the project and on expenditures of both the construction and operations workforce for goods and services. Dominion estimates that about half of the day-to-day expenditures during construction would occur in the region (Dominion 2006). Corporate income taxes on profits would also be paid by those companies engaged in construction at the site.

There are two types of property taxes in Virginia. The first is the tangible personal property tax paid by contractors during construction of the additional units. This tax is based on the value of property owned by the contractors that acquire taxable status in Surry County during the construction period. The second is the real property tax levied for the incremental increase in value to the entire site from the operation of the additional units. It is expected that Surry County would be the only beneficiary of this tax. Dominion has a significant impact on the economic well-being of Surry County, with Dominion paying well over 70 percent of the property taxes between 1996 and 2000 (NRC 2002).

Based on the foregoing, the staff concludes that the overall impacts from construction and operation of taxes collected through the income, sales and use, and property taxes would be SMALL (with the exception of Surry County for property taxes). The taxes paid, while substantial, are nevertheless a small sum when compared to the total amount of taxes collected by Virginia and local governments in the region. The staff concludes that the overall impacts of the property taxes collected in Surry County would be beneficially MODERATE (construction) and LARGE (operation) relative to the total amount of taxes the county collects through property taxes.

Transportation

The area around the Surry site is served by several major freeways and State and Federal highways (NRC 2002). The most direct vehicular access to the Surry site is from the more populous cities and counties on the north bank of the James River via State Route (SR) 31 and the James River Ferry service, operated by the Virginia Department of Transportation. The principal road access to the Surry site is via SR 650, which is a two-lane paved road. SR 650 carries a level-of-service (LOS) designation of “A,” which reflects a free flow of traffic and users unaffected by the presence of others.

The construction of new nuclear units would involve additions to the workforce. In addition, construction materials, wastes, and excavated materials would be transported both to and from the site. These activities would result in increases in operation of personal-use vehicles by commuting construction workers, in commercial truck traffic, and in traffic associated with daily operations. However, five of the seven reactor types under consideration for this project are generally smaller and modular in nature. Consequently, transportation of plant equipment could be less challenging and workforce needs are expected to be less than those for conventional nuclear plants (Dominion and Bechtel 2002).

The LOS designation on SR 650 would likely be degraded from “A” to “C” (which reflects a stable flow that marks the beginning of the range of flow in which the operation of individual users is significantly affected by interactions with the traffic stream) during the peak construction period for a new nuclear plant at the Surry site (Dominion and Bechtel 2002).

SR 650 intersects SR 10 approximately 8 km (5 mi) from the plant. SR 10 in the vicinity of the site, from Surry County Courthouse to the divergence of the business and bypass north of Smithfield, carries a LOS designation of “C.” Portions of Highway 10 would receive significantly more traffic during plant construction (NRC 2002; Dominion and Bechtel 2002).

No direct rail access is available to the Surry site, so large equipment would have to be offloaded and transported by road and/or barge from the nearest rail access points in Richmond or Norfolk. Surry has an excellent barge slip adjacent to the cooling water intake. This slip was used for the transport of the replacement steam generators in the late 1970s and is regularly used to receive spent fuel storage casks and other large loads (Dominion and Bechtel 2002).

The Williamsburg-Jamestown Airport, Newport News/Williamsburg International Airport, Norfolk International Airport, and the Richmond International Airport all serve the area. The airports in Richmond and Norfolk provide regular freight and passenger jet services and are of sufficient size to accommodate the relatively small air shipments normally associated with a construction project (Dominion and Bechtel 2002).

The impact of station operation employees on the transportation system would be less than the impact incurred during construction. There would be increases in operation of personal-use vehicles by commuting operators of both the existing and new units and in traffic associated with daily operations. Portions of SR 10 may be impacted by commuters to the plant site, particularly during shift changes. During new plant operation, the LOS designation on SR 650 may retain its “A” status or perhaps degrade to “B” designation, which reflects a condition of stable flow instead of the free flow indicated under an “A” designation. This change in designation indicates that the freedom to select speed is unaffected, but the freedom to maneuver is slightly diminished (Dominion and Bechtel 2002).

Based on the foregoing, the staff concludes that the impacts of a construction workforce and related transportation of construction supplies and materials on transportation infrastructure at Surry would be SMALL to MODERATE (but temporary). Some of the local roads could have their LOS degraded during construction to the point where operations of individual drivers could be significantly affected by interactions with other traffic. This would be at LOS levels of C or lower. Also it is possible that, given the heavy loads carried by vehicles transporting construction materials to the Surry site, some of the roads may need repair to carry the additional load. The impacts during operation would be SMALL.

Aesthetics and Recreation

Although the Surry site is clearly an industrial site, its current structures are not visually intrusive from any vantage point, even from across the James River. However, Surry Units 1 and 2 are visible from the highest amusement rides at Busch Gardens (Dominion and Bechtel 2002) and at certain points of Jamestown Island and the Colonial Parkway. The reasons for the lack of visual intrusiveness are the general wooded habitat surrounding the site and the fact that the Units 1 and 2 reactor containment buildings are sunk into the ground to minimize visual obtrusion from offsite. The licensee for Units 1 and 2 took this unusual step because of the highly sensitive nature of the historic resources across the James River (i.e., Jamestown and Williamsburg) (VEPCo 1970). Not all of the seven new reactor technologies being considered for the Surry site could be designed to allow the reactor containment building to be placed lower in the ground. For example, the AP1000, which has a reactor containment building approximately 71 m (234 ft) above grade, could potentially be more easily seen from Williamsburg across the James River from the Surry site. The design of this building includes a hatch that determines the height that it must be above ground. Dominion states that redesigning the AP1000 would be prohibitively expensive to allow the building to be placed lower in the ground. In its ER, Dominion did not address the feasibility of adapting the remaining reactor technology to minimize visual intrusiveness (Dominion and Bechtel 2002).

The Surry site is a minimum of 5 km (3 mi) from any point across the James River. Except for the west side of the site, which is open to the James River, the dense tree stands surrounding the site effectively screen the existing unit from all but a few locations. No parks or recreational areas are within 3 km (2 mi) of the Surry site. The closest recreational park is Chippokes Plantation State Park located 4 km (2.5 mi) to the southwest (NRC 2002). The only distinguishable view of the transmission lines by offsite observers is available from the James River (Dominion and Bechtel 2002).

The addition of new units at the site would likely involve the use of cooling towers. Given the historical nature of some of the surrounding communities (e.g., Jamestown), Dominion would be more likely to use mechanical-draft cooling towers rather than the taller, natural-draft towers, which may be considered unacceptable. Traditionally, visible plumes generated by the operation of cooling towers could cause a negative aesthetic effect. These plumes would be visible a majority of the time.

Most construction activities would be screened from offsite viewing. The exception may be the reactor containment building as it nears completion. The AP1000 at 71 m (234 ft) would be visibly intrusive.

Concerns regarding the design and operation of additional units on the viewshed of the Colonial National Historic Park were raised by the National Park Service. The Colonial National Historic Park includes Jamestown, the Yorktown Battlefield, and the Colonial Parkway. The staff and its contractor met with the Park Service prior to conducting a supplemental visit to the Surry site on September 19, 2005, to assess the potential adverse effects at Surry as an alternative site to the proposal for the North Anna ESP site. The summary of the site visit is contained in a trip report dated July 6, 2006 (ML061720366) (NRC 2006). In its letter dated October 25, 2005, the National Park Service suggested that the physical size of the units and the operational impacts, would have an adverse effect on the viewshed from both Jamestown and the Colonial Parkway (NPS 2005).

In its summary (NRC 2006), the staff found:

> The Colonial National Historical Park (NHP), particularly the Jamestown Unit and the associated initial stretch of the Colonial Parkway that extends eastward along the shoreline of the James River, and the Jamestown National Historic Site would be the most directly visually impacted. The Colonial NHP is managed by the National Park Service while the adjoining Jamestown National Historical Site is owned and managed by the Association for the Preservation of Virginia Antiquities. In the words of the co-managers: “Jamestown is a world-class cultural historic site that needs to be promoted, explored, and fully presented to communicate its significance in history.”

and

> Based on the high level of historical significance attributed to the Jamestown historical features and the fact that current views of the Surry Power Plant range from full to partial, from both the island and the Colonial Parkway, even more visible plant structures and the added cooling towers and condensation plumes would constitute a major visual intrusion from this significant historic property. ...In the context of an ESP with a building height of 234 feet at the Surry site, the visual impacts to Colonial NHP and the Jamestown National

Historical Site would be considered clearly noticeable and would be sufficient to possibly destabilize the viewshed.

Based on the foregoing, the staff concludes that the impacts of construction and operation on aesthetics in the vicinity of the Surry site generally would be SMALL to MODERATE, but that a LARGE impact could occur at historically important sites (Section 8.5.5.4).

Housing

A 10 percent vacancy rate out of a total 110,250 housing units currently exists in Isle of Wight, Surry, and James City Counties and the city of Newport News Independent City. Surry County has the highest vacancy rate at 20 percent (NRC 2002). Given the proximity of the Surry site to four major metropolitan areas, housing for construction workers, most of whom will be coming from within the region, and the operations workforce is expected to be available.

Based on the foregoing, the staff concludes that the impacts of a construction and operations workforce on the demand and housing availability would be SMALL. The conclusion is based on approximately 10,000 vacant housing units in the region and the Surry site's proximity to the larger metropolitan areas in the region.

Public Services

<u>Water Treatment Facilities</u>

Isle of Wight County has municipal water supply systems in the towns of Windsor, Smithfield, and Franklin. Permitted groundwater wells supply these systems. Surry County has municipal water supply systems in the towns of Claremont, Dendron, and Surry. The municipal water supply for James City County is provided by the Newport News Waterworks and the James City Service Authority. Newport News Waterworks is one of the top 100 largest water utilities in the United States and one of the three largest in Virginia. James City Service Authority's water system consists of the central system with 29 well facilities and six independent water systems with five well facilities servicing them. Public water supply for Newport News is provided by the Newport News Waterworks. Water is supplied to nearly 400,000 residents of Poquoson, Hampton, and Newport News, and to portions of York and James City Counties. The primary source of raw water is the Chickahominy River. Water supply needs in the intermediate term are expected to be met, with all towns and cities in the region having excess capacity (NRC 2002).

Water supply needs near the Surry site are not a current concern with all towns and cities in the region having excess capacity. Most of the construction workforce would come from within the region and, therefore, are already accounted for in the demands being placed on the systems and their excess capacities. The station operating workforce, while relocating to the region, would probably take up residence across the region, thus not particularly impacting any one community or jurisdiction. Based on the foregoing, the staff concludes that the impacts of construction and operation on water supply treatment facilities would be SMALL.

Police, Fire, and Medical Facilities

In the larger metropolitan areas of Richmond and Henrico County and the cities of Norfolk, Hampton Roads, and Virginia Beach, police, fire, and medical facilities would not be materially impacted by an increase in the construction workforce. Many of the construction workers are anticipated to already live in the region and would commute to the Surry site. As a result, these workers are already served by existing services and facilities.

The operations workforce of about 720 workers and their families is anticipated to relocate to the site from outside the region. Most likely they would locate in residences across the region and would not concentrate in one location. As such, inordinate demands are not likely to be placed on these services and facilities.

Most construction workers already live within the region. The incoming operations workforce would likely have residences scattered across the region. As a result, there should be minimal new demands placed on these services and facilities by either construction or operations employees. Based on the foregoing, the staff concludes that the impacts of construction and operations workforce on police, fire, and medical facilities would be SMALL.

Social Services

Social services in the Commonwealth are provided in each county by the Virginia Department of Social Services. The Department, which provides a variety of services to children and adults, has 131 local departments located throughout Virginia (VDSS 2004). During the construction phase at the Surry site, there may be an increased demand for social services.

Generally, construction and operation of new units on the Surry site would be viewed as economically beneficial to the disadvantaged population segments served by the Department. The workforce associated with the Surry site would be relatively higher paid than other employment categories in the region. Construction and operation of the new units, through the multiplier effect, may enable members of the disadvantaged population to improve their social and economic position by moving up to higher paying jobs. At a minimum, the expenditures of the construction and operations workforce in the counties for items such as food and services could, through the multiplier effect, increase the number of jobs that could be filled by the disadvantaged population.

Based on the foregoing, the staff concludes that the demand for social and related services as a result of construction and operation of two new units would be SMALL. Construction and operation of two new units would be expected to have a beneficial economic impact to the economically disadvantaged population of the region, which should lessen the demand for social services. There could be an initial increase in demand for social services at the beginning of the construction period, but this is considered manageable and limited.

Education

The Surry County School system has just over 1200 students (Great Schools 2004). There currently is no overcrowding in the system (NRC 2002). In the other counties and cities of the region, it is anticipated that the construction and operations workforce would minimally impact school infrastructure. Many construction workers already live within the region. Those that do not live within the area are not expected to move their families into the area. This conclusion is based on Dominion's assertions in its ER for the North Anna ESP site (Dominion 2006), and by inference is applicable to the Surry site because of the geographical proximity of the two sites. The operations workforce, while coming from outside and relocating into the region, would probably be scattered throughout the region, placing little demand on school infrastructure as a result.

It is anticipated that most of the construction workforce would come from within the area and would not relocate their families. Those construction and operations workers potentially relocating to the region would most likely be scattered throughout the region and, as a result, would not be in sufficient concentrated pockets to place an undue burden on the existing infrastructure. Based on the foregoing, the staff concludes that the impacts of the construction and operations workforce on education facilities in Surry County and the area would be SMALL.

8.5.5.4 Historic and Cultural Resources

Historic and cultural resources at the Surry site have been addressed in the recent supplemental EIS relating to renewal of the existing operating licenses for Surry Units 1 and 2 (NRC 2002) and supporting information (Louis Berger Group, Inc. 2001). Associated with that effort was consultation with eight Commonwealth of Virginia-recognized Native American Indian Tribes: the Chickahominy Indian Tribe, Chickahominy Indians-Eastern Division, Mattaponi Indian Tribe, Monacan Indian Nation, Nansemond Indian Tribe, the Pamunkey Indian Tribe, the Rappahannock Tribe, and the Upper Mattaponi Indian Tribe.

While there are no currently recorded historic and cultural resources at the Surry site, evaluations of the potential for such occurrences included acreages with the following designations: No Potential (areas previously disturbed during initial construction of the plant), Low Potential (areas that may or may not have been disturbed during construction and areas with little potential for human occupation), and Moderate-to-High Potential (areas with little past surface disturbance and with a likelihood for prehistoric and historic sites based on regional comparative data). Should this alternate site be selected for an ESP, the staff expects that

Dominion would consult with the Virginia Department of Historic Resources concerning the need for additional field inventory of acreage for historic and cultural resources prior to undertaking any ground-disturbing activities.

As noted in Section 8.5.5.3, the existing Units 1 and 2 containment structures were originally constructed below grade so as to minimize visibility of the Surry plant from historic Jamestown Island, located across the James River about 4.8 km (3 mi) from the plant. Because new units could involve construction of a taller containment structure and the addition of mechanical draft cooling towers at Surry, the potential for visual impacts to the area's significant historical resources would be increased through increased visibility of the new structures and view of a condensation plume from the cooling towers during plant operation, or both. In addition to the Colonial National Historical Park, which includes both Jamestown Island and the Colonial Parkway, other historic sites/districts that could be affected include the Williamsburg Historic District and Carter's Grove Plantation on the north side of the James River. South of the river, other historic properties that could experience visual intrusions include Bacon's Castle and Smith's Fort Plantation, both owned and operated as visitor attractions by the Association for the Preservation of Virginia Antiquities, and the Chippokes Plantation Historic District, a component of the Chippokes Plantation State Park managed by the Virginia Department of Conservation and Recreation. Under certain weather conditions, such as cooler winter days, taller plumes of condensation could possibly be seen from other historic properties, such as some of the James River Plantations located upriver from the Surry plant.

Based on the foregoing, the staff concludes that the potential impacts within the plant site boundaries on historic and cultural resources from construction and operation of two new nuclear units at the Surry site would be SMALL. However, the potential exists for visual intrusion at the area's significant historic properties, districts and landscapes. The potential impacts could range from SMALL to LARGE depending on distance and geographic orientation from the Surry site. At the Colonial National Historic Park where there are vantage points from historic Jamestown and the Colonial Parkway, the physical size of additional units and the presence of condensation plumes from operation of units within the bounds of the PPE could be considered a MODERATE to LARGE visual impact to the historic qualities of this nationally significant cultural landscape.

8.5.5.5 Environmental Justice

As part of the evaluation of the potential environmental justice impacts related to the Surry site, the staff used information from NRC's supplemental EIS for the license renewal of Surry Units 1 and 2 (NRC 2002). The pathways through which the environmental impacts associated with the construction of two additional new nuclear units at the Surry site could affect human populations were ascertained. The staff then evaluated whether minority and low-income populations could be disproportionately affected by these impacts. The staff found no unusual resource dependencies or practices, such as subsistence agriculture, hunting, or fishing, through which the populations could be disproportionately affected. In addition, the staff did not identify any location-dependent disproportionate impacts affecting these minority and low-income populations.

Based on the foregoing, the staff concludes that the offsite impacts of construction and operation of the new units at the Surry site to minority and low-income populations would be SMALL. No disproportionately high and adverse impacts affecting minority and low-income populations were identified.

8.6 Evaluation of the Portsmouth Site

Dominion identified a 138-ha (340-ac) parcel of land in the northeastern portion of the Portsmouth site in Ohio as a possible location for two commercial nuclear units (Dominion and Bechtel 2002). The parcel has been evaluated by DOE and slated for transfer from DOE to the Southern Ohio Diversification Initiative for possible reindustrialization (66 FR 64963).

For this evaluation, the following assumptions were made by the staff about locating the new units at the Portsmouth alternative site:

- The units would use closed-cycle cooling.
- Natural- or mechanical-draft cooling towers would be employed.
- Groundwater would be the source of cooling water (indirectly from the Scioto River).
- The plant would discharge blowdown water to the Scioto River.
- The land-area needed for the site would be approximately 140 ha (340 ac).
- Additional transmission lines would be needed.

The Portsmouth site is located in Pike County, Ohio, approximately 35 km (22 mi) north of the Ohio River and 5 km (3 mi) southeast of the town of Piketon. The Portsmouth site vicinity is shown in Figure 8-3.

Pike County's largest community, Waverly, is about 16 km (10 mi) north of the Portsmouth site and has a population of about 4400 residents. The nearest residential center to the site is Piketon, which is about 5 km (3 mi) north on U.S. 23; its population in 2000 was approximately 1900 people. Additional population centers within 80 km (50 mi) of the plant are Portsmouth (population 20,909), 35 km (22 mi) south; Chillicothe (population 21,796), 43 km (27 mi) north; and Jackson (population 6184), 29 km (18 mi) east (Bechtel Jacobs 2003). Approximately 90 percent of Portsmouth site workers reside in Jackson, Pike, Ross, and Scioto Counties.

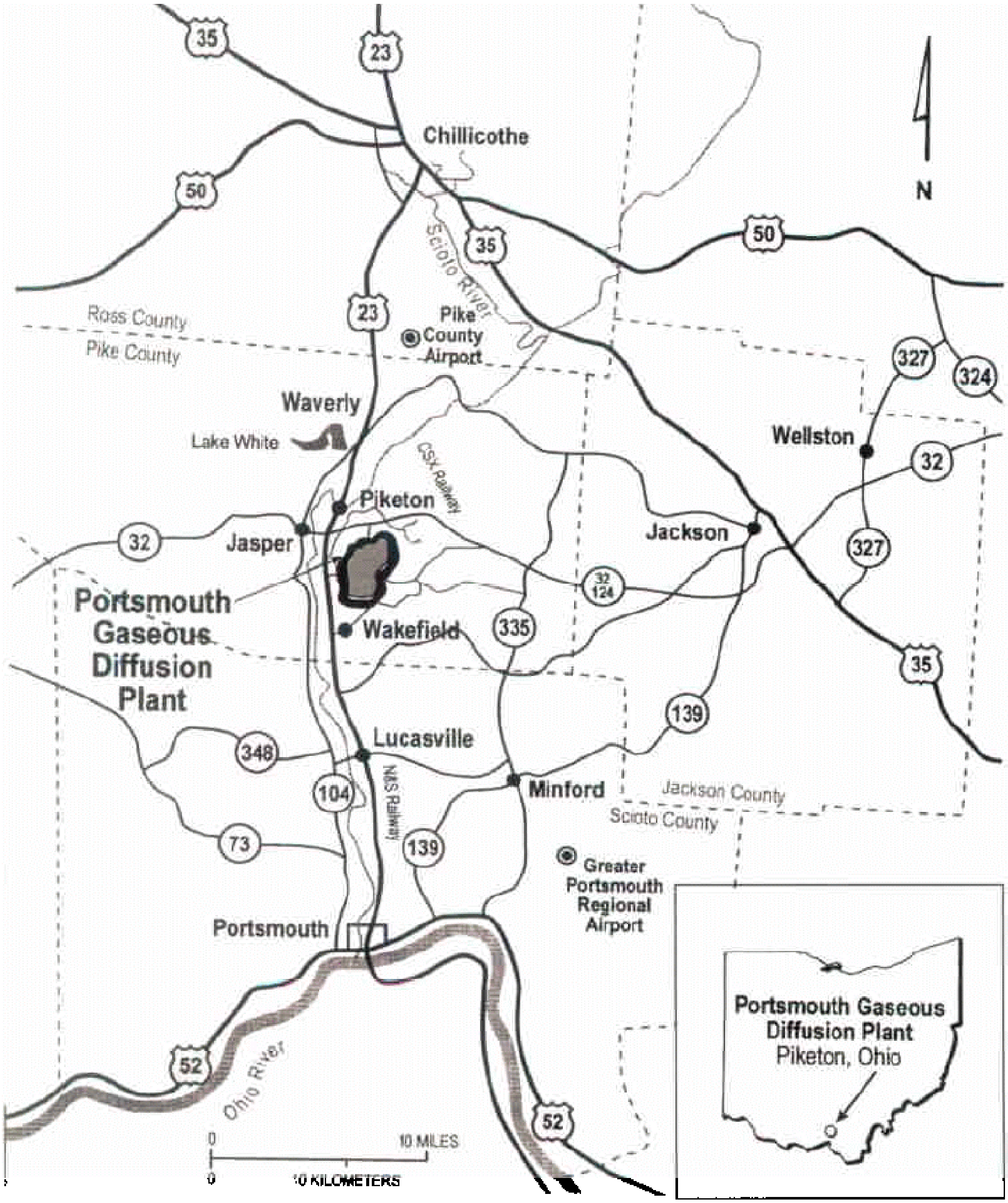

Figure 8-3. Portsmouth Gaseous Diffusion Plant Site Vicinity Map

In 2003, the estimated population of the four counties was 215,700 (DOE 2003). The primary facility at the Portsmouth site is the Portsmouth Gaseous Diffusion Plant, a gaseous diffusion uranium enrichment plant previously operated first by DOE until 1993 and since then by the United States Enrichment Corporation (USEC). Uranium enrichment operations were discontinued in May 2001, and the plant was placed in cold standby, a nonoperational condition in which the plant retains the ability to resume operations within 18 to 24 months.

In December 2002, USEC announced that the Portsmouth site will be the location for a Lead Cascade Demonstration Facility for advanced centrifuge enrichment technology (SAIC 2004). NRC has recently authorized possession and use of source and special nuclear material at the proposed enrichment facility (69 FR 3956). In addition, USEC announced on January 12, 2004, that the Portsmouth site was selected as the location for a new $1.5 billion advanced centrifuge commercial plant (referred to as the American Centrifuge Uranium Enrichment Plant), expected to be operational by the end of the decade (DOE 2003). USEC submitted a license application for this proposed facility to the NRC on August 23, 2004.

The Portsmouth site encompasses approximately 1500 ha (3714 ac), including a 320-ha (800-ac) fenced core area that contains the former production facilities. The 1180-ha (2914-ac) area outside the core area includes restricted buffers, waste management areas, plant management and administrative facilities, gaseous diffusion plant support facilities, and vacant land. The site is 3 km (2 mi) east of the Scioto River in a small valley that runs parallel to and approximately 37 m (120 ft) above the Scioto River floodplain (Bechtel Jacobs 2003). Wayne National Forest borders the plant site on the east and southeast, and Brush Creek State Forest is located to the southwest, slightly more than 1.6 km (1 mi) from the site boundary. On the basis of an analysis of Landsat satellite imagery from 1992, dominant land cover categories in Pike County include deciduous forest (64.6 percent), pasture/hay (21.6 percent), and row crops (10.3 percent) (DOE 2003).

Water for the Portsmouth site comes from an onsite water treatment plant that in turn draws water from offsite supply wells adjacent to the Scioto River. The Ohio Valley Electric Corporation supplies the site with electrical power.

The topography of the Portsmouth site area consists of steep hills and narrow valleys, except where major rivers have formed broad floodplains. The site is underlain by bedrock composed of shale and sandstone. The most common type of vegetation on the Portsmouth site is managed grassland, which makes up approximately 30 percent of the site or about 445 ha (1100 ac). Approximately 28 percent of the site is forested, predominately by stands of oak-hickory and mixed hardwood (DOE 2003).

The Portsmouth site is located in the humid continental climatic zone and has weather conditions that vary greatly throughout the year. The site is in a rural setting, and no residences or other sensitive locations (e.g., schools or hospitals) exist in the immediate vicinity of the site.

The Portsmouth site has direct access to major highway and rail systems, a nearby regional airport, and barge terminals on the Ohio River. Use of the Ohio River barge terminals requires transportation by public road to or from the Portsmouth site.

The site is located within the Western Allegheny Plateau ecological province (Omernik 1987). The hilly, forested areas of the 138-ha (340-ac) site were harvested for timber before the Portsmouth facilities were established. The eastern portion of the site has steep forested slopes while the central and western areas are composed mainly of old fields and managed grasslands that are not considered unique habitat or environmentally sensitive areas. Little Beaver Creek runs through the southwestern part of the 138-ha (340-ac) alternative site area and is identified as having riparian forest along its banks (DOE 2003). Oak-hickory forest borders the riparian forest. Other than Little Beaver Creek, there is only about 1 ha (2 ac) of wetlands within the alternative site. There is one Federally listed endangered species, the Indiana bat (*Myotis sodalis*), and one non-listed Federal species of concern, (the timber rattlesnake *Crotalus horridus*), that potentially could be found on the site.

The Portsmouth site itself has provided significant socioeconomic benefits for the surrounding communities over the last 50 years, including jobs with above-average salaries. DOE does not pay property taxes to the local communities around the Portsmouth site. However, it has provided $12.9 million in grants to the Southern Ohio Diversification Initiative. Other economic benefits include the collection of sales tax on uranium enrichment services. Sales, property, and income taxes have been paid over the years to Ohio and local governments by employees working at the site (Dominion and Bechtel 2002).

Major economic activities around Portsmouth consist mainly of farming, lumbering, and small businesses. Other industries include a cabinet manufacturer and an automotive parts manufacturer. The site itself has no prime agriculture lands. Sufficient public transportation (rail and road) is present to support activities at the site (Dominion and Bechtel 2002).

8.6.1 Land Use Including Site and Transmission Lines

The alternative ESP parcel at the Portsmouth site is irregular in shape. At its widest points, the parcel spans about 1737 m (5700 ft) in the north-south direction and about 1798 m (5900 ft) in the east-west direction. The parcel is in a mostly undisturbed part of the site. No hazardous substances have been stored, released, or disposed of on the parcel (Dominion and Bechtel 2002). The closest disturbed land is used by security personnel for training and as a firing range. The firing range is outside the 138-ha (340-ac) parcel, but is adjacent to the parcel's boundary lines. The location of the 138-ha (340-ac) parcel is shown in Figure 8-4. Two commercial nuclear units sited at the Portsmouth site would need to have an exclusion area that meets NRC requirements (10 CFR 100.21(a)). The exclusion area is the area surrounding the reactor within which the reactor licensee has the authority to determine all activities, including exclusion or removal of personnel and property from the area (10 CFR 100.3).

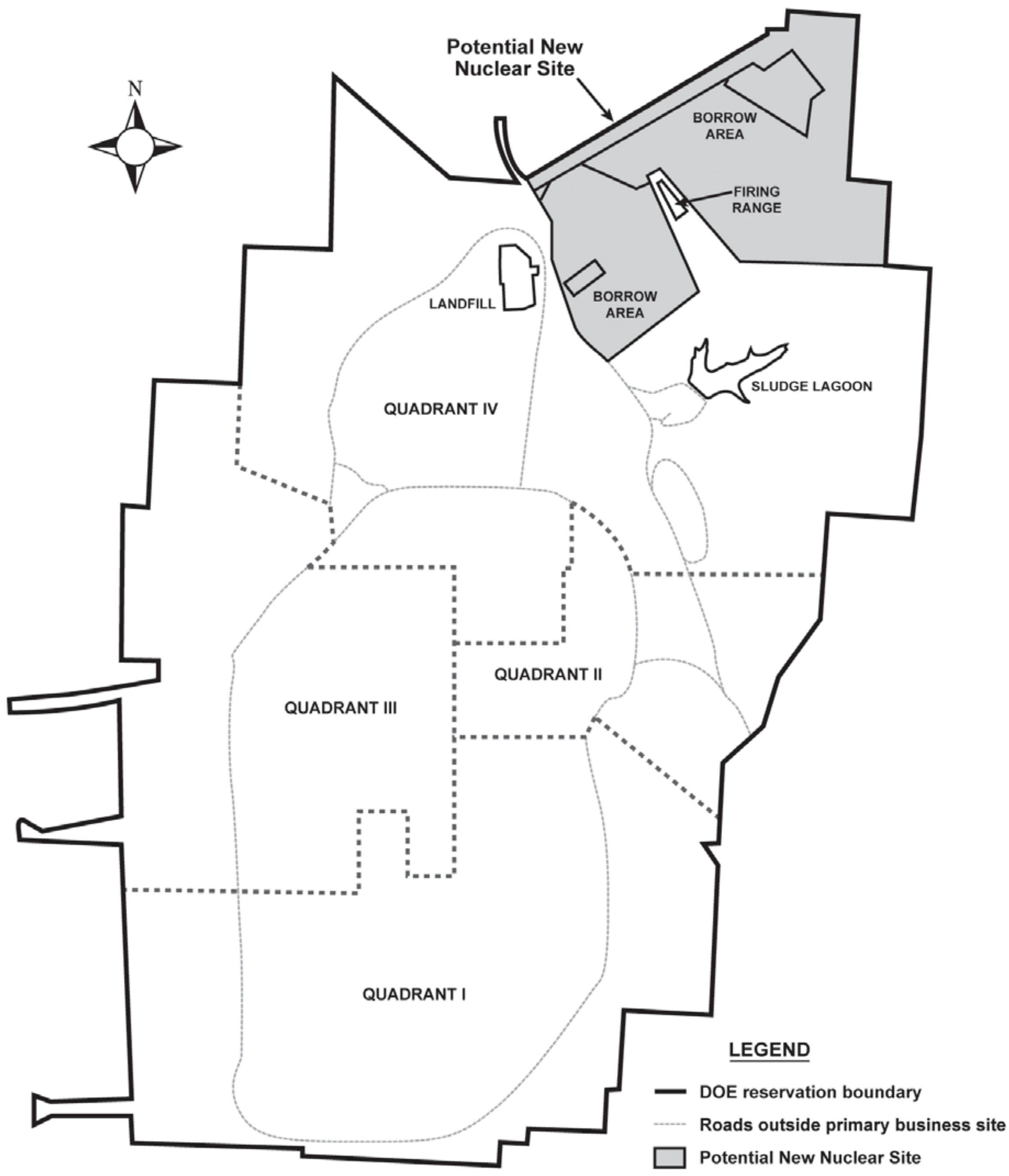

Figure 8-4. Potential New Nuclear Station Site at Portsmouth

Six wetland areas comprise approximately 1 ha (2 ac) within the 138-ha (340-ac) parcel (66 FR 64963). Five of these areas are ditches within a borrow area. The remaining wetland is associated with a previously disturbed natural area. Dominion determined that construction activities could take place without affecting the wetland areas (Dominion and Bechtel 2002).

Land within 8 km (5 mi) of the Portsmouth site is used primarily for farms, forests, and urban or suburban residences (Dominion and Bechtel 2002). About 10,291 ha (25,430 ac) of farmland, including cropland, wooded lots, and pasture, are within 8 km (5 mi) of the site. The cropland is mostly found on or adjacent to the Scioto River floodplain and is farmed extensively, particularly with grain crops. The hillsides and terraces are used as pasture for both beef and dairy cattle. There are no state or national parks, conservation areas, wild and scenic rivers, or other areas of recreational, ecological, scenic, or aesthetic importance within the immediate vicinity of the Portsmouth site. There are approximately 9874 ha (24,400 ac) of forestland within 8 km (5 mi) of the site. This land includes some commercial woodlands and a small portion of Brush Creek State Forest. A relatively small area of urban land, about 206 ha (510 ac), is also within 8 km (5 mi) of the Portsmouth site. This land is situated primarily in and around Piketon, approximately 5.6 km (3.5 mi) north of the center point of the site.

The Portsmouth site is about 113 km (70 mi) south of Columbus, Ohio, and 121 km (75 mi) east of Cincinnati, Ohio, the two closest metropolitan areas. Huntington, West Virginia, is approximately 140 km (87 mi) southeast of the site. The cities of Portsmouth, Jackson, and Chillicothe, Ohio, are approximately 40 km (25 mi) from the facility (south, east, and north, respectively). There are numerous small towns within 80 km (50 mi) of the site. Together, these communities could supply an adequate workforce for construction of new generating units and are within a 2-hour commuting distance via local transportation routes (Dominion and Bechtel 2002). The regional transportation network consists of two major highways, U.S. Route 23 and SR 32, and numerous state routes including SRs 35, 52, 124, and 139. Offsite land-use impacts associated with construction of new nuclear generating units are likely to be relatively limited, given the temporary nature of the construction. Construction of new rental housing and/or new manufactured home and recreational vehicle parks could be expected to accommodate construction workers.

The majority of current Portsmouth workers live in Scioto and Pike Counties and in the city of Portsmouth, which is the county seat of Scioto County (DOE 2003). The staff assumed that workers at two units located at the Portsmouth site would also primarily live in Scioto and Pike Counties. Some new housing in Scioto and Pike Counties plus surrounding communities would likely be constructed to accommodate permanent workers at the new units. The property tax revenue from the new units could affect future land use in the area surrounding the plant as a result of infrastructure improvements made possible by the tax revenue.

Based on the foregoing, the staff concludes that the land-use impacts on the site and in the vicinity of construction and operation would be SMALL.

An extensive existing electric power transmission system serves the Portsmouth site. During previous full-power operations of the enrichment facility, the site imported approximately 1900 MW(e) of power with a reported system capacity of approximately 2260 MW(e) (Dominion and Bechtel 2002). One or more relatively short transmission lines (approximately 900 m [3000 ft]) could be used to connect to the existing transmission system serving the Portsmouth site. Transmission lines that would be constructed to connect new power reactors with the existing Portsmouth transmission system would primarily cross previously developed industrial lands within the boundaries of the Portsmouth site (Dominion and Bechtel 2002). Otherwise, relatively little land would be altered for the construction of the new lines. Accordingly, the staff concluded that the overall impacts of constructing new lines and operating and maintaining them would be SMALL.

8.6.2 Water Use and Quality

Whether the consumptive water use for new nuclear units at the Portsmouth site would be provided indirectly from the Scioto River aquifer via groundwater wells or directly from the river itself, the consumptive water use for a power reactor at the Portsmouth site would impact the Scioto River. Groundwater in the aquifer is directly connected to the Scioto River. The aquifer is a major source of water to domestic, industrial, and agricultural users in the region.

The staff reviewed streamflow records reported by the USGS for stream gauge 03231500 (Scioto River at Chillicothe, Ohio). This gauge reflects runoff from a drainage of 9969 km^2 (3849 mi^2) and has data for the period from 1921 to present. Using these data, the staff independently estimated the lowest 7-day discharge for low water condition that is estimated every 10 years (7Q10) and the lowest 30 days of flow in an average year (30Q2) values. For this gauge, the 7Q10 was estimated to be 5.72 m^3/s (202 cfs) and the 30Q2 was estimated to be 11.4 m^3/s (403 cfs). The 7Q10 provides an estimate of the short-term, low-flow conditions in a dry year. The 30Q2 provides an estimate of the intermediate-term low-flow conditions in an average year.

The maximum make-up water flow rate for a single unit is estimated in the PPE as 2.78 m^3/s (98.0 cfs); however, the portion of the flow not evaporated is ultimately returned to the river as blowdown flow. Based on the PPE, the maximum evaporation for a single unit using mechanical draft cooling towers is 1.23 m^3/s (43.5 cfs). For either one or two units, this represents a significant fraction of both the 7Q10 and the 30Q2 values. Some mitigation, such as aquifer recharge, offstream storage, etc., may be warranted to limit the impacts to other water users in the region. Therefore, the staff estimates water use impacts at the Portsmouth site during construction would be SMALL, and during operation would be SMALL to MODERATE except during drought years when the impact is expected to be MODERATE. Discharge of thermal and chemical effluents would be regulated by the State of Ohio's National Pollutant Discharge Elimination System (NPDES) permitting process to limit water quality impacts to the Scioto River. Therefore, the staff concludes that water quality impacts during construction and operation would be SMALL.

8.6.3 Terrestrial Resources Including Endangered Species

Site preparation and construction of one or more nuclear reactor units at the Portsmouth alternative site would result in the loss of wildlife habitat in the developed portion of the approximately 140 ha (340-acre) site. In general, the types of habitat that would be lost are relatively common in south-central Ohio, and are not considered to be unique or sensitive. Less than 0.4 ha (1 ac) of wetlands would be disturbed for the development of this site (Dominion and Bechtel 2002). Site development would have the potential to result in erosion, dust generation, and noise impacts that are typical of large construction projects. These could be mitigated using standard methods of erosion control, dust suppression, and noise abatement.

Site development could result in the loss of habitat for several Federally or State-listed species (Table 8-4). The Indiana bat (*Myotis sodalis*) could inhabit the riparian forest along Little Beaver Creek, while the rough green snake (*Opheodrys aestivus*) and sharp-shinned hawk (*Accipiter striatus*) may inhabit the forested portions of the Portsmouth site. The timber rattlesnake (*Crotalus horridus*) has not been observed on the Portsmouth site, but is believed to occur in the vicinity. DOE has indicated that additional field surveys and evaluations would be needed prior to development of this location (Dominion and Bechtel 2002).

Development of the site could adversely affect at least two Ohio State-listed plant species, the Virginia meadow-beauty (*Rhexia virginica*) and the Carolina yellow-eyed grass (*Xyris difformis*). Evaluations for these species would be necessary prior to site development. Pending site-specific surveys for Federally and State-listed species, site preparation and construction within the Portsmouth alternative site would not result in noticeable or destabilizing impacts to the terrestrial ecology of the site. Therefore, pending more detailed evaluations of threatened and endangered species, the construction impacts would be SMALL. If the Federally or State-listed animal species are observed at the site, the impacts could be larger.

If new reactor units were constructed at the Portsmouth alternative site, it would be expected that very little usable habitat would remain within the site. Operation of the facility would likely result in noise generation, and if wet cooling towers were employed, there could be impacts caused by salt drift, icing, fogging, and bird collisions. Noise is likely to be typical of operating reactor units and cooling towers, which has been found to have a minimal impact in most instances (NRC 1996). There are no sensitive habitat areas adjacent to the Portsmouth site that would be adversely affected by noise from plant operations. The terrestrial vegetation in the vicinity of the site is not believed to be unusually sensitive to salt drift, fogging, or icing (Dominion and Bechtel 2002). Bird collision impacts would not be expected to be different from

Table 8-4. Federally and State-Listed Threatened or Endangered Terrestrial Species Potentially Near the Portsmouth Alternative Site

Scientific Name	Species	Federal Status	State Status
Mammals			
Myotis sodalis	Indiana bat	E	E
Birds			
Accipiter stiatus	sharp-shinned hawk		E
Reptiles			
Crotalus horridus	timber rattlesnake		E
Opheodrys aistivus	rough green snake		S
Plants			
Rhexia virginica	Virginia meadow-beauty		P
Xyris difformis	Carolina yellow-eyed grass		E

E = endangered, S = Special concern, P = potentially threatened.
Source: DOE 2003.

most other power plants (NRC 1996). Based on the foregoing, the staff concludes that the impacts of operation of one or more reactor units at the Portsmouth alternative site on terrestrial ecosystems would be SMALL.

Transmission lines that would be constructed to connect new power reactors with the existing Portsmouth transmission system would primarily cross either industrial lands or early-successional plant communities that are not considered to be unique in the region or otherwise sensitive. One exception is the potential for Indiana bats to inhabit the riparian zone along Little Beaver Creek. Additional evaluations and habitat preservation precautions may be necessary if the transmission lines cross this habitat. Otherwise, very little land would be altered for the construction of the new lines, and the overall impacts of constructing new lines would be minimal and would be similar to those of the construction of the reactor units.

Dominion has not indicated the specific maintenance procedures that would be followed for the new transmission lines, but they would likely include regular mowing and herbicide applications as needed. The primary area of potential concern is whether the lines must cross Little Beaver Creek, where precautions to protect Indiana bats and their habitat may be required. Additionally, there are at least two rare plant species (Table 8-4) that could occur within transmission lines rights-of-way and could therefore be affected by transmission line maintenance. Additional evaluations for the Indiana bat and rare plant species would be needed. Otherwise, because the transmission lines that would be needed are short, entirely within the bounds of the Portsmouth site and cross areas that have been previously disturbed, the impacts of operation and maintenance of the transmission line system on the terrestrial ecology would be expected to be minimal. No special mitigation measures would be warranted, except protection of the riparian zone along Little Beaver Creek and conservation of rare plant species, if present.

Based on the foregoing, the staff concludes that the overall impact on terrestrial ecological resources of the construction and operation of two commercial nuclear units and associated cooling systems and transmission facilities at the Portsmouth alternative site would be SMALL, pending additional surveys for threatened and endangered species within the construction area or transmission line rights-of-way. If such species were found, some mitigation measures may be warranted.

8.6.4 Aquatic Resources Including Endangered Species

The aquatic resources near the Portsmouth site would not be expected to be impacted by the construction and operation of two commercial nuclear units. The water used for cooling at Portsmouth would be withdrawn from groundwater wells. The cooling water would be expected to be discharged to the Scioto River. Discharge limits would be controlled by Federal and State regulations for protection of the river. Based on the foregoing, the staff concludes that the overall impact on aquatic ecological resources (including threatened and endangered species) of construction and operation of two commercial nuclear units and associated cooling towers and transmission facilities at the Portsmouth site would be SMALL.

8.6.5 Socioeconomics, Historic and Cultural Resources, Environmental Justice

The potential impacts on socioeconomics, historic and cultural resources, and environmental justice from construction and operation of two units at the Portsmouth site were evaluated using a reconnaissance survey of the site. That is, readily obtainable data from the Internet or published sources were used in the evaluation, and no new data were collected. The subsections that follow reflect the organizational structure of the socioeconomic discussions found in Sections 2.8, 4.5, and 5.5. The impacts resulting from both construction and operation of two units are addressed.

8.6.5.1 Physical Impacts

Construction activities can cause temporary and localized physical impacts due to matters such as noise, odor, vehicle exhaust, vibration, shock from blasting, and dust emission. The use of public roadways, railways, and barges would be necessary to transport construction materials and equipment to the site. SR 32 and U.S. Route 23 appear to be well maintained and have been used for transporting heavy loads in the past (Dominion and Bechtel 2002). The staff expects that all construction activities would occur within the boundaries of the Portsmouth site. Offsite areas that would support construction activities (e.g., borrow pits, quarries, disposal sites) are expected to be already permitted and operational. Impacts on those facilities from constructing two nuclear units would be small incremental impacts associated with their normal operation.

Potential impacts from station operation could result from matters including noise, odors, exhausts, thermal emissions, and visual intrusions. Noise would be produced from the operation of cooling towers, pumps, transformers, turbines, generators, and switchyard equipment, and from traffic. Dominion states in its ER that any noise coming from the North Anna ESP site would be controlled in accordance with applicable local county regulations. By inference, this is also expected to apply to the Portsmouth site. Good road conditions and appropriate speed limits would minimize the noise level generated by the workforce commuting to the Portsmouth site.

The nuclear units would be expected to have emissions from auxiliary power systems and standby diesel generators. It is expected that the combined annual emissions of any pollutant would be less than 91 MT/yr (100 tons/yr) (Dominion and Bechtel 2002). Air permits acquired for these generators would ensure that air emissions comply with regulations. Paved access roads and appropriate speed limits would minimize the amount of dust emissions generated by the commuting workforce.

The nuclear facility with its two units and associated buildings and its cooling towers and associated plume would change the landscape and would be visible from the sparsely populated area north of the site. These impacts would range from SMALL to MODERATE.

Based on the foregoing, the staff concludes that the physical impacts of construction and operation would be SMALL to MODERATE. Construction activities would be temporary and occur mainly within the boundaries of the Portsmouth alternative site. Offsite impacts would represent small incremental changes to offsite services supporting construction activities. During station operations, noise levels would be managed to meet local ordinance requirements. Air quality permits would be required for equipment such as diesel generators and auxiliary boilers, which should limit air emissions and ensure that applicable standards are met.

8.6.5.2 Demography

The Portsmouth site is located in Pike County, Ohio, approximately 35 km (22 mi) north of the Ohio River and 5 km (3 mi) southeast of the town of Piketon. Pike County's largest community, Waverly, has a population of 4433 residents. The nearest residential center to the site is Piketon with a population of 1907. Additional population centers within 80 km (50 mi) of the plant are Portsmouth (population 20,909), 35 km (22 mi) south; Chillicothe (population 21,796), 43 km (27 mi) north; and Jackson (population 6184), 29 km (18 mi) east. Approximately 90 percent of Portsmouth site workers reside in Jackson, Pike, Ross, and Scioto Counties. The population for the four counties in 2000 was 212,876 (USCB 2000b).

Most of the construction and operations workforce are expected to come from within the region, and those who might relocate to the region would represent a small percentage of the larger population base. Those who do relocate to the region would most likely take up residency across the region. Based on the foregoing, the staff concludes that any environmental impacts caused by population increases within an 80-km (50-mi) radius of the Portsmouth site attributable to construction or operation of two units would be SMALL.

8.6.5.3 Community Characteristics

Economy

Economic activities near the Portsmouth site consist primarily of farming, timber harvesting and processing, and small businesses. The only significant industry in the vicinity is an industrial park south of Waverly. Industries include a cabinet manufacturer and an automotive parts manufacturer (Dominion and Bechtel 2002).

The unemployment rate in Ohio was 6.1 percent as of July 2004. At that time, the unemployment rates in Jackson, Pike, Ross, and Scioto Counties were 9.2, 8.3, 7.8 and 8.5 percent, respectively (ODJFS 2004). This data indicates that this area of Ohio has not fully recovered from the recession of 2001. The Portsmouth site itself has provided significant socioeconomic benefits for the surrounding communities over the last 50 years, providing jobs that paid above average wages and salaries. The overall economic impacts of constructing and operating two units at the Portsmouth alternative site would be beneficial to the local economy.

Dominion estimates it would take approximately 5000 construction workers more than 5 years to build two nuclear units at the Portsmouth site. The Portsmouth site would draw its workers from the tri-state area of southern Ohio, northern Kentucky, and western West Virginia. The construction workforce in this region is estimated to be 491,265.[a]

Except for electricians, skilled craft workers in the Portsmouth area are reported as fully employed. The concentration of industrial facilities within this region (e.g., oil refineries and steel mills) provides yearly employment for the building trades. This could present significant competition for manpower if this site were selected for construction of new nuclear units. Moreover, this area has a reputation as a complicated labor environment, and the shutdown of the Portsmouth enrichment facility operations has contributed to this climate (Dominion and Bechtel 2002).

(a) The estimate is based on a methodology explained in Dominion and Bechtel (2002) and updated using 2000 census data.

The Portsmouth site currently provides employment for more than 1800 people. The site employs a highly skilled workforce with decades of nuclear-related experience. During the last several years, Portsmouth has undergone a major downsizing. Dominion would need approximately 720 new employees to operate two new nuclear units. The addition of commercial nuclear generation would be expected to add jobs of similar or higher quality to the existing workforce, many of which could be filled by current or former Portsmouth site employees (Dominion and Bechtel 2002).

Based on the foregoing, the staff concludes that there appears to be a large supply of construction workers but a limited availability of skilled craft workers. Dominion may have to recruit from outside the region to fill its requirements for skilled craft workers. Employees for station operation would be expected to be available from within the region because of the downsizing of the Portsmouth site workforce.

Based on the foregoing, the staff concludes that the beneficial impacts of station construction and operation on the economy of the region would be SMALL everywhere in the region except Pike County, where the beneficial impact level on the region would be MODERATE. The magnitude of the economic impacts would be diffused in the larger economic bases of the region; whereas, within the smaller economic base of Pike County and given the fact the new units would be located in the county, the economic impacts could be more noticeable and have a greater beneficial impact.

Taxes

The State of Ohio has a 5-percent sales tax. In addition to the State sales tax, each county in Ohio has a county sales tax. Jackson, Ross, and Scioto Counties each have a sales tax rate of 1.5 percent, and Pike County has a sales tax rate of 1 percent (NRC 2004). Sales taxes would be paid from the sales of construction materials and supplies purchased for the project. The State of Ohio has a personal income tax rate with a top marginal rate of 5.2 percent for incomes in excess of $40,000 (NRC 2004).

The average property tax rates for Ohio cities are divided into three separate classifications: Class I Real (residential and agricultural); Class II Real (commercial, industrial, mineral, and public utility); and Class III Tangible Personal (general and public utility) (NRC 2004). For Waverly in Pike County, the rate was $0.07412 per $1000 for all three classifications in 2001; for Portsmouth in Scioto County, the rate was $0.06013 per $1000 for all three classifications in 2001; for Wellston in Jackson County, the rate was $0.05500 per $1000 for all three classifications; and for Chillicothe in Ross County, the Class I rate was $0.05407, the Class II rate was $0.05394, and the Class III rate was $0.05402 per $1000. Finally, because the units would be built by a private company (Dominion) and not DOE, a property tax might be levied on the value of the property that hosts the units as they are constructed and on the appraised value of the units once construction is completed and the units are brought online. These taxes would most likely go to Pike County.

DOE does not pay property taxes to the local communities around the Portsmouth site. However, DOE has provided $12.9 million in grants to the Southern Ohio Diversification Initiative. Other economic benefits include the collection of sales tax on uranium enrichment services. Adding commercial nuclear capacity at the Portsmouth site would be expected to increase the tax base for these localities for the life of the two units (Dominion and Bechtel 2002).[a]

Workers living outside Ohio and commuting to Portsmouth likely will have to pay income taxes to their state of residence (West Virginia and Kentucky). They may also have to pay sales taxes to the State and local governments in the region where sales take place and property taxes to the counties in which they might own a residence.

Based on the foregoing, the staff concludes the overall beneficial impacts of construction and operation of the new facility on taxes collected in the region through the income, sales and use, and property taxes (except for Pike County) would be SMALL. The taxes paid, while substantial, are nevertheless a small sum when compared to the total amount of taxes collected by states and local governments in the region. For property taxes for Pike County, the staff considers the overall beneficial impacts of the property taxes collected would be MODERATE (construction) and LARGE[b] (operations) relative to the total amount of taxes the county collects through property taxes.

Transportation

Two major highways serve the Portsmouth site: U.S. 23 and SR 32. At their nearest points, these highways run within 1.6 km (1 mi) of the site. Access to the site is by the main access road, a four-lane interchange with U.S. 23, and the north access road, which initially is a two-lane road that transitions to four lanes with SR 32. SR 32 and U.S. 23 both appear to be well maintained and have been used for the transport of heavy loads (Dominion and Bechtel 2002).

(a) The site would not be on land owned by Dominion. Most likely, should the Portsmouth site be chosen for the new plant, the site for the new units would be leased to Dominion by DOE.

(b) The derivation of this impact is based on the fact that the fiscal year 2003 amount of property taxes collected in Pike County was $9,878,000 (Burton in Jaksch and Scott 2005). For comparison, NAPS Units 1 and 2 pay approximately $10 million in annual property tax to Louisa County (the actual amount that nuclear utility would pay to Pike County would depend on assessed value and millage rate per thousand of assessed value). On the assumption that there is a rough comparison between what Dominion pays to Louisa County and what they might pay to Pike County, it can be concluded that the potential percentage of a nuclear facility's property taxes to the total of all property taxes paid in Pike County would be significant

As previously mentioned, constructing the two units would employ a construction workforce of 5000. Operating two nuclear units would employ an operations workforce of 720. During the Portsmouth site operational period, between the 1970s and 2001, the total workforce numbered about 5000 at its peak. Currently 1800 people work at the site. Based on this previous peak, nearby access roads should be capable of supporting both construction and operations commuter traffic at this level with some roadway upgrades and traffic signal improvements. In addition, there are adequate transportation routes in the area to handle transportation of bulk materials to and from the site (Dominion and Bechtel 2002).

