Chapter 4 Environmental Impacts of Construction

Chapter 4 presents the potential impacts of the construction of the new units. In accordance with 10 CFR 51, impacts are analyzed, and a single significance level of potential adverse impacts (i.e., small, moderate, or large) has been assigned to each analysis. This is noted in respective topic discussions. Mitigation of adverse impacts is also presented, where appropriate. Construction activities would take place within a clearly-defined and access-controlled area designated as the construction site. This chapter is divided into six subsections which address the following topics:

- Land use impacts
- Water-related impacts
- Ecological impacts
- Socioeconomic impacts
- Radiation exposure to construction workers
- Measures and controls to limit adverse impacts during construction

The environmental description, where referenced, includes the following definitions:

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

4.1 Land-Use Impacts

This section discusses the potential land use impacts associated with construction of the new units. Construction activities would not require any current, or planned, land uses to be changed or modified from the existing NAPS site or vicinity land uses, either temporarily or permanently. The land use areas considered include those that have the potential to be directly impacted by construction activities (e.g., the site, the vicinity, along transmission corridors, and offsite areas). Additionally, land use considerations include those historic properties identified in the NRHP, as well as those properties that have the potential to hold potential historically significant items such as artifacts and human remains. This section is divided into three subsections: 1) site and vicinity, 2) transmission corridors and offsite areas, and 3) historic properties.

4.1.1 The Site and Vicinity

This section describes the construction impacts on land use of the NAPS site and vicinity. The NAPS site is located in Louisa County, Virginia. The area identified as the NAPS site, which includes the EAB extending out 5000 feet from the reactors, creates an entire site area of approximately 730 hectares (1803 acres). The ESP site is located entirely within the NAPS site. The ESP vicinity is defined as the area approximately within 6 miles of the existing units, making the entire vicinity area approximately 29,300 hectares (72,400 acres). The vicinity surrounding the ESP site contains parts of Louisa and Spotsylvania counties. Each county has different designations and definitions for land-use categories. Unless otherwise referenced, the information used in this section was taken from the Final Supplement 7 to the Generic Environmental Impact Statement (GEIS) Regarding License Renewal for the NAPS, Units 1 and 2 (Reference 1) as well as from contacts with applicable county-level agencies.

4.1.1.1 **Louisa County Land Use**

Louisa County lies on the southern shore of Lake Anna. During the 30 years since the existing units were constructed, Louisa County has experienced substantial growth in population but relatively little growth in industry. The predominant land use in the county remains forestry. Forestry activities are a major contributor to the county's economy through employment, the sale of timber and forest products, and the generation of forest-related support activities. Other land uses include: agricultural lands occupy 23.5 percent, developed land uses occupy 6 percent (i.e., residential development predominates with 5.5 percent of the county land area) and water resources about 3 percent. Residential land use has increased 3.7 percent since 1979.

Louisa County land-use changes have been generally consistent with changes in the region as a whole. The county's proximity to metropolitan areas (i.e., Richmond, Charlottesville, and Fredericksburg, Virginia), combined with regional population growth trending away from metropolitan areas toward less developed areas like Louisa County, are the predominant forces resulting in county land-use changes.

4.1.1.2 **Spotsylvania County Land Use**

Spotsylvania County lies on the northern shore of Lake Anna. Historically, agriculture and forestry have been important components of the county's economy. Currently, 11 percent of the total county land is in agriculture and 64 percent is in forest. Developed lands (e.g., residential, industrial, commercial, public lands) cover 25 percent of the county, with residential use representing 22 percent of the developed land.

4.1.1.3 **Vicinity Land Use Areas**

Land use maps of the NAPS site and the vicinity have been prepared by the County of Louisa, Department of Planning and Zoning, and the Spotsylvania Planning Department (Reference 2) (Reference 3). Within the vicinity of the ESP site, the predominant land use is forestry and agricultural, followed by residential. Table 4.1-1 identifies the land areas developed for major uses within the ESP site boundary and vicinity.

Table 4.1-1 Land Use within the ESP Site and Vicinity

Land Use	Area[a] (Hectares)
Forestry	15,000
Industrial	2,700
Agriculture	5,600
Residential	2,200
Recreational	3,200
Other	600
Total Area	29,300

a. Areas shown are approximated based on zoning maps provided by Louisa and Spotsylvania counties (Reference 2) (Reference 3).

4.1.1.4 NAPS Land Use

The entire NAPS site is zoned for industrial use by Louisa County. All construction activities for the new units, including ground-disturbing activities, would occur within the NAPS site boundary. The area that would be affected on a long-term basis as a result of permanent facilities is approximately 52 hectares. The additional areas that would be disturbed on a short-term basis (e.g., as a result of temporary facilities, lay down areas) is approximately 27.5 hectares. Table 4.1-2 lists the general construction zones and their expected areas within the NAPS site boundary.

Table 4.1-2 Construction Areas

Construction Zone	Area (Hectares)
Material Lay Down	10
Parking Lot	6
Temporary Offices and Warehouses	6
Spoil Stockpile and Overflow	4
Batch Plant	1.5
Total Area	27.5

A site redress plan has been developed (see Part 4: Chapter 1, Site Redress) that addresses the need to stabilize and/or restore lands disturbed by pre-construction activities. Locations that are permanently disturbed would be stabilized and contoured in accordance with design specifications to meet the surrounding areas. Re-vegetation of disturbed lands would be compliant with site maintenance and safety requirements. Methods used to stabilize and restore areas would be compliant with applicable laws and regulations, permit requirements, good engineering and construction practices, and recognized environmental best management practices. Methods that may be used to restore and stabilize disturbed areas are as follows:

- Re-contour with heavy equipment
- Mulch, seed, and plant
- Re-vegetate
- Provide permanent stabilization (e.g., pavement, rock, and gravel)
- Install permanent and/or temporary storm water management and erosion and sediment controls

4.1.1.5 Highways, Railroads, and Rights-of-Way

Figure 4.1-1 illustrates the existing highways, railroads, and transmission rights-of-way that cross the NAPS site and vicinity. No new or modified (e.g., widened) highways or railroads are planned to support the new units. As described in Section 2.2.2 and Section 3.7, 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, if and when Dominion decided to proceed with the development of new units at the ESP site to confirm this conclusion.

4.1.1.6 Other Land Uses Considered

4.1.1.6.1 Recreational Areas

Lake Anna extends along the northern border of the NAPS site. Recreational use of the North Anna Reservoir is controlled by VDCR and is open to the public. Construction of a new water intake system would generally be limited to activity along a small portion of the North Anna Reservoir shoreline. Any work conducted immediately adjacent to the lake would be performed in accordance with applicable federal, Virginia, and local laws and regulations, permits, and authorizations. Therefore, construction-related impacts would not affect the recreational uses of the lake. See Section 2.4.1 and Section 2.4.2 for potential ecological impacts and Section 4.4.1 for physical impacts associated with the new units.

Another recreational area within the vicinity of the ESP site is Lake Anna State Park. The park is across the lake from the ESP site and to the northeast in Spotsylvania County. No construction-related impacts would affect recreation at the park.

4.1.1.6.2 Water Courses and Wetlands

A few small wetland areas and two intermittent streams exist on the ESP site (refer to Section 2.4.1). Watercourses and wetlands would be avoided to the extent possible during any construction. Any work that has the potential to impact a wetland would be performed in accordance with the applicable regulatory requirements and necessary mitigation strategy. Therefore, construction-related impacts would be small.

4.1.1.6.3 **Floodplains**

The floodplain along the Lake Anna shoreline has been determined using the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (Reference 4). Any flooding that might occur during construction of the new units would be limited to areas adjacent to the lake shoreline (i.e., below elevations of 255 feet above msl). Limited construction activity would occur within the lake floodplain for the construction and installation of a new water intake structure. Any construction work conducted within the floodplain would be performed in accordance with the applicable regulatory requirements. Therefore, no construction-related impacts are expected to affect current land uses within floodplains.

4.1.1.6.4 **Forested Areas**

Forested land does exist within the ESP site. Clearing and removal of trees within the ESP site would be required. The removal of the trees would not create land-use impacts on the existing (industrial) site or vicinity. Section 4.3.1 describes the removal of trees and ecological impacts resulting from such removal.

4.1.1.6.5 **Agriculture**

There are no agricultural lands within or adjacent to the ESP site. Therefore, no farmlands would be impacted by proposed construction activities.

4.1.1.7 **Significant Cumulative or Other Impacts**

Since construction activities would be limited to the ESP site, the new units would not impact federal, Virginia, regional, local, or Native American tribal land-use plans. Additionally, the new units would not significantly impact any future local or regional land-use plans (see Section 2.2.1 and Section 2.2.3). There are no known federally-sponsored actions that would have cumulatively significant impacts on construction activities, either at the ESP site or within the vicinity. Land or other similarly designated areas that may be considered for development (other than industrial) would be addressed through local county jurisdiction. All construction impacts on land use would be small and would not warrant mitigation.

4.1.2 **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, if and when Dominion decided to proceed with the development of new units at the ESP site, to confirm this conclusion. Additional transmission system information is provided in Section 3.7.

No new routes of access corridors would be necessary to serve operation of the new units. No offsite land uses would be affected by operation of the new units.

4.1.3 Historic Properties and Cultural Resources

This section provides information on potential impacts from new unit construction activities on historic properties in the NAPS site and vicinity, along transmission corridors, and offsite areas.

Historic properties listed in the NRHP that exist within the vicinity of the ESP site are identified in Section 2.5.3. There are no known historic properties listed in the NRHP that exist within the NAPS site boundary or within the existing transmission corridors. No offsite areas would be impacted by construction activities associated with the new units.

Virginia Power has maintained communications with the Virginia Division of Historic Resources (VDHR) regarding the management of the NAPS site and the potential ground-disturbing activities in areas that have the potential for containing historic and/or archaeological artifacts.

Prior to any activities that would disturb existing ground conditions, Dominion would assess the need, in coordination with VDHR, to undertake subsurface investigations for the identification of potentially significant historic or cultural resources in the area(s) to be disturbed. The investigations would be conducted in accordance with professional archeological practices and recommendations as developed in coordination with VDHR.

Additionally, 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.

Section 4.1 References

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

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

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

4. *Flood Insurance Rate Map, Louisa County, VA and Incorporated Areas*, Federal Emergency Management Agency (FEMA), U.S. Department of Interior, November 1997.

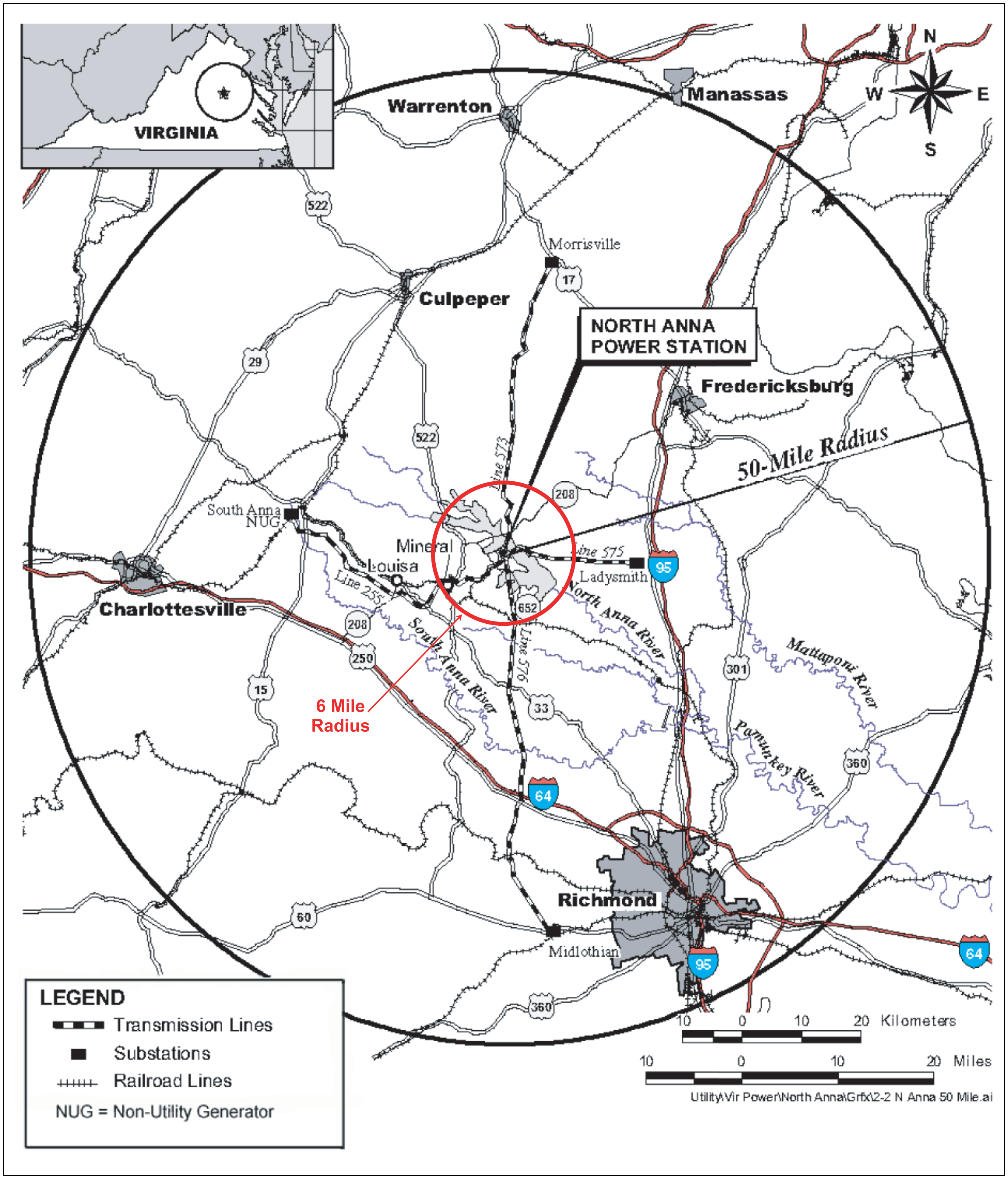

Figure 4.1-1 Vicinity Highways, Railroads, and Utility Rights-of-Way

Source: Reference 1, Figure 2-5

4.2 Water-Related Impacts

This section addresses hydrologic alterations and water-use impacts that would result from new unit construction activities at the ESP site. The discussion includes mitigation measures that would be incorporated to reduce adverse impacts from hydrologic alterations and water-use. Compliance with applicable regulatory requirements is also addressed.

4.2.1 **Hydrologic Alterations**

During construction of new units at the ESP site, hydrologic alterations would occur to two small ephemeral streams, the North Anna Reservoir, and groundwater. Mitigation measures would be implemented to reduce adverse impacts. This section addresses each of the alterations and the mitigation measures that would be used to reduce the adverse impacts.

4.2.1.1 **Surface Water**

Currently, the ESP site area slopes gently north toward the North Anna Reservoir. Runoff from the majority of the site reaches the North Anna Reservoir as sheet flow or shallow concentrated overland flow. In the cooling tower area that is west of the power block area, two small ephemeral streams discharge to the North Anna Reservoir. These streams are designated Stream A and Stream B on Figure 4.2-1. The drainage areas for Streams A and B are about 74 and 56 acres, respectively (Reference 1). Should dry cooling towers be constructed, portions of these ephemeral steams would be filled to level the site. Approximately 1500 feet of stream channel would require filling.

The ESP site drainage system design would incorporate measures to convey streamflows to Lake Anna. Construction activities would comply with the applicable regulatory requirements governing the filling of these ephemeral streams. All required permits would be obtained prior to the commencement of construction.

During construction of the new units, the potential would exist for sediment from the construction site to be eroded and conveyed to Lake Anna by storm water runoff until the ESP site drainage system is installed and construction is completed. Best management practices (BMPs) described in the Virginia Erosion and Sediment Control Handbook (Reference 2) would be used to control erosion and minimize the sediment load to Lake Anna in accordance with an approved erosion and sediment control plan. Best management practices may include sediment basins, sediment barriers, vegetative stabilization and filter strips, rip rap, rock filter berms, mulching, etc. Other than the two ephemeral streams, there are no other existing defined drainage channels or streams in the proposed area of construction.

Once construction is completed and the ESP site has been stabilized, the risk of increased sediment loading to the lake would be minimal. Given the volume of Lake Anna and the use of state-approved BMPs, the adverse impacts from sediment loading to Lake Anna would be small.

The small amount of sediment that could reach Lake Anna during construction would settle out in the vicinity of the ESP site.

The make-up water intake for the new Unit 3 would be located along the shoreline of the North Anna Reservoir west of the intakes for the existing units. A cofferdam installed in the early 1980s for the construction of the intake for the abandoned Units 3 and 4 exists at this location. Construction of the intake for the new Unit 3 would require dewatering. Because of the cofferdam, the intake location is not in contact with the North Anna Reservoir. Therefore, construction of the shoreline intake could proceed without any hydrologic impacts to the North Anna Reservoir. State-approved BMPs would be implemented prior to construction of the intake to reduce the impacts of erosion and sedimentation.

After construction of the intake, the cofferdam would be removed. Removal of the cofferdam would temporarily create the potential for increased sediment loading to the North Anna Reservoir in the vicinity of the new intake. The increased sediment loading would be mitigated by the installation of approved mitigation measures, such as silt curtains or similar methods, and BMPs. Federal, state, and local permits associated with the removal of material from the cofferdam area and/or lake would be obtained prior to construction of the new units. By implementing the mitigation measures, any adverse impacts to the reservoir would be small, and limited to the duration of the cofferdam removal. Removing the cofferdam would also permanently increase the North Anna Reservoir surface area and shoreline as the lake fills in the void behind the cofferdam and reaches the original shoreline.

4.2.1.2 **Groundwater**

Depending on the reactor type selected, excavations for foundations could reach depths of up to 140 feet below the final grade elevation. The final grade elevation is anticipated to be at or near the grade at the existing units at Elevation 271.0 ft. Therefore, the foundation excavations could reach approximately Elevation 130 ft msl. Based on measurements in observation wells at the site, groundwater is present at depths as shallow as about 5 feet below existing grade (Section 2.3.1.2). Dewatering would be required to a greater or lesser extent in excavations extending below the water table to permit construction of foundations. Dewatering for individual excavations would continue until construction is raised to a point above the water table and backfill is placed in the excavation.

The dewatering process would draw down the water table in the excavated area and the area surrounding the excavation. Subsurface investigations indicate that the subsurface materials underlying the ESP site consist of residual soils and metamorphic bedrock. Based on the experience gained from the construction of the existing units and abandoned Units 3 and 4, the drawdown created by dewatering would be localized to the area of the ESP site.

Impacts of the dewatering drawdown would be temporary and small.

Groundwater extracted from the excavations would be monitored and, if necessary, treated to remove sediment before discharging it to the North Anna Reservoir. The additional flow to the North Anna Reservoir resulting from dewatering activities would be temporary and small. Groundwater at the ESP site is generally of good quality, as presented in Section 2.3.3.2, and its discharge to the North Anna Reservoir would not have an adverse affect on the quality of the water in the lake.

4.2.2 **Water-Use Impacts**

This section identifies construction activities or construction-related alterations that could impact water use. Proposed practices to minimize adverse impacts are also presented.

Construction activities for the new units would be limited to the ESP site adjacent to Lake Anna.

In addition to the existing units, there are three known industrial water users (Bear Island Paper Co., St. Laurent Paper Products, and the Doswell Water Treatment Plant) that take water from the affected hydrologic system. The existing units use lake water for their circulating water systems. The general public uses the lake for recreational boating and fishing. Impacts of construction activities to the lake and the North Anna River would be temporary and limited to the area near the construction site. The only impact would be a small increase in sediment loading in the lake near the new units. Other than increased sediment loading near the site, no other water quality impacts to surface waters are anticipated.

In addition to the Erosion and Sediment Control Plan, an approved construction storm water pollution prevention plan (SWPPP) would be implemented for the duration of construction activities at the ESP site. The SWPPP would provide approved measures to prevent fuel, oil, and other chemicals associated with construction from contaminating the surface water or the groundwater. Applicable federal, state, and local permits would be obtained prior to the commencement of construction. Because any impacts would be limited to the area adjacent to the lake, no impacts to the recreational water use of Lake Anna are anticipated. Additionally, there would be no water quality impacts to the North Anna River upstream or downstream of the ESP site.

The private groundwater user nearest to the ESP site is about one mile south-southeast. Because the impacts of dewatering would be confined to the area around the ESP site, private groundwater uses would not be affected. There are also existing potable water wells at the NAPS site. Some of the existing potable water supply wells at the site could be affected by the resulting drawdown.

The combined production capacity of the water supply wells of the existing units is greater than the water use requirements (Section 2.3.2.2.2). Because not all of the water supply wells would be affected by construction dewatering, the excess capacity of the unaffected wells would be sufficient to supply the needs for the existing units. However, if additional water is needed, a temporary supply of potable water could be obtained from an offsite source.

4.2.3 **Future Growth and Development Impacts**

As shown in Figure 2.3-9, the watershed draining to Lake Anna upstream of the North Anna Dam, referred to as the "upstream watershed," lies within three counties: Louisa, Spotsylvania and Orange Counties. Downstream of the North Anna Dam, the North Anna River becomes part of the Pamunkey River Basin, which lies within the land of Hanover County, Caroline County, New Kent County and King William County. Further downstream, the Pamunkey River joins with the Mattaponi River to form the York River, which is tidal and its flow availability will not be affected by the inflow from the North Anna River and the Pamunkey River.

In the consideration of regional water use and water budget, future growth and development will impact a watershed in three ways:

1. Increase withdrawal from surface water and/or groundwater resources to meet the rising water demand from population, commercial and industrial growth.

2. Increase impervious area due to urbanization and land development will reduce groundwater recharge and affect the local and regional water budget.

3. Increase impervious area due to urbanization and land development will increase runoff volume and/or peak runoff intensity.

Anticipated changes in the upstream land-use and downstream water demand are described below.

4.2.3.1 **Future Upstream Land-Use Changes**

The upstream watershed lies in three counties in Virginia: Louisa, Spotsylvania and Orange. The watershed is predominantly rural with residential areas in the immediate surrounding of Lake Anna. Of the acreage in the Lake Anna watershed, 57 percent is forest, 38 percent is covered with cropland and pasture. Only 3 percent of the land is developed for residential use (Reference 3). The comprehensive plan for each county (Reference 4, Reference 5, and Reference 6) indicates that future growth and land use changes are expected in all three counties.

The following examines the projected growth and impact in each of the three upstream counties.

4.2.3.1.1 **Louisa County**

Louisa County has projected a population increase of about 36 percent over the 20-year period from 2000 to 2020. The Comprehensive Plan proposes the designation of growth centers to guide future growth and development to preserve and protect the rural character of the county as well as provide for efficient delivery of public services. Most of the growth will center around existing towns in the county. Of these towns, parts of Louisa, Mineral, and Gordonsville lie within the Lake Anna watershed. The town of Gordonsville is actually in Orange County, but portions of the growth area for this town are in Louisa County. Most of the area adjacent to Lake Anna has been designated as low density residential with smaller portions designated as village residential (see Map 24 of Comprehensive Plan). (Reference 4)

The Plan recognizes that water resources in Louisa County are somewhat limited, and careful planning for allocation of scarce and costly water resources is required to support the projected growth. Historically, Louisa has been a county of individual well and septic systems with 89 percent of the county's residents relying on groundwater for their drinking water. Public water and sewer are provided for the towns of Louisa and Mineral and the adjoining areas. The Northeast Creek Reservoir just north of Route 33 between the towns of Louisa and Mineral, outside the Lake Anna watershed, serves the water needs of the two towns and would provide water for the future development in that area. Future growth and development in the areas not supported by the reservoir would increase groundwater withdrawal rate. However, impact to both the groundwater and surface water resources in the Lake Anna watershed is not expected to be extensive since future land use outside the towns is planned to be low density development.

According to Louisa County website (Reference 7), about 71 percent of County's land is in natural and planted forest land, 16 percent in crop, pasture and open land, 10 percent developed as urban, residential and industrial, and 3 percent in water bodies. With growth projected for these areas, the percentage of developed land is expected to increase slightly in future years leading to more impervious areas. To minimize the impacts of this growth on storm water runoff and downstream water resources, the Comprehensive Plan recommends implementation of policies to encourage the use of storm water management measures that promote infiltration and discourage the use of impervious surfaces. Since the majority of the Lake Anna watershed within Louisa County is not designated as growth centers and future development is expected to be primarily of the low-density residential type, the impact to groundwater recharge and surface runoff are expected to be small.

4.2.3.1.2 **Spotsylvania County**

Spotsylvania County's population has increased rapidly at an annual growth rate of 4.5 percent from 1990 to 2000. The rapid growth in the county has been primarily concentrated in the northern and central portions of the county in a concentric pattern around the City of Fredericksburg as well as along Route 3, Route 17, and Route 208, outside of the Lake Anna watershed. There has also been significant growth around Lake Anna, primarily recreational and retirement living. In the remainder of Spotsylvania County, a rural settlement pattern predominates even though growth is occurring. One of the goals of the 2002 Comprehensive Plan of Spotsylvania County (Reference 5) is to implement policies to limit the growth rate to 2 percent annually and achieve a 70/30 mix of residential to commercial/industrial development. The Plan recommends that the residential growth continue within the settlement areas of the county in proportion to existing development patterns. Most of the county's residential, commercial, office and industrial development has occurred and will continue in the "Primary Settlement District" near Fredericksburg. To discourage growth outside the designated areas, a Primary Development Boundary has been established to define the area within which public utilities would be provided. Both the Primary Settlement District and the Primary Development Boundary are outside the Lake Anna watershed. In the Lake Anna District, there is a plan to allow for development of a village center and to allow public water and sewer services within the boundaries of the village center. The rest of the Lake Anna watershed in Spotsylvania County would remain largely low-density residential area and would rely on private groundwater wells. (Reference 5)

Water supply for the county mainly comes from surface water. The county's water supply system consists of the Ni Reservoir, the Motts Run Reservoir, an intake on the Rappahannock River, and the Hunting Run Side-Stream Storage Reservoir with an intake on the Rapidan River, all of which are outside the Lake Anna watershed.

Groundwater is not considered a viable public water source for Spotsylvannia County. Currently, approximately one-third of Spotsylvania County residents use small private wells that withdraw from the Piedmont aquifers, which are generally low yielding and highly variable in thickness and hydrologic characteristics. Because of this, groundwater is dedicated for residential use only, and withdrawals for commercial and industrial purposes are denied. (Reference 8)

Several alternatives have been considered to meet future water supply demands including expanding existing reservoirs and adding new impoundments. The Rappahannock River is considered a promising source of water for domestic and industrial consumption. It has been determined that Lake Anna, on the other hand, would be unavailable as a significant water resource for Spotsylvania County (Reference 8). Future growth in the County is therefore not expected to impact the water budget of the Lake Anna watershed.

The Plan recommends implementation of land use and best management practices to limit the increase of impervious areas created due to future growth to reduce their impact on groundwater recharge and runoff increases.

4.2.3.1.3 **Orange County**

Orange County is a rural community whose economic base is primarily agricultural. The future land-use plan is built around the goal of striving to protect the farm and forest land. In the next decade (2000-2010), the population growth is projected at 2.25 percent per year, which is somewhat above the normally accepted highest level for orderly growth rate of 2 percent. The Comprehensive Plan (Reference 6) advises that the County should limit growth to those areas that can support it: places where water supply, sewage disposal, transportation and other public facilities and services can be provided at low cost. Development is encouraged in the existing growth areas: the Towns of Orange, Gordonsville, Unionville, and Rhoadesville, the area around the Orange County Airport, and the Germanna Highway Corridor. Among these areas, parts of the towns of Orange, Gordonsville, Unionville, and Rhoadesville border on the Lake Anna watershed. According to the future land use map 2000-2020, a majority of the county lying within the Lake Anna watershed would remain agricultural. (Reference 6)

The county lies between the headwaters of York and Rappahannock Rivers, with its northern limit bounded by the Rapidan River and the southern limit bounded by the North Anna River. The primary sources of water for the near term are the Rapidan River and domestic wells. Impoundments have yet to be exploited as a source of water except on a few farms. In most parts of the county, an adequate supply of water is obtained from springs, streams, and wells. Farm ponds are used to supply water for livestock. A total of 300 to 370 farm ponds have been inventoried in the county. The North Anna River and its tributaries are small and supply only a small amount of water. As the county's population continues to grow, new development would be encouraged where it can be supplied from surface water sources. The flow of the Rapidan River is limited, but the water supply can be augmented through impoundments. The Comprehensive Plan recommends that the county should look well into the future when planning for impoundments due to the lengthy permitting processes. (Reference 6)

Under the current Riparian Rule, Orange County has little control over how much water is withdrawn upstream on the Rapidan River. Construction of impoundments in the county has been considered for several decades. It does not appear that North Anna River and its tributaries would be considered as future water source for the county due to their small flow. Groundwater offers several advantages compared to river withdrawal and surface reservoirs. The Plan recommends investigating groundwater conjunctively or independently, with surface water sources. The area of the county appearing most suited for groundwater resource is the northern tip of the Triassic Barboursville Basin. (Reference 6)

Over 58 percent of Orange County's 355 square miles land area is in commercial farms and forestland, areas that are critical to groundwater recharge. Residential, commercial, industrial and public uses occupy about 5 percent. The Plan also recognizes that the location of new development has an impact on groundwater. It is a goal of the Comprehensive Plan to protect the groundwater resources by implementing policies to identify and protect groundwater recharge areas as well as to minimize impact on surface runoff. (Reference 6)

4.2.3.2 **Future Downstream Water Withdrawal Changes**

The North Anna and Pamunkey River are both potential water sources for industrial and potable use in the downstream counties. These rivers pass through Hanover, Caroline, King William, and New Kent Counties in Virginia. Counties downstream along the York River will not be discussed further since the river is tidal and inflows from the Pamunkey River would not affect the availability of the York River water.

The comprehensive plan for each of these counties (Reference 9, Reference 10, Reference 11, and Reference 12) indicates that growth is anticipated and that additional water resources would be needed. The Hanover County Comprehensive Plan (Reference 9) describes an alternative that includes water withdrawal from the North Anna River. Additionally, the Comprehensive Plan for Caroline County (Reference 10) and New Kent County (Reference 11) list the Pamunkey River as a possible source for future water needs. The King William County plan, while indicating future water needs, does not list the Pamunkey River as a possible source.

Use of the North Anna/Pamunkey River by the downstream counties for future water use would further reduce the overall water volume in the Pamunkey River in addition to the reduction from the addition of the new units at North Anna Power Station.

The following examines the projected growth and impact in each of the four downstream counties that will affect the flow in the North Anna River or Pamunkey River:

4.2.3.2.1 **Hanover County**

The Hanover County Comprehensive Plan adopted in June 2003 (Reference 9) states that the long-range population growth should be maintained at an average rate of 2.5 percent, and that suburban development should be concentrated in those sections of the county with an existing infrastructure so that suburban services can be most economically provided within the 2022 suburban boundary.

The need for future water supplies has been recognized since the 1970s. The findings of numerous studies agree that the groundwater resources of Hanover County are restricted by quantity and quality and are not viable for meeting the county's long-term water resource requirements.

Currently, the county provides water service from 11 wells and 2 surface water treatment plants. In addition, the county has water supply contracts to purchase water from Henrico County and from the City of Richmond. Of the two water treatment plants, Doswell Water Treatment Plant has a capacity of 4 million gallons per day (MGD) (6.1 cfs) and uses the North Anna River as its source. Through its contract with the City of Richmond, the county would have 20 MGD of water available to it through 2010. Currently, 10 MGD of water is available from Richmond. It is estimated that the 20 MGD capacity of this contract, when combined with other supply sources available to the county, would meet the county's average and peak day demands to sometime during 2020–2025 period, depending on growth within the Suburban Service Area (Reference 9).

Among the various water supply alternatives proposed, two are being retained for incorporation into the Comprehensive Plan, one of which would require a new river intake of 30 MGD (46 cfs) estimated capacity at the North Anna River. The minimum instantaneous release from the North Anna Dam under normal conditions is 25.8 MGD (40 cfs) when lake level is at or above 248 ft MSL in accordance with the Lake Level Contingency Plan operating rules (Reference 13). During drought condition, when the lake level reaches 248 ft MSL, the Lake Level Contingency Plan operating rules requires a minimum instantaneous release limit of 12.9 MGD (20 cfs). Although the Hanover County Comprehensive Plan does not specify the location of the North Anna River intake, it does not appear feasible to plan for a new intake at the North Anna River with a capacity of 30 MGD as the river may not be able to support this flow in addition to the existing Doswell WTP intake with a 4 MGD of capacity given the Lake Level Contingency Plan operating rules as defined for the North Anna dam. The addition of Unit 3 at the North Anna site would have no impact on these operating rules and there would be no changes in the minimum instantaneous release values.

4.2.3.2.2 **Caroline County**

During the period of 2000 to 2010, the population of Caroline County is projected to grow by 14 percent to 36 percent, depending on the growth scenario. The Comprehensive Plan (Reference 10) recognizes the need to conduct a long range water supply planning for the county as a whole to sustain anticipated growth, inclusive of surface water, groundwater, flood hazards, and regular potable water quality. Currently, groundwater is the primary source of potable water in Caroline County. Only Lake Caroline is served by surface water withdrawal for its water requirements. The county anticipates that groundwater supplies are probably sufficient to meet the water needs in the near future. To avoid depletion of the groundwater supply, the Virginia Water Control Board regulates withdrawals from wells in the Groundwater Management Area. The county also has an abundant supply of surface water resources available. The Rappahannock, Mattaponi, and Pamunkey Rivers are considered as potential water supply sources for the county, however, no definite plan or study has yet been developed. (Reference 10)

4.2.3.2.3 **New Kent County**

The New Kent County Planning Department projects continued population growth of 33.7 percent during the period of 2000 to 2010, and another 30.6 percent from 2010 to 2020 (Reference 11). The county's residents have relied primarily on groundwater to provide their potable water needs. The continued withdrawal of groundwater has caused a lowering of the water levels throughout the aquifer system creating problems for existing shallow wells and raising concerns about the long-term viability of groundwater as a dependable, safe source of water. The county lies within two major river basins: the York in the northeast and the James in the south. Approximately one-third of the county lies in the Pamunkey River basin, which is part of the York basin. The county's rivers, streams, and water bodies provide opportunities for a variety of surface water users, but difficulties in federal and state permitting severely restrict the county's ability to develop its own surface water resources. Although permitting issues would need to be evaluated, considerations have been given to develop a future reservoir or reservoirs to be used for the collection of both surface runoff and as a storage site for pump-over from the upper, freshwater portion of Pamunkey River. Future water resource plans for New Kent County would be developed based on the preliminary state water resource plan which would include criteria for development of local and regional plans. No defined study or plan has yet been developed. (Reference 11)

4.2.3.2.4 **King William County**

The 2003 Comprehensive Plan Update of King William County (Reference 12) on population projections indicates that the county would continue to experience accelerated population growth during the planning period. It is estimated that the county's population would grow from 2000 to 2010 by over 20 percent, twice the rate projected for Virginia as a whole. The vast majority of King William County residents are served by private wells, though the county does have three small water systems that have specific service areas. Within Virginia, King William ranks in the second highest category for groundwater withdrawal. A reservoir is being planned by damming Cohoke Creek near its confluence with the Pamunkey River. However, water would be taken from the Mattaponi River at Scotland Landing and pumped to the proposed Cohoke Reservoir. It would provide the county with an alternate surface water supply. There is no plan of using North Anna or Pamunkey Rivers or their tributaries as future water sources. (Reference 12)

4.2.3.3 Impacts of Future Development on Inflow and on Low Water Condition of the Lake

Most of the upstream counties do not rely on the North Anna River or its tributaries for their current or future water supply. Groundwater withdrawal would increase with the rising demand from the projected growth of the counties, but impact on the inflow to the lake is expected to be small due to the relatively low percentage of overall development and the low density of the projected development in the majority of the watershed.

Due to the increase in impervious area, increased growth and urbanization in the watershed would generally increase runoff volume and peak discharges in local streams and rivers, and reduce groundwater recharge. Through storm water management measures that promote stormwater retention and infiltration, these impacts can be reduced significantly. The growth and development projected for the upstream counties would tend to increase the runoff volume into Lake Anna. Increased flow into the lake could reduce the impacts of increased evaporation that would result from the operation of Unit 3. However, current development in the counties located in the watershed is small relative to the size of the watershed and even with the projected growth, the increase in the runoff to the lake is expected to be small.

During periods of low runoff, the lake could receive less inflow because of the higher groundwater withdrawal and the potentially lower groundwater recharge as a result of increased impervious area from future development. But the effect should be small due to the relatively small percentage of current and projected future development relative to the size of the watershed.

4.2.3.4 Impacts of Future Development on Downstream River Flow

The future growth in the upstream counties is not likely to have a significant impact on the watershed's surface and groundwater resources, and on the inflow to Lake Anna. Consequently, the impact of future development of the upstream counties would have small impact on the release from the North Anna Dam to the downstream river.

Three of the counties downstream of the dam are considering using the North Anna River or Pamunkey River as future water sources to support their projected growth. No firm estimate or definite water use plans have been developed to this date, but detailed state water resource studies would be required to demonstrate the feasibility of using these downstream rivers as potential water sources for the downstream counties. The operation of Unit 3 would have no effect on the instantaneous minimum releases from Lake Anna and would not affect the minimum flows available for any future downstream development. The duration of the minimum flow release rates would increase with the addition of Unit 3 as presented in Section 5.2.2.2.