Two major rail lines service the site: CSX and Norfolk and Southern. Both railways appear to be in excellent condition. Approximately 35 km (22 mi) south of the Portsmouth site, two main rail lines run east-west along the Ohio River. The river is used for barge transportation, so materials could be off-loaded from barges onto rail cars, making transportation to the Portsmouth site by either rail or road achievable (Dominion and Bechtel 2002).

Numerous airports are within 161 km (100 mi) of the site, including the airports at Columbus, Cincinnati, and Dayton, Ohio, and Charleston, West Virginia. All these airports conduct regular freight and passenger air services. In addition, there are numerous smaller airports in the immediate vicinity. Thus, air passenger service and freight service for shipment of small items via air are readily available (Dominion and Bechtel 2002).

The Portsmouth site is in a rural, low-population area. The regional transportation network is adequate for commuter and transient traffic in the area. The transportation system around the Portsmouth site was capable of handling 5000 workers during previous periods of peak operations. Based on the foregoing, the staff concludes that the transportation impacts of a construction or operating workforce on the transportation infrastructure would be SMALL.

Aesthetics and Recreation

There are no significant recreational or residential areas within 3 km (2 mi) of the Portsmouth alternative site. Mechanical-draft cooling towers or natural-draft towers could function as part of the new nuclear units' cooling system, which could produce visible plumes offsite. Nearby trees may serve as a visual buffer for the transmission facilities. The preferred location at the Portsmouth site is situated in an area with open terrain. Because the preferred site is close to the northeast corner of the existing site boundary, it is possible that any nuclear units would have an identifiable nuclear power plant view offsite (Dominion and Bechtel 2002), especially if natural draft towers were used for cooling.

Recreational facilities in the Portsmouth area include Brush Creek State Forest. Use of Lake White State Park is occasionally heavy and is concentrated on the 43 ha (107 ac) of land closest to the lake. The number of visitors in 1992 was 55,876 with a daily average of 153 (Dominion and Bechtel 2002).

The AP1000 reactor has a tall containment building, approximately 71 m (234 ft) above grade level. Natural-draft cooling towers would be about 170 m (550 ft) above grade and mechanical-draft towers would be about 18 m (60 ft) above grade. The design of the AP1000 containment building includes a hatch that determines the height that it must be above grade. This building would be expensive to redesign to allow the building to be placed lower in the ground. Thus, depending on the type of cooling tower chosen, the height of the AP1000 containment building could set the upper bound of what buildings would be visible from offsite.

There are no significant residential areas or recreational facilities within 3 km (2 mi) of the site. Plumes from mechanical-draft cooling towers could be visible offsite. Trees ordinarily serve as a visual buffer for the power transmission infrastructure. Based on the foregoing, the staff concludes that the impacts of construction and station operation on aesthetics at a wooded site would be SMALL. But the impacts could also be MODERATE, if the Portsmouth site is on a mostly undisturbed part of the site and on open terrain, enabling the reactors and the cooling towers and their plumes to be viewed from offsite.

Housing

In the four-county area of Jackson, Pike, Ross, and Scioto Counties, there were 89,026 housing units in 2000. Of these, 22,824 were rental units, 2150 of which were vacant, for an 8.6 percent vacancy rate (USCB 2000c). The Portsmouth site is about 113 km (70 mi) south of Columbus, Ohio, (population in 2000 of 711,470), and 121 km (75 mi) east of Cincinnati, Ohio, (population in 2000 of 331,285), which are the two closest metropolitan areas (USCB 2000b). Huntington, West Virginia (population 51,475), is approximately 140 km (87 mi) away to the southeast. These three cities have a total housing stock of 519,075, of which 256,326 are renter-occupied and 24,868 units are available for rent for a vacancy rate of 8.8 percent (USCB 2000c). Because it is not unusual for construction workers to commute up to 2 hours (one way) per day, there appears to be enough vacant rental housing to house those who might relocate to the region.

In the four-county area of Jackson, Pike, Ross, and Scioto Counties there were 58,246 owner-occupied housing units in 2000. In the four-county area, 1085 units were for sale, or 1.8 percent of the total of owner-occupied houses. In the three-city area of Columbus, Cincinnati, and Huntington, there were 218,258 owner-occupied housing units and 4778 units for sale, or 2.1 percent of total of owner-occupied houses (USCB 2000c). In both the local and larger metropolitan areas (i.e., Columbus, Cincinnati, and Huntington), the percentage of houses for sale in relation to owner-occupied housing is very low, indicating a fairly tight housing market.

The operations workforce is expected to come from current or former employees at the Portsmouth site. If, however, a substantial number of workers have to be recruited into the area, upward pressure on housing values could emerge. This assumption is based on the low number of homes for sale in the area and the fact that the workforce, which would be on the higher end of the salary scale when compared to other job classifications in the area, may tend to buy more upscale homes. In this case, the operational impacts could be moderate.

It is not unusual for construction workers to commute up to 2 hours (one way) per day to the job site, and many of the construction workers are assumed to already live within the region. There appears to be sufficient vacant rental housing to house those who might relocate to the region. If, as expected, most of the operations workforce have residences already in the region, then the impacts on housing because of station operation would be small. Based on the foregoing, and assuming the operations workforce comes from within the region, the staff concludes that the impacts to housing from construction and operation of the two units would be SMALL, and mitigation is not warranted.

Public Services

Water and Wastewater Treatment

The capacity of communities to absorb an increase in population depends on the availability of sufficient community resources, such as water and wastewater treatment. Two large metropolitan areas (Columbus and Cincinnati) are within 145 km (90 mi) of the site. Huntington, West Virginia, is approximately 140 km (87 mi) away. The cities of Portsmouth, Jackson, and Chillicothe, Ohio, are within about 50 km (30 mi) from the facility (south, east and north, respectively). There are numerous small towns within 80 km (50 mi) of Portsmouth. All these towns and cities are within a 2-hour commuting distance via local transportation routes of the site (Dominion and Bechtel 2002) and could provide public services such as water and wastewater treatment to the construction and operations workforce who might relocate to the area.

Many of the construction and operations workforce would come from within the region, and those that choose to relocate to the region would most likely take up residence throughout the region, thus placing minimal demands on the existing infrastructure. Based on the foregoing, the staff concludes that the impacts of the construction and operations workforces on water and wastewater treatment in the region would be SMALL.

Police, Fire, and Medical Facilities

The hospital nearest to the Portsmouth site is the Pike Community Hospital, located approximately 12.1 km (7.5 mi) north of the facility on SR 104 south of Waverly. No other acute-care facilities are located in Pike County. There is an urgent-care facility, Adena Health Center, also on SR 104 near the hospital. In addition, two licensed nursing homes are located near Piketon, and one nursing home is located in Wakefield; all are located within 8 km (5 mi) of the Portsmouth site (NRC 2004). Other medical facilities exist in Jackson, Chillicothe, and Waverly.

Several State, county, and local police departments provide law enforcement in the region (NRC 2004). Any additional demands on law enforcement services could potentially be met by the increased tax revenues available to support the services. There would most likely be a time delay between the demand for the services and the collection of the tax revenues, which could cause some short-term financial issues for the impacted jurisdictions.

Many of the potential construction and operations workforce probably already live within an 80-km (50-mi) radius of the region. There are a number of towns within a 2-hour commuting distance of the site. Any new workers relocating to the area would most likely have places of residency located throughout the region, which would not place an undue burden on any one jurisdictional entity's infrastructure. Based on the foregoing, the staff concludes that the impacts of the construction and operations workforce on police, fire and medical facilities in the Portsmouth area would be SMALL.

<u>Social Services</u>

In Ohio, social services at the state level are overseen by the Ohio Department of Jobs and Family Services. It develops and oversees programs and services designed to help Ohio residents become independent through education, employment, job skills, and training. A major responsibility of the department is to work with county departments of job and family services, child support enforcement agencies, and public children's services agencies to develop social service programs to strengthen families, protect children, and provide children with an opportunity for a better life. The Department also administers the unemployment and medicaid programs for Ohio. During construction, there could be increased demand for these social services.

Generally, construction and operation of new nuclear units at the Portsmouth site would be viewed as beneficial economically to the disadvantaged population segments served by the Department. The workforce associated with the new units would most likely be better paid than workers in other employment categories in the region. It is expected that, through the multiplier effect, the number of jobs that could be filled by the disadvantaged population would increase.

Construction and operation would have a beneficial economic impact to the economically disadvantaged population in the region, which should lessen the demand for social services. There could be an initial increase in demand for social services at the beginning of the construction period, but this is considered manageable and limited. Based on the foregoing, the staff concludes that the impacts of construction and station operation of two units at the Portsmouth site on social and related services would be SMALL.

Education

Twenty-four public school districts provide public education for approximately 36,000 students in the region. The two school systems nearest the Portsmouth site are in Pike and Scioto Counties. In 2002, the combined enrollment of these schools was approximately 2387 (NRC 2004). Within the same area, three facilities provide daycare or schooling for preschool-aged children and after-school care for school-aged children. Two of these facilities accommodate 390 children (NRC 2004).

Many in the potential construction and operating workforce probably already live within the region, and any new workers relocating to the area would most likely take up residency throughout the region. Based on the foregoing, the staff concludes that the impacts of construction and station operation on educational facilities and services as a result of construction and operation of two units would be SMALL.

8.6.5.4 Historic and Cultural Resources

The area of southern Ohio where the Portsmouth site is located contains evidence from each of the major prehistoric periods for eastern North America, including the Paleo-Indian, Archaic, Woodland, and Fort Ancient periods. In early historic times, the area was occupied by the Shawnee Tribe. The Euro-American historic period occupation in the vicinity began about 1800. DOE completed archaeological and historic architectural surveys in 1996 at the Portsmouth site. Consultation is ongoing with the Ohio State Historic Preservation Officer concerning the results of these surveys (DOE 2003). Consultations with the Shawnee Indian Tribe have not identified any traditional cultural properties or other resources of Native American cultural value at the site.

The DOE survey found three archeological sites near the 138-ha (340-ac) parcel. The three sites are northeast of the parcel (Dominion and Bechtel 2002). The closest site to the Portsmouth parcel is the Holt Cemetery, which is located about 183 m (600 ft) from the eastern boundary of the parcel. No national landmarks are near the Portsmouth site, and no properties presently on the National Register of Historic Places are within the Portsmouth site. The nearest National Register locations are Buzzardroost Rock and Lynx Prairie in Adams County, about 48 km (30 mi) southeast of the Portsmouth site.

Based on the foregoing, the staff concludes that the potential impacts on historic and cultural resources would be SMALL for construction at the Portsmouth site. Potential impacts from operation of two units at the Portsmouth alternative site would also be SMALL, because any such potential impacts would be identified and appropriate mitigation measures could be effected during the construction phase.

8.6.5.5 Environmental Justice

DOE recently performed an environmental assessment (DOE 2001) for the Portsmouth site as part of its winterization activities for placing the facility in cold standby. As part of that assessment, an evaluation of potential environmental justice impacts was conducted. DOE evaluated the distribution of minority populations in a four-county area around the Portsmouth site. DOE defined a minority population as any area in which minority representation was greater than the national average of 24.2 percent. In all four counties, minority populations are smaller than the national average. Hence, using this definition, environmental justice was not a concern (DOE 2001), nor is it a concern using the NRC criteria defined in 69 FR 52040 (which is different than that used by DOE – see Section 2.10). DOE then carried the analysis a step further and examined the minority populations in the census tracts closest to the site. None of the tracts closest to the site had minority representation greater than the national average of 24.2 percent (DOE 2001).

Individuals with incomes below the poverty level were identified in the four-county region. A low-income population included any census tract (1990 data) in which the percentage of people with income below the poverty level was greater than the national average of 13.1 percent (Dominion and Bechtel 2002). Nearly all (41 of 48) of the census tracts in the four-county area qualified as low-income populations, but none of the low-income populations would suffer disproportionate impacts as a result of the construction and operation of new nuclear units at the Portsmouth site.

Based on the foregoing, the staff concludes that the offsite impacts of construction and operation of two units at the Portsmouth alternative site on minority and low-income populations would be SMALL. No disproportionately high and adverse impacts were identified.

8.7 Evaluation of the Savannah River Site

Dominion selected a 100-hectare (250-acre) parcel of land in the northern portion of DOE's Savannah River Site as a possible location for two commercial nuclear units (Dominion and Bechtel 2002). For this evaluation, the following assumptions were made by the staff about locating nuclear units at the alternative site at the Savannah River site.

- The units would use closed-cycle cooling.
- Natural- or mechanical-draft cooling towers would be employed.
- Par Pond would be the primary and Savannah River would be the secondary source of cooling water.
- The existing intake structure is sufficient.

- Blowdown water would be discharged to the Savannah River or to Par Pond.
- The land area would be approximately 100 ha (250 ac).
- New transmission lines would be needed.

DOE's Savannah River Site occupies an area of approximately 800 km^2 (310 mi^2) adjacent to the Savannah River, in Aiken and Barnwell Counties, South Carolina. The site is approximately 40 km (25 mi) southeast of Augusta, Georgia, and 31 km (19.5 mi) south of Aiken, South Carolina. The site is bounded along its southwest border by the Savannah River for approximately 56 river km (35 river mi). The Savannah River Site vicinity is shown in Figure 8-5.

The average population density in the counties surrounding the site is approximately 85 people per square mile, with the largest concentration in the Augusta metropolitan area. Approximately 70 percent of the site employees live in South Carolina, primarily Aiken County, and 30 percent live in Georgia (Westinghouse 2001).

The U.S. Atomic Energy Commission, predecessor agency to DOE, established the Savannah River Site in the early 1950s. Historically, the mission of the site has been the production of special radioactive isotopes to support national programs. DOE produced these isotopes in five production reactors. After the material was produced at Savannah River Site, it was shipped to other DOE sites for further processing.

Approximately 73 percent of the surface area of the Savannah River Site is composed of open fields and upland forest. The forested areas consist primarily of upland pine and mixed hardwoods. The remaining area consists of wetlands, streams, and reservoirs (22 percent) and developed industrial and administrative areas (5 percent) (DOE 1999).

The Savannah River is the principal surface water system associated with the Savannah River Site. Five of its major tributaries (Upper Three Runs, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs) flow through and drain the site. The Savannah River is a domestic and industrial water source for the site and several downstream communities (the cities of Port Wentworth and Savannah in Georgia and Beaufort and Jasper Counties in South Carolina). In addition, the Vogtle Electric Generating Plant, located across the Savannah River from the Savannah River Site, uses water from the river for its cooling system (DOE 1999).

The southeastern United States has a humid subtropical climate characterized by relatively short, mild winters and long, warm, humid summers. Summer-like weather typically lasts from May through September. The humid conditions often result in scattered afternoon thunderstorms. Average seasonal rainfall is usually lowest during the fall (DOE 1999).

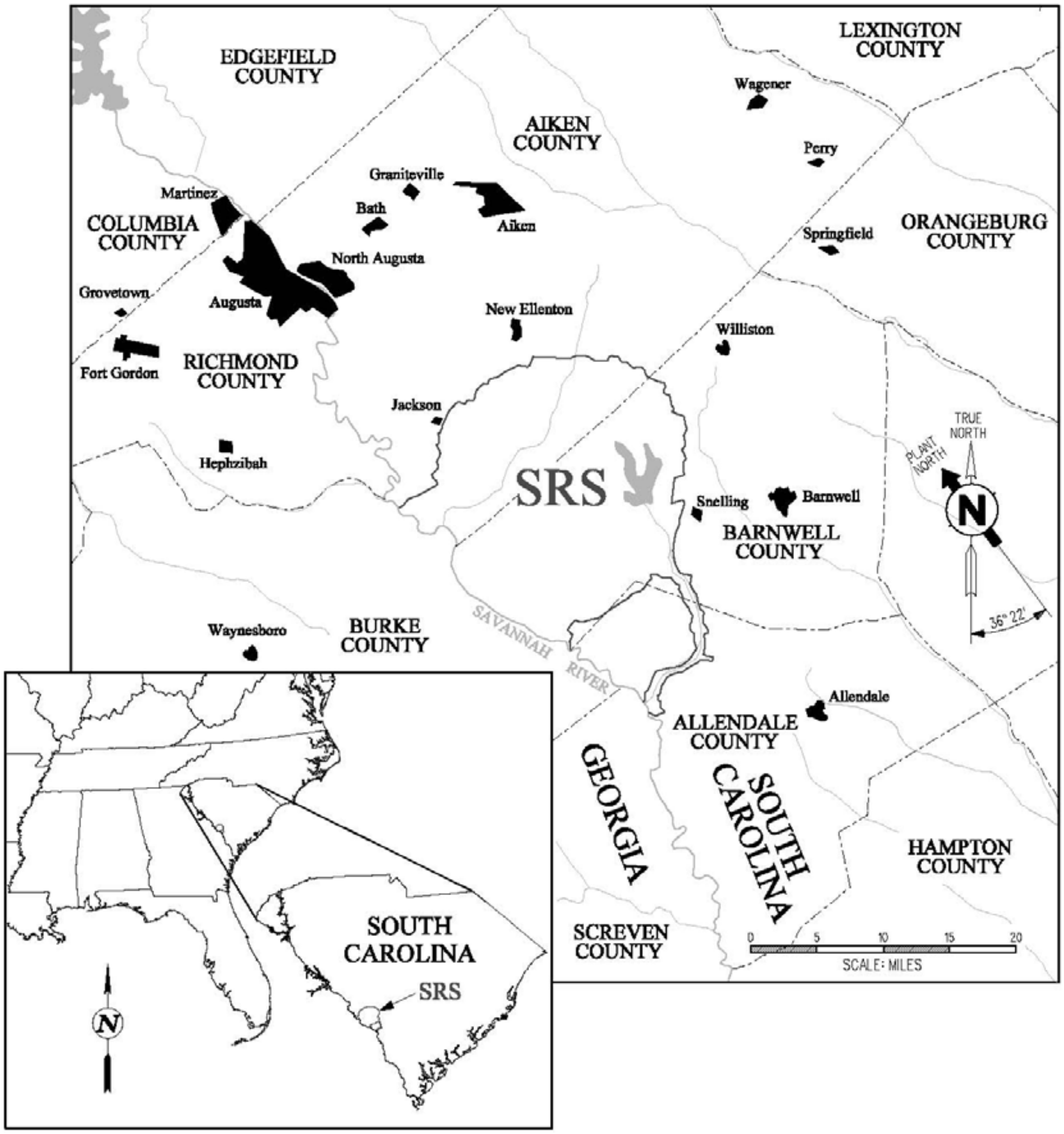

Figure 8-5. Savannah River Site Vicinity Map

The Savannah River Site is within the Southeastern Plains ecological province (Omernik 1987) near the transition between northern oak-hickory-pine forest and southern mixed forest. Thus, species typical of both associations are found on the Savannah River Site (DOE 1995). Farming, fire, soil, and topography have strongly influenced Savannah River Site vegetation patterns.

The Savannah River Site currently provides employment for more than 13,000 people, many of whom have nuclear facility training and who are highly skilled. Salaries are above average for the area. During the last decade, the Savannah River Site has undergone a major downsizing primarily because of the end of the Cold War. Because of downsizing, the Savannah River Site has contracted many nonclassified operations to private companies for support services (Dominion and Bechtel 2002).

The Savannah River Site itself has provided significant socioeconomic benefits for the surrounding communities over the last five decades. The facility injects about $1.5 billion annually into the economies of South Carolina and Georgia, the two states bordering the site. The facility provides thousands of jobs with above-average salaries, conducts environmental and nuclear technology research, and offers business development programs for local communities (Dominion and Bechtel 2002).

8.7.1 Land Use Including Site and Transmission Lines

The Savannah River Site has extensive undeveloped land that is potentially suitable for commercial nuclear power generation. DOE conducted a review of potential locations on the site for possible location of an accelerator for the production of tritium (DOE 1999). DOE identified six possible locations that satisfied its siting criteria. The preferred site from the DOE review is approximately 10.4 km (6.5 mi) from the Savannah River Site boundary, 5 km (3 mi) northeast of the Tritium Loading Facility, and north of Roads F and E (Dominion and Bechtel 2002). The site, which is divided by the boundary line between Aiken and Barnwell Counties, is bordered on the southwest by a 115-kV transmission line, a buried super-control and relay cable, and Monroe Owens Road. Three other secondary roads cross the site. The elevation of the site is 91 to 100 m (300 to 330 ft) MSL. Dominion has adopted the DOE site for the accelerator as an alternative site for new nuclear generation. For this analysis, the site boundaries are shown in the upper center portion of Figure 8-6, and the site is referred to as the Savannah River alternative site.

Dominion did not identify any current or possible future land-use restrictions that would prohibit the construction of new units on the Savannah River alternative site (Dominion and Bechtel 2002). DOE, however, would need to approve any such construction.

New nuclear generating units located at the Savannah River alternative site would need to have an exclusion area that meets NRC requirements (10 CFR Part 100). The exclusion area is the area surrounding the reactor within which the reactor licensee has the authority to determine all activities, including exclusion or removal of personnel and property from the area.

Section 307(c)(3)(A) of the Coastal Zone Management Act (16 USC 1456(c)(3)(A)) requires that applicants seeking a Federal permit to conduct an activity that affects a coastal zone area provide to the permitting agency a certification that the proposed activity complies with the enforceable policies of the state's coastal zone program. However, the Savannah River Site is not within the coastal zone of South Carolina for purposes of the Act (SCDHEC 2004).

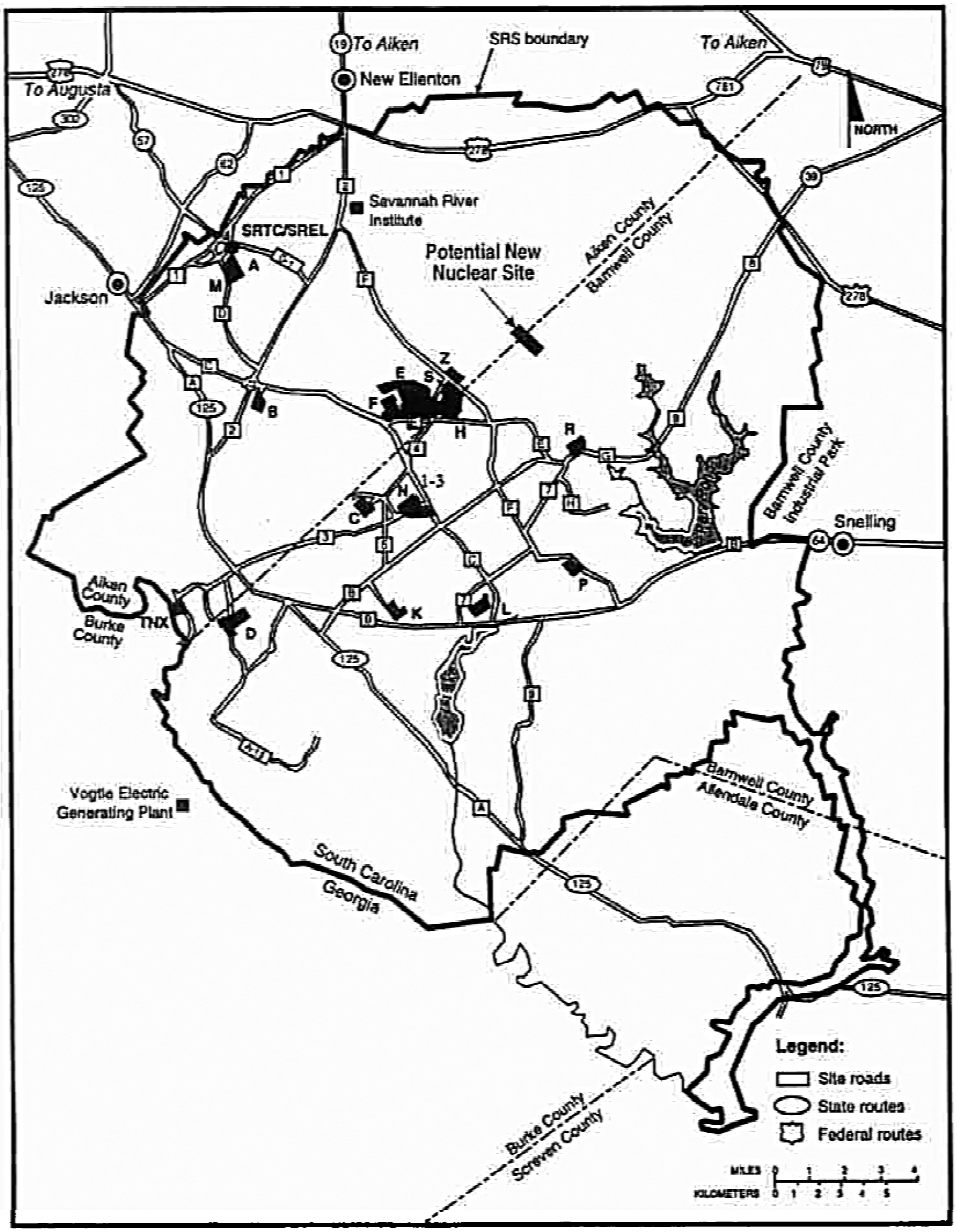

Figure 8-6. Potential New Nuclear Station Site within the DOE Savannah River Site

Approximately 90 percent of the workforce for the Savannah River Site lives in Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia. There are numerous small towns within 80 km (50 mi) of the site. These communities could supply an adequate construction and operating workforce and are within a 2-hour commuting distance via local transportation routes. Offsite land-use impacts associated with construction of two commercial nuclear units are likely to be relatively limited, given the temporary nature of the construction. Some new rental housing or new manufactured home and recreational vehicle parks would be expected to be constructed to accommodate construction workers.

The staff assumed that workers at new units that would be located at the Savannah River alternative site would live primarily in the aforementioned counties. Some new housing in these counties would likely be constructed to accommodate permanent workers at the new units. The property tax revenue from the new units could affect future land use in these counties as a result of infrastructure improvements made possible by the tax revenue. Based on the foregoing, the staff concludes that the land-use impacts of construction and operation are expected to be SMALL.

The transmission system on the Savannah River Site consists of multiple 115-kV transmission lines forming a ring network around the site. Three switching stations for the 115-kV transmission lines exist around the site to feed the different area loads. Construction of one or more new 500-kV transmission lines or several 230-kV transmission lines would be needed to transmit power from new nuclear units located on the site to the regional grid (Dominion and Bechtel 2002). Several options for transmitting the electrical output of new nuclear units were evaluated by Dominion. The likely option would be to construct transmission lines either to the west through the Savannah River Site, then cross the Savannah River to connect with the existing system near the Vogtle Nuclear Power Plant in Burke County, Georgia, or to a connection point approximately 97 km (60 mi) west of the Savannah River Site. Because the detailed routing of these transmission line rights-of-way are not known at this time, a detailed evaluation of the impacts to land use cannot be made. However, if a tie-in to the Vogtle Nuclear Power Plant is used, there would be minimal impacts to land use because most of the rights-of-way would be located on the Savannah River Site. The staff concludes that the land use impact of construction of new transmission capability at the Savannah River alternative site would likely be in the range of SMALL to MODERATE.

8.7.2 Water Use and Quality

The water consumed by the new units at the Savannah River alternative site would be pumped from Par Pond. In dry years, local inflows to Par Pond may be inadequate to offset consumption water demands for the new units. During such times, water to refill Par Pond would be pumped from the Savannah River. Therefore, new units at the Savannah River alternative site would impact the Savannah River. The staff reviewed streamflow records reported by the U.S. Geological Survey for stream gauge 02197000 (Savannah River at

Augusta, Georgia). This gauge reflects runoff from a drainage of 19,450 km^2 (7508 mi^2) and has provided data for the period from 1884 to 2001. Using these data, the staff independently estimated the lowest 7-day discharge for low water condition that is estimated every 10 years (7Q10) and the lowest 30 days of flow in an average year (30Q2) values. For this gauge the 7Q10 discharge was estimated to be 60.8 m^3/s (2150 cfs) and 30Q2 was estimated to be 130 m^3/s (4600 cfs). The 7Q10 provides an estimate of the short-term, low-flow conditions in a dry year. The 30Q2 provides an estimate of the moderate-term, low-flow conditions in an average year.

The maximum makeup water flow rate for a single unit is estimated in the PPE as 2.78 m^3/s (98.0 cfs); however, the portion of the flow not evaporated would ultimately be returned to the Par Pond as blowdown flow. Based on the PPE, the maximum evaporation for a single unit using mechanical-draft cooling towers would be 1.23 m^3/s (43.5 cfs). For either one or two units, this would represent a small fraction of both the 7Q10 and the 30Q2 values. Discharge of thermal and chemical effluents would be regulated by the State of South Carolina's NPDES permitting process to limit impacts to the Savannah River. Therefore, based on the foregoing, the staff concludes the impact of construction and operation of two units on water use and quality at the Savannah River alternative site would be SMALL. The staff concludes that water quality impacts during construction and operation would be SMALL.

8.7.3 Terrestrial Resources Including Endangered Species

The Savannah River alternative site is within the Southeastern Plains ecological province (Omernik 1987) near the transition between northern oak-hickory-pine forest and southern mixed forest. Thus, species typical of both associations are found on the site (DOE 1995). Farming, fire, soil, and topography have strongly influenced vegetation patterns at the Savannah River Site.

A variety of plant communities occur in the upland areas. Typically, scrub oak communities are found on the drier, sandier areas. Longleaf pine (*Pinus palustris*), turkey oak (*Quercus laevis*), bluejack oak (*Q. incana*), and blackjack oak (*Q. marilandica*) dominate these communities, which typically have understories of wiregrass (*Aristida stricta*) and huckleberry (*Vaccinium* spp.). Oak-hickory communities are usually located on more fertile, dry uplands; characteristic species are white oak (*Q. alba*), post oak (*Q. stellata*), red oak (*Q. falcata*), mockernut hickory (*Carya tomentosa*), pignut hickory *(C. glabra*), and loblolly pine (*P. taeda*), with an understory of sparkleberry (*V. arboreum*), holly (*Ilex* spp.), greenbriar (*Smilax* spp.), and poison ivy (*Toxicodendron radicans*) (DOE 1995).

Before the Federal government established the Savannah River Site, the area was mainly farmland that had been highly eroded. Approximately 90 percent of the site has been planted with loblolly, slash pine (*P. elliottii*), and hardwood trees. The Savannah River alternative site consists of mostly forested land, made up predominantly of loblolly and slash pine that have been planted since the late 1950s. The site is part of a designated forest timber unit under the Savannah River Site land-use system. The Savannah River Institute (formerly known as the Savannah River Forest Station) coordinates the removal and sale of marketable timber from the site (Dominion and Bechtel 2002).

The departure of residents in 1951 and the subsequent reforestation have provided the wildlife of Savannah River Site with excellent habitat. The site has extensive, widely distributed wetlands, most of which are associated with floodplains, creeks, or impoundments. In addition, approximately 200 Carolina bays occur on the site (DOE 1995). Carolina bays are unique wetland features of the southeastern United States.

Federally and State-listed rare, threatened, and endangered species, including the bald eagle, wood stork (*Mycteria americana*), and red-cockaded woodpecker (*Picoides borealis*), reside within the Savannah River Site. Federally and State threatened or endangered species potentially occurring in Aiken or Barnwell Counties are listed in Table 8-5. In addition to the species listed in Table 8-5, a large number of species, although not listed as threatened or endangered, are still of concern or interest to the U.S. Fish and Wildlife Service (FWS) (FWS 2004a, b) and/or the South Carolina Department of Natural Resources (SCDNR 2004).

Table 8-5. Federally and State-Listed Threatened or Endangered Terrestrial Species Potentially Occurring in Aiken and Barnwell Counties, South Carolina

Scientific Name	Species	Federal Status	State Status
Birds			
Haliaeetus leucocephalus	bald eagle	T	E
Mycteria americana	wood stork	E	E
Picoides borealis	red-cockaded woodpecker	E	E
Mammals			
Corynorhinus rafinesquii	Rafinesque's big-eared bat	SC	E
Amphibians			
Rana capito	gopher frog	SC	E
Reptiles			
Clemmys guttata	spotted turtle	--	T
Gopherus polyphemus	gopher tortoise	SC	E
Plants			
Trillium reliquum	relict trillium	E	E
Ptilimnium nodosum	harperella	E	E
Echinacea laevigata	smooth coneflower	E	E
Linderna melissifolia	pond berry	E	E
Oxypolis canbyi	Canby's dropwort	E	E
Schwalbea americana	American chaffseed	E	E

E = endangered, T = threatened, SC = species of concern.
Sources: FWS 2004a, b; SCDNR 2004.

Operation of new units would likely result in noise generation, and if wet cooling towers were employed, there could be impacts caused by drift, icing, fogging, and bird collisions. Noise would likely be typical of operating reactor units and cooling towers, which has been determined to be a SMALL impact in most instances (NRC 1996). There are no sensitive habitat areas adjacent to the Savannah River alternative site that would be adversely affected by noise from plant operations. The nearest bald eagles and wood storks are approximately 5 km (3 mi) distant. Red-cockaded woodpeckers have not been observed at the Savannah River alternative site, but could be deterred from using the area if there were increased noise and human activity.

The terrestrial vegetation in the vicinity of the Savannah River alternative site is not believed to be unusually sensitive to drift, fogging, or icing (Dominion and Bechtel 2002). Bird collisions would not be expected to be different from most other power plants (NRC 1996), and if mechanical-draft towers are selected, bird strikes are likely to be very rare. Overall, it would be expected that the impacts of operation of one or more nuclear units at the Savannah River alternative site on terrestrial systems would be minimal.

The actual routes of transmission lines that would connect new units at the Savannah River alternative site with the regional grid have not been determined (Dominion and Bechtel 2002). Maintenance of the transmission line rights-of-way could impact wetlands, threatened or endangered species habitat areas, or other sensitive ecological resources. Therefore, the potential impacts of construction, operation, and maintenance of the transmission line rights-of-way on terrestrial ecosystems cannot be determined without more detailed information concerning the location of the transmission line rights-of-way and the maintenance procedures that would be employed. However, large impacts could be avoided by careful route selection; therefore, the staff concludes the impact of construction on terrestrial resources (including threatened and endangered species) would be SMALL to MODERATE depending on the routing of the transmission line rights-of-way. Based on the foregoing, the overall impact on terrestrial resources including threatened or endangered species of operating two units and associated cooling systems at the Savannah River alternative site would be SMALL. Depending on the location of transmission line rights-of-way, the construction and operational impacts on threatened and endangered species could be SMALL to MODERATE.

8.7.4 Aquatic Resources Including Endangered Species

The aquatic environment at the Savannah River Site is associated with the Savannah River. The two main bodies of water onsite, Par Pond and L-Lake, were constructed to support site operations. Par Pond, which was constructed to provide cooling water for, and to receive heated cooling water from, P-Reactor and R-Reactor, has a surface area of about 1093 ha (2700 ac). The 405-ha (1000-ac) L-Lake was constructed to receive heated cooling water from L-Reactor. The Savannah River Site is bounded on its southwest border by the Savannah River for about 56 river km (35 river mi). Five major streams from the Savannah River Site feed into the river.

All the water for cooling is expected to be withdrawn from the Par Pond or the Savannah River. The cooling water blowdown would likely be discharged to Par Pond or the Savannah River. Because the expected cooling system would be a closed-cycle system, the impacts to aquatic resources would be expected to be minimal. The potential for impingement and entrainment of aquatic resources would be expected to be mitigated by the current operation of the intake structure. The potential impacts of heated water would be expected to be mitigated by the placement of the discharge structures.

There are two endangered species in the Savannah River alternative site. They are the shortnose sturgeon (*Acipenser brevirostrum*) and the fanshell (*Cyprogenia stegaria*). Both are protected under current management practices used by DOE at the Savannah River Site. The staff evaluated the potential impacts of operating new nuclear units, including operating the plants, cooling systems, and transmission systems on aquatic threatened and endangered species.

Based on the foregoing, the staff concludes that the overall impact on aquatic ecological resources, including threatened and endangered species, of construction and operation of two units and associated cooling towers and transmission facilities at the Savannah River alternative site would be SMALL.

8.7.5 Socioeconomics, Historic and Cultural Resources, Environmental Justice

In evaluating the socioeconomic impacts of constructing and operating two units at the Savannah River Site, the staff undertook a reconnaissance survey of the site. That is, readily obtainable data from the Internet or published sources were used in the evaluation, and no new data were collected. The subsections that follow reflect the organizational structure of the socioeconomic discussions found in Sections 2.8, 4.5, and 5.5. The impacts resulting from both construction and operation of the two units are addressed.

8.7.5.1 Physical Impacts

Construction activities can result in temporary and localized physical conditions such as noise, odor, vehicle exhaust, vibration, shock from blasting, and dust emissions that affect the environment. Further, the use of public roadways, railways, and waterways would be necessary to transport construction materials and equipment to the site. There would, as a result, be increased use of these infrastructures, both in terms of increased volume and type of vehicular traffic.

Road access to the Savannah River Site is via SR 125. U.S. 278 cuts through a portion of the Savannah River Site. Easy access to the Savannah River alternative site could be accommodated by installing access roads from U.S. 278. Most roads leading to the site are two-lane roads, but appear to be kept in excellent condition (Dominion and Bechtel 2002).

CSX Transportation, Inc., provides rail service to the Savannah River Site. Some upgrades would likely be needed to accommodate the large and heavy loads associated with construction of new nuclear units (Dominion and Bechtel 2002).

On the Savannah River, there is a barge slip situated on DOE property. This barge slip has been used in the past for heavy loads and large components such as steam generators. Shipment of heavy loads by barge to the Savannah River Site depends on the water level in the Savannah River. The Savannah River alternative site is on the opposite side of the property from the barge slip and some additional heavy-haul routes would need to be constructed to reach it (Dominion and Bechtel 2002).

All construction activities would likely occur within the boundaries of the Savannah River Site. Offsite areas that would support construction activities (e.g., borrow pits, quarries, disposal sites) are expected to be already permitted and operational. Impacts on those facilities from constructing new nuclear units are expected to be small incremental impacts associated with their normal operation. The alternative site is approximately 10.5 km (6.5 mi) from the Savannah River Site boundary (Dominion and Bechtel 2002).

Station operation could cause noise, odors, exhausts, thermal emissions, and visual intrusions. Noise would be produced by operation of cooling towers, pumps, transformers, turbines, generators, and switchyard equipment, and from traffic. The Savannah River Site is a Federal Reservation. Dominion would need to comply with State and local ordinances which apply to the Department of Energy (NCA 1972). Good road conditions and appropriate speed limits would minimize the noise level generated by the workforce commuting to the site. Nearby trees would serve as a visual buffer, minimizing visual effects.

The new units would be expected to have emissions from auxiliary power systems, standby diesel generators, and standby gas turbine generators (Dominion and Bechtel 2002). It is expected that the combined annual emissions of any pollutant would be less than 91 MT/yr (100 tons/yr) (Dominion and Bechtel 2002). Air quality permits acquired for these generators would ensure that air emissions comply with regulations. Paved access roads and appropriate speed limits would minimize the amount of dust generated by the commuting workforce. Impacts on visual aesthetics would be minimal because the identified site is near the middle of the Savannah River Site, 10.4 km (6.5 mi) from the site boundary.

Direct site-specific impacts from construction activities would be temporary and would occur mainly within the boundaries of the Savannah River Site. Offsite impacts would represent small incremental changes to offsite services supporting the construction activities. During station operations, noise levels would be managed to comply with State and local ordinances as required by Section 4(b) of the Noise Control Act (42 USC 4903). Air quality permits would be required for the diesel generators, auxiliary boilers, and other equipment, which should limit air emissions and meet applicable standards. Based on the foregoing, the staff concludes that the physical impacts of construction and operation of new units at the Savannah River alternative site would be SMALL.

8.7.5.2 Demography

The center of the Savannah River Site is approximately 40 km (25 mi) southeast of the city limits of Augusta, Georgia. The population for Augusta-Richmond County, Georgia, was 195,182 in 2000 (USCB 2000d). The site is 161 km (100 mi) from the Atlantic Coast, and about 175 km (110 mi) south-southeast of the North Carolina border. The largest nearby population centers are Aiken, South Carolina, with a population of 25,337 in 2000 (USCB 2000d), and Augusta, Georgia. The only towns within 24 km (15 mi) of the center of the Savannah River Site are New Ellenton, with a population of 2250; Jackson with a population of 1625; Barnwell with a population of 5035; Snelling, with a population of 246; and Williston with a population of 3307 (USCB 2000d). All of these towns are in South Carolina.

Most of the construction and operations workforce are expected to come from within the region (see more detailed discussion in Section 8.7.5.3), and those who might relocate to the region would represent a small percentage of the larger population base. Those who do relocate to the region would most likely take up residency across the region. Based on the foregoing, the staff concludes that any environmental effects caused by population increases within an 80-km (50-mi) radius of the Savannah River Site resulting from construction and operation of new units would be SMALL.

8.7.5.3 Community Characteristics

Economy

The unemployment rate in the Augusta-Aiken Metropolitan Statistical Area was 5.7 percent in June 2004 (Georgia Department of Labor 2004). This compares to a 4.6 percent unemployment rate for Georgia (Georgia Department of Labor 2004) and a 6.6 percent unemployment rate for South Carolina in June 2004 (South Carolina Employment Security Commission 2004). Regional unemployment statistics for selected South Carolina counties in the vicinity of the Savannah River Site include Barnwell County at 12.3 percent unemployment in June 2004 and Aiken County at 7.1 percent (South Carolina Department of Social Services 2004).

The Savannah River Site itself has provided significant socioeconomic benefits for the surrounding communities over the last 50 years, and currently provides employment for more than 13,000 people who are highly skilled workers, most of whom are college educated. Salaries are above average salaries of the area. The site injects about $1.5 billion annually into the economies of South Carolina and Georgia (Dominion and Bechtel 2002).

Dominion estimates it would take approximately 5000 construction workers over 5 years to build two commercial nuclear units (Dominion 2006). As discussed in the previous section on the economy, the Savannah River Site currently provides employment for more than 13,000 people. However, during the last decade, some loss of jobs occurred because of the end of the Cold War (Dominion and Bechtel 2002).

Construction of a nuclear generating facility would draw workers from South Carolina and Georgia. The estimated number of construction workers in the two-state region is approximately 459,725 (BEA 2000). With the extensive local transportation network in the area, nearby cities could supply an adequate workforce and are well within a 2-hour commuting distance of the Savannah River Site. Therefore, a minimal influx of project-related population during plant construction and operation could be expected (Dominion and Bechtel 2002).

Dominion would need approximately 720 new employees to operate a two-unit nuclear facility. The Savannah River Site currently provides employment for more than 13,000 people but also has undergone downsizing. The addition of a new power generating facility would be expected to add jobs for skilled craft workers (i.e., with skills comparable to or higher than skills of the existing Savannah River Site workforce). Many of the jobs for skilled craft workers could be filled by current or former Savannah River Site employees (Dominion and Bechtel 2002).

There appears to be a large supply of construction labor and skilled craft workers available. Dominion may have to add incentives to draw craft workers from out-of-state with specific skills to the area because of the lower prevailing wages when compared to other areas outside Georgia and South Carolina, but it believes it can successfully manage this issue. The unemployment rates in Aiken and Barnwell Counties are above the State of South Carolina average unemployment rate. Likewise, the unemployment rate in Augusta is above the average rate for the State of Georgia. Employees for station operation are expected to be available from within the region because of the downsizing at Savannah River Site. Based on the foregoing, the staff concludes that Dominion would be able to obtain a ready supply of construction and operations labor for the new units.

During the last decade, a major downsizing has occurred at the site because of the end of the Cold War. Construction and operation of new units would increase employment at the site. These jobs would provide economic benefits to the local communities (Dominion and Bechtel 2002). The magnitude of the economic impacts would be diffused in the larger economic bases of the region, whereas with the smaller economic base of Barnwell County and the higher unemployment rate (compared to Aiken County and the State of South Carolina), the economic impacts could be more noticeable and have a greater beneficial impact. Based on the foregoing, the staff concludes that the beneficial impacts of construction and operation of two units on the economy of the region would be SMALL everywhere in the region except Barnwell County, where the beneficial impacts to the county could be MODERATE.

Taxes

In lieu of property taxes, DOE pays a fee to the localities bordering the site. For 2002, Barnwell County received a fee of approximately $2 million, Aiken County approximately $800,000, and Allendale County approximately $100,000 (Dominion and Bechtel 2002).

Construction and operation workers would pay personal income taxes to Georgia and South Carolina, sales taxes to the State and local governments in the region where sales take place, and property taxes to the counties in which they might own a residence. In addition, sales taxes would be paid from the sales of construction materials and supplies purchased for the project. Finally, because the units would be built by a private company (Dominion) and not DOE, a property tax might be levied on the value of the property that becomes part of the additional units as they are constructed. These taxes would most likely go to Aiken and Barnwell Counties.[a] Georgia and South Carolina both have corporate income taxes, with the tax rates being 6 and 5 percent, respectively (Federation of Tax Administrators 2004).

Based on the foregoing, the staff concludes that the overall beneficial impacts of taxes collected in the region through the income, sales and use, and property taxes would be SMALL to LARGE. The staff also concludes that the overall impacts of taxes collected through the income, sales and use, and property taxes collected in the region would be SMALL for jurisdictions other than Barnwell County. The taxes paid, while large in absolute value, are nevertheless a small sum when compared to the total amount of taxes collected by State and local governments in the region. For property taxes in Barnwell County, the staff concludes that the overall beneficial impacts of the property taxes collected would be MODERATE (construction) and LARGE (operation), relative to the total amount of property taxes the county collects.[b]

Transportation

(a) The potential site for locating new units would not be on land owned by Dominion. Most likely, should the Savannah River alternative site be chosen for the new power generating facility, the land for the new units would be leased from DOE by Dominion.

(b) The derivation of this impact is based on the fact the fiscal year 2003 amount of property taxes collected in Aiken and Barnwell Counties were $68,046,000 (Cornwell in Jaksch and Scott 2005) and $9,774,000 (Gibson in Jaksch and Scott 2005), respectively. For comparison, NAPS Units 1 and 2 pay approximately $10 million in annual property tax to Louisa County (the actual amount that a nuclear utility would pay to Barnwell County would depend on assessed value and millage rate per thousand of assessed value). On the assumption that there is a rough comparison between what Dominion pays to Louisa County and what they might pay to Barnwell County, it can be concluded that the potential percentage of a nuclear facility's property taxes to the total of all property taxes paid in Barnwell County would be significant.

Two interstate highways serve the vicinity of the Savannah River Site. Several other highways (U.S. Highways 221, 278, 301, 321, and 601) provide additional transport routes for the area. Approximately 84 percent of the Savannah River Site workforce of 13,000 resides in Aiken and Barnwell Counties in South Carolina and Columbia and Richmond Counties in Georgia (Dominion and Bechtel 2002).

The regional transportation networks in the Savannah River Site vicinity serve Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina and Columbia and Richmond Counties in Georgia. Approximately 88 percent of the Savannah River Site commuter traffic originates from these counties. On the site itself, there are more than 322 km (200 mi) of primary roads and more than 1600 km (1000 mi) of unpaved secondary roads.

In general, heavy traffic occurs in the early morning and late afternoon when workers commute to and from the Savannah River Site. For the roads in the general region, the worst-case LOS is associated with routes near the Savannah River bridges, including I-20 and U.S. 1 and urban routes in North Augusta and Aiken, including South Carolina SRs 230, 25, 19, and 118. Significant congestion occurs during peak traffic periods onsite on U.S. Highways 1-A and 278 and on SRs 19 and 125 at Savannah River Site access points. Long delays are also experienced offsite along I-20 and U.S. Highways 25 and 1 where they cross the Savannah River. The Savannah River Site has implemented changes to remedy the congestion at some access points (Dominion and Bechtel 2002).

Other transportation in the area also includes a rail line for CSX Transportation, Inc. The Savannah River Site has its own railroad system. Rail traffic is separated into two categories depending on which track system it would use: CSX operations and the Savannah River Site railway (Dominion and Bechtel 2002).

The nearest major airport to the Savannah River Site is in Atlanta, Georgia, and the closest regional airport is in Augusta, Georgia. The Augusta airport conducts regular freight and passenger airline services and is large enough to accommodate the relatively small air shipments normally associated with a large construction project. The Atlanta airport can accommodate large air shipments. Ground transportation from the Augusta airport takes approximately 1 hour, and from the Atlanta airport, approximately 3 hours (Dominion and Bechtel 2002).

During peak new plant construction, 5000 construction workers would be needed.[a] The units' operations workforce would be approximately 720. The extensive existing roadway network in the area and the rail lines near the Savannah River alternative site are expected to be capable

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(a) Dominion and Bechtel (2002) states that 3000 to 3500 craft and an additional 800 to 1000 non-manual labor personnel (or 4500 workers) would be needed at the Savannah River Site. In its ER (Dominon 2006), Dominion states that 5000 workers would be needed at the North Anna ESP site.

of handling an additional 38 percent of the workforce commuting to the site during construction and the transportation of bulk materials to and from the site. In addition, the workforce would still be far below the peak levels of employment achieved in 1993. With implementation of traffic mitigation measures, the construction of two units at the Savannah River alternative site is expected to result in impacts that are manageable for traffic patterns, workforce commuter traffic, and rail/truck delivery of materials (Dominion and Bechtel 2002).

The Savannah River alternative site is in a limited-access DOE site adjacent to a rural, low-population area. The regional transportation network is adequate for commuter and transient traffic in the area. Based on the foregoing, the staff concludes that the transportation impacts of a construction workforce resulting in an approximately 38 percent increase to the existing workforce at Savannah River Site would be SMALL. Because the increase in employment with the operations workforce is less than 5.5 percent of the existing site workforce, the staff concludes the transportation impacts of the operations workforce would be SMALL.

Aesthetics and Recreation

The preferred location for the two units on the Savannah River Site is more than 10 km (6 mi) from the closest site boundary. There are no public amenity areas within 3 km (2 mi) of the site. Most of the site is dense forest; therefore, nearby trees would provide a visual buffer for the construction and operation of the units to the public. Because the location is at least 10 km (6 mi) away from the existing site boundary, offsite observers would not have an identifiable nuclear power plant view (Dominion and Bechtel 2002).

Cooling towers, which could produce visible plumes offsite, are being proposed as part of the new nuclear units' cooling system. Dry cooling towers could be an alternative method for plant cooling. Nearby trees would serve as a visual buffer for the transmission lines (Dominion and Bechtel 2002).

The surrogate AP1000 reactor has a tall containment building that is approximately 71 m (234 ft) above grade. The design of this building includes a hatch that determines the height that it must be above ground. This building would be expensive to redesign to allow the building to be placed lower in the ground. Thus, the height of the AP1000 containment building sets the upper bound of what would be visible from offsite. In addition, if natural draft cooling towers are used, the height of the towers would be approximately 170 m (550 ft).

Prominent geographical features within 80 km (50 mi) of the Savannah River Site are Thurmond Lake (formerly called Clarks Hill Reservoir) and the Savannah River. The principal surface-water body associated with the Savannah River Site is the Savannah River, which flows along the site's southwest border (Dominion and Bechtel 2002). The closest State park is Redcliffe Plantation State Park, about 16 km (10 mi) northwest of the site location.

The potential location identified for the plant would be about 10 km (6 mi) from the nearest site boundary and would be screened by trees. There are no significant residential areas or recreational facilities within 3 km (2 mi) of the site. Plumes from cooling towers could be visible offsite. Based on the foregoing, the staff concludes that the construction and station operation impacts on aesthetics and recreation would be SMALL.

Housing

In the four-county area of Richmond and Columbia Counties in Georgia and Barnwell and Aiken Counties in South Carolina, there were 187,811 housing units in 2000. Of these units, 52,405 were rental units, 6424 of which were vacant (10.9 percent vacancy rate) (USCB 2000e). There appears to be vacant rental housing units available for construction workers who might want to relocate to the region.

In the same four-county area discussed above, there were 117,243 owner-occupied houses; 3089 of these houses were for sale (2.6 percent vacancy rate). The percentage of houses for sale in relation to owner-occupied housing is low, indicating the market for resale housing is tight.

The operations workforce is expected to come primarily from current or former employees at the Savannah River Site. If, however, a substantial number of workers were recruited into the area, there could be upward pressure on housing values. This assumption is based on the low number of homes for sale in the area and the fact that the workforce, which would be on the higher end of the salary scale when compared to other job classifications in the area, could tend to buy more expensive homes.

It is not unusual for construction workers to commute up to 2 hours (one way) per day to the job site. Many of the construction workers are assumed to already live within the region. Therefore, there appears to be enough vacant rental housing to house those who might relocate to the region. For the operations workforce, it is expected that most would already have residences in the region, and few would relocate to the area given the potential supply of workers in the region resulting from Savannah River Site downsizing. Based on the foregoing, the staff concludes that the impacts to housing from construction and operation of two units at the Savannah River alternative site would be SMALL.

Public Services

Water and Wastewater Treatment

Four major public sewage treatment facilities with a combined design capacity of 302.2 million liters (79.8 million gallons) per day serve the six-county region composed of Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina and Columbia and Richmond Counties in

Georgia. In 1989 (the latest year for which data were readily available), these systems were operating at approximately 56 percent capacity, with an average daily flow of 170 million L/day (44.9 MGD). Capacity utilization ranged from 45 percent in Aiken County to 80 percent in Barnwell County (DOE 2000).

There are approximately 120 public water systems in the six-county area. About 40 of these county and municipal systems are major facilities, while the remainder serve individual subdivisions, water districts, manufactured home parks, or miscellaneous facilities. In 1989 (again the latest year for which data are readily available), the 40 major facilities had a combined total flow of 576.3 million L/day (152.2 MGD). With an average daily flow rate of approximately 268.8 million L/day (71 MGD), these systems were operating at 47 percent capacity in 1989. Facility utilization rates ranged from 13 percent in Allendale County to 84 percent in the City of Aiken (DOE 2000).

The Savannah River alternative site is approximately 40 km (25 mi) southeast of Augusta, Georgia, and 31.4 km (19.5 mi) south of Aiken, South Carolina. There are numerous towns and cities within 80 km (50 mi) of the site, and all these towns and cities are within a 2-hour commuting distance of the site via local transportation routes (Dominion and Bechtel 2002). In addition, the utility infrastructures of the towns and cities could provide public services such as water and wastewater treatment to members of the construction and operations workforce who might relocate to the region. Based on the foregoing, the staff concludes that the impacts of the construction and operations workforces on water and wastewater treatment in the region would be SMALL.

Police, Fire and Medical Facilities

Eight general hospitals operate in the six-county region. Four of the eight general hospitals are in Richmond County (Augusta), Georgia, while Columbia County, Georgia, has no hospital. Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina each have one general hospital (USHospital.info 2005).

Fifty-six fire departments provide fire protection in the region. Twenty-seven of these fire departments are classified as municipal fire departments, but many provide protection to rural areas outside municipal limits (DOE 2000).

County sheriff and municipal police departments provide most of the law enforcement in the region. In addition, State law enforcement agents and State troopers assigned to each county provide protection and assist county and municipal officers (DOE 2000).

Many of the potential construction and operations workforce probably already live within an 80-km (50-mi) radius of the region. There are a number of towns within a 2-hour commuting distance of the site. Any new workers relocating to the area would most likely have places of residency located throughout the region, which would not place an undue burden on the infrastructure of any one jurisdictional entity. Based on the foregoing, the staff concludes that the impacts of the construction and operations workforce on public facilities in the Savannah River Site area would be SMALL.

Social Services

In Georgia, social services at the state level are overseen by the Department of Human Resources. It oversees about 80 wide-ranging programs that include controlling the spread of disease, enabling older people to live at home longer, preventing children from developing lifelong disabilities, training single parents to find and hold jobs, and helping people with mental or physical disabilities live and work in their communities (Georgia Department of Human Resources 2004).

In South Carolina, social services are overseen by the Department of Social Services, which administers its programs through county offices. Services offered by the Department include child care assistance to needy families, adult protective services, child protective services, independent living, and emergency shelters food program, among other services (South Carolina Employment Security Commission 2004). During construction of new nuclear units at the Savannah River alternative site, there may be increased demand for social services from the construction workforce and their dependents.

Generally, construction and operation of the new units at Savannah River alternative site would be viewed as beneficial economically to the disadvantaged population segments served by the Georgia Department of Human Resources and South Carolina Department of Social Services. The workforce associated with construction and operation of two units at the Savannah River alternative site would most likely receive higher wages than other employment categories in the region. It is expected that through the multiplier effect, the number of jobs that could be filled by members of the disadvantaged population would increase.

Construction and operation of two units would have a beneficial economic impact to the disadvantaged population in the region, which should lessen the demand for social services. There could be an initial increase in demand for social services at the beginning of the construction period, but this is considered manageable and limited. Based on the foregoing, the staff concludes that the impacts of construction and station operation of two units on social and related services would be SMALL.

Education

Public education facilities in the six-county region (Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia) include approximately 116 elementary or intermediate schools and 28 high schools (Great

Schools 2005). In addition to the public schools, there are approximately 50 private schools in the region (NCES 2005). There are several local colleges, technical schools, and training facilities available, such as the University of South Carolina Aiken, Augusta State University, Paine College, Aiken Technical College, and Augusta Technical College.

Many of the potential construction and operating workforce probably already live within the region, and any new workers relocating to the area would most likely take up residency throughout the region. Based on the foregoing, the staff concludes that the impacts of construction and operation of two units on educational facilities in the region would be SMALL.

8.7.5.4 Historic and Cultural Resources

Historic and cultural resources at the Savannah River Site are managed through a cooperative agreement between DOE and the South Carolina Institute of Archaeology of the University of South Carolina as the Savannah River Archaeological Research Program. Since 1974, more than 60 percent of the 777-km^2 (300-mi^2) site has been inventoried for prehistoric and historic sites and more than 1200 sites have been recorded, ranging in age from the Middle Archaic prehistoric period to the 20th century (DOE 2002). Archaeological research has provided considerable information about the distribution and content of historic and cultural sites on the Savannah River Site.

Archaeologists have divided the Savannah River Site into three zones related to their potential for containing sites with multiple archaeological components or dense or diverse artifacts, and their potential for nomination to the National Register of Historic Places.

- Zone 1 is the zone of the highest archaeological site density with a high probability of encountering large archaeological sites with dense and diverse artifacts and a high potential for nomination to the National Register of Historic Places.
- Zone 2 includes areas of moderate archaeological site density. Activities in this zone have a moderate probability of encountering large sites with more than three prehistoric components or that would be eligible for nomination to the National Register of Historic Places.
- Zone 3 includes areas of low archaeological site density. Activities in this zone have a low probability of encountering archaeological sites and virtually no chance of encountering large sites with more than three prehistoric components; the need for site preservation is low. Some sites in the zone could be considered eligible for nomination to the National Register of Historic Places.

The Savannah River alternative site parcel identified by Dominion lies in Zone 3. According to Savannah River Site staff (Dominion and Bechtel 2002), no known historic and cultural properties exist in the site.

In conjunction with previous studies, DOE solicited the concerns of Native American tribes about traditional cultural values in the Central Savannah River Valley. Three Native American groups, the Yuchi Tribal Organization, the National Council of Muskogee Creek, and the Indian People's Muskogee Tribal Town Confederacy, expressed general concerns about the Savannah River Site and the Central Savannah River Area but did not identify specific sites as possessing religious significance. The Yuchi Tribal Organization and the National Council of Muskogee Creek are interested in several plant species traditionally used in tribal ceremonies.

Based on the foregoing, the staff concludes that the potential impacts on historic and cultural resources from construction and operation of two units at the Savannah River alternative site would be SMALL.

8.7.5.5 Environmental Justice

DOE has performed an environmental assessment for the construction and operation of a linear accelerator (since dropped from consideration in the general area of the Savannah River alternative site) that would produce tritium (DOE 1999). As part of that assessment, an evaluation of potential environmental justice impacts was conducted (Dominion and Bechtel 2002).

DOE's environmental justice assessment evaluated whether minorities or low-income populations could receive disproportionately high and adverse human health and environmental impacts. Minority and low-income populations were identified by census tract. DOE's analysis concluded that releases from the site would not disproportionally affect minority communities (population equal to or greater than 35 percent of the total population) or low-income (equal to or greater than 25 percent of the total population) within an 80-km (50-mi) radius of the region, because the compared per capita doses did not vary significantly.[a] In addition, regarding downstream communities, DOE evaluated doses to people using the Savannah River for drinking water, sports, and food. Because the identified communities in the areas downstream from the Savannah River Site are well distributed, DOE concluded there were no disproportionate impacts among minority and low-income populations (Dominion and Bechtel 2002).

Based on the foregoing, the staff concludes that the offsite impacts of construction and operation of two units at the Savannah River alternative site on minority and low-income populations would be SMALL. There are no disproportionately high and adverse impacts to these populations.

(a) NRC uses more complex threshold limits than DOE for defining whether minority or low-income populations exist within an 80-km (50-mi) radius of the Savannah River Site. See Section 2.10 for a more detailed discussion of the NRC criteria. However, the geographic distribution of minority low-income populations would be similar using either method for the region surrounding the Savannah River Site.

8.8 Summaries of Alternative Site Impacts

Summaries of the impacts of construction and operation on each of the three alternative sites selected by Dominion are presented in Tables 8-6 and 8-7. Discussions of the stated impacts are presented in the individual site sections (Sections 8.5 through 8.7). A comparison of the alternative site impacts with impacts at the proposed North Anna ESP site is presented in Chapter 9.

Table 8-6. Characterization of Construction Impacts at the Alternative ESP Sites

Category	Surry	Portsmouth	Savannah River
Land-use impacts	--	--	--
Site and vicinity	SMALL	SMALL	SMALL
Transmission line rights-of-way	SMALL	SMALL	SMALL to MODERATE
Air quality impacts	SMALL	SMALL	SMALL
Water-related impacts	--	--	--
Water use	SMALL	SMALL	SMALL
Water quality	SMALL	SMALL	SMALL
Ecological impacts	--	--	--
Terrestrial ecosystems	SMALL	SMALL	SMALL to MODERATE
Aquatic ecosystems	SMALL	SMALL	SMALL
Threatened and endangered species	SMALL	SMALL	SMALL to MODERATE
Socioeconomic impacts	--	--	--
Physical impacts	SMALL to MODERATE	SMALL to MODERATE	SMALL
Demography	SMALL	SMALL	SMALL
Social and economic[(a, b)]	SMALL BENEFICIAL to MODERATE BENEFICIAL	SMALL BENEFICIAL to MODERATE BENEFICIAL	SMALL BENEFICIAL to MODERATE BENEFICIAL
Infrastructure and community services[(c)]	SMALL to MODERATE	SMALL to MODERATE	SMALL
Historic and cultural resources	MODERATE to LARGE	SMALL	SMALL
Environmental justice	SMALL	SMALL	SMALL
Nonradiological health impacts	SMALL	SMALL	SMALL
Radiological health impacts	SMALL	SMALL	SMALL

(a) Impacts of construction on the economy and increases in taxes collected are considered beneficial impacts. These beneficial impacts are discussed in the applicable sections.
(b) Social and economic impacts include impacts on the economy and taxes.
(c) Infrastructure and community services impacts include impacts on transportation, aesthetics and recreation, housing, public services, and education.

Table 8-7. Characterization of Operational Impacts at the Alternative ESP Sites

Category	Surry	Portsmouth	Savannah River
Land-use impacts		--	--
The site and vicinity	SMALL	SMALL	SMALL
Transmission line rights-of-way	SMALL	SMALL	SMALL
Air quality impacts	SMALL	SMALL	SMALL
Water-related impacts	--	--	--
Water use	SMALL	SMALL to MODERATE	SMALL
Water quality	SMALL	SMALL	SMALL
Water use in drought year	SMALL	MODERATE	SMALL
Ecological impacts	--	--	--
Terrestrial ecosystems	SMALL	SMALL	SMALL
Aquatic ecosystems	SMALL	SMALL	SMALL
Threatened and endangered species	SMALL	SMALL	SMALL to MODERATE
Socioeconomic impacts	--	--	--
Physical impacts	SMALL to MODERATE	SMALL to MODERATE	SMALL
Demographics	SMALL	SMALL	SMALL
Social and economic[(a)]	SMALL BENEFICIAL to LARGE BENEFICIAL	SMALL BENEFICIAL to LARGE BENEFICIAL	SMALL BENEFICIAL to LARGE BENEFICIAL
Infrastructure and community services	SMALL to MODERATE	SMALL to MODERATE	SMALL
Historic and cultural resources	MODERATE to LARGE[(b)]	SMALL	SMALL
Environmental justice	SMALL	SMALL	SMALL
Nonradiological health impacts	SMALL	SMALL	SMALL
Radiological health impacts	SMALL	SMALL	SMALL
Impacts of postulated accidents	SMALL	SMALL	SMALL
Fuel cycle impacts[(c)]	SMALL	SMALL	SMALL

(a) Impacts of operation on the economy and increases in taxes collected are considered beneficial impacts. The beneficial economic impacts are discussed in the applicable sections.
(b) Aesthetic impacts could be LARGE at historically important sites in the vicinity. This is captured in the historic and cultural resources evaluation. (Sections 8.5.5.3 and 8.5.5.4).
(c) Fuel cycle impacts are evaluated in Chapter 6 and includes impacts from the fuel cycle, solid waste management, transportation, and decommissioning.

8.9 References

Note: Because the web pages cited in this document may become unavailable, the staff has entered the appropriate pages into ADAMS. The accession number of the package containing the Web-sites used as references in Chapter 8 of the North Anna ESP EIS is ML051580551.

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9.0 Comparison of the Impacts of the Proposed Action and Alternative Sites

The need to compare the proposed early site permit (ESP) site at the North Anna Power Station (NAPS) with alternative sites arises from the requirement in Section 102(2)(c)(iii) of the National Environmental Policy Act of 1969 (NEPA) (42 USC 4332(2)(c)(iii)) that environmental impact statements (EISs) include an analysis of alternatives to the proposed action. The U.S. Nuclear Regulatory Commission (NRC) criterion to be employed in assessing whether a proposed ESP site should be rejected in favor of an alternative site is whether the alternative site is "obviously superior" to the site proposed by the applicant (NRC 1977). An alternative site is "obviously superior" to the proposed site if it is "clearly and substantially" superior to the proposed site.

The standard of obvious superiority "...is designed to guarantee that a proposed site will not be rejected in favor of a substitute unless, on the basis of appropriate study, the Commission can be confident that such action is called for" (NRC 1978a). The "obviously superior" test is appropriate for two reasons. First, the analysis performed by NRC in evaluating alternative ESP sites is necessarily imprecise. Key factors considered in the alternative site analysis, such as population distribution and density, hydrology, air quality, aquatic and terrestrial ecological resources, aesthetics, land use, and socioeconomics, are difficult to quantify in common metrics. Given this difficulty, any evaluation of a particular site would necessarily have a wide range of uncertainty. Second, the applicant's proposed ESP site has been analyzed in detail, with the expectation that most adverse environmental impacts associated with the site have been identified. By design, the alternative sites have not undergone a comparable level of detailed study. For these reasons, a proposed ESP site may not be rejected in favor of an alternative site when the alternative is "marginally better" than the proposed site, but only when it is "obviously superior" (NRC 1978b). NEPA does not require that a nuclear plant be constructed on the single best site for environmental purposes. Rather, "...[a]ll that NEPA requires is that alternative sites be considered and that the effects on the environment of building the plant at the alternative sites be carefully studied and factored into the ultimate decision" (NRC 1978a).

The NRC staff's review of alternative sites consists of a two-part sequential test for obvious superiority (NRC 2000). The first part of the test determines whether there are "environmentally preferred"[(a)] sites among the candidate ESP sites. The staff considers whether the applicant has (1) reasonably identified alternative sites, (2) evaluated the likely environmental impacts of construction and operation at these sites, and (3) used a logical means of comparing sites that

(a) An "environmentally preferred" alternative site is a site for which the environmental impacts are sufficiently less than the proposed site so that environmental preference for the alternative site can be established (NRC 2000).

has led to the applicant's selection of the proposed site. Based on its independent review, the staff then determines whether any of the alternative sites are environmentally preferable to the applicant's proposed ESP site.

If the staff determines that one or more alternative sites is environmentally preferable, it would then compare the estimated costs (e.g., environmental, economic, and time) of constructing the proposed plant at the proposed site and at the environmentally preferable site or sites (NRC 2000). To find an obviously superior alternative site, the staff must determine that (1) one or more important aspects, either singly or in combination, of a reasonably available alternative site are obviously superior to the corresponding aspects of the applicant's proposed site and (2) the alternative site does not have offsetting deficiencies in other important areas. A staff conclusion that an alternative site is obviously superior to the applicant's proposed site would normally lead to a recommendation that the application for the ESP be denied.

9.1 Comparison of the Proposed Site with the Alternatives

The staff reviewed the Environmental Report (ER) submitted by Dominion Nuclear North Anna, LLC (Dominion) (Dominion 2006), the Dominion and Bechtel study for the U.S. Department of Energy on potential sites for nuclear power plant development (Dominion and Bechtel 2002), and supporting documentation. The staff also conducted site visits at the proposed North Anna ESP site and the alternative sites. As discussed in Section 8.3, the staff concluded that Dominion had reasonably identified alternative sites, evaluated the environmental impacts of construction and operation of new nuclear power facilities at those sites, and used a logical means of comparing the sites. As discussed in Section 8.4, some environmental impacts considered for the North Anna ESP site and the alternative sites are generic to all sites and, therefore, do not influence the comparison of impacts between the North Anna ESP site and the alternative sites. These generic environmental impacts common to all sites include air quality, nonradiological and radiological health impacts, fuel cycle impacts for light water reactors, and environmental impacts from postulated accidents. For severe accidents, the combination of population characteristics and dispersion potential are not significantly different among the sites to differentiate one from another given the extremely low risk already. Fuel cycle impacts for gas-cooled reactors are unresolved for all sites, but are likely to be SMALL. Decommissioning impacts were determined to be unresolved because the reactor design has not been selected at the ESP stage. The impacts from decommissioning are likely to be SMALL and affect all sites in a similar manner.

The staff conducted its own evaluation of the sites at a reconnaissance level before writing the *Draft Environmental Impact Statement (EIS) for an Early Site Permit (ESP) at the North Anna ESP Site* (Draft EIS) (NRC 2004) by touring the sites and reviewing existing environmental and socioeconomic assessments and data maintained by State and Federal agencies for information relevant to potential impacts at the alternative sites. For this Final EIS, the staff visited the proposed and alternative sites, evaluated the information presented in the ER (Dominion 2006), and determined expected environmental impacts at the proposed North Anna ESP site and at the three alternative sites.

The staff's characterization of the expected environmental impacts of constructing and operating two new nuclear units at the proposed ESP site and alternative sites within the revised plant parameter envelope presented by Dominion in the ER (Dominion 2006) are summarized in Tables 9-1 and 9-2. For those impacts to environmental resources for which the staff was unable to reach a significance level for the North Anna ESP site or the alternative sites as a result of insufficient information, the most likely level of impact for the purposes of comparison to alternative sites was identified and the staff assumed that impacts would affect all sites in a similar manner. In the following analysis, the staff indicates a likely impact level for these unresolved issues based on professional judgment, experience, and consideration of controls likely to be imposed under required Federal, State, or local permits that would not be acquired until an application for a construction permit or combined license were underway. These considerations and assumptions were similarly applied at each of the alternative sites to provide a common basis for comparison. These impact levels are, therefore, best estimates of impacts that the staff used for its "obviously superior" determination. No new data were collected.

The environmental impact categories shown in Tables 9-1 and 9-2 have been evaluated using NRC's three-level standard of significance – SMALL, MODERATE, or LARGE – developed using the Council on Environmental Quality guidance (Title 40 of the Code of Federal Regulations [CFR] Part 1508.27). The rationale for these significance levels is outlined in the footnotes to Table B-1 of 10 CFR Part 51, Subpart A, Appendix B:

> SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
>
> MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize important attributes of the resource.
>
> LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

The socioeconomic impact level category reflects both adverse and beneficial impacts. Positive impacts (e.g., tax receipts to local government) would occur but are not the determining factors in the analysis of an environmentally preferable or obviously superior site. For impact categories in which no impact is predicted, the adverse impact level is shown as SMALL. Within some impact categories, the impact levels varied. Professional judgments were made to conclude, where possible, a single overall level of impact. In several cases, a range of probable impacts is given.

Table 9-1. Comparison of the Construction Impacts at the Proposed ESP and Alternative Sites

Impact Area Category	North Anna ESP Site	Surry Site	Portsmouth Site	Savannah River Site
Land-use impacts	--	--	--	--
The site and vicinity	SMALL	SMALL	SMALL	SMALL
Transmission line rights-of-way	SMALL	SMALL	SMALL	SMALL to MODERATE
Air quality impacts	SMALL	SMALL	SMALL	SMALL
Water-related impacts	--	--	--	--
Water use	SMALL	SMALL	SMALL	SMALL
Water quality	SMALL	SMALL	SMALL	SMALL
Ecological impacts	--	--	--	--
Terrestrial ecosystems	SMALL	SMALL	SMALL	SMALL to MODERATE
Aquatic ecosystems	SMALL	SMALL	SMALL	SMALL
Threatened and endangered species	SMALL	SMALL	SMALL	SMALL to MODERATE
Socioeconomic impacts	--	--	--	--
Physical impacts	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL
Demography	SMALL	SMALL	SMALL	SMALL
Social and Economic[(a,b)]	SMALL BENEFICIAL to MODERATE BENEFICIAL	SMALL BENEFICIAL to MODERATE BENEFICIAL	SMALL BENEFICIAL to MODERATE BENEFICIAL	SMALL BENEFICIAL to MODERATE BENEFICIAL
Infrastructure and community services[(c)]	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL
Historic and cultural resources	SMALL	MODERATE to LARGE	SMALL	SMALL
Environmental justice	SMALL	SMALL	SMALL	SMALL
Nonradiological health impacts	SMALL	SMALL	SMALL	SMALL
Radiological health impacts	SMALL	SMALL	SMALL	SMALL

(a) Impacts of construction on the economy and increases in taxes collected are considered beneficial impacts. These beneficial impacts are discussed in the applicable sections.
(b) Social and economic impacts include impacts on the economy and taxes.
(c) Infrastructure and community services impacts include impacts on transportation, aesthetics and recreation, housing, public services, and education.

Table 9-2. Comparison of the Operational Impacts at the Proposed ESP and Alternative Sites

Impact Area Category	North Anna ESP Site	Surry Site	Portsmouth Site	Savannah River Site
Land-use impacts	--	--	--	--
The site and vicinity	SMALL	SMALL	SMALL	SMALL
Transmission line rights-of-way	SMALL	SMALL	SMALL	SMALL
Air quality impacts	SMALL	SMALL	SMALL	SMALL
Water-related impacts	--	--	--	--
Water use	SMALL	SMALL	SMALL to MODERATE	SMALL
Water quality	Unresolved, but likely SMALL[(a)]	SMALL	SMALL	SMALL
Water use in drought year	MODERATE	SMALL	MODERATE	SMALL
Ecological impacts	--	--	--	--
Terrestrial ecosystems	SMALL	SMALL	SMALL	SMALL
Aquatic ecosystems	SMALL	SMALL	SMALL	SMALL
Threatened and endangered species	SMALL	SMALL	SMALL	SMALL to MODERATE
Socioeconomic impacts	--	--	--	--
Physical impacts	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL
Demographics	SMALL	SMALL	SMALL	SMALL
Social and economic[(b)]	SMALL BENEFICIAL to LARGE BENEFICIAL	SMALL BENEFICIAL to LARGE BENEFICIAL	SMALL BENEFICIAL to LARGE BENEFICIAL	SMALL BENEFICIAL to LARGE BENEFICIAL
Infrastructure and community services[(c)]	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL
Historic and cultural resources	SMALL	MODERATE to LARGE	SMALL	SMALL
Environmental justice	SMALL	SMALL	SMALL	SMALL
Nonradiological health impacts[(d)]	SMALL	SMALL	SMALL	SMALL
Radiological health impacts	SMALL	SMALL	SMALL	SMALL
Postulated accidents	SMALL	SMALL	SMALL	SMALL
Fuel cycle impacts[(e)]	SMALL	SMALL	SMALL	SMALL

(a) Impact level estimated for purposes of comparison
(b) Social and economic impacts include impacts on the economy and taxes.
(c) Infrastructure and community services impacts include impacts on transportation, aesthetics and recreation, housing, public services, and education.
(d) Health effects of electromagnetic fields is unresolved.
(e) Fuel cycle impacts are evaluated in Chapter 6 and include impacts from the fuel cycle, solid waste management, transportation, and decommissioning.

The staff determined that the impact level from construction on most of the environmental resources at most of the sites is SMALL. In some cases, there are factors related to a site that could cause the impact level to increase from SMALL to MODERATE. In one case, the impact level category for an alternative site could be as high as LARGE. Impacts on the local economy and tax base range from SMALL BENEFICIAL to MODERATE BENEFICIAL at the various sites. More detailed information on these cases is presented in Chapter 4 for the North Anna ESP site, and Chapter 8 for the alternative sites. The staff based its analysis of the environmental impacts on the implementation of mitigation measures in accordance with Federal, State, and local permit requirements and on the mitigation measures identified in the ER. In its analysis of the alternative sites, the staff assumed that similar permit requirements and mitigative measures would apply.

The staff determined that the impact from operation on most of the environmental resources at most of the sites is SMALL. In some cases, there are factors related to a site that could cause the impact level to range from SMALL to LARGE. Impacts on the local tax base range from SMALL BENEFICIAL to LARGE BENEFICIAL at all sites. More detailed information on these cases is presented in Chapters 5 and 6 for the North Anna ESP site and Chapters 6 and 8 for the alternative sites.

9.2 Environmentally Preferable Sites

9.2.1 Construction

The impacts of construction at the North Anna ESP site are SMALL for most major impact categories. However, as noted in Section 4.5, there are some impact subcategories under infrastructure and community services (housing, public services, and education) for which the impacts could be MODERATE if a larger number of construction workers than the staff assumed relocate to Louisa or Orange Counties. The tax benefits to Louisa County could be MODERATE BENEFICIAL, and the impacts on jobs and the economy could also be MODERATE BENEFICIAL.

The impacts of construction at the Surry alternative site are SMALL for all impact categories except physical impacts (aesthetics), infrastructure and community services, economy and taxes, and historic and cultural resources. As noted in Section 8.5, the impacts for this site are SMALL to MODERATE for transportation and aesthetics and MODERATE to LARGE for historic and cultural resources because of its potential effect on the Colonial National Historic Park. Impacts on the economy and taxes may be SMALL BENEFICIAL to MODERATE BENEFICIAL.

The impacts of construction at the Portsmouth alternative site are SMALL for all impact categories except physical impacts (aesthetics), infrastructure and community services, and economy and taxes. As noted in Section 8.6, the impacts for this site are SMALL to MODERATE for aesthetics. In addition, the impacts on the economy and taxes are SMALL BENEFICIAL to MODERATE BENEFICIAL.

The impacts of construction at the Savannah River alternative site are SMALL for all impact categories except transmission line land use, terrestrial resources (including endangered species), and economy and taxes. As noted in Section 8.7, the impacts on transmission line land use and terrestrial resources are SMALL to MODERATE. The staff arrived at this range of potential impacts because the routing for the new transmission line rights-of-way that would be needed is not known with certainty and, consequently, neither are the impacts of construction. In addition, the impacts on the economy and tax base are SMALL BENEFICIAL to MODERATE BENEFICIAL.

While there are minor differences in most of the construction impacts at the four sites, none of these differences is sufficient to determine that any of the alternative sites is environmentally preferable to the proposed North Anna ESP site.

9.2.2 Operations

The impacts of operations at the North Anna ESP site are SMALL for all major impact categories except water use and socioeconomic categories. As discussed in Section 5.3, the impacts of Unit 3 operations on water use are SMALL most years. However, during a significant drought, the impacts could be MODERATE. The impacts on water quality are not resolved, but are likely to be SMALL for purposes of comparison with the alternative sites. In addition, as discussed in Section 5.5, the impacts for aesthetics are SMALL to MODERATE, and impacts to recreation may be MODERATE during drought years. The impacts on the economy and taxes are SMALL BENEFICIAL to LARGE BENEFICIAL.

The impacts of operations at the Surry alternative site are SMALL for all impact categories except physical impacts (aesthetics), infrastructure and community services, and historical and cultural resources. As noted in Section 8.5, the impacts for this site are SMALL to MODERATE for aesthetics in the vicinity and MODERATE to LARGE because of the particular impacts that could be realized on the Colonial National Historic Park's resources. The impacts on the economy and taxes are SMALL BENEFICIAL to LARGE BENEFICIAL.

The impacts of operations at the Portsmouth alternative site are SMALL for all impact categories except water use and socioeconomic categories. As noted in Section 8.6, the impacts of plant operations on water use are SMALL to MODERATE most years. However, during a significant drought, the impacts would be MODERATE. In addition, physical impacts and impacts under infrastructure and community services are SMALL to MODERATE for aesthetics. The impacts on the economy and taxes are SMALL BENEFICIAL to LARGE BENEFICIAL.

The impacts of operations at the Savannah River alternative site are SMALL for all impact categories except threatened and endangered species and socioeconomics. As noted in Section 8.7, the impacts to threatened and endangered species are SMALL to MODERATE because the routing for the new transmission line rights-of-way that would be needed for plant operation is not known and so the associated impacts of operation and maintenance must be assigned a range of potential impacts. The impacts on the economy and taxes are SMALL BENEFICIAL to LARGE BENEFICIAL.

In summary, although the water-use impacts at the North Anna ESP site are projected to be MODERATE during years when there is a severe drought, this event and its associated impacts are expected to be infrequent and temporary. Aesthetic impacts are expected to be periodic and MODERATE. The operation of the units at North Anna is also expected to have a MODERATE impact in the recreational subcategory of community characteristics during a severe drought, at which time the lake marinas could be affected. The Portsmouth alternative site has a similar water-use issue, and the Savannah River alternative site has unknown impacts associated with the transmission line rights-of-way, which could range from SMALL to MODERATE. The Surry alternative site has a cultural and historical impact that could be LARGE. The impacts on economy and taxes are generally beneficial and similar across sites, and the impacts on infrastructure and community services are similar and up to MODERATE.

For those impacts to environmental resources for which the staff was unable to reach a significance level for the North Anna ESP site or the alternative sites as a result of insufficient information, the most likely level of impact for the purposes of comparison to alternative sites was identified and the staff assumed that impacts would affect all sites in a similar manner. In the following analysis, the staff indicated a likely impact level for these unresolved issues based on professional judgment, experience, and consideration of controls likely to be imposed under required Federal, State, or local permits that would not be acquired until an application for a construction permit or combined license were underway. These considerations and assumptions were similarly applied at each of the alternative sites to provide a common basis for comparison. These impact levels are, therefore, best estimates of impacts that the staff used for its “obviously superior” determination. No new data were collected. For example, insufficient information was provided for operational water quality, gas-cooled reactor fuel cycle, decommissioning, and severe accident mitigation alternatives. While there is insufficient information to reach a conclusion on the significance levels for the unresolved issues, the staff does not expect, based on the information available, that there would be significant differences in impact categories among the proposed and alternative sites. While there are some differences in the environmental impacts of operation at the four sites, none of these differences is sufficient for the staff to determine that any of the alternative sites is environmentally preferable to the proposed North Anna ESP site.

9.3 Obviously Superior Sites

None of the alternative sites was determined to be environmentally preferable to the proposed North Anna ESP site. Therefore, the staff concluded that none of the alternative sites is obviously superior to the proposed North Anna ESP site.

9.4 Comparison with the No-Action Alternative

The no-action alternative refers to a scenario in which the NRC would deny the ESP application. If the ESP application for the proposed North Anna ESP site were denied, the impacts of construction and operation of a new nuclear power facility would not occur. Further, denial of the ESP application would prevent early resolution of safety and environmental issues for the site. These issues would have to be addressed during a future licensing action (ESP, construction permit, or combined license), should an applicant decide to pursue construction and operation activities for a nuclear facility at the site at a later time.

In the event of NRC's denial of the ESP application, Dominion could follow several paths to satisfy its electric power needs. The potential paths include (1) seeking an ESP for a different proposed site, (2) purchase of power from other electricity providers, (3) conservation and demand-side management programs, (4) construction of new generation facilities other than nuclear at the North Anna site, (5) construction of new generation facilities at other locations, (6) delayed retirement of existing generating facilities, and (7) reactivation of previously retired generating facilities. These paths could be pursued individually or in combination. Each of the paths would have associated environmental impacts. Nonetheless, since Title 10 of the Code of Federal Regulations (CFR) Part 52 does not require an ER or EIS for an ESP to include consideration of energy alternatives or the benefits of construction and operation of a reactor or reactors at the ESP site, Dominion did not address those matters in its ER, and this EIS does not consider such matters. Accordingly, should the NRC ultimately determine to issue an ESP for the North Anna ESP site, these matters would be considered in the EIS for any construction permit or combined license application that references such an ESP.

The activities that may be permissible under an ESP are limited to the site preparation and preliminary construction activities enumerated in 10 CFR 50.10(e)(1). Pursuant to 10 CFR 52.25, such activities are permissible only if the final environmental impact statement concludes that the activities would not result in any significant impacts that could not be redressed, and an ESP that incorporates the site redress plan is granted. The results of the staff's assessment of the site redress plan are discussed in Section 4.11 in which the staff concludes that the potential site preparation activities described in Dominion's redress plan would not result in any significant adverse impacts that could not be redressed. Because the site preparation and preliminary work could be redressed by the site redress plan described in Section 4.11, the impacts of the proposed action and the no-action alternative would be similar.

9.5 References

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, “Domestic Licensing of Production and Utilization Facilities.”

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions.”

10 CFR Part 52. Code of Federal Regulations, Title 10, *Energy*, Part 52, “Early Site Permits Standard Design Certification and Combined License for Nuclear Power Plants.”

40 CFR Part 1508. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 1508, “Council on Environmental Quality, Terminology and Index.”

Dominion Energy, Inc. and Bechtel Power Corporation (Dominion and Bechtel). 2002. *Study of Potential Sites for the Deployment of New Nuclear Plants in the United States*. U.S. Department of Energy Cooperative Agreement No. DE-FC07-02ID14313, Washington, D.C.

Dominion Nuclear North Anna, LLC (Dominion). 2006. *North Anna Early Site Permit Application – Part 3 – Environmental Report*. Revision 9, Glen Allen, Virginia.

National Environmental Policy Act of 1969 (NEPA). 42 USC 4321 et seq.

U.S. Nuclear Regulatory Commission (NRC). 1977. Public Service Co. of New Hampshire (Seabrook Station, Units 1 & 2), CLI-77-8, 5 NRC 503, 526 (1977), *aff'd*, *New England Coalition on Nuclear Pollution v. NRC*, 582 F.2d 87, 95-96 (1st Cir 1978).

U.S. Nuclear Regulatory Commission (NRC). 1978a. New England Coalition on Nuclear Pollution. *New England Coalition on Nuclear Pollution v. NRC,* 582 F.2d 87 (1st Circuit 1978).

U.S. Nuclear Regulatory Commission (NRC). 1978b. Rochester Gas & Electric Corp. (Sterling Power Project Nuclear Unit No. 1), ALAB-502, 8 NRC 383, 397 (1978), *aff'd*, CLI-80-23, 11 NRC 731 (1980).

U.S. Nuclear Regulatory Commission (NRC). 2000. *Standard Review Plans for Environmental Reviews for Nuclear Power Plants*. NUREG-1555, Vol. 1, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2004. *Draft Environmental Impact Statement (EIS) for an Early Site Permit (ESP) at the North Anna ESP Site.* NUREG-1811, Draft. Office of Nuclear Reactor Regulation, Division of Regulatory Improvement Programs, Washington, D.C.

10.0 Conclusions and Recommendations

On September 25, 2003, the U.S. Nuclear Regulatory Commission (NRC) received an application from Dominion Nuclear North Anna, LLC (Dominion) for an early site permit (ESP) for a location adjacent to North Anna Power Station (NAPS) Units 1 and 2. The North Anna ESP site is located in Louisa County, Virginia, approximately 10 km (6 mi) northeast of the town of Mineral. Dominion submitted revisions to the Environmental Report (ER) on October 2, 2003, July 15, 2004, September 7, 2004, May 12, 2005, July 25, 2005, April 13, 2006, June 21, 2006, July 31, 2006, and September 13, 2006 (Dominion 2006a). On December 10, 2004, the staff published a Draft Environmental Impact Statement (Draft EIS) with its evaluation of the Dominion application through ER Revision 3 (NRC 2004). Any reference in this Final Environmental Impact Statement (Final EIS) to the ER refers to Revision 9 (Dominion 2006a), unless otherwise stated.

In Revision 6 to the North Anna ESP application, Dominion proposed (1) changing its approach for cooling the proposed Unit 3 reactor from a once-through cooling system (as described in previous versions of the ER) to a closed-cycle system and (2) increasing the maximum power level per unit from 4300 megawatts-thermal (MW(t)) to 4500 MW(t) for proposed Units 3 and 4 (referred to hereafter as Units 3 and 4). Under the revised cooling system approach, Unit 3 would use a closed-cycle, combination wet and dry cooling system. The proposed increase in power level corresponds to the revision of the maximum power of an economic simplified boiling water reactor (ESBWR), which is one of the reactor designs used to develop the plant parameter envelope (PPE) and evaluated in the Draft EIS.

The NRC staff determined that the changes to the proposed action were substantial; therefore, the staff prepared a Supplement to its Draft EIS (referred to as the SDEIS) pursuant to Title 10 of the Code of Federal Regulations (CFR) Section 51.72. The staff published the SDEIS on July 2006 (NRC 2006a). The scope of the SDEIS was limited to the environmental impacts associated with the change in the cooling system for Unit 3 and the increase in the power level for both units. The evaluation presented in the SDEIS replaced the evaluation of the impacts associated with the originally proposed once-through cooling for Unit 3 and modified the analysis of impacts related to the power level increase. These revised evaluations, along with public comments received on the analysis presented in the SDEIS, were incorporated into this Final EIS, together with comments received concerning the Draft EIS, insofar as they were not determined to be moot because of changes to the version of Dominion's proposal evaluated in the Draft EIS.

An ESP is a Commission approval of a site or sites for one or more nuclear power facilities. Issuance of an ESP is an action separate from the issuance of a construction permit (CP) or a combined construction permit and operating license (combined license or COL) for such a facility. An ESP application may refer to a reactor's or reactors' design parameters or a PPE, which is a set of values of plant design parameters that an ESP applicant expects will bound the design characteristics of the reactor or reactors that might be built at a selected site; alternatively, an ESP application may refer to a detailed reactor design. An ESP is not a license to build a nuclear power plant; rather, the application for an ESP initiates a process undertaken to assess whether a proposed site is a suitable location for such a plant should the applicant be granted an ESP and later decide to pursue a CP or COL.

Section 102 of the National Environmental Policy Act of 1969 (NEPA) (42 USC 4321) directs that Federal agencies prepare an EIS for major Federal actions that significantly affect the quality of the human environment. The NRC has implemented Section 102 of NEPA in 10 CFR Part 51. Subpart A of 10 CFR Part 52 contains the NRC regulations related to ESPs. As set forth in 10 CFR 52.18, the Commission has determined that an EIS will be prepared during the review of an application for an ESP. The purpose of Dominion's proposed action, issuance of the ESP, is to provide stability in the licensing process by addressing site safety and environmental issues before the proposed new facilities are built rather than after construction is completed. Part 52 of Title 10 (10 CFR 52.21) describes an ESP as a "partial construction permit." An applicant for a CP or COL for a nuclear power plant or plants to be located at a site for which an ESP has been issued can reference the ESP, and matters resolved in the ESP proceeding are considered resolved in the subsequent proceeding absent the identification of new and significant information (10 CFR 52.39). However, issuance of either a CP (and OL) or COL to construct and operate a nuclear power plant is a major Federal action that requires its own environmental review in accordance with 10 CFR Part 51.

The holder of an ESP, or an applicant for a CP or COL that references an ESP that includes a site redress plan, may, in accordance with 10 CFR 52.25, perform the site preparation and preliminary construction activities enumerated in 10 CFR 50.10(e)(1), provided that the final ESP EIS concludes that the activities will not result in any significant adverse environmental impacts that cannot be redressed. Dominion provided a site redress plan as part of its ESP application.

Pursuant to 10 CFR 52.17(a)(2), Dominion did not address the benefits of the proposed action (e.g., the need for power).

In accordance with 10 CFR 52.18, the Final EIS is focused on the environmental effects of construction and operation of a reactor, or reactors, that have characteristics that fall within the design parameters that would be specified in the ESP if it is granted.

Under 10 CFR 52.17, three primary issues – site safety, environmental impacts, and emergency planning – must be addressed in an ESP application. Likewise, in its review of an ESP application under 10 CFR 52.18, the NRC assesses the applicant's proposal in relation to these issues and determines whether the application meets the requirements of the Atomic Energy

Act of 1954 and NRC regulations. Site safety and emergency planning are addressed in the staff's safety evaluation report (NRC 2006b).

To guide its assessment of environmental impacts of a proposed action or alternative actions, the NRC has established a standard of significance for impacts using Council on Environmental Quality (CEQ) guidance (40 CFR 1508.27). Using this approach, the NRC has established three significance levels – SMALL, MODERATE, or LARGE – which are defined below:

> SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
>
> MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
>
> LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

Mitigation measures were considered for each resource area and are presented in the appropriate sections.

If an ESP is issued and an application for a CP or COL references it, the application would have to demonstrate, among other things, that the design selected falls within the site characteristics and plant parameters considered in the environmental review, as set forth in the ESP. In addition, the applicant would be required to verify that the environmental permit conditions have been met. Further, the applicant should address the representations and staff assumptions used by the staff as bases for the final impact assessments. Appendix J addresses the permit conditions, representations, and staff assumptions associated with this EIS.

Section 102(2)(C) of NEPA requires that an EIS include information on:

- the environmental impact of the proposed action [102(2)(C)(i)]
- any adverse environmental effects that cannot be avoided should the proposal be implemented [102(2)(C)(ii)]
- alternatives to the proposed action [102(2)(C)(iii)]
- the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity [102(2)(C)(iv)]

- any irreversible and irretrievable commitments of resources that would be involved if the proposed action is implemented [102(2)(C)(v)]

The environmental impacts of the proposed action are discussed in Section 10.1. Adverse environmental effects which cannot be avoided should the proposal be implemented are discussed in Section 10.2. Alternatives to the proposed action are discussed in Section 10.3. The relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity is discussed in Section 10.4. Irreversible and irretrievable commitments of resources that would be involved if the proposed action is implemented are discussed in Section 10.5.

10.1 Environmental Impacts of the Proposed Action

Impacts associated with construction of the proposed ESP facilities are discussed in Chapter 4 of the Final EIS and are characterized in Table 4-1. Impacts associated with operation of the proposed facilities are discussed in Chapter 5 of the Final EIS and are characterized in Table 5-22. Construction and operational impacts are discussed in the Final EIS to make an informed decision on siting. The impacts of operations would only occur if an OL or a COL is issued by the NRC. A summary characterization of the environmental impacts of constructing and operating the proposed ESP facilities at the proposed and alternative sites is in Table 10-1.

Table 10-1. Comparison of Environmental Impacts of Constructing and Operating Two Units at the North Anna ESP Site and the Alternatives

	Proposed Action	No-Action Alternative	Alternative Sites		
Impact Category	**ESP at North Anna**	**Denial of ESP**	**Surry**	**Portsmouth**	**Savannah River**
Land use	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE
Ecology	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE
Water use and quality	SMALL to MODERATE(a)	SMALL	SMALL	SMALL to MODERATE	SMALL
Air quality	SMALL	SMALL	SMALL	SMALL	SMALL
Human health	SMALL	SMALL	SMALL	SMALL	SMALL
Socioeconomics	MODERATE ADVERSE to LARGE BENEFICIAL	SMALL	MODERATE ADVERSE to LARGE BENEFICIAL	MODERATE ADVERSE to LARGE BENEFICIAL	SMALL ADVERSE to LARGE BENEFICIAL
Historic and cultural resources	SMALL	SMALL	MODERATE to LARGE	SMALL	SMALL
Environmental justice	SMALL	SMALL	SMALL	SMALL	SMALL

(a) Impacts on water quality are unresolved, but likely to be SMALL.

The cumulative impacts associated with the proposed action are discussed and characterized in Chapter 7 of the Final EIS. The staff considered the potential cumulative impacts resulting from construction and operation of Units 3 and 4 in the context of past, present, and future actions at the North Anna ESP site. For each impact area, the staff determined that the potential cumulative impacts resulting from construction and operation are SMALL, and mitigation is not warranted. The geographical area over which past, present, and future actions could contribute to cumulative impacts is dependent on the type of action considered. Several impact categories have the potential for MODERATE impacts, most of which would occur under temporary circumstances or as the result of a larger than expected concentration of construction workers settling near the North Anna ESP site. Some impact issues were not resolved. The cumulative impacts for these issues would have to be addressed in a future EIS, should an applicant for a CP or COL reference an ESP for the North Anna ESP site.

10.2 Adverse Environmental Effects Which Cannot be Avoided if the Proposal is Implemented

There would be no unavoidable adverse environmental impacts associated with the granting of the ESP with the exception of impacts associated with the site preparation and preliminary construction activities. If the ESP is granted, the ESP holder could, pursuant to 10 CFR 52.25, perform the following site preparation and preliminary construction activities consistent with the type enumerated in 10 CFR 50.10(e)(1):

- preparation of the site for construction of the facility (including such activities as clearing, grading, and construction of temporary access roads and borrow areas)
- installation of temporary construction support facilities (including such items as warehouse and shop facilities, utilities, concrete mixing plants, docking and unloading facilities, and construction support buildings)
- excavation for facility structures
- construction of service facilities (including such facilities as roadways, paving, railroad spurs, fencing, exterior utility and lighting systems, and sanitary sewage treatment facilities)
- construction of structures, systems, and components that do not prevent or mitigate the consequences of postulated accidents, that could cause undue risk to the health and safety of the public.

These activities are identified in Dominion's site redress plan.

If the ESP is granted and any or all of the activities above are performed, but the ESP is not referenced in an application for a CP under 10 CFR Part 50 or a COL under 10 CFR Part 52 while the ESP remains valid, the ESP holder would be required to redress the site according to the site redress plan included in Part 4, Chapter 1 of the ESP application (Dominion 2006b). The staff reviewed the list of allowed site preparation and preliminary construction activities in the event that the ESP is granted and reviewed the full site redress plan submitted by Dominion. In accordance with 10 CFR 52.17(c), the application demonstrated that there is reasonable assurance that redress carried out under the plan will achieve an environmentally stable and aesthetically acceptable site suitable for whatever non-nuclear use may conform with local zoning laws. Accordingly, in accordance with 10 CFR 52.25(a), the staff concludes that the potential site preparation and preliminary construction activities described in Dominion's site redress plan would not result in any significant adverse environmental impacts that could not be redressed. As discussed in Section 1.5, the staff proposes to include a condition in the ESP prohibiting Dominion from conducting any site preparation and preliminary construction activity that would result in a discharge into navigable waters without first submitting to the NRC a Virginia Water Protection Permit (which Virginia considers to cover that requirement for a Clean Water Act, Section 401 Certification) or a determination by the Virginia Department of Environmental Quality (VDEQ) that no certification is required.

The impacts associated with the site preparation and preliminary construction activities are bounded by the overall construction activities. However, there are unavoidable adverse environmental impacts associated with the construction and operation of two units at the North Anna ESP site which are described below.

Unavoidable Adverse Impacts During Construction

Chapter 4 discusses the impacts from construction in detail. The unavoidable adverse impacts related to construction are identified in Table 10-2 and summarized below. The primary unavoidable adverse environmental impacts during construction would be related to land use. All construction activities for Units 3 and 4, including ground-disturbing activities, would occur within the existing NAPS site boundary. According to Dominion, the area that would be affected on a long-term basis as a result of permanent facilities is approximately 52 ha (128 ac); up to an additional 27.5 ha (67.9 ac) could be disturbed on a short-term basis as a result of temporary activities and facilities and laydown areas (Dominion 2006a).

The construction impacts on the terrestrial ecology of the site would be expected to be short-term. Construction of two units would result in the removal of approximately 32 ha (80 ac) of forested habitat within the ESP site. The ESP site does not contain any old growth timber or unique or sensitive plants or communities. Therefore, construction activities would not noticeably reduce the local or regional diversity of plants or plant communities.

There are no important animal species or habitats on the ESP site. No areas designated by the U.S. Fish and Wildlife Service as critical habitat for endangered or threatened species exist at or near the site, nor are threatened or endangered plants or animals known to exist at the site. Therefore, construction would be expected to have no impact on any threatened or endangered species or other important species or habitats. Socioeconomic impacts of construction include an increase in traffic. Atmospheric and meteorological impacts include fugitive dust from construction activities that can be mitigated by the dust control plan. Radiological doses to construction workers from the adjacent units are expected to be well below regulatory limits. Regarding environmental justice, there are no unusual resource dependencies by low income or minority groups and therefore no disproportionate adverse unavoidable impacts.

Table 10-2. Unavoidable Adverse Environmental Impacts from Construction

Impact Category	Adverse Impacts Based on Dominion's Proposal	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
Land use	Yes	Comply with requirements of applicable Federal, State, and local permits	52 ha (128 ac) disturbed on long-term basis, additional 27.5 ha (67.9 ac) would be disturbed on a short-term basis.
Hydrological and water use	Yes	Obtain a Clean Water Act Section 401 certification prior to site preparation activities; use best construction management practices;	Fill and grading operations at the North Anna ESP site would alter two ephemeral streams.
Ecological			
Terrestrial **Aquatic**	Yes Yes	(a) Use of construction best management practices, adherence to applicable permit conditions, and avoidance of sensitive areas. Where possible, reestablish habitat after construction. (b) Obtain a Clean Water Act Section 404 Permit	(a) Removal of trees and vegetation and habitat. (b) Disturbance of intermittent streams, destruction of wetlands.
Socioeconomic	Yes	Implement traffic management plan	Increased traffic congestion
Radiological	Yes	Use of as low as reasonably achievable (ALARA) principles	Dose to construction workers
Atmospheric and meteorological	Yes	Implement dust control plan	Equipment emissions and fugitive dust from operation of earth-moving equipment are sources of air pollution.
Environmental justice	No	None	None

Unavoidable Adverse Impacts During Operation

Chapter 5 of the Final EIS provides a detailed discussion of the impacts from operation. The unavoidable adverse impacts related to operation are identified in Table 10-3 and summarized below.

Operation of the closed-cycle, combination wet and dry cooling system for Unit 3, described in the ER, would result in an occasional and temporary decrease in the level of Lake Anna and a reduction in available water released from the dam into the North Anna River.

Socioeconomic impacts are primarily increased demand for services, with the increased tax revenue to support the increase in services. The visual impact of lower water levels, and their effect on shoreline exposure during intermittent severe drought, could temporarily impact the area. Regarding environmental justice, there are no unusual resource dependencies by low income or minority groups and therefore no disproportionate adverse unavoidable impacts.

Table 10-3. Unavoidable Adverse Environmental Impacts from Operation

Impact Category	Adverse Impacts Based on Dominion's Proposal	Actions to Mitigate Impacts	Unavoidable Adverse Impacts
Land use	No	Local land management plans; comply with requirement of applicable Federal, State, and local permits.	Possible new housing and retail space added in vicinity because of potential growth.
Hydrological and water use	Yes	Comply with Commonwealth permit limits.	Occasional and temporary decrease in level of Lake Anna and reduction in available water released from dam into the North Anna River.
Ecological			
Terrestrial	No	None	None
Aquatic	Yes	None	Proportion of resources subject to impingement and entrainment would be small.
Socioeconomic	Yes	Consider plume abatement measures.	Impacts to recreation because the level of Lake Anna would be lower during drought conditions. Periodic adverse visual aesthetic impact due to Unit 3 cooling tower plume.
Radiological	Yes	Use of ALARA principles	Dose to workers, the public, and biota.
Atmospheric and meteorological	No	None	None
Environmental justice	No	None	None

Meteorological impacts are expected to be negligible, although wet cooling towers would put moisture into the air in the form of a visible condensation plume. Pollutants emitted during operations are considered insignificant. The unavoidable adverse impacts from operation for land use are small and further mitigation is not warranted.

10.3 Alternatives to the Proposed Action

Alternatives to the proposed action are discussed in Chapter 8 of the Final EIS. Alternatives considered are the no-action alternative, alternative cooling systems, and alternative sites.

The no-action alternative refers to a scenario in which the NRC would deny the ESP request. The no-action alternative is discussed in Section 8.1 of the Final EIS. A comparison of the proposed action with the no-action alternative is in Section 9.4 of the Final EIS. Impacts associated with the no-action alternative are characterized as SMALL in Table 10-1.

Alternative cooling systems are discussed in Section 8.2 of the Final EIS. Section 8.2 discusses once-through, wet, and dry cooling as alternatives to the proposed combination of wet and dry cooling for Unit 3. The staff concluded in Section 8.2 that the proposed combination of wet and dry cooling for Unit 3 is preferable to the three cooling alternatives. No cooling alternatives are considered for Unit 4 because dry cooling is the only technically feasible alternative identified by the applicant, as discussed in Section 8.2.

Alternative sites are discussed in Sections 8.3 - 8.8 of the Final EIS. Additionally, the impacts of construction and operation of the ESP facilities are compared to the impacts at the proposed North Anna site in Chapter 9 of the Final EIS. Table 9-1 contains the staff's characterization of construction impacts at the proposed and alternative sites. Table 9-2 contains the staff's characterization of operational impacts at the proposed and alternative sites. The staff concluded that while there are differences in construction and operational impacts at the proposed and alternative sites, none of the alternative sites is environmentally preferable or obviously superior to the proposed site.