Section 4.2 References

1. 38077-A7-TF-024, *Lake Anna West, VA*, 7.5 Minute Series Topographic Map, U.S. Department of Interior, U.S. Geological Survey, Photorevised 1983.

2. *Virginia Erosion and Sediment Control Handbook,* 3rd Edition, Virginia Department of Conservation, Division of Soil and Water Conservation, 1992.

3. Lake Anna Special Plan Committee, “Lake Anna Special Area Plan,” March, 2000.

4. County of Louisa, Virginia, “Louisa County Comprehensive Plan,” September 4, 2001.

5. County of Spotsylvania, Virginia, “Comprehensive Plan,” 2002.

6. County of Orange, Virginia, “Comprehensive Plan,” adopted on September 14, 1999.

7. Website of County of Louisa, Virginia, “Louisa County At a Glance,” www.louisacounty.com/glance.htm, accessed on April 15, 2004

8. County of Spotsylvania, Virginia, “Water and Sewer Master Plan,” Revisions 2002.

9. County of Hanover, Virginia, “Hanover County Comprehensive Plan - Vision 2022,” adopted June 2003.

10. County of Caroline, Virginia, “2001 - 2004 Caroline County Comprehensive Plan,” adopted on February 27, 2001.

11. New Kent County, Virginia, “Vision 2020, New Kent County Comprehensive Plan,” adopted August 4, 2003.

12. King William County, Virginia, “2003 Comprehensive Plan Update,” adopted June 23, 2003

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

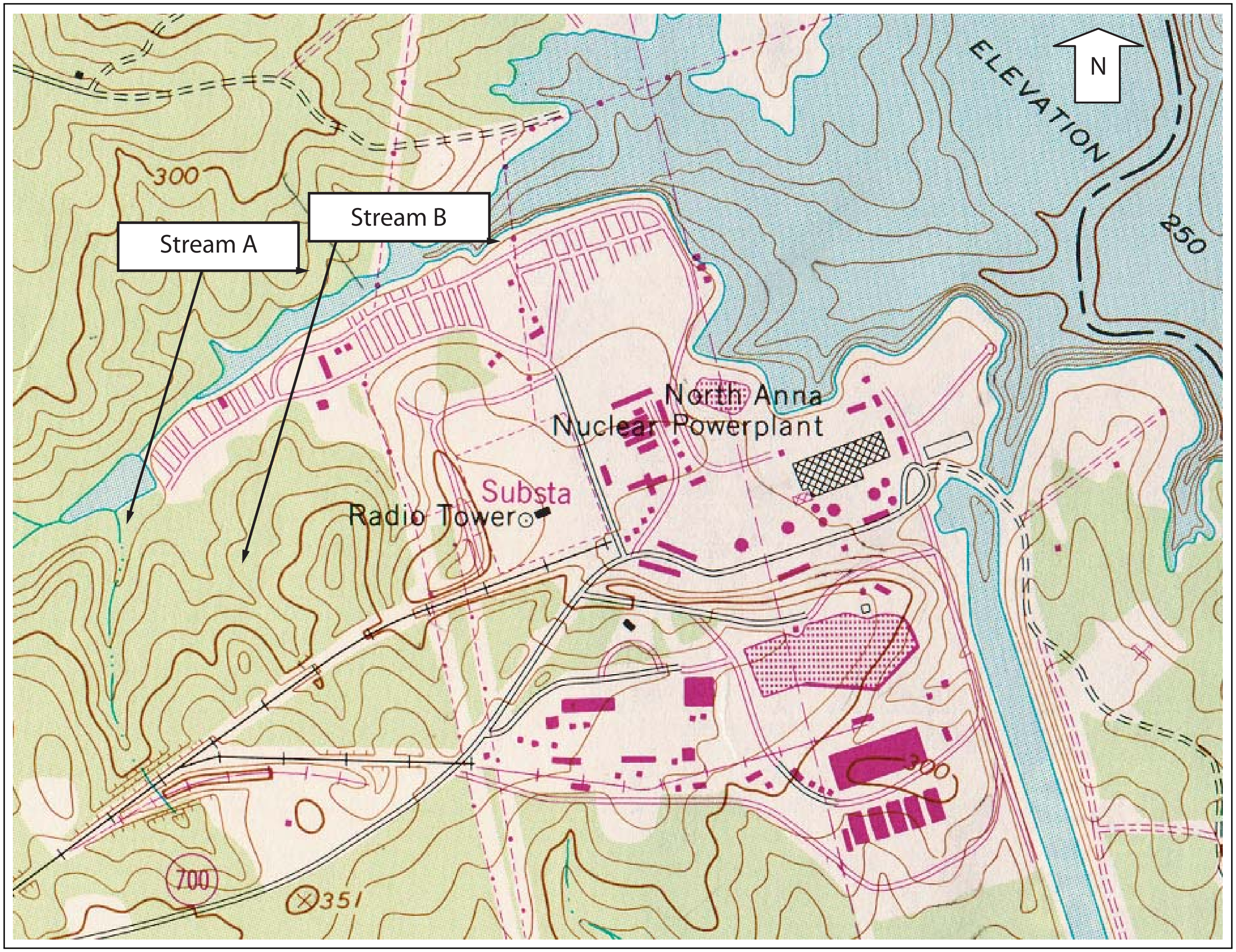

Figure 4.2-1   Ephemeral Steam Locations

4.3 Ecological Impacts

This section describes the potential impacts to the ecological resources that could result from construction activities. This section is divided into two subsections: 1) Terrestrial ecosystems, and 2) Aquatic ecosystems. Each subsection provides sufficient detail to assess the nature and magnitude of potential impacts on the identified resources.

4.3.1 Terrestrial Ecosystems

4.3.1.1 Transmission Corridors

Section 3.7 discusses assessment of the power transmission system. No impacts on transmission corridors, transmission towers, transmission-tower configurations, or transmission tower access roads are anticipated.

4.3.1.2 ESP Site

Section 2.4.1 discusses terrestrial ecological habitats at the ESP site. The approximate area of the ESP site is 200 acres. Natural habitats are absent from the industrial/developed portions (approximately 120 acres) of the ESP site (Figure 2.1-1). As a result, construction activity would have no impact on ecological resources within these portions of the ESP site.

Construction of the new units would result in the removal of essentially all forested habitat (approximately 80 acres) within the ESP site (Figure 2.1-1). The ESP site does not contain any old growth timber, unique or sensitive plants, or unique or sensitive plant communities. Therefore, construction activities would not noticeably reduce the local or regional diversity of plants or plant communities. There are no “important” species or habitats on the ESP site. No areas designated by the USFWS as “critical habitat” for endangered species exist at or near the ESP site, nor are threatened or endangered plants or animals known to exist there. Therefore, construction would have no impact on any threatened or endangered species, or other “important” species or habitats. Section 2.4.1 discusses the results of consultation with agencies regarding protected species.

A few small wetland areas and two intermittent streams exist on the ESP site (refer to Section 2.4.1). Watercourses and wetlands would be avoided to the extent possible during any construction. Any work that has the potential to impact a wetland would be executed in accordance with the applicable laws, regulations, permits, and authorizations. Therefore, construction-related impacts would be small.

Land clearing associated with construction would be conducted according to federal and state regulations, permit conditions, existing procedures, good construction practices, and established best management practices (e.g., directed drainage ditches, silt fencing). Fugitive dust would be minimized by watering the access roads and construction site as necessary. Thus, impacts from dust would be small and mitigation would be unwarranted. Emissions from heavy construction equipment would be minimized through scheduled equipment maintenance procedures.

Section 4.1.1 describes the physical impacts of construction at the site. To minimize construction-related impacts, Dominion would adhere to permit conditions that may restrict the timing of certain construction activities. As the site undergoes clearing and grading, disturbance and forested habitat loss would displace mobile animals such as birds and larger mammals. Species that can adapt to disturbed or developed areas (e.g., raccoon, opossum, mockingbird, Northern cardinal) may recolonize portions of the site where grasses and other vegetation are undisturbed or are 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 the less mobile animals such as toads, lizards, snakes, moles, and mice.

Construction activities would involve movement of workers and construction equipment, and would be associated with noisy activities from construction equipment (e.g., earth-moving equipment, portable generators, pile drivers, pneumatic equipment, and hand tools). Although short-term noise levels from construction activities could be as high as approximately 110 dBA, (e.g., impulse noise during pile driving activities), these noise levels would not extend far beyond the boundaries of the ESP site. Table 4.3-1 illustrates the rapid attenuation of construction noise over relatively short distances.

Construction noises would range from approximately 60 to 80 dBA 120 meters (400 feet) from the construction site. These noise levels are below the 80 to 85 dBA threshold at which birds and small mammals are startled or frightened (Reference 1). Thus, noise from construction activities would not disturb wildlife beyond 120 meters from the construction site. After initial land clearing, wildlife such as mammals and songbirds that are associated with uplands would be impacted only by the construction noise in the area to the west of the ESP site. In addition, only a narrow lake inlet immediately north of the laydown area and a small wet area near the existing units comprise portions of Lake Anna that are within 120 meters of the ESP site. Furthermore, it is noted that construction would occur adjacent to the existing units, where wildlife have presumably become accustomed to typical existing operating facility noise levels of approximately 50 to 60 dBA at the security fence.

Avian collisions with man-made structures are a result of numerous factors related to species' characteristics such as flight behavior, age, habitat use, seasonal habits, and diurnal habitats; and to environmental characteristics such as weather, topography, land use, and orientation of the structures. Most authors on the subject of avian collisions with utility structures agree that collisions are not a biologically significant source of mortality for thriving populations of birds with good reproductive potential (Reference 2). The number of construction-related bird collisions with structures has not been quantitatively assessed; however, because no avian collisions with existing structures at the NAPS site have been noted, such collisions during the construction phase would also be negligible.

Table 4.3-1 Peak and Attenuated Noise (in dBA) Levels Expected from Operations of Construction Equipment[a]

Source	Nose Level (peak in dBA)	Distance from Source			
		50 feet[b]	100 feet	200 feet	400 feet
Heavy trucks	95	84-89	78-83	72-77	66-71
Dump trucks	108	88	82	76	70
Concrete mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Generator	96	76	70	64	58
Crane	104	75-88	69-82	63-76	55-70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73
Dragline	105	85	79	73	67
File driver	105	95	89	83	77
Fork lift	100	95	89	83	77

a. Source: (Reference 1)

b. To convert feet to meters, multiply by 0.3048.

In summary, while the construction-related impacts of forested habitat loss to local wildlife populations cannot be quantitatively assessed because population data for species on and adjacent to the NAPS site are not available, relatively large tracts of forest to the north, west, and south of the NAPS site are available to displaced animals. Given the fact that approximately 80 acres of forested habitat at the site represents a small portion of the available undeveloped land in the vicinity, the construction-related mortality and temporary displacement of wildlife would be minimal, relative to wildlife populations in the region. In addition, construction activities would not reduce the local or regional diversity of plants or plant communities, and would not impact endangered or threatened species. Noise-related impacts and bird collisions during construction would be negligible.

4.3.2 **Aquatic Ecosystems**

Construction of an intake structure would be the primary source of construction impacts on the aquatic environment. Construction would involve major modifications to an existing intake structure. Section 3.4.2 provides a description of the proposed construction activities.

The new intake structure would be approximately 70 feet long and 70 feet wide, and would house the trash racks, traveling screens, and intake pumps (Figure 3.4-3 and Figure 3.4-4). No major modifications to the shoreline or short intake channel are expected, except that the existing cofferdam would be removed to allow reservoir water access to the new intake through the intake channel that is now behind the cofferdam.

Approximately 84,000 cubic yards of material would be moved from the cofferdam. All of the material would be properly disposed of in accordance with regulatory requirements and permit conditions.

In anticipation of construction, topsoil would be removed from the construction footprint, stored, rolled, and seeded as necessary, to minimize erosion. Some disturbed areas may be graveled, paved, or compacted to prevent erosion. These soil preparation procedures and others would minimize impacts to the aquatic environment from earth-moving activities. Following the cessation of construction activities, areas that are disturbed temporarily would be graded and contoured, covered with topsoil, and seeded with native vegetation.

Degraded water quality (e.g., increased turbidity and siltation) as a result of cofferdam removal and intake construction would pose the greatest potential for impacts on the North Anna Reservoir ecosystem in the immediate vicinity of the construction activities. Construction activities would result in the temporary loss of benthic habitat and the displacement or loss of benthic organisms, which provide food for other animals such as fish and shorebirds. After construction, the intake channel and cove would be re-colonized by benthic organisms available to predators. To minimize impacts to benthic populations in the reservoir, intake construction and protection activities would be conducted in accordance with state regulations and permit requirements. The benthic habitat lost would be temporary and a small percentage of the available benthic habitat. The loss of this habitat would not have a long-term impact on the aquatic ecosystem.

Some fishery habitat may be changed as well. Fish inhabiting the intake channel and the lake near the intake channel would likely leave the area temporarily during construction activities. After construction is completed, fish would re-populate those areas. Temporary habitat loss would be a small percentage of the total fishery habitat available in the North Anna Reservoir. To minimize impacts to fish populations in the reservoir, intake construction and protection activities would be conducted in accordance with state regulations and permit requirements. Construction impacts on the reservoir's fishery would be small and temporary.

Construction activities in the new intake channel could re-suspend heavy metals from the Contrary Creek area (see Section 2.4.2) that may be in the bottom sediments of the old North Anna River channel in the lake. Should heavy metals be present in the re-suspended sediments they could result in impacts to aquatic biota. Any environmental concerns would be addressed through the permitting process for the new units.

Increased turbidity also could result in a temporary reduction in primary productivity due to reduced light penetration and smothering of periphyton and aquatic macrophytes in the intake channel. After construction, primary productivity would be expected to increase to previous levels and macrophyte re-colonization would occur. A barrier (e.g., turbidity curtain, sheet piling) may be installed between the ESP site and the lake to reduce the potential for silt and soil entrainment through the existing units to the WHTF, where it could adversely affect primary production.

The potential for fuel or other fluid spills exists throughout the construction phase. To prevent contaminants from entering the aquatic system any spills would be handled according to an approved Spill Prevention Control and Countermeasure (SPCC) Plan.

As stated in Section 2.4.2, 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 operations of the existing units. No federal or state-listed protected fish species has been collected in any of these monitoring studies, nor has any listed species been observed in creel surveys or special studies conducted by Virginia Power biologists and affiliated researchers. Refer also to the discussion in Section 2.4.2 for other field and database searches regarding threatened, endangered, or state-listed aquatic species. Based on the absence of federal and state-listed protected fish species, construction impacts to threatened, endangered, or important aquatic species in Lake Anna, its tributary streams or the North Anna River would be unlikely.

Construction of cooling towers could be near an intermittent stream (Figure 2.1-1). See Section 4.3.1 for additional discussion. Construction could result in soil erosion and silt entry into the stream.

Refurbishment of an existing rail spur or construction of a new one also could occur near the stream. Intermittent streams in this area are not known to provide key fishery habitat for any important species. However, sedimentation and erosion control BMPs and/or effective stormwater management would be used to protect aquatic resources in the construction area.

In summary, construction activities would affect the North Anna Reservoir and its aquatic communities in the vicinity of the intake channel. These impacts would be small and temporary and would be mitigated through adherence to applicable laws, regulations, and permit conditions, and the use of good construction and BMPs to minimize impacts on aquatic resources. No critical habitats or protected aquatic species exist in the area, so none would be adversely affected by construction activities.

4.3.2.1 **Deleted**

Section 4.3 References

1. Golden, J., Ouellette, R. P., Saari, S, and Cheremisinoff, P. N.; *Environmental Impact Data Book* (Second Printing), Chapter 8, “Noise.” Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, 1980.

2. Brown, W. M., *Proceedings: Avian Interactions with Utility Structures International Workshop*, Miami, Florida, September 13-16, 1992, “Avian Collisions with Utility Structures: Biological Prospectives.” Prepared by EPRI, Palo Alto, California, December 1993.

4.4 Socioeconomic Impacts

This section discusses the socioeconomic impacts of construction activities, including those impacts that could result from the construction-related activities at the ESP site, and from the activities and demands of the workforce on the surrounding region. Evaluated socioeconomic impacts include potential effects on individual communities, the surrounding region, and minority and low-income populations.

This section has three subsections:

- Physical impacts,
- Social and economic impacts,
- Environmental justice impacts.

4.4.1 Physical Impacts

Construction activities can cause temporary and localized physical impacts such as noise, odor, vehicle exhaust, and dust. Vibration and shock impacts are not expected, due to the strict restriction or control of such activities onsite. This section addresses those potential impacts that may affect people, buildings, roads, and recreational facilities (e.g., Lake Anna). The physical impacts would be small and, therefore, are presented qualitatively.

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 would occur within the NAPS site boundary. Offsite areas that would support construction activities (e.g., borrow pits, quarries, disposal sites) would already be permitted and operational. Therefore, impacts on those facilities from constructing new units would be small incremental impacts associated with their normal operation. The use of public roadways and railways would be necessary to transport construction materials and equipment. The roadways could require some minor repairs or upgrading, such as patching and filling potholes, to allow safe equipment access. However, no extensive work is planned to the existing roads or railways and no new routes would be required.

4.4.1.1 Groups Vulnerable to Physical Impacts

4.4.1.1.1 People

The area within 10 miles of the ESP site is estimated to be populated by approximately 15,500 people (See Section 2.5). This area is predominately rural and characterized by farmland and wooded tracts (Reference 1). No significant industrial or commercial facilities exist or are planned for this area. Population distribution details are given in Section 2.5.1.1.

People who could be vulnerable to noise, fugitive dust, and gaseous emissions resulting from construction activities are listed below in order of most vulnerable to least vulnerable:

- Construction workers and personnel working onsite
- People working or living immediately adjacent to the site
- Transient populations (i.e., temporary employees, recreational visitors, tourists)

Construction workers would have adequate training and personal protective equipment to minimize the risk of potentially harmful exposures. Services would be provided for emergency first-aid care, and regular health and safety monitoring would be conducted during construction.

People working onsite or living near the ESP site would not experience any physical impacts greater than those that would be considered an annoyance or nuisance. In the event that atypical or noisy construction activities would be necessary (e.g., pile driving), public announcements and/or notifications would be provided. These activities would be performed in compliance with local, state, and federal regulations, and site-specific permit conditions.

Fugitive dust and odors could be generated as a result of normal construction activities. Mitigation measures (e.g., paving disturbed areas, water suppression, reduced material handling) would be in place to prevent or reduce such occurrences Additional mitigation control measures would address any nuisance issues on a case-by-case basis.

Noise and exhaust emissions from construction equipment would have no discernible impact on the local noise level and air quality. All equipment would be operated in accordance with local, state, and federal emission requirements (see Section 4.4.1.2).

Reasonable efforts would be made to ensure that transient populations are aware of the potential impacts of construction activities. Signs would be posted at or near construction site entrances and exits to make the public aware of potentially high construction traffic areas.

4.4.1.1.2 **Buildings**

Construction activities would not impact any offsite buildings. In the event that pile driving would be necessary, the building(s) most vulnerable to shock and vibration would be those within the NAPS site boundary. Onsite buildings have been constructed to safely withstand any possible impacts, including shock and vibration, from construction activities associated with the proposed activity. (No historically significant buildings (see Section 2.5.3) exist near the ESP site.

4.4.1.1.3 **Roads**

The transportation network in Louisa County and at the ESP site already a well-developed system, would not be significantly impacted as a result of construction activities. Material transportation routes (haul routes) would be selected based on equipment accessibility, existing traffic patterns, and noise restrictions, logistics, distance, costs, and safety. Methods to mitigate potential impacts 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 activities during daylight hours and delivery times.

No new public roads would be required as a result of construction activities. No public roads would be altered (e.g., widened) as a result of construction activities. Some minor road repairs and improvements (e.g., patching cracks and potholes, adding turn lanes, re-enforcing soft shoulders) would be necessary to enable equipment accessibility and reduce safety risks.

Construction site exits onto public roads would be marked clearly with signs and maintained such that they are clear of debris and markings are visible. Any damage to public roads, markings, or signs caused by construction activities would be repaired to pre-existing conditions or better.

A new access road on the NAPS site would support construction activities. The new road would be private and fully contained within the existing NAPS site boundary. The road would be maintained by Virginia Power personnel as needed.

4.4.1.1.4 **Recreational Facilities**

Lake Anna was created in 1971 on the main stem of the North Anna River to supply cooling water for the power station. The lake has public access, and its resource use includes recreational boating, fishing, camping and picnicking. People live along its shoreline. Virginia Power and ODEC own, and Virginia Power controls, the land that forms Lake Anna, both above and beneath water surfaces, up to the expected high-water marks (i.e., Elevation 255 ft msl). The aquatic resources of Lake Anna are managed cooperatively by Virginia Power and state natural resource agencies, including the VDGIF and the VDCR.

Construction activities would include limited in-water activity to construct the intake structure, remove a portion of the existing cofferdam and local dredging. The work would be executed in accordance with applicable regulations such as the CWA and permit conditions such as CWA Section 404 administered by the U.S. Army Corps of Engineers. Fugitive dust would be generated during site construction activities; however, quantities would not have any discernible impact on Lake Anna or adjacent environs. Water turbidity could be temporarily degraded in the immediate construction area during cofferdam removal and localized dredging. Measures to control turbidity include permit conditions, use of best management practices and, if necessary, installing a barrier (e.g. silt curtain) to prevent the migration of a turbid water plume into the lake.

4.4.1.2 **Applicable Standards**

Applicable local, state, and federal standards for noise, fugitive dust, and equipment emissions are described in these subsections.

4.4.1.2.1 **Noise**

The Commonwealth of Virginia has no state regulations nor guidelines for noise limits and provides no model noise ordinance for municipalities. Additionally, the state does not provide guidelines or limitations for impulse noise like a sharp sound pressure peak occurring in a short interval of time.

Within the County of Louisa, “it shall be unlawful to create any unreasonable loud, disturbing and unnecessary noise in the county, and noise of such character, intensity and duration as to be detrimental to the life or health of any person or to unreasonably disturb or annoy the quiet comfort or repose of any person is hereby prohibited. This prohibition shall not be construed to apply to any livestock, domesticated animal, fowl, or agricultural operation.” (Reference 2) No guidelines or ordinances have been identified that are written specifically to address construction activities.

Within the County of Spotsylvania, “The creation of any unreasonably loud, disturbing, and unnecessary noise in the county is prohibited. Noise of such character, intensity, and duration as to be detrimental to the life or health of any individual is prohibited.” (Reference 3) Construction activities are exempt from this ordinance between the hours of 6:00 a.m. and 10:00 p.m.

The Noise Control Act of 1972 gives authority to the EPA to determine the limits of noise and to set noise emission standards for major sources of noise in the environment, including construction equipment. Federal regulations exist for noise emitted from construction (40 CFR 204, Noise Emission Standards for Construction Equipment).

4.4.1.2.2 **Fugitive Dust**

Virginia Administrative Code (VAC) 9 VAC 5-50 establishes standards for visible emissions and fugitive/dust emissions. 9 VAC 5-50 defines “fugitive dust” as particulate matter composed of soil or other materials of natural origin, or both. Fugitive dust may include emissions from haul roads, wind erosion of exposed surfaces and storage piles, and other activities in which the material (dust) is removed, stored, transported, or redistributed.

4.4.1.2.3 **Gaseous Pollutants**

Virginia Administrative Code 9 VAC 5-40-5680 establishes emission standards for mobile sources.

4.4.1.3 **Predicted Noise Levels**

The impacts from noise would be small; therefore, no modeling was undertaken for of this analysis. As presented previously, Louisa and the surrounding counties are predominantly farmland and wooded tracts. Areas that are subject to farming are prone to seasonal noise-related events such as planting and harvesting. Wooded areas provide natural noise abatement control to reduce noise propagation. Table 4.4-1 identifies expected noise levels in the immediate vicinity (less than 10 feet) of operating pieces of construction equipment. (Reference 4)

Table 4.4-1 Equipment and Approximate Noise Level

Equipment	Noise Level (dB)
Pneumatic chip hammer	103-113
Earth Tamper	90-96
Jackhammer	102-111
Crane	90-96
Concrete joint cutter	99-102
Hammer	87-95
Skilsaw	88-102
Gradeall	87-94
Front-end loader	86-94
Bulldozer	93-96
Backhoe	84-93

Noise level attenuates with distance. The noise from a gradeall earth mover can be as high as 94 decibels (dB) from 10 feet away, and from 70 feet away can be 82 dB. A 10-dB decrease is perceived as roughly halving loudness; a 10-dB increase doubles the loudness. A crane lifting a load can make 96 dB of noise; at rest, it may make less than 80 dB. Moderate auto traffic at a distance of 100 feet (30 m) rates about 50 dB. To a driver with a car window open or a pedestrian on the sidewalk, the same traffic rates about 70 dB; that is, it sounds four times louder. The level of normal conversation is about 50 to 60 dB.

The EAB extends 5000 feet from the center line of the abandoned Unit 3 containment building. No major roads, public buildings or residences are located within the exclusion area. Distances from the construction site to the EAB are shown in Table 4.4-2 (See Section 4.1.1.4). As presented in Section 4.1.1, the land adjacent to the ESP site along the western boundary is zoned light industrial.

Table 4.4-2 Distances from Construction Site to EAB

Direction	Approximate Distance (feet)
North	2650
South	4450
East	4680
West	70

In addition to the local ordinances and permitted noise restrictions that would be adhered to by construction activities to reduce potential noise impacts, the following controls could also be incorporated into activity planning:

- Regular inspection and maintenance of equipment to include noise aspects
- Restrict noise-related activities (e.g., pile driving) to daylight hours
- Restrict delivery times

4.4.1.4 **Predicted Air Pollutant Levels**

Physical impacts from air pollutants such as engine exhaust and fugitive dust would be small; therefore, no modeling was undertaken for this analysis. Temporary and minor impacts to local ambient air quality occur as a result of normal construction activities. Fugitive dust and fine particulate matter emissions – including those less than 10 microns (PM10) in size, are generated during earth-moving and material-handling activities. Construction equipment and offsite vehicles used for hauling debris, equipment, and supplies also produce emissions during construction. The pollutants of primary concern include PM10 fugitive dust, reactive organic gases, oxides of nitrogen, carbon monoxide, and, to a lesser extent, sulfur dioxides. Because the variables affecting construction, emissions (e.g. type of construction vehicles, timing and phasing of construction activities, and haul routes) cannot be determined until the project is ready for construction; no reasonable estimate of construction emissions can be undertaken. However, construction would be conducted in accordance with all federal, state and local regulations that govern construction activities and emissions from construction vehicles.

Specific mitigation measures to control fugitive dust would be identified in a dust control plan, or similar document, prepared prior to project construction. These mitigation measures would include any or all of the following:

- Stabilize construction roads and spoil piles
- Limit speeds on unpaved construction roads
- Perform housekeeping (e.g., remove dirt spilled onto paved roads daily)
- Cover haul trucks when loaded or unloaded
- Minimize material handling (e.g., drop heights, double-handling)
- Cease grading and excavation activities during high wind speeds and during extreme air pollution episodes
- Phase grading to minimize the area of disturbed soils
- Phase construction to minimize daily emissions
- Perform proper maintenance of construction vehicles to maximize efficiency and minimize emissions

- Re-vegetate road medians and slopes in accordance with the site redress plan (see, Part 4: Chapter 1, Site Redress)

While emissions from construction activities and equipment would be unavoidable, a mitigation plan would minimize impacts to local ambient air quality and the nuisance impacts to the public in proximity to the project. Other mitigation measures would include temporary storm water management and erosion and sediment control strategies.

4.4.2 Social and Economic Impacts

The social and economic impacts on the immediate vicinity and surrounding region during construction of new units at the ESP site are evaluated in this section. This evaluation assesses both the potential impacts that could result from the construction-related activities at the ESP site and the activities and demands of the workforce on the surrounding region.

Construction of a new unit is estimated to occur over a 5-year period. Construction of the second unit may lag the first by a year or more. Because a specific reactor design has not been selected, the peak workforce estimate does not include consideration of reactor-specific approaches which could reduce the types and lengths of activities onsite.

The peak workforce is estimated to be about 5,000 people, which would be maintained for a large part of the construction period(s). If such a large workforce were introduced into the region, it could affect traffic, taxes, housing, and public services. Most of the workforce would probably come from the 50-mile region. This peak workforce estimate and the assumption that most of the workforce would be local are consistent with experience during prior construction projects at NAPS.

The magnitude of impacts is dependent on two considerations:

- The percentage of the workforce that would come from the region and, therefore, be expected to commute
- Where those who have to relocate to the region would reside

4.4.2.1 Economic Impacts

The impacts of construction of the new units on the local and regional economy of the ESP region are based on the region’s current and projected economy and population. The projected economy is based on information developed internally by Virginia Power and from Comprehensive Land Use plans for applicable localities. Because the ESP would be in effect for 20 years after approval, construction could start anytime within that 20-year timeframe, once a COL authorizing construction has been issued. The issuance of an ESP allows, under certain regulatory conditions, the start of limited early construction activities (see Part 4). Therefore, the positive economic benefits of construction could begin some time before the start of major construction.

4.4.2.1.1 Potential Non-Income Taxes Related to Construction of New Units

The actual monetary value of the revenues generated because of the construction of the new units cannot be estimated with precision because the type of reactor has not been selected. This decision would affect the size of the work force and the percentage of the work force that could come from outside the region. Therefore, at this time it is not possible to estimate the value of taxes that could be paid to the regional governments nor expenditures that the regional governments would have to incur to accommodate the workforce.

a. **Sales and Use Taxes**

The Commonwealth of Virginia and counties surrounding the 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 (restaurants, hotels, merchant sales) of construction workers. It is estimated that about half of the day-to-day expenditures during construction would occur in the region.

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, Louisa County.

b. **Property Taxes**

Louisa County would benefit from additional property tax revenue from two sources. The first source would be tangible personal property taxes paid by contractors during construction of the additional units. The tax would be 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 ten percent of the original cost, which is then taxed at the rate of $1.90 per $100 of value.

The second source would be the property taxes levied for the incremental increase in value to the entire site from the additional units. During the construction phase, 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.

4.4.2.1.2 Housing

If the entire construction workforce came from within a 50-mile radius of the ESP site, there would be no impact on housing. However, based on prior experience on projects of similar size, up to 20 percent of the workforce could come from beyond the 50-mile region. Most, if not all, of these workers from outside the region would be expected to relocate to the region at least during the workweek.

If up to 1000 workers were to come from outside the region, there would be a demand for up to that many housing units, mainly apartments, although, some single-family residences might be required if construction workers decide to relocate with their families. A review of the vacant housing available in the year 2000, shows that there were sufficient numbers of rentals (5,884 units) and permanent housing units (2,656 units) in the region to accommodate the expected workforce. Most of these were in the City of Richmond and Henrico County. Very few rental properties were available in Louisa, Hanover, Spotsylvania, or Orange Counties.

There is also the possibility that some relocated construction workers would bring trailers for the duration of their employment. For purposes of this ER, it is assumed that the number of such workers who bring trailers would be low. If this is not the case, an influx of construction workers into the local area could compete with recreational users for spaces at existing trailer/RV parks.

Alternatively, if the incoming construction force were to generate demand for additional private trailer parks, this demand could lead to an increase in spaces being made available. However, there are no public water or sewer systems in the vicinity of the ESP site except for those of the incorporated towns. It is not likely that new trailer/RV parks would be constructed within the boundaries of these towns. New trailer/RV parks would most likely be located in Henrico County, nearer to the City of Richmond where public water and sewer systems are in place and where expansion of infrastructure is currently planned.

Neither Henrico County nor the City of Richmond would benefit directly from property taxes paid by Dominion. However, both should benefit from increased sales taxes and rents for housing units.

It is assumed that the number of housing units for rent or sale in the nearby counties would remain at or near the Year 2000 levels in future years. Under this assumption, an in-migration of up to 1000 construction workers should be able to find housing without creating issues for the region regardless of when construction is initiated.

4.4.2.2 **Social Impacts**

Under the assumption that the construction workforce would come from the region, the main social impact of the proposed construction would be most related to the transportation network in the vicinity of the ESP site. It is assumed that workers who relocate would settle in the City of Richmond, or, Henrico County. The relative social impact of such an in-migration to these two areas should be small, given the population of the areas. Impacts on the fire, police, school systems, recreational facilities, medical facilities, and the sewer and water systems would be small.

The installation of the new units would not displace families, because housing is not allowed on the NAPS site and construction activities would be entirely on site.

Most of the larger pieces of equipment or structures would probably be brought in to the site by rail. However, the transport of such large pieces of equipment would be an infrequent occurrence.

4.4.2.2.1 **Transportation-Related Impacts**

Impacts of construction of new units at the ESP site could be associated with transportation-related activities offsite, such as the delivery of major pieces of equipment.

Construction-related impacts on the transportation network in the region would arise from an additional 5,000 people commuting to the NAPS site.

a. **Federal Highways**

Construction workers traveling south on Interstate 95 (I-95) (Figure 2.1-3) from Spotsylvania or further north would take the Virginia Route 606 west exit, or the Spotsylvania Turnpike exit to the Route 208 Bypass (under construction in 2003), and then south on Route 208 (Courthouse Road) to reach the site.

The Route 606 - Interstate 95 interchange is congested, generally at a level of service D (LOS D) or better (Table 4.4-3). A VDOT I-95 interchange study has determined that this interchange would become more congested with time (Reference 5). The addition of commuting construction workers would increase this congestion.

The VDOT I-95 study includes an analysis of traffic patterns for the Route 606 – I-95 interchanges out to the 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 due to funding. This study also identifies the need for widening the western section of Route 606 to alleviate the existing congestion that affects traffic trying to access I-95 north and south.

I-95 north from Richmond would not be adversely impacted by commuting construction workers coming from the Greater Richmond area, because the more likely commuting routes would be Virginia Route 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. Commuting construction workers from the Greater Richmond Area to Virginia Route 208 or Route 522 would not cause congestion problems.

b. **Virginia Roadway System**

The Louisa-Orange-Spotsylvania Advisory’s 3-county planning group, the Lake Anna Advisory Committee (LAAC), has recommended that planners in each of the three counties upgrade their local roads around Lake Anna. This recommended upgrade would provide a circumferential roadway system around the lake with adequate lanes for towed boats and bicycles (Reference 6). Such upgrades would alleviate congestion on local roads due to the influx of construction workers.

The Louisa County draft Comprehensive Plan of 2001 recognizes the need to improve roadways around Lake Anna. The draft Comprehensive Plan of 2001 recommends improvement of the roads within Louisa County, but provides no information on funding or the timing of the road improvements. (Reference 7)

Spotsylvania County plans to widen Route 606 west of I-95 to four lanes and has included this project in their Comprehensive Plan (Reference 8). This project should be completed in the near-term and should reduce additional impacts of large number of construction workers commuting on Route 606 to the site. Additionally, the Route 208 Bypass around the historic Courthouse District is currently under construction and should be completed in the near-term. When completed, the 208 Bypass would connect the Spotsylvania Parkway (Route 208 north), with Courthouse Road (Route 208) south of its intersection with Route 606. Route 208 south is a minor road with a bridge over the North Anna Reservoir west of the ESP site. Spotsylvania County plans to upgrade the 2-lane roads around Lake Anna by widening them to include shoulders to accommodate larger vehicles such as motor homes. This upgrade is in line with the 3-county planning group's plans for the Lake Anna area.

In Hanover County, U.S. Route 33 links Richmond with Louisa and points north and west. This 2-lane road in the northern part of the County is subject to congestion and needs to be widened according to the Hanover Comprehensive Plan of 1998. No time frame has been set because the source of funding has not been identified. If the widening does not occur before the start of construction of the new units, U.S. Route 33 congestion could increase from construction workers commuting from Richmond. The magnitude of the impact would depend to some extent on the shift schedule for the construction of the new units relative to the normal commuting schedule of other road users. Traffic congestion would be considered in developing a traffic management plan as a mitigation measures. (Reference 9)

c. **Local Roads**

According to the North Anna License Renewal Environmental Report, the major commuting routes in the immediate vicinity of the ESP site are local roads Routes 700, 652, 208, 522, and 618 (Figure 2.1-2). These roads carry a LOS designation of B. (Reference 4)

Table 4.4-3 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.

Table 4.4-3 Level-of-Service Designation Characteristics

Level of Service	Conditions
D	High-density stable flow, in which the freedom to maneuver are 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: Environmental Report (Reference 4), Appendix E of the North Anna Power Station Unit 1 and 2 Applications for Renewed Operating Licenses, Page 2-39, May 2001.

d. **Route 700 East of Route 652**

Route 700 is the only road that leads directly into the ESP site, and the traffic east of the intersection with Route 652 is normally related only to the power station site. This would be true during the construction of the new units.

Construction worker access to the ESP site would be via a construction access road that would be built on the north side of Route 700 on Virginia Power property and would intersect with Route 700 several hundred yards west of the access road to the existing units. Therefore, the potential exists for congestion to develop on site access roads and on Route 700, if the construction shifts and the plant shifts are not synchronized. To avoid congestion, a traffic management plan would be developed in cooperation with VDOT as a construction mitigation measure.

Beginning at the intersection of Route 700 with Route 652, the increased construction traffic would start to disperse onto local roads. However, congestion could develop at the 700/652 intersection during construction shift changes even if the shift changes for construction and operation are synchronized.

Currently, about 850 employees commute to NAPS. These workers are spread over three 8-hour shifts. Planned outages of 4 to 6 weeks occur at each existing unit on a staggered basis. The workforce onsite doubles during these outages (Reference 4). Outage workers are also spread over three 8-hour shifts. Route 700 has historically been able to handle the peak demands of around 2,000 workers without creating a major traffic problem on the local road system. Assuming an average of 1.8 workers per vehicle, this represents about 1100 cars per day traveling this road into and out of the site.

The construction of the new units would add a maximum of approximately 5,000 workers over two 10-hour shifts. These workers would travel the section of Route 700 between Route 652 and the access road to the ESP site on a daily basis. Assuming the same average of 1.8 workers per vehicle, this would represent 2800 additional vehicles, for a total of about 3300 vehicles per day. This would be a major increase in Route 700 traffic. Implementation of a traffic management plan for construction would alleviate the traffic increase to some extent.

At least four outages at the existing units would occur during the 5-year period when the peak construction workforce of 5,000 workers would be onsite. This would create short-term periods when the total onsite workforce (for construction of the new units and work at the existing units) would be about 7,000. Of these, 5,000 would be working two 10-hour shifts and 2,000 would be spread over three 8-hour shifts. During outages, the number of vehicles could rise to 3900 per day unless the use of multi-person vans is strongly encouraged by both the construction and the outage workforces.

e. **Proposed Mitigation Measures**

Currently, Route 700 into the NAPS site has a LOS B. The objective of any traffic mitigation measures would be to maintain LOS on Route 700 at D or better.

To avoid congestion on Route 700 that could congest the Route 700-652 intersection and the construction access road-Route 700 intersection, a construction management traffic plan would be developed prior to the start of construction. This plan would include approaches to increase the number of workers per vehicle above the average of 1.8. The traffic management plan would include methods for enhancing the use of multi-person vans by the construction workforce. Typically, such a plan involves providing offsite parking areas from which workers can be bused to the site and ways to encourage the use of vanpools and carpools.

Concurrently, Dominion would implement measures that enhance the use of vanpools for use by the outage workforce. Additionally, schedules for shift changes for operating personnel, outage workers, and construction workforce would be coordinated to reduce the number of vehicles on the road at any one time. The need to hand-off work from the outgoing to the incoming shift workers may complicate this scheduling effort for the construction workforce and, possibly, for the outage workforce.

Currently, traffic control at the intersection of the Routes 700 and 652 consists of a blinking red light for traffic exiting the NAPS site. Upgrades to Route 700 may be necessary to reduce congestion during shift changes that could develop at the intersection of Routes 652 and 700 due to construction traffic. Upgrades may include construction of turning lanes, and, possibly traffic lights, including green arrows for left-turning vehicles. These options would be assessed after the type of reactor is selected and a better definition of the size of the required workforce can be determined.

4.4.2.2.2 **Impacts on Lake Anna Recreational Area**

Lake Anna is a recreational area that attracts visitors during the summer and early fall months, as well as year-round residents. Therefore, any construction impacts that would substantially reduce the number of visitors could have adverse socioeconomic impacts on the local area. Most impacts that would affect local residents would be related to traffic, and would be confined to discrete times of day when worker shifts were changing.

4.4.2.2.3 **Conclusion**

Analyses of potential impacts of construction activities on the surrounding vicinity and region, presented in Section 4.1, Section 4.2, Section 4.3, and Section 4.4.1, concluded that most impacts would be small. Impacts from traffic would be moderate and would be mitigated with a construction management traffic plan.

4.4.3 **Environmental Justice Impacts**

This section addresses the potential for disproportionately high and adverse human health or environmental impacts on minority and low-income populations that reside within an 80-km (50-mile) radius of the NAPS site during construction of the new units at the ESP site.

The potential for environmental impacts associated with the installation of new units at the ESP are based on the following findings:

- Construction impact analyses presented in Section 4.4.1 and Section 4.4.2 conclude that the physical and socioeconomic impacts would be small to moderate.
- The ESP site is located in an area that does not raise environmental justice concerns. There are relatively few minority and low-income populations in the environmental impact area. The nearest minority or low-income populations are 20 km (about 12 miles) from the ESP site and most types of impacts associated with construction of the new units decrease rapidly with distance from the construction site.
- As described in Section 4.4.2, the only potential moderate impact from construction of the new units would be associated with traffic congestion created by the large workforce. However, these traffic issues would affect all drivers in the impacted areas equally. That is, there would not be a disproportionately high and adverse impact on minorities and low-income populations within the 80-km (50-mile) radius of the ESP site.

Based on the above, it can be concluded that there would be no disproportionately high and adverse human health or environmental impacts on minority and low-income populations due to construction of new units. There are potential beneficial impacts for these populations related to increased direct employment.

Section 4.4 References

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

2. Louisa County Ordinance, Section 51-3, Unnecessary and disturbing noise prohibited.

3. Spotsylvania County Ordinance, Section 14-14, Unreasonably loud, disturbing, and unnecessary noise.

4. *Environmental Report* (ER) as Appendix E of the North Anna Power Station, Units 1 and 2 Application for Renewed Operating Licenses, Dominion Energy, May 2001.

5. *I-95 Collector-Distribution Access Feasibility Study Final Report*, prepared by BMI et al. for Virginia Department of Transportation, March 2002.

6. *Lake Anna Special Area Plan* by the Lake Anna Special Area Plan Committee appointed by the Boards of Supervisors of Louisa, Orange and Spotsylvania Counties, March 2000.

7. *The County of Louisa Tomorrow – The Plan*, The County of Louisa, Virginia, Comprehensive Plan, Chapter V, September 4, 2001.

8. *Spotsylvania County Approved 2002 Comprehensive Plan*, Transportation Plan, February 12, 2002.

9. *Hanover County Comprehensive Plan – Vision 2017*, Transportation Plan, adopted September 1998.

4.5 Radiation Exposure to Construction Workers

4.5.1 Site Layout

The physical location of the new units relative to the existing units at the NAPS site is presented on Figure 2.1-1. As shown, the new units would be located west of the protected area for the existing units. Hence, construction activity would take place outside the protected area for the existing units, but inside the restricted area boundary.

4.5.2 Radiation Sources

During the construction of the new units, the construction workers may be exposed to radiation sources from the routine operation of the existing units as described in the following paragraphs.

4.5.2.1 Direct Radiation

The boron recovery tanks and the low-level contaminated storage area are among the existing units' principal sources contributing to direct radiation exposure at the construction site. The design basis radiation source term for the boron recovery tank is listed in the North Anna UFSAR, Table 11.2-4. The UFSAR also estimates that the low-level contaminated storage area contains the equivalent of less than 1 Ci of Co-60 (Reference 1).

Another source of direct radiation is the ISFSI, which is located south of the construction site. The source terms for the ISFSI are provided in the ISFSI Safety Analysis Report (SAR), Tables 7-1 to 7-4 (Reference 2).

4.5.2.2 Gaseous Effluents

Sources of gaseous releases include the waste decay tanks, boron recovery and high-level waste tanks, containment purge system, auxiliary building vent, main condenser air ejector vents, auxiliary steam drain receiver, turbine building ventilation exhaust, and gland seal ejector vent. The annual releases for 2001 have been reported as 270 Ci of fission and activation gases, 2.1E-3 Ci of I-131, 4.0E-5 Ci of particulates with half-lives greater than eight days, and 82 Ci of tritium (Reference 3). The annual releases for 2001 are typical for the existing units.

4.5.2.3 Liquid Effluents

Effluents from the liquid waste disposal system produce small amounts of radioactivity in the North Anna Reservoir and the WHTF. The annual liquid radioactivity releases for 2001 have been reported as 0.49 Ci of fission and activation products, 810 Ci of tritium, and 1.2E-2 Ci of dissolved and entrained gases (Reference 3). The annual releases for 2001 are typical for the existing units.

4.5.3 Measured and Calculated Dose Rates

The measured or calculated dose rates used to estimate worker dose are presented below.

4.5.3.1 Direct Radiation

Table 4.5-1 provides thermo-luminescent dosimeter (TLD) measurements at the west protected area fence of the existing units from 1996 to 2002. The average annual dose for this period is 56 mrem. It should be noted that the TLD measurements include background radiation. A radiological survey taken at the same location in April 2003 shows a dose rate of 0.02 mrem/hr.

The average distance from the ISFSI pads to the construction area for the new units is about 1600 feet. The dose rate at 1600 feet from a fully loaded ISFSI has been previously calculated using the MCNP computer program as 4.7E-3 mrem/hr.

4.5.3.2 Gaseous Effluents

The Annual Radioactive Effluent Release Report for 2001 (Reference 3) indicates a total body dose of 4.6E-2 mrem, a skin dose of 1.1E-1 mrem, and a critical organ dose of 1.5E-1 mrem to the maximally exposed member of the public due to the release of gaseous effluents from the existing units, calculated in accordance with the existing units' Offsite Dose Calculation Manual (Reference 4).

4.5.3.3 Liquid Effluents

The Annual Radioactive Effluent Release Report for 2001 (Reference 3) reports a whole body dose of 0.308 mrem and a critical organ dose of 0.352 mrem to the maximally exposed member of the public due to the release of liquid effluents from the existing units, calculated in accordance with the existing units' Offsite Dose Calculation Manual (Reference 4).

4.5.4 Construction Worker Doses

Construction worker doses were conservatively estimated using the following information (see Section 4.4.2):

- The estimated maximum dose rate for each pathway
- An exposure time of 2080 hours per year
- A peak loading of 5000 construction workers per year

The estimated maximum annual dose for each pathway as well as the total dose are shown below.

4.5.4.1 Direct Radiation

At the west protected area fence, Section 4.5.3 indicates an average annual dose of 56 mrem based on TLD measurements and a dose rate of 0.02 mrem/hr based on a radiological survey. The latter reading reflects the sensitivity of the instrument in measuring such low instantaneous dose rates. TLD measurements, however, are more accurate as they reflect continuous exposures for long periods of time. The average measured dose rate over a seven-year period of 56 mrem/yr is based on continuous exposure at the protected area fence between the existing and new units.

Since the construction workers would spend most of their time west of this fence, further away from the existing units, using this dose rate for the workers is conservative. Adjusting for an exposure time of 2080 hr/yr yields an annual worker whole body or total effective dose equivalent (TEDE) dose of 13 mrem.

Although the TLD reading includes the dose contribution from the ISFSI loading at the time of the measurement, the dose from a fully loaded ISFSI is conservatively added to the TLD dose. The ISFSI dose rate of 4.7E-3 mrem/hr with an exposure time of 2080 hr/yr is equivalent to an annual dose of 9.8 mrem. Adding the two contributions results in a total annual dose of 23 mrem.

4.5.4.2 **Gaseous Effluents**

The annual gaseous effluent doses to the maximally exposed member of the public (Section 4.5.3.2) are based on continuous occupancy. Adjusted for an exposure time of 2080 hr/yr and multiplying by a factor of 10 to account for the fact that the worker is located closer to the effluent release point than is the maximally exposed member of the public, the estimated worker doses are 1.1E-1 mrem for the total body, 2.7E-1 mrem for the skin, and 3.5E-1 mrem for the critical organ. Applying a weighting factor of 0.3 to the critical organ dose (Reference 5) and adding to the total body dose, a TEDE of 2.1E-1 mrem is estimated.

4.5.4.3 **Liquid Effluents**

As the annual liquid effluent doses to the maximally exposed member of the public in Section 4.5.3 are based on continuous occupancy, they are adjusted for an exposure time of 2080 hr/yr. Although the liquid effluent dose rates to which the workers would be exposed are expected to be no higher than those to the maximally exposed member of the public, the doses are multiplied by a factor of 10 for conservatism and consistency with the gaseous dose factor above. The resulting doses are 7.3E-1 mrem for the whole body and 8.4E-1 mrem for the critical organ. Applying a weighting factor of 0.3 to the organ dose and adding to the whole body dose, a TEDE of 9.8E-1 mrem is estimated.

4.5.4.4 **Total Doses**

The annual doses from all three pathways are summarized in Table 4.5-2 and compared to the public dose criteria in 10 CFR 20.1301 (Reference 6) and 40 CFR 190 (Reference 7) in Table 4.5-3 and Table 4.5-4, respectively. The unrestricted area dose rate in Table 4.5-3 was estimated by rounding up the 0.02 mrem/hr reading (Section 4.5.3) to 0.1 mrem/hr. Since the calculated doses meet the public dose criteria of 10 CFR 20.1301 and 40 CFR 190, the workers would not need to be classified as radiation workers. Table 4.5-5 shows that the doses also meet the design objectives of 10 CFR 50, Appendix I, for gaseous and liquid effluents (Reference 8).

The maximum annual collective dose to the construction work force (5000 workers) is estimated to be 120 person-rem.

The calculated 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.

Section 4.5 References

1. *Updated Final Safety Analysis Report,* North Anna Power Station, Revision 38.
2. *Independent Spent Fuel Storage Installation Safety Analysis Report,* North Anna Power Station, Revision 3.
3. *Annual Radioactive Effluent Release Report, North Anna Power Station (January 01, 2001 to December 31, 2001),* Virginia Electric and Power Company, 2002.
4. Procedure No. VPAP-2103N, *Offsite Dose Calculation Manual,* Revision 2, Administrative Procedure, Dominion.
5. ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers*, Part 1, Published for the International Commission on Radiological Protection by Pergamon Press, 1979.
6. 10 CFR 20.1301, *Code of Federal Regulations*, “Dose Limits for Individual Members of the Public.”
7. 40 CFR 190, *Code of Federal Regulations*, “Environmental Radiation Protection Standards for Nuclear Power Operations.”
8. 10 CFR 50, Appendix I, *Code of Federal Regulations*, “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.”

Table 4.5-1 TLD Dose Measurements at West Protected Area Fence of Existing Units

	Dose (mrem)				
Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
1996	25	0	16	18	59
1997	13	9	12	14	48
1998	14	13	12	13	52
1999	1	9	8	15	32
2000	16	22	0	17	55
2001	16	19	13	21	69
2002	18	15	15	26	74
Average					56

Note: The west protected area fence represents the closest approach to the existing units for construction workers working on the new units; see Section 4.5.1.

Table 4.5-2 Annual Construction Worker Doses

	Annual Dose (mrem)		
	Whole Body	Critical Organ	TEDE
Direct radiation	2.3E+01	-	2.3E+01
Gaseous effluents	1.1E-01	3.5E-01	2.1E-01
Liquid effluents	7.3E-01	8.4E-01	9.8E-01
Total	2.4E+01	1.2E+00	2.4E+01

Table 4.5-3 Comparison with 10 CFR 20.1301 Criteria for Doses to Members of the Public

Criteria	Dose Limit	Estimated Dose
Annual TEDE (mrem)	100	24
Unrestricted area dose rate (mrem/hr)	2	0.1

Table 4.5-4 Comparison with 40 CFR 190 Criteria for Doses to Members of the Public

	Annual Dose (mrem)	
Organ	**Limit**	**Estimated**
Whole body	25	24
Thyroid	75	1.2
Other organ	25	1.2

Note: The estimated whole body dose conservatively includes background radiation whereas the dose limit applies to exposures from plant operation only.

Table 4.5-5 Comparison with 10 CFR 50, Appendix I Criteria for Effluent Doses

	Annual Dose (mrem)	
	Limit	**Estimated**
Total body dose from liquid effluents	3	0.73
Organ dose from liquid effluents	10	0.84
Total body dose from gaseous effluents	5	0.11
Skin dose from gaseous effluents	15	0.27
Organ dose from radioactive iodine and radioactive material in particulate form	15	1.2

4.6 Measures and Controls to Limit Adverse Impacts During Construction

The following measures and controls would limit adverse environmental impacts:

- Compliance with applicable federal, Virginia, and local laws, ordinances, and regulations intended to prevent or minimize adverse environmental impacts (e.g., solid waste management, erosion and sediment control, air emissions, noise control, storm water management, spill response and cleanup, hazardous material management).
- 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 (e.g., U.S. Army Corps of Engineers Section 404 Permit, VDEQ wetlands permit).
- Compliance with existing Virginia Power processes and/or procedures applicable to construction environmental compliance activities for the NAPS site (e.g., solid waste management, hazardous waste management, spill prevention and response).
- Incorporation of environmental requirements into construction contracts.
- Identification of environmental resources and potential impacts during the development of this Environmental Report and the Early Site Permitting process.

The Potential Impact Significance columns in Table 4.6-1 list the elements identified in NUREG-1555, Section 4.6, (Reference 1) that relate to the construction issues. The significance levels – (S)mall, (M)oderate, or (L)arge – provided for each element in the table are determined by evaluating the potential impacts after any controls or mitigation measures are implemented.

Section 4.6 References

1. NUREG-1555, *Standard Review Plans for Environmental Reviews of Nuclear Power Plants,* Section 4.6, “Measures and Controls to Limit Adverse Impacts During Construction,” Office of Reactor Regulation, U.S. Nuclear Regulatory Commission (USNRC), October 1999.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Specific Measures and Controls**
4.1 Land-Use Impacts																
4.1.1 The Site and Vicinity		S				S				S	S				• Ground disturbing activities including grading and re-contouring • Removal of existing trees and vegetation. Potential impacts to wetlands and intermittent streams. • Stockpiling of soils onsite. • Construction of new buildings and impervious surfaces (e.g., parking lots).	• Conduct ground disturbing activities in accordance with regulatory and permit requirements. Use adequate erosion controls and stabilization measures to minimize impacts. • Limit tree and vegetation removal to the existing NAPS site, which is zoned “industrial.” • Minimize potential impacts to wetlands and intermittent streams through avoidance and compliance with applicable permitting requirements. • Restrict soil stockpiling and re-use to the NAPS site. • Restrict construction activities to the NAPS site.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Specific Measures and Controls**
4.1.2 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 modeling these lines with the new units' power contribution would be performed to confirm this conclusion. This evaluation would be conducted at a suitable time after a decision is made by Dominion to proceed with the new capacity.	None
4.1.3 Historic Properties and Cultural Resources														S	• Ground disturbing activities including grading, excavation, and re-contouring.	• Conduct sub-surface testing prior to initiating ground disturbing activities to identify buried historic or archeological resources. • Take appropriate actions (e.g., stop work) following discovery of potential historic or archeological resources. • Use existing Virginia Power procedures that require contacting the appropriate regulatory agencies following a discovery of potential historic or archeological resources.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

	Potential Impact Significance [a, b]															
Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Specific Measures and Controls
4.2 Water-Related Impacts																
4.2.1 Hydrologic Alterations		S				S	S		S		S	S			• Removal of existing cofferdam for the construction of new water intake on Lake Anna. • Impact to intermittent streams. • Erosion, sediment, and storm water runoff from construction site to Lake Anna prior to permanent stabilization, and installation of storm water drainage system • Potential impact to some potable water wells at the NAPS site from construction dewatering activities.	• Design and install appropriate barrier (e.g., turbidity curtain in Lake Anna near cofferdam work location) to prevent turbid water from migrating into the Lake. • Adhere to applicable regulations and permit requirements with regard to seasonal restrictions for in-water work, installation of appropriate erosion control measures, drainage controls to convey stream flow, and construction storm water management. • Use Best Management Practices (BMP) described in the Virginia Erosion and Sediment Control Handbook to control erosion and minimize the sediment load from the construction zone. • Use wells unaffected by dewatering activities to maintain needed capacity for the NAPS site. Not all wells are expected to be affected by dewatering activities.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Specific Measures and Controls**
4.2.2 Water-Use Impacts		S			S	S	S		S		S	S			• Potential impacts from releases of fuel, oils, or other chemicals associated with construction to surface or ground water. • Potential impacts from increased sediment loading in storm water runoff to North Anna Reservoir. • Potential impact to the local water table due to construction dewatering activities.	• Develop and implement a construction Storm Water Pollution Prevention Plan (SWPPP) and spill response plan during construction at the NAPS site. • Implement an Erosion and Sediment Control Plan that describes use of approved/recognized Best Management Practices (BMP). • Limit dewatering activities to only those necessary for construction. • Use offsite sources of potable water, if necessary, to temporarily supplement onsite water resources.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Specific Measures and Controls**
4.3 Ecological Impacts (i.e., impacts on the physical environment)																
4.3.1 Terrestrial Ecosystems	S		S					S		S					• Clearing and grading activities and habitat loss would displace existing mobile animals such as birds and larger mammals from construction zone. • Wildlife (e.g., birds and small mammals) may be startled or frightened away by noisy construction activities. • Potential impacts from avian collisions with man-made structures (e.g., cranes, buildings) during construction.	• No measures and controls are necessary because impacts would be small.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

Section Reference	Potential Impact Significance [a, b] Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Specific Measures and Controls
4.3.2 Aquatic Ecosystems		S	S			S			S		S				• Potential impacts on surface water from releases of fuel, oils, or other chemicals associated with construction to surface water. • Potential impacts on the North Anna Reservoir from increased sediment loading in storm water runoff to the North Anna Reservoir. • Temporarily degraded water quality due to in-water and shoreline work near the cofferdam. • Temporary loss of benthic habitat and organisms near cofferdam. • Potential impact from re-entrainment of contaminated sediments into the water column.	• Develop and implement a construction Storm Water Pollution Prevention Plan (SWPPP) and spill response plan during construction at the site. • Implement an Erosion and Sediment Control Plan that describes use of approved/recognized BMPs. • Design and install appropriate barrier (e.g., turbidity curtain in the North Anna Reservoir near cofferdam work location) to prevent turbid water from migrating into the lake. • Adhere to seasonal restrictions on in-water construction activities. Following temporary construction disturbance, intake channel cove would likely be re-colonized by benthic organisms and fish.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

Section Reference	Potential Impact Significance [a, b]														Impact Description or Activity	Specific Measures and Controls
	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)		
4.4 Socioeconomic Impacts (i.e., Impacts on the Human Community)																
4.4.1 Physical Impacts	S		S	S		S			S		S	S			• Potential temporary and limited impact to sensitive populations due to noise, fugitive dust, and gaseous emissions resulting from construction activities. • Potential for traffic accidents with increased construction traffic near the NAPS site. • Limited in-water construction activity to remove the existing cofferdam.	• Train and appropriately protect NAPS site and temporary construction personnel (i.e., those most directly and frequently affected by construction noise, dust and gaseous emissions) to reduce the risk of potential harmful exposures from noise, dust, and gaseous emissions. • Provide onsite services for emergency first aid care and conduct regular health and safety monitoring for affected personnel on site. • In the event of atypical or noisy construction activities are necessary (e.g., pile driving), make public announcements and/or notifications prior to undertaking such activities. • Use normal dust control measures (e.g., watering, stabilizing disturbed areas, covering truck loads). • Manage concerns from adjacent residents, business owners, or landowners, on a case-by-case basis through a Dominion prepared concern resolution process. • Post signs at or near construction site entrances and exits to make the public aware of potentially high construction traffic areas. • Design and install appropriate barrier (e.g., turbidity curtain in the North Anna Reservoir near cofferdam work location) to prevent turbid water from migrating into the lake.

Table 4.6-1 Summary of Measures and Controls to Limit Adverse Impacts During Construction

Section Reference	Potential Impact Significance [a, b] Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Specific Measures and Controls
4.4.2 Social and Economic Impacts				M								S			• Potential impact on existing transportation network in the vicinity of the ESP site due to increased construction workforce traffic. • General increase in construction equipment and material deliveries affecting local and regional roadways.	• Develop a construction traffic management plan prior to construction to address potential impacts on local roadways. • Encourage the use of shared (e.g., carpooling) and multi-person transport (e.g., buses) of construction personnel to the ESP site. • Coordinate schedules during work force shift changes to limit impacts on local roads. • Schedule delivery of larger pieces of equipment or structures on off-peak traffic hours (e.g., at night) or through other transportation modes (e.g., rail). • If necessary, consider/coordinate with local planning authorities the upgrading of local roads, intersections, and signals to handle increased traffic loads.
4.4.3 Environmental Justice Impacts															No impacts identified	No mitigation measure or controls proposed
4.5 Radiation Exposure to Construction Workers															No impacts identified	No mitigation measure or controls proposed

a. The assigned significance levels [(S)mall, (M)oderate, or (L)arge are based on the assumption that for each impact, the associated proposed mitigation measures and controls (or equivalents) would be implemented.

b. A blank in the elements column denotes “no impact” on that specific element due to the assessed impacts.

Chapter 5 Environmental Impacts of Station Operation

This chapter presents the potential environmental impacts from the operations of new units on the ESP site. In accordance with 10 CFR 51, impacts are analyzed, and a single significance level of potential adverse impacts (i.e., small, moderate, or large) has been assigned to each analysis. This is noted in respective topic discussions. Mitigation of adverse impacts is also presented, where appropriate. This chapter is divided into ten subsections:

- Land use impacts
- Water-related impacts
- Cooling system impacts
- Radiological impacts of normal operation
- Environmental impacts of waste
- Transmission system impacts
- Uranium fuel cycle impacts
- Socioeconomic impacts
- Decommissioning
- Measures and controls to limit adverse impacts during operation

These subsections also present potential ways to avoid, minimize, or mitigate environmental impacts to the extent possible, including complying with the applicable sections of the following laws, regulations, guidelines, or procedures:

- Federal, Virginia, and local laws and regulations that minimize or prevent adverse environmental impacts (e.g., waste management, air emissions, noise control, storm water management, spill response and cleanup, hazardous material management)
- Recognized industry-standard codes and practices
- Site permits and licenses (e.g., VPDES Permit, Operating License) and other permits that would be required if/when operation and maintenance activities commence
- Existing Virginia Power policies and/or procedures that address environmental compliance requirements

The environmental description, where referenced, includes the following definitions:

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

5.1 Land-Use Impacts

This section discusses the potential land-use impacts associated with operations of the new units. The operational activities of the new units would not require any current or planned land-uses to be changed or modified either temporarily or permanently. The land use areas considered include those that have the potential to be impacted by operational activities (e.g., the site, the vicinity, the area along transmission corridors, and offsite areas). Additionally, land-use considerations include those historic properties that have been identified in the NRHP, as well as those properties that have the potential to hold historic significance, such as artifacts and human remains. The section is further segregated into the following subsections:

- Site and vicinity
- Transmission corridors and offsite areas
- Historic properties

5.1.1 The Site and Vicinity

Section 2.2.1 describes the NAPS site and vicinity. The NAPS site (including the EAB) has been zoned by Louisa County for industrial use. Land-use impacts to the ESP site as a result of operating the new units would not be significant to the region. Potential land-use impacts to the vicinity from the new units may occur as a result of the following:

- Additional discharges through the WHTF
- Heat dissipation from the dry towers
- Heat, salt deposition, and moisture dissipation (from evaporation and drift) from the wet towers
- Increased traffic loads on the existing local transportation network

5.1.1.1 Waste Heat Treatment Facility Discharges

A detailed description of the WHTF is provided in Section 3.3. The WHTF discharges to the North Anna Reservoir through the Virginia Power owned and operated Dike 3. The North Anna Reservoir has public access and is used for recreational boating, swimming, fishing, camping, and picnicking, and has residential (vacation and year-round) housing along its shores.

All discharges to the WHTF due to operations would continue to be in accordance with federal, state, and local laws and regulations and applicable permit requirements (e.g., VPDES Permit). State agencies (e.g., VDEQ) conduct regular inspections and advise Virginia Power of any concerns or problems that require resolution. The expected increase in discharge water volume from Unit 3 wet cooling tower system blowdown would be negligible when compared with the discharge water volume from the existing units. The change in temperature at the discharge point of the WHTF due to operation of the new units would be negligible and would not impact the current or future recreational uses of the lake.

Section 5.3.2.2, provides an assessment of the potential operational impacts to aquatic ecosystems in Lake Anna due to anticipated increases in discharge volume and temperature resulting from the new units.

5.1.1.2 **Heat and Moisture Dissipation for Dry and Wet Towers**

Potential impacts on land use would be related to possible increases in local temperatures due to heat dissipation to the atmosphere from the new dry and wet towers. A closed-cycle, combination dry and wet tower cooling system would be used for Unit 3 and a dry tower cooling system would be used for Unit 4. Section 3.4.1.1 contains a detailed description of the operation of the wet and dry towers. As ambient air is drawn over sealed piping containing heated water in dry towers, excess heat is transferred to the air through conduction and convection. In wet towers, heat from the water is transferred to the air by allowing a small portion of the water to evaporate thus raising the air temperature and relative humidity. The heated air from the dry and wet towers is then released to the atmosphere where it mixes and is entrained into the surrounding air mass. Any increases in overall atmosphere temperature would be very localized to the NAPS site, and would not affect the atmospheric or ground temperatures beyond the NAPS site boundary. Therefore, there would be no impacts to offsite land use due to heat dissipation to the atmosphere from the new dry and wet towers for Units 3 and 4. Fogging, icing, and salt deposition, which could result from the moisture dissipation (from evaporation and/or drift) from the wet towers, are discussed in Section 5.3.3.

5.1.1.3 **Increased Use of the Existing Local Transportation Network**

The impact on the transportation network accessing the ESP site would be small as a result of operational activities associated with the new units. During the operation of the new units there could be minor increases in traffic on existing public roads leading to and from the NAPS site due to an increase in operations personnel. However, any increases would be small.

5.1.2 **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. If Dominion decides to proceed with development of new units at the ESP site, a system study (load flow) modeling these lines with the new units' power contribution would be performed at that time, to confirm this conclusion. Additional information regarding the existing transmission system is provided in Section 3.7.

No new routes of access corridors would be necessary to serve operation of the new units. No offsite land uses would be affected by operation of the new units.

5.1.3 **Historic Properties**

Impacts of operations on historic properties or cultural resources would be small. (See Section 4.1.3)

Section 5.1 References

None

5.2 Water-Related Impacts

This section describes the hydrological alterations, plant water supply, and water-use impacts associated with the operation of new units at the ESP site. The following topics are covered.

- Hydrologic alterations resulting from station operations and the effects of these alterations on other water users
- Adequacy of water supplies to meet plant water needs
- Water quality changes and possible effects on water use
- Practices that would minimize or avoid hydrologic alterations having adverse impacts
- Identification and compliance with federal, state, regional, and local regulations applicable to water use and water quality

The evaluation of hydrologic alterations and water quality changes considers both surface water and groundwater uses, including domestic, municipal, industrial, mining, recreation, navigation, and hydroelectric power uses.

5.2.1 Hydrologic Alterations and Plant Water Supply

This section describes the hydrological alterations resulting from plant operation and the adequacy of the water sources to supply water needs to the new units. The following topics are covered.

- Identification and description of proposed operational activities that could result in hydrologic alterations
- Identification, description, and analysis of the resulting hydrologic alterations and the effects of these alterations on other water users
- Analysis of proposed practices to minimize hydrologic alterations having adverse impacts.
- Analysis and comparison of plant water needs and the availability of water supplies to meet the plant water needs
- Conclusions with respect to the adequacy of water supplies to meet plant water needs

As described in Section 3.3.1, the North Anna Reservoir would supply most water needs during operation of the new units, which include plant cooling, the initial fill and make-up water for the UHS cooling tower, water supply to the demineralized water system, and fire protection water. Most of the water needs would be for plant cooling. Unit 3 would use a closed-cycle system for plant cooling and a combination of dry and wet cooling towers for heat dissipation. Make-up water to replace the water lost due to evaporation in the wet cooling towers would be supplied from the North Anna Reservoir. Unit 4 would use a closed-cycle system for plant cooling and dry cooling towers for heat dissipation. There would typically be no make-up water needs since the cooling water would be circulated in a closed loop from the surface condenser to the dry towers of Unit 4. In the event that the Unit 4 cooling water loop would use an open pump sump configuration with a free surface, a small amount of make-up water estimated to be on the order of 1 gpm (0.002 cfs) would be needed to replenish the evaporative loss. This make-up water would be obtained from the North Anna Reservoir. There would be no blowdown discharge from the Unit 4 dry cooling towers.

Water needs other than for plant cooling would be required on an intermittent, short-term basis and would be small relative to the long-term plant water use for normal cooling of Unit 3. The water needs supplied by Lake Anna would include UHS cooling tower make-up, demineralized water supply, and fire protection water supply, as described Section 3.3.1. Based on information provided in Table 3.3-1 and Table 3.3-2, withdrawals would total 2.5 cfs during normal plant operation and 11.0 cfs during abnormal or upset conditions for each unit. Plant water releases back to the lake via the WHTF are described in Section 3.3.1. These releases would total 1.1 cfs during normal plant operation and 3.0 cfs during abnormal or upset conditions for each unit, based on information provided in Table 3.3-1 and Table 3.3-2. Considering these withdrawals and returns, the net use of Lake Anna water for each of the new units would be 1.4 cfs during normal plant operation and up to 8.0 cfs during upset or abnormal conditions. Because the 1.4 cfs value (2.8 cfs for two new units) is small relative to the other terms in the Lake Anna water balance and because water consumption at this rate would occur on an intermittent, short-term basis, this water usage would have no impact on the adequacy of the water supplies to meet plant water needs.

5.2.1.1 **Operational Activities That Could Result in Hydrologic Alterations**

The operational activity that could result in the most significant hydrologic alterations is the use of water from the North Anna Reservoir for plant cooling. The associated hydrologic alterations are presented below.

The operation of Unit 3 would result in evaporative losses from the wet cooling towers used for plant cooling. Table 3.3-1 indicates MWC mode and EC mode evaporation rates of 25.7 and 37.2 cfs, respectively. To maintain the water balance in the closed-cycle cooling system, water supplied from the North Anna Reservoir would be used to make up the water lost to evaporation. Table 3.3-1 indicates the maximum make-up water withdrawal rate of 34.3 cfs when in the MWC mode and 49.6 cfs when in the EC mode, which includes evaporation, drift losses, and blowdown requirement. These make-up withdrawal rates are in addition to the 4246 cfs of cooling water withdrawn currently by the existing units (Reference 1). Blowdown from the wet cooling towers would be returned to the North Anna Reservoir via the WHTF. MWC mode and EC mode blowdown rates are 8.6 and 12.4 cfs, respectively, as indicated in Table 3.3-1. The rates expressed for evaporation, make-up, and blowdown are maximums for the defined modes of operation, and would occur on an instantaneous basis only when maximum dry and wet bulb ambient conditions are at their defined 0.4 percent exceedence condition. The average evaporative loss during normal plant operation is expected to be 19.4 cfs based on the operating plan described in Section 3.4.1.1.

Operation of Unit 4 would increase the quantity of water withdrawn from the North Anna Reservoir by a small amount to supply for the other plant water uses, as presented in Section 5.2.1. An additional, negligible amount (0.002 cfs) of make-up water may also be necessary for normal plant cooling. There would also be a small increase in plant water releases discharged to the WHTF for return to the North Anna Reservoir. The Unit 4 closed-cycle dry cooling system would have no blowdown discharge and therefore would have no impact on Lake Anna water temperatures.

5.2.1.2 Hydrologic Alterations and Effects on Other Water Users

The additional water use would reduce the volume of water available for release from the North Anna Dam. Evaporation from Unit 3's wet cooling towers would decrease the water available to be released from the dam by a maximum of 25.7 cfs during MWC mode operating conditions and 37.2 cfs during EC mode operating conditions on an instantaneous basis. Operation of the Unit 4 closed-cycle dry cooling system would have no measurable impact on the quantity of water available for dam release. No reductions in the minimum releases specified in the Lake Level Contingency Plan (Reference 2) would occur.

Additional effects of the hydrologic alterations would be reductions in the Lake Anna water levels during periods of extended drought, due to the additional evaporative losses associated with the operation of Unit 3's wet cooling towers. The impacts on lake level from the operation of the new units are presented in Section 5.2.2.

No hydrologic alterations in addition to those identified and analyzed above are anticipated.

5.2.1.3 Proposed Practices to Minimize Hydrologic Alterations Having Adverse Impacts

As described in Section 3.4.1.1, the closed-cycle, dry and wet tower cooling system for normal plant cooling of Unit 3 would be operated to conserve water when lake inflows are insufficient to maintain a pool level of 250 ft or above. When lake level falls below 250 ft msl and the level is not restored within a reasonable period of time, the cooling system would be operated in the MWC mode. The period assumed was 7 days; however, the actual time frame from switching to the MWC mode would be established with State agencies at the time of permitting. In this mode, only the dry towers would be used to dissipate the entire heat load from the surface condenser when the ambient DBT is sufficiently low. When the ambient DBT is above the temperature where the dry tower can reject the plant waste heat on its own, the necessary capacity of wet tower cells required to assist in the dissipation of condenser heat load would be placed in operation in series with the dry towers. Using the MWC mode would reduce adverse impacts on lake levels and reservoir releases during sustained dry periods.

5.2.1.4 Comparison of Plant Water Needs to the Availability of Water Supplies

The available water supplies are compared to plant water needs on a time-averaged basis in Table 5.2-1. The available water supply is estimated from the water balance equation:

$$\text{Available Water Supply} = \text{Net Inflow} - \text{Evaporation} - \text{Minimum Release} \qquad \text{(Equation 5.2-1)}$$

where:

Net Inflow = average net inflow to Lake Anna from tributary inflow, groundwater discharge, and direct precipitation;

Evaporation = average pre-operational evaporation, including natural evaporation and forced evaporation from the existing units; and

Minimum Release = minimum amount of flow that must be released from the North Anna Dam.

Table 5.2-1 summarizes the results for the combined operation of the existing units plus new Unit 3 using a closed-cycle, combination dry and wet cooling tower system. The results would be similar to the combined operation of the existing units plus new Unit 3 using a closed-cycle, combination dry and wet cooling tower system along with new Unit 4 using a closed-cycle, dry cooling tower system with no or negligible make-up water needs. The average evaporative loss from Unit 3's wet cooling towers is used to define the plant water needs on a long-term operating basis. The results provided in Table 5.2-1 indicate that the available water supply (236 cfs) exceeds the plant water needs (19.4 cfs).