10.4 Relationship Between Short-Term Uses and Long-Term Productivity of the Human Environment

Section 102(2)(C)(iv) of NEPA requires that an EIS include information on the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity. The only short-term use of the environment that could occur if the proposed action is granted would be site preparation and limited construction activities. Any such activities are unlikely to adversely affect the long-term productivity of the environment. The evaluation of the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity for the construction and operation of the two new units can only be performed by discussing the benefits of operating the units. The principal societal benefit associated with construction and operation of the proposed units is the production of electricity. In accordance with 10 CFR 52.17 and 52.18, an ER and an EIS prepared in conjunction with an ESP application need not include an assessment of the benefits of the proposed action and no such assessment is included in this Final EIS. Therefore, an assessment of the evaluation of the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity for the construction and operation of the two units would be performed at the CP/COL stage should the NRC grant an ESP to Dominion and an applicant references the ESP in an application for a CP or COL.

10.5 Irreversible and Irretrievable Commitments of Resources

Section 102(2)(C)(v) of NEPA requires that an EIS include information on any irreversible and irretrievable commitments of resources that would occur if the proposed action is implemented. The only irreversible and irretrievable commitments of resources that would be expended if the proposed action is implemented would be resources used by Dominion for site preparation activities. If not used during the duration of the ESP, any such resource commitments for site preparation activities would be used at the CP/COL stage or could potentially be used for other activities even if the ESP is issued but not referenced in a CP or a COL application.

Irretrievable commitments of resources during construction of the proposed new units generally would be similar to that of any major construction project. The actual commitment of construction resources (e.g., concrete, steel, and other building materials) would depend on the reactor design selected at the CP/COL stage. Hazardous materials such as asbestos would not be used, if possible (Dominion 2006a). If materials such as asbestos were used, then the use would be in accordance with applicable safety regulations and practices. The actual estimate of construction materials would be performed at the CP/COL stage when the reactor design is selected.

The staff expects that the use of construction materials in the quantities associated with those expected for the two new units, while irretrievable, would be a small impact with respect to the availability of such resources.

The main resource that would be irretrievably committed during operation of two new nuclear units would be uranium for the fuel and ultimately the offsite storage space for the spent fuel assemblies. The availability of uranium ore and existing stockpiles of highly enriched uranium in the United States and Russia that could be processed into fuel is sufficient; therefore the irreversible and irretrievable commitment would be of only small consequence.

10.6 Staff Conclusions and Recommendations

The staff's recommendation, after consideration of the environmental impacts described in this Final EIS, is that an ESP for North Anna Units 3 and 4 should be issued. This recommendation is based on (1) the ER submitted by Dominion; (2) consultation with Federal, State, Tribal and local agencies; (3) the staff's independent review; (4) the staff's consideration of public comments related to the environmental review that were received during the review process; and (5) the assessments summarized in this Final EIS, including the potential mitigation measures identified in the ER and in this Final EIS. In addition, in making its recommendation, the staff has concluded that the alternative sites considered are not obviously superior to the proposed site. Finally, the staff concludes that the site preparation and preliminary construction activities enumerated in 10 CFR 50.10(e)(1) would not result in any significant adverse environmental impact that cannot be redressed.

A comparative summary showing the environmental impacts of constructing and operating two new units at the North Anna ESP site or at any of the alternative sites is shown in Table 10-1. The estimated environmental significance of the no-action alternative, or denial of the ESP application, is also shown. Table 10-1 shows that the significance of the environmental impacts of the proposed action is SMALL for all impact categories at all sites with the exception of certain land use, ecology, water use and quality, socioeconomic, and historic and cultural resource impacts. The alternative sites may have adverse environmental effects in at least some categories that reach MODERATE to LARGE significance.

The range of impacts estimated by the NRC staff for resolved issues is predicated on certain assumptions that are identified in each section. Should the Commission issue an ESP for the North Anna ESP site, and it is referenced in an application for a CP or COL, the staff will verify that the assumptions identified in this Final EIS remain applicable. In addition, certain issues are not resolved because of a lack of information. An applicant for a CP or COL referencing an ESP for the North Anna ESP site would need to provide the necessary information to resolve these issues, if the proposed action ultimately would affect the resources associated with these issues.

10.7 References

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 52. Code of Federal Regulations, Title 10, *Energy*, Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

40 CFR Part 1508. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 1508, "Council on Environmental Quality, Terminology and Index."

Atomic Energy Act of 1954. 42 USC 2011, et seq.

Clean Water Act (CWA) (also referred to as the Federal Water Pollution Control Act). 33 USC 1251, et seq.

Dominion Nuclear North Anna, LLC (Dominion). 2006a. *North Anna Early Site Permit Application – Part 3 – Environmental Report*. Revision 9, Glen Allen, Virginia.

Dominion Nuclear North Anna, LLC (Dominion). 2006b. *North Anna Early Site Permit Application – Part 4 – Programs and Plans*. Revision 9, Glen Allen, Virginia.

National Environmental Policy Act of 1969 (NEPA). 42 USC 4321 *et seq*.

U.S. Nuclear Regulatory Commission (NRC). 2004. *Draft Environmental Impact Statement for an Early Site Permit (ESP) for the North Anna ESP Site.* NUREG-1811, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2006a. *Draft Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site*. NUREG-1811, Supplement 1, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2006b. *Supplement to the Final Safety Evaluation Report for an Early Site Permit (ESP) at the North Anna ESP Site*. September 2006. Accession No. ML062210441.

Appendix A

Contributors to the Environmental Impact Statement Related to Dominion Nuclear North Anna, LLC's Application for an Early Site Permit at the North Anna ESP Site

Appendix A

Contributors to the Environmental Impact Statement Related to Dominion Nuclear North Anna, LLC's Application for an Early Site Permit at the North Anna ESP Site

The overall responsibility for the preparation of this environmental impact statement was assigned to the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission (NRC). The statement was prepared by members of the Offices of Nuclear Reactor Regulation with assistance from other NRC organizations and Pacific Northwest National Laboratory.

Name	Affiliation	Function or Expertise
	NUCLEAR REGULATORY COMMISSION	
Jack Cushing	Nuclear Reactor Regulation	Project Manager
Andrew Kugler	Nuclear Reactor Regulation	Section Chief/Project Manager
John Tappert	Nuclear Reactor Regulation	Section Chief
Chris Nolan	Nuclear Reactor Regulation	Section Chief
Brent Clayton	Nuclear Reactor Regulation	Section Chief
Stacey Imboden	Nuclear Reactor Regulation	Project Management Support
Alicia Williamson	Nuclear Reactor Regulation	Project Management Support
Samuel Quinones-Hernandez	Nuclear Reactor Regulation	Project Management Support
Laura Quinn	Nuclear Reactor Regulation	Project Management Support
Barry Zalcman	Nuclear Reactor Regulation	Technical Monitor
Tom Kenyon	Nuclear Reactor Regulation	Project Management
James Wilson	Nuclear Reactor Regulation	Biologist
Michael Masnik	Nuclear Reactor Regulation	Biologist
Harriet Nash	Nuclear Reactor Regulation	Biologist
Nancy Kuntzleman	Nuclear Reactor Regulation	Biologist
Brad Harvey	Nuclear Reactor Regulation	Meteorology
Rich Emch	Nuclear Reactor Regulation	Radiological Impacts
Charles Hinson	Nuclear Reactor Regulation	Radiological Impacts
Steve Klementowicz	Nuclear Reactor Regulation	Radiological Impacts
Audrey Hayes	Nuclear Reactor Regulation	Radiological Impacts
Jay Lee	Nuclear Reactor Regulation	Design Basis and Severe Accidents
Robert Palla	Nuclear Reactor Regulation	Severe Accidents
Amy Snyder	Nuclear Material Safety and Safeguards	Fuel Cycle Impacts
James Park	Nuclear Material Safety and Safeguards	Fuel Cycle Impacts
Cynthia Barr	Nuclear Material Safety and Safeguards	Fuel Cycle Impacts
Nina Barnett	Nuclear Reactor Regulation	Administrative Support
Yvonne Edmonds	Nuclear Reactor Regulation	Administrative Support
Jennifer Davis	Nuclear Reactor Regulation	Cultural Resources

Name	Affiliation	Function or Expertise
	PACIFIC NORTHWEST NATIONAL LABORATORY[(a)]	
Mary Ann Parkhurst		Task Leader
Beverly Miller		Deputy Task Leader
Kimberly Leigh		Deputy Task Leader
William Sandusky		Air Quality
John Jaksch		Socioeconomics
Mike Scott		Socioeconomics
Duane Neitzel		Aquatic Ecology
Jeffrey Ward		Aquatic Ecology
Mike Sackschewsky		Terrestrial Ecology
Greg Stoetzel		Radiation Protection
Paul Nickens		Cultural Resources
Paul Hendrickson		Land Use, Related Federal Programs, Alternatives
Lance Vail		Water Use, Hydrology
Chris Cook		Water Use, Hydrology
Stuart Saslow		Water Use, Hydrology
Eva Hickey		Decomissioning
Van Ramsdell		Design Basis and Severe Accidents
Dennis Strenge		Severe Accidents
Maha Mahasenan		Transportation
Philip Daling		Transportation
Michael Smith		Technical Review
Nona Diediker		Comment Deliniation
Cary Counts		Technical Editing
Barbara Wilson		Publications Assistant
Debbie Schulz		Document Production
Jean Cheyney		Document Production
Mike Parker		Document Production
Susan Tackett		Document Production
Trina Russell		Document Production
Rose Urbina		Document Production
Seleste Williams		Document Production

(a) Pacific Northwest National Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute.

Appendix B

Organizations Contacted

Appendix B

Organizations Contacted

During the course of the staff's independent review of potential environmental impacts from siting two new nuclear units at the North Anna site, the following Federal, State, regional, Tribal and local agencies were contacted:

Lake Anna State Park, Spotsylvania, Virginia

Louisa County Historical Society, Louisa, Virginia

Virginia Department of Conservation and Recreation, Richmond, Virginia

Virginia Department of Historic Resources, Richmond, Virginia

Chickahominy Indian Tribe, Providence Forge, Virginia

Chickahominy Indians – Eastern Division, Providence Forge, Virginia

Mattaponi Indian Tribe, West Point, Virginia

Monacan Indian Nation, Madison Heights, Virginia

Nansemond Indian Tribe, Suffolk, Virginia

Pamunkey Indian Tribe, King William, Virginia

Rappahannock Tribe, Indian Neck, Virginia

Upper Mattaponi Indian Tribe, Mechanicsville, Virginia

Virginia Council on Indians, Richmond, Virginia

U.S. Army Corps of Engineers

South Carolina Field Office, U.S. Fish and Wildlife Service, Charleston, South Carolina

Ohio Field Office, U.S. Fish and Wildlife Service, Reynoldsburg, Ohio

Virginia Department of Environmental Quality, Richmond, Virginia

Department of Conservation and Recreation, Richmond, Virginia

Virginia Department of Game and Inland Fisheries, Richmond, Virginia

Wildlife Diversity Division, Virginia Department of Game and Inland Fisheries, Richmond, Virginia

Department of Mines, Minerals, and Energy, Richmond, Virginia

Marine Resources Commission, Newport News, Virginia

Virginia Department of Transportation, Richmond, Virginia

Department of Agriculture and Consumer Services, Richmond, Virginia

Chesapeake Bay Field Office U.S. Fish and Wildlife Service, Annapolis, Maryland

Budget Director, Spotsylvania County, Spotsylvania, Virginia

Finance Director, Louisa County, Louisa, Virginia

Treasurer, Orange County, Orange, Virginia

Reservoir Coordinator, Nuclear Site Services, Dominion Generation, North Anna Site

Commissioner of Revenue, Louisa County, Louisa, Virginia

Assessor, Louisa County, Louisa, Virginia

Director of the Department of Community Development, Louisa County, Louisa, Virginia

Director of the Planning Division, Louisa County, Louisa, Virginia

Director Department of Planning, Spotsylvania County, Spotsylvania, Virginia

Customer Services Supervisor, Department of Public Utilities Henrico County, Virginia

Director of Economic Development, Spotsylvania County, Spotsylvania, Virginia

President of Fredericksburg Regional Alliance, Fredericksburg, Virginia

Realtor, Century 21, Fredericksburg, Virginia

Owner/Broker Century 21, Fredericksburg, Virginia

Rappahannock Area Development Commission, Fredericksburg, Virginia

Louisa County Farm Service Agency, Louisa, Virginia

Administrative Assistant for School Admissions, Spotsylvania Public Schools, Spotsylvania, Virginia

School Superintendent, Louisa County Public Schools, Louisa, Virginia

School Superintendent, Orange County Public Schools, Orange, Virginia

County Administrator, Louisa County, Louisa, Virginia

Director Office of Economic Development, Orange County, Orange, Virginia

Director Planning and Zoning, Orange County, Orange, Virginia

Director of Economic Development, Louisa County, Louisa, Virginia

Louisa Town Manager, Louisa, Virginia

Real Estate Agent, Century 21, Mineral, Virginia

Director of Social Services, Orange County, Virginia

Director of Social Services, Louisa County, Virginia

County Administrator, Orange County, Virginia

Town Manager, Orange, Virginia

Director of Public Works, Orange, Virginia

Managing Broker, Century 21, Orange, Virginia

Branch Manager, Virginia Community Bank, Louisa, Virginia

Town Manager, Mineral, Virginia

Interim County Manager, Spotsylvania County, Spotsylvania, Virginia

Deputy Superintendent, Colonial National Historic Park, National Park Service

Appendix C

Chronology of NRC Staff Environmental Review Correspondence Related to Dominion Nuclear North Anna, LLC's Application for an Early Site Permit (ESP) at the North Anna ESP Site

Appendix C

Chronology of NRC Staff Environmental Review Correspondence Related to Dominion Nuclear North Anna, LLC's Application for an Early Site Permit (ESP) at the North Anna ESP Site

This appendix contains a chronological listing of correspondence between the U.S. Nuclear Regulatory Commission (NRC) and Dominion Nuclear North Anna, LLC (Dominion) and other correspondence related to the NRC staff's environmental review, under 10 CFR Part 51, for Dominion's application for an early site permit at the North Anna Nuclear Plant site. All documents, with the exception of those containing proprietary information, have been placed in the Commission's Public Document Room, at One White Flint North, 11555 Rockville Pike (first floor), Rockville, MD, and are available electronically from the Public Electronic Reading Room found on the Internet at the following web address: http://www.nrc.gov/reading-rm.html. From this site, the public can gain access to the NRC's Agencywide Document Access and Management Systems (ADAMS), which provides text and image files of NRC's public documents in the Publicly Available Records (PARS) component of ADAMS. The ADAMS accession numbers for each document are included below.

September 25, 2003 Letter from Mr. David A. Christian, Dominion, to NRC submitting the application for an early site permit at North Anna (Accession No. ML032731511)

September 29, 2003 Letter from Mr. Tony Banks, Dominion, to Ms. Joanne Tetrault, Louisa County Library, forwarding application for an early site permit at North Anna (Accession No. ML032880335)

September 29, 2003 Letter from Ms. Pamela Faggert, Dominion, to Ms. Ellie Irons, Virginia Department of Environmental Quality (VDEQ), forwarding the early site permit application and requesting a Coastal Zone Management Act consistency determination (Accession No. ML040780219)

October 2, 2003 Letter from Mr. David A. Christian, Dominion, to NRC submitting Revision 1 of the application for an early site permit at North Anna (Accession No. ML032731511)

October 9, 2003 Letter from NRC to Mr. David A. Christian, Dominion, regarding the receipt and availability of the application for an early site permit at North Anna (Accession No. ML032600005)

October 9, 2003	NRC press release announcing the availability of the early site permit application for North Anna (Accession No. ML032820297)
October 16, 2003	Federal Register Notice of receipt of the application for an early site permit at North Anna (68 FR 59642)
October 23, 2003	Letter from NRC to Mr. David A. Christian, Dominion, regarding acceptance of the application for an early site permit at North Anna (Accession No. ML032740025)
October 29, 2003	Federal Register Notice of acceptance for docketing of the application and notice of opportunity for a hearing regarding the application for an early site permit at North Anna (68 FR 61705)
November 6, 2003	Letter from Ms. Pamela Faggert, Dominion, to Ms. Ellie Irons, VDEQ, forwarding a Coastal Zone Management Act consistency determination for the early site permit application and requesting concurrence (Accession No. ML033280533)
November 24, 2003	Federal Register Notice of Intent to prepare an environmental impact statement and conduct scoping process for an early site permit at North Anna (68 FR 65961)
November 24, 2003	NRC meeting notice announcing public meeting in Mineral, Virginia on December 8, 2003, to discuss the environmental scoping process for the application for an early site permit at North Anna (Accession No. ML033280550)
November 28, 2003	Letters from NRC to public officials announcing receipt and review of the application for an early site permit at North Anna (Accession No. ML033020111)
December 3, 2003	Letter from NRC to Ms. Deanna Beacham, Virginia Council on Indians, regarding the early site permit review for the North Anna Power Station site (Accession No. ML033390103)
December 3, 2003	Letter from NRC to Chief Leo Henry, Tuscarora Nation, regarding the early site permit review for the North Anna Power Station site (Accession No. ML033390155)

December 3, 2003	Letter from NRC to Chief Arnold Hewitt, Tuscarora Nation, regarding the early site permit review for the North Anna Power Station site (Accession No. ML033390191)
December 3, 2003	Letter from NRC to Neil Patterson, Jr., Tuscarora Environmental Nation, regarding the early site permit review for the North Anna Power Station site (Accession No. ML033390172)
December 8, 2003	Placement of public meeting materials into public document room (Accession No. ML033450406)
December 12, 2003	E-mail from Ms. Carrie E. Girstantas to NRC, providing scoping comments regarding the early site permit review for the North Anna Power Station site (Accession No. ML040140310)
December 12, 2003	Letter from NRC to Mr. David Ritter, Mr. Brendan Hoffman, and Mr. Jon Kessler regarding requests made during the environmental scoping meeting to extend the time to file a petition for leave to intervene in proceeding on early site permit for the North Anna Power Station site (Accession No. ML033580505)
December 21, 2003	Letter from NRC to Mr. John Wolflin, Chesapeake Bay Field Office of the U.S. Fish and Wildlife Service, requesting a list of species and information on protected, proposed, and candidate species and critical habitat that may be in the vicinity of the North Anna Power Station and Surry Power Station sites (Accession No. ML033570088)
December 21, 2003	Letter from NRC to Ms. Mary Colligan, Northeast Regional Office of NOAA Fisheries, requesting a list of species and information on protected, proposed, and candidate species and critical habitat that may be in the vicinity of the North Anna Power Station and Surry Power Station sites (Accession No. ML033560365)
December 21, 2003	Letter from NRC to Dr. Mary Knapp, Reynoldsburg Ecological Services Office of the U.S. Fish and Wildlife Service, requesting a list of species and information on protected, proposed, and candidate species and critical habitat that may be in the vicinity of the U.S. Department of Energy's Portsmouth Site (Accession No. ML033560384)

December 21, 2003	Letter from NRC to Mr. Roger L. Banks, Charleston Ecological Services Office of the U.S. Fish and Wildlife Service, requesting a list of species and information on protected, proposed, and candidate species and critical habitat that may be in the vicinity of the U.S. Department of Energy's Savannah River Site (Accession No. ML033560437)
December 21, 2003	Email from Aviv Goldsmith to NRC, providing scoping comments regarding the early site permit review for the North Anna Power Station site (Accession No. ML040060329)
January 5, 2004	Letter from NRC to Ms. Georgia Cranmore, Southeast Regional Office of NOAA Fisheries, requesting a list of species and information on protected, proposed, and candidate species and critical habitat that may be in the vicinity of the U.S. Department of Energy's Savannah River Site (Accession No. ML040080759)
January 5, 2004	Letter from NRC to Mr. Don Klima, Advisory Council on Historic Preservation, inviting comments on the effects of an early site permit for the North Anna Power Station site on historic properties in accordance with the National Historic Preservation Act (Accession No. ML040080790)
January 6, 2004	Letter from Ms. Mary Colligan, Northeast Regional Office of NOAA Fisheries, to NRC, providing a response to a letter requesting a list of species in the vicinity of the North Anna Power Station and Surry Power Station sites (Accession No. ML040230669)
January 7, 2004	Letter from the Hanover County, Virginia, Department of Public Utilities to NRC, providing scoping comments regarding the early site permit review for the North Anna Power Station site (Accession No. ML040130744)
January 8, 2004	Letter from an unknown individual to NRC, providing scoping comments regarding the early site permit review for the North Anna Power Station site (Accession No. ML040230552)
January 9, 2004	Email from Diane Curran to NRC, providing scoping comments on behalf of Blue Ridge Environmental Defense League, Nuclear Information and Resource Service, and Public Citizen regarding the early site permit review for the North Anna Power Station site (Accession No. ML040230548)

January 12, 2004	Letter from Ms. Pamela Faggert, Dominion, to Ms. Ellie Irons, VDEQ, withdrawing Federal Consistency Certification under the Coastal Zone Management Act for North Anna's Early Site Permit Application (Accession No. ML040230690)
January 13, 2003	NRC summary of public scoping meetings to support review of the early site permit application for the North Anna Power Station site (Accession No. ML040140627)
January 15, 2004	Letter from Mr. Timothy N. Hall, U.S. Fish and Wildlife Service, Charleston, South Carolina, to NRC, providing a response to a letter requesting a list of species in the vicinity of the Savannah River alternate site (Accession No. ML040270227)
February 3, 2004	Letter from Dr. Mary Knapp, U.S. Fish and Wildlife Service, Reynoldsburg, Ohio, to NRC, providing a response to a letter requesting a list of species in the vicinity of the Portsmouth alternate site (Accession No. ML040480521)
February 10, 2004	Letter from Ms. Ellie Irons, VDEQ, to Ms. Pamela Faggert, Dominion, acknowledging January 12, 2004 withdrawal of Federal Consistency Certification under the Coastal Zone Management Act and forwarding copies of comments developed by reviewing agencies regarding the early site permit application for the North Anna Power Station site (Accession No. ML40490249)
February 26, 2004	Letter from NRC to Mr. David A. Christian, Dominion, revising schedule for review of early site permit for North Anna Power Station site (Accession No. ML040570185)
March 12, 2004	Letter from NRC to Mr. David A. Christian, Dominion, transmitting request for additional information regarding environmental portion of early site permit application for North Anna Power Station site (Accession No. ML040720580)
March 19, 2004	Letter from Mr. Eugene Grecheck, Dominion, to NRC providing Lake Anna modeling calculations for North Anna Early Site Permit application (Accession No. ML040910433)
March 27, 2004	Summary of Environmental Site Audit to Support Review of the North Anna Early Site Permit Application (Accession No. ML040860222)

March 31, 2004	Letter from Mr. Eugene Grecheck, Dominion, to NRC stating revised approach for Unit 4 normal plant cooling (Accession No. ML040980485)
April 5, 2004	Letter from NRC to Mr. Brent Gutierrez, Savannah River Operations Office, expressing thanks for support provided during site visit at Savannah River Site, an alternative to the North Anna Power Station site (Accession No. ML040970408)
April 5, 2004	Letter from NRC to Mr. Russ Vranicar, Portsmouth Project, expressing thanks for support provided during site visit at Portsmouth site, an alternative to the North Anna Power Station site (Accession No. ML040970276)
April 14, 2004	Letter from NRC to Mr. David A. Christian, Dominion, regarding new Environmental Project Manager for the review of the Early Site Permit application at the North Anna site (Accession No. ML041050879)
April 19, 2004	Summary of Telephone Call between NRC and Dominion concerning clarification of the request for additional information pertaining to the North Anna Early Site Permit Application (Accession No. ML041130241)
May 6, 2004	NRC Trip Report of Visits to the Savannah River Site and Portsmouth Site, Alternatives to the North Anna Early Site Permit Site (Accession No. ML041270548)
May 12, 2004	Letter from NRC to Mr. Steven D. Routh, Bechtel Power Corporation, regarding request for withholding information from public disclosure for the North Anna Early Site Permit (Accession No. ML041390448)
May 17, 2004	Dominion’s Response to NRC’s March 12, 2004 Request for Additional Information Regarding Environmental Portion of Early Site Permit Application (Accession No. ML041450037)
June 22, 2004	Letter from NRC to Mr. David Christian, Dominion, regarding revised early site permit environmental review schedule (Accession No. ML04170014)
June 23, 2004	Summary of Telephone Call between NRC and Dominion concerning clarification of Dominion’s May 17, 2004, response to NRC’s requests for additional information pertaining to the North Anna Early Site Permit Application (Accession No. ML041830193)

June 24, 2004	Issuance of Environmental Scoping Summary Report (Accession No. ML041770579)
June 28, 2004	Letter from Dominion to NRC, responding to comments in VDEQ's February 10, 2004, letter related to the Coastal Zone Management Act certification (Accession No. ML041890324)
July 12, 2004	Letter from Dominion to NRC, Additional Responses to NRC's March 2, 2004 Request for Additional Information Regarding Environmental Portion of Early Site Permit Application (Accession No. ML041970396)
July 15, 2004	Letter from Dominion to NRC, forwarding Revision 2 to the North Anna early site permit application (Accession No. ML042010009)
August 17, 2004	Summary of telephone calls between the U.S. Nuclear Regulatory Commission and Dominion pertaining to the environmental review of the North Anna early site permit application (Accession No. ML042310737)
August 27, 2004	E-mail from NRC (Andrew Kugler) to Bill Borduin in response to concerns expressed regarding the early site permit for the North Anna Power Station (Accession No. ML042440891)
September 16, 2004	E-mail from Mr. Joseph Hegner, Dominion, to NRC in response to August 2004 Telecon question No. 4 pertaining to NRC's Environmental Review (Accession No. ML042640344)
September 22, 2004	Email from Mr. Tony Banks, Dominion, to NRC transmitting Lake Anna State Park attendance data (Accession No. ML042670291)
September 30, 2004	North Anna Early Site Permit Application, Revision 3, Part 3-Environmental Report Chapters 1 - 3:2:260 (Accession No. ML042590096)
September 30, 2004	North Anna Early Site Permit Application, Revision 3, Part 3-Environmental Report Chapters 3:3:1 - 4:1:9 (Accession No. ML042590097)
October 29, 2004	Letter from the US Fish and Wildlife service containing a list of threatened or endangered species for the North Anna ESP site and the alternate Surry ESP site (Accession No. ML 043090290)

October 29, 2004	Letter from the NRC to Mr. David Christian, Dominion, requesting additional information regarding the uranium fuel cycle (Accession No. ML043030707)
November 12, 2004	Letter from the NRC to Mr. David A. Christian, Dominion, forwarding revised environmental review schedule (Accession No. ML043080347)
November 18, 2004	Response from Dominion to the NRC's October 29, 2004, request for additional information on the uranium fuel cycle (Accession No. ML043240229)
November 30, 2004	NUREG 1811, "Draft Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site" (Accession No. ML043380308)
December 2, 2004	Letter to EPA transmitting NUREG 1811, "Draft Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site" (Accession No. ML043370446)
December 2, 2004	Letter to Dominion transmitting Federal Register Notice of Availability of the Draft Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site (Accession No. ML043370460)
December 27, 2004	Meeting Notice for meeting on the draft environmental impact statement (Accession No. ML043650007)
January 26, 2005	Meeting Notice of rescheduled meeting on the draft environmental impact statement (Accession No. ML05027019)
January 31, 2005	Biological Assessment for the Early Site Permit (ESP) of the North Anna ESP Site and a Request for Informal Consultation (Accession No. ML050320461)
January 31, 2005	Trip report for the January 6, 2005, drop in visit with the County Commissioners of Spotsylvania, Orange and Louisa Counties (Accession No. ML050340579)
February 23, 2005	EPA letter requesting an extension of the comment period (Accession No. ML050610265)
March 17, 2005	NRC response to EPA request for extension of comment (Accession No. ML050500497)

March 18, 2005	Supplemental Request for Additional Information (RAI) (Accession No. ML050840226)
March 20, 2005	Meeting summary for public meeting held to on February 17, 2005, in Mineral Virginia to receive comments on the draft environmental impact statement (Accession No. ML050880304)
March 22, 2005	Trip report for the January 19, 2005, drop in visit with the Commonwealth of Virginia (Accession No. ML050810272)
March 31, 2005	Summary of a Telephone Call Between U.S. Nuclear Regulatory Commission and Dominion Concerning the Request for Additional Information (RAI) Pertaining to the North Anna Early Site Permit Application (Accession No. ML050920010)
April 12, 2005	Dominion's response to the March 18, 2005, RAI number 4, requesting documentation of Dominion's commitment to the Commonwealth of Virginia regarding the striped bass (Accession No. ML0501090376)
April 13, 2005	Email from Jack Cushing (NRC) to Ellie Irons Commonwealth of Virginia Department of Environmental Quality requesting clarification of commitment between the Commonwealth and Dominion regarding the striped bass (Accession No. ML051040399)
April 13, 2005	Dominion's response to the March 18, 2005, RAI number 1, 2 and 3 (Accession No. ML051100321)
April 21, 2005	Email from the Commonwealth of Virginia (Ellie Irons) clarifying mitigation for the striped bass (Accession No. ML051120483)
May 12, 2005	Revision 4 to North Anna Early Site Permit Application (Accession No. ML051450310)
May 20, 2005	Letter from the U.S. Fish and Wildlife Service Chesapeake Bay Field Office, concurring with the NRC's biological assessment (Accession No. ML051600263)
June 14, 2005	Summary of Telephone Conference with the Virginia Department of Historic Resources Regarding the North Anna Early Site Permit Review (Accession No. ML05166060)

June 16, 2005	Memo to: Andrew Kugler, Section Chief, NRR/DRIP/RLEP/ES Subject: Report Containing Comments Received Pertaining to the Draft Environmental Impact Statement for the North Anna Early Site Permit Application (Accession No. ML051720560)
June 30, 2005	Letter to U. S. Army Corps of Engineers transmitting NUREG 1811, “Draft Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site” (Accession No. ML051880003)
July 7, 2005	Letter from Virginia Department of Environmental Quality Requesting Comment and Response Document Pertaining to North Anna Early Site Permit Draft Environmental Impact Statement (Accession No. ML052010112)
July 15, 2005	Letter from U. S. Army Corps of Engineering Regarding NUREG 1811, “Draft Environmental Impact Statement for the North Anna Early Site Permit (ESP) at the North Anna ESP Site” (Accession No. ML052020342)
July 15, 2005	Trip Report Tour of Doswell Limited Partnership Combined Cycle Facility (Accession No. ML052170374)
July 20, 2005	Letter from the NRC to Mr. David Christian, Dominion, requesting additional information regarding compliance with Section 307 of the Coastal Zone Management Act and Section 401 of the Federal Water Pollution Control Act (Accession No. ML052010524)
July 25, 2005	Transmittal of Final Safety Evaluation Report Review Items and Revision 5 to the North Anna ESP Application (Accession No. ML052150226)
August 16,2005	Letter transmitting revised schedule (Accession No. ML051520461)
September 8, 2005	Supplemental request for additional information (RAI) regarding the environmental portion of the Early Site Permit (ESP) Application for the North Anna Site (Accession No. ML052520272)
September 22, 2005	Dominion's response to the supplemental request for additional information (Accession No. ML052660062)
September 27, 2005	Letter from the NRC to Dr. Ethel Eaton, Virginia Department of Historic Resources regarding the North Anna Early Site Permit Review (Accession No. ML052730103)

September 30, 2005	Safety Evaluation Report for an early site permit (ESP) at North Anna ESP Site (Accession number ML052710305)
October 6, 2005	Dominion's response to the supplemental request for additional information dated July 20, 2005 (Accession No. ML052790657)
October 24, 2005	Letter from Dominion to the NRC regarding North Anna Early Site Permit Application Planned Revision to Unit 3 Cooling Water Approach (Accession No. ML052980117)
October 25, 2005	Letter from Mr. Brooks, Deputy Superintendent, National Park Service, to the NRC, providing comments on the National Park Service's concern regarding the alternative Surry ESP site potential impact on the viewshed. (Accession No. ML053080128)
November 2, 2005	Letter from NRC to Dominion responding to Dominion's notification of modification of the cooling system for the North Anna ESP Site (Accession No. ML053000566)
November 3, 2005	Letter from the Virginia Department of Historic Resources regarding consultation under Section 106 of the National Historic Preservation Act (Accession No. ML0531301730)
November 22, 2005	Letter from Dominion to NRC regarding North Anna ESP Application submittal schedule for the ESP application supplement (Accession No. ML053260619)
December 5, 2005	Letter from the NRC to Dominion regarding revision to the North Anna ESP schedule (Accession No. ML0532100541)
January 13, 2006	Dominion North Anna Early Site Permit Application Supplement to Address a Modified Approach to Unit 3 Cooling and To Ensure the Plant Parameter Envelope Remains Bounding (Accession No. ML060250396)
February 10, 2006	Letter from the NRC to Dominion regarding the North Anna ESP Application Review Schedule (Accession No. ML060390208).
March 2, 2006	Letter from the NRC to Dominion regarding information needs in revision to the ESP application in regards to the change in cooling system and the increase in power level (Accession No. ML060610065)

March 13, 2006	Letter from the NRC to Dominion regarding possible Bald Eagle nest (Accession No. ML060650396)
April 3, 2005	North Anna Early Site Permit Application, Response to NRC Question 10.q - Water Budget Analysis Spreadsheets. (Accession No. ML061040606)
April 11, 2006	Meeting Summary of the March 10, 2006, meeting with Dominion to discuss the supplement to the North Anna ESP Application (Accession No. ML060860305)
April 13, 2006	North Anna Early Site Permit Application Response to NRC Questions and Revision 6 to the Plant Application (Accession No. ML061180180)
May 4, 2006	North Anna Review Schedule letter (Accession No. ML061230005)
May 5, 2006	Press Release regarding Review Schedule and Informing Public of the Intent to Prepare a Supplement to the Draft Environmental Impact Statement (Accession No. ML 061250437)
May 2, 2006	Letter transmitting Federal Register Notice of Intent to Prepare a Supplement to the Draft Environmental Impact Statement (ML061240025 and ML061240029)
May 10, 2006	Letter to Dominion transmitting the Requests for Additional Information (Accession No. ML061290142).
May 12, 2006	Summary of May 3-4, 2006, Site Audit to Support the Review of the North Anna ESP Application (Accession No. ML061320447)
May 24, 2006	North Anna Early Site Permit Application, Response to NRC May 10, 2006 Request for Additional Information May 12, 2006 Site Audit Summary Report Comments, and NRC Site Audit Follow-up Questions (Accession No. ML061510131).
June 16, 2006	Letter from Jeffery Steers Regional Director, Virginia Department of Environmental Quality to Jack Cushing, Senior Project Manager, NRC Re: Dominion North Anna Early Site permit Application, Section 410 of the Clean Water Act (Accession No. ML061720278)

June 21, 2006	Letter from Dominion Nuclear North Anna, LLC to the NRC transmitting the North Anna Early Site Permit Application Response to NRC Questions and Revision 7 to the North Anna ESP Application (Accession No. ML061870030).
June 28, 2006	Letter from NRC to US Fish and Wildlife regarding the biological assessment for the ESP (Accession No. ML061510149)
July 3, 2006	Letter from NRC to EPA official filing of Supplement 1 to the DEIS (Accession No. ML06166011)
July 6, 2006	Letter to Dominion from NRC - notice of availability of the Supplement to the DEIS (Accession No. ML061660030)
July 6, 2006	Memo to Chris Nolan, PE, North Anna/Surry trip report, September 18-22, 2005 tour of North Anna River, Lake Anna, and the Surry alterative site (Accession No. ML061720366)
July 6, 2006	Trip report for December 13, 2005, tour of the North Anna ESP site. (Accession No. ML061810009)
July 31, 2006	Letter from Dominion Nuclear North Anna, LLC to the NRC transmitting the North Anna Early Site Permit Application Response to NRC Questions and Revision 8 to the North Anna ESP Application (Accession No. ML062140009).
August 2, 2006	Letter from Virginia DEQ requesting extension of time for submission of their comments to the Supplement to the DEIS (Accession ML062260339)
August 7, 2006	Email from VA Dept of Game and Inland Fisheries to NRC staff attaching a copy of the July 7 letter from Mr. Fernald that they have sent to DEQ as part of CZMA review (Accession No. ML062760076)
August 8, 2006	Letter from NRC to Mr. Harry Ruth (Friends of Lake Anna) regarding Mr. Ruth's request for an extension of the public comment period for the supplement to DEIS for North Anna ESP Application (Accession No. ML062130213)

August 8, 2006	Letter from Jack Cushing (NRC) to Ellie Irons Commonwealth of Virginia Department of Environmental Quality regarding Ms. Irons' request for an extension of the public comment period for the supplement to the DEIS for North Anna ESP (Accession No. ML062160207)
August 15, 2006	Letter from the NRC to Dominion regarding Supplement 1 to the Final Safety Evaluation Report for the North Anna ESP Application (Accession No. ML062210405)
September 6, 2006	Email from Dominion to NRC staff with Wetlands Delineation Information that Dominion provided to USACE (Accession No. ML062760080)
September 7, 2006	Email from Dominion to NRC staff forwarding a copy of the Wetlands Delineation Confirmation letter from USACE (Accession No. ML062760087)
September 12, 2006	Letter from Dominion Nuclear North Anna, LLC to the NRC transmitting the North Anna Early Site Permit Application Response to NRC Questions and Revision 9 to the North Anna ESP Application (Accession No. ML062580096).
September 13, 2006	Summary of Public Meeting Held to Receive Comments on the Supplement to the DEIS for the North Anna ESP Application (Accession No. ML062440229)
September 21, 2006	Email from Dominion to NRC staff attaching Dominion's Archaeological Survey Report (Accession No. ML062770252)
September 26, 2006	Summary of the teleconference on September 6, 2006 and site visit on September 8, 2006 dealing with review of the bounding values for tritium concentrations (Accession No. ML062620039)
November 3, 2006	Request by the U.S. Fish and Wildlife Service for a Memorandum of Agreement Regarding Eagle Management at Lake Anna (Accession No. ML062720052)
November 3, 2006	Letter from NRC to Dr. Eaton (Virginia Department of Historic Resources) notifying the VDHR that consultation responsibilities under Section 106 of the National Historic Preservation Act have been satisfied (Accession No. ML062900330)

November 10, 2006	Letter from Dominion Nuclear North Anna, LLC to the NRC requesting to amend the North Anna ESP Application to include a commitment to conduct an instream flow incremental methodology study (Accession No. ML063180258)
November 14, 2006	Letter from NRC to Dominion Nuclear North Anna, LLC agreeing to include a commitment to conduct an instream flow incremental methodology study as an enforceable permit condition (Accession No. ML0663190284)
November 22, 2006	Letter from Dominion Nuclear North Anna, LLC to the NRC stating that Dominion had received conditional concurrence under the Coastal Zone Management Act from the Commonwealth of Virginia (Accession No. ML063260423)

Appendix D

Scoping Meeting Comments and Responses

Appendix D

Scoping Meeting Comments and Responses

On November 24, 2003, the U.S. Nuclear Regulatory Commission (NRC) published a Notice of Intent in the *Federal Register* (68 FR 65961) to notify the public of the staff's intent to prepare an environmental impact statement (EIS) to support the ESP application for the North Anna early site permit (ESP) site. The EIS will be prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), Council on Environmental Quality guidelines, and Title 10 of the Code of Federal Regulations (CFR) Parts 51 and 52. As outlined by NEPA, NRC initiated the scoping process with the issuance of the *Federal Register* Notice. NRC invited the applicant; Federal, Tribal, State, and local government agencies; local organizations; and individuals to participate in the scoping process by providing oral comments at the scheduled public meeting and/or submitting written suggestions and comments no later than January 9, 2004.

The scoping process included a public scoping meeting, which was held at the Louisa County Middle School in Louisa, Virginia, on December 8, 2004. Approximately 80 members of the public attended the meeting. This session began with NRC staff members providing a brief overview of the ESP process and the NEPA process. Following the NRC's prepared statements, the meeting was open for public comments. Twenty-nine attendees provided either oral comments or written statements that were recorded and transcribed by a certified court reporter. The transcript of the meeting can be found as an attachment to the Scoping Meeting Summary, which was issued on January 13, 2004. The meeting summary is available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS) under accession number ML040140614. ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room) (Note that the URL is case-sensitive). Additional comments received later are also available.

The scoping process provides an opportunity for public participation to identify issues to be addressed in the EIS and highlight public concerns and issues. The Notice of Intent identified the following objectives of the scoping process:

- Define the proposed action which is to be the subject of the EIS.

- Determine the scope of the EIS and identify significant issues to be analyzed in depth.

- Identify and eliminate from detailed study those issues that are peripheral or that are not significant.
- Identify any environmental assessments and other EISs that are being prepared or will be prepared that are related to, but not part of the scope of the EIS being considered.
- Identify other environmental review and consultation requirements related to the proposed action.
- Indicate the relationship between the timing of the preparation of the environmental analyses and the Commission's tentative planning and decisionmaking schedule.
- Identify any cooperating agencies and, as appropriate, allocate assignments for preparation and schedules for completing the EIS to the NRC and any cooperating agencies.
- Describe how the EIS will be prepared, and include any contractor assistance to be used.

At the conclusion of the scoping period, the NRC staff and its contractor reviewed the transcripts and all written material received, and identified individual comments. Two letters and three email messages containing comments were received during the scoping period. All comments and suggestions received orally during the scoping meeting or in writing were considered. Each set of comments from a given commenter was given a unique alpha identifier (commenter ID letter), allowing each set of comments from a commenter to be traced back to the transcript, letter, or email in which the comments were submitted.

Table D-1 identifies the individuals providing comments and the commenter ID letter associated with each person's set(s) of comments. The commenter ID letter is preceded by NASC (short for North Anna scoping). For oral comments, the individuals are listed in the order in which they spoke at the public meeting. Accession numbers indicate the location of the written comments in ADAMS.

Comments were consolidated and categorized according to the topic within the proposed EIS or according to the general topic if outside the scope of the EIS. Comments with similar specific objectives were combined to capture the common essential issues that had been raised in the source comments. Once comments were grouped according to subject area, the staff and contractor determined the appropriate action for the comment. The staff made a determination on each comment that it was one of the following:

- A comment that was actually a question and introduces no new information.

- A comment that was either related to support or opposition of early site permitting in general (or specifically, the North Anna ESP) or that makes a general statement about the early site permit process. In addition, it provides no new information and does not pertain to 10 CFR Part 52.

- A comment about an environmental issue that

  - provided new information that will require evaluation during the review, or
  - provided no new information

- A comment that is outside the scope of the ESP, which includes, but is not limited to

  - comment regarding the need for, or cost of, power
  - comment regarding alternative energy sources
  - comment on the safety of the existing units.

The comments that are considered in the evaluation of environmental impacts in this EIS are summarized in the following pages. To review all the comments received during scoping, refer to the scoping summary (ML041770579). For reference, the unique identifier for each comment (commenter ID letter listed in Table D-1 plus the comment number) is provided. The responses provided here have been updated to provide the location in the EIS where the subject is addressed.

Table D-1. Individuals Providing Comments During Scoping Comment Period

Commenter ID	Commenter	Affiliation (if stated)	Comment Source (ADAMS Accession #)
NASC-A	Paul Gunter	Nuclear Information and Resource Service	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-B	Ernie Reed	Citizen and teacher from Charlottesville, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-C	Alexis Zeigler	Citizen of Charlottesville, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-D	Donald Day	Citizen of Charlottesville, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-E	Dave Ritter	Public Citizen Critical Mass Energy and Environment Program	12/8/03 Scoping Meeting Transcript (ML040140634)

Table D-1. (contd)

Commenter ID	Commenter	Affiliation (if stated)	Comment Source (ADAMS Accession #)
NASC-F	Dewey Keeton	Citizen of Louisa County, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-G	Lou Zeller	Blue Ridge Environmental Defense League	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-H	Brian Buckley	Citizen of Louisa, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-I	Gene Grecheck	Vice President, Nuclear Support Services	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-J	Bill Borduin	Lake Anna Civic Association	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-K	Jerry Rosenthal	Concerned Citizens of Louisa County, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-L	Terry Jones	Member First Baptist Church and Louisa County, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-M	Dan Holmes	Piedmont Environmental Council	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-N	Abhaya Thiele	Resident of Buckingham County, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-O	Bill Murphey	Resident of Louisa County, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-P	Marione Cobb		12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-Q	Brianne Boylan		12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-R	Olivia Ryan	Resident of Louisa County, Virginia, and Lake Anna	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-S	James Griffis	Retired Presbyterian Pastor living at Lake Anna	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-T	Sam Forrest	Citizen of Greensprings, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)

Table D-1. (contd)

Commenter ID	Commenter	Affiliation (if stated)	Comment Source (ADAMS Accession #)
NASC-U	Steve Montgomery	Citizen of Louisa, Virginia. Employee North Anna Power Station	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-V	Page Kemp	Citizen of Louisa County, Virginia. Employee North Anna Power Station	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-W	Bill Streit	Resident of Louisa County, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-X	Alex McGee	Resident of Albermarle County, Virginia. Previously of Louisa County	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-Y	Amzic Sullivan	Resident of Green County, Virginia	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-Z	Jon Kessler	Resident of Charlottesville, Virginia. Past Resident of Louisa.	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-AA	Ian Burke		12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-BB	Bob Bishop	Nuclear Energy Institute	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-CC	Brendan Hoffman	Public Citizen, Washington D.C.	12/8/03 Scoping Meeting Transcript (ML040140634)
NASC-DD	Carrie Girstantas	Citizen of Louisa County, Virginia	12/12/03 - email (ML040140310)
NASC-EE	Aviv Goldsmith	Citizen of Spotsylvania, Virginia	12/21/03 - email (ML040060329)
NASC-FF	Frank W. Harksen, Jr	Director Department of Public Utilities, Hanover County, Virginia	1/7/04 - letter (ML040130744)
NASC-GG	Diane Curran	Harmon, Curran, Spielberg and Eisenberg, LLP	1/9/04 - email/letter (ML040230548)
NASC-HH	Unsigned		1/8/04 - letter (ML040230552)

(a) The transcripts can be found under accession number ML040140634.

Preparation of the EIS will take into account all the relevant issues raised during the scoping process. The EIS will be made available for public comment. The comment period for the EIS will offer the next opportunity for the applicant; interested Federal, Tribal, State, and local government agencies; local organizations; and members of the public to provide input to the NRC's environmental review process. The comments received on the EIS will be considered in the preparation of the final EIS. The final EIS, along with the staff's Safety Evaluation Report (SER), will provide much of the basis for the NRC's decision on the North Anna ESP.