Table 5.2-1 Available Water Supply Versus Plant Water Needs

	Flow Rate (ft^3/s)
Quantity	**Existing Units Plus Units 3 & 4**
Net Inflow[a]	369
Pre-Operational Evaporation[b]	93
Minimum Release[c]	40
Available Water Supply[d]	236
Plant Water Needs[e]	19.4

a. Average net inflow derived from water balance model described in Section 5.2.2.

b. Natural evaporation from Lake Anna plus forced evaporation from the existing units on a time-averaged basis; derived from the thermal model described in Section 5.3. Forced evaporation is based on a 93% plant capacity factor.

c. Minimum release for Lake Anna water levels in excess of 248 ft above mean sea level (Reference 2).

d. Equation 5.2-1

e. Average evaporation associated with Unit 3's wet cooling towers based on a 96% plant capacity factor; the evaporation rate was derived from the water balance model described in Section 5.2.2. Unit 4's dry towers incur no to negligible evaporative losses.

5.2.1.5 Adequacy of Water Supplies to Meet Plant Water Needs

The analysis presented in Section 5.2.1.4 demonstrates that the available water supply from the Lake Anna watershed is adequate to meet plant water needs for the existing units plus Unit 3 alone, or the existing units plus new Units 3 and 4, on a long-term average basis.

5.2.2 Water-Use Impacts

This section analyzes and assesses the impacts of plant operation on water use. The following topics are covered in the section:

- Analysis of hydrologic alterations that could have impacts on water use, including water availability
- Analysis of water-quality changes that could affect water use
- Analysis and evaluation of impacts resulting from hydrologic alterations and changes
- Analysis and evaluation of proposed practices to minimize or avoid water-use impacts
- Evaluation of compliance with federal, state, regional, local, and affected Native American tribal regulations applicable to water use and water quality

As described in Section 5.2.1, the primary hydrologic alterations resulting from the operation of new units at the ESP site include:

- reductions in the volume of water available for release from the North Anna Dam, and
- reductions in Lake Anna water levels during periods of drought.

A water balance model for Lake Anna was developed to quantitatively assess the impacts of adding the new units. This model considers the evaporation of cooling water associated with the operation of Unit 3. Unit 4 is not represented in the model because operation of its cooling system would have no measurable impacts. The model formulation, input data, and results, in terms of lake outflow and lake level, are described below. Analysis and evaluation of impacts are described subsequently.

5.2.2.1 Water Balance Model

5.2.2.1.1 Model Formulation

Figure 5.2-1 illustrates the conceptual model used to represent the Lake Anna water balance. The continuity equation for this control volume may be expressed as (Reference 3):

$$\frac{dS}{dt} = I - O, \quad S(0) = S_0 \qquad \text{(Equation 5.2-2)}$$

where:

S is the storage
t is time

I is the inflow rate
O is the outflow rate
S_0 is the initial storage

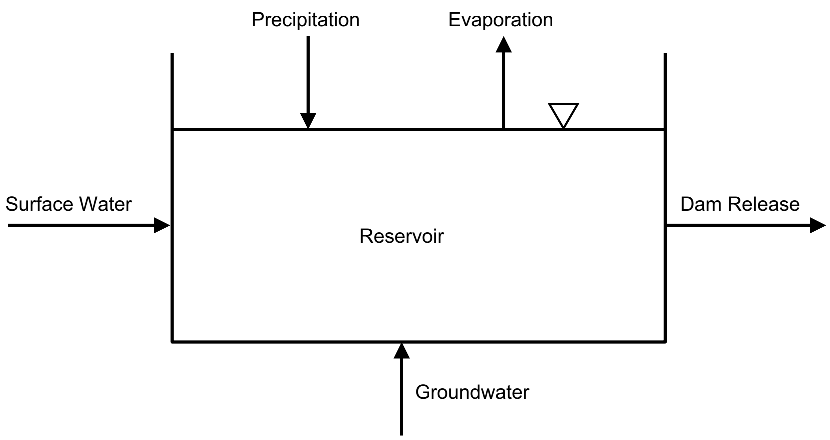

Figure 5.2-1 Lake Anna Water Balance Model

In this analysis, S includes the combined storage of the North Anna Reservoir and the WHTF. The inflow rate to Lake Anna, I, is defined as:

$$I \equiv I_{SW} + I_{GW} + I_P \qquad \text{(Equation 5.2-3)}$$

where:

I_{SW} is the surface water inflow to the lake from contributing tributaries
I_{GW} is the groundwater inflow to lake
I_P is the inflow from precipitation falling directly on the lake

Because data are not available to characterize I_{SW} and I_{GW} adequately, the total inflow rate to Lake Anna, I, is unknown. The basis for estimating this time series will be described subsequently.

The outflow rate from Lake Anna, O, is defined as

$$O \equiv O_{Preop\text{-}Evap} + O_{Unit3\text{-}Evap} + O_R \qquad \text{(Equation 5.2-4)}$$

where:

$O_{Preop\text{-}Evap}$ is the pre-operational outflow due to evaporation
$O_{Unit3\text{-}Evap}$ is the evaporative loss associated with Unit 3's wet cooling towers
O_R is the outflow from dam releases

Note that $O_{Preop\text{-}Evap}$ includes the natural evaporation from the lake plus the forced evaporation from operating the once-through cooling systems of the existing units.

The initial value problem defined by Equation 5.2-2 is solved by the finite-difference method. Using subscript n and $n+1$ to represent the beginning and end of any given time period, Equation 5.2-2 can be written:

$$\frac{S_{n+1} - S_n}{\Delta t} = I_n - O_n \qquad \text{(Equation 5.2-5)}$$

and rearranged to yield:

$$S_{n+1} = (I_n - O_n)\Delta t + S_n \qquad \text{(Equation 5.2-6)}$$

Note that S_{n+1} is a function of reservoir elevation, h, which can be obtained from the reservoir's elevation-storage relationship. Equation 5.2-6 is solved first for S_1 given the initial conditions at $t = 0$. The computation is then repeated for succeeding time steps.

5.2.2.1.2 **Model Input Data**

Required model input includes the relationship between water surface elevation and lake storage, the relationship between water surface elevation and lake outflow, the inflow time history to Lake Anna, and the time histories of evaporative losses from the lake and the wet cooling towers. The bases for assigning these input data are described below.

The relationship between water surface elevation and storage is derived from the elevation-volume curves for the North Anna Reservoir and the WHTF, which are reported in the UFSAR for the existing units (Reference 1, Appendix 2A). These curves have been added to yield a single elevation-storage curve for the entire Lake Anna for the purpose of this water balance study. Table 5.2-2 summarizes the storage volumes determined at Elevations 240, 250 and 260 ft msl. A quadratic equation was fitted to the values for interpolating between elevations. The estimated storage volume of 305,100 acre-ft at 250 ft msl lake level used in the water budget model is slightly higher (by 0.03 percent) than the 305,000 acre-ft volume reported in UFSAR Section 2.4.1.2 (Reference 1) or Part 2: Table 2.4-1. This small difference would have no impact on any of the hydrologic and water use evaluations.

Table 5.2-2 Data Input for Water Balance Model

	Storage (acre-feet)		
Elevation (ft msl)	North Anna Reservoir	WHTF	Total Lake Anna
240	161,900	33,300	195,200
250	244,300	60,800	305,100
260	352,750	105,300	458,050

The operating rule curve implemented in the model, which relates water surface elevation to dam releases, has been developed as follows. For lake levels less than or equal to the normal pool elevation of 250 ft above msl, the Lake Level Contingency Plan is followed (Reference 2). This plan requires a minimum instantaneous release from the Lake Anna impoundment of 40 cfs. When lake level drops to or below 248 ft msl, releases can be incrementally reduced to a 20 cfs minimum. For lake levels greater than or equal to 250.1 ft msl, it is assumed that any inflow in excess of the evaporative losses is released, provided the minimum release requirements are met.

The inflow time history to Lake Anna has been calculated by a reverse routing procedure using observed Lake Anna releases and water levels and estimated pre-operational evaporation. This procedure has been adopted because only a small fraction of the Lake Anna watershed is gauged, as is described in Section 2.3.1. The inflow to Lake Anna is calculated by solving Equation 5.2-5 for I_n, or:

$$I_n = \frac{S_{n+1} - S_n}{\Delta t} + O_n \qquad \text{(Equation 5.2-7)}$$

This calculation requires the time histories for storage, S, and outflow, O. The storage time history has been determined using the available period of record for lake level observation, which extends from October 1, 1978, through April 10, 2003. Lake levels, h, have been related to S through quadratic interpolation of the values summarized in Table 5.2-2. According to Equation 5.2-4, O includes the historical releases from the North Anna Dam, and the historical rate of Lake Anna evaporation associated with operation of the existing units. Historical releases from the dam from October 1, 1978, through October 9, 1995, have been derived from the Partlow stream gauging station, which is located approximately one-half mile downstream of the dam. Stream gauging at this station was discontinued on October 10, 1995. Releases from October 10, 1995, through April 10, 2003 have, therefore, been estimated from the historical gate openings and associated rating curves for the North Anna Dam. The determination of historical lake evaporation is described below.

Historical evaporation from Lake Anna has been estimated using the Lake Anna Cooling Pond Model developed by the Massachusetts Institute of Technology (Reference 4) (Reference 5). This model calculates, as part of the heat balance, the heat lost to the atmosphere due to evaporation and the associated evaporation rate on a daily basis for the control volumes used to represent the main ponds in the WHTF and the North Anna Reservoir. The model assumed a constant lake level at 250 ft msl. The thermal model also includes a number of side arms for which the model does not provide the evaporation rates directly. To determine these evaporation rates, an exponentially decreasing function is used to represent the temperature distribution in the surface layer of each side arm based on the entrance and return flow temperatures predicted by the thermal model. Using the mean value of this function to assign a characteristic temperature for the entire side arm, side arm evaporation is calculated using the Ryan-Harleman function (Reference 6). The pre-operational evaporative loss, $O_{Preop\text{-}Evap}$, is then determined as the sum of the values calculated directly by the thermal model for the ponds and those calculated for the side arms. Note that this time series has been estimated using the historical waste heat load from the existing units.

For predictive purposes, the evaporative losses associated with the existing units, which use once-through cooling systems, have been determined on a daily basis using the thermal model following the methodology described above. The calculated evaporation rates have been corrected to reflect a 93 percent plant capacity factor for the existing units and averaged to obtain weekly values for use in the water budget model. The corresponding waste heats loads are 1.26×10^{10} Btu per hour for the existing units combined.

Evaporative losses from the new units were determined as follows:

Evaporation rates from Unit 3’s wet cooling towers were calculated on a daily basis as a function of air temperature and relative humidity, using performance data supplied by a cooling tower vendor, and a waste heat load of 1.03×10^{10} Btu/hour from the circulating and plant service water systems. Evaporation rates were determined for plant operation in the EC and MWC modes, as described in Section 3.4.1.1. In the EC mode, which applies when lake levels are at or above Elevation 250 ft msl, Unit 3’s circulating water system wet cooling towers would be used to dissipate 100 percent of the waste heat from the main condenser. When lake levels fall below Elevation 250 ft msl for seven successive days, the plant is assumed to be operated in the MWC mode, wherein the dry towers would be used to dissipate a minimum of about one-third of the waste heat and the wet towers would be used to dissipate the remaining waste heat. For any given time step, the determination of whether Unit 3 would be in an EC or MWC mode of operation was made based on the lake elevation from the previous time step. The circulating water system cooling tower evaporation rates were combined with those from the service water cooling towers, corrected to reflect a 96 percent plant capacity factor for Unit 3, and averaged to obtain weekly values for use in the water budget model. The closed-cycle dry cooling systems of Unit 4 would introduce negligible additional evaporative losses.

5.2.2.1.3 **Model Results**

The water balance model described above has been used to predict releases from the North Anna Dam and water levels in Lake Anna on a weekly basis for the 24-year period extending from October 1, 1979, through April 10, 2003 considering the addition of Unit 3 as described above. For comparative purposes, the existing units running at a plant capacity factor of 93 percent, which exceeds their historical operating experience, have been simulated as well. An assumption inherent to this analysis is that the climatic conditions and variations during this historical period would be representative of future conditions. Figure 5.2-2 and Table 5.2-3 summarize the results for water releases from the North Anna Dam. Figure 5.2-3 and Table 5.2-4 summarize the results for Lake Anna water levels. The water releases used in the following analyses are determined by the computed lake level at the beginning of each model time step. The lake levels shown below correspond to the end of each time step. As a result of this difference, the percentage of time when the outflow is less than or equal to 20 cfs would be similar, but not necessarily identical, to the percentage of time when the lake level is less than or equal to 248 ft msl. A discussion of these results is provided below.

Table 5.2-3 Lake Anna Low Outflow Frequency

	Percent of Time Outflow is Less Than or Equal to Indicated Values	
Outflow (ft^3/s)	**Existing Units**	**Existing Units plus Unit 3**
100	50.6%	56.1%
80	48.2%	53.4%
60	46.5%	51.1%
40	44.6%	49.6%
20	5.2%	7.3%

Figure 5.2-2 illustrates the variation in the flow released from the North Anna Dam as a function of time for the 24-year period as simulated by the water balance model for the existing units, and the existing units with the addition of Unit 3. These results indicate that outflows from the dam vary seasonally and annually. Typically, flow rates are relatively high in the wetter fall and winter months due to the need to release water in order to maintain the normal pool elevation of 250 ft msl. Releases in the drier summer months are typically limited to the minimum releases required by the Lake Level Contingency Plan. With the onset of wetter conditions in the fall months, inflows to the lake increase, and releases typically increase above the minimum values. Exceptions to this pattern

would have occurred during the droughts of 1980–1981 and 2001–2002 during which the minimum release was maintained over the winter months due to diminished lake inflow.

Table 5.2-3 summarizes the outflow frequency for the low flows of interest. Results for the existing units indicate that water would have been released from the dam at a rate of 40 cfs or less for 44.6 percent of the time and at a rate of 20 cfs for 5.2 percent of the time. These frequencies increase with the increasing plant water needs associated with the addition of Unit 3 to 49.6 percent and 7.3 percent of the time, respectively.

Figure 5.2-3 illustrates the variation in Lake Anna water level as a function of time, as simulated by the water balance model for the two cases under consideration. These results indicate that the water level in Lake Anna varies seasonally and annually in response to climatic conditions. The typical seasonal pattern is as follows. Water levels are normally at their minimum values in October, the beginning of the water year. In response to runoff from fall and winter precipitation, water levels then normally increase to the normal operating pool level of 250 ft msl. This normal pool level is usually maintained over the winter months. With the reduction in precipitation beginning in April, decreased tributary inflows, and increased lake evaporation, water levels in the lake are typically drawn down during the summer months such that the maximum annual drawdown occurs near the end of the water year in September. The magnitude of the lake drawdown varies year to year in response to annual variations in surface water and groundwater inflow, which are caused by annual variations in climate conditions. In particular, the maximum annual drawdown during drought years, such as 1980–1981 and 2001–2002, is substantially greater than in other years.

Table 5.2-4 provides the water level frequency for the low water levels of interest to Lake Anna users and the minimum water level for the 24-year simulation period. These results demonstrate that the percent of time that the water level is less than or equal to a given elevation increases with the increasing plant cooling water needs associated with the addition of Unit 3. The results also indicate that the minimum water level for the simulation period decreases with increasing plant cooling water needs of Unit 3. The minimum water levels are above Elevation 242 ft msl, which is the minimum operating elevation specified in the Technical Requirements Manual for Units 1 and 2 (Reference 11) and the minimum operating elevation proposed for Units 3 and 4. The reduction in the lake level due to the future operation of Unit 3's cooling system would have negligible impact on the water temperature and evaporative loss from the lake. On a long-term basis, the average lake temperature has been estimated to increase less than 0.1°F. The corresponding lake evaporation has been estimated to have a small savings of the order of 0.1 cfs due to a reduction in natural evaporation from the reduced lake area. These variations are not expected to affect the results of the water use impact analysis.

Table 5.2-4 Lake Anna Low Water Level Frequency

	Percent of Time Water Level is Less Than or Equal to Indicated Values	
Elevation (ft msl)	**Existing Units**	**Existing Units plus Unit 3**
248	5.2%	7.0%
246	1.1%	1.4%
244	0%	0%
242	0%	0%
Minimum Water Level	245.1 feet	244.2 feet

5.2.2.2 Analysis and Evaluations of Impacts on Water Use

The results described in Section 5.2.2.1 indicate there would be water-use impacts associated with the operation of Unit 3. These impacts include reductions in the volume of water available for release from the North Anna Dam, which would decrease the volume of water available for downstream users. Impacts also include increases in lake drawdown during the summer months, which could impact other lake users. These impacts are analyzed and evaluated below. Section 5.2.2.1 indicates that the operation of Unit 4 would have no or negligible water-use impacts.

Results included in Figure 5.2-2 and Table 5.2-3 quantify the impact of the releases from the North Anna Dam that would occur with the addition of Unit 3. Given that the minimum releases would comply with the existing VPDES permit Lake Level Contingency Plan (Reference 2), there would be no impact on downstream water users in terms of the minimum flow rate in the North Anna River. The duration of the minimum flow release rates would increase with the addition of Unit 3, however. For the existing units, the duration for which the minimum release is less than or equal to 40 cfs would be 44.6 percent of the time; and the duration for which the minimum release is 20 cfs would be 5.2 percent of the time. Comparable durations with the addition of Unit 3 are 49.6 percent of the time for flows less than or equal to 40 cfs, and 7.3 percent of the time for a flow of 20 cfs. Potential impacts would be greatest in the reach of the North Anna River extending from below the North Anna Dam to its confluence with the South Anna River.

To better quantify impacts to instream flows in the North Anna River, Indicators of Hydrologic Alteration (IHA) have been calculated for the outflow from the North Anna Dam under both pre- and post-impact conditions, and the Range of Variability Approach (RVA) has been applied to assess hydrologic alteration. These analyses have been performed using the methodology proposed by Richter et al. (Reference 8, Reference 9, Reference 10), which calculates statistical descriptions of the streamflow record and changes in these statistics for 33 hydrologic parameters. These parameters are organized into five groups that are intended to characterize the following:

- Magnitude of monthly water conditions
- Magnitude and duration of annual extreme water conditions
- Timing of annual extreme water conditions
- Frequency and duration of high and low pulses
- Rate and frequency of water condition changes

The IHA software package (Reference 11) has been used to perform the IHA and RVA analyses. The current release of the IHA software (Version 7) calculates some parameter values differently than those computed by earlier versions of the software. In particular, the monthly flow values determined for non-parametric analysis are now medians, whereas in previous versions of the software, these values were means. Any statistics subsequently derived from these sub-annual data also would be affected. The application of this methodology to the North Anna River and associated results are described below.

IHA were calculated for the Lake Anna weekly outflows as predicted by the water balance model described in Section 5.2.2.1. The period of record for this simulation includes water years 1979–2002 (24 years). Daily outflows, required as input to the IHA software package, were obtained through linear interpolation of the weekly time series. The pre-impact condition is defined to be Lake Anna in its current, impounded condition with the existing Units 1 and 2 utilizing the lake for condenser cooling. The post-impact condition assumes the addition of Unit 3 with a closed-cycle, dry and wet cooling tower system, and the addition of Unit 4 with a closed-cycle dry tower system. The heat dissipation system selected for Unit 4 will have negligible impacts to lake levels or outflows.

Results of the statistical analyses are summarized in Table 5.2-5, Table 5.2-6, and Table 5.2-7. Table 5.2-5 includes the 10 percent, 25 percent, 50 percent, 75 percent, and 90 percent quantiles for each of the 33 hydrologic parameters for pre- and post-impact conditions. Table 5.2-6 summarizes the results of the IHA analysis, provides the medians and coefficients of dispersion for each hydrologic parameter in a “scorecard” format, and quantifies changes in the IHA between the pre-impact and post-impact water regimes. Table 5.2-7 provides the results of the RVA analysis. In each of these tables, the IHA statistics have been calculated non-parametrically as recommended in the IHA User’s Manual (Reference 11). Note that post-impact period is assumed to extend from 2003–2026 for the purpose of comparing pre- and post-impact streamflow statistics. Also note that several IHA are associated with durations of less than 7 days (e.g., 1-day minimum flow). Because the daily outflows were obtained through linear interpolation of the weekly values, any of the IHA associated with durations of less than 7 days may not be representative.

The results in Table 5.2-5, Table 5.2-6, and Table 5.2-7 indicate that there are no changes in the median 7-day, 30-day, and 90-day minimum flows as a consequence of adding Unit 3. The results do indicate greater variability in the minimum flows with the addition of Unit 3. Results included in Table 5.2-5, Table 5.2-6, and Table 5.2-7 also demonstrate that the Julian date of the annual maximum does not change significantly with the addition of Unit 3.

Because of interest in striped bass spawning and early life stage rearing, the Pamunkey River flows in April and May at the Hanover gauge were analyzed for two-unit and three-unit operation. The low flow (5 percent occurrence frequency, as 7-day running average) was diminished from 207 to 206 cfs (0.5 percent difference), while the median flow was reduced from 851 cfs to 824 cfs (3 percent difference). Across all flows, the flow reduction ranged from 0.5 to 5 percent. Mandated minimum flows would be highly unlikely in April and May. This would indicate that the spring spawning regime in the North Anna River below the North Anna Dam would not be impacted by operation of a new Unit 3 on Lake Anna.

The Pamunkey River in the vicinity of striped bass spawning is accustomed to wide variations of freshwater inflow during April and May, as shown by the Hanover gage data. The variations of freshwater inflow in the spawning areas are attenuated, however, by the tidal flows in the freshwater tidal reach. There are wide temperature variations and considerable variation in timing of spawning episodes in the Pamunkey River (Reference 13). Thus, it would seem reasonable that the spawning fish or their developing eggs, larvae and early juveniles would not detect the small changes in freshwater inflow caused by 25 to 35 cfs reduction of North Anna flows. The adjacent Mattaponi River, with a considerably lower springtime average flow of 961 cfs, also has excellent striped bass spawning and early life rearing (Reference 12).

The abundance in rearing areas for juvenile striped bass is unlikely to be influenced by the changes in freshwater inflow on the order of 1–5 percent, especially when the dynamics of the estuary are largely governed by tidal flows. This conclusion is bolstered by recognition that the adjacent Mattaponi River, with much lower freshwater flow than the Pamunkey, is also a major striped bass spawning river.

Dominion concludes that there will be indistinguishable biological impacts to the general aquatic community of the North Anna River and the striped bass spawning and early rearing areas of the Pamunkey River from changes in flows from the additional evaporative water loss from a new Unit 3 that uses evaporative wet-dry cooling towers. Therefore impacts would be small.

Results presented in Figure 5.2-3 and Table 5.2-4 quantify the impact on lake levels that would occur with the addition of Unit 3. Figure 5.2-3 indicates that the maximum annual drawdown in most years would not differ greatly from the current operation of the existing units. This figure also shows that the minimum lake levels occur in the latter half of the calendar year. To further quantify the impact on lake levels associated with the addition of Unit 3, the minimum lake elevation for the latter half of each year in the 1978–2002 period simulated along with the date on which the minimum lake elevation would have occurred have been summarized in Table 5.2-8. Data are provided for both pre-impact (existing units by themselves) and post-impact (existing units plus Unit 3) conditions. The last column in Table 5.2-8 represents the difference between post- and pre-impact minimum lake elevations for each year.

The Table 5.2-8 results indicate that annual minimum lake elevations under post-impact conditions are 0.01 to 0.89 feet lower than for pre-impact conditions, with this difference averaging 0.26 feet. The greatest difference occurs during drought years, such as those that occurred in 1981 (0.79 feet) and 2002 (0.89 feet). During non-drought years, the differences in minimum lake elevations are significantly less. The Table 5.2-8 results further indicate that the minimum lake elevation occurs most frequently in October for the existing units by themselves and for the existing units plus Unit 3 (9 out of 25 years in both cases). With respect to the recreational impact due to the additional drawdown from operation of Unit 3, the analysis of the effects in non-drought years shows that the overall impacts on the lake levels are relatively small, with the minimum lake levels averaging 248.6 ft msl (versus 248.9 ft currently), mainly in the fall months. Throughout the summer months, the lake levels would be higher than these minimum levels. Although the recreational use of the lake would still be high in the early fall, the greatest use would be during the summer months. Therefore, the impacts on the recreational use of the lake due to decreases in lake level during these non-drought years would be small.

Lake drawdown to Elevation 244.2 ft msl would not impact the existing units. The Technical Requirements Manual for the existing units requires plant shutdown when the lake level drops below Elevation 242 ft msl (Reference 7). Results included in Table 5.2-4 indicate that lake levels would not fall to Elevation 242 ft msl when Unit 3 is added.

No other water-use impacts on surface water or groundwater users due to the normal operation of a new unit or units at the ESP site are anticipated other than those described above.

5.2.2.3 **Analysis of Water-Quality Changes**

The primary impact on water quality from operating new units at the ESP site would be the discharge of cooling tower blowdown from Unit 3’s wet cooling towers to the WHTF for return to the North Anna Reservoir. The cooling tower blowdown would contain elevated levels of dissolved solids, concentrated by evaporation, and various anti-fouling chemicals as described in Section 3.4.1.3.4. The blowdown would also add a small amount of waste heat to the WHTF. Section 5.3.2 details and quantifies the thermal and chemical impacts.

As presented in Section 5.2.1, Unit 4 would not add any waste heat to Lake Anna since there would be no blowdown discharges from its closed-cycle dry cooling tower system.

Other than the water-quality changes identified above, no other water-quality impacts on either surface-water or groundwater users would result from the normal operation of new units at the ESP site.

5.2.2.4 **Proposed Practices to Minimize or Avoid Impacts**

As described in Section 3.4.1.1, the closed-cycle, dry and wet tower cooling system for normal plant cooling of Unit 3 would be operated to conserve water when lake inflows are insufficient to maintain a pool level of 250 ft or above. When lake level falls below 250 ft msl and the level is not restored within a reasonable period of time, the cooling system could be operated in an MWC mode. The time period was assumed to be 7 days; however, the actual time frame would be established with State agencies at the time of permitting. In the MWC mode, only the dry tower would be used to dissipate the entire heat load from the surface condenser when the ambient dry bulb temperature is sufficiently low. When the ambient dry bulb temperature is above the temperature where the dry tower can reject the plant waste heat on its own, the necessary capacity of wet tower cells required to assist in the dissipation of condenser heat load would be placed in operation in series with the dry tower. The use of the MWC mode would reduce adverse impacts on lake levels and reservoir releases during sustained dry periods.

5.2.2.5 **Compliance With Regulations Applicable to Water Use and Water Quality**

The new units at the ESP site would comply with all regulations applicable to water use and water quality. Compliance would be demonstrated in the COL application. Modification of the existing units' VPDES permit (Reference 2) to include discharges from the new units would be required. See Section 5.3.4 for a discussion of potential chemical additives to cooling tower water. The discharge of heated water to the North Anna Reservoir via the WHTF would be subject to CWA Section 316(a) regulations which require that the thermal discharges assure the maintenance of a balanced, indigenous population of shellfish, fish, and wildlife in and on the receiving body of water. The withdrawal of cooling water from the North Anna Reservoir would meet Section 316(b) of the CWA and the implementing regulations, as applicable.

Section 5.2 References

1. *Updated Final Safety Analysis Report,* North Anna Power Station, Revision 38.

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

3. Linsley, Jr., R. K., M. A. Kohler, and J. L. H. Paulhus. *Hydrology for Engineers,* 2nd Edition, McGraw-Hill, 1975.

4. Ho, E., S. A. Wells, and E. E. Adams, User's Manual for Lake Anna Cooling Pond Model, Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, January 1983.

5. Ho., E., and E. E. Adams, Final Calibration of the Cooling Lake Model, North Anna Power Station, Report No. 295, Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, August 1984.

6. Ryan, P. J., and D. R. F. Harleman, An Analytical and Experimental Study of Transient Cooling Pond Behavior, Report No. 161, Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, 1973.

7. Technical Requirements Manual for North Anna Units 1 & 2, Revision 41, Dominion, March 24, 2004.

8. Richter, B. D., J. V. Baumgartner, J. Powell, and D. P. Braun. A method for assessing hydrologic alteration within ecosystems. *Conservation Biology* 10:1163-1174, 1996.

9. Richter, B. D, J. V. Baumgartner, R. Wigington, and D. P. Braun. How much water does a river need? *Freshwater Biology* 37:231-249, 1997.

10. Richter, B. D., J. V. Baumgartner, D. P. Braun, and J. Powell, A Spatial Assessment of Hydrologic Alteration Within a River Network. *Regul. Rivers: Res. Mgmt.* 14:329-340, 1998.

11. Indicators of Hydrologic Alteration, Version 7, User’s Manual, The Nature Conservancy with Smythe Scientific Software and Totten Software Design, October 2005.

12. Bilkovic, D. M., J. E. Olney, and C. H. Hershner, Spawning of American shad (*Alosa sapidissima*) and striped bass (*Morone saxatilis*) in the Mattaponi and Pamunkey rivers, Virginia. *Fishery Bulletin*, U.S. 100:632-640, 2002.

13. Olney, J. E., J. D. Field, and J. C. McGovern, Striped bass egg mortality, production, and female biomass in Virginia rivers, Transactions of the American Fisheries Society, 120:354-367, 1991.

Table 5.2-5 IHA Percentile Data North Anna River

	Pre-Impact Period: 1979-2002 (24 years)						Post-Impact Period: 2003-2026 (24 years)					
	10%	**25%**	**50%**	**75%**	**90%**	**(75-25)/50**	**10%**	**25%**	**50%**	**75%**	**90%**	**(75-25)/50**
Parameter Group #1												
October	40	40	40	79	259	0.97	21	40	40	58	221	0.44
November	30	40	104	273	365	2.25	20	40	48	217	312	3.71
December	30	40	196	332	525	1.50	30	40	161	269	501	1.43
January	40	98	380	529	780	1.14	40	43	359	506	759	1.29
February	40	165	344	592	1147	1.24	40	140	321	570	1122	1.34
March	107	199	480	713	1256	1.07	93	173	455	687	1231	1.13
April	46	146	300	448	1111	1.01	40	119	274	422	1083	1.11
May	40	76	152	318	501	1.59	40	53	123	288	472	1.92
June	40	40	49	111	274	1.47	40	40	46	80	243	0.86
July	40	40	40	63	331	0.58	40	40	40	40	300	0.00
August	40	40	40	90	208	1.24	36	40	40	43	177	0.07
September	40	40	40	40	227	0.00	30	40	40	40	199	0.00
Parameter Group #2												
1-day minimum	30	40	40	40	40	0.00	20	25	40	40	40	0.38
3-day minimum	30	40	40	40	40	0.00	20	25	40	40	40	0.38
7-day minimum	30	40	40	40	40	0.00	20	25	40	40	40	0.38
30-day minimum	26	40	40	40	40	0.00	20	27	40	40	40	0.33
90-day minimum	27	40	40	49	94	0.23	20	27	40	42		0.36

Table 5.2-5 IHA Percentile Data North Anna River

	Pre-Impact Period: 1979-2002 (24 years)						Post-Impact Period: 2003-2026 (24 years)					
	10%	**25%**	**50%**	**75%**	**90%**	**(75-25)/50**	**10%**	**25%**	**50%**	**75%**	**90%**	**(75-25)/50**
1-day maximum	269	1086	1642	2846	3961	1.07	257	926	1615	2817	3936	1.17
3-day maximum	262	1042	1614	2534	3681	0.92	249	890	1588	2505	3656	1.02
7-day maximum	250	976	1572	2067	3240	0.69	236	853	1545	2038	3215	0.77
30-day maximum	202	601	873	1317	1650	0.82	187	570	847	1290	1626	0.85
90-day maximum	121	411	598	796	1168	0.64	104	381	572	769	1143	0.68
Number of zero days	0	0	0	0	0	0	0	0	0	0	0	0
Base flow	0.08	0.10	0.15	0.25	0.65	0.98	0.08	0.10	0.15	0.23	0.46	0.83
Parameter Group #3												
Date of minimum	165	275	275	275	288	0.00	205	275	275	275	284	0.00
Date of maximum	339	38	85	170	275	0.36	339	33	82	143	275	0.30
Parameter Group #4												
Low pulse count	0	0	0	0	1	0.00	0	0	0	0	1	0.00
Low pulse duration	55	55	204	352	352	1.46	27	34	76	304	373	3.55
High pulse count	0.5	3	4	6	8	0.75	1	3	4	6	8	0.69
High pulse duration	9	12	18	22	29	0.52	9	11	15	20	28	0.55

Table 5.2-5 IHA Percentile Data North Anna River

	Pre-Impact Period: 1979-2002 (24 years)						Post-Impact Period: 2003-2026 (24 years)					
	10%	25%	50%	75%	90%	(75-25)/50	10%	25%	50%	75%	90%	(75-25)/50
Parameter Group #5												
Rise rate	10.21	15.45	21.91	31.13	38.49	0.72	12.67	16.44	22.54	30.52	36.43	0.62
Fall rate	–35.83	–30.68	–14.76	–10.09	–6.36	–1.39	–35.82	–31.39	–16.18	–10.01	–4.48	–1.32
Number of reversals	3	14	19	21	25	0.41	3	13	16	21	24	0.48

Table 5.2-6 Non-Parametric IHA Scorecard, North Anna River

	Pre-impact period: 1979-2002 (24 years)	**Post-impact period: 2003-2026 (24 years)**
Watershed area	343	343
Mean annual flow	283	257
Mean flow/area	0.82	0.75
Annual C. V.	0.84	0.95
Flow predictability	0.45	0.45
Constancy/predictability	0.71	0.70
% of floods in 60d period	0.26	0.26
Flood-free season	3	3

(continued on next page)

Table 5.2-6 Non-Parametric IHA Scorecard, North Anna River

	Medians		Coeff. of Disp.		Deviation Factor		Significance Count	
	Pre	Post	Pre	Post	Medians	C.V.	Medians	C.V.
Parameter Group #1								
October	40	40	0.97	0.44	0.00	0.54	0.00	0.74
November	104	48	2.25	3.71	0.54	0.65	0.73	0.48
December	196	161	1.50	1.43	0.18	0.05	0.66	0.88
January	380	359	1.14	1.29	0.06	0.14	0.76	0.69
February	344	321	1.24	1.34	0.07	0.08	0.91	0.83
March	480	455	1.07	1.13	0.05	0.06	0.83	0.88
April	300	274	1.01	1.11	0.09	0.10	0.78	0.84
May	152	123	1.59	1.92	0.19	0.21	0.49	0.52
June	49	46	1.47	0.86	0.04	0.42	0.99	0.33
July	40	40	0.58	0.00	0.00	1.00	0.00	0.20
August	40	40	1.24	0.07	0.00	0.94	0.00	0.55
September	40	40	0.00	0.00	0.00		0.00	0.00
Parameter Group #2								
1-day minimum	40	40	0.00	0.38	0.00		0.00	0.00
3-day minimum	40	40	0.00	0.38	0.00		0.00	0.00
7-day minimum	40	40	0.00	0.38	0.00		0.00	0.00
30-day minimum	40	40	0.00	0.33	0.00		0.00	0.00
90-day minimum	40	40	0.23	0.36	0.00	0.57	0.01	0.59
1-day maximum	1642	1615	1.07	1.17	0.02	0.09	0.96	0.79
3-day maximum	1614	1588	0.92	1.02	0.02	0.10	0.94	0.77
7-day maximum	1572	1545	0.69	0.77	0.02	0.11	0.85	0.81
30-day maximum	873	847	0.82	0.85	0.03	0.04	0.78	0.90
90-day maximum	598	572	0.64	0.68	0.04	0.05	0.60	0.92
Number of zero days	0	0	0.00	0.00			0.00	0.00
Base flow	0.15	0.15	0.98	0.83	0.02	0.15	0.96	0.76

Table 5.2-6 Non-Parametric IHA Scorecard, North Anna River

	Medians		Coeff. of Disp.		Deviation Factor		Significance Count	
	Pre	Post	Pre	Post	Medians	C.V.	Medians	C.V.
Parameter Group #3								
Date of minimum	275	275	0.00	0.00	0.00		0.00	0.00
Date of maximum	85	82	0.36	0.30	0.02	0.16	0.72	0.82
Parameter Group #4								
Low pulse count	0	0	0.00	0.00			0.00	0.00
Low pulse duration	204	76	1.46	3.55	0.63	1.43	0.75	0.09
High pulse count	4	4	0.75	0.69	0.00	0.08	0.47	0.79
High pulse duration	18	15	0.52	0.55	0.16	0.06	0.38	0.87
The low pulse threshold is 40								
The high pulse level is 348								
Parameter Group #5								
Rise rate	21.91	22.54	0.72	0.62	0.03	0.13	0.84	0.61
Fall rate	–14.76	–16.18	–1.39	–1.32	0.10	0.05	0.83	0.89
Number of reversals	19	16	0.41	0.48	0.16	0.19	0.37	0.53

Table 5.2-7 IHA Non-Parametric RVA Scorecard, North Anna River

	Pre-impact period: 1979-2002				Post-impact period: 2003-2026				RVA Categories		Hydrologic Alteration (Middle Category)
	Medians	Coeff. Disper-sion	Range Limits Min	Range Limits Max	Medians	Coeff. Disper-sion	Range Limits Min	Range Limits Max	Low	High	
Parameter Group #1											
October	40	0.97	34	290	40	0.44	20	255	40	40	-0.13
November	104	2.25	20	702	48	3.71	20	675	40	233	0.14
December	196	1.50	20	658	161	1.43	20	634	45	259	0.13
January	380	1.14	20	836	359	1.29	20	812	151	465	0.00
February	344	1.24	20	2688	321	1.34	20	2664	241	485	0.13
March	480	1.07	20	1353	455	1.13	20	1328	271	644	0.25
April	300	1.01	20	1388	274	1.11	20	1360	172	388	0.25
May	152	1.59	20	648	123	1.92	20	618	92	255	0.00
June	49	1.47	20	561	46	0.86	20	531	40	104	0.27
July	40	0.58	20	486	40	0.00	20	455	40	43	0.20
August	40	1.24	20	331	40	0.07	20	318	40	40	–0.06
September	40	0.00	20	483	40	0.00	20	454	40	40	–0.06
Parameter Group #2											
1-day minimum	40	0.00	20	40	40	0.38	20	40	40	40	–0.18
3-day minimum	40	0.00	20	40	40	0.38	20	40	40	40	–0.18
7-day minimum	40	0.00	20	40	40	0.38	20	40	40	40	–0.18
30-day minimum	40	0.00	20	173	40	0.33	20	145	40	40	–0.25

Table 5.2-7 IHA Non-Parametric RVA Scorecard, North Anna River

	Pre-impact period: 1979-2002				Post-impact period: 2003-2026				RVA Categories		Hydrologic Alteration (Middle Category)
	Medians	Coeff. Disper-sion	Range Limits Min	Range Limits Max	Medians	Coeff. Disper-sion	Range Limits Min	Range Limits Max	Low	High	
90-day minimum	40	0.23	20	270	40	0.36	20	240	40	42	–0.08
1-day maximum	1642	1.07	40	4756	1615	1.17	20	4733	1283	2376	–0.13
3-day maximum	1614	0.92	40	4692	1588	1.02	20	4669	1233	2219	0.00
7-day maximum	1572	0.69	40	4577	1545	0.77	20	4554	1136	1930	0.13
30-day maximum	873	0.82	40	3432	847	0.85	20	3408	657	1185	0.00
90-day maximum	598	0.64	40	1931	572	0.68	20	1906	449	679	0.00
Number of zero days	0	0	0	0	0	0	0	0	0	0	0
Base flow	0.15	0.98	0.07	1.00	0.15	0.83	0.04	1.00	0.12	0.20	0.25
Parameter Group #3											
Date of minimum	275	0	153	313	275	0	153	292	275	275	0.00
Date of maximum	85	0.36	13	343	82	0.30	13	343	81	218	0.00
Parameter Group #4											
Low Pulse Count	0	0.00	0	1	0	0.00	0	2	0	0	–0.09
Low Pulse Duration	204	1.46	55	352	76	3.55	27	373	55	352	0.00
High Pulse Count	4	0.75	0	10	4	0.69	0	9	3	6	0.18
High Pulse Duration	18	0.52	5	36	15	0.55	4	36	13	18	0.00
The low pulse threshold is 40											

Table 5.2-7 IHA Non-Parametric RVA Scorecard, North Anna River

	Pre-impact period: 1979-2002				Post-impact period: 2003-2026				RVA Categories		Hydrologic Alteration (Middle Category)
	Medians	Coeff. Disper-sion	Range Limits Min	Range Limits Max	Medians	Coeff. Disper-sion	Range Limits Min	Range Limits Max	Low	High	
The high pulse level is 348											
Parameter Group #5											
Rise rate	21.91	0.72	4.38	47.15	22.54	0.62	2.86	57.71	16.08	28.33	0.22
Fall rate	–14.76	–1.39	–36.47	–2.86	–16.18	–1.32	–37.78	–2.86	–24.11	–10.90	0.11
Number of reversals	19	0.41	0	25	16	0.48	0	24	15	21	–0.08

Table 5.2-7 IHA Non-Parametric RVA Scorecard, North Anna River

	Assessment of Hydrologic Alteration								
	Middle RVA Category			High RVA Category			Low RVA Category		
	Expected	Observed	Alter.	Expected	Observed	Alter.	Expected	Observed	Alter.
Parameter Group #1									
October	16	14	-0.13	7	6	–0.14	1	4	3.00
November	14	16	0.14	8	5	–0.38	2	3	0.50
December	8	9	0.13	8	6	–0.25	8	9	0.13
January	8	8	0.00	8	7	–0.13	8	9	0.13
February	8	9	0.13	8	7	–0.13	8	8	0.00
March	8	10	0.25	8	6	–0.25	8	8	0.00
April	8	10	0.25	8	6	–0.25	8	8	0.00
May	8	8	0.00	8	7	–0.13	8	9	0.13
June	15	19	0.27	8	4	–0.50	1	1	0.00
July	15	18	0.20	8	5	–0.38	1	1	0.00
August	16	15	–0.06	7	7	0.00	1	2	1.00
September	18	17	–0.06	5	5	0.00	1	2	1.00
Parameter Group #2									
1-day minimum	22	18	–0.18	0	0	0.00	2	6	2.00
3-day minimum	22	18	–0.18	0	0	0.00	2	6	2.00
7-day minimum	22	18	–0.18	0	0	0.00	2	6	2.00
30-day minimum	20	15	–0.25	1	1	0.00	3	8	1.67

Table 5.2-7 IHA Non-Parametric RVA Scorecard, North Anna River

	Assessment of Hydrologic Alteration								
	Middle RVA Category			High RVA Category			Low RVA Category		
	Expected	Observed	Alter.	Expected	Observed	Alter.	Expected	Observed	Alter.
90-day minimum	12	11	–0.08	8	6	–0.25	4	7	0.75
1-day maximum	8	7	–0.13	8	8	0.00	8	9	0.13
3-day maximum	8	8	0.00	8	7	–0.13	8	9	0.13
7-day maximum	8	9	0.13	8	7	–0.13	8	8	0.00
30-day maximum	8	8	0.00	8	7	–0.13	8	9	0.13
90-day maximum	8	8	0.00	8	7	–0.13	8	9	0.13
Number of zero days	24	24	0.00	0	0	0.00	0	0	0.00
Base flow	8	10	0.25	8	7	–0.13	8	7	–0.13
Parameter Group #3									
Date of minimum	17	17	0.00	4	3	–0.25	3	4	0.33
Date of maximum	8	8	0.00	8	7	–0.13	8	9	0.13
Parameter Group #4									
Low Pulse Count	22	20	–0.09	2	4	1.00	0	0	0.00
Low Pulse Duration	2	2	0.00	22	1	–0.95	0	1	0.00
High Pulse Count	11	13	0.18	8	6	–0.25	5	5	0.00
High Pulse Duration	9	9	0.00	9	6	–0.33	6	7	0.17

Table 5.2-7 IHA Non-Parametric RVA Scorecard, North Anna River

	Assessment of Hydrologic Alteration								
	Middle RVA Category			High RVA Category			Low RVA Category		
	Expected	**Observed**	**Alter.**	**Expected**	**Observed**	**Alter.**	**Expected**	**Observed**	**Alter.**
Parameter Group #5									
Rise rate	9	11	0.22	8	7	–0.13	7	4	–0.43
Fall rate	9	10	0.11	8	6	–0.25	7	7	0.00
Number of reversals	13	12	–0.08	5	4	–0.20	6	8	0.33

Table 5.2-8 Minimum Lake Elevation for the Latter Half of Years 1978–2002

Year[a]	Existing Units		Existing Units + Unit 3		Difference in Minimum Lake Elevation (ft)
	Minimum Lake Elevation (ft MSL)	Date of Minimum Lake Elevation	Minimum Lake Elevation (ft MSL)	Date of Minimum Lake Elevation	
1978	248.44	11/05/1978	248.43	11/05/1978	–0.01
1979	250.07	07/29/1979	249.95	07/29/1979	–0.12
1980	248.48	10/26/1980	248.07	10/26/1980	–0.41
1981	248.04	10/11/1981	247.25	10/11/1981	–0.79
1982	249.48	10/10/1982	249.36	10/10/1982	–0.12
1983	248.56	10/02/1983	248.27	10/02/1983	–0.29
1984	249.87	09/16/1984	249.78	09/16/1984	–0.09
1985	249.64	08/04/1985	249.44	08/04/1985	–0.19
1986	248.69	10/12/1986	248.27	10/19/1986	–0.42
1987	248.99	08/23/1987	248.68	08/23/1987	–0.30
1988	248.87	10/23/1988	248.65	10/23/1988	–0.22
1989	249.94	08/27/1989	249.87	08/27/1989	-0.07
1990	249.67	09/30/1990	249.49	09/30/1990	-0.18
1991	248.83	11/10/1991	248.66	11/10/1991	–0.17
1992	249.63	09/13/1992	249.49	10/18/1992	–0.14
1993	248.33	11/14/1993	248.01	11/14/1993	–0.32
1994	249.91	10/02/1994	249.84	07/03/1994	-0.07
1995	249.27	09/17/1995	249.08	09/17/1995	–0.19
1996	250.04	09/22/1996	250.01	09/22/1996	–0.03
1997	249.31	10/05/1997	248.95	10/05/1997	–0.36
1998	247.81	11/22/1998	247.56	12/20/1998	–0.25
1999	248.34	08/15/1999	248.01	08/22/1999	–0.33
2000	249.48	11/12/2000	249.25	11/12/2000	-0.23
2001	247.33	12/30/2001	247.04	12/30/2001	–0.28
2002	245.06	10/13/2002	244.17	10/13/2002	-0.89

a. Minimum lake elevations identified from July-December period of each year to ensure independence of events.

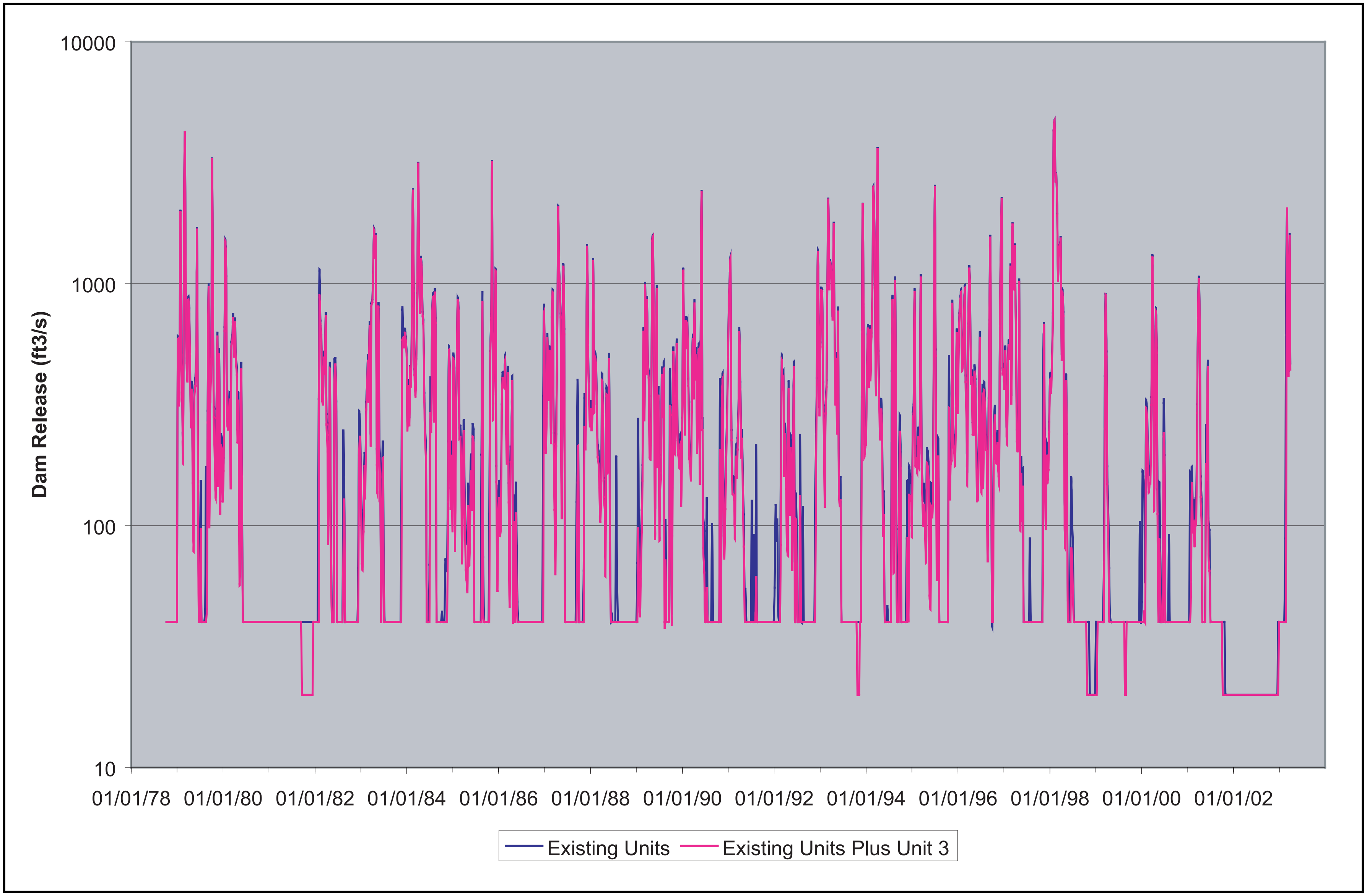

Figure 5.2-2 Lake Anna Outflow Hydrographs

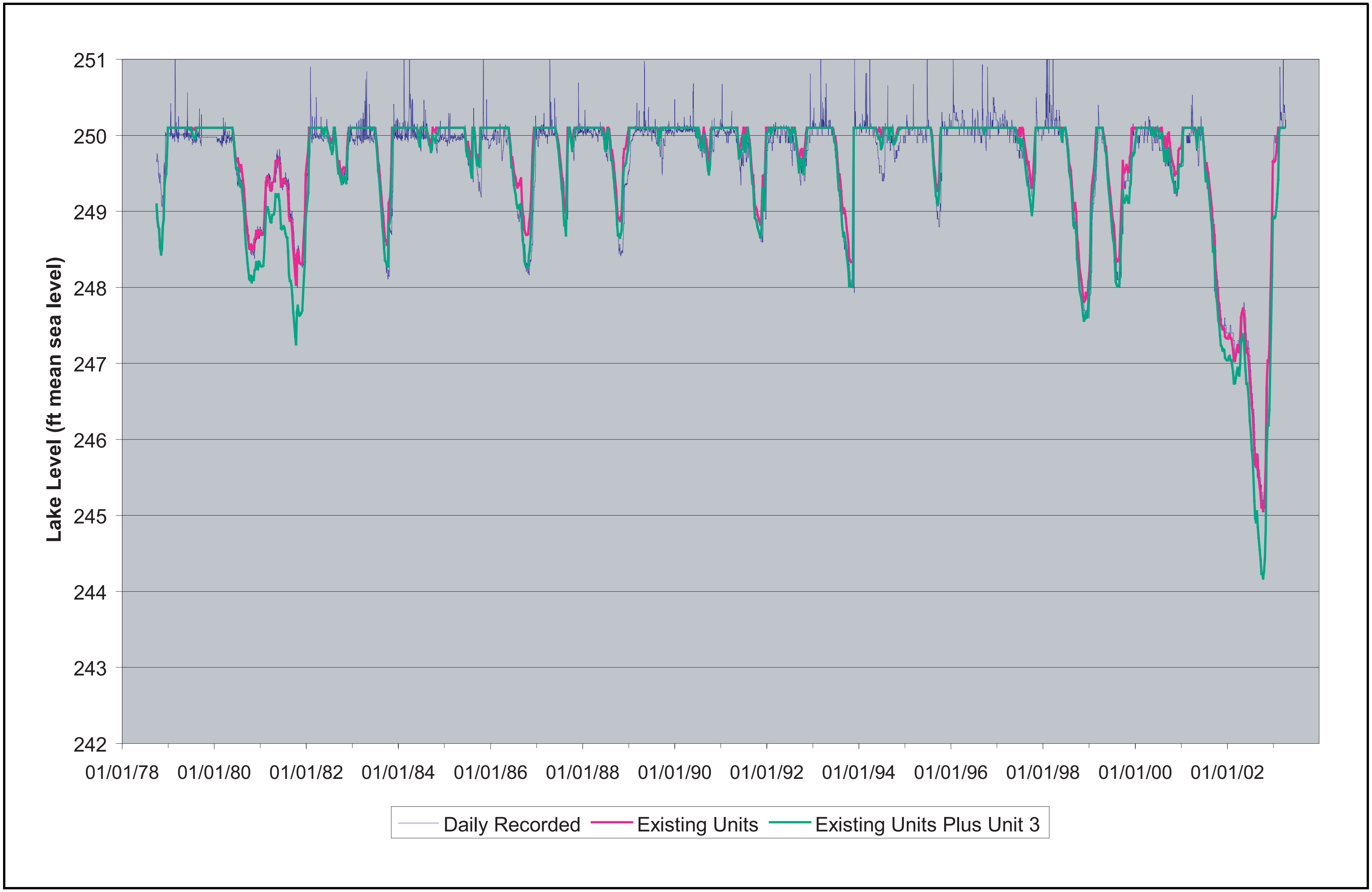

Figure 5.2-3 Lake Anna Water Level Hydrographs

5.3 Cooling System Impacts

This section discusses the impacts on Lake Anna of the cooling systems associated with operation of new units at the ESP site. As described in Section 3.3, and Section 3.4, the lake would be the main source of cooling water make-up for the new units.

For normal plant operation, Unit 3 would use a closed-cycle, combination dry and wet cooling tower system for the circulating water system and closed-cycle wet towers for the service water system, both with cooling water make-up supply from the lake. Unit 4 would use closed-cycle dry cooling towers for the circulating water system and for the service water system cooling during normal plant operation. As presented in Section 3.4.1.1, there would be negligible impacts to Lake Anna from the closed-cycle dry cooling tower systems that would be used for Unit 4. For those reactor designs that require an UHS, safety-related cooling would be provided by mechanical draft cooling towers. Those cooling towers would have a separate basin to provide a minimum 30-day water supply. The lake would provide make-up to this 30-day storage basin as necessary. Make-up water would be withdrawn from the North Anna Reservoir through a new intake structure located in a cove adjacent to the intake structure for the existing units. All cooling system discharges for the new units, including the UHS tower blowdown, would be sent to the WHTF via a new outfall at the head of the existing discharge canal.

The different aspects of cooling system impacts are addressed separately in the following sections:

- Intake system
- Discharge system
- Heat-discharge system
- Impacts to members of the public

5.3.1 Intake System

This section describes the impacts of the intake system for the new units, including the physical impacts of the projected hydrodynamic condition induced by the new intake flow and the potential impacts on the aquatic community of Lake Anna.

As described in Section 3.4.2, the new units' intake system would consist of an intake structure at the end of an approach channel located in a cove on the south shore of the North Anna Reservoir near Harris Creek. The area that would be occupied by this intake system, originally planned for the intake of the abandoned Units 3 and 4, is adjacent to the cove that houses the intake structure for the existing units.

During normal plant operation, the new intake would supply make-up water at a maximum flow rate of 2.23×10^4 gpm (49.6 cfs) to the Unit 3 closed-cycle wet cooling towers, and up to 1 gpm (0.002 cfs) of make-up water to the Unit 4 closed-cycle dry cooling towers. The new intake structure would also supply lake water as make-up water to the underground storage basins of the UHS cooling towers.

Other water use for the new units, including demineralized water and fire protection water, would be supplied through the new intake structure as well. According to Section 3.3.1, the total of the maximum incidental plant water usage would be an additional 4920 gpm (11 cfs) of intermittent intake flow per each new unit. The new intake structure would be equipped with screen wash pumps that would withdraw up to 1.1 cfs per unit of lake water to clean the traveling water screens. The screen wash flow would be returned back to the intake upstream of the traveling water screens after cleaning and would result in no water loss.

5.3.1.1 **Hydrodynamic Descriptions and Physical Impacts**

The intake hydrodynamics and the potential alteration of the ambient flow field induced by the intake system operation are presented in this section. The physical hydrological impacts to the lake during operation of the new units, including shoreline erosion, bottom scouring, induced turbidity and silt buildup, have been assessed. Unless site-specific data are available, bounding parameters from the Generic PPE are used to characterize the cooling water flow and other plant water uses for the new units. As demonstrated in the following analysis, adverse impacts would be small. This section also identifies and evaluates design considerations, engineering practices, and operating procedures that would increase stability of the shore and lakebed.

Currently, the North Anna Reservoir is the principal water source for the existing units, providing circulating water for the once-through cooling system and other plant water needs during normal plant operation. Up to 4310 cfs of lake water is withdrawn from an existing intake structure located on the south shore of the North Anna Reservoir in a cove about 5 miles upstream of the dam (Reference 1). Of the 4310 cfs withdrawn, a maximum flow of 4246 cfs is used for the normal plant cooling of the existing units and is discharged at an elevated temperature to the WHTF via a common outfall at the head of the discharge canal. The remaining 64 cfs is for incidental plant use.

As described in Section 3.3 and Section 3.4, the North Anna Reservoir would also be a main source of cooling water make-up for Unit 3 during normal station operation. Unit 4 plant cooling would be provided by dry cooling towers, which require no or a negligible amount of make-up water.

The lake would also provide make-up water to maintain the separate 30-day supply of emergency cooling water needed for the UHS for both new units, as presented in Section 3.4.2. However, during any shutdown requiring the UHS, no cooling or make-up water from the lake would be needed for any of the affected reactors to reach safe shutdown.

The new intake system would consist of a compartmented intake structure with a common screenwell, separate pump bays dedicated to each unit, and an approach channel in the cove adjacent to the intake for the existing units. During normal plant operation, the new intake system would supply up to 49.6 cfs of cooling water make-up to the Unit 3 closed-cycle wet cooling towers and zero to 0.002 cfs of make-up water to the Unit 4 closed-cycle dry cooling towers. Additional plant water needs of up to 2.5 cfs (during normal conditions), 11 cfs (during upset or abnormal conditions) for each new unit, including water to supply the demineralized water system, fire protection water, and the make-up water for the 30-day storage of UHS cooling tower, would also be withdrawn from the lake through the new intake structure. An additional 1.1 cfs of screen wash water per new unit would be withdrawn from the intake but would be returned back to the intake flow upstream of the traveling water screens, resulting in zero net water use. These incidental plant water needs would be intermittent and small compared to the once-through cooling water flow of the existing units. They would have no adverse physical impact to the lake.

At the downstream end of the plant cooling system, a new outfall would discharge up to 12.4 cfs of blowdown effluent from the Unit 3 wet towers. The Unit 4 closed-cycle dry cooling towers would have no blowdown discharges. Other permitted plant discharges, including discharges from the demineralized water and sanitary waste systems, would be released to the new outfall, but their volume would be small and would have no physical impact on the lake. The new outfall structure would be next to the outfall of the existing units at the head of the discharge canal in the WHTF. From the discharge canal, the Unit 3 cooling tower blowdown and the cooling water discharge from the existing units would flow through the WHTF's various canals, ponds, and side-arms to dissipate heat, and would eventually re-enter the North Anna Reservoir at Dike 3 via six adjustable, submerged skimmerwall gates. The physical impacts of the operation of the discharge system are presented in Section 5.3.2.1.

5.3.1.1.1 Lake Hydrologic Characteristics

Section 2.3.1 describes the hydrologic characteristics of the Lake Anna watershed and the impoundment that was created by the construction of the North Anna Dam. Figure 5.3-1 is a map of Lake Anna showing the upper lake, mid-lake and lower lake reaches of the North Anna Reservoir, the WHTF, as well as the relative location of the existing station intake, the new intake, and the discharge canal.

Lake Anna is about 17 miles long with a shoreline length of approximately 272 miles. At the normal operating lake level of 250 ft msl, the reservoir and the WHTF have a combined volume of about 305,000 acre-feet and a surface area of approximately 13,000 acres. The watershed area above the dam draining into Lake Anna is 343 square miles. Based on the water budget analysis described in Section 5.2.1, the long-term average inflow to the lake including surface water runoff, direct precipitation, and ground water flow is estimated to be about 369 cfs. The average outflow at the dam varies, depending on various water uses on the lake, including water loss due to evaporation. The outflow is estimated to be about 276 cfs during the operation of the existing units.

The hydrologic characteristics of the North Anna Reservoir gradually change from riverine upstream to lacustrine downstream. The upper lake is primarily riverine, shallow (average depth of 4 m (13 ft)) and slightly stratified in summer. The mid-lake is more lacustrine and stratified. The lower lake is deeper (average depth of 11 m (36 ft)) and displays lacustrine characteristics (e.g., more vertical gradients of light, temperature, and decomposition). Both the lower lake and mid-lake reaches tend to be stratified in summer and mixed in winter. (Reference 2)

Because the additional waste heat from the new units discharged to the North Anna Reservoir through the WHTF would be very small, there would be no perceptible impact on the temperature or stratification in Lake Anna as discussed in Section 5.3.2.1.

According to the Lake Anna Special Area Plan (Reference 3), the primary cause of lakeshore erosion is wave action induced by wind and wakes from boats. The additional units would have no impact on lakeshore erosion due to the small intake and discharge flow rates associated with their proposed operation.

5.3.1.1.2 **Intake Hydrodynamics and Physical Impacts**

The hydrodynamics of the North Anna Reservoir are different from those of most other lakes and reservoirs, in that during station operation, the mid-lake and lower lake reaches, where the intakes and the Dike 3 skimmer gates are located, have a circulation pattern induced by the plant circulating water flow. Most of the cooling water from the existing plant, which discharges at a rate of up to 4246 cfs into the reservoir via Dike 3, is drawn uplake by the cooling water and service water pumps in the existing intake structure. Since the circulating water flow is very large compared to the average inflows to the lake and the average release flow at the dam, the plant’s cooling system flow dominates the circulation in the lake except during periods of high inflows from the tributaries upstream.

As shown in Figure 5.3-1, the width of the reservoir perpendicular to the main flow direction varies from less than 1600 feet near Dike 1 to over 7000 feet near Dike 2 in the lower lake reach. With a typical epilimnion thickness of 26 feet to 33 feet in the lower lake region during the operation of the existing units (Reference 2), the induced surface current is estimated to be flowing in a general uplake direction at 0.1 fps or less on the average during the normal lake level of 250 ft msl. The colder return flow from the upper lake toward the dam occurs in the lower part of the water column (the hypolimnion) and is predicted to have a lower velocity. A conservative estimate has been made based on the assumption that the return flow would be the same as the total inflows to the lake. In the lower lake reach upstream of the Dike 3 discharge, the velocity of the bottom current is predicted to be less than 0.1 fps on a long-term average basis. The flow near Dike 3 is more complicated and is dominated by the mixing process at the skimmer gates. The outfall hydrodynamics and the physical impacts to the lake are presented in Section 5.3.2.1. With operation of the new units, the additional blowdown discharge of 12.4 cfs from Unit 3 flowing through Dike 3 to the reservoir would not have any measurable impact on the lake hydrodynamics. Operation of the new intake system would not increase the lake current by any detectable extent and would have no adverse impact on the scouring of the lakebed or erosion of the shoreline.

Water quality parameters in the lake and the WHTF were measured as part of the 316(a) demonstration study for the existing units (Reference 2). Measured turbidity levels were reported as generally low, except during periods of heavy inflows from the tributary streams. According to the 316(a) demonstration study, the mean annual turbidities from 1981 to 1986 ranged from 6 to 10 NTUs in the upper lake, and 2 to 5 NTUs in the lower lake reaches. Most of the turbidity measurements greater than 15 NTUs were taken in February, March, and April, months with higher runoff. The combined operations of the existing and new units would not increase turbidity in the lake.

The intake channel for the existing units has a bottom width of approximately 320 feet at the mouth of the cove opening to the North Anna Reservoir, and narrows down to 185 feet wide just in front of the screen well. The channel banks have a typical side slope of 3:1 (horizontal to vertical) and the bottom of the channel has been dredged to Elevation 220 ft msl. At a proposed minimum operating lake level of Elevation 242 ft msl and the existing intake flow rate of up to 4310 cfs, the flow velocity in the channel is estimated to be about 0.5 fps at the mouth to less than 1 fps at the approach to the screen well. At the normal lake level of 250 ft msl, the velocity in the existing channel is slightly lower, in the range of 0.3 fps to 0.8 fps. The approach channel of the new intake would have a bottom width that varies from approximately 300 feet near the mouth to 230 feet upstream of the screen well and pump house. As shown in Figure 5.3-2, the channel bottom is at approximately Elevation 220 ft msl and the channel banks have a side slope of about 3:1 (horizontal to vertical). At the proposed minimum lake operating level of Elevation 242 ft msl, the flow velocity in the channel would be about 0.01 fps, based on the maximum combined intake flow of 72 cfs (which includes 49.6 cfs of cooling water make-up for Unit 3, 0.002 cfs of cooling water make-up potentially required for Unit 4, and 11 cfs of miscellaneous plant water uses per new unit for upset or abnormal conditions) for the new units. At the normal operating lake level of 250 ft msl, the velocity in the approach channel to the new intake would be further reduced. Because there is no indication of scour or erosion at the existing intake, and because the new units would have lower approach velocities than the existing units, neither intake channel is expected to have any scouring and erosion concerns on the bottom or shoreline. In the event that a partial opening, instead of a full opening, would be constructed at the cofferdam to connect the reservoir and the approach channel to the new intake, the flow velocity at the opening would be designed to be no greater than 0.1 fps, similar to the average current velocity in the reservoir, to reduce impact to the lake hydrodynamics and entrainment of debris, aquatic life, and sediment.

Lake Anna in general does not have a sediment problem. Siltation in the approach channel to the new intake would not be a concern during normal lake conditions as the coarse and medium sediment would settle out in the reservoir where the current velocity is typically small, on the order of 0.1 fps or less. Sediment could come into the approach channel during floods and deposit there due to the low channel velocity. Operation of the new intake, however, would not be affected because the channel bottom is 12 feet deeper than the design invert of the new intake, allowing room for occasional sediment deposition and buildup. Any suspended sediment entrained into the intake structure would remain in suspension as the flow velocity increased downstream of the screen well and pump house, and would either be filtered out during the water treatment process or carried through the plant cooling system and discharged to the WHTF.

The banks of the approach channels to the new intake and the existing intake are stabilized with riprap to protect against erosion due to wind waves. Any areas that would be disturbed during construction of the new intake would be stabilized in a similar fashion. The design approach velocity to the traveling water screens and trash racks would be less than 1.0 fps at the lowest estimated operating lake level of 242 ft msl, and would enhance the performance of the debris filtering system and create a non-eroding environment. The new intake structure would have a sill at the entrance to avoid the entrainment of bed sediment into the screen well and pump house. Regular maintenance dredging during operation of the new units would not be necessary.

Section 5.3.1.2 discusses in further detail the impact of the operation of the intake system on the aquatic ecosystem of the lake.

5.3.1.2 **Aquatic Ecosystems**

Cooling water intake systems (CWIS) can potentially impact aquatic communities by either impingement or entrainment. The first mechanism by which a CWIS may adversely impact aquatic organisms is through impingement. Traveling screens in the front of the cooling water pumps filter the water and provide protection to the cooling water pumps from damage and clogging. Impingement occurs when swimming organisms are not strong enough to escape the cooling water intake flow and are driven into the screens (i.e., impinged). Impinged organisms are generally fish, but can include other semi-aquatic animals such as amphibians (e.g., frogs and salamanders), waterfowl (e.g., ducks and coots), or mammals (e.g., muskrats). The screens are periodically cleaned using a spray wash system from which the impinged organisms are collected and disposed.

The second mechanism that may cause adverse impact is entrainment (i.e., the intake of organisms into the cooling water system). Entrained organisms are generally small in size and include phytoplankton, zooplankton, and fish eggs and larvae. As these entrained organisms pass through the cooling water system, they are subjected to stresses that may result in mortality. Impacts to the entrained organisms include physical damage from contact with pumps, pipes, and condensers; pressure damage from passage through pumps; shear damage from complex water flows; thermal damage from elevated temperatures in the condenser passage; and toxicity damage from the addition of chemicals to the cooling water system.

In May 1985, Virginia Power published *Impingement and Entrainment Studies for North Anna Power Station, 1978-1983* (Reference 4). This study was conducted in accordance with Section 316(b) and in compliance with the NAPS Environmental Technical Specifications and the existing VPDES Permit under Special Conditions: Environmental Studies. The objective of the study was to examine the effects of impingement and entrainment at the CWIS and determine if they adversely affect the fish populations in Lake Anna.

When the existing units are operating, there is a maximum total withdrawal capacity of 1,934,300 gpm, or about 2.8 percent of the total Lake Anna volume per day (305,000 acre-feet at 250 ft msl). In addition, the existing units operate in a once-through mode and all water withdrawn is returned to the lake, but at a higher temperature. Each unit uses four circulating water pumps to withdraw condenser cooling water from Lake Anna. The cooling water is withdrawn through two screenwells (one for each unit) located in a cove north of the station (see Figure 5.3-1). Each screenwell 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 centimeters (cm) wide by 8.9 cm thick vertical bars spaced 10.2 cm on center. The flow through the trash racks is about 0.2 meters per second (0.69 fps) (Reference 4). The traveling screens, constructed of 14-gauge wire with 9.5 mm square openings, are designed to rotate once every 24 hours or whenever a predetermined pressure differential exists across the screens. Debris collected at the trash racks is removed by mechanical rakes and collected in hoppers that discharge the debris into wire baskets. Debris and fish collected in the wire baskets are disposed of as solid waste (Reference 4). The existing units also withdraw a small volume of water for a variety of other uses (e.g., backup service water, bearing cooling; Section 3.3.1). These additional uses contribute less than 3 percent of the total water withdrawal and are included in the total withdrawal capacity presented earlier.

5.3.1.2.1 **Impingement**

Impingement studies were conducted at NAPS from April 1978 through December 1983 in compliance with Section 316(b) of the CWA (Reference 4). An average of just over 47,400 fish representing 34 species was collected annually during each full year of the study. 1978 was not included because sampling was not conducted for the entire year (Reference 4).

For each sample collection the screens were washed to ensure that all fish were removed. The fish were washed into a catch basket at the end of a sluiceway and were removed and transported to the laboratory. Decayed fish that obviously had been dead for longer than 24 hours were excluded from the impingement sample. In the laboratory, up to 50 individuals of each species were measured and weighed. Those species numbering over 50 were counted and weighed in bulk (Reference 4).

To determine the total estimated number of fish impinged over a given time period, daily impingement values (number per gallon withdrawn) were multiplied by the average volume of intake cooling water withdrawn on that sample day, which provides the number of fish impinged per day per gallon of water withdrawn. Period estimates were computed using daily estimates and the number of days in each period. Totaling period estimates by species results in estimates of total fish impinged by month; yearly estimates are the sum of the months.

Six species accounted for 99 percent of all fish impinged during the study. The most commonly impinged fish were gizzard shad (61 percent), followed by black crappie (16 percent), yellow perch (16 percent), bluegill (4 percent), white perch (1 percent), and striped bass (1 percent). No other species comprised more than 1.0 percent of the total number impinged (Reference 4). Based on the estimation process outlined above, an average of 182,000 fish was impinged each year from 1979 through 1983 (Table 5.3-1), 114,000 of which were gizzard shad. These impingement estimates represent a maximum number based on the withdrawal capacity for the existing units on the specific sample collection date. A comparison of impingement numbers to standing crop estimates based on cove rotenone data from Lake Anna indicates that the percentage of the fish population affected by impingement is very low. Gizzard shad impingement losses represent 0.38 percent by number and 0.32 percent by weight of the total standing crop for Lake Anna. For black crappie, the percentages were 3.1 percent by number and 3.8 percent by weight. Values for all other species were 1.4 percent or less (Reference 4).

Table 5.3-1 Mean Number of Representative Important Fish Species Estimated Impinged per Month at the Existing Units from 1979–1983

Month	Striped Bass	Black Crappie	Bluegill	Gizzard Shad	White Perch	Yellow Perch	Total All Species
January	213	929	134	14,600	92	44	16,012
February	265	2,360	235	26,459	162	1,392	30,873
March	381	9,734	465	58,314	625	24,436	93,955
April	87	4,347	636	8,407	471	1,754	15,702
May	10	1,643	630	1,607	390	84	4,364
June	0	480	839	57	135	49	1,560
July	0	372	392	67	164	39	1,034
August	3	426	985	84	159	23	1,680
September	12	845	644	485	161	19	2,166
October	30	3,449	574	236	160	5	4,454
November	357	2,143	1,944	714	176	26	5,360
December	682	1,211	293	2,827	231	36	5,280
Yearly Totals	2,040	27,939	7,771	113,857	2,926	27,907	182,440

Source: Reference 4.

During the study period, total impingement rates declined; the decline appeared to be associated with the reduction in gizzard shad impingement after 1979. On a yearly basis, the majority of the fish impinged were gizzard shad during 1979, 1981, and 1983. However, black crappie were impinged most often in 1980 and 1982 (Reference 4). Most fish were impinged during the winter (75 percent, January–March), followed by spring (13 percent, April-June), fall (9 percent, October–December), and summer (3 percent, July–September). Lower water temperatures during the winter months tend to make fishes lethargic and thus more susceptible to impingement. During 1979, gizzard shad accounted for over 78 percent of the impingement total: 64 percent of these shad (290,000) were impinged between February 20 and March 20. This large gizzard shad impingement occurred when water temperature (1.18°C, February 20, 1979) was the lowest recorded during the study period (Reference 4). Winter kills are common for gizzard shad when water temperatures fall below 3.3°C (Reference 5). This suggests that impingement rates may have been inflated by winter-killed or cold-stunned shad that float into the intake area and are "impinged." In subsequent years of the study impingement levels for gizzard shad never reached the levels of 1979.

a. **Impingement Estimate for Unit 3 Using Dry and Wet Cooling Towers**

Data from the 1978–1983 sampling study (Reference 4) were used to estimate the impacts of adding a new CWIS with a maximum intake flow of 27,309 gpm on the impingement of fish in the North Anna Reservoir. The following assumptions were used to extrapolate fish impingement rates for a new cooling tower make-up system:

- Fish distribution and composition has remained generally the same as in the 1978–1983 study,
- A new CWIS would operate at 100 percent pumping capacity, and
- The intake screen mesh size and approach flow velocity of the new units would be the same as that of the existing units.