D.1 Comments and Responses

This summarizes the in-scope comments and suggestions received as part of the scoping process, and discusses their disposition. Parenthetical numbers after each comment refer to the commenter's ID letter and the comment number. Comments can be tracked to the commenter and the source document through the ID letter and comment number listed in Table D-1. Comments are grouped by the following categories:

D.1.1 Comments concerning air quality

D.1.2 Comments concerning aquatic ecology

D.1.3 Comments concerning groundwater use and quality

D.1.4 Comments concerning surface water use and quality

D.1.5 Comments concerning socioeconomics

D.1.6 Comments concerning human health

D.1.7 Comments concerning uranium fuel cycle and waste management

D.1.8 Comments concerning postulated accidents

D.1.9 Comments concerning site redress

D.1.10 Comments concerning alternatives

D.1.11 Comments concerning the safety review for the ESP, including safeguards and security and emergency preparedness

D.1.1 Air Quality

Comment: You should know that nuclear energy does not emit greenhouse gases. That is of grave concern to many who study and worry about environmental future. (NASC-BB 4)

***Response**: This information will be considered in the staff's evaluation of air quality impacts in the EIS. The results of the analysis will be presented in Chapter 4 [now Chapter 5] of the EIS.*

D.1.2 Aquatic Ecology

Comment: The EIS for the North Anna nuclear power station is therefore required to address all of the following environmental impacts, including but not limited to: 3. All impacts on Lake Anna arising from the increased impingement and entrainment of fish, fish spawn, other aquatic life and nutrients arising from the increased reactor cooling water intake for any proposed additional nuclear power units. (NASC-GG 2)

Comment: One of the areas that the Lake Anna Civic Association should be looking at is the impact of not only fish but spawn of fish and how that impacts the future populations of fish in the Lake Anna area. (NASC-A 6)

Comment: [The Lake Anna Civic Association has identified seven issues of concern, one of which is] natural environments such as fish and plant life. (NASC-J 5)

Comment: What impact would this [additional water use] have on wildlife and fish species in and surrounding the lake, and on the North Anna River downstream? (NASC-M 3)

***Response**: The NRC staff will evaluate aquatic and terrestrial impacts during its evaluation of the ESP application, and the results of the analysis will be presented in Chapter 4 [and Chapter 5] in the EIS.*

Comment: There were two studies that just came out in early summer of this year. One was prepared by the New York State Department of Environmental Protection looking at the Hudson River and it was a detailed study that looked at both the thermal pollution and the entrainment and impingement of fish on and through the Indian Point units 2 and 3 nuclear power station as well as a couple of much smaller fossil fuel facilities. ...Another study we'd like to provide you with is from the State of California, the Central Coastal Water Region, that's the equivalent to the DEP for the coastal water regions of California where they looked at the impingement and entrainment of fish in Diablo Cove, which is the receiving water for Diablo Canyon's 1 and 2 nuclear power stations. (NASC-A 11)

***Response**: The NRC staff will consider the results of these two studies in preparing its evaluation of the aquatic impacts of the ESP. The results of the analysis will be presented in Chapter 4 [now Chapter 5] of the EIS.*

Comment: We currently have problems with contaminants in the fish in Lake Anna that we're unsure where the contaminants are coming from. The way I understand it, the checks and balances of the NRC or the plant itself in the checking of these fish have long since ceased. And Lake Anna Civic Association now are monitoring the lake. Is this going to be something that's going to happen again?...I've read the plant was regulating and checking on the fish population. And they stopped at some point in time and its just [a] concern of mine because what's bad for the fish is bad for me. ...Since the lake was created for the nuclear plant, it seems to me that they should be checking on this fish population and monitoring the water at all times. ...For all contaminants. (NASC-F 1)

***Response**: The human health impacts related to radioactive effluent releases from any new nuclear plants will be evaluated in the EIS. NRC regulations require strict monitoring of radioactive effluent releases. In addition, new plants are commonly required to perform special monitoring of aquatic and terrestrial species for some period of time after a new plant commences operation. With respect to effluents that are not radioactive, the Virginia Department of Environmental Quality (VDEQ) would regulate the release of such effluents to Lake Anna. The VDEQ would specify whatever monitoring requirements it deems necessary. These requirements would normally be included in the NPDES/VPDES permit.*

D.1.3 Groundwater Use and Quality

Comment: I actually heard tonight that even ground water would be considered [as a possible cooling water source]. Since this additional source would be necessary for the operation of the facility, why is it suggested in the permit that this issue be addressed during the COL application and not in the EIS? Consider the difficulties in bringing the additional water to the [plant] and the fact that this is an essential piece for operation, we urge NRC to consider addressing this issue now during the EIS process rather than later with the construction permitting processes. (NASC-M 6)

***Response**: The NRC will evaluate cooling system impacts in the EIS. This portion of the review would include the impacts associated with the source of cooling tower makeup-water for Unit 4. The results of this analysis will be presented in Chapter 4 [now Chapter 5] of the EIS.*

D.1.4 Surface Water Quality and Use

Comment: The County [Hanover] wishes to ensure that any environmental impact review evaluates the changes to Lake Anna releases and related impacts on County facilities, its citizens and other instream and offstream beneficial uses of the North Anna and Pamunkey Rivers that will result from the construction and operation of an additional reactor. Such a review should also determine the appropriate and necessary minimum Lake Anna release to protect these uses. (NASC-FF 1)

Comment: Downstream users have designed their water intake and wastewater discharge systems around this 40 cfs low flow condition, and cannot get by with less water. And, increasingly more stringent regulations affect the ability to operate at the 40 cfs [cubic feet per second]. (NASC-FF 2)

Comment: Although this is a different permit and permitting process, many of the prior [historical] comments [related to water availability] are applicable from an environmental perspective and should be included in the scope of an environmental impact statement. (NASC-FF 3)

Comment: The EIS for the North Anna nuclear power station is.... required to address the following environmental impacts, including but not limited to: 1. All impacts on the water levels in Lake Anna arising from increased intake of reactor cooling water for the operation of any proposed new nuclear power units 2. All impacts on the aquatic environment of Lake Anna arising from the increase in thermal discharge of reactor cooling water as result of the operation of additional nuclear power units. [and].... 4. All impacts arising from the increase in the routine discharge of chemicals, heavy metals, cleaning solvents, biocides and radioactive isotopes into Lake Anna arising from the operation of additional nuclear power units. (NASC-GG 3)

Comment: The Lake Anna Civic Association has identified seven issues of concern, one of which is Water issues. They consist of thermal changes, volume, flow and lake level. (NASC-J 1)

Comment: It's our understanding that the additional reactors would increase the water use of the facility dramatically. It's been estimated that the evaporative loss could be as high as 41 million gallons per day. ...Will this affect the flow rates downstream from the lake and the dam, and downstream users of the river? (NASC-M 1)

Comment: The temperature changes are addressed in great detail in the application itself. And the temperature concerns are real, but I believe there are reasonable solutions to them. (NASC-O 4)

Comment: I wanted to address was the lake level concerns for units 3 and 4. ...So one observation is that [some]one should examine the agreement between Dominion Power and the State of Virginia on the matter of water released over the dam. (NASC-O 5)

Comment: What I understand is that Virginia Power or Dominion Power has submitted a sort of an envelope that describes the potential impact of this new project….we just experienced, of course, a serious drought in Central Virginia followed by a year of abundant rainfall. But I wanted to know how you approached issues of drought; whether or not when you do that, you just sort of look at the historical record and then make extrapolations of what you can expect in terms of meeting the demands for water that this new project might have. ...So in other words history, the recent history as well as more distant history plays a major role in projecting forward? (NASC-D 1)

Comment: One other environmental issue I wanted to mention was as far as drought and water issues, ...I would encourage when the water issues are examined, that more severe droughts are considered, certainly than the one a couple of years ago, recently. Even worse than any on record, I would suggest being considered. (NASC-Z 4)

Comment: Flows into the lake may not be sufficient to meet the demands of the expansion. Within the early site permit it is noted that the makeup water may have to be taken from another source if all units were to continue operation during low flow periods. What is the estimated amount of additional water needed to meet the demand of the facility during these low flow periods? And what are the possible sources under consideration? (NASC-M 4)

Comment: Another point, on page 3-5-8 of the early site permit application under the heading "Water Use Impacts" there appears the sentence "The impacts of adding new unit four would depend on specific heat dissipation systems selected and would be evaluated in the COL application." Again, we urge NRC to request the data necessary from the applicant to determine the impacts. If we are determining the feasibility of new reactors, it seems reasonable to know these impacts with the completion of an EIS. (NASC-M 7)

Comment: During this drought it [the lake level] went down five feet. And if there's a third unit in operation, it would go down to about 7 feet below. ...What can one do about that? One recommendation has been to make up this evaporative loss from other water sources. ...The second recommendation is that Dominion start looking now into other sources of water. That is, most of the time no additional water makeup would be needed. But there would be times where it would be very good for public relations to be able to make up the evaporative loss, mainly during times of drought. (NASC-O 6)

Comment: And so toward the fourth unit, we would like to recommend very strongly that Dominion look into getting additional water from another source, it could be from another river, it could be from the cities, they're processing more, that sort of thing. But to have an external source of water to make up for the loss for the fourth unit. (NASC-O 7)

***Response**: Surface water impacts of the types described in the comments will be evaluated by the NRC staff in Chapter 4 [now Chapter 5] of the EIS.*

D.1.5 Socioeconomics

Comment: The EIS for the North Anna nuclear power station is ..... required to address all potential socio-economic impacts from the elevated national security requirements and counter-measures to protect a larger target of terrorism with the expansion of the nuclear power station site including the indefinite and possibly permanent closure of Lake Anna to public access for sporting, recreation and other means of community economic livelihood.
(NASC-GG 4)

Comment: We've also committed tonight to provide you with an ongoing and increasing list of lake closures and restrictions to public right of way to lakes around nuclear power stations because of security reasons. (NASC-A 12)

***Response**: The NRC staff will evaluate socioeconomic impacts of the proposed action in Chapter 4 [now Chapter 5] of the EIS, including any reasonably foreseeable impacts resulting from security measures.*

Comment: And as we look at this from those of us who live here and who plan on living here, and want our children to live here, we have to look at our property values. Putting a new nuclear plant out there has no chance of doing anything but reducing property values around the lake. (NASC-K 3)

Comment: It's our understanding that the additional reactors would increase the water use of the facility dramatically. It's been estimated that the evaporative loss could be as high as 41 million gallons per day. ...What impact would this have on the residents of the lake and their continued recreational use? (NASC-M 2)

Comment: So the one question that had to be asked was what's the public reaction to the change in the lake level as a function of height below 250? And the answer is people start to get concerned when it goes down three feet. (NASC-O 2)

Comment: Now for the fourth unit, we're talking about evaporative loss of around 23,900 gallons per minute, or about 54 cubic feet per second. It's all opinion, but there is no way that this can be taken from the input to Lake Anna without having the lake level drop, you know, beyond what is considered by useful use for the people around the lake. (NASC-O 3)

Comment: I'm also glad for the school building and the thousands of taxes that Virginia Power pays to Louisa County so we citizens didn't have to build it alone. I'm glad for the influence it has made in the past 25 years in Louisa County. I'd like to see it continue. (NASC-S 2)

Comment: In the business I ran here, many customers were Dominion Power employees, so I am definitely aware of the economic value of the plant being here. (NASC-X 1)

***Response**: The NRC staff will evaluate the socioeconomic impacts of the proposed action in Chapter 4 [and Chapter 5] of the EIS, including impacts related to taxes, property values, and recreational use of the lake.*

D.1.6 Human Health

Comment: The EIS for the North Anna nuclear power station is.... required to address all impacts on the public health and environment arising out of the increase in routine and accidental radioactive emissions to the air and to the water as the result of the operation of additional nuclear power units. The analysis should consider work by Dr. John Gofman, showing that low-level radiation, at levels considered to be safe for medical use, is a significant contributor to deaths from heart disease and cancer. See Radiation from Medical Procedures in the Pathogenesis of Cancer and Ischemic Heart Disease (Committee for Nuclear Responsibility: 1999). (NASC-GG 5)

Comment: Build this nuclear reactor? I don't think so. Killing tens of thousands of people and not to mention years of genetic mutation in all walks of life. (NASC-AA 5)

Comment: Strontium-90 remains radioactive for 600 years and concentrates in the food chain. Like other isotopes it’s odorless, tasteless and invisible. It acts like calcium in the body's organisms where it enters the bones and animals and lactating breasts of mammals. It's a carcinogen causing leukemia, bone and breast cancer. Cesium-137, another byproduct, also remains radioactive for 600 years. It also concentrates in the food chain, but it stores in the muscles where it induces malignant muscle cancers called sarcomas. Plutonium is so carcinogenic that one pound of the stuff evenly distributed can cause cancer in every person on earth. Plutonium has a radioactive life of half a million years. It enters the body through the lung, migrates to the bone and liver, crosses the placenta into the embryo, mothers with child. Causes bone cancer, leukemia, liver cancer, testicular cancer, birth deformities and genetic mutations in humans and other animals that are passed from generation to generation. (NASC-B 14)

Comment: I heard something about permitted releases. The plants are actually allowed, as long as its diluted to the proper amount, to put radioactive releases into air, water and the surrounding environment. And this occurs at the same time that the Nuclear Regulatory Commission formally agrees with the linear-no-threshold – response model which says that any increase in radioactive dose, no matter how small, results in an incremental increase in risk. And at the same time, the Nuclear Regulatory Commission tells us that its primary mission is to protect the public health and safety in matters regarding radiation exposure. (NASC-E 11)

Comment: This is from the Nuclear Regulatory Commission, NUREG/CR-2907, radioactive materials released from nuclear power plants. This was an annual report from 1988. I've selected 1988, about 15 years ago, because of the cancer latency period. After 20 years you have – and I believe you are beginning – maybe beginning to reap the whirlwind. In this report, this NUREG report, there was a risk in here for the North Anna plant 40 miles northwest of Richmond, unit 1 and unit 2. There are airborne effluents and radionuclides released which number 26 including some of the cesium and other elements that were mentioned by previous speakers. Liquid effluents, nuclear – or radionuclides released number 32 in this report. And just scanning the highlights here. The volume of total liquid tritium released in that year was 1,940 liters. (NASC-G 2)

Comment: I'm standing here because of concerns as far as public health. ...In my line of work in my job, I see a lot of our fellow community citizens coming and they have been diagnosed with cancer. The cancer rate for Louisa County has increased in the last 20 years. And my concern is what's happening? What's happening? I'm not saying that this is because of Dominion Power, but there are issues that we need to consider before we go any further. (NASC-L 1)

Comment: For 30 years I lived downstream from the Connecticut Nuclear Power plant that Old Dominion runs. And 27 years after I was in college I was diagnosed with breast cancer. I had both my breasts cut off to save my life so that I could raise my two young daughters. (NASC-Y 3)

Comment: We do know, as has been said very eloquently by the scientists who have spoken already, that radiation is exceedingly dangerous and toxic. (NASC-Y 4)

Comment: The Nuclear Regulatory Commission essentially is not even going to take a serious look at...placing the onus on the waste generator, the polluter or the creator of the energy to prove that energy is safe for us. ...The onus should not be on the affected individual to prove the health detriment. (NASC-E 12)

Comment: According to our estimation, nuclear power is a public health catastrophe hidden in plain sight. (NASC-G 8)

Comment: It's not about -- so much about the water and the temperature of the water and what's happening, but what happens to the people who play in that water? What happens to the grandfathers who take their children fishing? And they eat fish from that lake. These are things that we need to address. (NASC-L 2)

Comment: I think that we need to look at the issue of public health more so than the issue of is it just a safety factor for the environment. (NASC-L 3)

Comment: And I ask that those of you on the nuclear regulation committee whose salaries my tax dollars pay, that higher consideration be given to the risk, to the life and health and my daughter, the water, the air and the animals than to the financial risk of 21st century of robber barons who are so disconnected from reality that they cannot see the risk not just to me, but to their own families. (NASC-Y 1)

Comment: We know that the only safe decision, the only decision that carries no risk is the decision not to use nuclear decision. We know that. We don't need more research. (NASC-Y 2)

***Response**: The NRC will evaluate human health impacts of the proposed action in the EIS. The results of this analysis will be presented in Chapter 4 [now Chapter 5] of the EIS.*

Comment: I previously lived in Utah with my parents where they have seen the tragedy of "downwinders." This is the term used for the cities subjected to radioactive waste in testing in the 1940s. And these people were assured by the government that they were safe. And these people are now suffering from deformities and their children are suffering from deformities. (NASC-X 2)

***Response**: Nuclear testing in the 1940s is outside the scope of this review and will not be addressed in the EIS.*

D.1.7 Uranium Fuel Cycle and Waste Management

Comment: The EIS for the North Anna nuclear power station is.... required to address ..all impacts arising from the additional accumulation of high-level nuclear waste generated and indefinitely stored on-site at the North Anna nuclear power station as the result of the operation of additional nuclear power reactors. This discussion is required, given that the Waste Confidence Rule applies only to waste generated by “existing facility licenses.” 55 Fed. Reg. 38,474 (September 18, 1990). (NASC-GG 6)

Comment: This agency [the NRC] has confidence, enough confidence [in the Waste Confidence Act] that they're not going to allow the issue of more nuclear waste being stored on the shores of Lake Anna to be raised in the early site permit process and the environmental review. (NASC-A 9)

Comment: And all of these [uranium fuel] processes from mining, processing the uranium to taking it to Yucca Mountain, if indeed that is going to be the alleged solution, all of these things are going to take massive quantities of fossil fuels and will in their own way contribute to greenhouse gases, global warming, whatever, carbon dioxide emissions we want to talk about there. ...do we want global warming or do we want nuclear waste and the water to be drained from our local lake? ...I think that's a false choice to present to the public, and it's also questionable just on the scientific basis if you really look at the entire fuel cycle. (NASC-E 8)

Comment: And I also think there's a larger problem with the waste issue. If someone has made some decision at some point that waste is not being considered as part of the environmental impact, it seems like a major problem. There's been waste in the plant for the whole existence, and there's no reason to think – I mean, there's always going to be waste there, even if it's transported out of the county. Even if it is transported, it'll still be generated there, so the waste issue has to be addressed. (NASC-Z 3)

Comment: Will the scope, environmental scoping of this project include the continued storage of that waste on site? ...So, I guess my question is will the continued storage of high level radioactive waste be included in the environmental impact statement for this new facility? (NASC-D 2)

Comment: There's a reluctance for other states to allow transport of nuclear materials through their jurisdiction. Given this, will the EIS address the plan for disposal of the additional nuclear waste generated by the new units? (NASC-M 8)

Comment: My parents' home State, Utah, is a popular destination for the nuclear waste that no one knows what to do with. Impoverished Navajos are resorting to selling their land for nuclear waste storage. (NASC-X 3)

Comment: I'd really add in this situation it's like getting a permit without a plan for a septic system. And that's something that's not reasonable to build a home, and it's certainly not reasonable to build a nuclear power station. (NASC-A 10)

Comment: Man has never created a more long lived or dangerous substance than the radioactive substances that are byproducts of the nuclear reaction process. ...Both fuel waste and decommissioned equipment all pose long term health threats of many lifetimes to humans and other species and animals. (NASC-B 8)

Comments: There's no solution to the nuclear waste problem. People have asked this question tonight about how much nuclear waste is extracted out of the reactors. …Virginia Power has gone 450 days between refuelings. But at every refueling, approximately 1500 metric tons of highly radioactive waste is removed from the reactor. There's no solution to this radioactive waste problem that at present is being stored on the site waiting for a solution that, frankly, will never appear because of the confluence of technical and political problems. (NASC-D 5)

Comments: [The Lake Anna Civic Association has identified seven issues of concern, one of which is] spent fuel, dry cask storage. (NASC-J 6)

Comments: Does anybody really have confidence that they're going to move the nuclear waste? They [NRC] are starting this discussion saying that's where they are. They have the confidence that this waste is going to be moved, and it hasn't. (NASC-K 1)

Comment: I am concerned about the toxicity of the waste that's generated. ...I would like this waste not to be stored here, and I would like this waste not to be stored anywhere. I think this is a danger for ourselves, for our children and our great, great, great, great, great, great, great grandchildren. (NASC-P 1)

Comment: And I just think that public health and the environmental events cannot be separated, ...And that the site is obviously not environmentally safe if we cannot take care of the plant's waste. It's not -- nuclear energy is obviously not suitable because we have no way of reintegrating this waste back into our environment in any foreseeable future. Clean up your own mess before you make a new one. (NASC-Q 1)

Comment: My opposition to nuclear weapons is not only the nightmare at the opposing their use, but their very existence because of the pollution and the poisoning of the planet. And whether it's wastes from nuclear weapons or waste from a commercial reactor, it's poison. It seems to me it doesn't make any sense when we don't have, as was said so well by so many others here, we don't have any solution to this problem why create more of the problem? (NASC-W 2)

Comment: You know, if we don't know what we're doing with all the waste that's piling up already, you know, why create more. It's like the toilet that doesn't work, you know. (NASC-W 4)

Comment: The NRC claims that it can produce this electricity with minimal effects on the environment, but all it can do is postpone the effects by further regulations and burying its waste underground for future generations to deal with. These things that we're burying underground are leaking into our underground aquifers and poisoning the environment. All it's going to do is leave it for, like I said, other people to deal...with later instead of us. It's already been pointed out [that] most of the effects of isotopes are produced in nuclear waste. On of them is plutonium, which one pound of it is enough to give everybody in the world cancer. And in the year 2000 it was estimated that nuclear power generated 1,139 tons of plutonium. (NASC-AA 3)

Comment: We do know that the half life of spent nuclear material is far longer than our ability to contain it. (NASC-Y 6)

Comment: You commented on a waste confidence decision that was made by the NRC. And guaranteed that in the first quarter of this century a repository will be made available. …And it seems like Yucca Mountain is a proposed site, ...My question is how much waste is Lake Anna putting out, how much more waste would Lake Anna with two additional reactors? (NASC-H 1)

Comment: How much additional waste will be generated? We still don't really have an idea. And I'd really like to get a hold of that figure. (NASC-M 9)

***Response**: The NRC staff will evaluate the environmental impacts of the uranium fuel cycle including the impacts of fuel manufacturing, transportation, and onsite storage and eventual disposal of spent fuel. The staff's evaluation will account for the Commission's "Waste Confidence" decision embodied in 10 CFR 51.23 to the extent that decision applies to such impacts. The results of this analysis will be presented in Chapter 4 [now Chapter 6] of the EIS.*

D.1.8 Postulated Accidents

Comment: The EIS for the North Anna nuclear power station is ....required to address all of the ... impacts on public health and safety and the environment arising from a severe accident, including the impacts of the accident itself, and the impacts of any emergency response measures such as relocation of the population. (NASC-GG 7)

Comment: In building the nuclear power plants we must remember that the costs go way beyond that of economic decisions that govern the decisions that things such as the power company entities make. But it causes high environmental devastation one way or another – if there is a nuclear meltdown. (NASC-AA 4)

Comment: Hopefully we're all aware of past nuclear accidents. In the winter of 1957 a tank holding radioactive waste exploded and 10,000 people were evacuated in a rural Russian countryside. And the names of 30 towns and villages disappeared from Soviet maps. And I shouldn't have to remind you of history lessons from Liverpool, England, Browns Ferry, Alabama, Three Mile Island, Pennsylvania or Chernobyl. (NASC-B 16)

Comment: We do know that Murphy's Law says that what can go wrong, will go wrong. Think Chernobyl, Three Mile Island and so forth. (NASC-Y 5)

***Response**: The environmental impacts of postulated accidents will be evaluated, and the results of this analysis will be presented in Chapter 5 of the EIS.*

Comment: The EIS for the North Anna nuclear power station is.... required to address all of the ....impacts arising from the simultaneous operation of the existing and aging North Anna Unit 1 and Unit 2 power reactors in close proximity to any new proposed advanced reactor design, including the possibility of multiple, simultaneous accidents, whether related (e.g. by fire or natural disaster) or unrelated. (NASC-GG 8)

Comment: What liability did they have in the event of some significant environmental catastrophe connected with this? (NASC-B 4)

***Response**: The issue of severe accidents will be addressed in Chapter 5 of the EIS. In addition cumulative impacts will be addressed in Chapter 4 [now Chapter 5] of the EIS.*

D.1.9 Site Redress

Comment: And I'd like to, first of all, just point out that we are at the beginning of a process on a very crucial process. ... this process does provide for the expansion of a site which in fact is probably both the agency and the industry emphasize that this does not authorize construction, but in fact it is a partial construction permit. (NASC-A 5)

***Response**: As the staff stated during the scoping meeting, the North Anna ESP application includes a site redress plan. The environmental impacts of the site redress plan will be evaluated in the EIS. If the redress plan is approved and incorporated into an approved ESP, then Dominion would have NRC authorization to perform the activities listed in the site redress plan. These include activities such as clearing the land, excavating for buildings, etc. The redress plan explains how Dominion would repair any environmental damage associated with these pre-construction activities if it later decided not to apply for a construction permit or a combined license. The applicant's site redress plan includes a commitment to provide the NRC with a guarantee of $10 million as financial assurance for Dominion's obligation to comply with the redress plan.*

D.1.10 Alternatives

Comment: As an engineer, I know that the state of art with regards to Nuclear Power has changed, as well as many other forms of electricity generation being possible. I would like the options developed [in the EIS] and a clear choice offered to the citizens of Louisa County. (NASC-DD 2)

Comment: The environmental impacts of such alternatives that need to be explored and objectively evaluated include: 1. Whether effects on the environment would be reduced if Dominion alternatively implemented more applications of energy efficiency technologies and energy conservation rather than the development of additional nuclear power capacity at the North Anna site. For instance, for the entire southeastern United States, the Renewable Energy Policy Project has demonstrated that innovative and well-managed efficiency programs would reduce annual increases in electric growth by 61%, reducing new demand by 236 MWh over a twenty-year period. See Powering the South: a Clean and Affordable Energy Plan for the Southern United States (Renewable Energy Project: January 2002). www.repp.org. 2. Whether effects on the environment would be reduced if Dominion alternatively implemented use of passive solar, photovoltaic, wind turbines and hybrid renewable energy systems rather than the development of additional nuclear power capacity at the North Anna site. 3. Whether effects on the environment would be reduced if Dominion alternatively implemented greater use of natural gas energy rather than the development of additional nuclear power capacity at the North Anna site. 4. Whether effects on the environment would be reduced if Dominion alternatively implemented broader applications of the above-mentioned resources as distributed power systems rather than increased reliance on an increasingly vulnerable electrical grid system connecting any additional new power capacity at the North Anna site. (NASC-GG 9)

Comment: So there is a very cheap answer to the energy problem, which is to use much, much less of it. There were about -- I don't know -- 20 percent of us in the world who live like we Americans do, yet we use 80 percent of its resources. So I'm sure we could use much, much less. (NASC-AA 1)

Comment: Conservation is undoubtedly the most effective method of ensuring energy security. Conservation efforts defuse energy producers of energy by reducing the need for generating capacity while stimulating the technologies, the research, the manufacturing and the job creation of more efficient technology's progress. Less for you means more for us. It's a fact that with existing technologies we could continue our current standard of living with less than half the energy generating capacity now in this country. (NASC-B 12)

Comment: The environmental benefits of nuclear are not well known, and are certainly not emphasized. ...nuclear energy in Virginia caused there to be roughly 7 million -- it's a big number -- metric tons less of carbon …not to be emitted into the environment in 2002 because of the operation of their nuclear facilities. (NASC-BB 3)

Comment: All over the world people are generating power either by creating megawatts, meaning you use less or wind, which is the fastest growing of the alternative energies. If you take the train from the Washington, D.C. to Chicago and you'll see the big wind mills popping up in Pennsylvania. That's real. That's something that people are doing. It works. That's a large scale power that could meet future demand. (NASC-C 4)

Comment: Conservation is the best and cheapest way to go with preserving that power. (NASC-CC 3)

Comment: We don't need nuclear power, we need conservation. We need to respect current generations and future ones. Using the earth's resources for our material needs cannot do any of this. (NASC-AA 6)

Comment: To be frank, nuclear power actually is just a ridiculously stupid and expensive method for doing what is nothing more than boiling water. There are alternatives to boiling water, ones that don't involve nuclear waste that lasts for hundreds of thousands of years. ...Dominion Power owes Virginians a better place. And I might note that in the words and comments of a Dominion Power official here tonight, he never mentioned the one technology, the one opportunity to provide our future needs, and that is conservation. (NASC-D 8)

Comment: This was generated by Institute for Energy and Environmental Research in April of 1996."...reliance on nuclear power has grown and the already large quantities of weaponsuseable plutonium in the world are rising rapidly." He quotes Johanson here. ...The path of sustainable society requires more efficient use and a shift to a variety of renewable energy resources." (NASC-G 3)

Comment: And people call this NIMBY, not in my backyard syndrome, and yet I think it a very natural instinct that people do not want someone else's waste in their state or in their locality. ...should we not be focused more on using a type of energy that doesn't have such a poisonous effect on people, on life? (NASC-H 2)

Comment: Just about anything that burns fuel, whether it's burning oil or coal, natural gas; anything that's burning anything is putting various contaminants into the atmosphere, including various types of oxides and carbon dioxide. And carbon dioxide is, of course, what's related to various theories to explain global warming. So again, one of the reasons that we think that nuclear energy is an option to consider whether we'll do it in the future is that of all the various alternative energy forms that we're aware of, it is the only one that can produce energy on a scale large enough to make a difference in terms of what we actually put in the air by energy production. So it is the only large scale non-emitting generation technology that's available. (NASC-I 6)

Comment: Now if you look over the last 10 or 15 years, the only generation that has been added in the United States has been natural gas. So if you think about what we're doing here, is we are banking our entire future on the supply of natural gas. And what that does, it certainly makes us very vulnerable to any disruption in fuel supply. We're already talking about now importing natural gas from overseas, which would put us into the same situation that we've had with oil for the last 20 or 30 years. And natural gas up to now has been a domestic supply, but we're outstripping that supply and we're now saying in order to meet the natural gas demand, we're going to have to start importing natural gas from many of the same areas of the world that currently are problems in terms of imported oil. (NASC-I 9)

Comment: I for one as a taxpayer would like to see my money go to the support of energy that's renewable and safe. (NASC-N 3)

Comment: But I would like the subsidies to go to safer forms of energy that would not be a threat to me and my children and my children's children. (NASC-P 3)

Comment: So I would really like to be a part of a meeting in the future that talks seriously about dismantling the power stations at Lake Anna and that seriously considers alternative ways of energy and conservation. (NASC-W 3)

Comment: And we do know that monied interests are more interested in technology which can enrich them further than in finding safe sources of energy which are less lucrative and would protect someone like me or my daughter or your sister. (NASC-Y 3)

Comment: As a consumer of Dominion Power, I would like my consumer dollars to go to wind and hydro power, not nuclear power. I believe these are safer for employees and all citizens. And as a taxpayer, I would like to ask of the NRC to use your government influence to reallocate government subsidies away from nuclear power and towards hydro and wind power. (NASC-X 4)

***Response**: The NRC staff will prepare an EIS in accordance with the requirements of 10 CFR 52.18 and 10 CFR Part 51. The EIS need not address the benefits of reactor construction and operation, including the need for power, as discussed in 10 CFR 52.18 and the NRC's "Environmental Standard Review Plan," NUREG-1555, Appendix A. As discussed in a June 2, 2003, letter from NRC to Dominion, and in proposed changes to Part 52 published in the Federal Register on July 3, 2003 (68 Fed. Reg. 40025), consideration of alternative energy sources need not be included in the applicant's environmental report. In the case of the North Anna ESP application, Dominion chose not to include consideration of alternative energy sources, and therefore, these will not be included in the EIS. If Dominion applies for a construction permit or a combined license in the future, the issue of alternative energy sources will then be evaluated, as required to satisfy NEPA.*

In addition with respect to the comments on conservation, 10 CFR Part 51, Appendix A, states that "consideration will be given to the potential impacts of conservation in determining demand for power and the consequent need for additional generating capacity". Section 52.18, however, provides that the EIS need not include an assessment of the benefits (for example, the need power) of the proposed action. Because need for power and alternative energy sources need not be considered in the EIS, conservation need not be considered in that context. Accordingly, conservation need not be considered in the EIS.

Comment: My question is why the North Anna site was chosen in the first place?…[and why did they choose] North Anna specifically as opposed to all the other potential sites around the country that could have been chosen, why North Anna was picked. (NASC-CC 1)

***Response**: The applicant is required by the regulations (10 CFR 52.17) to evaluate alternative sites to determine whether there is any obviously superior alternative to the site proposed. In preparing its application for the ESP, Dominion considered multiple sites. The details of their evaluation are presented in Chapter 9 of the Environmental Report and in "Study of Potential Sites for the Deployment of New Nuclear Plants in the United States," prepared by Dominion and Bechtel Power Corporation through an agreement with the U.S. Department of Energy. This report is available through the NRC's document management system (ADAMS; Accession Number ML040630512). Based on the results of this study, Dominion concluded that North*

Anna was the best option for construction of new nuclear plants. The alternate sites will be evaluated, and the results of this analysis will be presented in the EIS.

Comment: Well, according to my understanding of the law that under the National Environmental Policy Act the no action alternative must also be considered. The no action alternative if power needs are rising, forces us to consider other forms of power generation. Not only fossil fuel but the other forms which are renewable. (NASC-G 5)

***Response**: The NRC staff will consider the no-action alternative in its EIS. For this review, the no-action alternative means denying the ESP application. As discussed above, alternative energy sources will not be evaluated at this time.*

D.1.11 Comments Concerning the Safety Review for the ESP, Including Safeguards and Security and Emergency Preparedness

Safety Review

Comment: [The EIS for the North Anna nuclear power station is therefore required to address all of the following environmental impacts, including but not limited to: 11.] All impacts arising from seismic hazards posed to the North Anna site expansion highlighted as a consequence of the December 09, 2003 regional earthquake, given that the U.S. Geological Survey considers that Virginia is vulnerable to earthquakes. (NASC-GG 10)

***Response**: The seismic hazards posed to such a reactor or reactors is not within the scope of the environmental review. As part of the NRC's site safety review, the staff will consider whether, taking into consideration the site criteria in 10 CFR Part 100, such a reactor or reactors can be constructed and operated without undue risk to the health and safety of the public.*

Safeguards and Security

Comment: The EIS for the North Anna nuclear power station is required to address all impacts arising from increased security risks and tasks associated with the proposed site expansion of the North Anna nuclear power station given the federal government's acknowledgment that threats to nuclear power stations by acts of terrorism can be delivered in part or in combination from the air, the water and by land. (NASC-GG 11)

Comment: Tonight as we're talking about expanding the site of North Anna, we're talking about expanding the possible pre-deployed weapons of mass destruction if used against us. (NASC-A 7)

Comment: 9/11 changed everything, and at the same time it changed nothing. The officials at

Dominion Power have not yet realized that on their power station exists one of the most attractive – [targets] for a terrorist organization. ...I can imagine that a direct hit on the spent fuel nuclear storage would have a catastrophic environmental impact. (NASC-D 6)

Comment: [The Lake Anna Civic Association has identified seven issues of concern, one of which is] security issues, issues that deal with terrorists that would lead to radiation release. (NASC-J 3)

Comment: Security is another big issue that we need to deal with. (NASC-K 2)

Comment: I hate to say this, but with the amount of terrorism in the world, we do not need more invitations to terrorists, and that's what nuclear power plants are. They cannot be safe enough, despite the claims by the nuclear industry. (NASC-N 4)

***Response**: Comments related to aspects of the security plan, including a safeguards contingency plan, a physical security plan, and a guard training and qualifications plan are safety issues that are not within the scope of the staff's environmental review. In addition, the Commission, has determined that terrorism is not predictable and is not an inevitable consequence of a proposed licensing action, and that an EIS is not an appropriate format to address the challenges of terrorism. Additional information about the NRC staff's actions regarding physical security since September 11, 2001, can be found on the NRC's public web site (www.nrc.gov).*

<u>Emergency Preparedness</u>

Comment: My concern is for notification and evacuation of the public in the North Anna area, as this area is rapidly developing. My chief concern is for the safety, protection and welfare of the public. (NASC-HH 1)

Comment: My concern is in regard to the rapid development in the immediate area, the installation of new early warning sirens, emergency backup notification and route alerting. Dominion closely works with the Virginia Department of Emergency Management who provides plans regarding these areas. An audit of this area, by your organization, would better identify these areas concerning early warning notification. (NASC-HH 3)

Comment: Backup Route Alerting is essential for the protection of the general public in the North Anna area since it is rapidly developing in areas where no early warning sirens are currently located and residents must rely on route alerting. …please verify that these newly developed areas requiring backup route alerting or the installation of an early warning siren are identified by Dominion. Additionally, if no measures are currently in place, they should be implemented to ensure future identification of any new additional areas of development and how they will be addressed for the protection and safety of the general public before any additional site permit is obtained. (NASC-HH 4)

Comment: I don't live in a house, I live in an apartment. But my apartment doesn't release radiation on a regular basis. It doesn't require an evacuation plan, only if there is a fire, of course. But for other people, there's no iodine pills if you live nearby my apartment. (NASC-E 6)

Comment: [The Lake Anna Civic Association has identified seven issues of concern, one of which is] an evaluation [evacuation] plan relative to roads. (NASC-J 4)

***Response**: The comments relate to the adequacy of emergency plans, which is a safety issue that is outside the scope of the staff's environmental review. As part of its site safety review, the NRC staff will determine, after consultation with the U.S. Department of Homeland Security (DHS) and the Federal Energy Management Administration (FEMA), whether there are any significant impediments to the development of emergency plans and whether the major features of emergency plans submitted by Dominion are acceptable. The currently operating units have emergency plans in place that have been reviewed by NRC, DHS, and FEMA.*

Appendix E

Comments and Responses on
the Draft Environmental Impact Statement
and the Supplement to the Draft Environmental Impact Statement

Note: Due to the size of the documents, Appendix E is bound in Volume II.

Appendix F

Key Correspondence

Note: Due to the size of the documents, Appendix E is bound in Volume II.

Appendix G

Environmental Impacts of Transportation

Appendix G

Environmental Impacts of Transportation

This appendix discusses the potential environmental impacts of transporting reactor fuel and radioactive waste to and from potential early site permit (ESP) sites including North Anna Power Station and its associated alternative sites. Section G.1 discusses the effects of transporting unirradiated fuel to ESP sites, and Section G.2 discusses the effects of transporting spent fuel from ESP sites to a spent fuel disposal facility or monitored retrievable storage facility. Section G.3 discusses the environmental effects of radioactive waste shipments.

G.1 Unirradiated Fuel Shipping

This section addresses the number and characteristics of shipments of unirradiated fuel to ESP sites relative to the conditions in 10 CFR 51.52. Comparisons are also made against Table S–4 in 10 CFR 51.52(c) and WASH-1238 (AEC 1972), which provided the data that supports Table S–4. Section G.1.1 presents the basic unirradiated fuel shipping requirements for each advanced reactor design. These data were extracted from INEEL (2003) and Dominion (2006a). Section G.1.2 presents the comparisons to 10 CFR 51.52 conditions.

G.1.1 Advanced Reactor Unirradiated Fuel Shipping Data

In WASH-1238 (AEC 1972), a reference boiling water reactor (BWR) and pressurized water reactor (PWR) were used to formulate the basic numbers of unirradiated fuel shipments required for initial core loading and refueling. Both reference reactor types were 1100 MW(e) plants that were assumed to operate with an 80 percent capacity factor for a net electrical generating output of 880 MW(e). The reference BWR assumed an initial core loading of 150 metric tons of uranium (MTU), and the reference PWR assumed a 100 MTU initial loading. Both reactor types resulted in 18 truck shipments of unirradiated fuel per reactor for initial core loading. Annual reload quantities were assumed to be 30 MTU/yr for both reactor types, which resulted in an additional six truck shipments per year per reactor. In total, about 252 truck shipments of unirradiated fuel would be required over a 40-year reactor life, including the initial core and 39 years of reloads, for both reactor types.

The initial fuel loading and annual reload quantities for the Advanced Boiling Water Reactor (ABWR), a 1500-MW(e) reactor, and the Economic Simplified Boiling Water Reactor (ESBWR) are approximately the same: 156.96 MTU per reactor initial core loading and 32.76 MTU/yr per reactor reload quantities (INEEL 2003). The staff evaluated the impacts of the increased thermal power for the surrogate ESBWR as characterized in the ER (Dominion 2006a) and determined that the number of unirradiated fuel shipments was essentially unchanged from the estimates presented in INEEL (2003). This equates to about 872 unirradiated fuel assemblies in the initial core and 213 assemblies per year for refueling. Truck shipment capacities were stated in INEEL (2003) to be 28 to 30 unirradiated fuel assemblies per truck shipment. Assuming 30 fuel assemblies per truck shipment, approximately 30 shipments of unirradiated fuel would be required to load the initial core and 6.1 truck shipments per year would be needed for refueling. If 28 fuel assemblies per truck shipment are used, the initial core load would require about 32 shipments of unirradiated fuel and annual refueling would require about 6.5 truck shipments per year.

The surrogate AP1000 is an 1150-MW(e) advanced PWR. The initial core load was estimated to be 84.5 MTU per reactor, and the annual reload requirement was estimated to be 24.4 MTU/yr per reactor. The data in INEEL (2003) also indicated that the average uranium mass in an unirradiated surrogate AP1000 fuel assembly would be 0.583 MTU and that 12 fuel assemblies per truck shipment would be transported. Therefore, about 14 truck shipments would be needed to supply the initial core and about 3.8 truck shipments per year would be needed to support refueling. For a site with two reactors, these estimates would be doubled.

The ACR-700 is an advanced design Canada Deuterium Uranium (CANDU) reactor assumed to generate 731 MW(e). It was stated in INEEL (2003) that the initial core load for the ACR-700 is 61.3 MTU per reactor, and the annual refueling requirement is 33.1 MTU/yr per reactor. Each fuel assembly contains 18 kg of uranium (INEEL 2003). This corresponds to 3406 fuel assemblies in the initial core loading and 1839 fuel assemblies per year for refueling. The range of truck shipment capacities given by INEEL (2003) was 180 to 240 fuel assemblies per truck shipment. This equates to 15 to 19 truck shipments needed to supply the initial core load and from 7.7 to 10.2 annual refueling shipments. For a site with two reactors, these estimates would be doubled.

The International Reactor Innovative and Secure (IRIS) design is a 335-MW(e) advanced PWR. It requires an initial core load of 48.67 MTU or 89 fuel assemblies per unit (546.9 kg of uranium per fuel assembly) (INEEL 2003). For refueling, the IRIS reactor was assumed to require an additional 6.26 MTU/yr of unirradiated fuel per reactor or about 40 unirradiated fuel assemblies every 3.5 years. INEEL (2003) indicates that a “typical” site may contain three reactors. Assuming each truck shipment carries eight fuel assemblies, the initial core load would require 34 truck shipments per three-reactor site, and annual refueling would require an additional 4.3 truck shipments per year per three-reactor site.

The Gas Turbine–Modular Helium Reactor (GT-MHR) is a gas-cooled reactor that uses a substantially different fuel design than current and advanced Light Water Reactors (LWRs). The reactor’s thermal power level is rated at 600 MW(t) per reactor, and the electric generation capacity is rated at 285 MW(e) per reactor. A standard GT-MHR site is assumed to be composed of four reactors. INEEL (2003) states that the initial core load for a single reactor would be about 1020 fuel assemblies. Annual average reload requirements would be 510 fuel assemblies per reactor. INEEL (2003) also indicates that each truck shipment could carry 80 fuel assemblies, so for all four reactors, about 51 truck shipments would be required to transport the initial core load and about 20 truck shipments per year would be required for the annual reload requirements.

The Pebble Bed Modular Reactor (PBMR) is a gas-cooled reactor that is rated at 400 MW(t) (165 MW(e)) per reactor. A typical PBMR site is assumed to consist of eight reactors. The PBMR uses a substantially different fuel design than a typical LWR. INEEL (2003) states that each reactor requires 260,000 fuel spheres per reactor for its initial core load; 120,000 fuel spheres per reactor are required for annual average reloads. A total of 48,000 fuel spheres is assumed to be transported in a typical truck shipment. As a result, it would take about 44 shipments of fuel spheres to transport the initial core load for all eight reactors and about 20 shipments per year to transport the annual reload quantity for all eight reactors.

To make comparisons to Table S–4, the environmental impacts were normalized to a reference reactor-year. The reference reactor is an 1100 MW(e) reactor that has an 80 percent capacity factor, for a net electrical generating capacity of 880 MW(e). The environmental impacts can be adjusted to calculate impacts per site by multiplying the normalized impacts by the ratio of the net electrical output for the advanced reactor sites to the net electrical output of the reference reactor.

G.1.2 Analysis of the Environmental Impacts of Unirradiated Fuel Shipments

As required by 10 CFR 51.52, applicants for a construction permit are required to submit a statement that the reactor and the transportation of fuel and waste to and from the reactor meet all the conditions specified in 10 CFR 51.52(a) or 10 CFR 51.52(b). The conditions specified in 10 CFR 51.52(a) that apply to unirradiated fuel include the following:

(1) The reactor core has a thermal loading less than 3800 MW. [51.52(a)(1)]

(2) The reactor fuel is in the form of sintered UO_2 pellets not exceeding 4 percent uranium-235 by weight, and the pellets are encapsulated in zircaloy rods. [51.52(a)(2)]

(3) Unirradiated fuel is shipped to the reactor by truck. [51.52(a)(5)]

(4) The environmental impacts of transportation of fuel and waste are as set forth in Summary Table S–4 in 10 CFR 51.52(c). [51.52(a)(6)]

If these conditions are not met, 10 CFR 51.52(b) requires the applicant to provide a full description and detailed analysis of the environmental impacts of transporting fuel and waste to and from the reactor, including values for the environmental impact under normal conditions of transport and the environmental risk from accidents in transport.

Unirradiated fuel shipment information for the advanced reactors is discussed below for each of these criteria.

G.1.2.1 Reactor Core Thermal Loading

The thermal output ratings of the seven advanced reactor types, as given in INEEL (2003), are as follows:

- ABWR – 4300 MW(t) (single reactor)
- Surrogate ESBWR – 4500 MW(t) (single reactor)[a]
- Surrogate AP1000 – 3400 MW(t) (single reactor)
- ACR-700 – 1982 MW(t) per reactor x two reactors per site = 3964 MW(t) per site
- IRIS – 1000 MW(t) per reactor x three reactors per site = 3000 MW(t) per site
- GT-MHR – 600 MW(t) per reactor x four reactors per site = 2400 MW(t) per site
- PBMR – 400 MW(t) per reactor x eight reactors per site = 3200 MW(t) per site.

As shown above, single-unit ABWR and surrogate ESBWR plants exceed the 3800-MW(t) condition in 10 CFR 51.52(a)(1). In addition, the twin-reactor ACR-700 site exceeds the core thermal power condition.

G.1.2.2 Reactor Fuel Form

All of the advanced LWRs (i.e., the ABWR, ESBWR, surrogate AP1000, IRIS, and ACR-700) use sintered UO_2 fuel pellets encapsulated in zircaloy rods. The average enrichment for the ACR-700 fuel is about 2 percent, which is well within the 10 CFR 51.52(a)(2) condition. The average enrichments for the other advanced LWR fuels exceed the 4 percent uranium-235 by weight condition in 10 CFR 51.52(a)(2).

The gas-cooled reactors (i.e., the GT-MHR and PBMR) have substantially different fuel forms than those described in 10 CFR 51.52(a)(2). The fuel forms for these reactors are coated uranium oxycarbide fuel kernels (GT-MHR) or coated uranium dioxide fuel kernels (PBMR). The fuel kernels are coated with layers of pyrolitic carbon and silicone carbide. Thus, these fuel forms are not the same as those specified in 10 CFR 51.52(a)(2). Furthermore, the equilibrium enrichments for these fuels are 12.9 percent (PBMR) and 19.8 percent (GT-MHR).

G.1.2.3 Shipping Mode

Trucks are used to ship unirradiated fuel to the various sites for all the reactor types (INEEL 2003).

(a) Source is Dominion (2006a).

G.1.2.4 WASH-1238 and Table S–4 of 10 CFR 51.52(c)

The condition specified in Table S–4 that applies to shipment of unirradiated fuel limits the number of shipments of fuel and waste to and from a commercial nuclear power plant to less than one per day. Table G-1 summarizes the number of truck shipments of unirradiated fuel required for each reactor type. The numbers of shipments are normalized to the net electrical generation output for the reference reactor in WASH-1238 (AEC 1972), or 880 MW(e) (1100-MW[e] plant operating at 80-percent annual capacity factor).

As shown in Table G-1, the ACR-700, PBMR, and GT-MHR advanced reactor types exceed the number of truck shipments estimated for the reference LWR in WASH-1238 (AEC 1972). The largest number of shipments, in excess of 700 shipments over 40 years, is for the GT-MHR. However, the combined number of unirradiated fuel, spent fuel, and radioactive waste shipments per day equate to far less than one truck shipment per day for all reactor types. Consequently, the numbers of shipments for all the advanced reactor types are within the conditions specified in Table S–4 of 10 CFR 51.52. Table S–4 includes a condition that the truck shipments not exceed 33,000 kg (73,000 lb) as governed by Federal or State gross vehicle weight restrictions. All of the advanced reactors were indicated in INEEL (2003) to be capable of meeting this restriction for unirradiated fuel shipments.

Finally, Table S–4 includes conditions related to radiological doses to transport workers and members of the public along transport routes. These doses are a function of the radiation dose rate emitted from the unirradiated fuel shipments, the number of exposed individuals and their locations relative to the shipment, the time in transit (including travel time and stop time), and the number of shipments to which the individuals are exposed. The radiological dose impacts of the transportation of unirradiated fuel were calculated using the RADTRAN 5 computer code (Neuhauser et al. 2003). The RADTRAN 5 calculations were performed to develop estimates of the worker and public doses associated with annual unirradiated fuel shipments to the ESP sites.

One of the key assumptions in WASH-1238 (AEC 1972) for the reference LWR unirradiated fuel shipments is that the radiation dose rate at 1 m (3 ft) from the transport vehicle is about 0.001 mSv/hr (0.1 mrem/hr). This assumption was also used in the analysis of advanced reactor unirradiated fuel shipments. This assumption is reasonable for all the advanced reactor fuel types because the fuel materials will be low-dose-rate uranium radionuclides and will be packaged similarly. The numbers of shipments per year were obtained by dividing the normalized shipments in Table G-1 by 40 years of operation. Other key input parameters used in the radiation dose analysis for unirradiated fuel are shown in Table G-2.

Table G-1. Numbers of Truck Shipments of Unirradiated Fuel for Each Advanced Reactor Type

Reactor Type	Number of Shipments per Reactor Unit			Unit Electric Generation, MW(e)[c]	Capacity Factor[c]	Normalized Shipments per 1100 MW(e)[d,e]
	Initial Core[a]	Annual Reload	Total[b]			
Reference LWR (WASH-1238)	18	6	252	1100	0.8	252
ABWR[e]	30	6.1	267	1500	0.95	165
Surrogate ESBWR[e]	30	6.1	267	1520[f]	0.96[f]	162
Surrogate AP1000	14	3.8	161	1150	0.95	130
ACR-700	30	15.4	628	1462[g]	0.9	420
IRIS	34	4.3	201	1005[h]	0.96	184
GT-MHR	51	20	831	1140[i]	0.88	729
PBMR	44	20	824	1320[j]	0.95	579

NOTE: The reference LWR shipment values have all been normalized to 880 MW(e) net electrical generation.
(a) Shipments of the initial core have been rounded up to the next highest whole number.
(b) Total shipments of unirradiated fuel over a 40-year plant lifetime (i.e., initial core load plus 39 years of average annual reload quantities).
(c) Unit capacities and capacity factors were taken from INEEL (2003).
(d) Total shipments over a 40-year plant lifetime normalized to net electric output for WASH-1238 reference LWR (i.e., 1100 MW(e) plant at 80 percent or net electrical output of 880 MW(e)).
(e) Ranges of capacities are given in INEEL (2003) for these reactor unirradiated fuel shipments. The unirradiated fuel shipment data for these reactors were derived using the upper limit of the ranges.
(f) Values taken from ER Revision 9 (Dominion 2006a).
(g) The ACR-700 unit includes two reactors at 731 MW(e) per reactor.
(h) The IRIS unit includes three reactors at 335 MW(e) per reactor.
(i) The GT-MHR unit includes four reactors (modules) at 285 MW(e) per reactor.
(j) The PBMR unit includes eight reactors (modules) at 165 MW(e) per reactor.

The RADTRAN 5 results for this “generic” unirradiated fuel shipment are as follows:

- Worker dose: 1.71×10^{-5} person-Sv/shipment (1.71×10^{-3} person-rem/shipment)
- General public dose (onlookers/persons at stops and sharing the highway): 6.65×10^{-5} person-Sv/shipment (6.65×10^{-3} person-rem/shipment)

Table G-2. RADTRAN 5 Input Parameters for Unirradiated Fuel Shipments

Parameter	RADTRAN 5 Input Value	Source
Shipping distance, km	3200	AEC (1972)[(a)]
Travel fraction – rural	0.90	NRC (1977)
Travel fraction – suburban	0.05	
Travel fraction – urban	0.05	
Population density – rural, persons/km^2	10	DOE (2002a)
Population density – suburban, persons/km^2	349	
Population density – urban, persons/km^2	2260	
Vehicle speed – rural, km/hr	88.49	Based on average speed in rural areas given in DOE (2002a)
Vehicle speed – suburban, km/hr	88.49	
Vehicle speed – urban, km/hr	88.49	
Traffic count – rural, vehicles/hr	530	DOE (2002a)
Traffic count – suburban, vehicles/hr	760	
Traffic count – urban, vehicles/hr	2400	
Dose rate at 1 m from vehicle, mSv/hr	0.001	AEC (1972)
Packaging length, m	7.3	Approximate length of two LWR fuel element packages placed on end
Number of truck crew	2	AEC (1972), NRC (1977), and DOE (2002a)
Stop time, hr/trip	4.5	Based on 0.0014-hour stop time per km (Hostick et al. 1992). Assume no overnight stops.
Population density at stops, persons/km^2	64,300	Based on 20 people in annular ring extending from 1 to 10 m (3.3 to 33 ft) from the vehicle

(a) AEC (1972) provides a range of shipping distances between 40 km (25 mi) and 4800 km (3000 mi) for unirradiated fuel shipments. A 3200-km (2000-mi) “average” shipping distance was assumed here.

- General public dose (along route - persons living near a highway): 1.61×10^{-6} person-Sv/ shipment (1.61×10^{-4} person-rem/shipment).

These values were combined with the average annual shipments of unirradiated fuel for each advanced reactor type (see Table G-1) normalized to the WASH-1238 (AEC 1972) reference LWR electric output (880 MW(e)) to calculate annual doses to the public and workers. The results are compared to Table S–4 conditions. The results are shown in Table G-3. As demonstrated, the calculated radiation doses for shipping unirradiated fuel to advanced reactor sites are within the conditions shown in Table S–4.

Table G-3. Radiological Impacts of Transporting Unirradiated Fuel to Advanced Reactor Sites

Plant Type	Normalized Average Annual Shipments	Cumulative Annual Dose; person-Sv/yr per 1100 MW(e)[a]		
		Workers	Public - Onlookers	Public - Along Route
Reference LWR (WASH-1238)	6.3	1.1×10^{-4}	4.2×10^{-4}	1.0×10^{-5}
ABWR[b]	4.1	7.1×10^{-5}	2.7×10^{-4}	6.6×10^{-6}
Surrogate ESBWR[c]	4.1	6.9×10^{-5}	2.7×10^{-4}	6.5×10^{-6}
Surrogate AP1000	3.3	5.6×10^{-5}	2.2×10^{-4}	5.2×10^{-6}
ACR-700	10.5	1.8×10^{-4}	7.0×10^{-4}	1.7×10^{-5}
IRIS	4.6	7.9×10^{-5}	3.1×10^{-4}	7.4×10^{-6}
GT-MHR	18.2	3.1×10^{-4}	1.2×10^{-3}	2.9×10^{-5}
PBMR	14.5	2.5×10^{-4}	9.6×10^{-4}	2.3×10^{-5}
10 CFR 51.52, Table S–4 Condition	<1 per day	4.0×10^{-2}	3.0×10^{-2}	3.0×10^{-2}

(a) Multiply person-Sv/yr times 100 to obtain doses in person-rem/yr.
(b) In the Draft EIS (NRC 2004), the ABWR and ESBWR were assumed to be identical based on information in INEEL (2003). See also the "surrogate ESBWR" information in this table.
(c) Dominion 2006a

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposures to low doses below about 100 mSv (10,000 mrem) and at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2005), the BEIR VII report, supports the linear, no-threshold dose response theory. This theory states that any increase in dose, no matter how small, results in an incremental increase in health risk. The NRC accepts this theory as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably overestimates those risks.

Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv [1,000,000 person-rem]) from International Commission on Radiological Protection (ICRP) Publication 60 (ICRP 1991). All the public doses presented in Table G-3 are less than or equal to 0.0012 person-Sv/yr

(0.12 person-rem/yr); therefore, the total detriment estimates associated with these doses would all be less than 1 x 10^{-4} fatal cancers, nonfatal cancers, and severe hereditary effects per year.

These risks are very small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would be expected to occur annually to the same population from exposure to natural sources of radiation, based on the same risk model.

G.1.3 Transportation Accidents

Accidents involving unirradiated fuel shipments are also addressed in Table S–4. Accident risks are the product of accident frequency times consequence. Accident frequencies are likely to be lower than they were when WASH-1238 (AEC 1972) was published because traffic accident, injury, and fatality rates have fallen over the past 30 years. Consequences of accidents that are severe enough to result in a release of unirradiated fuel particles are not significantly different for advanced LWRs because the fuel form, cladding, and packaging are similar to those analyzed in WASH-1238. Consequently, the impacts of accidents during transport of unirradiated fuel to advanced LWR sites would be smaller than the WASH-1238 results that formed the basis for Table S–4.

With respect to the advanced gas-cooled reactors, accident rates (accidents per unit distance) and associated accident frequencies (accidents per year) would follow the same trends as for LWRs (i.e., overall reduction relative to the accident rates used in WASH-1238). The consequences of accidents involving gas-cooled reactor unirradiated fuel, however, are more uncertain. A literature search was conducted to identify publicly available documents that describe the effects of accidents (i.e., exposure of unirradiated gas-cooled reactor fuel to structural and thermal transients). No definitive references were found. Consequently, it was assumed here that the gas-cooled reactor unirradiated fuel shipments would have the same abilities as LWR unirradiated fuel to maintain functional integrity following a traffic accident. This assumption is judged to be conservative because gas-cooled reactor fuel operates at significantly higher temperatures and thus maintains integrity under more severe thermal conditions than LWR fuel. Detailed information about the behavior of the gas-cooled reactor fuel under impact conditions was not available. However, packaging systems for unirradiated gas-cooled reactor fuel will be required to meet the same performance requirements as unirradiated LWR fuel packages including fissile material controls to prevent criticality under normal and accident conditions. Consequently, packaging systems for unirradiated gas-cooled reactor fuels are expected to provide protection equivalent to those designed for unirradiated LWR fuels. In addition, the fuel forms for the gas-cooled reactors are somewhat similar to those for LWRs (i.e., uranium oxide for the PBMR and uranium oxycarbide for the GT-MHR versus uranium oxide for LWRs). Nevertheless, the inherent failure resistance provided by unirradiated gas-cooled reactor fuels was assumed to be similar to that provided by LWR fuels. Based on the assumption that unirradiated gas-cooled and LWR fuels and associated packaging systems provide similar resistance to various environmental conditions, the staff concluded that the impacts of accidents involving unirradiated gas-cooled reactor fuel are not expected to be significantly different than those for unirradiated LWR fuel.

The advanced gas-cooled reactor fuels consist of uranium oxycarbide (GT-MHR) or uranium oxide (PBMR) spheres coated with layer of pyrolytic carbon and silicon carbide that are expected to provide improved resistance to releases of gaseous and metallic fission products during normal and accident conditions (INEEL 2003).

G.2 Spent Fuel Shipping

This section discusses the impact of transporting irradiated or spent advanced reactor fuel from candidate sites to a potential high-level waste repository; for these analyses, the staff considered Yucca Mountain, Nevada, as a surrogate destination. The section is divided into two parts. The first part considers incident-free transportation, and the second part considers transportation accidents.

The analysis is based on shipment of spent fuel by legal-weight trucks in casks with characteristics similar to casks currently available (i.e., massive, heavily shielded, cylindrical metal pressure vessels). Each shipment is assumed to consist of a single shipping cask loaded onto a modified trailer. These assumptions are consistent with assumptions made in the evaluation of the environmental impacts of transportation of spent fuel presented in Addendum I to NUREG-1437 (NRC 1999). As discussed in Addendum I, these assumptions are conservative because the alternative assumptions involve rail transportation or heavy-haul trucks, which would reduce the number of spent-fuel shipments.

Environmental impacts of the transportation of spent fuel were calculated using the RADTRAN 5 computer code (Neuhauser et al. 2003). Routing and population data for input to RADTRAN 5 for shipment by truck were obtained from the TRAGIS routing code (Johnson and Michelhaugh 2000). The population data in the TRAGIS code is based on the 2000 Census.

G.2.1 Incident-Free Transportation of Spent Fuel

“Incident-free” transportation refers to transportation activities in which the shipments of radioactive material reach their destination without releasing any radioactive cargo to the environment. The vast majority of radioactive shipments are expected to reach their destination without experiencing an accident or incident or releasing any cargo. The “incident-free” impacts from these normal, routine shipments arise from the low levels of radiation that penetrate the heavily shielded spent fuel shipping cask. Although Federal regulations in 10 CFR Part 71 and 49 CFR Part 173 impose constraints on radioactive material shipments, some radiation penetrates the shipping container and exposes nearby persons to low levels of radiation.

Incident-free, legal-weight truck transportation of spent fuel has been evaluated by considering shipments from four representative reactor sites to the proposed high-level waste repository at Yucca Mountain, Nevada, (referred to here as the proposed Yucca Mountain Repository) for disposal. This assumption is conservative because it tends to maximize the shipping distance from the East Coast and Midwest, where most of the reactors are assumed to be located. Therefore, shipment to one or more other potential sites, such as a monitored retrievable storage facility, would reduce the impacts.

Environmental impacts from these shipments will occur to persons residing along the transportation corridors between the potential advanced reactor sites and the proposed repository; to persons in vehicles in close proximity to the spent-fuel shipment along the route; to persons at vehicle stops for refueling, rest, and vehicle inspections; and to transportation crew members. The impacts to these exposed population groups were quantified using the RADTRAN 5 computer code (Neuhauser et al. 2003).

This analysis assumes that all spent nuclear fuel will be transported to the proposed Yucca Mountain repository because Congress has directed (Nuclear Waste Policy Act of 1982, as amended) the U.S. Department of Energy to study only Yucca Mountain for the proposed repository.

The characteristics of specific shipping routes (e.g., population densities, shipping distances) influence the normal radiological exposures. To address the differences that arise from the specific reactor site from which the spent fuel shipment originates, each advanced reactor design was assumed to be located at all of the primary and alternative ESP sites. These sites are:

- Primary Site
  - North Anna Power Station, Virginia

- Alternative Sites
  - Savannah River Site (SRS), South Carolina
  - Portsmouth Gaseous Diffusion Plant (PGDP), Ohio
  - Surry Power Station, Virginia

Input to RADTRAN 5 includes the total shipping distance between the origin and destination sites and the population distributions along the routes. This information was obtained by running the TRAGIS computer code (Johnson and Michelhaugh 2000) for the origin-destination combinations of interest for legal-weight trucks. The resulting route characteristics information is shown in Table G-4. Note that for truck shipments, all the spent fuel is assumed to be shipped to the proposed Yucca Mountain repository over designated Highway Route Controlled Quality (HRCQ) routes. The routes used here are the same as those used in the Yucca Mountain Environmental Impact Statement (DOE 2002b).

Table G-4. Transportation Route Information for Shipments from the North Anna and Alternative Sites to the Proposed High-Level Waste Repository at Yucca Mountain

	One-way Shipping Distance, km				Population Density, persons/km^2			Stop Time per Trip, hr
ESP Site	**Total**	**Rural**	**Suburban**	**Urban**	**Rural**	**Suburban**	**Urban**	
				Primary Site				
North Anna	4409.5	3498	812.4	99.1	11.3	319	2310.6	5
				Alternative Site				
Savannah River Site	4263	3260	881	122	11	331.5	2311.2	5
Portsmouth Gaseous Diffusion Plant	3902.2	3166.9	647.2	88.1	10.7	316.4	2339.7	4.5
Surry	4555.4	3590.7	863.9	100.8	11.4	317.6	2301.6	5

Shipping casks have not been designed for advanced reactor spent fuel. Although some of the advanced reactor fuel designs are similar to current LWR fuel, no attempt has been made to optimize the cargo capacities of shipping casks for advanced LWR fuels. For the non-LWR fuel types (i.e., the GT-MHR and PBMR), there is little information on even a conceptual basis that would provide a defensible technical basis for shipping cask capacities. The shipping cask capacity data in the *Early Site Permit Environmental Report Sections and Supporting Documentation* (INEEL 2003) is summarized as follows:

- ABWR – The ABWR fuel is not significantly different from existing LWR fuel designs; thus, the number of ABWR assemblies that can be transported in a legal-weight truck shipment (i.e., 23 MT [25-ton] shipping cask) is not expected to be different from current cargo capacities.

- Surrogate ESBWR – The surrogate ESBWR fuel is similar to the ABWR fuel.

- Surrogate AP1000 – The surrogate AP1000 fuel assemblies are similar to current-generation PWR fuel. No information was provided in INEEL (2003) on shipping cask capacities for surrogate AP1000 spent nuclear fuel.

- ACR-700 – The ACR-700 fuel is somewhat different from the current and advanced LWR fuel designs. INEEL (2003) estimated that an ACR-700 rail cask would hold about 10 MTU of spent fuel. This value is nearly identical to the cargo capacities of current rail cask designs; thus, it was assumed that the truck cask capacity for ACR-700 and current-generation LWRs would also be about the same (i.e., 1.8 MTU/shipment).

- IRIS – The IRIS fuel is similar to current-generation PWR fuel. No information was provided in INEEL (2003) on shipping-cask capacities for IRIS spent nuclear fuel.

- GT-MHR – The GT-MHR fuel is a spherical coated-particle fuel with a uranium oxycarbide fuel kernel loaded into graphite fuel assemblies. This fuel concept is significantly different from current and advanced LWR fuels (sintered UO_2 pellets loaded into zircaloy tubes). According to INEEL (2003), six spent fuel assemblies containing 0.023 MTU of spent fuel is assumed to be transported in a legal weight truck cask.

- PBMR – The PBMR fuel is also a spherical coated-particle fuel with uranium oxide fuel kernels. INEEL (2003) estimated that 0.495 MTU of spent PBMR fuel can be transported in a single legal-weight truck shipment.

These shipping cask capacities are approximations based on current shipping cask designs. Actual shipping cask capacities in the future may be significantly different. Applicants must account for changes in shipping cask capacities in applications at the construction permit (CP) or combined operating license (COL) stage.

Incident-free radiation doses are a function of many variables. The most important of these variables are presented in Table G-5. Most of these variables, which are extracted from the literature, are considered to be “standard” values used in many RADTRAN 5 applications, including environmental impact statements and regulatory analyses.

For purposes of this analysis, the transportation crew for spent fuel shipments delivered by truck is assumed to consist of two drivers. Escorts were considered, but they were not included because their distance from the shipping cask would reduce the dose rates to levels well below the dose rates experienced by the drivers. Stop times were assumed to accrue at the rate of 30 minutes per 4-hour driving time. TRAGIS outputs were used to determine the number of stops for each origin-destination.

Doses to the public at truck stops have been significant contributors to the doses calculated in previous RADTRAN 5 analyses. For this analysis, stop doses are the sum of the doses to individuals located in two annular rings centered at the stopped vehicle, as illustrated in Figure G-1. The inner ring represents persons who may be at the truck stop at the same time as a spent fuel shipment and extends 1 to 10 m from the edge of the vehicle. The outer ring represents persons who reside near a truck stop and extends from 10 to 800 m from the vehicle. This scheme is the same as that used in Sprung et al. (2000).

Population densities and shielding factors were also taken from Sprung et al. (2000) and were based on the observations of Griego et al. (1996).

The results of these routine (incident-free) exposure calculations are shown in Table G-6 for spent fuel shipments from all 11 primary and alternative sites to the proposed Yucca Mountain repository. Population dose estimates are given for workers (i.e., truck crew members), onlookers (doses to persons at truck stops and persons and on highways exposed to the spent fuel shipments), and along the route (persons living near the highway).

Table G-5. RADTRAN 5 Incident-Free Exposure Parameters

Parameter	RADTRAN 5 Input Value	Source
Vehicle speed – rural, km/hr	88.49	Based on average speed in rural areas given in DOE (2002a). Because most travel is on interstate highways, the same vehicle speed is assumed in rural, suburban, and urban areas. No speed reductions were assumed for travel at rush hour.
Vehicle speed – suburban, km/hr	88.49	
Vehicle speed – urban, km/hr	88.49	
Traffic count – rural, vehicles/hr	530	DOE (2002a)
Traffic count – suburban, vehicles/hr	760	
Traffic count – urban, vehicles/hr	2400	
Dose rate at 1 m from vehicle, mSv/hr	0.14	Approximate dose rate at 1 m (3 ft) that is equivalent to maximum dose rate allowed by DOT and NRC regulations (i.e., 0.1 mSv/hr at 2 m (~7 ft) from the side of a transport vehicle) (DOE 2002b)
Packaging dimensions, m	Length – 5.2 Diameter – 1.0	DOE (2002b)
Number of truck crew	2	AEC (1972), NRC (1977), and DOE (2002a)
Stop time, hr/trip	Route-specific	See Table G-4.
Population density at stops, persons/km^2	30,000	Sprung et al. (2000)
Min/max radii of annular area around vehicle at stops, m	1 to 10	Sprung et al. (2000)
Shielding factor applied to annular area surrounding vehicle at stops	1(no shielding)	Sprung et al. (2000)
Population density surrounding truck stops, persons/km^2	340	Sprung et al. (2000)
Min/max radius of annular area surrounding truck stop, m	10 to 800	Sprung et al. (2000)
Shielding factor applied to annular area surrounding truck stop	0.2	Sprung et al. (2000)

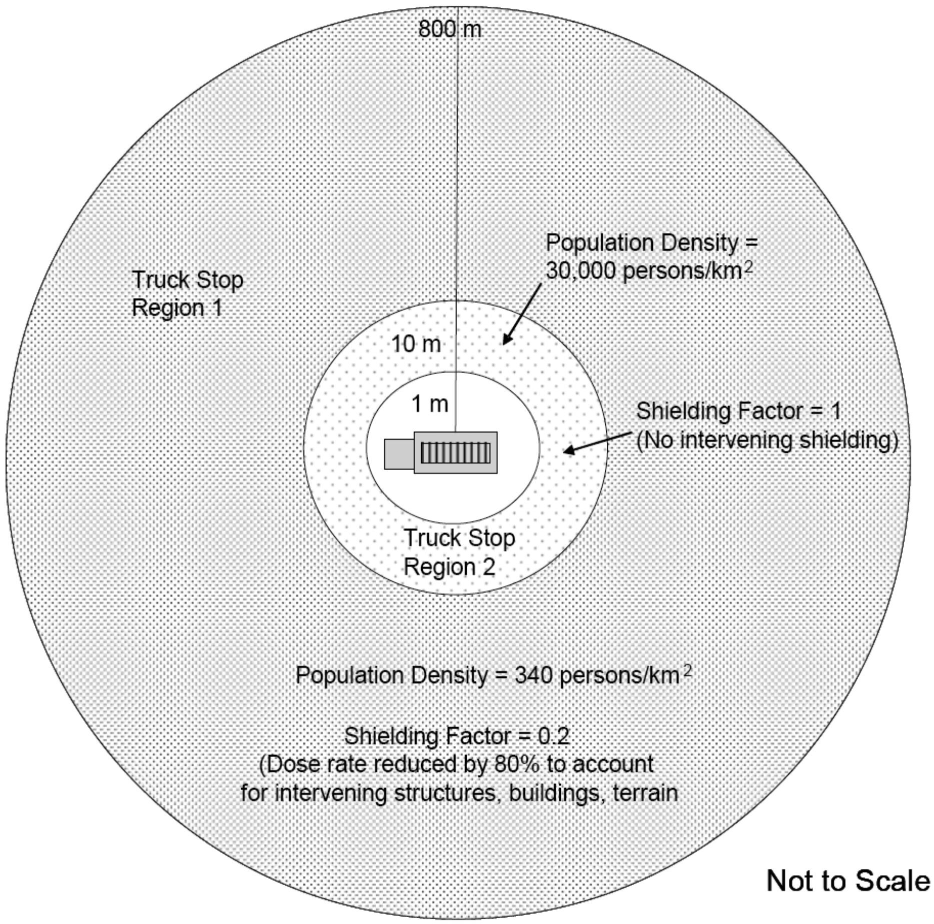

Figure G-1. Illustration of Truck Stop Model (Sprung et al. 2000)

This discussion addresses whether or not the environmental effects of incident-free advanced reactor spent fuel shipments are within the guidelines established in Table S–4. The bounding cumulative doses to the exposed population given in Table S–4 are:

- Transport workers — 0.04 person-Sv (4 person-rem) per reference reactor year.
- General public (onlookers and along route) — 0.03 person-Sv (3 person-rem) per reference reactor year.

Calculation of the cumulative doses entailed converting the per-shipment risks given in Table G-6 to estimates of environmental effects per reference reactor year of operation. The per-shipment results, which are independent of reactor type (i.e., the doses are dependent on the assumed external radiation dose rate emitted from the cask, which is fixed at the regulatory maximum limit for all of the advanced reactor types), are given in terms of the population dose

Table G-6. Routine (Incident-Free) Radiation Doses to Transport Workers and the Public from Shipping Spent Fuel from the North Anna and Alternative Sites to the Proposed High-Level Waste Repository at Yucca Mountain

Reactor Site	Population Dose, person-Sv/shipment[a] Crew	Onlookers	Along Route
North Anna	1.0×10^{-3}	3.5×10^{-3}	9.2×10^{-5}
Portsmouth	9.1×10^{-4}	3.2×10^{-3}	7.3×10^{-5}
Savannah River	9.9×10^{-4}	3.5×10^{-3}	1.0×10^{-4}
Surry	1.1×10^{-3}	3.5×10^{-3}	9.7×10^{-5}

(a) Multiply person-Sv/shipment times 100 to obtain doses in person-rem/shipment.

per shipment of spent fuel. To develop estimates of the annual environmental impacts, the following assumptions were made:

- The basis for the annual number of shipments of spent fuel from the reference LWR in WASH-1238 (AEC 1972) will be used. In WASH-1238, it was assumed that 60 shipments per year would be made, each shipment carrying 0.5 MTU of spent fuel. This equates to shipping 30 MTU of spent fuel per year. This is equivalent to the annual refueling requirements for the reference LWR. It was assumed that the other reactor types would also ship spent fuel at a rate equal to their annual refueling requirements.

- Shipping cask capacities that were used to calculate annual spent fuel shipments for the advanced LWRs were assumed to be the same as for the reference LWR (i.e., approximately 0.5 MTU per truck shipment).

- The annual numbers of spent fuel shipments from the advanced gas-cooled reactors were taken directly from INEEL (2003). These estimates were 34 shipments per year from a GT-MHR site and 12 shipments per year from the PBMR site.

Table G-7 provides the estimated annual population doses from routine (incident-free) transportation of spent fuel from ESP sites to the proposed Yucca Mountain Repository. The results in Table G-7 have been normalized to the WASH-1238 (AEC 1972) net electrical generation (i.e., 880 MW(e)). Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 100 mSv (10,000 mrem) and at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2005), the BEIR VII report, supports the linear, no-threshold dose response theory. This theory states that any increase in

Table G-7. Routine (Incident-Free) Population Doses from Spent Fuel Transportation, Normalized to Reference LWR Net Electrical Generation

Reactor Type	Reference LWR (WASH-1238)			ABWR[b]			Surrogate ESBWR			Surrogate AP1000		
No. Shipments per year	60			41			40			40		
Environmental Effects, person-Sv per reference reactor year[a]												
Reactor Site	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route
North Anna	6.2×10^{-2}	2.1×10^{-1}	5.5×10^{-3}	4.2×10^{-2}	1.4×10^{-1}	3.7×10^{-3}	4.1×10^{-2}	1.4×10^{-1}	3.6×10^{-3}	4.1×10^{-2}	1.4×10^{-1}	3.6×10^{-3}
Portsmouth	5.5×10^{-2}	1.9×10^{-1}	4.4×10^{-3}	3.7×10^{-2}	1.3×10^{-1}	3.0×10^{-3}	3.6×10^{-2}	1.3×10^{-1}	2.9×10^{-3}	3.6×10^{-2}	1.2×10^{-1}	2.9×10^{-3}
Savannah River	6.0×10^{-2}	2.1×10^{-1}	6.0×10^{-3}	4.0×10^{-2}	1.4×10^{-1}	4.1×10^{-3}	4.0×10^{-2}	1.4×10^{-1}	4.0×10^{-3}	3.9×10^{-2}	1.4×10^{-1}	4.0×10^{-3}
Surry	6.4×10^{-2}	2.1×10^{-1}	5.8×10^{-3}	4.3×10^{-2}	1.4×10^{-1}	3.9×10^{-3}	4.2×10^{-2}	1.4×10^{-1}	3.8×10^{-3}	4.2×10^{-2}	1.4×10^{-1}	3.8×10^{-3}

Reactor Type	ACR-700			IRIS			GT-MHR			PBMR		
No. Shipments per year	90			35			34			12		
Environmental Effects, person-Sv per reference reactor year[a]												
Reactor Site	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route	Crew	Onlookers	Along Route
North Anna	9.2×10^{-2}	3.2×10^{-1}	8.2×10^{-3}	3.6×10^{-2}	1.2×10^{-1}	3.2×10^{-3}	3.4×10^{-2}	1.2×10^{-1}	3.1×10^{-3}	1.2×10^{-2}	4.0×10^{-2}	1.0×10^{-3}
Portsmouth	8.1×10^{-2}	2.8×10^{-1}	6.6×10^{-3}	3.1×10^{-2}	1.1×10^{-1}	2.5×10^{-3}	3.0×10^{-2}	1.1×10^{-1}	2.4×10^{-3}	1.0×10^{-2}	3.6×10^{-2}	8.2×10^{-4}
Savannah River	8.9×10^{-2}	3.2×10^{-1}	9.0×10^{-3}	3.4×10^{-2}	1.2×10^{-1}	3.5×10^{-3}	3.3×10^{-2}	1.2×10^{-1}	3.3×10^{-3}	1.1×10^{-2}	3.9×10^{-2}	1.1×10^{-3}
Surry	9.5×10^{-2}	3.2×10^{-1}	8.7×10^{-3}	3.7×10^{-2}	1.2×10^{-1}	3.3×10^{-3}	3.5×10^{-2}	1.2×10^{-1}	3.2×10^{-3}	1.2×10^{-2}	4.0×10^{-2}	1.1×10^{-3}

(a) Multiply person-Sv/yr times 100 to obtain doses in person-rem/yr.
(b) In the Draft EIS (NRC 2004), the ABWR and ESBWR were assumed to be identified based on information in INEEL (2003). See also the "Surrogate ESBWR" columns in this table

dose, no matter how small, results in an incremental increase in health risk. NRC accepts this theory as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks.

Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv [1,000,000 person-rem]) from ICRP Publication 60 (ICRP 1991). All the population doses presented in Table G-7 are less than one person-Sv/yr (100 person-rem/yr); therefore, the total detriment estimates associated with these population doses would all be less than 0.1 fatal cancers, nonfatal cancers, and severe hereditary effects per year. These risks are very small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would occur annually in the same population from exposure to natural sources of radiation.

As shown in Table G-7, many of the estimated population doses are higher than the Table S–4 conditions. Two key reasons for the higher population doses relative to Table S–4 are the higher number of spent fuel shipments estimated for some of the reactor technologies and the longer shipping distances used in this assessment than were used in WASH-1238 (AEC 1972). WASH-1238 used a “typical” distance for a spent fuel shipment of 1600 km (1000 mi), whereas the shipping distances used in this assessment ranged from about 2900 km (1800 mi) to 4700 km (2900 mi). The higher numbers of shipments are based on spent fuel shipping casks designed to transport short-cooled fuel (150 days out of the reactor). It was assumed in this analysis that the shipping cask capacities are 0.5 MTU/shipment, roughly equivalent to one PWR or two BWR spent fuel assemblies per shipment. Newer designs are based on longer-cooled spent fuel (5 years out of reactor) and have larger capacities than those used in this assessment. DOE (2002b) spent fuel shipping cask capacities were approximately 1.8 MTU/shipment, or up to four PWR or nine BWR fuel assemblies per shipment. Use of the newer shipping cask designs will reduce the number of spent fuel shipments and the associated environmental impacts. If the population doses are adjusted for the shipping distance (a factor of 2 to 3) and shipping cask capacity (a factor of 4), the routine population doses from spent fuel shipments from all reactor types and all sites fall within the Table S–4 conditions.

Most of the stops made for actual spent fuel shipments are short duration stops (i.e., 10 minutes) for brief visual inspections of the cargo (e.g., checking the cask tie-downs). These stops typically occur in areas devoid of people, such as overpasses or freeway ramps in unpopulated areas. Therefore, doses to residents surrounding these types of stops are negligible. In DOE (2002b), close-proximity exposures (i.e., from 1 to 15.8 m from the cask) were not assumed to occur at the short-duration inspection stops. In this analysis, for the purpose of developing bounding estimates of environmental effects, close-proximity (1 to 10 m from cask) exposures at all truck stops were included in the RADTRAN 5 calculations. Because the numbers of stops in this analysis are effectively doubled relative to DOE (2002b), truck stop doses are also doubled. The doses to residents would also be lower; however, because doses to residents are two to three orders of magnitude (i.e., a factor of 100 to 1000) less than the calculated close-proximity doses, this reduction does not affect the total stop dose.

The number of exposed persons at stops is higher in this analysis by about a factor of 1.5 relative to DOE (2002b) assumptions (6.9 persons in DOE 2002b versus 10 persons assumed in this analysis). Thus, the bounding doses calculated in this analysis are also a factor of 1.5 (10 divided by 6.9) greater than those given in DOE (2002b). Furthermore, empirical data provided in Griego et al. (1996) indicate that a 30-minute stop is toward the high end of the stop time distribution. Average stop times for food and refueling observed by Griego et al. (1996) are on the order of 18 minutes. This amounts to another factor of 1.5 increase in stop doses calculated here relative to DOE (2002b).

Based on these observations, the staff concludes that the stop model used in this study overestimates public doses at stops by approximately a factor of four (factor of two for close-proximity exposure time at stops, a factor of 1.5 for average stop time at food and refueling stops, and a factor of 1.5 for the number of people in proximity to the shipping cask). Coupled with the factor of two reduction in shipping cask dose rates that result from fuel aging, the doses to onlookers at stops could be reduced to about one-eighth of the doses shown in Table G-7 [$1/(2 \times 1.5 \times 1.5 \times 2) \approx 0.12$] to reflect more realistic truck shipping conditions. Based on the previous discussion, use of more realistic dose rates, shipping cask capacities, and truck stop model assumptions in the RADTRAN 5 calculations could substantially reduce the environmental effects presented in Table G-7.

Table G-8 provides a comparison between the radiological incident-free doses calculated in NUREG-0170 (NRC 1977) and those calculated here. The table also summarizes the key incident-free input parameters used in NUREG-0170 and in this study. Comparisons are also made between the doses for spent fuel shipments in NUREG-0170 and doses calculated in this EIS for a shipment with a similar shipping distance, to the proposed Yucca Mountain Repository (2530 km in NUREG-0170 versus 2853 km to Yucca Mountain). As shown in the table, many parameters have changed over the years and the technical bases for them have improved. For example, the work of Griego et al. (1996) has improved the basis for assumptions about stop times and persons exposed at truck stops, and the TRAGIS computer code has improved the basis for shipping distances and population distributions along highway routes.

The incident-free impacts at truck stops shown in the table have been adjusted, as discussed above, to reflect more realistic conditions than assumed in the bounding analysis. Adjustments were not made to the onlookers, along route, and crew doses shown in Table G-7. As shown, the adjusted doses in Table G-8 for spent fuel shipments to the proposed Yucca Mountain Repository are about a factor of two lower than the per-shipment doses from NUREG-0170 when the doses to and doses associated with in-transit storage from NUREG-0170 are excluded. Storage doses were excluded from this analysis because spent fuel shipments proceed directly from the reactor site to Yucca Mountain with no intermediate storage involved.

Table G-8. Comparison of Incident-Free Doses from NUREG-0170 (NRC 1977) Spent Fuel Shipments and Spent Fuel Shipment from a Similar Distance to the Proposed High-Level Waste Repository at Yucca Mountain

Incident-Free Exposure Parameter	NUREG-0170 (NRC 1977)	Shipment to Yucca Mountain
One-way shipping distance, km	2530	2853
Travel fraction		
Urban	0.05	0.02
Suburban	0.05	0.12
Rural	0.9	0.86
Population density along highway, persons per km^2		
Urban	3861	2391.3
Suburban	719	310.2
Rural	6	9.1
Speed, km/hr		
Urban	24	88
Suburban	40	88
Rural	88	88
Traffic count, vehicles/hr		
Urban	2800	2400
Suburban	780	760
Rural	470	530
Shipment dose Rate, mSv/hr at 2m	0.1	0.1
Crew dose rate, mSv/hr	0.02	Calculated (7.4 m from package)
Stop time, hr per trip		
Urban	2	3 hours per trip (30 minutes per 4 hours driving time)
Suburban	5	
Rural	1	
Population density at stops (per km^2)		
Urban	3861	Distribution: 1 to 10 m - 30,000; 10 to 800 m - 340 (see Figure G-1)
Suburban	719	
Rural	6	
Person-Sv/shipment		
Crew	1.2×10^{-3}	4.8×10^{-4}
Off-link	1.5×10^{-4}	3.1×10^{-4}
On-link	7.4×10^{-5}	1.7×10^{-4}
Stops	1.9×10^{-4}	1.7×10^{-4}[(a)]
Total	1.6×10^{-3}	8.5×10^{-4}
Handlers + Storage	2.1×10^{-3}	Not calculated
Grand Total	**3.7×10^{-3}**	**8.5×10^{-4}**

(a) Stop doses have been adjusted as described in the text to reflect more realistic assumptions than were used in the bounding analysis (Table G-7).

Handler doses were excluded from this analysis because doses to workers who load the spent fuel cask at reactors and unload them at the proposed repository are treated as facility doses, not transportation doses.

G.2.2 Transportation Accident Impacts

RADTRAN 5 assesses accident risk by calculating a risk value, which is the product of the probabilities and consequences of accidents. RADTRAN 5 considers a spectrum of potential transportation accidents, ranging from those with high frequencies and low consequences (e.g., “fender-benders”) to those with low frequencies and high consequences (e.g., accidents in which the shipping container is exposed to severe mechanical and thermal conditions).

Radionuclide inventories are important parameters in the calculation of accident risks. The radionuclide inventories used in this analysis were taken directly from the *Early Site Permit Environmental Report Sections and Supporting Documentation* (INEEL 2003). The report included hundreds of radionuclides for each advanced reactor type. A screening analysis was conducted to select the dominant contributors to accident risks to simplify the RADTRAN 5 calculations. The screening identifies the radionuclides that will contribute more than 99.999 percent of the dose from inhalation.

A sum-of-fractions approach was used for this screening. First, the inventory of each radionuclide was multiplied by its respective inhalation dose conversion factor, taken from Federal Guidance Report 13 (EPA 2002).[a] These values were then summed. Then, each inventory-conversion factor product was divided by the sum of the products to obtain the fraction of the total inhalation dose for each radionuclide. The resulting fractions were then sorted from largest to smallest, their cumulative contributions were calculated, and those that contributed to 99.999 percent of the inhalation-dose potential were selected. Two gases, krypton-85 and iodine-129, were added to the list because they are more easily released than the solid and semi-volatile species contained in the fuel.

The inventories of radionuclides used in this study are shown in Table G-9. Note that the list of radionuclides provided in the table includes all of the radionuclides that were included in the analysis conducted by Sprung et al. (2000), which validates the screening process used in this EIS. Also note that INEEL (2003) did not provide radionuclide source terms for radioactive material deposited on the external surfaces of LWR spent fuel rods, which is commonly referred to as “crud.” In addition, data on activation products was provided for only the ABWR. The ABWR spent fuel transportation risks were calculated assuming the entire Co-60 inventory is in the form of crud. This is very conservative as the source term used here is about two orders of

(a) Inhalation dose factors were used because inhalation is the dominant dose pathway based on information in NUREG-0170 (NRC 1977) and Sprung et al. (2000).

magnitude greater than that given in Sprung et al. (2000). Because crud is deposited from corrosion products generated elsewhere in the reactor cooling system and the complete reactor design and operating parameters are uncertain, the quantities and characteristics of crud deposited on advanced reactor spent fuel are unknown at this time. Consequently, the impacts of crud and activation products on spent fuel transportation accident risks will need to be examined at the CP or COL stage.

Table G-9 shows that the dominant radionuclides are approximately the same regardless of fuel type. The table does not show radionuclide inventory data for the ACR-700 and IRIS advanced reactors, as those were not given in INEEL (2003). Nor were they provided in WASH-1238 (AEC 1972) for the reference LWR. Consequently, accident risks were not quantified for these reactor types.

Robust shipping casks are used to transport spent fuel because of the heavy radiation shielding and accident resistance required by 10 CFR Part 71. Spent fuel shipping casks must be certified Type B packaging systems, which means they must withstand a series of severe hypothetical accident conditions with essentially no loss of containment or shielding capability. These casks are also designed with fissile material controls to ensure that the spent fuel remains subcritical under both normal and accident conditions. The tests include a 9-m (30-ft) free drop onto an unyielding surface, a drop onto a puncture probe, an exposure to an engulfing 800°C fire for 30 minutes, and an underwater immersion. According to Sprung et al. (2000), the probability of encountering accident conditions more severe than these tests that could lead to shipping cask failure are less than 0.01 percent of all accidents (i.e., more than 99.99 percent of all accidents would not result in a release of radioactive material from the shipping cask). It was assumed that shipping casks for advanced reactor spent fuels will provide equivalent mechanical and thermal protection of the spent fuel cargo.

The RADTRAN 5 accident risk calculations were performed using unit radionuclide inventories (Bq/MTU) for the spent fuel shipments from the various reactor types. The resulting risk estimates were then multiplied by assumed annual spent fuel shipments (MTU/yr) to derive estimates of the annual accident risks associated with spent fuel shipments from each potential ESP site. As was done for routine exposures, it was assumed that the numbers of shipments of spent fuel per year are equivalent to the annual discharge quantities: 32.76 MTU/yr for the ABWR and surrogate ESBWR; 24.4 MTU/yr for a single-reactor surrogate AP1000 site; 6.8 MTU/yr for the four-reactor GT MHR site; and 8.3 MTU/yr for the eight-reactor PBMR site. These data were taken from INEEL (2003) and have not been normalized to the reference LWR net electrical generation.

Route-specific accident rates (accidents per km) were derived for the RADTRAN 5 accident risk analysis. The approach used to develop accident rates for spent fuel shipments is as follows. The TRAGIS data provide estimates of the distance traveled in each state along a route and the type of highway (interstate, state highway, or other). Saricks and Tompkins (1999) provide

Table G-9. Radionuclide Inventories Used in Transportation Accident Risk Calculations for Each Advanced Reactor Type, Bq/MTU[a]

Radionuclide	ABWR Inventory, Bq/MTU	Surrogate ESBWR Inventory[b], Bq/MTU	Surrogate AP1000 Inventory, Bq/MTU	GT-MHR Inventory, Bq/MTU	PBMR Inventory, Bq/MTU
Am-241	4.96×10^{13}	4.81×10^{13}	2.69×10^{13}	8.18×10^{13}	7.55×10^{13}
Am-242m	1.24×10^{12}	1.02×10^{12}	4.85×10^{11}	5.03×10^{11}	8.51×10^{11}
Am-243	1.20×10^{12}	1.21×10^{12}	1.24×10^{12}	5.14×10^{11}	4.77×10^{12}
Ce-144	4.22×10^{14}	5.00×10^{14}	3.28×10^{14}	2.15×10^{15}	1.19×10^{15}
Cm-242	2.04×10^{12}	1.80×10^{12}	1.05×10^{12}	1.51×10^{12}	2.78×10^{12}
Cm-243	1.37×10^{12}	1.28×10^{12}	1.14×10^{12}	2.02×10^{11}	1.96×10^{12}
Cm-244	1.80×10^{14}	1.84×10^{14}	2.87×10^{14}	2.83×10^{13}	5.48×10^{14}
Cm-245	2.43×10^{10}	2.50×10^{10}	4.48×10^{10}	1.65×10^{8}	5.29×10^{10}
Co-60[a]	1.01×10^{14}	1.06×10^{14}	(c)	(c)	(c)
Cs-134	1.78×10^{15}	1.92×10^{15}	1.78×10^{15}	2.21×10^{15}	4.03×10^{15}
Cs-137	4.59×10^{15}	4.70×10^{15}	3.44×10^{15}	1.08×10^{16}	1.41×10^{16}
Eu-154	3.81×10^{14}	3.90×10^{14}	3.38×10^{14}	3.23×10^{14}	3.74×10^{14}
Eu-155	1.93×10^{14}	2.00×10^{14}	1.71×10^{14}	8.77×10^{13}	1.08×10^{14}
Pm-147	1.25×10^{15}	1.31×10^{15}	6.51×10^{14}	6.92×10^{15}	5.07×10^{15}
Pu-238	2.27×10^{14}	2.28×10^{14}	2.25×10^{14}	1.17×10^{14}	4.55×10^{14}
Pu-239	1.43×10^{13}	1.43×10^{13}	9.44×10^{12}	2.25×10^{13}	1.11×10^{13}
Pu-240	2.28×10^{13}	2.30×10^{13}	2.01×10^{13}	3.96×10^{13}	3.32×10^{13}
Pu-241	4.51×10^{15}	4.51×10^{15}	2.58×10^{15}	8.33×10^{15}	7.18×10^{15}
Pu-242	8.29×10^{10}	8.29×10^{10}	6.73×10^{10}	1.56×10^{11}	4.51×10^{11}
Ru-106	6.07×10^{14}	6.88×10^{14}	5.74×10^{14}	1.48×10^{15}	1.68×10^{15}
Sb-125	1.99×10^{14}	2.14×10^{14}	1.42×10^{14}	2.21×10^{14}	2.51×10^{14}
Sr-90	3.27×10^{15}	3.36×10^{15}	2.29×10^{15}	8.95×10^{15}	1.08×10^{16}
Y-90	3.27×10^{15}	3.36×10^{15}	2.29×10^{15}	8.95×10^{15}	1.08×10^{16}

(a) To convert Bq/MTU to Ci/MTU, divide the value by 3.7×10^{10} Bq/Ci.
(b) The source of the spent fuel inventories is INEEL (2003) except for the surrogate ESBWR inventories, which were taken from Dominion (2006b). The surrogate ESBWR inventories reflect the increased core thermal power assumed in Dominion (2006a).
(c) Cobalt-60 is an activation product. Only the ABWR/ESBWR submittal in INEEL (2003) provided inventory data for activation products; it was scaled up for the surrogate ESBWR.

accident rates for each state that are a function of highway type. The approach taken to estimate route-specific accident rates was to multiply the state-level accident or fatality rates by the distances traveled in each state on the corresponding highway type and then sum over all the states on each route. For example, for interstate highways, the interstate distances and interstate accident rates were used. For non-interstate highway travel, either the “Primary” or “Other” accident rates given by Saricks and Tompkins (1999) were used. This approach allowed computation of route-specific accident rates.

Transportation accident risk analysis in RADTRAN 5 is performed using an accident severity and package release model. The user can define up to 30 severity categories, with each category increasing in magnitude. Severity categories are related to fire, puncture, crush, and immersion environments created in vehicular accidents. For this analysis, the 19 severity categories defined by Sprung et al. (2000) were adopted.

Each severity category has an assigned conditional probability (or the probability, given an accident occurs, that it will be of the specified severity). The accident scenarios are further defined by allowing the user to input release fractions and aerosol and respirable fractions for each severity category. These fractions are a function of the physical-chemical properties of the materials being transported as well as the mechanical and thermal accident conditions that define the severity categories. The severity categories and release fractions used here are presented in Table G-10.

The severity categories and release fractions published by Sprung et al. (2000) were designed specifically to address accidents involving current generation LWR fuel and the current generation of spent fuel shipping casks. While some of the advanced reactor fuel designs are similar to current-generation reactor fuel designs (e.g., the ABWR, surrogate ESBWR, Surrogate AP1000, ACR-700, and IRIS), others are significantly different, including the GT-MHR and PBMR. Extrapolating the current generation of LWR fuel and shipping casks to advanced LWR fuels and shipping casks is expected to be relatively straightforward because the fuel form, cladding, and physical and mechanical properties are similar. Furthermore, substantial experimental data exist to develop technically defensible release fractions for various radionuclide groups (e.g., gases, semi-volatiles such as cesium and ruthenium, and particulates). However, because detailed experimental studies of releases from GT-MHR and PBMR fuels have not been conducted, there are significant uncertainties about potential release quantities from these fuels.

For this assessment, release fractions for current generation LWR fuels were used to approximate the impacts from the advanced reactor spent fuel shipments. This essentially assumes that the behavior of the fuel materials and containment systems (i.e., cladding, fuel coatings) is similar to that of current LWR fuel under applied mechanical and thermal conditions. Because of the lack of experimental data on gas-cooled reactor fuels, it is currently not known if this approach is bounding. However, gas-cooled reactors operate at much higher temperatures than LWRs; thus, high-temperature conditions anticipated in transportation accident fires are expected to have less effect on radionuclide releases than they would for LWR fuels. Consequently, smaller release fractions are anticipated for advanced gas-cooled reactor fuels than for LWR fuels subjected to thermal transients.

For accidents that result in a release of radioactive material, RADTRAN 5 assumes the material is dispersed into the environment according to standard Gaussian diffusion models. The code allows the user to choose two different methods for modeling the atmospheric transport of

Table G-10. Severity and Release Fractions Used to Model Spent Fuel Transportation Accidents (Sprung et al. 2000)

		Release Fractions[a]				
Severity Category	**Severity Fraction[b]**	**Gas**	**Cesium**	**Ruthenium**	**Particulates**	**Corrosion Products**
1	1.53×10^{-8}	0.8	2.4×10^{-8}	6.0×10^{-7}	6.0×10^{-7}	2.0×10^{-3}
2	5.88×10^{-5}	0.14	4.1×10^{-9}	1.0×10^{-7}	1.0×10^{-7}	1.4×10^{-3}
3	1.81×10^{-6}	0.18	5.4×10^{-9}	1.3×10^{-7}	1.3×10^{-7}	1.8×10^{-3}
4	7.49×10^{-8}	0.84	3.6×10^{-5}	3.8×10^{-6}	3.8×10^{-6}	3.2×10^{-3}
5	4.65×10^{-7}	0.43	1.3×10^{-8}	3.2×10^{-7}	3.2×10^{-7}	1.8×10^{-3}
6	3.31×10^{-9}	0.49	1.5×10^{-8}	3.7×10^{-7}	3.7×10^{-7}	2.1×10^{-3}
7	0[c]	0.85	2.7×10^{-5}	2.1×10^{-6}	2.1×10^{-6}	3.1×10^{-3}
8	1.13×10^{-8}	0.82	2.4×10^{-8}	6.1×10^{-7}	6.1×10^{-7}	2.0×10^{-2}
9	8.03×10^{-11}	0.89	2.7×10^{-8}	6.7×10^{-7}	6.7×10^{-7}	2.2×10^{-3}
10	0[c]	0.91	5.9×10^{-6}	6.8×10^{-7}	6.8×10^{-7}	2.5×10^{-3}
11	1.44×10^{-10}	0.82	2.4×10^{-8}	6.1×10^{-7}	6.1×10^{-7}	2.0×10^{-3}
12	1.02×10^{-12}	0.89	2.7×10^{-8}	6.7×10^{-7}	6.7×10^{-7}	2.2×10^{-3}
13	0[c]	0.91	5.9×10^{-6}	6.8×10^{-7}	6.8×10^{-7}	2.5×10^{-3}
14	7.49×10^{-11}	0.84	9.6×10^{-5}	8.4×10^{-5}	1.8×10^{-5}	6.4×10^{-3}
15	0[c]	0.85	5.5×10^{-5}	5.0×10^{-5}	9.0×10^{-6}	5.9×10^{-3}
16	0[c]	0.91	5.9×10^{-6}	6.4×10^{-6}	6.8×10^{-7}	3.3×10^{-3}
17	0[c]	0.91	5.9×10^{-6}	6.4×10^{-6}	6.8×10^{-7}	3.3×10^{-3}
18	5.86×10^{-6}	0.84	1.7×10^{-5}	6.7×10^{-8}	6.7×10^{-8}	2.5×10^{-3}
19	0.99993	0	0	0	0	0

(a) RADTRAN 5 also models the fraction of the released particulate material that is small enough to be dispersible in prevailing wind conditions and the fraction that is respirable. For this analysis, these parameters were set to 1.0 (i.e., 100 percent dispersible and 100 percent respirable).

(b) Severity fractions are the conditional probabilities, given the occurrence of an accident, that the mechanical and thermal conditions experienced by a spent fuel shipping cask are within the conditions defined by the Severity Category. See Sprung et al. (2000) for detailed information about the derivation of these data. Generic steel-depleted uranium-steel cask designs were assumed for the severity fractions.

(c) The “0" values for certain severity fractions indicate the conditional probability of an accident that results in the mechanical and thermal accident conditions defined by the severity category is 0.0. The severity categories with “0" values were retained in the table for consistency with the source document (i.e., Sprung et al. 2000).

radionuclides after a potential accident. The user can input either Pasquill atmospheric-stability category data or averaged time-integrated concentrations. In this analysis, the default standard cloud option (using time-integrated concentrations) was used.

RADTRAN 5 was used to calculate the population dose from the released radioactive material for four of five[a] possible exposure pathways:

- External dose from exposure to the passing cloud of radioactive material (cloudshine).
- External dose from radionuclides deposited on the ground by the passing plume (groundshine). The analysis included the radiation exposures from this pathway even though the area surrounding a potential accidental release would be evacuated and decontaminated, thus preventing long-term exposures from this pathway.
- Internal dose from inhalation of airborne radioactive contaminants (inhalation).
- Internal dose from radioactive materials that were deposited on the ground and then resuspended (resuspension). The analysis included the radiation exposures from this pathway even though evacuation and decontamination of the area surrounding a potential accidental release would prevent long-term exposures.

A sixth pathway, external doses arising from increased radiation fields surrounding a shipping cask with damaged shielding, was considered but not included in the analysis. It is possible that shielding materials incorporated into the cask structures could become damaged as a result of an accident. For example, casks with lead shielding could undergo a slumping phenomenon in which impact or fire causes gaps to form in the lead. Radiation would penetrate through the gaps in the shielding at higher intensities, leading to higher radiation dose rates. These events, which are commonly referred to as “loss of shielding events,” were not included in this assessment because their contribution to spent fuel transportation risks is much smaller than the dispersal accident risks.

Standard radionuclide uptake and dosimetry models are incorporated into RADTRAN 5. The computer code combines the accident consequences and frequencies of each severity category, sums up the severity categories, and then integrates across all the shipments. Accident-risk impacts are provided in the form of a collective population dose (person-rem over the entire shipping campaign).

The shipping distances and population distribution information for the routes used for the evaluation of the impacts of incident-free transportation (see Table G-4) were also used to calculate transportation impacts. Representative shipping casks described above were assumed.

Table G-11 presents unit (per MTU) accident risks associated with transportation of spent fuel from each potential ESP site to the proposed Yucca Mountain Repository.

(a) The internal dose from ingestion of contaminated food was not considered, as the staff assumed evacuation and subsequent interdiction of foodstuffs following a potential transportation accident.

Table G-11. Unit Spent Fuel Transportation Accident Risks for Advanced Reactors

Site	Advanced Reactor Type				
	ABWR	Surrogate ESBWR	Surrogate AP1000	GT-MHR	PBMR
Population Dose, person-Sv/MTU[a]					
North Anna	2.3×10^{-7}	2.4×10^{-7}	2.1×10^{-8}	3.2×10^{-8}	5.4×10^{-8}
Portsmouth	2.3×10^{-7}	2.4×10^{-7}	2.1×10^{-8}	3.1×10^{-8}	5.2×10^{-8}
Savannah River	2.6×10^{-7}	2.8×10^{-7}	2.4×10^{-8}	3.6×10^{-8}	6.1×10^{-8}
Surry	2.4×10^{-7}	2.5×10^{-7}	2.2×10^{-8}	3.3×10^{-8}	5.6×10^{-8}

(a) To convert to person-rem, multiply person-Sv by 100.

Projected annual accident risks are presented in Table G-12. As expected, accident risks are highest for the longest shipments. Also, consistent with past spent fuel transportation risk assessments, the accident impacts are several orders of magnitude lower than routine impacts.

Considering the small magnitude of the risks presented in Table G-12 and the conservative computational methods and data used to address uncertainties, the overall transportation accident risks associated with ABWR, surrogate ESBWR, Surrogate AP1000, GT-MHR, and PBMR spent fuel shipments are judged to be small. Although likely to also be small, accident risks associated with IRIS and ACR-700 spent fuel shipments could not be analyzed because of the lack of radionuclide source-term data. Additional analyses are necessary to quantify the impacts of IRIS and ACR-700 spent fuel shipments.

Table G-12 presents the environmental risks of transportation accidents when shipping spent fuel from the proposed ESP sites and alternative sites to the proposed Yucca Mountain Repository. The shipping distances and population distribution information for the routes were the same as those used for the normal “incident-free” conditions. The table presents estimates of population dose (person-Sv/reference reactor year) for several of the advanced reactor designs.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 100 mSv (10,000 mrem), and low dose rates. However, radiation protection experts conservatively assume that any amount of radiation exposure may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response model is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the BEIR VII report (National Research Council 2005), supports the linear, no-threshold dose response theory. This theory states that any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative

Table G-12. Annual Spent Fuel Transportation Accident Impacts for Advanced Reactors, Normalized to Reference LWR Net Electrical Generation

	Advanced Reactor Type				
	ABWR	Surrogate ESBWR	Surrogate AP1000	GT-MHR	PBMR
MTU/reference reactor year	**20.3**	**20.3**	**19.7**	**6.0**	**5.8**
Population Dose, person-Sv/per reference reactor year[(a)]					
North Anna	4.7×10^{-6}	5.0×10^{-6}	4.2×10^{-7}	1.9×10^{-7}	3.1×10^{-7}
Portsmouth	5.2×10^{-6}	5.5×10^{-6}	4.0×10^{-7}	1.8×10^{-7}	3.0×10^{-7}
Savannah River	5.3×10^{-6}	5.6×10^{-6}	4.7×10^{-7}	2.2×10^{-7}	3.5×10^{-7}
Surry	4.9×10^{-6}	5.1×10^{-6}	4.3×10^{-7}	2.0×10^{-7}	3.2×10^{-7}

(a) Multiply person-Sv/reference reactor year times 100 to obtain doses in person-rem/reference reactor year.

model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks.

Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 person-Sv [1,000,000 person-rem]) from ICRP Publication 60 (ICRP 1991). All the population doses presented in Table G-12 are less than 1.0×10^{-5} person-Sv (1.0×10^{-3} person-rem) per year; therefore, the total detriment estimates associated with these population doses would all be less than 1.0×10^{-6} fatal cancers, nonfatal cancers, and severe hereditary effects per year. These risks are quite small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would be expected to occur annually in the same population from exposure to natural sources of radiation using the same risk model.

G.3 Shipment of Radioactive Waste

This section discusses the environmental effects of transporting radioactive waste from advanced reactor sites. The environmental conditions listed in 10 CFR 51.52 that apply to shipments of radioactive waste are as follows:

- radioactive waste (except spent fuel) is packaged and in a solid form [51.52(a)(4)]
- radioactive waste (except spent fuel) is shipped from the reactor by truck or rail [51.52(a)(5)].

INEEL (2003) indicates that all of the advanced reactors will transport their radioactive waste by truck. Furthermore, INEEL (2003) indicates that all of the advanced reactors plan to solidify and package their radioactive waste. In addition, all of the advanced reactors will be subject to NRC (10 CFR Part 71) and U.S. Department of Transportation regulations for the shipment of radioactive material (49 CFR Parts 171, 172, 173, and 178).

Table S–4 also specifies the following conditions that apply to shipments of radioactive waste:

- weight – less than 33,000 kg (73,000 lb) per truck or 100 tons per cask per rail car
- traffic density – less than one truck shipment per day or three rail cars per month.

The advanced reactors are assumed to be capable of shipping their radioactive wastes in compliance with Federal or State weight restrictions. With respect to the traffic density, all of the advanced reactor vendors provided radioactive waste generation estimates. Table G-13 provides these estimates, in addition to the radioactive waste generation estimates for the reference LWR in WASH-1238 (AEC 1972).

Table G-13. Summary of Radioactive Waste Shipments for Advanced Reactors

Reactor Type	INEEL (2003) Waste Generation Information	Annual Waste Volume, m^3/yr per Unit	Electrical Output, MW(e) per Unit	Normalized Rate, m^3/1100 MW(e) Unit (880 MW(e) Net)[(a)]	Shipments/ 1100 MW(e) (880 MW(e) Net) Electrical Output[(b)]
Reference LWR (WASH-1238)	100 m^3/yr per unit	108	1100	108	46
ABWR	100 m^3/yr per unit	100	1500	62	27
Surrogate ESBWR	100 m^3/yr[(c)] per unit	100	1520[(d)]	60	26
Surrogate AP1000	55 m^3/yr per unit	56	1150	45	20
ACR-700	47.5 m^3/yr per unit	47.5	731	64	28
IRIS	25 m^3/yr per modules	74 (3 modules)	1005 (3 modules)	67	29
GT-MHR	98 m^3/yr (4 module Plant)	98 (4 modules)	1140 (4 modules)	86	37[(e)]
PBMR	100 drums/yr per modules	168 (8 modules)	1320 (8 modules)	118	51[(e)]

Conversions: 1 m^3 = 35.31 ft^3. Drum volume = 210 liters (0.21 m^3).

(a) Capacity factors used to normalize the waste generation rates to an equivalent electrical generation output are given in Table 6-3 for each reactor type. All are normalized to 880 MW(e) net electrical output (1100-MW(e) unit with an 80 percent capacity factor).

(b) The number of shipments per 1100 MW(e) was calculated assuming the WASH-1238 average waste shipment capacity of 2.34 m^3 per shipment (108 m^3/yr divided by 46 shipments/yr).

(c) Dominion indicated in its May 24, 2006 response to RAIs that no change is anticipated in the volume of radioactive waste produced (Dominion 2006b). The quantity of radioactive waste generated is more closely related to Dominion's operational practices than the reactor's power output. The staff concludes that increases in solid radioactive waste generation estimates for the surrogate ESBWR, if any, would be small and that any increase would be within the range of uncertainty of the waste generation estimates.

(d) Dominion 2006a

(e) The applicant states in INEEL (2003) that 90 percent of the waste could be shipped on trucks carrying 28 m^3 (1000 ft^3) of waste and the remaining 10 percent in shipments carrying 5.7 m^3 (200 ft^3) of radioactive waste. This would result in six to seven shipments per year after normalization to the reference LWR electrical output.

As shown in the table, only the PBMR generates a larger volume of radioactive waste than the reference LWR in WASH-1238. However, the GT-MHR and PBMR information in INEEL (2003) assumed these advanced reactors would ship wastes using two different packaging systems: one that hauls 28.3 m^3/shipment (1000 ft^3 per shipment) and one that hauls 5.7 m^3/shipment (200 ft^3/per shipment). Under those conditions, the number of shipments of radioactive waste per year, normalized to 1100 MW(e) electric generation capacity, would be about six shipments/year per 1100 MW(e) (880 net MW(e)) for the GT-MHR and seven shipments/year per 1100 MW(e) for the PBMR. These estimates are well below the reference LWR (42 shipments per 1100 MW(e)). In any event, all the estimates are well below the one truck shipment per day condition given in 10 CFR 51.52(c), Table S–4. Doubling the shipment estimates to account for empty return shipments is still well below the one shipment per day condition.

G.4 References

10 CFR Part 51. Code of Federal Regulations. Title 10, *Energy,* Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 71. Code of Federal Regulations. Title 10, *Energy*, "Packaging and Transportation of Radioactive Material."

49 CFR Part 171. Code of Federal Regulations. Title 49, *Transportation*, Part 171, "General Information, Regulations, and Definitions."

49 CFR Part 172. Code of Federal Regulations. Title 49, *Transportation*, Part 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements."