These assumptions were used to provide a very conservative estimate that results in bounding impingement estimates that are considerably higher than expected.

Based on the impingement rate for the six representative important fish species from the 1978–1983 study and assuming the maximum flow rate of 27,309 gpm and 100 percent pumping capacity, an estimate was calculated of the total number of fish that could be impinged. Mean monthly impingement estimates for the six representative important fish species were calculated for the same five full years of operation (Table 5.3-2). It was determined that using the mean of the five representative years would give the most accurate estimate for annual fish impingement. As expected, gizzard shad dominated the impingement estimates for the new system with an estimated annual impingement of approximately 3460 fish. This estimate is about 97 percent less than the yearly estimate for the existing units (Table 5.3-1), and is primarily due to significantly less cooling water intake flow for the new unit.

Table 5.3-2 Mean Number of Representative Important Fish Species Estimated Impinged per Month at NAPS With a Cooling Tower Water Make-up Intake System for Unit 3

Month	Striped Bass	Black Crappie	Bluegill	Gizzard Shad	White Perch	Yellow Perch	Total All Species
January	6	21	3	277	2	1	310
February	8	57	6	696	4	40	811
March	11	304	14	2123	18	788	3258
April	3	150	17	233	15	62	480
May	0	39	15	46	14	3	117
June	0	12	18	2	3	2	37
July	0	7	7	2	3	1	20
August	0	7	19	1	3	0	30
September	0	15	11	7	3	1	37
October	1	79	13	4	4	0	101
November	8	58	39	14	3	1	123
December	15	34	6	55	5	1	116
Yearly Totals	52	783	168	3460	77	900	5440

Estimated impingement for the other representative important species would be proportional to those of the existing units. In addition, seasonal impingement would be highest during the winter and lowest during the summer; all reflective of the 1985 study (Table 5.3-2).

Cumulatively, based on the maximum flow rate and 100 percent pumping capacity, impingement would increase by less than 3 percent with the addition of Unit 3. Total estimated impingement for the six representative important species would be approximately 188,000 fish annually. Approximately 94 percent of the annual impingement would be gizzard shad (63 percent), yellow perch (16 percent), and black crappie (15 percent) (Table 5.3-3).

Table 5.3-3 Mean Number of Representative Important Fish Species Estimated Impinged per Month with Existing Units and With a Unit 3 Cooling Tower Make-Up Water Intake System.

Month	Striped Bass	Black Crappie	Bluegill	Gizzard Shad	White Perch	Yellow Perch	Total All Species
January	219	950	137	14,877	94	45	16,322
February	273	2417	241	27,155	166	1432	31,684
March	392	10,038	479	60,437	643	25,224	97,213
April	90	4497	653	8640	486	1816	16,192
May	10	1682	645	1653	404	87	4481
June	—	492	857	59	138	51	1597
July	—	379	399	69	167	40	1054
August	3	433	1004	85	162	23	1710
September	12	860	655	492	164	20	2203
October	31	3528	587	240	164	5	4555
November	365	2201	1983	728	179	27	5483
December	697	1245	299	2882	236	37	5396
Yearly Totals	2092	28,722	7939	117,857	3003	28,807	187,880

b. **Impingement Estimates for Unit 3 Plus Unit 4**

Because Unit 4 would use a dry cooling tower system, there would be no regular withdrawal of water from Lake Anna and therefore no additional impingement impacts beyond those associated with Unit 3.

Table 5.3-4 Deleted

5.3.1.2.2 Impingement Discussion

Gizzard shad are the major forage fish in Lake Anna (Section 2.4.2). Threadfin shad, which were introduced by VDGIF in 1983, were collected in impingement samples only in late summer and fall of 1983, and were not included in the impingement estimates due to lack of data. Threadfin shad contribute to the forage base, but the population is cyclic and subject to die-offs during cold winters (Section 2.4.2).

The percentage of the total reservoir population that is impinged is very low. Based on cove rotenone sampling in Lake Anna, the average annual standing crop of gizzard shad over a five year period (1979–1983) was 121 kg per hectare and the average annual impingement weight of gizzard shad was 2200 kg (Reference 4). Therefore, the average percentage of gizzard shad standing crop in the North Anna Reservoir that was removed annually by impingement was 0.32 percent by weight. Similarly, values for black crappie were 3.8 percent, yellow perch 1.4 percent, bluegill 0.02 percent, and white perch 0.1 percent (Reference 4). Using the assumptions presented earlier, the addition of Unit 3 would increase the number of fish impinged by less than 3 percent. Therefore, a new CWIS for Unit 3 in combination with the current once-through system for Units 1 and 2 would remove approximately 0.33 percent by weight of gizzard shad annually, 3.9 percent of black crappie, just over 1.4 percent of yellow perch, 0.02 percent of bluegill, and 0.1 percent of white perch. Adding Unit 4 with a new dry tower system would not increase these numbers because no regular water withdrawals would be made from Lake Anna for the new system.

Gizzard shad have a high reproductive potential because they grow rapidly, mature quickly, and produce a large number of eggs per female. As reported in Carlander (Reference 6), gizzard shad can reproduce at 2 years of age and each age-2 female can produce from 211,000 to 543,000 eggs. The average yearly combined impingement estimates for the existing units, and towers for Units 3 and 4, is approximately 115,000 gizzard shad, considerably less than the maximum egg production of one average size age-2 female gizzard shad. Likewise, black crappie become sexually mature at age-2 or age-3 and a mature female can produce from 11,000 to 188,000 eggs annually (Reference 7). The average yearly impingement estimates for black crappie from all existing and new units combined would be approximately 29,000 fish; well below the maximum egg production of one mature female. These trends hold true for the other representative important species.

There are a number of factors that directly influence recruitment in fish populations. Growth rates, survival rates, and age at maturity are critical elements in determining recruitment success in fish populations. Fish that grow and mature quickly are more likely to be added to the population than those that grow and mature slowly. Growth, survival, and age at maturity are in turn influenced by an array of interrelated factors that include water quality, disease, competition, predator-prey relationships, and genetics. Generally speaking, high mortality rates are associated with low rates of recruitment. Fish can be preyed on by larger fish, by wading birds, and by fishermen. Power plants can function as predators, and like predators, tend to be more “successful” as prey populations expand and densities increase. The theory of natural compensation relies on the principle that fish populations would grow when the population density (standing crop) is low and would likewise decline when the density is high. In other words, compensation is the capacity of a population to offset, to some extent, reductions in numbers caused by some disturbance. This is a natural compensation process that works to ensure that population size remains relatively stable over time. The assessment presented in Section 2.4.2 concludes that the Lake Anna fish population is balanced and has remained balanced is an indication that natural compensation is occurring. Therefore, natural compensation would offset fishery losses from impingement in Lake Anna.

Generally, new reservoirs exhibit high initial productivity followed by a decline in productivity, and finally a period of stability, but at a productivity level below the initial level. The initial surge in productivity is primarily due to high nutrient levels from freshly inundated vegetation and soil and thus cannot be maintained (Reference 8) (Reference 9). Environmental conditions tend to stabilize 5–10 years after impoundment, and fish biomass stabilization follows. Lake Anna exhibited high initial fish abundance during 1973 and 1974 followed by a decline in succeeding years. Since 1978, the mean standing crop of fishes has remained relatively stable, with the exception of 1985 when the standing crop increased significantly due to the introduction of threadfin shad in 1983 and concurrently an excellent year-class for gizzard shad. Lake Anna appears to support a standing crop of fish higher than most reservoirs in the United States, with thriving populations of several forage and gamefish species (see Section 2.4.2).

The 1985 Section 316(b) study showed no significant impacts due to impingement, a conclusion validated by 20-plus years of monitoring in Lake Anna. In addition, the Section 316(a) demonstration (Reference 2) and more recent monitoring data and annual reports (Reference 10) indicate that Lake Anna fish populations are healthy and diverse. Operating new cooling towers for Units 3 and 4 would not change this conclusion. This conclusion is supported because the fish impinged most frequently are prolific, exhibit a high reproductive potential, and compensatory responses of the fish population would occur to offset losses due to impingement, and therefore would not require mitigation.

5.3.1.2.3 **Entrainment**

During the 1978–1983 study referenced earlier, entrainment samples were collected once a week in front of the intake forebays from March through July of each year, which represents the spawning period of Lake Anna fish (Reference 4). During this six-year study, an average of 1318 fish larvae were collected annually in the entrainment samples. No fish eggs were collected. Most of the fish species in Lake Anna produce demersal (sinking), adhesive eggs, which reduces their potential for entrainment. For purposes of the study and as a conservative estimate, 100 percent entrainment and 100 percent mortality were assumed for all larval fish collected (Reference 4).

During the study, five larval fish taxa dominated the collections; with gizzard shad (65.7 percent) being the most commonly entrained larvae followed by white perch (15 percent), sunfishes (*Lepomis* sp.) (13.3 percent), yellow perch (4.9 percent), and black crappie (1.0 percent). All of the larvae collected were representatives of common, widely distributed species found across Virginia and the southeast (Reference 11) (Reference 12). As noted in Section 2.4.2, no threatened or endangered fish species have been recorded from Lake Anna. Seasonal differences in the sample collections of the various species reflected the spawning characteristics of the individual species (Reference 4).

More sunfish (*Lepomis* sp.) and yellow perch larvae were collected in the first year of the study (1978) than in subsequent years. Gizzard shad were collected in relatively greater numbers in 1979 and 1981. White perch exhibited a general increase in samples over the study period. Collections of black crappie were considered too low to make any meaningful comparison between years. With the exception of 1978, when sunfish and yellow perch dominated the collections, trends in total numbers of larvae entrained from year to year were generally reflected in the number of gizzard shad, sunfishes, and white perch collected. The percentage of the total larvae collected represented by gizzard shad remained high (between 43 and 88 percent) and stable each year of the study, whereas the percentage of white perch increased each year from 0.3 percent in 1978 to 31 percent in 1983 (Reference 4).

Seasonally, yellow perch larvae were the first to appear each year in collections, generally in early April, when water temperatures approached 12°C. White perch appeared in April when temperatures approached 14°C, peaked in numbers in mid-May, and were collected into July. Gizzard shad larvae generally were first collected in late April to early May at water temperatures between 14°C and 18°C and peaked in numbers in mid-May to early June. Sunfishes were the last group to appear in samples (May-June) and were first collected when water temperatures rose to 19°C. Both gizzard shad and sunfish larvae were collected in relatively fewer numbers in July (Reference 4).

To determine the total estimated number of larvae entrained over a time period, daily entrainment values (number per gallon withdrawn) were multiplied by the average volume of intake cooling water withdrawn on that sample day. Period estimates were computed using daily estimates and the number of days in each period. Totaling period estimates by species results in estimates of total numbers of larvae entrained by month; yearly estimates are the sum of the months (Reference 4).

Based on the estimation method outlined above, an average of 149,400,000 fish larvae was entrained each year from 1978 through 1983 (Table 5.3-5). During this period, gizzard shad had an average yearly entrainment of approximately 95,500,000 or about 63 percent of the total entrainment, while white perch represented 15.4 percent; sunfish 14.9 percent; yellow perch 4.6 percent and black crappie 1.2 percent.

On a seasonal basis, highest estimated larval fish entrainment occurred in May (47.6 percent) when all representative important species were present (Table 5.3-5). June estimates were the second highest with collections dropping dramatically in July.

Table 5.3-5 Mean Number of Representative Important Fish Species Estimated Entrained per Month From 1979-1983 With Existing Units Operating

Taxa	March	April	May	June	July	Yearly Totals
Black Crappie	-	-	1,144,967	598,711	-	1,743,678
Lepomis sp.	-	-	892,255	12,326,144	9,031,991	22,250,390
Gizzard Shad	-	367,705	51,580,191	41,131,018	2,396,247	95,475,161
White Perch	-	3,923,856	17,157,903	1,818,796	92,820	22,993,375
Yellow Perch	223,513	6,309,313	384,800	10,400	-	6,928,026
Monthly Totals	223,513	10,600,874	71,160,116	55,885,069	11,521,058	149,390,630

Source: Reference 4.

a. **Entrainment Estimates for Unit 3 Using Dry and Wet Cooling Towers**

In order to estimate the impacts of the addition of a new CWIS with a maximum intake flow of 27,309 gpm on the entrainment of fish from the North Anna Reservoir, data from the 1978–1983 sampling study (Reference 4) were used. The following assumptions were used to extrapolate fish entrainment rates for a new cooling tower make-up system:

- Fish distribution and composition has remained generally the same as in the 1978–1983 study,
- A new CWIS would operate at 100 percent pumping capacity, and
- The intake screen mesh size and approach flow velocity of the new unit would remain the same as that of the existing units.

These assumptions were used to provide a very conservative estimate that results in bounding entrainment estimates that are considerably higher than expected.

Based on the entrainment rate (number per gallon) for the five representative important fish species from the 1978–1983 study and the maximum flow rates for the new CWIS, an estimate of the total number of these species' larvae entrained was calculated. As noted earlier in this section, the maximum cooling water withdrawal rate from the North Anna Reservoir for Unit 3 towers would be 27,309 gpm. Combined with current usage of 1,934,300 gpm for the existing Units 1 and 2, this would result in 3.6 percent of Lake Anna's volume being used each day. Entrainment rates were calculated for the following representative important species: gizzard shad, sunfishes, white perch, yellow perch, and black crappie.

Mean monthly and yearly entrainment estimates for Unit 3 were calculated for the five representative important fish species for each of the six years of the study (Table 5.3-6). Because the sampling period was similar in all six years, all data were used and an average yearly estimate was calculated. As expected, the entrainment estimates for Unit 3 follow those of the existing Units 1 and 2 very closely.

Entrainment estimates for Unit 3 averaged approximately 3,350,000 larvae annually, with gizzard shad dominating the estimates. Estimated entrainment for the other representative important species also would be proportional to those of the existing units on an annual and monthly basis.

Table 5.3-6 Mean Number of Representative Important Fish Species Estimated Entrained per Month With Cooling Tower Make-Up Water Intake System for Unit 3

Taxa	March	April	May	June	July	Yearly Totals
Black Crappie	—	—	29,547	11,595	—	41,143
Lepomis sp.	—	—	31,170	256,714	178,893	466,577
Gizzard Shad	—	8809	1,153,671	904,014	49,889	2,114,381
White Perch	—	100,812	418,854	31,791	1634	553,091
Yellow Perch	5251	162,714	10,865	199	—	179,029
Monthly Totals	5251	272,335	1,644,107	1,204,313	230,416	3,354,224

Cumulatively, entrainment would increase by less than 3 percent (Table 5.3-7) with the addition of a CWIS for Unit 3. As noted earlier, this is based on a maximum intake flow rate and 100 percent pumping capacity. Total estimated entrainment with the old and new units operating for the five representative important species would be approximately 152,000,000 fish larvae annually. Once again, gizzard shad would account for approximately 63 percent of all larvae entrained (Table 5.3-7).

Table 5.3-7 Mean Number of Representative Important Fish Species Estimated Entrained per Month With Existing Units and a Cooling Tower Make-Up Water Intake System for Unit 3

Taxa	March	April	May	June	July	Yearly Totals
Black Crappie	-	-	1,174,514	611,306	-	1,784,821
Lepomis sp.	-	-	923,425	887,392	17,079,735	22,716,967
Gizzard Shad	-	376,514	52,733,862	42,035,032	2,446,136	97,589,545
White Perch	-	4,024,668	17,567,757	1,850,587	94,454	23,546,466
Yellow Perch	228,764	6,472,027	395,665	10,599	-	7,107,055
Monthly Totals	228,764	10,873,209	72,804,223	57,089,382	11,751,474	152,744,854

b. **Entrainment Estimate for Unit 3 Plus Unit 4 Cooling**

Because Unit 4 would use a dry cooling tower system, there would be no regular withdrawals of water from Lake Anna and therefore no additional entrainment impacts beyond those associated with the Unit 3 CWIS.

Table 5.3-8 Deleted

5.3.1.2.4 Entrainment Discussion

Reproductive strategies vary among fish species. In general, the strategy is to produce large numbers of eggs but provide little protection thereafter. Therefore, mortality rates are extremely high, with generally less than 1 percent of the larvae surviving to one year of age (Reference 13). Survival rates are higher in species (e.g., sunfish, salmonids) that build nests and provide protection until the larvae swim away from the nest, but are still generally 10 percent or less (Reference 13). To assess the impact of the loss of fish larvae due to entrainment on the fisheries of Lake Anna, the adult equivalent model of Goodyear (Reference 14) was used (Reference 4). Assumptions used included:

- There is 100 percent mortality of entrained larvae,
- The stock populations are at equilibrium and the total lifetime fecundity produces two adults,
- No compensatory mechanisms are operating, and
- 75 percent of the eggs produced by the entrained species survive to the larval stage.

This model estimates the number of adult fish that would have resulted from the entrained larvae had they not been lost to entrainment. It also provides an estimate of the potential percent reduction in the adult fish population as a consequence of entrainment. Values ranged from 0.01 percent for black crappie in 1978 and 1979 and sunfishes in 1982, to 4.13 percent for gizzard shad in 1980. Percent reductions of this magnitude would not have a significant adverse effect on the Lake Anna fishery, especially when viewed in concert with other population mechanisms such as compensation (see Section 5.3.1.2.2) (Reference 4).

The analysis from the adult equivalent model provided a conservative estimate of entrainment impact, primarily as a result of assumptions used in the analysis (Reference 4). Applying the adult equivalent model analysis to a CWIS for Unit 3 would increase the entrainment losses for the existing units by less than 3 percent (Reference 4). Losses of this magnitude would not impact the Lake Anna fishery. Adding Unit 4, with a dry cooling tower system, would not increase these entrainment numbers because no regular water withdrawals from Lake Anna would be required for this system.

The information summarized in Section 2.4.2 and in the *Environmental Study of Lake Anna and the Lower North Anna River Annual Report for 2000 including summary for 1998–2000* (Reference 10) indicates that the fish population in Lake Anna represents a balanced community. Over the years, the fishery of Lake Anna has matured and changed to meet the demands for public fishing through species additions (threadfin shad) and annual stockings of striped bass. Overall, the abundance and quality of the fishery has remained healthy and balanced despite increased fishing pressure and shoreline development. Therefore, based on the information presented in Section 2.4.2 that summarizes the Lake Anna fish community and its thriving populations of gamefish and the forage species that support them, the additional entrainment resulting from the operation of a new CWIS for Unit 3 would have a small impact on the fishery community and would not require mitigation.

5.3.2 **Discharge System**

This section describes the impacts on Lake Anna of the discharge system during operation of the units at the ESP site. The existing temporal and spatial temperature distributions in Lake Anna and the potential physical impacts resulting from the new units' cooling water discharges are described in Section 5.3.2.1. Potential thermal, physical, and chemical stresses to aquatic organisms that may occur as a result of plant cooling system discharges to the North Anna Reservoir via the WHTF are described and assessed in Section 5.3.2.2.

5.3.2.1 **Thermal Description and Physical Impacts**

This section discusses the thermal distribution in Lake Anna and potential physical impacts, including increased turbidity, scouring, erosion, and sedimentation in the lake resulting from the new units' cooling system discharges, noting that only Unit 3 would have blowdown discharge from its wet cooling towers during normal plant operation. Section 5.3.2.2 evaluates the aquatic impact on the lake's ecosystem. Section 5.2.1 and Section 5.2.2 describe the water use impacts of the new cooling systems. Unless site-specific data were available, the bounding design parameter values from the Generic PPE were used as the basis for the analysis and evaluation of the new units' discharge system. Section 3.4.2 describes the physical attributes of the new discharge system.

Each new unit would generate, during normal full load operation, up to 10.3×10^9 Btu/hr of waste heat that needs to be dissipated. This heat load is in addition to the 13.54×10^9 Btu/hr of waste heat currently permitted for discharge to the WHTF from the existing units (Reference 15). Three alternative systems are identified as technically viable options for normal plant cooling of the new units:

- A once-through system using Lake Anna as the heat sink
- A closed-cycle system with wet evaporative-type cooling towers
- A closed-cycle system with a combination of dry and wet evaporative-type cooling towers
- A closed-cycle system with air-cooled condensers or dry cooling towers

As noted in Section 3.4, Unit 3 would use a closed-cycle, dry and wet cooling tower system, whereas Unit 4 would use a closed-cycle system with dry cooling towers for the circulating water system during normal station operation. A separate, service water cooling system would use a closed-cycle wet cooling tower system for Unit 3 and a dry cooling tower system for Unit 4 for dissipation of waste heat from auxiliary heat exchangers not cooled by the unit's circulating water system. The blowdown effluent from Unit 3's wet cooling towers of both the circulating water and service water systems would discharge to the WHTF, but Unit 4 would have no cooling system discharges and therefore no associated heat load released to the WHTF. Due to the small discharge flow rate of no greater than 12.4 cfs and small heat load on the order of 4.2×10^7 Btu/hr during extreme summer months (See Section 3.4.1.1) that would be associated with the blowdown discharge from the wet towers, the circulating water and service water cooling systems of Unit 3 would have very small, if not imperceptible, physical, chemical, biological or ecological impacts to Lake Anna.

The UHS for each unit would dissipate decay heat of up to 1.2×10^8 Btu/hr during normal conditions, and 4.2×10^8 Btu/hr during shutdown or accident conditions. A blowdown flow of 0.3 cfs (normal) to 1.9 cfs (maximum) per unit would be discharged to the WHTF if a plant was in UHS mode, but the heat load associated with this discharge would be very small, with its impact bounded by the normal plant cooling discharge of Unit 3. No thermal analysis was conducted specifically for the UHS discharge. The following discussion pertains to the thermal impacts on the lake due to normal plant cooling only.

5.3.2.1.1 **Existing Hydrothermal Condition**

The existing units each have a reactor core power level of 2893 MWt (uprated in 1986) and an expected gross electrical output of about 982 MWe (Reference 1), rejecting a waste heat load of about 1911 MW (6.5×10^9 Btu/hr) per unit to the condenser cooling system for dissipation. The total heat load to the existing heat dissipation system is, therefore, below the current VPDES permit limit of 13.54×10^9 Btu/hr (Reference 15). The existing units use a once-through cooling system to dissipate the waste heat from the turbine condensers and from the auxiliary cooling systems. When both units are operating, eight circulating water pumps draw water to the plant from the North Anna Reservoir at a design rate of 4246 cfs (2123 cfs per unit). The cooling water, at a design temperature rise of about 14°F above the water temperature at the intake, is discharged through rectangular tunnels to an outfall structure at the head of the WHTF discharge channel. The actual temperature rise across the condensers may be greater or less than 14°F, depending on the power station load and the number of circulating water pumps operating. For instance, at lower condenser flow rates with three circulating water pumps running per unit rather than four, the temperature increase across the condenser averages approximately 18.3°F. A minimum of three circulating water pumps is required for each operating unit in the summer months when the intake temperature exceeds 75°F. (Reference 16)

In the WHTF, the heated effluent flows through a series of ponds and connecting canals, and returns to the North Anna Reservoir via a 6-bay skimmer wall submerged structure at Dike 3. Each discharge bay can be adjusted to maintain the discharge velocity at about 7 fps to promote mixing with the receiving water. Although the discharge is submerged, the slope of the reservoir bottom immediately adjacent to the Dike 3 discharge structure directs the discharge to the surface. (Reference 16)

Circulation in Lake Anna results from four mechanisms:

- Station pumping, which produces a forced horizontal surface flow through the WHTF and the North Anna Reservoir
- Wind stresses, which produce currents in the direction of the wind
- Water temperature differences, which produce natural convective flows into the sidearms of the WHTF and the main reservoir
- Inflows and outflows to and from the reservoir

Station pumping normally dominates the flow pattern and forces the majority of the cooling water flow to circulate back to the intake, because the cooling water flow rate is much higher than the average inflow to the lake and outflow at the dam. The average inflow to the lake including surface runoff, direct precipitation, and groundwater flow is estimated to be about 369 cfs (Section 5.2.1). The average outflow at the dam varies and is estimated to be about 276 cfs when the existing units are in operation (see Section 5.3.1.1). Waste heat is transferred to the atmosphere mostly by evaporation, conduction, and back radiation. Only a small percentage of waste heat is released downstream via the North Anna Dam. It is estimated that, with the existing units operating, the cooling water's residence time in the WHTF is approximately 7 days, where about half of the waste heat is dissipated. The remaining waste heat is dissipated to the atmosphere from the North Anna Reservoir surface.

As presented in Section 5.3.1.1, the natural hydrologic characteristics of Lake Anna gradually change from riverine upstream to lacustrine downstream. Figure 5.3-1 shows the three different reaches of the lake: the upper, middle, and lower. The upper lake is primarily riverine, shallow (average depth of 4 m (13 ft)) and slightly stratified in summer. The mid-lake is more lacustrine and stratified. The lower lake is deeper (average depth of 11 m (36 ft)) and displays lacustrine characteristics (e.g., more vertical gradients of light, temperature, and decomposition). It is stratified in summer and mixed in winter.

Table 5.3-10 identifies physical attributes of the North Anna Reservoir and WHTF.

With the additional waste heat from the new units discharged to Lake Anna, the lower North Anna Reservoir reach near Dike 3 and the North Anna Dam would be strongly stratified in summer and mixed or weakly stratified in winter. As in a typical cooling lake, one of the defining features is the temperature differential that exists between the discharge and the intake. If transient fluctuations are averaged, this differential is equal to the condenser temperature rise. As density changes are associated with temperature changes, buoyancy forces arise, which tend to cause the spreading of lighter (warmer) water over heavier (cooler) water. The discharge of heated effluent into the lower lake at Dike 3 causes the surface water to become warmer and lighter than the bottom water. Thus, the lower lake tends to be more stratified. Turnover of the hypolimnion (deeper, colder water) of the lower lake occurs through vertical entrainment of the hypolimnion by the horizontally circulating warmer cooling water. Fresh water from the upper lake, which is cooler and denser than the heated surface water, tends to sink to the bottom of the lake, or to some intermediate depth, and thus reinforces stratification in the reservoir, especially in the lower lake. (Reference 17)

The stratification pattern in the lake would not change with the addition of new units. The thermal plume and the hypolimnion would be the same as a consequence of the very small flow and heat load added to WHTF by the new units.

Temperature data collected prior to the operation of the existing units indicated that the more shallow upper lake warmed more quickly than the lower lake water in the spring. The water in the upper lake reach was also warmer into the early summer, and it reached a higher maximum temperature than the water in the lower lake reach. The large volume of the water in the lower lake retained heat longer, as the natural heat inputs decreased in the fall. In 1976, the lower lake temperature changes lagged about 2-3 weeks behind the temperature changes in the upper lake from February through July, and surface temperatures were warmer in the lower lake from mid-July through December. In 1983, a year when the existing units were operating at close to full load capacity, the surface temperature in the lower lake exceeded the upper lake temperature, except during the spring and early summer. Hence, station operation apparently causes the following lake temperature changes:

- The lower lake is more closely aligned with the upper lake temperature in spring.
- Peak summer temperatures of both lake reaches are similar (whereas the lower lake was cooler pre-operation).
- Heat retention of the lower lake is prolonged. (Reference 2)

Quarterly field temperature surveys have been conducted since 1983 to characterize the thermal plume entering the reservoir via the discharge structure at Dike 3. The data show that in the hottest months of the year (July and August), near-maximum operating conditions have not produced a distinct thermal plume in the lower lake reach. In fact, results show nearly uniform temperatures across the reservoir. There is also no clearly defined thermal plume in the lower lake in the fall, winter, or spring. The results of recent quarterly plume studies (1994 to 1998) are similar. Typically, no thermal plume is evident in spring and summer surveys. In cooler months, differences between upper lake, mid-lake, and lower lake temperatures have been noticeable, both at the surface and at depth. However, seasonal cooling and warming trends of surface waters in the shallow upper lake and in the deeper lower lake have made it difficult to identify or precisely define a thermal plume. (Reference 16) (Reference 2)

Table 5.3-11 shows the observed maximum, average, and minimum daily temperature at four monitoring stations: NALDISC1 near the end of the discharge channel in the WHTF; NALST10 near Dike 3 in the WHTF side; NALBRPT near Burrus Point, which is about one-third of the way up the

North Anna Reservoir from the dam; and NALINT, near the intake. In this context, daily temperature refers to the 24-hour average temperature. The temperature summary is based on the continuous surface temperature measurements at the monitoring stations since 1978. Surface temperatures are taken in the top 1 m of the water column. Figure 6.1-1 shows the relative locations of the continuous temperature monitoring stations. Table 5.3-12 summarizes the time exceedence of the measured surface temperatures at the same four locations. Table 5.3-13 shows the seasonal trend of the monthly maximum and average surface temperature observed near the intake (monitoring station NALINT), and near Burrus Point (monitoring station NALBRPT). The temperature at the intake monitoring station is considered to be representative of the mid-lake condition, whereas the temperature of the Burrus Point monitoring station is representative of the lower lake condition. During the spring months, the monthly maximum temperature near the intake is warmer than the temperature at the Burrus Point. This temperature difference is due to the effect of the warmer inflows from the shallower upper lake reach and the potentially more pronounced natural stratification near the sheltered area around the intake monitoring station. During the summer months, the monthly maximum temperatures at the two locations are more similar due to the effect of the station heat load, as stated previously.

Figure 5.3-3 and Figure 5.3-4 show the observed seasonal average vertical temperature profiles near the dam (monitoring station A) and near the intake (monitoring station I). These profiles have been generated from plume survey data measured quarterly since 1983. The location of the plume survey monitoring stations is illustrated in Figure 6.1-2. The seasonal warming and cooling trend in the lower lake and mid-lake reaches can easily be identified in the observed temperature profiles.

5.3.2.1.2 **Thermal Impact**

The maximum heat load associated with the new units for release to WHTF during normal operation would be very small, on the order of 4.2×10^7 Btu/hr during the extreme summer months when the wet-bulb temperature is close to 80°F, and the average lake temperature is in the mid-80°F range. Compared to the total heat load of 1.35×10^{10} Btu/hr from the normal plant once-through cooling system of Units 1 and 2, the new units would add about 0.3 percent of heat content to the WHTF during these summer months. As the cooling tower blowdown from Unit 3 exits through the new outfall at the beginning of the discharge canal, it will mix with the cooling water discharge of Units 1 and 2 from the existing outfall nearby. Using a maximum blowdown flow rate of 12.4 cfs and discharge temperature of 100°F for Unit 3, and a total circulating water discharge flow rate of 4246 cfs and a condenser temperature rise of 14°F for the existing units, the average water temperature increase due to the new units is estimated to be less than a hundredth of a degree Fahrenheit at the end of the discharge canal where fully mixed condition of the two flow streams would be expected. This is based on an average ambient lake temperature of 85°F during the summer months when the thermal impact would be most critical. In the cooler months when the average lake temperature is lower in the 60°F range, a conservative estimate of the heat load associated with the new units would increase to about 1.1×10^8 Btu/hr due to the potentially higher temperature difference between the ambient lake water and the blowdown flow. The corresponding water temperature increase at the end of the discharge canal due to the new units would be less than a tenth of a degree Fahrenheit in the cooler months. The small water temperature increase due to the new units would dissipate to an undetectable level within a short distance of travel in the WHTF. The North Anna Reservoir would, therefore, experience no thermal impact as a result of the proposed operation of the new units.

Section 5.3.2.2 presents the potential impact on the aquatic ecological system of the North Anna Reservoir due to the additional heat load from the new units.

5.3.2.1.3 **Other Physical Impacts**

Section 5.3.1.1 discusses the hydrodynamics and the flow distribution induced in the North Anna Reservoir with the addition of new units. The conclusion is that, with the small water demand from the new units, the impacts such as increased shoreline erosion, lakebed scouring, and turbidity levels due to operation of the new intake system would be negligible.

The flow velocity in the discharge channel, the connecting canals, and the main ponds of the WHTF would be slightly higher than in the North Anna Reservoir due to their smaller dimensions. Unit 3 would release a maximum of 12.4 cfs of blowdown discharge to the WHTF and Unit 4 would use a closed-cycle system with dry cooling towers that would have no blowdown discharges. Including the cooling water discharge of 4246 cfs from the existing units, the total maximum plant cooling discharge to the WHTF would be 4258 cfs, which represents an increase in the velocity in the WHTF of about 0.3 percent. During the existing operation of Units 1 and 2, scouring and erosion have not been a concern in the WHTF where the flow velocity is typically less than 1 fps. The small increase in flow and velocity due to the new units would therefore not cause any scouring or erosion problems in the lake.

Banks of the connecting canals are currently protected by rip-rap from 242 ft msl to 250 ft msl to protect against erosion. The flow velocity decreases substantially in the main ponds of the WHTF beyond the entrance-mixing zone near the end of the connecting canals. At the Dike 3 discharge to the reservoir, the exit velocity is designed to be about 7 fps. The bottom of the discharge structure is protected by a concrete apron to minimize local erosion at the discharge, as shown in Figure 3.4-9. No adverse impact due to scouring from the existing plant discharge has occurred, and none would occur as a result of the future combined operation of four units.

There is limited record of turbidity level measurements in the WHTF, but based on the projected discharge flow velocity, the range of the turbidity level in the WHTF would be approximately the same as current turbidity.

Siltation would be minimal, because the medium to coarse sediment would settle before reaching the intake approach channel during normal lake conditions. Sediment could come into the approach channel during floods and deposit there due to the low channel velocity. Operation of the new intake, however, would not be affected because the channel is 12 feet deeper than the design invert of the new intake, allowing room for occasional sediment deposition. A small amount of fine, suspended sediment could be entrained into the new intake structure and would either be filtered out during water treatment processes or be returned to the North Anna Reservoir via the WHTF as part of the plant effluent from the cooling systems. Regular maintenance dredging would not be necessary for the operation of the new units.

5.3.2.2 **Aquatic Ecosystems**

5.3.2.2.1 **Overview**

Nuclear power plant heat dissipation systems can affect aquatic communities in receiving waters in a number of ways. High flows associated with circulating water systems have the potential for scouring discharge substrates and transporting sediment to downstream locations, potentially harming benthic organisms and damaging fish spawning habitats. Chemicals used in circulating water systems to control biofouling and corrosion can be harmful to aquatic organisms. Heated effluent from once-through cooling systems can affect the distribution and abundance of aquatic organisms in receiving waters. For example, fish may avoid a heated discharge area in summer and be attracted to the same area in winter and spring.

5.3.2.2.2 **Aquatic Ecosystem Impacts: Unit 3 Dry and Wet Cooling Towers**

a. **Physical effects**

The NRC has queried utilities and regulatory agencies and reviewed operational monitoring reports of more than 100 nuclear power plants in the course of preparing the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS). With regard to physical effects (scouring, sediment transport, and siltation), the NRC has observed in the GEIS that sediment scouring has caused “minor localized effects” at three operating plants, but has not been a problem at most plants. (Reference 19)

The addition to the existing once-through units at NAPS of a new Unit 3 that uses a closed-cycle, dry and wet cooling tower system would have almost no effect on circulating water discharge flows. The increase in discharge flow would range from 0.2 percent (the MWC mode maximum blowdown rate of 3844 gpm added to two-unit, open-cycle flow of approximately 1,900,000 gpm) to 0.6 percent (maximum blowdown rate of 5565 gpm added to one-unit, open-cycle flow of approximately 950,000 gpm). Discharge flow would range from 3844 gpm (Units 1 and 2 off-line; Unit 3 operating and discharging blowdown at maximum MWC mode rate) to 1,905,565 gpm (Units 1, 2, and 3 operating; Unit 3 discharging blowdown at maximum rate). An increase in circulating water flow of this magnitude would have no discernible effect on the substrate of the discharge canal or WHTF, and would have no impact at the Dike 3 discharge, the VPDES point of compliance. Impacts to aquatic organisms would be negligible. Mitigation would not be warranted.

b. **Chemical effects**

Nuclear power plants use a variety of chemicals, including biocides, corrosion inhibitors, and dispersants to control biofouling, corrosion, and scale formation in circulating and service water systems. For North Anna, the use of these chemicals is regulated and monitored under the VPDES permit, which prescribes their use (i.e., frequency, concentrations, and limits) and their monitoring frequency (i.e., continuous, daily, or monthly monitoring). Because of continuing efforts of utilities to reduce the use of these chemicals and required National Pollutant Discharge Elimination System (NPDES) monitoring and reporting, water quality degradation from cooling water system chemicals used in once-through cooling systems at nuclear power plants has not been a major regulatory concern. The GEIS notes that "…water quality effects of [the] discharge of chlorine and other biocides are considered to be of small significance for all plants" (Reference 19). NAPS submits monthly discharge monitoring reports to the VDEQ, which administers the Commonwealth's VPDES program. In addition, on a 5-year cycle, VDEQ conducts an extensive review of the effectiveness of existing VPDES programs, ensuring that water treatment systems in place adequately protect aquatic communities.

The GEIS notes (p 4-11) that discharges of sanitary wastes are regulated by NPDES permit, and discharges that do not violate the permit limits "are of small significance." Similarly, the GEIS notes (p 4-11) that water quality impacts of minor chemical discharges and spills do not have a significant impact on aquatic biota for all plants and have been mitigated as needed. NAPS has not had a pattern of permit exceedances or violations, and there is no basis for predicting that operation of an additional unit with cooling towers would increase the frequency or severity of VPDES permit exceedances.