49 CFR Part 173. Code of Federal Regulations. Title 49, *Transportation,* Part 173, "Shippers - General Requirements for Shipments and Packagings."

49 CFR Part 178. Code of Federal Regulations. Title 49, *Transportation,* Part 178, "Specifications for Packagings."

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Appendix H

Supporting Documentation on Radiological Dose Assessment

Appendix H

Supporting Documentation on Radiological Dose Assessment

The staff performed an independent dose assessment on the radiological impacts of normal operation for new nuclear units at the Dominion Nuclear North Anna, LLC (Dominion) early site permit (ESP) site. The results of this assessment are presented in this appendix and are compared to the results from Dominion found in Section 5.9 (Radiological Health Impacts). The appendix is divided into three sections: (1) H.1 – Dose Estimates to the Public from Liquid Effluents, (2) H.2 – Dose Estimates to the Public from Gaseous Effluents, and (3) H.3 – Dose Estimates to the Biota from Liquid and Gaseous Effluents. Additional supporting documentation on the staff's independent radiological dose assessment to include the computer runs is available through ADAMS (NRC 2006).

To facilitate comparison with Dominion's estimates, all doses and radioactivity levels are reported in millirem (mrem) and curies (Ci), respectively.

H.1 Dose Estimates to the Public from Liquid Effluents

To estimate doses to the maximally exposed individual (MEI) and the population from the liquid effluent pathway, the staff used the LADTAP II code (Strenge et al. 1986) and input parameters supplied by Dominion as part of their ESP Environmental Report (ER) (Dominion 2006).

H.1.1 Scope

Doses to the MEI were calculated for the following:

- *Total Body* – Dose was the total from all pathways (i.e., drinking water, fish consumption, shoreline usage, swimming exposure, and boating) with the highest value for either the adult, teen, child, or infant compared to the 0.03 mSv/yr (3 mrem/yr) per reactor design objective in Title 10 of the Code of Federal Regulations (CFR) Part 50, Appendix I.

- *Organ* – Dose was the total for each organ from all pathways (i.e., drinking water, fish consumption, shoreline usage, swimming exposure, and boating) with the highest value for either the adult, teen, child, or infant compared to the 0.1 mSv/yr (10 mrem/yr) per reactor design objective in 10 CFR Part 50, Appendix I.

The values of input parameters used by Dominion were reviewed by the staff and determined to be appropriate to use as inputs into the LADTAP II code for its independent calculation. Default values from Regulatory Guide 1.109 (NRC 1977) were used when input parameters were not available.

H.1.2 Resources Used

The staff used a version of the LADTAP II code entitled NRCDOSE version 2.3.4 (Bland 2000), obtained through the Oak Ridge Radiation Safety Information Computational Center (RSICC) to calculate doses to the public from liquid effluents.

H.1.3 Input Parameters

Table H-1 provides a listing of the major parameters used by the staff in calculating dose to the public from liquid effluent releases during normal operation. Table H-2 lists the liquid effluent releases used by the staff in calculating dose to the public from one ESP unit. This table is the same as Table 5.4-6 of Dominion (2006).

In latest revision to the Dominion ER (Dominion 2006), the tritium release was revised from 3100 Ci/yr per unit to 850 Ci/yr per unit. The basis for this change was the potential for the 3100 Ci/yr per unit tritium release rate to result in concentrations in Lake Anna exceeding the Environmental Protection Agency drinking water standard of 20,000 pCi/L found in 40 CFR Part 141. As discussed in Section H.3.3, the revised tritium release rate of 850 Ci/yr per unit would result in an estimated tritium concentration in Lake Anna of 9417 pCi/L which is well below EPA's drinking water standard for tritium of 20,000 pCi/L found in 40 CFR Part 141.

Table H-1. Parameters Used in Calculating Dose to Public from Liquid Effluent Releases

Parameter	Staff Value	Comments
Source term (Ci/yr)[(a)]	Table 5.4-6 of the ER (Dominion 2006)	Table 5.4-6 of Dominion (2006) represents the bounding liquid effluent source term based on the plant parameter envelope approach.
Discharge flow rate m^3/s (gpm)	0.0062 (100)	Site-specific value from Table 5.4-1 of the ER (Dominion 2006).
Source term multiplier	1	Site-specific value from the ER (Dominion 2006).
Site type	Fresh water	Site-specific value from the ER (Dominion 2006).
Reconcentration model	None	Table 5.4-1 of the ER (Dominion 2006).
Effluent discharge rate from impoundment system to receiving water body	N/A	Not applicable because reconcentration was not assumed
Impoundment total volume	N/A	Not applicable because reconcentration was not assumed

Table H-1. (contd)

Parameter	Staff Value	Comments
Shore width factor	0.3	Value from Regulatory Guide 1.109 (NRC 1977).
Dilution factors for aquatic food and boating, shoreline and swimming, and drinking water	1000	Site-specific value from the ER (Dominion 2006). The dilution factor of 1000 is based on a plant effluent discharge rate of 0.0062 m^3/s (100 gpm) with a dilution flow of 0.62 m^3/s (100,000 gpm) per Table 5.4-1 of ER (Dominion 2006).
Transit time (h)	0	Site-specific value from Table 5.4-1 of the ER (Dominion 2006). The value is conservative.
Consumption and usage factors for adult, teen, children, and infant	Values from Table 5.4-2 of the ER (Dominion 2006)	Values were the default values from Regulatory Guide 1.109 (NRC 1977).
Population supplied by drinking water (population)	22,100	Site-specific value provided by Dominion (Dominion 2004a).
Dilution factor for water intake locations, shoreline exposure location, swimming usage location, and boating usage location (population)	1000	Site-specific value from the ER (Dominion 2006). The dilution factor of 1000 is based on a plant effluent discharge rate of 0.0062 m^3/s (100 gpm) with a dilution flow of 0.62 m^3/s (100,000 gpm) per Table 5.4-1 of ER (Dominion 2006).
Total shoreline usage time (person-hours/year) (population)	1.31×10^6	Site-specific value provided by Dominion (Dominion 2004a).
Total exposure time for swimming usage location (person-hours/year) (population)	8.76×10^5	Site-specific value provided by Dominion (Dominion 2004a).
Total exposure time for boating activities (person-hours/year) (population)	2.19×10^6	Site-specific value provided by Dominion (Dominion 2004a).

(a) To convert Ci/yr to Bq/yr, multiply the value by 3.7×10^{10}.

Table H-2. Liquid Effluent Release Source Terms from the ER on a Per Unit Basis (Dominion 2006)[a,b]

Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)
C-14	4.4×10^{-4}	Rb-88	2.7×10^{-4}	Rh-103m	4.9×10^{-3}	Cs-138	2.1×10^{-4}
Na-24	3.5×10^{-3}	Rb-89	4.8×10^{-5}	Rh-106	7.4×10^{-2}	Ba-137m	1.2×10^{-2}
P-32	6.6×10^{-4}	Sr-89	3.6×10^{-4}	Ag-110m	1.1×10^{-3}	Ba-139	2.5×10^{-5}
Cr-51	2.1×10^{-2}	Sr-90	3.8×10^{-5}	Ag-110	1.4×10^{-4}	Ba-140	5.5×10^{-3}
Mn-54	2.8×10^{-3}	Sr-91	9.8×10^{-4}	Sb-124	6.8×10^{-4}	La-140	7.4×10^{-3}
Mn-56	4.2×10^{-3}	Sr-92	8.8×10^{-4}	Te-129m	1.4×10^{-4}	La-142	2.5×10^{-5}
Fe-55	6.4×10^{-3}	Y-90	3.4×10^{-6}	Te-129	1.5×10^{-4}	Ce-141	1.3×10^{-4}
Fe-59	2.0×10^{-4}	Y-91m	1.0×10^{-5}	Te-131m	1.0×10^{-4}	Ce-143	1.9×10^{-4}
Co-56	5.7×10^{-3}	Y-91	2.4×10^{-4}	Te-131	3.0×10^{-5}	Ce-144	3.2×10^{-3}
Co-57	7.9×10^{-5}	Y-92	6.6×10^{-4}	Te-132	2.4×10^{-4}	Pr-143	1.4×10^{-4}
Co-58	3.4×10^{-3}	Y-93	9.8×10^{-4}	I-131	1.4×10^{-2}	Pr-144	3.2×10^{-3}
Co-60	1.0×10^{-2}	Zr-95	1.0×10^{-3}	I-132	2.8×10^{-3}	W-187	2.1×10^{-4}
Ni-63	1.5×10^{-4}	Nb-95	1.9×10^{-3}	I-133	2.4×10^{-2}	Np-239	1.4×10^{-2}
Cu-64	8.2×10^{-3}	Mo-99	3.9×10^{-3}	I-134	1.9×10^{-3}	Total w/o H-3	3.7×10^{-1}
Zn-65	7.5×10^{-4}	Tc-99m	5.1×10^{-3}	I-135	8.2×10^{-3}	H-3	8.5×10^{2}
Zn-69m	6.0×10^{-4}	Ru-103	4.9×10^{-3}	Cs-134	9.9×10^{-3}		
Br-83	7.5×10^{-5}	Ru-105	1.0×10^{-4}	Cs-136	1.2×10^{-3}		
Br-84	2.0×10^{-5}	Ru-106	7.4×10^{-2}	Cs-137	1.3×10^{-2}		

(a) Table 5.4-6 of Dominion (2006).
(b) To convert from Ci/yr to Bq/yr, multiply the value by 3.7×10^{10}.

H.1.4 Comparison of Results

Table H-3 compares Dominion's results on a per unit basis with those calculated by the staff. Doses calculated were similar.

Table H-3. Comparison of Doses to the Public from Liquid Effluent Releases on a Per Unit Basis

Type of Dose	Applicant's ER (Dominion 2006)[a]	Staff's Calculation[a]	Percentage Difference
Total body (mrem/yr)	0.81 (adult)	0.81 (adult)	0
Organ dose (mrem/yr)	2.5 (child bone)	2.5 (child bone)	0
Thyroid (mrem/yr)	0.68 (infant)	0.69 (infant)	1.5
Population dose from liquid pathway (person-rem)	8.6	8.6	0

(a) To convert mrem/yr to mSv/yr divide by 100.

H.2 Dose Estimates to the Public from Gaseous Effluents (Units 3 and 4)

The gaseous effluents from the proposed ESP reactor units are evaluated in this section. To estimate doses to the maximally exposed individual and to the population within an 80-km (50-mi) radius of the ESP site from these gaseous effluents, the staff used the GASPAR II code (Strenge et al. 1987) and input parameters supplied by Dominion in the ER (Dominion 2006).

H.2.1 Scope

The staff calculated gamma air dose, beta air dose, total body dose, and skin dose from noble gases at the nearest site boundary located 1.4 km (0.88 mi) east-southeast of the North Anna ESP site. Dose to the MEI was also calculated for the following locations:

- nearest site boundary (plume and inhalation)
- nearest residence (plume and inhalation)
- nearest garden (vegetable)nearest meat cow (meat).

MEI doses were not calculated for the nearest dairy cow and goat, within 8 km (5 mi) as specified in NUREG-1555 because as stated in the ER (Dominion 2006), there were no milk cows or goats within 8 km (5 mi) of the proposed ESP units.

The values of input parameters used by Dominion are given in the ER (Dominion 2006) or in a response to a Request for Additional Information (RAI) dated May 17, 2004 (Dominion 2004b). These values were reviewed by the staff and determined to be appropriate to use as input into GASPAR II for its independent calculation. Default values from Regulatory Guide 1.109 (NRC 1977) were used when input parameters were not available.

Population doses were calculated for all types of releases (noble gases, iodine and particulates, and H-3 and C-14) using the GASPAR II code.

H.2.2 Resources Used

The staff used a version of GASPAR II code entitled NRCDOSE, Version 2.3.5 (Bland 2000), obtained through the Oak Ridge RSICC to calculate doses to the public from gaseous effluents.

H.2.3 Input Parameters

Table H-4 provides a listing of the major parameters used in calculating dose to the public from gaseous effluent releases during normal operation. Table H-5 lists the gaseous effluent releases used by the staff in calculating dose to the public. This table is the same as Table 5.4-7 of Dominion (2006).

Table H-4. Parameters Used in Calculating Dose to Public from Gaseous Effluent Releases

Parameter	Staff Value	Comments
Source term for calculating noble gas dose at site boundary and dose to the maximally exposed individual (Ci/yr)[(a)]	Table 5.4-7 of the ER (Dominion 2006)	These are the bounding plant parameter envelope (PPE) values.
Population distribution	2.784×10^6 – from Table 2.5-8 of the ER (Dominion 2006)	Site-specific data provided by Dominion.
Atmospheric dispersion factors (sec/m^3)	Table 2.7-17 to Table 2.7-19 of the ER (Dominion 2006)	Site-specific data provided by Dominion.
Ground deposition factors (m^{-2})	Table 2.7-20 of the ER (Dominion 2006)	Site-specific data provided by Dominion.
Milk production rate within 80 km (50 mi) (L/yr)	7.2×10^8 – Table 5.4-3 of the ER (Dominion 2006)	Site-specific data provided by Dominion.
Meat production rate within 80 km (50 mi) (kg/yr)	1.7×10^9 – Table 5.4-3 of the ER (Dominion 2006)	Site-specific data provided by Dominion.
Vegetable/fruit production rate within 80 km (50 mi) (kg/yr)	5.4×10^8 – Table 5.4-3 of the ER (Dominion 2006)	Site-specific data provided by Dominion.
Pathway receptor locations (direction, distance, and atmospheric dispersion factors): nearest site boundary, vegetable garden, residence, meat animal	Table 5.4-4 and Table 2.7-14 of the ER (Dominion 2006)	Site-specific data provided by Dominion.
Consumption factors for leafy vegetable, meat, milk, and vegetable/fruit	Table 5.4-5 of the ER (Dominion 2006)	Factors taken from Regulatory Guide 1.109 (NRC 1977).
Fraction of year leafy vegetables that are grown	0.5	Site-specific data provided by Dominion.
Fraction of year that milk cows that are on pasture	0.67	Site-specific data provided by Dominion.
Fraction of milk-cow intake that is from pasture while on pasture	1	Default value of GASPAR II code.
Average absolute humidity over the growing season (g/m^3)	8.0	Default value of GASPAR II code.
Average temperature over the growing season (°F)	0	Default value of GASPAR II code.
Fraction of year goats are on pasture	0.75	Site-specific data provided by Dominion.
Fraction of year beef-cattle are on pasture	0.67	Site-specific data provided by Dominion.
Fraction of beef-cattle intake that is from pasture while on pasture	1	Default value of GASPAR II code.

(a) To convert Ci/yr to Bq/yr, multiply the value by 3.7×10^{10}.

Table H-5. Gaseous Effluent Release Source Term from the ER on a Per Unit Basis (Dominion 2006)[a,b]

Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)
H-3	3.5×10^{3}	Kr-85	4.1×10^{3}	Ru-103	3.8×10^{-3}	Xe-135m	7.7×10^{2}
C-14	1.2×10^{1}	Kr-87	4.9×10^{1}	Rh-103m	1.2×10^{-4}	Xe-135	8.2×10^{2}
Na-24	4.4×10^{-3}	Kr-88	7.4×10^{1}	Ru-106	7.8×10^{-5}	Xe-137	9.8×10^{2}
P-32	1.0×10^{-3}	Kr-89	4.7×10^{2}	Rh-106	2.1×10^{-5}	Xe-138	7.8×10^{2}
Ar-41	3.0×10^{2}	Kr-90	4.2×10^{-4}	Ag-110m	2.2×10^{-6}	Xe-139	5.3×10^{-4}
Cr-51	3.8×10^{-2}	Rb-89	4.7×10^{-5}	Sb-124	2.0×10^{-4}	Cs-134	6.8×10^{-3}
Mn-54	5.9×10^{-3}	Sr-89	6.2×10^{-3}	Sb-125	6.1×10^{-5}	Cs-136	6.5×10^{-4}
Mn-56	3.8×10^{-3}	Sr-90	1.2×10^{-3}	Te-129m	2.4×10^{-4}	Cs-137	1.0×10^{-2}
Fe-55	7.1×10^{-3}	Y-90	5.0×10^{-5}	Te-131m	8.3×10^{-5}	Cs-138	1.9×10^{-4}
Co-57	8.2×10^{-6}	Sr-91	1.1×10^{-3}	Te-132	2.1×10^{-5}	Ba-140	3.0×10^{-2}
Co-58	2.3×10^{-2}	Sr-92	8.6×10^{-4}	I-131	5.1×10^{-1}	La-140	2.0×10^{-3}
Co-60	1.4×10^{-2}	Y-91	2.6×10^{-4}	I-132	2.4	Ce-141	1.0×10^{-2}
Fe-59	8.9×10^{-4}	Y-92	6.8×10^{-4}	I-133	1.9	Ce-144	2.1×10^{-5}
Ni-63	7.1×10^{-6}	Y-93	1.2×10^{-3}	I-134	4.1	Pr-144	2.1×10^{-5}
Cu-64	1.1×10^{-2}	Zr-95	1.7×10^{-3}	I-135	2.6	W-187	2.1×10^{-4}
Zn-65	1.2×10^{-2}	Nb-95	9.2×10^{-3}	Xe-131m	1.8×10^{3}	Np-239	1.3×10^{-2}
Kr-83m	1.3×10^{-3}	Mo-99	6.5×10^{-2}	Xe-133m	8.7×10^{1}	Total	1.8×10^{4}
Kr-85m	3.6×10^{1}	Tc-99m	3.3×10^{-4}	Xe-133	4.6×10^{3}		

(a) Table 5.4-7 of the ER (Dominion 2006).
(b) To convert from Ci/yr to Bq/yr, multiply the value by 3.7×10^{10}.

H.2.4 Comparison of Doses to the Public from Gaseous Effluent Releases

Table H-6 compares Dominion's results for doses from noble gases at the site boundary on a per unit basis with the results calculated by the staff. The calculated doses were similar.

Table H-6. Comparison of Doses to the Public from Noble Gas Releases on a Per Unit Basis

Type of Dose	Dominion's ER (Dominion 2006)	Staff's Calculation	Percentage Difference
Gamma air dose at site boundary – (mrad/yr)[a]	3.2	3.2	0
Beta air dose at site boundary – (mrad/yr)[a]	4.8	4.7	-2.1
Skin dose at site boundary – (mrem/yr)[a]	6.2	6.2	0

(a) To convert from mrad/yr or mrem/yr to mGy/yr or mSv/yr, divide by 100.

Table H-7 compares doses to the MEI calculated on a per unit basis by Dominion and the staff. Doses to the MEI were calculated at the nearest site boundary, nearest residence, nearest garden, and nearest meat cow. The calculated doses were similar.

Table H-7. Comparison of Doses to the MEI from Gaseous Effluent Releases on a Per Unit Basis

Location	Pathway	Total Body Dose (mrem/yr)[(a,b)]	Skin Dose (mrem/yr)[(a,b)]	Thyroid Dose (mrem/yr)[(a,b)]
Nearest site boundary (1.4 km [0.88 mi] east-southeast)	Plume	2.1 (2.1)	6.2 (6.2)	(d)
Nearest site boundary (1.4 km [0.88 mi] east-southeast)	<u>Inhalation</u>			
	Adult	0.3 (0.3)	(c)	1.6 (1.6)
	Teen	0.31 (0.3)	(c)	2.0 (2.0)
	Child	0.27 (0.27)	(c)	2.3 (2.3)
	Infant	0.16 (0.16)	(c)	2.0 (2.0)
Nearest garden (1.5 km [0.94 mi] northeast)	<u>Vegetable</u>			
	Adult	0.44 (0.43)	(c)	4.9 (4.9)
	Teen	0.57 (0.57)	(c)	6.6 (6.6)
	Child	1.1 (1.1)	(c)	13.1 (12.6)
Nearest residence (1.5 km [0.96 mi] north-northeast)	Plume	1.4 (1.4)	4.0 (4.0)	(d)
Nearest residence (1.5 km [0.96 mi] north-northeast)	<u>Inhalation</u>			
	Adult	0.2 (0.19)	(c)	1.0 (1.0)
	Teen	0.2 (0.2)	(c)	1.3 (1.3)
	Child	0.18 (0.17)	(c)	1.5 (1.5)
	Infant	0.10 (0.10)	(c)	1.3 (1.3)
Nearest meat cow (2.2 km [1.37 mi] southeast)	<u>Meat</u>			
	Adult	0.067 (0.067)	(c)	0.15 (0.15)
	Teen	0.049 (0.049)	(c)	0.11 (0.11)
	Child	0.079 (0.079)	(c)	0.17 (0.17)

(a) Values in parentheses represent the values that the staff calculated. The Dominion values (those not in parentheses) were taken from Table 5.4-9 of the ER (Dominion 2006).
(b) To convert from mrem/yr to mSv/yr, divide by 100.
(c) Skin dose is not applicable for the inhalation, vegetable, and meat pathways.
(d) Thyroid dose is not applicable for the plume pathway.

H.2.5 Comparison of Results – Population Doses

Table H-8 compares Dominion's population dose estimates on a per unit basis taken from Table 5.4-12 of the ER (Dominion 2006) with the staff's estimate. The calculated doses were similar.

Table H-8. Comparison of Population Doses from Gaseous Effluent Releases on a Per Unit Basis

Pathway	Applicant's Estimate (person-rem/yr)[a]	Staff's Estimate (person-rem/yr)	Percentage Difference
Liquid	8.6	8.6 (see Section H.1.4)	0
Noble gases	3.5	2.8 (plume)	-20
Iodine and particulates	1.4	1.2[b]	-14
H-3 and C-14	14	13.7	-2.1
Total	28	26.3	-6.1

(a) Estimated population dose for one ESP unit (see Table 5.4-12 of the ER) (Dominion 2006).
(b) Dose represents the summation of doses from iodine and particulates.

H.3 Dose Estimates to the Public from Airborne Tritium Releases from Unit 3 Wet Cooling Towers

As discussed in Section 5.9.1, the staff identified another atmospheric release pathway from the proposed new units, the release of tritium to the atmosphere, as water vapor, from the evaporation of cooling water from the Unit 3 wet cooling towers. Lake Anna is used as makeup water for the Unit 3 wet cooling towers (Dominion 2006). As reported in North Anna Station's annual radiological environmental operating reports (VEPCo 2001a-2006a), Lake Anna tritium concentrations are above ambient background levels, but are within the limit specified by the EPA drinking water standard. This section provides an analysis of the dose to the public from this pathway, which would be an addition to the dose estimated from the plant stacks presented in Section H.2.

H.3.1 Scope

The staff calculated dose to the MEI from Unit 3 wet cooling tower releases for the following locations:

- nearest site boundary (plume and inhalation)
- nearest residence (plume and inhalation)
- nearest garden (vegetable)
- nearest meat cow (meat).

MEI doses were not calculated for the nearest dairy cow and goat, within 8 km (5 mi) as specified in NUREG-1555 because as stated in the ER (Dominion 2006), there were no milk cows or goats with 8 km (5 mi) of the proposed ESP site.

Population doses were also calculated.

H.3.2 Resources Used

The staff used a version of GASPAR II code entitled NRCDOSE, Version 2.3.5 (Bland 2000), obtained through the Oak Ridge RSICC to calculate doses to the public from the tritium release from the Unit 3 cooling system.

H.3.3 Input Parameters

The input parameters in Table H-4 were used in this calculation with the exception of the source term. An estimated 216 Ci/yr of tritium was released to the atmosphere. The staff calculated this value by multiplying the average annual tritium concentration (9417 pCi/L) estimated in Lake Anna times the evaporation rate (727 L/s) from the Unit 3 wet cooling towers. Tritium concentration in Lake Anna during the operation of the current units and the proposed ESP units was estimated by summing the average tritium concentration in lake over the past six years (VEPCO 2001a-2006a) and the estimated additional tritium concentration that would result from two new units. The staff reviewed annual effluent monitoring reports for North Anna Units 1 and 2 (VEPCO 2001b-2006b) and annual radiological environmental operating reports (VEPCO 2001a-2006a) for the past six years and determined that the average annual tritium release into the liquid effluents was 814 Ci and the average annual tritium concentration in the lake was 3049 pCi/L. Assuming this same relationship for two new units results in a PPE tritium release activity of 850 Ci/yr per unit or 1700 Ci/yr for the ESP site, the estimated tritium concentration in the lake from two new units would be 6368 pCi/L. Adding this to the existing concentration of 3049 pCi/L, the total tritium concentration in Lake Anna is estimated to be 9417 pCi/L. The evaporation rate used in the staff's water budget model for the Unit 3 closed-cycle, combination wet and dry cooling system in the maximum water conservation mode (727 L/sec) was used in the calculation because it results in greater evaporation on a yearly basis than Dominion's value.

The following additional assumptions were made in this calculation: (1) the release point for the Unit 3 wet cooling tower was assumed to be located at the same location as the new reactor units (the Unit 3 cooling towers would be located just west of the new units, and (2) the atmospheric dispersion factors for releases from the new units were used.

H.3.4 Results

Table H-9 presents the doses to the MEI calculated by the staff from the tritium release from the Unit 3 wet cooling towers. These doses are insignificant when compared to MEI dose from

Table H-9. Dose Estimates to the MEI from Airborne Tritium Releases from New Unit 3 with Closed-Cycle Combination Wet and Dry Cooling Tower System

Location	Pathway	Total Body Dose (mrem/yr)[(a)]	Skin Dose (mrem/yr)[(a)]	Thyroid Dose (mrem/yr)[(a)]
Nearest site boundary (1.4 km [0.88 mi] east-southeast)	Plume	(b)	(b)	(d)
Nearest site boundary (1.4 km [0.88 mi] east-southeast)	Inhalation			
	Adult	0.018	(c)	0.018
	Teen	0.018	(c)	0.018
	Child	0.016	(c)	0.016
	Infant	0.0093	(c)	0.0093
Nearest garden (1.5 km [0.94 mi] northeast)	Vegetable			
	Adult	0.017	(c)	0.017
	Teen	0.020	(c)	0.020
	Child	0.031	(c)	0.031
Nearest residence (1.5 km [0.96 mi] north-northeast)	Plume	(b)	(b)	(d)
Nearest residence (1.5 km [0.96 mi] north-northeast)	Inhalation			
	Adult	0.012	(c)	0.012
	Teen	0.012	(c)	0.012
	Child	0.011	(c)	0.011
	Infant	0.0061	(c)	0.0061
Nearest meat cow (2.2 km [1.37 mi] southeast)	Meat			
	Adult	0.0018	(c)	0.0018
	Teen	0.0011	(c)	0.0011
	Child	0.0013	(c)	0.0013

Note: This type of release considers the presence of tritium in Lake Anna, which would be used as makeup water in the operating of the cooling system. Tritium would be released in the form of water vapor. This release would be in addition to that from the plant stacks.

(a) To convert from mrem/yr to mSv/yr, divide by 100.
(b) Tritium does not contribute to total body dose or skin dose.
(c) Skin dose is not applicable for the inhalation, vegetable, and meat pathways.
(d) Thyroid dose is not applicable for the plume pathway.

atmospheric releases from the stacks of both new units found in Table H-7. Results were less than 6 percent of the total body dose from the new units and less than 2 percent of the thyroid dose from the new units.

Population dose from the tritium released from the Unit 3 wet cooling towers was estimated to be 0.57 person-rem compared to 17.7 person-rem from atmospheric releases from the new units. This is approximately 3.2 percent of the population dose from the new units.

H.4 Cumulative Dose Estimates

Table H-10 compares Dominion's results for cumulative dose estimates to the MEI with those calculated by the staff. Cumulative dose estimates include doses from all pathways (i.e., external, liquid effluent, and gaseous effluent) for both the proposed Units 3 and 4 and existing NAPS Units 1 and 2. Cumulative doses estimates calculated by Dominion and the staff were similar.

Table H-10. Comparison of Cumulative Doses to the Maximally Exposed Individual

Dose	Dominion ER (Dominion 2006)[a, b]	Staff's Calculation[c]	Percentage Difference
Whole body dose equivalent (mrem/yr)	6.8	7.0	2.9
Thyroid dose (mrem/yr)	27	27	0
Dose to other organ – bone (mrem/yr)	12	12	0

(a) Doses from direct radiation were determined to be negligible (Dominion 2006).
(b) Sum of dose from liquid and gaseous effluent releases for the two existing NAPS units and the proposed units (Dominion 2006). Doses from exiting units were taken from VEPCo (2002b).
(c) The staff's calculation included the sum of doses from liquid and gaseous effluent releases from the two existing NAPS units and the proposed units. Dose from the existing units includes the contribution from tritium concentrations in Lake Anna. Dose from two new units includes the contribution from airborne tritium releases from the Unit 3 wet cooling towers as discussed in Section H.3.

H.5 Dose Estimates to the Biota from Liquid and Gaseous Effluents

To estimate doses to the biota from the liquid and gaseous effluent pathways, the staff used the LADTAP II code (Strenge et al. 1986) and GASPAR II code (Strenge et al. 1987) and input parameters supplied by Dominion as part of its ER (Dominion 2006).

H.5.1 Scope

Doses to both terrestrial and aquatic biota were calculated using the LADTAP II code. Aquatic biota include fish, invertebrate species, and algae. Terrestrial biota include muskrat, raccoon, heron, and duck. The code calculates an internal dose component and external dose component and sums them for a total body dose. The values of input parameters used by Dominion were reviewed by the staff and determined to be appropriate to use in its independent calculation. Default values from Regulatory Guide 1.109 (NRC 1977) were used when values of input parameters were not otherwise available.

The LADTAP II code calculates biota dose from the liquid effluent pathway only. Terrestrial biota will also be exposed via the gaseous effluent pathway. These values would be the same as those for the MEI calculated using the GASPAR II code. Dominion used the MEI doses at a location 0.40 km (0.25 mi) east-southeast from the proposed ESP site to estimate these doses. To account for the closer proximity of the main body mass of animals to the ground compared to humans, the MEI calculation for the biota assumed a ground deposition factor twice that used in the MEI calculation for a member of the public.

H.5.2 Resources Used

To calculate doses to the public from liquid releases, the staff used a computer code entitled NRCDOSE, Version 2.3.5 (Bland 2000), which is a version of the LADTAP II code and the GASPAR II code, obtained through the Oak Ridge Radiation Safety Information Computational Center.

H.5.3 Input Parameters

Most of the LADTAP II input parameters are specified in Section H.1.3 to include the source term, discharge flow rate, reconcentration model, effluent discharge rate from the impoundment system to the receiving water body, impoundment total volume, and shore width factor. Parameters unique to the biota dose calculation were taken from Table 5.4-14 (terrestrial biota parameters) and Table 5.4-15 (shoreline and swimming exposures) of the ER (Dominion 2006). These parameter values were default values used in the LADTAP II code (Strenge et al. 1986), and are appropriate values to use in calculating biota dose.

H.5.4 Comparison of Results

Table H-11 compares Dominion’s biota dose estimates from liquid effluents taken from Table 5.4-16 of the ER (Dominion 2006) with the staff's estimate. The estimated doses were similar.

Table H-12 compares Dominion’s biota dose estimates for gaseous effluents taken from Table 5.4-16 of the ER (Dominion 2006) with the staff’s estimate. The staff calculated the biota dose from gaseous effluents by summing the annual beta air dose, the annual gamma air dose, and two times the ground deposition dose at a location 0.40 km (0.25 mi) east-southeast from the proposed North Anna ESP site. Atmospheric dispersion factors used in the calculation were taken from Table 2.7-15, Table 2.7-18, Table 2.7-19, and Table 2.7-20 of the ER (Dominion 2006). The estimated doses were similar.

Table H-11. Comparison of Dose Estimates to the Biota from Liquid Effluents from One New Unit

Biota	Dominion's ER (mrad/yr)[(a)]	Staff's Calculation (mrad/yr)[(a)]	Percentage Difference
Fish	9.7	9.7	0
Invertebrate	46	47	2.2
Algae	54	55	1.9
Muskrat	43	43	0
Raccoon	4.9	4.9	0
Heron	54	54	0
Duck	43	43	0

(a) To convert from mrad/yr to mGy/yr, divide by 100.

Table H-12. Comparison of Dose Estimates to the Biota from Gaseous Effluents from One New Unit

Biota	Dominion's ER (mrad/yr)[(a)]	Staff's Calculation (mrad/yr)[(a,b)]	Percentage Difference
Fish	[(c)]	[(c)]	[(c)]
Invertebrate species	[(c)]	[(c)]	[(c)]
Algae	[(c)]	[(c)]	[(c)]
Muskrat	34	38	12
Raccoon	34	38	12
Heron	34	38	12
Duck	34	38	12

(a) To convert from mrad/yr to mGy/yr, divide by 100.
(b) Dose equals the sum of the annual beta air dose, the annual gamma dose, and two times the ground deposition dose at 0.4 km (0.25 mi) east-southeast of the North Anna ESP site.
(c) Fish, invertebrate species, and algae would not be exposed to gaseous effluents.

H.6 References

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities."

40 CFR Part 141, Code of Federal Regulations, Title 40, *Protection of the Environment*, Part 141, "National Primary Drinking Water Regulations."

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Appendix I

ESP Site Characteristics and Plant Parameter Envelope

Appendix I

ESP Site Characteristics and Plant Parameter Envelope

The site specific plant parameter envelope (PPE) values and the Early Site Permit (ESP) site characteristics are from Environmental Report (ER) Table 3.1-9 unless otherwise specified. The staff used time dependent atmospheric dispersion factors for this Environmental Impact Statement (EIS) instead of dispersion factors that are not time dependent.

In its ER, Dominion Nuclear North Anna, LLC (Dominion) listed its proposed ESP site characteristics and plant parameters. These characteristics and parameters were used by the Nuclear Regulatory Commission (NRC) staff in its independent evaluation of the environmental impacts of the proposed new Units 3 and 4. In some cases, as noted, the staff substituted values based on its own analysis. The ESP site characteristics specifically used in the staff's evaluation are presented in Table I-1. PPE parameters that are relevant to the environmental review are presented in Table I-2. The staff used the values in both Tables I-1 and I-2 in its evaluation.

Table I-1. ESP Site Characteristics

Item	Single Unit Value [Second Unit Value]	Description and References
Atmospheric Dispersion (χ/Q) (Accident)		Time-dependent values as listed in Table 5-14 of this EIS
• Exclusion Area Boundary (EAB)	3.34×10^{-5} sec/m^3 [Same for 2nd unit]	• 0 to 2 hr interval
• Low Population Zone (LPZ)	2.17×10^{-6} sec/m^3 [Same for 2nd unit]	• 0 to 8 hr interval
	1.5×10^{-6} sec/m^3 [Same for 2nd unit]	• 8 to 24 hr interval
	1.2×10^{-6} sec/m^3 [Same for 2nd unit]	• 1 to 4 day interval
	9.0×10^{-7} sec/m^3 [Same for 2nd unit]	• 4 to 30 day interval

Table I-1. (contd)

Item	Single Unit Value [Second Unit Value]	Description and References
Gaseous Effluents Dispersion, Deposition (Annual Average)		
• Atmospheric Dispersion (χ/Q)	χ/Q values presented in ER Table 2.7-14 [Same for 2nd unit]	• The atmospheric dispersion coefficients used to estimate dose consequences of normal airborne releases.
Residence	2.4×10^{-6} sec/m^3 2.4×10^{-6} sec/m^3 2.1×10^{-6} sec/m^3	• No decay • 2.26-day decay • 8-day decay
EAB	3.7×10^{-6} sec/m^3 3.7×10^{-6} sec/m^3 3.3×10^{-6} sec/m^3	• No decay • 2.26-day decay • 8-day decay
Meat animal	1.4×10^{-6} sec/m^3 1.4×10^{-6} sec/m^3 1.2×10^{-6} sec/m^3	• No decay • 2.26-day decay • 8-day decay
Vegetable garden	2.0×10^{-6} sec/m^3 2.0×10^{-6} sec/m^3 1.8×10^{-6} sec/m^3	• No decay • 2.26-day decay • 8-day decay
• Ground Deposition (D/Q)	D/Q values presented in ER Table 2.7-14 [Same for 2nd unit]	• The ground deposition coefficients used to estimate dose consequences of normal airborne releases
Residence	7.2×10^{-9}/m^2	
EAB	1.2×10^{-8}/m^2	
Meat animal	3.1×10^{-9}/m^2	
Vegetable garden	6.0×10^{-9}/m^2	
Dose Consequences		
• Normal	10 CFR Part 20; 10 CFR Part 50, Appendix I, Dose Objectives; and 40 CFR Part 190 dose limits	• Radiological dose consequences due to gaseous and liquid releases from normal operation of the plant
Liquid effluent	1.6 mrem/yr 1.4 mrem/yr 5.0 mrem/yr	• Total body (Value for two units, see ER Table 5.4-11) • Thyroid (Value for two units, see ER Table 5.4-11) • Other organ/bone (Value for two units, see ER Table 5.4-11)

Table I-1. (contd)

Item	Single Unit Value [Second Unit Value]	Description and References
Dose Consequences		
Gaseous effluent	4.8 mrem/yr 25 mrem/yr 6.5 mrem/yr 6.2 mrem/yr	• Total body (Value for two units, see ER Table 5.4-11) • Thyroid (Value for two units, see ER Table 5.4-11) • Other organ/bone (Value for two units, see ER Table 5.4-11) • Skin (Value for one unit, see ER Table 5.4-10)
Total	6.4 mrem/yr 27 mrem/yr 11 mrem/yr 6.2 mrem/yr	• Total body (Value for two units, see ER Table 5.4-11) • Thyroid (Value for two units, see ER Table 5.4-11) • Other organ/bone (Value for two units, see ER Table 5.4-11) • Skin (Value for one unit, see ER Table 5.4-10)
• Post-Accident	10 CFR 50.34(a)(1) and 10 CFR 100 dose limits [Same for 2nd unit]	• Radiological dose consequences due to gaseous releases from postulated plant accidents. • Design basis accidents (DBA) as listed in Tables 5-15, 5-16, and 5-17 of this EIS • Severe accidents as listed in Tables 5-18, 5-19, and 5-20 of this EIS
• Minimum Distance to Site Boundary	2854.9 ft [Same for 2nd unit]	• Minimum lateral distance from the ESP PPE boundaries to the EAB
Liquid Radwaste System		
• Normal Dose Consequences	10 CFR Part 20; 10 CFR Part 50, Appendix I, Dose Objectives; and 40 CFR Part 190 dose limits	
	1.6 mrem/yr 1.4 mrem/yr 5.0 mrem/yr	• Total body (Value for two units, see ER Table 5.4-11) • Thyroid (Value for two units, see ER Table 5.4-11) • Other organ/bone (Value for two units, see ER Table 5.4-11)

Table I-1. (contd)

Item	Single Unit Value [Second Unit Value]	Description and References
Population Density		
• Population density at the time of initial site approval and within about 5 years thereafter	Population density meets the guidance of RS-002, Section 2.1.3 for RG 4.7, Regulatory Position C.4 [Both units]	• At the time of initial site approval and within about 5 years hereafter, the population densities, including weighted transient population, averaged over any radial distance out to 20 miles (cumulative population at a distance divided by the circular area at that distance), would not exceed 500 persons per square mile.
• Population density at the time of initial operation	Population density meets the guidance of RS-002, Section 2.1.3 [Both units]	• The population densities, including weighted transient population, averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the area at that distance), would not exceed 500 persons per square mile at the time of initial operation.
• Population density over the lifetime of the new units until 2065	Population density meets the guidance of RS-002, Section 2.1.3 [Both units]	• The population densities, including weighted transient population, averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the area at that distance), would not exceed 1000 persons per square mile over the lifetime of new units.
Population Center Distance	10 CFR 100.21(b) Meets requirement [Both units]	• The distance from the ESP PPE to the nearest boundary of a densely populated center containing more than about 25,000 residents is not less than one and one-third times the distance from the ESP PPE to the outer boundary of the LPZ.
EAB	10 CFR 100.21(a) Meets requirement [Both units]	• The exclusion area boundary is the perimeter of a 5000-ft-radius circle from the center of the abandoned NAPS Unit 3 containment.
LPZ	10 CFR 100.21(a) Meets requirement [Both units]	• The LPZ is a 6-mile-radius circle centered at the NAPS Unit 1 containment building.

Table I-2. Plant Parameter Envelope (PPE)

Item	Single Unit Value [Second Unit Value]	Description and References
Structure Height	≤234 ft [Same for 2nd unit]	• The height from finished grade to the top of the tallest power block structure, excluding cooling towers
Structure Foundation Embedment	≤140 ft [Same for 2nd unit]	• The depth from finished grade to the bottom of the basemat for the most deeply embedded power block structure
Normal Plant Heat Sink		
• Condenser/Heat Exchanger Duty	≤1.03 x 10^{10} Btu/hr [Additional ≤1.03 x 10^{10} Btu/hr for 2nd unit]	• Waste heat rejected from the main condenser and the auxiliary heat exchangers during normal plant operation at full station load
• Maximum Inlet Temperature Condenser/ Heat Exchanger	100°F [Same for the 2nd unit]	• Maximum intake temperature at condenser and heat exchanger inlet
• Unit 3 Closed-Cycle, Dry and Wet Tower		
Height	≤180 ft	• The height above finished grade of the cooling towers
Make-Up Flow Rate	15,384 gpm, maximum (MWC mode) 22,268 gpm, maximum (EC mode)	• The expected rate of removal of water from Lake Anna to replace water losses from the closed-cycle cooling water system
Evaporation Rate	8707 gpm, 365-day rolling average[(a)], maximum (MWC mode) 16,695 gpm, maximum (EC mode)	• Maximum rates at which water is lost by evaporation resulting from operation of the plant cooling towers.

(a) The staff used a 100 percent capacity factor based on a 365-day rolling average evaporative water use vs. the applicant's 96 percent capacity factor based on long term annual average evaporative water use.

Table I-2. (contd)

Item	Single Unit Value [Second Unit Value]	Description and References
Drift Rate	8 gpm, maximum (MWC mode) 8 gpm, maximum (EC mode)	• Expected rates at which water is lost by drift resulting from operation of the plant cooling towers based on 0.001% of cooling water flow
Blowdown Flow Rate	3844 gpm, maximum (MWC mode) 5565 gpm, maximum (EC mode)	• Flow rate of the blowdown stream from the closed-cycle cooling water system to the WHTF
Blowdown Temperature	100°F, maximum	• The maximum expected temperature of the cooling tower blowdown stream to the WHTF
Blowdown Constituents and Concentrations		• The maximum expected concentrations for anticipated constituents in the cooling water system blowdown to the WHTF
• Free Available Chlorine	<0.3 ppm	
• Copper	<1 ppm	
• Iron	<1 ppm	
• Sulfate	<300 ppm	
• Total Dissolved Solids	<3000 ppm	
Heat Rejection Rate	≤1.03 E 10 Btu/hr	• The expected maximum heat rejection rate to the atmosphere during normal operation at full station load.
Noise	<65 dBA EAB	• Maximum expected sound level at the EAB from operation of the cooling towers
• Unit 4 Dry Cooling Towers		
Evaporation Rate	None or negligible (on the order of 1 gpm, average)	• The expected rate at which water is lost by evaporation from the cooling water system
Height	≤180 ft	• The vertical height above finished grade of the cooling towers
Makeup Flow Rate	None or negligible (on the order of 1 gpm, average)	• The expected rate of removal of water from Lake Anna to replace evaporative water losses from the cooling water system

Table I-2. (contd)

Item	Single Unit Value [Second Unit Value]	Description and References
Noise	<60 dBA at EAB	• Maximum expected sound level at the EAB from operation of the cooling towers
Heat Rejection Rate	$\leq 1.03 \times 10^{10}$ Btu/hr	• Waste heat rejected to the atmosphere from the cooling water system, during normal plant operation at full station load
Ultimate Heat Sink (UHS) Mechanical Draft Cooling Towers		
• Blowdown Constituents and Concentrations	[Same for 2nd unit]	• The maximum expected concentrations for anticipated constituents in the UHS blowdown to the WHTF
• Free Available Chlorine	<0.3 ppm	
• Copper	<1 ppm	
• Iron	<1 ppm	
• Sulfate	<300 ppm	
• Total Dissolved Solids	<3000 ppm	
• Blowdown Flow Rate	144 gpm expected, 850 gpm maximum [Same for 2nd unit]	• The normal expected and maximum flow rate of the blowdown stream from the UHS system to the WHTF
• Evaporation Rate	411 gpm normal, 850 gpm shutdown [Same for 2nd unit]	• The expected (and maximum) rate at which water is lost by evaporation from the UHS system
• Height	$\leq$60 ft [Same for 2nd unit]	• The vertical height above finished grade of mechanical draft cooling towers associated with the UHS system
• Maximum Consumption of Raw Water	850 gpm, nominal [Same for 2nd unit]	• The expected maximum short-term consumptive use of water from Lake Anna by the UHS system (evaporation and drift losses)

Table I-2. (contd)

Item	Single Unit Value [Second Unit Value]	Description and References
• Monthly Average Consumption of Raw Water	411 gpm [Same for 2nd unit]	• The expected normal operating consumption of water from Lake Anna by the UHS system (evaporation and drift losses)
Release Point		
• Elevation	Ground Level	• The elevation above finished grade of the release point for routine operational and accident sequence releases
Source Term		
• Gaseous (Normal)	Maximum values presented in Table H-5 of this EIS and ER Table 5.4-7 [Same for 2nd unit]	• The annual activity, by isotope, contained in routine plant airborne effluent streams
• Atmospheric (Design Basis Accidents)	Ci as indicated in	
	ER Table 7.1-3	• AP1000 Main Steam Line Break, Pre-existing Iodine Spike
	ER Table 7.1-5	• AP1000 Main Steam Line Break, Accident-Initiated Iodine Spike
	ER Table 7.1-6a	• ABWR Cleanup Water Line Break
	ER Table 7.1-6c	• ESBWR Feedwater System Pipe Break
	ER Table 7.1-7	• AP1000 Locked Rotor Accident
	ER Table 7.1-9	• AP1000 Rod Ejection Accident
	ER Table 7.1-12	• ABWR Failure of Small Lines Carrying Primary Coolant Outside Containment
	ER Table 7.1-13a	• ESBWR Failure of Small Lines Carrying Primary Coolant Outside Containment
	ER Table 7.1-14	• AP1000 Steam Generator Tube Rupture, Pre-Existing Iodine Spike
	ER Table 7.1-16	• AP1000 Steam Generator Tube Rupture, Accident Initiated Iodine Spike
	ER Table 7.1-18	• ABWR Main Steam Line Break
	ER Table 7.1-20a	• ESBWR Main Steam Line Break
	ER Table 7.1-11	• AP1000 Loss-of-Coolant Accident
	ER Table 7.1-11	• ABWR Loss-of-Coolant Accident
	ER Table 7.1-24a	• ESBWR Loss-of Coolant Accident

Table I-2. (contd)

Item	Single Unit Value [Second Unit Value]	Description and References
	ER Table 7.1-25	• AP1000 Fuel Handling Accident
	ER Table 7.1-25	• ABWR Fuel Handling Accident
	ER Table 7.1-29	• ESBWR Fuel Handling Accident
	ER Table 7.1-31	• ESBWR Cleanup Water Line Break
• Tritium	3500 Ci/yr [Same for 2nd unit] (maximum values)	• The annual activity of tritium contained in routine plant airborne effluent streams
Liquid Radwaste System		
• Release Point Dilution Factor	1000 (minimum) [Same for 2nd unit]	• The ratio of liquid potentially radioactive effluent streams to liquid non-radioactive effluent streams from plant systems to the WHTF through the discharge canal used for NAPS Units 1 and 2
• Liquid	Values presented in Table H-2 of the EIS and ER Table 5.4-6 (maximum values) [Same for 2nd unit]	• The annual activity, by isotope, contained in routine plant liquid effluent streams
• Tritium	$\leq$850 Ci/yr [Same for 2nd unit]	• The annual activity of tritium contained in routine plant liquid effluent streams
Solid Radwaste System		
• Activity	$\leq$2700 Ci/yr [Same for 2nd unit]	• The annual activity contained in solid radioactive wastes generated during routine plant operations
• Volume	$\leq$9041 cu ft/yr [Same for 2nd unit]	• The expected volume of solid radioactive wastes generated during routine plant operations

Table I-2. (contd)

Item	Single Unit Value [Second Unit Value]	Description and References
Plant Characteristics		
• Acreage	Approximately 128.5 acres [Both units]	• Approximate area on the NAPS site that would be affected on a long-term basis as a result of additional permanent facilities
• Megawatts Thermal	$\leq$4500 MWt [Same for 2nd unit]	• The thermal power generated by one unit (may be the total of several modules)
• Plant Population – Operation	Approximately 720 permanent employees [Both units]	• Anticipated number of new employees that would be required for operation of the new units
• Plant Population – Refueling / Major Maintenance	Approximately 700 to 1000 temporary workers during planned outages [Same for 2nd unit]	• Anticipated number of additional workers onsite during planned outages of the new units
• Plant Population – Construction	5000 people maximum [simultaneous construction]	• Peak workforce of 5000 for construction of both new units
• Maximum Fuel Enrichment for Light-Water-Cooled Reactors	5% [Same for 2nd unit]	• Concentration of U-235 in fuel
• Maximum Fuel Burn-up for Light-Water-Cooled Reactors	62,000 MWd/MTU [Same for 2nd unit]	• The value derived by calculating the reactor thermal power multiplied by the time of irradiation divided by fuel mass (expressed as megawatt-days per metric ton of irradiated fuel)
• Maximum Fuel Enrichment for Gas-Cooled Reactors	19.8% [Same for 2nd unit]	• Concentration of U-235 in fuel
• Maximum Fuel Burn-up for Gas-Cooled Reactors	133,000 MWd/MTU [Same for 2nd unit]	• The value derived by calculating the reactor thermal power multiplied by the time of irradiation divided by fuel mass (expressed as megawatt-days per metric ton of irradiated fuel)

Appendix J

Dominion Nuclear North Anna, LLC, Permit Conditions, Representations, Assumptions, and Unresolved Issues

Appendix J

Dominion Nuclear North Anna, LLC, Permit Conditions, Representations, Assumptions, and Unresolved Issues

If an early site permit (ESP) for the North Anna ESP site is issued and an applicant references it in an application for a construction permit (CP) or a combined license (COL), the applicant would have to demonstrate that the design selected for the site falls within the bounds of the Nuclear Regulatory Commission's (NRC's) ESP analysis in this environmental impact statement (EIS). With regard to the environmental impacts associated with construction and operation of proposed Units 3 and 4, Dominion Nuclear North Anna, LLC (Dominion), made a number of representations in its application. As listed in this appendix, the staff relied on these representations and staff-developed assumptions in assessing the environmental impacts associated with construction and operation of the units. As such, fulfillment of these representations and assumptions provide part of the basis for the final impact assessment. Should a CP or COL applicant reference the ESP, and the staff ultimately determine that a representation or assumption has not been satisfied at the CP/COL stage, that information would be considered new, and potentially significant, and the affected impact area could be subject to re-examination.

Table J-1 references Dominion's representations and the staff's assumptions about design (Appendix I, the plant parameter envelope), permits and authorizations (Appendix L), mitigation (Section 4.10 and 5.11 of the EIS), and the site redress plan (section 4.11). Table J-2 contains references to representations and assumptions organized by technical area without repeating the information in Table J-1. Table J-3 is a list of unresolved issues. Table J-4, is a list of recommended ESP environmental permit conditions.

Within the ER (Dominion 2006), Dominion provides:

(1) representations to address certain issues in the design, construction, and operation of the facility

(2) representations of planned compliance with current laws, regulations, and requirements

(3) representations of to future activities and actions that it will take should it receive an ESP and decide to apply for a COL for the North Anna ESP site

(4) representations of Dominion's estimates of future activities and actions of others and the likely environmental impacts of those activities and actions that would be expected should Dominion decide to apply for a CP or COL.

The following tables are meant to aid the staff and the applicant in the event this EIS is referenced in a CP or COL application. The tables are not meant to replace the analysis in the EIS.

Table J-1. Appendix I, Appendix L, Section 4.10, and 5.11 Assumptions and Commitments

Area	Representations/Assumptions
Site Characteristics	An applicant referencing this EIS will demonstrate its application is bounded by the ESP site characteristics contained in Table I-1.
Plant Parameter Envelope (PPE) Values	An applicant referencing this EIS will demonstrate its application is bounded by the PPE values contained and referenced in Table I-2.
Authorizations and Permits	An applicant referencing this EIS will provide the status of the authorizations and permits specified in Appendix L.
Mitigation of Construction Impacts	An applicant referencing this EIS will demonstrate its application contains the mitigation measures contained in Section 4.10.
Mitigation of Operational Impacts	An applicant referencing this EIS will demonstrate its application contains the mitigation measures contained in Section 5.11.
New and Significant Information	An applicant referencing this EIS will provide, in its application, any new information that could affect the technical basis or conclusions for determination of an impact level in the EIS.