Sewage treatment capacity may increase to accommodate additional on-site personnel. Any modification or expansion of existing sewage treatment facilities would be made in consultation with VDEQ, and any discharges from new or expanded facilities would comply with VPDES permit limits.

Adding a new Unit 3 with wet cooling towers to the two existing units would result in the discharge of cooling tower blowdown with concentrations of chemical constituents and solids that are up to approximately five times higher than those in water withdrawn from Lake Anna for make-up. However, this blowdown would mix with circulating water flow in the discharge canal and be further diluted downstream in the WHTF.

Based on five cycles of concentration in the cooling towers and the design blowdown flow, concentrations of lake water chemicals and solids would approach equilibrium (i.e., their concentration in circulating water) at the point at which the discharge canal enters the first pond of the WHTF. Concentrations of chemicals and solids would be below applicable VPDES permit limits at the Dike 3 discharge, the point of compliance. Impacts of chemicals in cooling tower blowdown on Lake Anna's aquatic communities would be small and would not warrant mitigation.

Metals such as copper and zinc, leached from condenser tubing and other heat exchangers, have accumulated in some water bodies receiving discharges from nuclear plants (Reference 19). Concentrations of metals in the discharges of once-through nuclear power plants are normally within NPDES permit limits, because the metals are quickly flushed from the area by the large volumes of cooling water or diluted by the receiving water (Reference 19). Concentrations of metals in the NAPS discharge are regulated by VPDES permit. There has been no pattern of exceedances or permit violations at NAPS.

Notwithstanding the fact that mining operations discharging to the Contrary Creek drainage have resulted in elevated concentrations of metals in some Lake Anna surface water and sediment samples in the past, there is no evidence of adverse impacts to aquatic communities. An additional unit with wet cooling towers would not result in additional impacts because discharges would continue to be regulated by the VPDES permit and thus be protective of aquatic biota. The impacts of chemicals associated with the operation of an additional unit with wet cooling towers on aquatic resources of Lake Anna would be small, regulated by VPDES permit, and would not warrant mitigation.

c. **Thermal effects**

1. **Thermal effects on important species**

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 sometimes occurs when single-unit power plants shut 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 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 (Reference 19).

There have been "winter kills" of fish in Lake Anna associated with cold weather and unusually cold water temperatures, but plant operations were not a factor. In February and March 1979, large numbers of gizzard shad were killed or stunned when Lake Anna water temperatures fell below 36°F (Reference 4). These fish drifted into the existing units' intake, and were observed in impingement samples. Limited threadfin shad kills have occurred during severe winters. The susceptibility of gizzard shad and threadfin shad to winter kills is well known.

The temperature of cooling tower blowdown from Unit 3 would be approximately the same as the temperature of the circulating water entering the WHTF from the two existing once-through units during the summer months. As noted previously, a new Unit 3 using a closed-cycle, dry and wet cooling tower system would contribute very little to discharge flow (less than one percent of total, when discharging blowdown) and would have almost no effect on discharge temperatures. The maximum temperature of cooling tower blowdown entering the discharge canal would be 100°F (Table 3.1-9). Over a recent three-year period that encompassed a severe drought, maximum temperatures recorded at the discharge canal with once-through units in operation ranged from 98.6°F in July 2000 (Reference 10) to 102.4°F in August 2002 (See Table 5.3-9). Based on the fact that blowdown from new Unit 3 would have negligible effect on temperatures in the WHTF, thermal impacts to aquatic organisms in the WHTF from operation of a third unit would be negligible, and would not warrant mitigation. Similarly, blowdown from Unit 3 would have no effect on temperature in Lake Anna and no impact on aquatic communities.

2. **Thermal effects on nuisance species**

   Densities of the introduced Asiatic clam (*Corbicula fluminea*) in Lake Anna increased from 1979 (when first discovered) to the late 1980s, and declined in the 1990s (see Section 2.4.2). As discussed in the previous sections, operation of a third unit with a closed-cycle, dry and wet cooling tower system would have negligible effect on discharge temperatures, and thus there would be no thermal impact on nuisance species, including the introduced Asiatic clam.

5.3.2.2.3 Aquatic Ecosystem Impacts: Unit 3 Using Dry and Wet Cooling Towers and Unit 4 Using Dry Towers

a. **Physical effects**

   Adding a new Unit 4, that uses dry cooling towers, to the two existing units and a new unit (Unit 3) with a combination of dry and wet towers would contribute very little to circulating water discharge flows. Such an addition would have no appreciable effect on substrate in the discharge area or the Dike 3 discharge beyond those described in Section 5.3.2.2.2.a for two once-through units and one unit with a combination of dry and wet cooling towers. Physical impacts to aquatic communities would be small, and would not warrant mitigation.

b. **Chemical effects**

   The dry cooling tower system proposed for Unit 4 would employ a closed loop of cooling water and, unlike wet cooling towers, would not require regular blowdown of water treatment chemicals and solids. Consequently, there would be no appreciable discharges of water treatment chemicals, biocides, salts, or other solids from the Unit 4 cooling systems, and no chemical effects on the aquatic communities of the WHTF and Lake Anna beyond those described in Section 5.3.2.2.2.b for two once-through units and one unit with a combination of dry and wet cooling towers. Chemical impacts would be small and would not warrant mitigation.

c. **Thermal effects**

As noted previously, a new unit (Unit 4), using dry towers would have no regular discharges (i.e., blowdown) and would have no appreciable affect on discharge temperatures beyond those already described in Section 5.3.2.2.2.c for the two existing units (Units 1 and 2) with once-through cooling systems and the new unit (Unit 3) with a closed-cycle, cooling tower-based system.

5.3.3 Heat-Discharge System

This section describes the impacts of the heat-discharge system during operation of the new units, including the impacts of heat dissipation on the atmosphere and on terrestrial ecosystems. Impacts of the heat-discharge system have been assessed assuming that Unit 3 would use a closed-cycle, dry and wet cooling tower system. All cooling system discharges for both the existing units and the new Unit 3 cooling tower system blowdown would be sent via the discharge canal to the existing WHTF and the North Anna Reservoir for heat dissipation, while Unit 4 would use closed-cycle, dry cooling towers for heat dissipation. Consideration is given to potential atmospheric phenomena resulting from operation of these types of heat-dissipation systems and the significance of their potential environmental impacts on terrestrial ecosystems and human activities in the ESP site vicinity.

5.3.3.1 Heat Dissipation to the Atmosphere

The cooling system options that have been evaluated for the new units would transfer waste heat from the plant components to the atmosphere and to surface water. A closed-cycle, dry and wet cooling tower system is the primary cooling process evaluated for Unit 3. Lake Anna would provide the make-up water to wet cooling towers. Unit 4 cooling would be provided by closed-cycle dry towers to transfer heat to the atmosphere.

Specifically, new Unit 3 would use the existing North Anna Reservoir as the make-up water supply source and the wet cooling tower blowdown would be discharged to the WHTF. A cooling system analysis was performed as described in Section 3.4. The WHTF dissipates the rejected heat from the plant by heat transfer to the atmosphere and through internal mixing within the water body itself. Under extreme humidity conditions during fall, winter, and spring, cool moist air above the WHTF could turn to fog (i.e., steam fog) and drift to adjacent areas. Based on informal observations from plant personnel, with Units 1 and 2 operating (with once-through cooling systems), this type of atmospheric phenomenon is infrequent and is very localized. Since the additional heat dissipated from the blowdown from the Unit 3 cooling towers would be negligible when compared to the heat dissipated from the existing units, any additional steam fog on and around the WHTF due to Unit 3 would be negligible. Additionally, the results from screening 5 years (1996–2000) of hourly meteorological data collected at Richmond, Virginia, indicate that there were no hours concurrently having relative humidity greater than 90 percent and ambient temperature below 32°F. Therefore, steam-fog-induced icing conditions are very infrequent at the site. Consequently, ice buildup on transmission lines, switchyard, insulators and structures due to steam fog would not be anticipated.

A combination of dry and wet towers would be used to dissipate plant rejected heat for Unit 3. Dry towers alone would be used to dissipate all of plant rejected heat for Unit 4. Except for the initial filling of the cooling water loop, there will be no appreciable additions of make-up water for the dry towers since a closed-cycle dry cooling system typically has no evaporative losses or need for continuous blowdown. Therefore, the operation of closed-cycle dry towers for Unit 3 and Unit 4 would not produce a visible plume, salt drift, or steam fog. Operation of the wet cooling towers may produce a visible plume, salt drift and steam fog, and warm, moist air would be discharged from the top of the towers. This would tend to cause the atmosphere to be saturated in the immediate vicinity of the tower discharge. As the vapor plume mixes with the cooler surrounding air, some of the water vapor may condense and fall to the ground in the area close to the towers. The remaining water vapor would dissipate into the atmosphere. Due to the buoyancy of water vapor and the natural movement of air (e.g., currents and breezes), the mixing of the water vapor in the plume with the atmosphere would cause any increase in the overall humidity due to the towers to be transient and very localized. Certain components located outdoors and in the proximity of the Unit 3 wet cooling towers could potentially be affected by fogging or by salt deposition from drift from towers. In the COL application, when specific cooling tower and power plant designs are selected, a confirmatory evaluation of the fogging and salt deposition will be performed to show that the analysis conducted for the ESP Application remains bounding. Most of the fogging from the wet cooling towers would occur within the site boundary in winter and spring. No icing would be anticipated within or beyond the site boundary. A description of the evaluation of the fogging, icing, salt deposition, and visible plume from the wet towers is provided in Section 5.3.3.2.1.

Section 3.4.1.1 contains a detailed description of the operation of the closed-cycle, dry and wet cooling towers. As ambient air is drawn over sealed piping containing heated water, excess heat is transferred to the air through conduction and convection. In wet towers, heat from the water is transferred to the air by allowing a small portion of the water to evaporate, thus raising the water temperature and relative humidity. The heated air from the dry and wet towers is then released to the atmosphere where it mixes and is entrained into the surrounding air mass. The mixture of heated air would continue to rise while it is transported downwind. Additional mixing with cooler air outside would further lower the temperature of the mixture. Therefore, any increases in overall atmosphere temperature would be localized to the NAPS site, and would not affect the atmospheric or ground temperatures beyond the NAPS site boundary.

5.3.3.2 **Terrestrial Ecosystems**

Heat dissipation systems associated with nuclear power plants have the potential to impact terrestrial ecosystem resources through salt drift, vapor plumes, icing, atmospheric temperature increases, noise, or avian collisions with surface structures (e.g., dry towers). Each of these topics is presented in later subsections.

No important terrestrial species or habitats exist within the vicinity of the closed-cycle, dry and wet towers for Unit 3 and the closed-cycle dry towers for Unit 4. Important species are defined as follows:

- State- or federally-listed (or proposed for listing) threatened or endangered species
- Commercially or recreationally valuable species
- Species that are essential to the maintenance and survival of species that are rare and commercially or recreationally valuable
- Species that are critical to the structure and function of the local terrestrial ecosystem
- Species that may serve as biological indicators to monitor the effects of the facilities on the terrestrial environment

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 USFWS (Reference 40) as threatened or endangered.

5.3.3.2.1 **Salt Drift, Vapor Plumes, and Icing**

The environmental impact of the operation of the wet cooling towers is evaluated using the SACTI computer model, a suite of programs developed by Argonne National Laboratories to describe fogging, icing, salt deposition, and visible plumes from traditional (e.g., non plume-abated) wet cooling towers. The programs were written specifically for the Electric Power Research Institute (EPRI) for use in licensing power plants with mechanical- or natural-draft cooling tower systems. Using the local meteorological conditions and operating characteristics of the cooling tower, the program predicts the potential seasonal and annual environmental effects of the plumes and drift. The programs that comprise SACTI and the models for cooling tower effects have been validated with field and laboratory data. The cooling tower characteristics used in this analysis were vendor-supplied and are representative of a typical wet tower system given the following as input:

- Cooling water flow rate 674,600 gpm
- Cooling water temperature (cold) 100F
- Range 29.87F
- Design wet bulb temperature 79F

The meteorological conditions used in the analysis were a combination of North Anna site data and data from the National Weather Service for Richmond, Virginia for the years 1998 through 2000. The site data was used for hourly wind speed and direction, station barometric pressure, relative humidity, dry bulb temperature, and dew point temperature. The site wet bulb temperature was calculated using the site dry bulb temperature, dew point temperature and station barometric pressure. The National Weather Service data for Richmond was used to compliment the site data and to complete the input requirements for SACTI, providing information on cloud cover, general description of weather conditions and visibility, and sea level barometric pressure. The combined data set was selected as representative of site conditions.

The SACTI program calculates the fogging, icing, salt deposition, and plume height and length without consideration of water-saving techniques or features that would be part of the design of the towers and would result in a reduction of the vapor plume as a consequence. As described in Section 3.4.1.1, these features can include incorporation of a dry cooling section in the wet tower or the use of heat exchange surfaces in the upper section of the wet tower, or the use of variable speed fans and pumps and adjustable louvers. However, for the analysis performed for the ESP application, to conservatively maximize the prediction of environmental impact due to visible plume, fogging, icing, and salt deposition, a lower profile (74 feet) non-plume-abated wet cooling tower was modeled. Seventy-four feet is the maximum expected non-plume-abated wet tower height.

The results of the SACTI analysis are presented in Table 5.3-22 through Table 5.3-41. The seasonal and annual fogging and icing results are presented in Table 5.3-22 through Table 5.3-26. The seasonal and annual salt deposition results are presented in Table 5.3-27 through Table 5.3-31, and the seasonal and annual plume height and length results are presented in Table 5.3-32 through Table 5.3-41. As may be seen from the tables, most fogging would occur in the winter. The number of hours of plume fogging is greatest at a distance of 300 m from the towers, mainly in the NNW direction. The SACTI calculated annual plume fogging hours due to the cooling towers is about 70 hours (excluding hours of natural fog). Therefore, the impact of the cooling tower induced fogging frequency is small. No cooling tower induced icing is predicted to occur at any distance from the cooling towers. Salt deposition, from drift from the cooling towers would be below 1 kg/ha/month at ground level at any distance from the tower within and beyond the site boundary. (Values for salt deposition in Table 5.3-27 through Table 5.3-31 are presented in terms of kg/km^2/mo.) The visible plume frequency is greatest during the winter. For all seasons, the plume can extend out to a maximum length of 4900 m and to a height of 980 m from the tower. The following table estimates by season, the approximate percentage of time that the plume would extend above the tallest structure in the PPE (234 feet/71 m) or would extend more than 0.5 mile (800 m) from the towers. The top of the tallest structure in the PPE is approximately 160 ft (49 m) above the top of the cooling towers in the model. The frequency results reported below are for 131 ft (40 m) and 164 ft (50 m). These results are based on the wet cooling towers operating 100 percent of the time in the energy conservation (EC) mode.

Season	Plume height >40 m above top of towers	Plume height >50 m above top of towers	Plume length >0.5 mile from towers
Winter	89	49	20
Spring	77	29	11
Summer	78	20	4
Fall	79	27	7

As stated in Section 5.3.3.1, steam fog formation and steam-fog-induced icing conditions resulting from operation of the Waste Heat Treatment Facility (WHTF) are very localized and infrequent at the NAPS site. The contribution of Unit 3 (from cooling tower blowdown) to the steam fog formation or steam-fog induced icing conditions would be negligible.

Since no important terrestrial species or habitats exist in the vicinity of Unit 3, any steam fog, drift and icing impacts resulting from operation of the WHTF and wet cooling towers on the local terrestrial ecosystems would be small.

As presented in Section 5.3.3.1, there are no evaporative losses associated with the operation of closed-cycle dry cooling systems. Therefore, dry cooling tower operation for Units 3 and 4 would pose no impacts from salt drift, salt deposition, vapor plumes, or icing.

5.3.3.2.2 **Local Temperature Increases**

Based on general industry experience, sensible atmospheric temperature increases resulting from operation of dry or wet cooling towers are typically small and are very localized near the tower location. Therefore, there are no expected impacts, adverse or beneficial, to terrestrial ecosystems beyond the NAPS site boundary from atmospheric temperature increases due to operation of the dry towers for Unit 3 or Unit 4.

5.3.3.2.3 **Noise**

Noise from the operation of the heat dissipation systems would be similar to current noise levels to which local species are adapted. Current noise levels at NAPS are occasionally as high as 100 dBA (measured at the security fence during outages), but they are typically less than 80 to 85 dBA, which is the threshold at which birds and small mammals are startled or frightened (Reference 41). As presented in Section 5.3.4, noise levels from cooling tower operation would be less than 65 dBA at the EAB. No important terrestrial species or important habitats are found in the vicinity of the heat dissipation systems. Noise impacts would be small.

5.3.3.2.4 **Avian Collisions**

A combination of dry and wet cooling towers with an overall height of less than 180 feet would be used for the Unit 3 heat dissipation system. Dry towers with an overall height of less than 150 feet would be used for the Unit 4 heat dissipation system. Use of these maximum cooling tower heights in the evaluation of avian collisions conservatively maximizes the prediction of that environmental impact. Since no avian collisions with existing NAPS structures have been noted, it is likely that bird collisions with the new towers would be rare. Therefore, the new towers would not adversely affect flying birds. Impacts to birds from collisions with heat dissipation structures would be small and would not warrant mitigation. The GEIS conclusion that impacts from bird collisions would be minimal (Reference 19) is valid for new units at the ESP site.

5.3.3.2.5 **Aesthetics**

Aesthetic impacts are addressed in Section 5.8.1.

5.3.3.2.6 **Conclusions**

Heat dissipation systems associated with new units at the ESP site would have small impacts on terrestrial ecosystem resources and mitigation would not be warranted.

5.3.4 **Impacts to Members of the Public**

This section describes the potential health impacts associated with the cooling system for the new units. Specifically, impacts to human health from thermophilic micro-organisms and from noise resulting from operation of the cooling system are addressed. (Reference 40) (Reference 19)

The existing units use an open-cycle cooling system which withdraws cooling water from the North Anna Reservoir and returns heated effluent to the WHTF. The WHTF discharges to the North Anna Reservoir through Dike 3 (Reference 38). Virginia Power considers the WHTF to be an integral part of the power station, and as such it has never been operated as an extension of the North Anna Reservoir for the purposes of public recreational use. However, with Virginia Power’s permission, homeowners on the shoreline of the WHTF have access to it for recreational use (boating, fishing, swimming). This limited access and use would remain unchanged following the addition of the cooling systems for the new units. The WHTF would be one of the areas possibly affected by the noise from the new cooling systems. The thermal effects on the WHTF due to the new cooling systems would be negligible.

Although the WHTF is a private treatment facility rather than state or federal waters under the VPDES program, given the use of the WHTF for recreation and has aquatic life, Dominion has evaluated the potential impact of chemical constituents discharged to the WHTF against EPA’s water quality criteria for these constituents. A review of historical impacts and current modeling results for the WHTF are presented in this section.

Public usage of the lake is transient and therefore less sensitive to noise impacts. Typically, noise limits apply at permanent residences or similar sensitive locations, as opposed to open ground where the public may have transient access. The noise impacts in this assessment were evaluated at the EAB, which is 5000 feet from the existing units.

As described in Section 3.4, the cooling needs of the new units would be provided by a closed-cycle, dry and wet tower system for Unit 3 and a closed-cycle dry tower system for Unit 4.

The Unit 3 closed-cycle wet tower cooling system would have a negligible thermal impact on the WHTF. The Unit 3 closed-cycle wet towers would generate more noise. The evaluations of thermophilic organisms and noise on the public are based on the composite cooling system (i.e., closed-cycle wet tower system operating in tandem with dry towers).

The chemistry of the circulating water in wet cooling towers is typically controlled through the use of additives. For example, typical treatment includes biocides to prevent fouling of heat exchanger surfaces by algae and other macroscopic organisms. Cooling tower water pH is adjusted with acid to discourage corrosion and the formation of scale. Other organic and inorganic corrosion inhibitors may be used in combination with an acid for pH control. Dispersants are commonly used to prevent the formation of deposits on the heat exchange surfaces.

Dominion would use treatment chemicals that have been tested for toxicity and determined to be protective of the environment and human health. The chemicals are added to the cooling tower water circulation system in concentrations in accordance with manufacturer's recommendations to ensure that they are below toxicity thresholds as defined by each chemical's Material Safety Data Sheet. Discharge limits are administratively controlled through the NPDES permitting process which prescribes the concentrations which can be released to surface waters.

Although Dominion has not selected which chemicals would be added to the proposed cooling towers to control water chemistry, the following are common additives which are typically used:

- Biocides
  - Sodium Hypochlorite
  - Sodium Bromide (in combination with Sodium Hypochlorite)
  - Bromonated Hydantoins (typically 1-bromo-3-chloro-5,5,-dimethylhydantoin, but others may be used)
  - Isothiazolin (typically 5-chloro-2-methyl-4-isothiazoline, but others may also be used)
- Corrosion Inhibitors
  - Organic and Inorganic Phosphates
  - Tolytriazole (and potentially other azoles)
  - Zinc Chloride or Zinc Sulfate
- Dispersants
  - Polyelectrolytes & Organophosphates
- Acid
  - Sulfuric Acid

The chemicals in these potential additives would be modeled against 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 for the environment. None of the listed additives are identified priority pollutants defined in 40 CFR 423 with the exception of chlorine. The Total Residual Chlorine concentration of the cooling tower blowdown would be maintained to meet permit limits. Dominion would provide adequate flow to ensure that the water quality in the WHTF would not differ significantly from water quality of the North Anna Reservoir.

5.3.4.1 **Thermophilic Micro-Organism Impacts**

NUREG-1555 and NUREG-1437 state that consideration of the impacts of thermophilic micro-organisms on public health are important for facilities using cooling ponds, lakes, canals, or small rivers, because use of such water bodies may significantly increase the presence and numbers of thermophilic micro-organisms. These micro-organisms could be causative agents of potentially serious human infections such as primary amoebic meningoencephalitis (PAM). (Reference 48).

Thermophilic micro-organisms (e.g., *Naegleria fowleri*) generally exist in water bodies with ambient temperatures between 77°F to 176°F. However, such organisms begin to thrive especially well (compared to their competitors) at ambient temperatures above 95°F (Reference 48) and maximum growth generally occurs when ambient temperatures are maintained between 122°F and 140°F (Reference 16, Section 4.12). Since 1975, Virginia Power has monitored water temperatures at various locations in the North Anna Reservoir, the WHTF, and the discharge canal. The highest temperatures recorded are summarized in Table 5.3-9:

While ambient summer water temperatures in the sampled locations were found to be within the range of those known to permit the reproduction and growth of pathogenic micro-organisms, the temperatures measured at all locations beyond the plant discharge to the WHTF were below those considered optimal for the growth of thermophilic forms. Temperatures in the WHTF downstream of the discharge structure were several degrees cooler than those in the immediate area of the discharge outfall, and under normal circumstances, would not create an environment especially conducive to the reproduction and growth of pathogenic micro-organisms.

Because the existing units currently discharge heated cooling water into the WHTF, and then into the North Anna Reservoir and the North Anna River, the potential impacts of thermophilic organisms have been investigated since the 1970s (Reference 16). The thermophilic pathogen amoeba *Naegleria fowleri*, found in freshwater throughout the United States, was found in the WHTF following start up of North Anna Unit 1 in June 1978. In 1981, VEPCO environmental personnel met with the Virginia Epidemiologist to determine whether *N. fowleri* at North Anna represented a public health risk. Following consultation with other state and federal agencies, the risk of contracting primary amoebic meningoencephalitis was determined to be too low to justify any action by VEPCO or state agencies. (Reference 38, Section 4.1.4; Reference 16, Section 4.12 & Appendix F) In 2002, the NRC concluded that the potential impacts of microbiological organisms on

Table 5.3-9 Lake Anna Reservoir Temperature Measurements

Date	Monitoring Station	Temperature
	Pre-Operation Period (Units 1 & 2)	
July 1977	North Anna Reservoir – Pamunkey Arm	92.7°F (hourly average)
August 1980	North Anna Reservoir – Lower Lake Station	91.6°F (hourly average)
	Operational Period (Units 1 & 2)	
Summer 1983	North Anna Reservoir	92.3°F (hourly average)
June 1984	North Anna Reservoir – Upper Lake Station	91.8°F (hourly average)
Summer Seasons 1983-1985	Dike 3 – Discharge of WHTF to North Anna Reservoir	88.2°F (monthly mean)
July 1993	Dike 3 – Discharge of WHTF to North Anna Reservoir	95.0°F (hourly average)
July 1993	Lake Anna – inlet structure	90.1°F (hourly average)
Summer Season 1997	North Anna Reservoir	86.4°F (max. recorded)
Summer Season 1997	Discharge Canal	97.7°F (max. recorded)
Summer Season 1997	WHTF	94.3°F (max. recorded)
August 2002	Discharge Canal	102.4°F (hourly average)

Data Source: Reference 15 and Reference 16, Section 4.12

public health resulting from the continued operation of the existing units is small. (Reference 38, Section 4.1.4)

There have been no known occurrences of PAM at Lake Anna or the WHTF. Recent correspondence with Virginia Department of Health (VDH, September 2005) (Reference 48) indicates PAM is rare, with only one death in Virginia due to PAM during the period 1979 to 2002. Nevertheless, the VDH suggests that to reduce risk of PAM, swimmers might wish to avoid swimming in freshwater venues when surface water temperatures are greater than or equal to 95°F, should avoid shallow stagnant areas and minimize forceful entry of water up nasal passages during jumping or diving activities, and should avoid digging in sediment while under water (Reference 48)

The addition of Unit 3 wet towers would require a small amount of continuous blowdown from the closed-cycle system to the WHTF, but the blowdown would not have any significant effect on the temperature of the WHTF. Further, there is no concern with thermophilic micro-organisms in the Unit 3 cooling tower basins because the makeup water to the cooling towers would be treated with a biocide (such as sodium hypochlorite) to prevent their growth. Therefore, the blowdown from the Unit 3 wet cooling towers would not contribute to an environment conducive to the growth of thermophilic organisms in the WHTF. Unit 3 and Unit 4 dry tower operation would pose no significant additional thermal impact to the North Anna Reservoir to support thermophilic micro-organisms. The downstream North Anna River temperatures would be unaffected by the negligible increase in thermal discharge. The maximum hourly average discharge canal and WHTF water temperatures would remain below the optimal range for thermophilic micro-organism growth (see Section 5.3.2).

Another component of the risk evaluation is the source of pathogenic materials; that is, the seeds or inoculants for such organisms. Wastewater (e.g., domestic sewage from the existing units case) represents the primary potential source of water-borne pathogens. Virginia Power recently upgraded the onsite sewage treatment plant to include disinfection processes that reduce coliform bacteria and other micro-organisms to levels that meet state water quality standards (see Section 3.6.2). The addition of personnel to support operation of the new units would not adversely impact the performance of this upgraded treatment facility.

In summary, the thermal and wastewater discharges from the addition of new units at the ESP site would result in the following:

- No significant alteration of the existing ambient temperature regime of the WHTF and the North Anna Reservoir
- No significant seeds or inoculants of pathogenic organisms would be present
- No significant increases to the population of naturally occurring micro-organisms

5.3.4.2 **Noise Impacts**

NUREG-1555, Section 5.3.4, mandates that the day-night average level of noise at the site boundary (dB[A-scale]) from the operation of the cooling system comply with applicable state limits. Because neither the Commonwealth of Virginia nor the counties surrounding the ESP site prescribe specific noise limitations, the noise evaluation compared potential offsite noise impacts with noise levels that the NRC considers to be at the threshold of significance: 65 dB(A) (Reference 40) (Reference 42) (Reference 43).

Using the CADNA/A Program, a ray-tracing noise model based on ISO 9613, Part 1 & 2, Noise Propagation Outside, predicted peak noise levels along the EAB from operation of the new composite cooling system would be below the applicable NRC-defined significance levels. Thus, the new units' cooling system would not produce adverse noise impacts to the public, and consequently, no noise mitigation measures would be required.

Section 5.3 References

1. *Updated Final Safety Analysis Report,* North Anna Power Station, Revision 38.

2. Virginia Power, 1986, Section 316(a) Demonstration for North Anna Power Station: Environmental Studies of Lake Anna and the Lower North Anna River. Virginia Power Corporate Technical Assessment, Water Quality Department, Richmond, Virginia, June.

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

4. Virginia Power, 1985, *Impingement and Entrainment Studies for North Anna Power Station,* 1978-1983, Prepared by Water Quality Department, Richmond, VA. May.

5. Jester, D. B., and B. L. Jensen. 1972, Life history and ecology of gizzard shad, *Dorosoma cepedianum* (Le Sueur) with reference to Elephant Butte Lake, New Mexico State University Agricultural Experiment Station Research Report 218, 56 p.

6. Carlander, K. D. 1969, *Handbook of Freshwater Fishery Biology,* Vol. 1, Iowa State University Press, Ames, 752 p.

7. Carlander, K. D. 1977, *Handbook of Freshwater Fishery Biology,* Vol. 2, Iowa State University Press, Ames, 431 p.

8. Kimmel, B. L. and A. W. Groeger. 1986, *Limnological and Ecological Changes Associated with Reservoir Aging,* in G. E. Hall and M. J. Van Den Avyle, editors, Reservoir Fisheries Management: Strategies for the 80’s, Reservoir Committee, Southern Division American Fisheries Society, Bethesda, Md.

9. Barwick, D. H., L. E. Miller, W. R. Geddings, and D. M. Rankin. 1995, *Fish Biomass and Angler Harvest from a South Carolina Cooling Reservoir,* Proceedings of the Annual Conference Southeast Association of Fish and Wildlife Agencies 49: 129-139.

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

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

12. Lee, D. S. 1980, *Atlas of North American Freshwater Fishes*. Publication #1980-12 of the North Carolina Biological Survey, North Carolina State Museum of Natural History, Raleigh, NC.

13. Baker, J. P., H. Olem, C. S. Creager, M. D. Marcus, and B. R. Parkhurst. 1993, *Fish and Fisheries Management in Lakes and Reservoirs,* EPA 841-R-93-002, Terrene Institute and U.S. Environmental Protection Agency, Washington, DC.

14. Goodyear, C.P. 1978, *Entrainment Impact Estimates Using the Equivalent Adult Approach,* FWS/OBS-78/65, U.S. Department of Interior, Fish and Wildlife Service, National Power Plant Team, Ann Arbor, MI.

15. VPDES Permit No. VA0052451, *Authorization to Discharge Under the Virginia Pollutant Discharge Elimination System and the Virginia State Water Control Act,* Commonwealth of Virginia, Department of Environmental Quality, permit's effective date, January 11, 2001; expiration date, January 11, 2006.

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

17. Final Environmental Statement, Related to the Continuation of Construction and the Operation of Units 1 & 2 and the Construction of Units 3 & 4, North Anna Power Station, Docket Nos. 50-338 & 50-339, and 50-404 & 50-405, United States Atomic Energy Commission, April 1973.

18. Deleted

19. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS),* Volumes 1 and 2, U.S. Nuclear Regulatory Commission, May 1996.

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

39. Deleted

40. NUREG-1555, *Standard Review Plans for Environmental Reviews of Nuclear Power Plants*, U.S. Nuclear Regulatory Commission (USNRC), Office of Nuclear Reactor Regulation. October 1999.

41. Golden, J., R. P. Ouellette, S. Saari, and P. N. Cheremisinoff. *Environmental Impact Data Book* (Second Printing) Chapter 8, Noise. Ann Arbor Science Publishers, Inc., 1980, Ann Arbor, Michigan.

42. Spotsylvania County Code, Section 14-14 “Unreasonably loud, disturbing, and unnecessary noise,” September 26, 1989.

43. Louisa County Code, Section 51-3, “Unnecessary and disturbing noise prohibited,” June 20, 1994.

44. Deleted

45. Deleted

46. Deleted

47. Deleted

48. Stroube, R. B., Commonwealth of Virginia Department of Health, letter to R. Burnely, Commonwealth of Virginia Department of Environmental Quality, September 15, 2005.

Table 5.3-10 Physical Attributes of North Anna Reservoir and WHTF

North Anna Reservoir	
Surface Area[a]	9600 acres
Downstream from NAPS[b]	4998 acres
Upstream from NAPS	4602 acres
Volume	10.6×10^9 ft^3
Mean Depth	25 ft
Downstream from NAPS	36 ft
Upstream from NAPS	13 ft
Maximum Depth	80 ft
Downstream from NAPS	46 ft
Upstream from NAPS	46 ft
Length	17 miles
Shoreline Length	272 miles
Waste Heat Treatment Facility	
Surface Area[c]	3400 acres
Volume	2.66×10^9 ft^3
Mean Depth	18 ft
Maximum Depth	50 ft
Side-Arm Areas	1530 acres

a. Reservoir area at the design pool level of 250 ft msl
b. From NAPS to the North Anna Dam
c. WHTF area at design water level of 251.5 ft msl

Table 5.3-11 Maximum, Minimum, and Average Daily Observed Surface Temperatures at Four Monitoring Stations in WHTF and North Anna Reservoir from 7/26/1978 to 4/10/2003

Discharge[a]	Dike 3[a]	Burrus Point[a]	Intake[a]
Maximum Daily Temperature[b] (°F)			
102.4	95.0	89.4	90.1
Average Daily Temperature[b] (°F)			
77.1	69.6	65.5	63.8
Average July-August Daily Temperature[b] (°F)			
95.0	88.9	84.3	83.8
Minimum Daily Temperature[b] (°F)			
39.4	36.1	34.7	34.2

a. Refer to Section 6.1 and Figure 6.1-1 for the location of the monitoring stations.

b. Daily temperature refers to the 24-hour average temperature.

Table 5.3-12 Exceedence Frequency of Observed Daily Surface Temperatures at Four Monitoring Stations in WHTF and North Anna Reservoir from 7/26/1978 to 4/10/2003

Daily Temperature[a]	Number of Days Equal to Or Exceeding (% of Total[b])			
	Discharge	Dike 3	Burrus Point	Intake
100°F	129 (1.5%)	0 (0%)	0 (0%)	0 (0%)
95.0°F	1186 (14%)	2 (0.02%)	0 (0%)	0 (0%)
90.0°F	2085 (24%)	527 (6.0%)	0 (0%)	1 (0.01%)
87.0°F	2588 (30%)	1346 (15%)	197 (2.4%)	109 (1.3%)

a. Daily temperature refers to the 24-hour average temperature.

b. Total number of days with observations: 8251 days for Burrus Point, 8449 days for Intake, 8766 days for Dike 3 and 8640 days for Discharge.

Table 5.3-13 Monthly Maximum and Average Observed Surface Temperature Near Intake from 7/26/1978 to 4/10/2003

	Monthly Maximum Temperature (°F)		Monthly Average Temperature (°F)	
Month	**Burrus Point**	**Intake**	**Burrus Point**	**Intake**
January	56.3	52.7	47.0	43.6
February	54.5	52.5	46.4	42.8
March	59.7	60.6[a]	51.0	48.5
April	71.4	72.1[a]	59.6	58.4
May	82.8	84.2[a]	69.8	69.5
June	86.5	86.9[a]	78.7	78.8[a]
July	89.2	90.1[a]	84.2	84.0
August	89.4	89.4	84.3	83.6
September	87.4	86.5	79.9	78.7
October	79.7	78.8	70.6	68.7
November	69.8	68.5	61.5	58.8
December	64.0	62.2	53.2	50.2

a. Higher temperature at intake during spring months due to effects of in-flows from the shallower upper reach and potentially more pronounced natural stratification in the sheltered area of the intake monitoring station.