Table J-2. Assumptions by Technical Area Not Contained in Table J-1

Technical Area	Representations/Assumptions	Source
Land Use–Transmission Corridors and Offsite Areas	Based on an initial evaluation, the existing transmission lines have sufficient capacity to carry the total output of the existing units and the new units. A system study (load flow) modeling these lines with the new units' power contribution would be performed to confirm this conclusion, if and when Dominion decided to proceed with the development of new units at the ESP site.	ER Section 4.1.2

Table J-2. (contd)

Technical Area	Representations/Assumptions	Source
Meteorology and Air Quality	The meteorological monitoring program would continue throughout the construction and operational phases of the project. The monitoring program would be a continuation of the ongoing meteorological monitoring program for the North Anna Power Station (NAPS) site. The impacts on local air quality from onsite construction activities would be mitigated through a dust control plan, while the impacts on local air quality from automobile exhaust from increased site workers would be mitigated through a construction management plan.	ER Sections 4.4.1.4, 4.4.2.2.1e, and 6.4
Water Use and Quality	Flows and temperatures specified in Appendix I are bounding.	ER Table 3.1-9
Water Use and Quality	Groundwater use would be limited to potable and landscape maintenance function.	ER Section 3.3.1
Terrestrial Ecology	The existing transmission lines would be adequate to transmit additional power generated by Units 3 and 4.	ER Section 3.7.2
Terrestrial Ecology	Once the facility design is finalized, appropriate analyses of transmission and distribution system adequacy would be made.	ER Section 3.7.2
Terrestrial Ecology	There would be no new impacts created as a result of operation of a new facility with regards to maintenance of transmission line rights-of-way.	ER Section 5.6.1
Terrestrial Ecology	No important species as described in NUREG-1555 currently live on the ESP site or are likely to, and except for a few small, potential wetlands, no important habitats are present on the ESP site.	ER Section 2.4.1
Terrestrial Ecology	The existing switchyard would be used, with modifications.	ER Section 3.7.1
Terrestrial Ecology	Total area for the ESP construction site is approximately 200 acres including approximately 80 acres of forested habitat.	ER Section 4.3.1.2
Aquatic Ecology	The operational-phase aquatic ecological monitoring program for the new units would be similar to the ongoing Virginia Power and Virginia Department of Game and Inland Fisheries (VDGIF) monitoring programs.	ER Section 6.5.2.3

Table J-2. (contd)

Technical Area	Representations/Assumptions	Source
Aquatic Ecology	The passage through the cofferdam will not represent critical velocity into the intake.	ER Section 3.4.2.1
Socioeconomics	Lake Anna lake levels, temperatures, and downstream flows are the same as shown in Appendix K and Section 5.4.2.4.	EIS Appendix K and Section 5.4.2.4
Socioeconomics	General growth of the regional economy and population will occur within the times and in the locations projected in the ER.	ER Section 2.5.1
Socioeconomics	State and local governments will continue to expand and upgrade infrastructure and public services to meet general population growth.	EIS Sections 4.5, 5.5
Socioeconomics	Construction workers moving into the region of the plant will concentrate in areas with larger amounts of available housing (e.g., Henrico County, Richmond). Operations work force will be geographically distributed similarly to the existing NAPS workforce.	ER Sections 4.4.2.2 and 5.8.2
Socioeconomics	Lake Anna lake levels, temperatures, and downstream flows are the same as shown in Appendix K and Sections 5.4.2.4.	EIS Appendix K and Section 5.4.2.4
Socioeconomics	Although noise would not cause adverse offsite impacts, a noise study would be performed as part of the final selection of the Units 3 and 4 cooling systems and the results described in the COL application.	ER Section 5.8.1.2
Socioeconomics	The evaluation of the need for noise impact from the transmission system would be completed at a “suitable time” within Dominion’s future planning work.	ER Section 5.8.1.2

Table J-2. (contd)

Technical Area	Representations/Assumptions	Source
Historic and Cultural Resources	Dominion would implement the necessary administrative steps to make proper notifications in the event of any unanticipated discovery (including human remains). These steps would include stop-work, assessment, and notification protocol. The primary controls to be used to minimize impacts in the event of an unanticipated discovery would include ongoing coordination with VDHR with regards to the potential presence of historic and cultural resources within planned disturbed areas, adherence to Dominion administrative procedures regarding activities to be implemented in the event of an unanticipated discovery, and adherence to specific permit requirements through their integration into construction scheduling and work practices.	ER Section 4.1.3
Environmental Justice	Minority and low income populations will continue to exist in the same proportions and locations as populations increase	EIS Section 2.10
Human Health	Radioactive waste management systems would be designed to minimize releases from reactor operations to values as low as reasonably achievable (ALARA). These systems would be designed and maintained to meet the requirements of 10 CFR 20 and 10 CFR 50, Appendix I.	ER Section 3.5
Human Health	Gaseous releases of light-water reactors (LWR) are well known, and studies of gas-cooled reactor operation have indicated that their gaseous releases would be bounded by the LWR data.	ER Section 3.5.2
Human Health	Nonradioactive solid wastes are addressed by local regulation under “truck-and-haul” permitting. Hazardous wastes are handled by permitted contractors and are addressed onsite in compliance with Federal regulations.	ER Section 3.6.3.3
Fuel Storage	All of the LWR technologies considered have a design storage capacity for spent fuel shipping casks that far exceeds that needed to accommodate 5-year cooling.	ER Section 3.8.1

Table J-2. (contd)

Technical Area	Representations/Assumptions	Source
Human Health	The calculated construction worker doses are based on available dose rate measurements and calculations. It is possible that these dose rates would increase in the future as site conditions change. However, the ESP site would be continually monitored during the construction period and appropriate actions would be taken as necessary to ensure that the construction workers are protected from radiation.	ER Section 4.5.4.4
Human Health	The new units would release liquid effluents to the Waste Heat Treatment Facility through the discharge canal used for the existing NAPS Units 1 and 2.	ER Section 5.4.1.1
Human Health	Transmission lines carrying the additional power would not exceed the NESC criteria for electric shock.	EIS Section 5.8.4
Human Health	Dominion would require appropriate procedures if it was necessary to store mixed wastes temporarily on the ESP site. These procedures would include proper labeling of containers, installation of fire detection and suppression equipment (if required), use of fences and locked gates, availability of emergency shower and eyewash facilities, posting of hazard signs, and regular inspections. Dominion would also develop and implement contingency plans, emergency preparedness plans, and spill prevention procedures that would be implemented in the event of a mixed waste spill. Personnel who are designated to handle mixed waste or to respond to mixed waste emergency spills would receive appropriate training to enable them to perform their work properly and safely.	ER Section 5.5.2.3
Human Health	The structure of the ESP site Radiation Environmental Management Program (REMP) would be based on the necessary components of the monitoring program established for the existing units, which encompasses the entire NAPS site and would be expanded to include radiological environmental monitoring for the new units. This expanded REMP would continue to be in accordance with the existing units' Technical Specifications and is described in the NAPS UFSAR Section 11.6. It would be implemented through the existing units' Offsite Dose Calculation Manual (ODCM), and via administrative and technical procedures.	ER Section 6.2.1

Table J-2. (contd)

Technical Area	Representations/Assumptions	Source
Transportation	The transportation impact analysis used information from INEEL (2003) to estimate the unirradiated and spent fuel shipping cask capacities.	EIS Sections 6.2.2.1, 6.2.2.2, G.1.1, and G.2.1
Transportation	The transportation impact analysis for advanced reactor spent fuel shipments assumed the radiation dose rate emitted from the shipments is at the maximum allowed by Federal regulations	EIS Sections 6.2.2.1 and G.2.1
Transportation	It was assumed that shipping casks for advanced reactor spent fuel will provide equivalent mechanical and thermal protection of the spent fuel cargo [relative to the current LWR spent fuel shipping cask designs].	EIS Sections 6.2.2.2 and G.2.2
Transportation	For this assessment, release fractions for current generation LWR fuels were used to approximate the impacts from advanced reactor spent fuel shipments. This essentially assumes that the behavior of fuel materials and containment systems (cladding, fuel coatings) is similar to that of the current generation LWR fuel under applied mechanical and thermal conditions.	EIS Sections 6.2.2.2 and G.2.2

Table J-3 Issues Not Resolved

Issue	EIS Section	Comment
Need for Power	1.1.3	In accordance with 10 CFR 52.18, assessment of benefits is not required at ESP stage.
Energy Alternatives	1.4	Commission determined that energy alternatives need not be addressed at the ESP stage. (68 FR 55905, 55911)
Water Quality	5.3.3	Chemical concentrations of waste streams other than Unit 3 blowdown to the WHTF was not defined.
Alternatives to Mitigate Severe Accident	5.10.3	Review Standard, RS-002, Processing Applications for Early Site Permits stated that the SAMA review could be deferred to the COL stage when the detailed design information is available. Design not selected. Issue to be resolved in COL application when a design is selected.
Design and Severe accident	5.10.3	Design and severe accident impacts are unresolved for gas-cooled reactors due to insufficient information. Issue to be resolved in COL application if a gas cooled is selected.
Fuel Cycle Impacts and Solid Waste Management	6.1	Environmental impacts from the uranium fuel cycle activities and solid waste management for other than LWR reactors are not resolved.
Transportation	6.2.4	For gas-cooled reactors, the impacts [of transporting fuel and radioactive waste to and from the reactor] are likely to be small, but this issue is not resolved because of the lack of verifiable information on these designs. Verifiable information is lacking about unirradiated and spent fuel shipping cask designs, fuel performance under applied mechanical and thermal accident conditions, unirradiate fuel initial core/refueling requirements, spent fuel generation rates, and radioactive waste generation rates.
Decommissioning	6.3	Design not selected. Issue to be resolved in COL application when a design is selected.

Table J-4. Recommended Permit Conditions for the North Anna Early Site Permit

Condition No.	EIS Section	Recommended Permit Condition
1	4.11	Applicant will have a site redress plan as stated in EIS section 4.11 and the North Anna ESP Application – Part 4 – Programs and Plans, Revision 9.
2	1.5	The holder of this ESP shall not perform any site preparation or preliminary construction activities authorized by 10 C.F.R. 52.25 unless such holder obtains the certification required pursuant to Section 401 of the Federal Water Pollution Control Act from the Commonwealth of Virginia, or obtains a determination by the Commonwealth that no certification is required and submits the certification or determination to the NRC before commencement of any such activities.
3		The CP or COL applicant will conduct an instream flow incremental methodology study pursuant to the Coastal Zone Management Act consistency determination.
4		Dominion shall conduct a comprehensive Instream Flow Incremental Methodology study (IFIM), designed and monitored in cooperation and consultation with the VDGIF and the VDEQ, to address potential impacts of the proposed Units 3 and 4 upon the fishes and other aquatic resources of Lake Anna and downstream waters. Development of the Scope-Of-Work for the IFIM study shall begin in 2007, and the IFIM study shall be completed prior to issuance of a combined construction and operating license (COL) for this project. Dominion agrees to consult with VDGIF and VDEQ regarding analysis and interpretation of the results of that study, and to abide by surface water management, release, and instream flow conditions prescribed by VDGIF and VDEQ upon review of the completed IFIM study, and implemented through appropriate state or federal permits or licenses.

Appendix K

Staff's Independent Review of Water Budget Impacts

Appendix K

Staff's Independent Review of Water Budget Impacts

K.1 Summary

This appendix discusses the methods used for the U.S. Nuclear Regulatory Commission (NRC) staff's independent review of Dominion Nuclear North Anna, LLC's (Dominion) assessment of the impacts of the proposed North Anna early site permit (ESP) Unit 3's closed-cycle, combination dry and wet cooling system and the staff's findings. The NRC staff computed impacts of plant operations on the Lake Anna reservoir lake level elevation and discharge to the North Anna River downstream of North Anna Dam. Dominion has proposed dry cooling for Unit 4, and the staff concluded that any resulting impacts to the water resources from Unit 4 would be undetectable and were not analyzed further. Therefore, no further mention of Unit 4 is included in this appendix.

The Lake Anna reservoir (or "the reservoir") was formed by impounding the North Anna River above the North Anna Dam. Construction of the dam was permitted by the Virginia State Corporation Commission in 1969 (Virginia State Corporation Commission 1969). The Lake Anna reservoir is divided into two distinct bodies of water, Lake Anna and the Waste Heat Treatment Facility (WHTF). The WHTF is composed of three lagoons and is designated by the Commonwealth of Virginia as a waste heat treatment facility in Dominion's Virginia Pollutant Discharge Elimination System (VPDES) permit (VDEQ 2001) for the North Anna Power Station (NAPS) (Figure K-1). The lagoons have a total surface area of approximately 3200 ac and are separated from the rest of Lake Anna by a series of dikes. The main body of the lake is approximately 17 mi long with 272 mi of irregular shoreline and approximately 9900 ac of water surface.

The scope of the staff's evaluation was limited to an assessment based on the relevant values stated in Dominion's plant parameter envelope (PPE). The staff evaluated whether or not PPE values were reasonable. If the ESP is granted and an applicant for a construction permit (CP) or combined license (COL) references the ESP, the applicant would be required to demonstrate that the design of the facility falls within the parameters specified in the ESP. The staff's evaluation also relied on a variety of environmental data that were obtained independently of Dominion. For instance, streamflow data were obtained from the U.S. Geological Survey, meteorological data were obtained from the National Weather Service, and lake geometry data were independently digitized from maps of the lake.

Heat rejected from proposed Unit 3 would be rejected to the atmosphere via the wet and dry cooling system, but blowdown associated with cooling system operation would be discharged into the WHTF. The cooling system blowdown would be discharged into the existing discharge

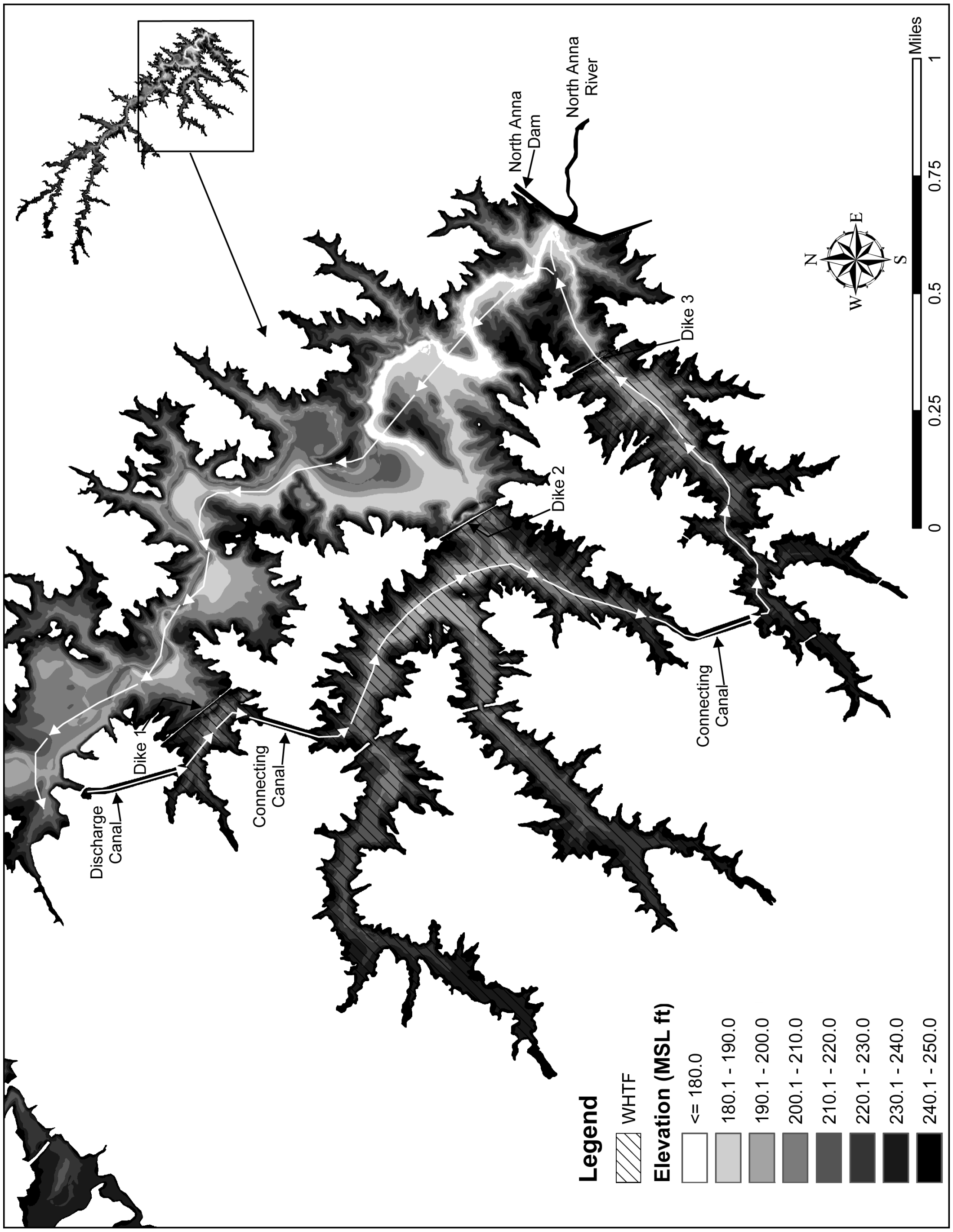

Figure K-1. Main Features of Lake Anna Reservoir

canal at a maximum PPE discharge rate of 12.4 cfs and a maximum PPE temperature of 100°F. Existing Units 1 and 2 employ once-through cooling water systems. With Units 1 and 2, and the proposed Unit 3 operating simultaneously, the blowdown discharge from Unit 3 would mix in the discharge canal with the circulating once-through water discharged from Units 1 and 2.
The combined discharge of Units 1 and 2 is approximately 4300 cfs, which is almost 350 times greater than the proposed Unit 3 system maximum blowdown rate of 12.4 cfs. Therefore, the waste heat associated with Unit 3 blowdown is not expected to alter water temperature in either the WHTF or Lake Anna.

The quantity of water consumed by the Unit 3 wet cooling tower system would reduce the net discharge from North Anna Dam. In addition, during periods of drought when the lake is below elevation 250 ft above mean sea level (MSL), the consumptive use of water from the operation of the Unit 3 wet cooling tower system would reduce the water volume in the lake. This reduction of volume would result in a warming of the reservoir, assuming that the waste heat load from Units 1 and 2 to the reservoir remains constant. Warming is expected to be minimal, as shown by staff's independent assessment, because the difference in overall reservoir volume is slight. For example, the difference in lake level elevation with and without operation of the Unit 3 cooling system was computed to be to be less than 3 in. for 69 percent of the simulated period (a 23 year period) and less than 1.0 ft for 94 percent of the simulation period.

The water budget assessment examined hydrological impacts from both the existing NAPS Units 1 and 2 and the proposed Unit 3 to bound the minimum lake level elevations. A period of record of more than 23 years was examined to determine a critical historical period for comparison between the existing conditions with Units 1 and 2 and the proposed conditions with Units 1, 2, and 3. The critical period selected was the 34-month period between June 2000 and April 2003, specifically targeting the minimum lake level elevations occurring during October of 2002. The staff estimated the following minimum lake level elevations for the critical period:

- Units 1 and 2 (existing/observed conditions): 245.2 ft
- Units 1 and 2 plus Unit 3 (proposed conditions): 243.5 ft

K.2 Plant Parameter Envelope

An ESP is a Commission approval of a location for siting one or more nuclear power facilities. An ESP application may refer to the characteristics of a specific reactor design, or a PPE, which is a set of postulated design parameters representing the characteristics of a reactor or reactors that might be built on a selected site.

The PPE values are a surrogate for actual reactor design information. Analysis of environmental impacts based on a PPE approach permits an ESP applicant to defer the selection of a reactor design until the construction permit (CP) or COL stage.

In this evaluation, the staff relied on the following PPE values from Dominion as listed in its Environmental Report (ER) as ESP site characteristics and design parameters (Table 3.1-9) (Dominion 2006) and summarized in Appendix I of this Environmental Impact Statement (EIS):

- Unit 3 Evaporation Rate – Dominion defined this parameter as "...expected rates at which water is lost by evaporation resulting from operation of the plant cooling towers." Dominion stated that the maximum flow rate varies from 16,695 gpm in Energy Conservation (EC) model to 11,532 gpm in Maximum Water Conservation (MWC) mode. Dominion stated that the average evaporation rate is 8707 gpm with an associated 96 percent plant capacity factor with wet tower cooling.

- Unit 3 Blowdown Flow Rate – Dominion defined this parameter as, "...flow rate of the blowdown stream from the closed-cycle cooling water system to the WHTF." Dominion stated that the maximum flow rate in EC mode is 5565 gpm and the maximum flow rate in MWC mode is 3844 gpm.

- Unit 3 Blowdown Discharge Temperature – Dominion defined this parameter as, "...the maximum expected temperature of the cooling tower blowdown stream to the WHTF." Dominion provided a value of 100°F.

K.3 Plant and North Anna Dam Operation Assumptions

The existing two NAPS units are able to operate at a lake level elevation as low as 242 ft MSL. Dominion is proposing that Unit 3 also be allowed to operate to a lake level elevation as low as 242 ft MSL.

Normal plant cooling for Unit 3 would be accomplished by a closed-cycle, combination dry and wet cooling tower system. The cooling system would operate in EC and MWC modes. In EC mode, all of the rejected heat would be dissipated through use of the wet tower system. When the reservoir water surface elevation is at or above elevation 250 ft MSL, EC mode would be used. In MWC mode, a minimum of one-third of the rejected heat from Unit 3 would be removed by the dry tower system. During periods of favorable atmospheric conditions, more than one-third (and possibly as much as 100 percent) of the rejected heat may be dissipated through the dry towers. MWC mode would be used when the lake level elevation falls below 250 ft MSL for seven consecutive days, and would continue to be used until the lake level elevation is restored to 250 ft MSL.

Operating rules for the North Anna Dam were assumed to be unchanged if the proposed Unit 3 is constructed. North Anna Dam is operated in accordance with the Lake Level Contingency Plan (a condition of the NAPS Virginia pollution discharge elimination system [VPDES] permit issued to Virginia Electric and Power Company [VEPCo] by the Virginia Department of

Environmental Quality [VDEQ]). Releases from the dam are designed to maintain the lake level elevation as close to elevation 250 ft MSL as possible. When the lake level elevation drops below elevation 250 ft MSL because of inadequate inflows to offset natural and induced evaporative losses, the releases from North Anna Dam are reduced to 40 cfs. If the lake level elevation continues to declined below elevation 248 ft MSL, releases are decreased to 20 cfs. Discharges are increased to 40 cfs when the lake level elevation rises again to elevation 248 ft MSL, and are increased further when the lake level rises above elevation 250 ft MSL.

K.4 WHTF and Lake Anna Bathymetry

The staff obtained digital 1:24,000 scale digital raster graphic quadrangles of Lake Anna from the Department of Geography at Radford University (http://www.runet.edu/~geoserve/Virginia.html). These images served as the source data set for bathymetry. A mosaic of the raw images was used to generate a geo-referenced base map that was then digitized using the ESRI™ software package ArcMap™ 9.0. The resulting 10 ft interval contours from elevation 180 to 250 ft MSL are shown in Figure K-1.

A continuous surface was created from these contours. This surface was broken into three zones based on observed water temperatures in the reservoir (see Figure K-1): (1) the WHTF, (2) Lake Anna from North Anna Dam upstream to the Highway 208 Bridge, and (3) Lake Anna arms upstream of the Highway 208 Bridge. Impounded surface areas and volumes were then calculated for each section as a function of water surface elevation, the results of which are presented in Table K-1.

The Lake Anna reservoir, which was formed when North Anna Dam began to impound water, is comprised of numerous fingers and arms. The reservoir is approximately 17 mi long, and several dikes have been constructed to increase travel time of water exiting from the NAPS discharge canal exit and flowing through the WHTF and the lake to the intake for existing Units 1 and 2. Connecting canals, which are trapezoidal in cross section, have been constructed to convey flow from each of the three ponds formed by these dikes. The collection of ponds and connecting canals are collectively labeled as the WHTF.

Water leaving the discharge canal may only exit the WHTF through Dike 3. This dike contains a submerged discharge structure with adjustable stop logs to constrict the exiting discharge. This structure creates a positively buoyant high velocity (typically >6 ft/s) jet, which was designed to quickly entrain cooler Lake Anna water.

Table K-1. Computed Areas and Volumes as a Function of Lake Level Elevation for the Various Zones of Lake Anna Reservoir (See Figure K-1)

Lake Anna Reservoir			WHTF		
Elevation (ft)	**Area (ac)**	**Volume (ac-ft)**	**Elevation (ft)**	**Area (ac)**	**Volume (ac-ft)**
250	13,068	312,171	250	3,194	64,082
240	9,219	200,737	240	2,120	37,515
230	6,553	121,877	230	1,374	20,045
220	4,418	67,021	220	830	9,026
210	2,715	31,354	210	418	2,787
200	1,281	11,377	200	139	
190	523	3,257			
180	129				
Lake Anna			**Lake Anna Arms**		
Elevation (ft)	**Area (ac)**	**Volume (ac-ft)**	**Elevation (ft)**	**Area (ac)**	**Volume (ac-ft)**
250	5,540	174,374	250	4,334	73,715
240	4,528	124,032	240	2,571	39,190
230	3,614	83,323	230	1,565	18,509
220	2,803	51,240	220	786	6,755
210	2,034	27,055	210	263	1,512
200	1,101	11,377	200	40	
190	523	3,257			
180	129				

K.5 Dominion's Assessment

Dominion developed a water balance model that simulated releases from the North Anna Dam and lake level elevations in the reservoir on a weekly basis for the period between October 1979 and April 2003. During this period, Units 1 and 2 were both operating (Existing Units Scenario). The model was separately used to predict releases from the dam and water surface elevations in the reservoir had Unit 3 been operating during the same period (Existing Units plus Unit 3 Scenario). Variations in dam outflow frequencies, periods below various lake level elevations, and the relative difference in lake level elevations between the two scenarios were then examined and presented by Dominion.

The minimum lake level elevation of the reservoir was 245.1 ft MSL for the Existing Units Scenario and 244.2 ft for the Existing Units plus Unit 3 Scenario, a difference of 0.9 ft. The percent of time North Anna Dam discharge was 20 cfs was 5.2 percent of the period for the Existing Units Scenario and 7.3 percent for the Existing Units plus Unit 3 Scenario, a difference of 2.1 percent.

K.6 Boundary Condition for Staff's Assessment

The staff performed an independent water balance calculation to predict impacts of the proposed Unit 3 on the reservoir and releases from North Anna Dam (Cook et al. 2005). This was accomplished by first simulating the more than 23 year period between October 1979 and April 2003, when only Units 1 and 2 were operating. The assessment was then used to predict how the reservoir and downstream releases would be altered had Unit 3 been operating.

The model required input of time-series boundary condition data. Inflows to the lake were input for each time step. Outflows were computed based on the previous time-step lake level elevation and the relationship between lake level and discharge for North Anna Dam. Meteorological data were used to estimate the volume of precipitation falling directly on the lake and to compute volume lost from the reservoir through evaporation. Lake inflows and meteorological data were held constant for all scenarios; however, outflows varied between scenarios according to the lake level elevation.

K.6.1 Inflows

The principal tributaries of Lake Anna are the North Anna River, Pamunkey Creek, and Contrary Creek. Unfortunately, no stream flow gauges were installed on these tributaries. Estimates of inflows to Lake Anna were derived from measurements of streamflow in an adjacent basin. Daily average stream flows for the Little River near Doswell, Virginia, were obtained from U.S. Geological Survey (http://waterdata.usgs.gov/nwis) gauge 01671100. The Little River is a tributary to the North Anna River downstream of North Anna Dam. The size of the Little River watershed at this gauging station is 107 mi^2, which is approximately one-third the size of the North Anna watershed where it enters Lake Anna. Inflows to Lake Anna were therefore computed during the simulation period by multiplying the watershed scale ratio to the daily average Little River discharges.

K.6.2 Meteorology

Meteorological information about the atmosphere above the lake is necessary to compute evaporation for this assessment. Dew point temperature and wind speed were obtained from the Richmond airport (EarthInfo 2003), which was the nearest location that collected data during the critical drought period. Hourly observed data were used as model inputs for the simulated drought period. Precipitation falling onto Lake Anna was considered an inflow boundary condition for the water budget assessment. Total accumulated precipitation on each day was obtained from National Climate Data Center (NCDC), and was originally collected at the Richmond airport (NCDC 2004).

Based on precipitation data measured at the Richmond airport from January 1, 1921, to May 31, 2004, Figure K-2 shows the long-term mean monthly precipitation and monthly precipitation for the three driest water years in the Richmond record (water years 1924, 2002, and 1954). The total precipitation during the 2002 water year was 26.4 in., which is 60.6 percent of mean annual precipitation. The precipitation for the 2001 water year totaled 33.1 in., which is 75.9 percent of mean annual precipitation. Combined precipitation during water years 2001 and 2002 was the driest 2-year period in the precipitation record. Table K-2 shows the monthly precipitation during water years 2001 and 2002 as a percentage of the long term corresponding monthly mean.

K.7 Staff's Assessment Approach

The staff's assessment was completed in two steps. In the first step, the natural evaporation rate from the lake, the induced evaporation from Units 1 and 2, and a small monthly-averaged inflow adjustment that force computed water surface elevations to match observed values were computed. Once these variables were computed, they were then held constant during the second step, which evaluated the impact of the proposed Unit 3 on the reservoir and releases from North Anna Dam.

Evaporation rate at the water's surface represents the volume per surface area per unit time of liquid water that is vaporized into the atmosphere. Numerous formulations to compute evaporation rate exist in the technical literature. The formulation used in this analysis is that recommended by TVA (1972), which is also reported in Bras (1990) and is credited to Marciano-Harbeck (1954). Additional details regarding the formulation as applied in the North Anna analysis can be found in Cook et al. (2005).

Water temperatures during the historical period were based on results from the Lake Anna Cooling Pond Model developed by the Massachusetts Institute of Technology (Ho and Adams 1984). This calibrated and validated model predicts water temperatures at various locations around the WHTF and lake with the two existing reactor operating. These water temperatures were used only to compute natural evaporation from the reservoir (i.e., the background evaporation rate in the case with no reactors operating) and the induced evaporation resulting from operation of NAPS Units 1 and 2.

The volumetric water balance for the first step was computed using the appropriate watershed inflows, precipitation falling onto the lake, natural evaporation, induced evaporation from Units 1 and 2, and observed and estimated outflows from North Anna Dam. The resulting volume was then converted to a water surface elevation in the reservoir and compared to observed data. Differences in computed elevations were removed using a monthly-averaged inflow adjustment. The inflow adjustment was small and averaged 4.6 cfs over the 1978 to 2003 simulation period.

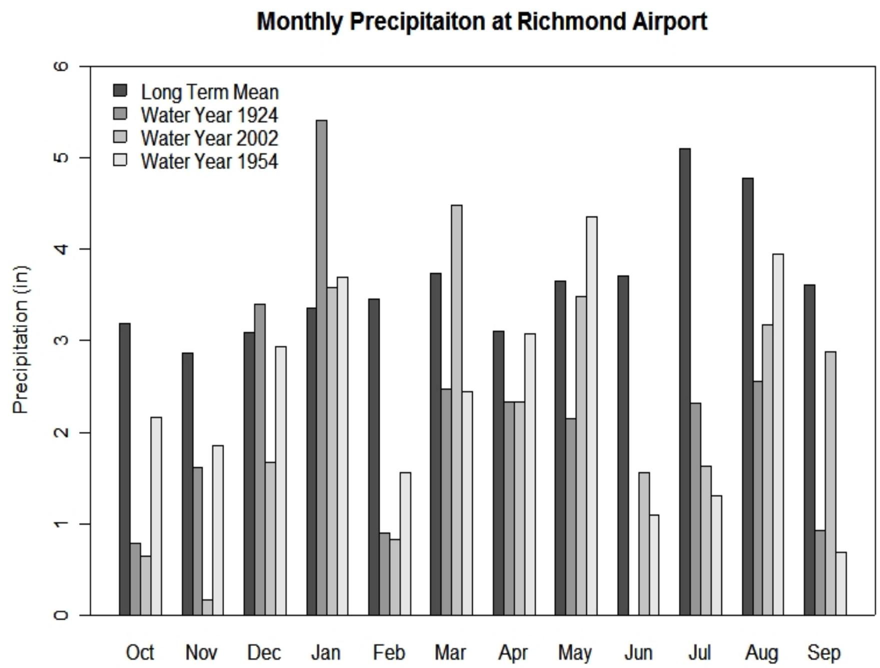

Figure K-2. Monthly Precipitation (in.) at the Richmond Airport

Table K-2. Monthly Precipitation as a Percentage of Long-Term Monthly Means During Water Years 2001 and 2002

	Percentage of Long-Term Monthly Mean	
Month	**Water Year 2001**	**Water Year 2002**
October	0.3	20.4
November	59.9	5.9
December	76.8	53.9
January	61.4	106.8
February	73.9	23.8
March	100.9	119.9
April	68.9	75.1
May	55.5	95.4
June	176.2	42.1
July	53.5	32.0
August	106.4	66.6
September	59.2	79.6
Total Annual	75.9	60.6

The second step of the assessment evaluated the relative impacts of Unit 3 operations on the reservoir and releases from the North Anna Dam. The time-series of natural evaporation rate, induced evaporation from NAPS Units 1 and 2, and inflow adjustment were applied from step one. Constant evaporation rates for the proposed Unit 3, based on PPE values, were applied and the volumetric water balance was computed. In these calculations, changes in surface area and volume as a result of reservoir drawdown were explicitly considered and influenced both the volume of natural evaporation leaving the lake and precipitation volume falling on the lake.

K.8 Assessment Results

While the entire period of October 15, 1978, through April 9, 2003, was simulated, the critical water surface elevation period was between April 2001 and February 2003. During this critical period, the region experienced a severe drought, and concerns over water use conflicts arose as the lake level elevation in Lake Anna reservoir dropped to record lows in October 2002.

Figure K-3 displays the computed time-series of lake level elevation throughout the entire simulation period. The Existing Units scenario represents the historical variation in lake level elevation during the more than 23 years of simulation with both Units 1 and 2 operating. The Existing Units plus Unit 3 scenario includes a constant loss rate of 8707 gpm from the lake, which represents the long-term average PPE evaporative loss rate from the proposed use of a wet cooling tower system for Unit 3. Figure K-4 displays the computed time-series of results during the critical drought period when minimum lake level elevation values were reached. As shown in the figure, the decline in lake level elevation is gradual, declining from elevation 250 ft above MSL in July 2001 to the minimum level in October 2002, a 15-month period. The return of lake level to elevation 250 ft MSL was rapid in comparison, and occurred over a 4-month period between October 2002 and February 2003.

Table K-3 presents the percentage of time the lake level elevation of the reservoir was near several threshold levels, which correspond to prescribed outflow discharge rates from North Anna Dam. Simulation results indicate that the percent of time the reservoir was at or below elevation 248 ft MSL and North Anna Dam was discharging 20 cfs would have increased from 6 percent with only the existing Units 1 and 2 operating to 11 percent if the proposed Unit 3 was also operating. The percent of time the reservoir elevation was at or below 246 ft was predicted to increase by 0.9 percent, from 1 to 2 percent, during the simulation period. The minimum lake level elevation reached in October 2002 during the critical drought period fell by 1.7 ft, from 245.2 ft MSL to 243.5 ft MSL. At no time during the simulation did the lake level elevation reach the minimum operational plant intake elevation of 242.0 ft MSL, when the plant would shut down.

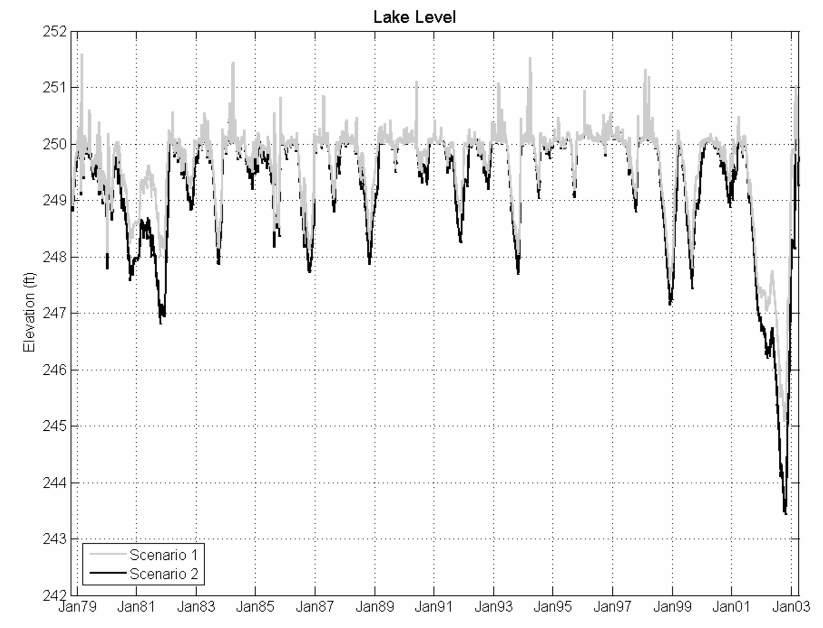

Figure K-3. Time Series of Lake Anna Lake Level Elevations for the Entire Simulation Period

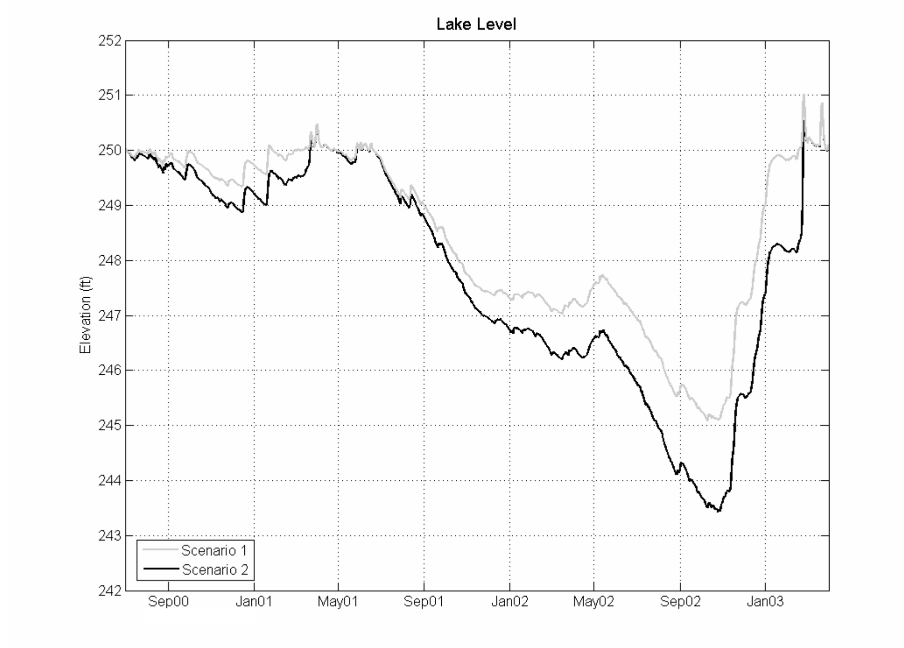

Figure K-4. Time Series of Lake Anna Lake Level Elevations During the Critical Drought Period

Table K-3. Lake Level Elevation Exceedance Table and the Minimum Water Surface Elevation for the 1978 to 2003 Simulation Period (values expressed as percent of the total simulation period)

Lake Level Elevation (ft)	North Anna Dam Discharge (cfs)	Existing Units 1 & 2	Existing Units 1 & 2 plus Unit 3
At or above 250 ft	Follows rating curve (>40 cfs)	37%	34%
Between 250 and 248 ft	40 cfs	57%	55%
At or below 248 ft	20 cfs	6%	11%
At or below 246 ft	20 cfs	1%	2%
Minimum elevation		245.2 ft	243.5 ft

Table K-4 presents differences in water surface elevation computed by subtracting the time-series of elevations computed for the Existing Units Scenario from the Existing Units plus Unit 3 scenarios (see Figure K-3). As a percent of the total simulation period, differences were less than 3 in. for over 69 percent of the simulation and less than 1 ft for over 94 percent of the simulation. The time-averaged difference in lake level elevation between the two scenarios was 2.8 in.

Figure K-5 presents the cumulative distribution frequency of Lake Anna lake level elevation for the simulation period for scenarios:

1. Existing Units
2. Existing Units plus Unit 3 at 8707 gpm average evaporation rate
3. Existing Units plus Unit 3 at 16,695 gpm (EC mode) when above 250 ft MSL dropping to the 8707 gpm average evaporation rate when below 250 ft MSL
4. Existing Units plus Unit 3 at 16,695 gpm (EC mode) when above 250 ft MSL decreasing to 11,532 gpm when below 250 ft MSL.

Figure K-5 shows that, because the lake does not store this water for later use during times of water scarcity, any additional Unit 3 evaporative losses that occur when the lake is above elevation 250 ft MSL do not impact the frequency of lake elevations below 250 ft MSL. However, if the Unit 3 evaporative loss is increased during periods when the lake is below 250 ft MSL, the duration of lake levels less than elevation 250 ft MSL would increase. For example, the frequency of lake elevation at or below 246 ft MSL increased from 1.1 percent for the existing units only scenario to 2.0 percent for the scenario where Unit 3 evaporative losses are 8707 gpm and 2.6 percent for the scenario when Unit 3 evaporation losses are 11,532 gpm.

Table K-4. Differences in Lake Level Elevation between the Existing Units 1 and 2 Scenario and the Existing Units 1 and 2 Plus Unit 3 Scenario for the 1978 to 2003 Simulation Period

Elevation Difference	Percent of Time of the Total Simulation
Less than 3 in.	69.0%
Less than 6 in.	85.0%
Less than 12 in.	94.2%
Average difference	2.8 in.
Maximum difference	1.7 ft

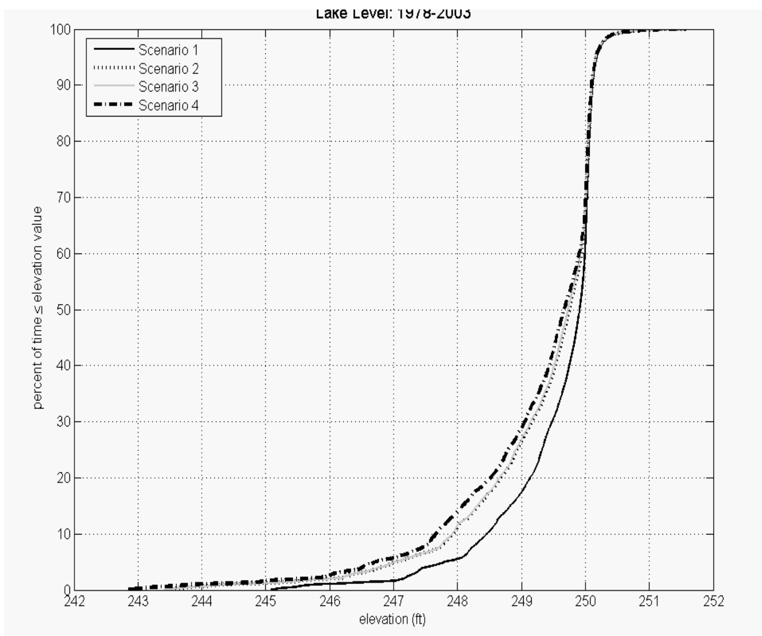

Figure K-5. Cumulative Distribution Function of Lake Anna Lake Level Elevation

Additional cumulative distribution frequencies, like those shown in Figure K-5, were developed for NAPS Units 1 and 2 plus proposed Unit 3 with modified lake level. The staff determined the increase in normal pool elevation necessary to maintain the current frequency of occurrence of 20 cfs discharge from North Anna Dam (i.e., the occurrence of 20 cfs releases). Inherent in this analysis is the assumption that the 23-yr period of record simulated would be representative of future conditions (e.g., inflows, precipitation, etc.) at the site.

If Unit 3 is constructed and the normal pool elevation of Lake Anna is concurrently raised 10 inches to 250.8 ft, the frequency of occurrence of elevation 248 ft would be unchanged. This conclusion assumes that the return period of drought and wet periods were approximately the same as the 23 year simulation period. This also implies that if the threshold for releasing 20 cfs from North Anna Dam is unchanged (i.e., remains at elevation 248 ft), the frequency of occurrence of 20 cfs would also remain the same.

Alternatively, the frequency of occurrence of 20 cfs releases from North Anna Dam could be reduced, if the threshold for decreasing releases from 40 cfs was lowered below an elevation of 248 ft. The staff evaluated lowering the threshold elevation for reducing releases from the dam to 20 cfs for the NAPS Units 1 and 2 plus proposed Unit 3 8707 gpm scenario. Results from this analysis indicate that if Unit 3 were operated and the threshold elevation reduced by approximately 10 in. to elevation 247.2 ft MSL, the occurrence frequency of 20 cfs releases would not change from the Units 1 and 2 only scenario.

The forced evaporation from proposed Unit 3 would reduce the volume of water released from North Anna Dam, thereby impacting downstream water users. To characterize this impact, the staff estimated the change in the reliability of a hypothetical off-stream storage reservoir used to service a steady water demand. The capacity of a reservoir adequate to provide releases of a steady flow of 20 cfs from the North Anna Dam from the operation of NAPS Units 1 and 2 was calculated to provide 95 percent reliability. The staff estimated that the reliability of the same hypothetical reservoir would decrease from 95 to 90 percent with the addition of Unit 3's additional consumptive water loss.

K.9 Conclusions

The separate analyses performed by the staff and Dominion resulted in different estimates of the frequency that the level of Lake Anna would drop below 75.6 m (248 ft) with Unit 3 operating. Without Unit 3, the staff and Dominion estimated that Lake Anna would drop below 75.6 m (248 ft) 5.7 percent of the time and 5.2 percent of the time, respectively. However, with Unit 3 operating the staff and Dominion estimated that Lake Anna would drop below 75.6 m (248 ft) 11 percent of the time and 7.3 percent of the time, respectively. The staff has concluded that there are two primary causes for this difference in the frequency estimates with Unit 3 operating. First, the staff used an evaporation rate of 47,462 m^3/day (8707 gpm) over any 365 day period compared to Dominion’s representation of 47,462 m^3/day (8707 gpm) at a 96 percent capacity factor. Second, the staff applied the average evaporation rate of 47,462 m^3/day (8707 gpm) throughout the period, while Dominion applied an evaporation rate that varied depending on temperature.

The staff’s analysis relied exclusively on the specific consumptive water use (evaporation) estimates that Dominion committed to in its plant parameter envelope (PPE). The PPE provides the bounding parameters used by the staff to analyze the impacts. However, in its analysis, Dominion made additional representations that were not in its PPE. For instance, as mentioned above, Dominion considered the relationship between the weather and the estimated consumptive water use for Unit 3. In its analysis, Dominion indicated that Unit 3 would use no water for condenser cooling (i.e., the condenser heat load for Unit 3 would be serviced entirely by the dry tower) if the air temperature was below 67°F. This temperature value is not a parameter that Dominion committed to in the PPE. Also, Dominion estimated the daily consumptive water losses for both the condenser and service water cooling systems based on air temperature and relative humidity. The staff concluded that the consumptive water use estimates used by Dominion are not unreasonable if the representations described above are fulfilled. However, because the bases for these values were not included in Dominion's PPE, the staff performed an independent analysis relying on average and maximum consumptive water use values reported by Dominion in its PPE.

In the PPE, Dominion stated that the average evaporation rate for Unit 3 was 8707 gpm with a 96 percent capacity factor. However, Unit 3 has the potential to operate at a capacity factor greater than 96 percent for extended periods. Therefore, the staff used the PPE definition described in Appendix I of the EIS that drops the 96 percent capacity factor and states that "...the average evaporation rate over any 365 day period will not exceed 8707 gpm". The definition of the PPE instantaneous maximum evaporation rate parameters for the MWC and EC modes was unchanged.

The only operational activity with respect to proposed Unit 3 that would result in a detectable hydrological alteration of the environment is the additional consumptive use of water to cool the unit. Although some blowdown from the closed-cycle, combination dry and wet cooling system would occur, the quantity of discharge is much less than the discharge from the existing Units 1 and 2. The additional withdrawal of cooling water for the new Unit 3 would increase the duration of time the lake level elevation is below 250 ft MSL, and hence periods of reduced releases from North Anna Dam would occur. Unit 3 evaporative cooling withdrawals would also reduce the minimum lake level elevation of Lake Anna during periods of drought.

Calculated lake level elevations during the critical period between June 2000 through April 2003 predicted minimum elevations during the second week of October 2002. The minimum elevation predicted for continuous operation of Units 1 and 2 is 245.2 ft, whereas, the addition of Unit 3 would result in further declines to 243.5 ft.

The periods of minimum releases from the dam would also increase with the operation of the proposed Unit 3. For example, the percentage of time of minimum release (20 cfs) would increase from 6 percent to 11 percent, and the percentage of time release greater than 40 cfs would decrease from 37 percent to 34 percent.

K.10 References

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Appendix L

Authorizations and Consultations

Appendix L

Authorizations and Consultations

Table L-1 contains a list of the environmental-related authorizations, permits, certifications, and consultations, potentially required by Federal, State, regional, local, and affected Native American tribal agencies for activities related to site preparation, construction, and operation of potential new nuclear units at the North Anna early site permit site.

Table L-1. Federal, State, and Local Authorizations and Consultations

Agency	Authority	Requirement	Activity Covered
Federal Aviation Administration	49 USC 1501; 14 CFR 77.13; Code of Virginia, Section 5.1-25.1	Construction Notice	Notice of erection of structures (>200 feet) potentially impacting air navigation. A permit from the Virginia Aviation Board would be needed if FAA identifies the structure as an air navigation obstruction.
NRC	10 CFR Part 52, Subpart C	Combined License	NRC requirements and procedures applicable to issuance of combined licenses for nuclear power facilities
NRC	10 CFR Part 30	Byproduct Materials License	NRC license to possess special nuclear materials
NRC	10 CFR Part 70	Special Nuclear Materials License	NRC license to possess nuclear fuel
ACE	CWA 33 USC 1344	Section 404 Permit	Disturbing or crossing wetland areas or navigable waters
ACE	Rivers and Harbors Act, Section 10; 33 USC 403	Section 10 Permit	Impacts to navigable waters of the United States
FWS and NOAA Fisheries	Endangered Species Act, 16 USC 1536	Consultation regarding potential to adversely impact protected species	Consultation concerning potential impacts to threatened and endangered species and their habitat
Virginia State Corporation Commission	Code of Virginia, Section 56-580D	Permit	Approval for construction of new generating facility
VDEQ	9 VAC 5-20-160	Registration	Annual re-certification of air emission sources
VDEQ	Clean Air Act, Title V; 9 VAC 5-80-50	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	CWA, Section 402; 9 VAC 25-10	Virginia Pollutant Discharge Elimination System Permit (VPDES)	Regulate limits of pollutants in liquid discharge to surface water

Table L-1. (contd)

Agency	Authority	Requirement	Activity Covered
VDEQ	9 VAC 25-150	General Permit Registration Statement for storm water discharges from industrial activity (VAR5)	General permit to discharge storm water during operations
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 ACE Section 404 permit.
VDEQ	CWA, Section 401; 33 USC 1341	Section 401 Certification	Compliance with water quality standards
VDEQ	9 VAC 25-220	Surface Water Withdrawal Permit	Permit to withdraw water from Lake Anna (unless otherwise regulated by State Water Control Board)
VDEQ	Coastal Zone Management Act, 16 USC 1456	Consistency determination	Compliance with Virginia Coastal Program
VDEQ	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
VDEQ	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 25-180	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
Virginia Department of Historical Resources	National Historic Preservation Act, Section 106; 36 CFR Part 800	Cultural Resources Survey/Review	Confirm ESP site does not contain protected historic/cultural resources
Virginia Marine Resources Commission	9 VAC 25-210	Permit	Permit to fill submerged land. Joint application with ACE Section 404 permit.

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(See instructions on the reverse)

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10. SUPPLEMENTARY NOTES

Docket Nos. 52-008

11. ABSTRACT *(200 words or less)*

This environmental impact statement (EIS) has been prepared in response to an application submitted to the U.S. Nuclear Regulatory Commission (NRC) by Dominion Nuclear North Anna, LLC (Dominion), for an early site permit (ESP). The proposed action requested in Dominion's application is for the NRC to (1) approve a site within the existing North Anna Power Station (NAPS) boundaries as suitable for the construction and operation of one or more new nuclear power generating facilities and (2) issue an ESP for the proposed site located at NAPS. The proposed action does not include any decision or approval to construct or operate one or more units; these are matters that would be considered only upon the filing of applications for a construction permit and an operating license, or an application for a combined license.

The staff's recommendation to the Commission related to its environmental review of the proposed action is that the ESP should be issued. This recommendation is based on (1)the Environmental Report (ER) submitted by Dominion; (2) consultation with Federal, State, Tribal, and local agencies; (3) the staff's independent review; (4) the staff's consideration of public comments on both the Draft EIS and the SDEIS; and (5) the assessments summarized in this Final EIS, including the potential mitigation measures identified in the ER and in the EIS. In addition, in making its recommendation, the staff has concluded that the alternative sites considered are not obviously superior to the proposed site. Finally, the staff concludes that the site preparation and preliminary construction activities enumerated in 10 CFR 50.10(e)(1) would not result in any significant adverse environmental impact that cannot be redressed.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

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