Table 5.3-14 Deleted

Table 5.3-15 Deleted

Table 5.3-16 Deleted

Table 5.3-17 Deleted

Table 5.3-18 Deleted

Table 5.3-19 Deleted

Table 5.3-20 Deleted

Table 5.3-21 Deleted

Table 5.3-22 Winter SACTI Fogging and Icing Results

Hours of Plume Fogging Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Winter

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	0.0	0.0	0.0	1.5	3.1	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.9	8.8
200	0.0	0.0	0.3	8.0	7.3	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	7.6	34.2
300	3.5	0.0	0.5	8.1	7.5	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	5.5	22.1	56.3
400	4.5	0.0	0.5	7.1	7.5	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	6.5	19.9	53.8
500	4.5	0.0	0.5	6.3	7.5	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	6.5	19.5	51.5
600	4.5	0.0	0.3	4.9	7.3	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	6.5	19.1	47.7
700	4.5	0.0	0.3	4.5	7.3	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	6.5	19.0	46.5
800	0.0	0.0	0.1	2.8	7.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.0	18.7	33.2
900	0.0	0.0	0.0	2.3	7.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	18.5	31.6
1000	0.0	0.0	0.0	0.9	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	18.5	28.9
1100	0.0	0.0	0.0	0.5	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	18.5	28.5
1200	0.0	0.0	0.0	0.5	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	18.5	26.7
1300	0.0	0.0	0.0	0.5	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	18.0	24.0
1400	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	18.0	23.5
1500	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	11.2	16.7
1600	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	9.0	14.5

Table 5.3-22 Winter SACTI Fogging and Icing Results

Hours of Rime Icing Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Winter

Distance From Tower	****** Wind From ******																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	****** Plume Headed ******																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.3-23 Spring SACTI Fogging and Icing Results

Hours of Plume Fogging Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Spring

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	0.0	0.0	0.0	0.4	0.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8
200	0.0	0.0	0.3	3.0	2.3	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	8.5
300	0.6	0.0	0.5	3.1	2.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.4	12.6
400	0.8	0.0	0.5	2.7	2.5	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	3.0	12.0
500	0.8	0.0	0.5	2.5	2.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	3.0	11.5
600	0.8	0.0	0.3	2.1	2.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	3.0	10.3
700	0.8	0.0	0.3	2.0	2.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	3.0	10.0
800	0.0	0.0	0.1	1.5	2.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	7.2
900	0.0	0.0	0.0	1.4	2.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	6.7
1000	0.0	0.0	0.0	0.9	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	5.9
1100	0.0	0.0	0.0	0.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	5.5
1200	0.0	0.0	0.0	0.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	5.0
1300	0.0	0.0	0.0	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	4.5
1400	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	4.0
1500	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	2.9
1600	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.5

Table 5.3-23 Spring SACTI Fogging and Icing Results

Hours of Rime Icing Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Spring

Distance From Tower	*** Wind From ***																
	N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	*** Plume Headed ***																
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.3-24 Summary SACTI Fogging and Icing Results

Hours of Plume Fogging Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Summer

Distance From Tower	************ Wind From ************																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	************ Plume Headed ************																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.3-24 Summary SACTI Fogging and Icing Results

Hours of Rime Icing Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Summer

Distance From Tower	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	******	******	******	******	******	******	******	******	Plume Headed	******	******	******	******	******	******	******	******
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.3-25 Fall SACTI Fogging and Icing Results

Hours of Plume Fogging Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Fall

Distance From Tower	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Wind From																
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	0.0	0.0	0.0	0.2	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.9	0.4	2.6
200	0.0	0.0	0.0	0.4	1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.0	0.8	5.4
300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.3-25 Fall SACTI Fogging and Icing Results

Hours of Rime Icing Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Fall

Distance From Tower	****** Wind From ******																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	****** Plume Headed ******																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1300.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1400.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.3-26 Annual SACTI Fogging and Icing Results

Hours of Plume Fogging Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Annual

Distance From Tower	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	********** Wind From **********																
	********** Plume Headed **********																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	0.0	0.0	0.0	2.2	4.4	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.8	1.3	13.1
200	0.0	0.0	0.6	11.4	10.6	9.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	4.0	9.4	48.1
300	4.1	0.0	1.0	11.2	10.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	6.1	25.5	69.0
400	5.3	0.0	1.0	9.8	10.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	7.3	22.9	65.8
500	5.3	0.0	1.0	8.8	10.0	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	7.3	22.5	63.0
600	5.3	0.0	0.6	7.0	9.6	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	7.3	22.1	58.0
700	5.3	0.0	0.5	6.5	9.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	7.3	22.0	56.5
800	0.0	0.0	0.2	4.3	9.2	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.0	21.7	40.5
900	0.0	0.0	0.0	3.7	9.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	21.5	38.3
1000	0.0	0.0	0.0	1.7	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	21.5	34.7
1100	0.0	0.0	0.0	1.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	21.5	34.0
1200	0.0	0.0	0.0	1.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	21.5	31.7
1300	0.0	0.0	0.0	1.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	21.0	28.5
1400	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	21.0	27.5
1500	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	13.1	19.6
1600	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	10.5	17.0

Table 5.3-26 Annual SACTI Fogging and Icing Results

Hours of Rime Icing Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Annual

Distance From Tower	Wind From →																
	N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	Plume Headed																
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
700	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.3-27 Winter SACTI Salt Deposition Results

Plume Salt Deposition Table (Kg./(Km.2-Mo.))**

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Winter

Distance From Tower (Wind From →)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M) (Plume Headed →)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	2.40	0.00	0.19
125	0.14	0.14	0.06	0.00	0.00	0.00	0.00	0.00	2.07	1.34	1.52	0.00	0.00	0.85	3.45	0.00	0.60
150	0.29	0.25	0.15	0.18	0.00	0.00	0.00	0.43	4.85	3.37	3.56	0.35	0.00	0.85	3.24	0.40	1.12
175	1.96	1.05	1.08	0.46	0.00	0.00	0.00	0.81	9.54	9.38	7.29	0.74	0.00	7.06	23.06	0.87	3.96
200	2.07	1.12	1.17	0.07	0.00	0.00	0.00	0.07	4.01	5.77	3.91	0.19	3.17	7.83	23.36	0.12	3.30
250	1.22	0.54	0.62	0.07	0.00	0.00	0.00	0.07	2.60	3.71	2.43	0.19	0.69	5.31	17.03	0.12	2.16
300	1.67	0.89	0.76	0.07	0.33	0.30	0.69	0.07	2.36	3.02	2.29	0.19	3.53	6.78	14.07	0.12	2.32
350	1.57	0.94	0.69	0.07	0.12	0.17	0.11	0.07	1.60	1.70	1.58	0.19	1.72	1.85	2.73	0.12	0.95
400	1.58	0.94	0.70	0.07	0.15	0.18	0.18	0.07	1.60	1.71	1.58	0.19	1.36	1.45	1.94	0.12	0.86
450	1.38	0.84	0.61	0.05	2.27	1.05	1.44	0.06	1.36	1.46	1.36	0.15	4.60	5.26	4.91	0.10	1.68
500	1.04	0.63	0.44	0.08	0.78	0.38	0.59	0.06	0.90	1.03	0.95	0.26	2.24	2.30	2.11	0.23	0.88
550	0.95	0.57	0.39	0.52	0.23	0.15	0.19	0.45	0.71	0.89	0.82	1.07	1.30	1.37	0.89	1.61	0.76
600	0.66	0.42	0.27	0.51	0.23	0.15	0.19	0.37	0.53	0.65	0.60	0.75	1.30	1.37	0.89	1.39	0.64
800	0.68	0.43	0.29	0.15	0.43	0.46	0.34	0.09	0.59	0.76	0.67	0.19	4.50	4.88	2.64	0.35	1.09
900	1.82	1.14	0.93	0.08	0.55	0.64	0.43	0.05	1.94	2.90	2.23	0.14	6.34	6.90	3.65	0.17	1.87
1000	1.77	1.11	0.90	0.26	0.33	0.31	0.27	0.14	1.88	2.79	2.16	0.49	2.88	3.11	1.76	0.47	1.29
1250	0.86	0.52	0.40	0.33	0.31	0.30	.250	0.18	0.83	1.18	0.95	0.63	2.85	3.08	1.72	0.59	0.94
1400	0.83	0.49	0.39	0.16	0.14	0.16	0.11	0.09	0.80	1.15	0.93	0.30	1.60	1.74	0.93	0.31	0.63
1525	0.72	0.42	0.33	0.16	0.10	0.10	0.07	0.09	0.67	0.94	0.78	0.30	0.94	1.03	0.57	0.31	0.47

Table 5.3-28 Spring SACTI Salt Deposition Results

Plume Salt Deposition Table (Kg./(Km.2-Mo.))**

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Spring

Distance From Tower	********	********	********	********	********	********	********	********	Wind From	********	********	********	********	********	********	********	********
	N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	********	********	********	********	********	********	********	********	Plume Headed	********	********	********	********	********	********	********	********
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	0.63	0.57	0.19	0.00	0.00	0.00	0.00	0.00	1.45	0.58	0.80	0.00	0.00	0.00	0.00	0.00	0.26
150	1.58	1.43	0.62	0.15	0.00	0.00	0.00	0.32	4.16	2.71	2.84	0.53	0.00	0.00	0.00	0.31	0.92
175	3.41	3.30	2.20	0.27	0.00	0.00	0.00	0.70	11.23	12.92	9.93	1.09	0.00	0.00	.00	0.75	2.86
200	3.35	1.66	1.39	0.10	2.47	0.57	0.34	0.10	4.83	6.62	4.33	0.11	3.14	3.26	4.83	0.15	2.33
250	3.35	1.27	1.32	0.10	0.99	0.11	0.06	0.10	4.41	6.25	4.12	0.11	1.29	0.97	1.56	0.15	1.64
300	2.50	1.05	0.97	0.10	0.81	0.41	0.64	0.10	2.76	3.57	2.47	0.11	1.41	2.67	1.68	0.15	1.34
350	1.18	0.62	0.44	0.10	0.16	0.14	0.21	0.10	0.74	0.51	0.49	0.11	0.64	1.37	0.73	0.15	0.48
400	1.18	0.62	0.44	0.10	0.46	0.45	0.68	0.10	0.74	0.51	0.49	0.11	1.52	2.26	1.25	0.15	0.69
450	0.99	0.53	0.38	0.10	1.47	1.19	1.08	0.10	0.62	0.44	0.41	0.11	2.95	4.41	2.90	0.13	1.11
500	0.64	0.35	0.26	0.06	0.44	0.31	0.25	0.09	0.39	0.29	0.24	0.14	0.88	1.50	0.93	0.20	0.44
550	0.56	0.30	0.21	0.36	0.13	0.09	0.07	0.39	0.31	0.25	0.19	0.68	0.34	0.81	0.41	0.88	0.37
600	0.41	0.24	0.17	0.34	0.13	0.09	0.07	0.25	0.25	0.19	0.17	0.56	0.34	0.81	0.41	0.88	0.33
800	0.40	0.25	0.16	0.07	0.23	0.19	0.17	0.03	0.26	0.20	0.17	0.08	1.00	2.72	1.42	0.17	0.47
900	0.75	0.66	0.30	0.05	0.29	0.25	0.22	0.02	0.53	0.40	0.24	0.04	1.38	3.83	2.00	0.10	0.69
1000	0.73	0.64	0.30	0.11	0.18	0.14	0.12	0.04	0.52	0.39	0.24	0.04	0.67	1.76	0.91	0.27	0.44
1250	0.41	0.31	0.16	0.13	0.17	0.14	0.11	0.06	0.26	0.21	0.15	0.04	0.66	1.74	0.90	0.35	0.36
1400	0.39	0.31	0.16	0.07	0.07	0.06	0.06	0.03	0.24	0.21	0.15	0.04	0.35	0.97	0.52	0.18	0.24
1525	0.36	0.27	0.14	0.07	0.05	0.04	0.04	0.03	0.21	0.19	0.14	0.04	0.22	0.58	0.31	0.18	0.18

Table 5.3-29 Summer SACTI Salt Deposition Results

Plume Salt Deposition Table (Kg./(Km.**2-Mo.))
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Summer

Distance From Tower	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	0.43	0.27	0.21	0.00	0.00	0.00	0.00	0.00	1.92	1.73	2.02	0.00	0.00	0.00	0.00	0.00	0.41
150	1.65	0.93	0.65	0.29	0.00	0.00	0.00	0.55	5.64	5.41	5.54	0.74	0.00	0.00	0.00	0.67	1.38
175	6.76	3.76	2.17	0.56	0.00	0.00	0.00	1.11	16.40	17.76	14.84	1.38	0.00	0.00	0.00	1.36	4.13
200	6.84	3.69	3.31	0.20	2.21	1.71	0.60	0.29	9.05	12.22	7.72	0.42	0.12	0.43	0.48	0.25	3.10
250	6.91	3.69	3.61	0.20	0.52	0.37	0.11	0.29	8.47	11.61	6.29	0.42	0.02	0.11	0.09	0.25	2.68
300	4.04	2.16	2.02	0.20	0.23	0.22	0.29	0.29	4.75	6.40	3.73	0.42	2.64	1.98	0.85	0.25	1.90
350	0.73	0.37	0.23	0.20	0.27	0.10	0.31	0.29	0.61	0.67	0.79	0.42	1.22	0.94	0.36	0.25	0.48
400	0.74	0.37	0.23	0.20	1.08	0.40	1.14	0.29	0.61	0.67	0.79	0.42	3.06	2.80	1.09	0.25	0.88
450	0.61	0.33	0.20	0.19	1.04	0.42	0.27	0.28	0.52	0.57	0.70	0.40	2.55	2.19	0.66	0.25	0.70
500	0.38	0.25	0.14	0.15	0.20	0.05	0.05	0.12	0.35	0.38	0.53	0.25	0.80	0.66	0.27	0.15	0.30
550	0.34	0.23	0.12	0.48	0.04	0.01	0.00	0.26	0.24	0.31	0.45	0.52	0.42	0.25	0.10	0.53	0.27
600	0.25	0.15	0.07	0.24	0.04	0.01	0.00	0.22	0.18	0.24	0.35	0.37	0.42	0.25	0.10	0.42	0.21
800	0.23	0.15	0.06	0.08	0.04	0.01	0.00	0.04	0.21	0.28	0.41	0.07	1.42	0.70	0.25	0.05	0.25
900	0.58	0.36	0.06	0.05	0.04	0.01	0.00	0.04	0.69	1.04	1.65	0.06	1.99	0.96	0.34	0.02	0.49
1000	0.56	0.35	0.06	0.17	0.04	0.01	0.00	0.15	0.66	1.00	1.59	0.23	0.91	0.47	0.18	0.02	0.40
1250	0.29	0.19	0.06	0.21	0.04	0.01	0.00	0.20	0.30	0.43	0.68	0.30	0.90	0.47	0.17	0.02	0.27
1400	0.29	0.19	0.06	0.10	0.01	0.00	0.00	0.09	0.30	0.42	0.67	0.14	0.51	0.25	0.09	0.02	0.20
1525	0.26	0.17	0.06	0.10	0.01	0.00	0.00	0.09	0.25	0.35	0.55	0.14	0.30	0.16	0.05	0.02	0.16

Table 5.3-30 Fall SACTI Salt Deposition Results

Plume Salt Deposition Table (Kg./(Km.2-Mo.))**
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Fall

Distance From Tower	Wind From N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.11
125	0.98	0.59	0.13	0.00	1.67	0.00	0.00	0.00	2.22	2.04	1.59	0.00	0.00	0.00	0.42	0.00	0.60
150	2.72	1.59	0.36	0.12	1.67	0.00	0.00	0.57	5.46	4.96	3.91	1.08	0.00	0.00	0.42	1.04	1.49
175	7.50	4.27	1.08	0.29	13.94	0.00	0.00	1.07	9.90	10.15	8.68	2.04	0.00	0.00	3.48	2.05	4.03
200	4.19	2.05	1.24	0.04	10.77	0.12	0.25	0.13	5.58	7.66	4.60	0.28	1.99	2.69	5.33	0.21	2.95
250	4.01	1.77	1.21	0.04	8.56	0.02	0.05	0.13	5.58	6.73	3.32	0.28	0.37	0.68	3.03	0.21	2.25
300	2.90	1.22	0.81	0.04	7.29	0.36	0.21	0.13	3.61	4.22	2.49	0.28	4.67	2.20	3.01	0.21	2.10
350	1.20	0.44	0.29	0.04	0.08	0.08	0.14	0.13	1.12	1.22	1.28	0.28	1.98	0.75	0.46	0.21	0.61
400	1.20	0.44	0.29	0.06	0.21	0.18	0.53	0.13	1.12	1.22	1.28	0.28	2.59	1.45	0.92	0.22	0.76
450	1.03	0.38	0.23	0.06	1.17	1.05	1.84	0.13	0.92	1.04	1.07	0.25	6.18	4.87	2.13	0.20	1.41
500	0.69	0.26	0.14	0.10	0.35	0.27	0.52	0.12	0.54	0.67	0.68	0.25	2.57	1.63	0.67	0.24	0.61
550	0.59	0.24	0.10	0.43	0.12	0.08	0.09	0.47	0.38	0.47	0.51	0.98	1.34	0.55	0.27	1.04	0.48
600	0.47	0.19	0.09	0.26	0.12	0.08	0.09	0.37	0.24	0.37	0.44	0.76	1.34	0.55	0.27	1.04	0.42
800	0.44	0.20	0.09	0.04	0.22	0.18	0.14	0.04	0.24	0.44	0.50	0.14	4.49	1.52	0.83	0.21	0.61
900	0.79	0.48	0.23	0.02	0.28	0.24	0.17	0.01	0.45	1.63	1.76	0.10	6.30	2.07	1.15	0.15	0.99
1000	0.77	0.46	0.23	0.05	0.17	0.13	0.11	0.01	0.44	1.57	1.70	0.36	2.90	1.03	0.55	0.41	0.68
1250	0.42	0.22	0.12	0.06	0.16	0.13	0.11	0.01	0.25	0.66	0.73	0.46	2.86	1.00	0.54	0.52	0.52
1400	0.39	0.21	0.12	0.04	0.07	0.06	0.06	0.01	0.24	0.65	0.70	0.22	1.59	0.54	0.30	0.27	0.34
1525	0.36	0.18	0.10	0.04	0.05	0.04	0.05	0.01	0.22	0.53	0.58	0.22	0.95	0.34	0.18	0.27	0.26

Table 5.3-31 Annual SACTI Salt Deposition Results

Plume Salt Deposition Table (Kg./(Km.**2-Mo.))

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Annual

Distance From Tower	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.68	0.00	0.08
125	0.54	0.39	0.14	0.00	0.42	0.00	0.00	0.00	1.92	1.42	1.48	0.00	0.00	0.21	0.95	0.00	0.47
150	1.56	1.05	0.44	0.19	0.42	0.00	0.00	0.47	5.03	4.12	3.97	0.67	0.00	0.21	0.90	0.60	1.23
175	4.91	3.10	1.64	0.39	3.48	0.00	0.00	0.92	11.79	12.59	10.21	1.31	0.00	1.74	6.55	1.26	3.74
200	4.12	2.13	1.78	0.10	3.85	0.60	0.30	0.15	5.88	8.08	5.15	0.25	2.13	3.56	8.44	0.18	2.92
250	3.89	1.82	1.69	0.10	2.51	0.13	0.05	0.15	5.28	7.09	4.05	0.25	0.60	1.77	5.37	0.18	2.18
300	2.78	1.33	1.14	0.10	2.16	0.33	0.45	0.15	3.38	4.31	2.75	0.25	3.06	3.39	4.86	0.18	1.91
350	1.17	0.59	0.41	0.10	0.16	0.12	0.19	0.15	1.01	1.02	1.03	0.25	1.39	1.22	1.06	0.18	0.63
400	1.17	0.59	0.41	0.11	0.48	0.30	0.64	0.15	1.01	1.02	1.03	0.25	2.14	1.99	1.30	0.19	0.80
450	1.00	0.52	0.35	0.10	1.49	0.93	1.15	0.14	0.85	0.88	0.88	0.23	4.06	4.17	2.63	0.17	1.22
500	0.69	0.37	0.24	0.10	0.44	0.25	0.35	0.10	0.54	0.59	0.60	0.22	1.62	1.52	0.99	0.21	0.55
550	0.61	0.34	0.20	0.45	0.13	0.08	0.09	0.39	0.41	0.48	0.49	0.81	0.85	0.74	0.41	1.01	0.47
600	0.45	0.25	0.15	0.34	0.13	0.08	0.09	0.30	0.30	0.36	0.39	0.61	0.85	0.74	0.41	0.93	0.40
800	0.44	0.26	0.15	0.08	0.23	0.21	0.16	0.05	0.32	0.42	0.44	0.12	2.84	2.44	1.28	0.20	0.60
900	0.98	0.66	0.38	0.05	0.29	0.28	0.21	0.03	0.90	1.48	1.47	0.08	3.99	3.42	1.77	0.11	1.01
1000	0.95	0.64	0.37	0.15	0.18	0.15	0.12	0.09	0.87	1.43	1.42	0.28	1.83	1.59	0.84	0.29	0.70
1250	0.49	0.31	0.18	0.18	0.17	0.14	0.12	0.11	0.41	0.62	0.63	0.36	1.81	1.56	0.83	0.36	0.52
1400	0.48	0.30	0.18	0.09	0.07	0.07	0.06	0.06	0.39	0.61	0.61	0.17	1.01	0.87	0.45	0.19	0.35
1525	0.42	0.26	0.16	0.09	0.05	0.05	0.04	0.06	0.34	0.50	0.51	0.17	0.60	0.52	0.28	0.19	0.27

Table 5.3-32 Winter SACTI Plume Length Frequency Results

Plume Length Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Winter

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	10.32	5.70	3.76	2.59	4.18	2.28	2.51	1.94	8.87	10.59	8.62	4.46	8.76	9.44	8.78	7.21	100.00
200	4.72	2.54	1.49	0.77	1.71	0.67	0.98	0.43	1.82	2.35	1.82	1.09	4.76	5.58	4.52	2.61	37.85
300	4.72	2.54	1.49	0.44	0.77	0.30	0.35	0.15	1.82	2.35	1.82	0.53	1.63	2.17	1.80	1.45	24.33
400	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
500	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
600	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
700	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
800	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
900	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1000	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1100	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1200	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1300	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1400	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1500	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1600	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1700	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1800	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
1900	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
2000	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
2100	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
2200	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
2300	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
2400	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
2500	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
2600	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
2700	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
2800	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15

Table 5.3-32 Winter SACTI Plume Length Frequency Results

Plume Length Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Winter

Distance From Tower	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
2900	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3000	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3100	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3200	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3300	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3400	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3500	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3600	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3700	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3800	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
3900	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
4000	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
4100	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
4200	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
4300	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
4400	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
4500	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
4600	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
4700	3.03	1.48	1.03	0.44	0.77	0.30	0.35	0.15	.68	1.10	0.87	0.53	1.62	2.10	1.69	1.45	17.60
4800	0.36	0.27	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.27	1.13
4900	0.36	0.27	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.27	1.13
5000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3-33 Winter SACTI Plume Height Frequency Results

Plume Height Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Winter

Distance From Tower	*** Wind From ***																
	N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	*** Plume Headed ***																
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
10	10.32	5.70	3.76	2.59	4.18	2.28	2.51	1.94	8.87	10.59	8.62	4.46	8.76	9.44	8.78	7.21	100.00
20	10.32	5.70	3.76	2.59	4.18	2.28	2.51	1.94	8.87	10.59	8.62	4.46	8.76	9.41	8.65	7.21	99.85
30	10.21	5.69	3.76	2.59	4.18	2.28	2.51	1.94	8.86	10.37	8.15	4.30	8.76	9.41	8.65	7.16	98.82
40	10.17	5.67	3.76	2.52	3.00	1.27	1.80	1.91	8.86	10.28	8.06	4.08	6.53	7.54	6.73	7.00	89.19
50	6.89	4.01	2.47	1.19	1.71	0.67	0.98	0.89	3.86	4.34	3.59	1.45	4.34	5.24	4.20	3.53	49.37
60	6.61	3.93	2.39	0.82	1.71	0.67	0.98	0.52	3.12	3.61	3.10	1.16	4.33	5.16	4.13	2.70	44.94
70	5.35	2.99	1.78	0.77	1.71	0.67	0.98	0.43	2.37	2.94	2.30	1.09	4.33	5.16	4.13	2.61	39.60
80	4.72	2.54	1.49	0.77	1.71	0.67	0.98	0.43	1.82	2.35	1.82	1.09	4.33	5.16	4.13	2.61	36.61
90	4.72	2.54	1.49	0.60	1.45	0.58	0.77	0.30	1.82	2.35	1.82	0.97	3.83	4.75	3.67	1.97	33.62
100	4.72	2.54	1.49	0.60	1.22	0.53	0.70	0.30	1.82	2.35	1.82	0.97	3.32	4.22	3.11	1.97	31.68
110	4.72	2.54	1.49	0.53	1.22	0.53	0.70	0.19	1.82	2.35	1.82	0.72	3.32	4.22	3.11	1.61	30.89
120	4.72	2.54	1.49	0.44	1.06	0.48	0.51	0.15	1.82	2.35	1.82	0.53	3.00	3.82	2.56	1.45	28.73
130	4.72	2.54	1.49	0.44	0.84	0.40	0.40	0.15	1.82	2.35	1.82	0.53	2.58	3.16	2.22	1.45	26.90
140	4.72	2.54	1.49	0.44	0.84	0.40	0.40	0.15	1.82	2.35	1.82	0.53	2.58	3.16	2.22	1.45	26.90
150	3.93	2.22	1.33	0.44	0.84	0.40	0.40	0.15	1.51	1.95	1.47	0.53	2.58	3.16	2.22	1.45	24.57
160	3.93	2.22	1.33	0.44	0.84	0.40	0.40	0.15	1.51	1.95	1.47	0.53	2.58	3.16	2.22	1.45	24.57
170	3.93	2.22	1.33	0.44	0.84	0.40	0.40	0.15	1.51	1.95	1.47	0.53	2.58	3.16	2.22	1.45	24.57
180	3.93	2.22	1.33	0.44	0.77	0.30	0.35	0.15	1.51	1.95	1.47	0.53	1.62	2.10	1.69	1.45	21.81
190	3.93	2.22	1.33	0.44	0.77	0.30	0.35	0.15	1.51	1.95	1.47	0.53	1.62	2.10	1.69	1.45	21.81
200	3.93	2.22	1.33	0.44	0.77	0.30	0.35	0.15	1.51	1.95	1.47	0.53	1.62	2.10	1.69	1.45	21.81
210	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
220	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
230	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
240	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
250	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
260	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
270	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
280	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15

Table 5.3-33 Winter SACTI Plume Height Frequency Results

Plume Height Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Winter

Distance From Tower	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
290	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
300	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
310	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
320	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
330	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
340	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
350	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
360	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
370	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
380	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
390	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
400	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
410	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
420	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
430	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
440	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
450	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
460	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
470	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
480	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
490	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
500	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
510	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
520	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
530	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
540	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
550	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
560	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15

Table 5.3-33 Winter SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Winter

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
570	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
580	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
590	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.10	1.69	1.45	20.15
600	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
610	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
620	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
630	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
640	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
650	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
660	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
670	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
680	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
690	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
700	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
710	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
720	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.45	20.09
730	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.82
740	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.82
750	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.82
760	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.82
770	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.82
780	3.68	2.06	1.19	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.82
790	3.32	1.80	1.01	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.02
800	3.32	1.80	1.01	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.02
810	3.32	1.80	1.01	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.02
820	3.32	1.80	1.01	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.02
830	3.32	1.80	1.01	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.02
840	3.32	1.80	1.01	0.44	0.77	0.30	0.35	0.15	1.22	1.48	1.12	0.53	1.62	2.08	1.64	1.18	19.02

Table 5.3-33   Winter SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Winter

Distance From Tower	**** Wind From ****																
	N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	**** Plume Headed ****																
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
850	1.46	1.00	0.56	0.44	0.40	0.19	0.24	0.15	0.78	0.73	0.62	0.53	1.14	1.49	0.71	1.18	11.62
860	1.46	1.00	0.56	0.08	0.40	0.19	0.24	0.03	0.78	0.73	0.62	0.19	1.14	1.49	0.71	0.32	9.94
870	1.46	1.00	0.56	0.08	0.40	0.19	0.24	0.03	0.78	0.73	0.62	0.19	1.14	1.49	0.71	0.32	9.94
880	1.46	1.00	0.56	0.08	0.40	0.19	0.24	0.03	0.78	0.73	0.62	0.19	1.14	1.49	0.71	0.32	9.94
890	1.46	1.00	0.56	0.08	0.40	0.19	0.24	0.03	0.78	0.73	0.62	0.19	1.14	1.49	0.71	0.32	9.94
900	0.65	0.58	0.16	0.08	0.40	0.19	0.24	0.03	0.54	0.38	0.25	0.19	1.14	1.49	0.71	0.32	7.35
910	0.65	0.58	0.16	0.00	0.09	0.08	0.13	0.00	0.54	0.38	0.25	0.00	0.52	0.58	0.36	0.00	4.32
920	0.65	0.58	0.16	0.00	0.09	0.08	0.13	0.00	0.54	0.38	0.25	0.00	0.52	0.58	0.36	0.00	4.32
930	0.65	0.58	0.16	0.00	0.09	0.08	0.13	0.00	0.54	0.38	0.25	0.00	0.52	0.58	0.36	0.00	4.32
940	0.65	0.58	0.16	0.00	0.09	0.08	0.13	0.00	0.54	0.38	0.25	0.00	0.52	0.58	0.36	0.00	4.32
950	0.65	0.58	0.16	0.00	0.09	0.08	0.13	0.00	0.54	0.38	0.25	0.00	0.52	0.58	0.36	0.00	4.32
960	0.65	0.58	0.16	0.00	0.09	0.08	0.13	0.00	0.54	0.38	0.25	0.00	0.52	0.58	0.36	0.00	4.32
970	0.65	0.58	0.16	0.00	0.09	0.08	0.13	0.00	0.54	0.38	0.25	0.00	0.52	0.58	0.36	0.00	4.32
980	0.65	0.58	0.16	0.00	0.09	0.08	0.13	0.00	0.54	0.38	0.25	0.00	0.52	0.58	0.36	0.00	4.32
990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3-34 Spring SACTI Plume Length Frequency Results

Plume Length Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Spring

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	10.02	5.12	4.72	3.89	6.10	4.57	3.15	2.30	7.36	9.32	7.79	4.35	7.10	9.18	8.12	6.93	100.00
200	2.79	1.37	1.26	1.08	2.09	0.86	0.44	0.25	0.41	0.45	0.45	0.19	1.81	3.25	2.56	1.20	20.46
300	2.79	1.37	1.26	0.77	1.11	0.42	0.20	0.16	0.41	0.45	0.45	0.08	0.53	0.93	0.72	0.78	12.44
400	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
500	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
600	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
700	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
800	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
900	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1000	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1100	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1200	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1300	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1400	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1500	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1600	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1700	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1800	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
1900	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
2000	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
2100	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
2200	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
2300	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
2400	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
2500	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
2600	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
2700	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
2800	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76

Table 5.3-34 Spring SACTI Plume Length Frequency Results

Plume Length Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Spring

Distance From Tower	****** Wind From ******																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	****** Plume Headed ******																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
2900	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3000	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3100	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3200	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3300	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3400	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3500	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3600	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3700	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3800	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
3900	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
4000	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
4100	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
4200	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
4300	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
4400	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
4500	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
4600	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
4700	1.71	.82	0.84	0.77	1.05	0.42	0.20	0.16	0.19	0.27	0.24	0.08	0.48	0.87	0.69	0.78	9.57
4800	0.46	0.10	0.15	0.10	.10	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00	0.03	0.21	1.19
4900	0.46	0.10	0.15	0.10	.10	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00	0.03	0.21	1.19
5000	0.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3-35 Spring SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Spring

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
10	10.02	5.12	4.72	3.89	6.10	4.57	3.15	2.30	7.36	9.32	7.79	4.35	7.10	9.18	8.12	6.93	100.00
20	10.02	5.12	4.72	3.89	6.10	4.57	3.15	2.30	7.36	9.32	7.79	4.35	7.10	9.18	8.12	6.93	100.00
30	9.34	4.86	4.47	3.28	6.10	4.57	3.15	2.28	7.23	8.52	6.92	3.77	7.10	9.18	8.12	6.14	95.02
40	9.16	4.80	4.33	3.25	3.08	2.01	1.67	2.17	7.22	8.35	6.74	3.66	3.88	6.15	4.26	5.98	76.72
50	4.57	2.34	1.83	1.45	1.83	0.78	0.39	0.56	2.20	2.31	1.96	.60	1.44	2.82	1.98	2.10	29.16
60	4.25	2.09	1.63	1.11	1.77	0.78	0.39	0.33	1.20	0.98	1.01	0.31	1.40	2.79	1.95	1.28	23.26
70	3.32	1.66	1.34	1.08	1.77	0.78	0.39	0.25	0.70	0.70	0.64	0.19	1.40	2.79	1.95	1.20	20.14
80	2.79	1.37	1.26	1.08	1.77	0.78	0.39	0.25	0.41	0.45	0.45	0.19	1.40	2.79	1.95	1.20	18.52
90	2.79	1.37	1.26	0.95	1.64	0.70	0.36	0.24	0.41	0.45	0.45	0.16	1.24	2.51	1.79	1.09	17.42
100	2.79	1.37	1.26	0.95	1.47	0.62	0.31	0.24	0.41	0.45	0.45	0.16	1.12	2.31	1.51	1.09	16.51
110	2.79	1.37	1.26	0.80	1.47	0.62	0.31	0.17	0.41	0.45	0.45	0.08	1.12	2.31	1.51	0.87	16.00
120	2.79	1.37	1.26	0.77	1.24	0.51	0.27	0.16	0.41	0.45	0.45	0.08	0.96	1.90	1.25	0.78	14.64
130	2.79	1.37	1.26	0.77	1.08	0.45	0.23	0.16	0.41	0.45	0.45	0.08	0.68	1.45	1.00	0.78	13.41
140	2.79	1.37	1.26	0.77	1.08	0.45	0.23	0.16	0.41	0.45	0.45	0.08	0.68	1.45	1.00	0.78	13.41
150	2.26	1.15	1.14	0.77	1.08	0.45	0.23	0.16	0.34	0.39	0.30	0.08	0.68	1.45	1.00	0.78	12.25
160	2.26	1.15	1.14	0.77	1.08	0.45	0.23	0.16	0.34	0.39	0.30	0.08	0.68	1.45	1.00	0.78	12.25
170	2.26	1.15	1.14	0.77	1.08	0.45	0.23	0.16	0.34	0.39	0.30	0.08	0.68	1.45	1.00	0.78	12.25
180	2.26	1.15	1.14	0.77	1.05	0.42	0.20	0.16	0.34	0.39	0.30	0.08	0.48	0.87	0.69	0.78	11.08
190	2.26	1.15	1.14	0.77	1.05	0.42	0.20	0.16	0.34	0.39	0.30	0.08	0.48	0.87	0.69	0.78	11.08
200	2.26	1.15	1.14	0.77	1.05	0.42	0.20	0.16	0.34	0.39	0.30	0.08	0.48	0.87	0.69	0.78	11.08
210	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
220	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
230	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
240	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
250	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
260	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
270	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
280	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76

Table 5.3-35 Spring SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Spring

Distance From Tower	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
290	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
300	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
310	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
320	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
330	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
340	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
350	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
360	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
370	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
380	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
390	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
400	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
410	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
420	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
430	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
440	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
450	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
460	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
470	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
480	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
490	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
500	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
510	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
520	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
530	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
540	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
550	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
560	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76

Table 5.3-35 Spring SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Spring

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
570	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
580	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
590	2.18	1.06	1.10	0.77	1.05	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.69	0.78	10.76
600	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
610	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
620	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
630	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
640	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
650	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
660	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
670	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
680	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
690	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
700	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
710	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
720	2.18	1.06	1.10	0.77	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.08	0.48	0.87	0.66	0.78	10.63
730	2.18	1.06	1.10	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.05	0.48	0.87	0.66	0.57	10.29
740	2.18	1.06	1.10	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.05	0.48	0.87	0.66	0.57	10.29
750	2.18	1.06	1.10	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.05	0.48	0.87	0.66	0.57	10.29
760	2.18	1.06	1.10	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.05	0.48	0.87	0.66	0.57	10.29
770	2.18	1.06	1.10	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.05	0.48	0.87	0.66	0.57	10.29
780	2.18	1.06	1.10	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.28	0.05	0.48	0.87	0.66	0.57	10.29
790	1.72	0.96	.96	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.27	0.05	0.48	0.87	0.66	0.57	9.57
800	1.72	0.96	.96	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.27	0.05	0.48	0.87	0.66	0.57	9.57
810	1.72	0.96	.96	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.27	0.05	0.48	0.87	0.66	0.57	9.57
820	1.72	0.96	.96	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.27	0.05	0.48	0.87	0.66	0.57	9.57
830	1.72	0.96	.96	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.27	0.05	0.48	0.87	0.66	0.57	9.57
840	1.72	0.96	.96	0.67	.95	0.42	0.20	0.16	0.28	0.34	0.27	0.05	0.48	0.87	0.66	0.57	9.57

Table 5.3-35 Spring SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Spring

Distance From Tower	****** Wind From ******																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	****** Plume Headed ******																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
850	0.98	0.51	0.51	0.67	0.70	0.26	0.12	0.16	0.14	0.19	0.15	0.05	0.40	0.68	0.34	0.57	6.43
860	0.98	0.51	0.51	0.41	0.70	0.26	0.12	0.02	0.14	0.19	0.15	0.03	0.40	0.68	0.34	0.11	5.55
870	0.98	0.51	0.51	0.41	0.70	0.26	0.12	0.02	0.14	0.19	0.15	0.03	0.40	0.68	0.34	0.11	5.55
880	0.98	0.51	0.51	0.41	0.70	0.26	0.12	0.02	0.14	0.19	0.15	0.03	0.40	0.68	0.34	0.11	5.55
890	0.98	0.51	0.51	0.41	0.70	0.26	0.12	0.02	0.14	0.19	0.15	0.03	0.40	0.68	0.34	0.11	5.55
900	0.47	0.24	0.27	0.41	0.70	0.26	0.12	0.02	0.09	0.08	0.05	0.03	0.40	0.68	0.34	0.11	4.27
910	0.47	0.24	0.27	0.00	0.33	0.08	0.08	0.00	0.09	0.08	0.05	0.00	0.19	0.30	0.09	0.00	2.26
920	0.47	0.24	0.27	0.00	0.33	0.08	0.08	0.00	0.09	0.08	0.05	0.00	0.19	0.30	0.09	0.00	2.26
930	0.47	0.24	0.27	0.00	0.33	0.08	0.08	0.00	0.09	0.08	0.05	0.00	0.19	0.30	0.09	0.00	2.26
940	0.47	0.24	0.27	0.00	0.33	0.08	0.08	0.00	0.09	0.08	0.05	0.00	0.19	0.30	0.09	0.00	2.26
950	0.47	0.24	0.27	0.00	0.33	0.08	0.08	0.00	0.09	0.08	0.05	0.00	0.19	0.30	0.09	0.00	2.26
960	0.47	0.24	0.27	0.00	0.33	0.08	0.08	0.00	0.09	0.08	0.05	0.00	0.19	0.30	0.09	0.00	2.26
970	0.47	0.24	0.27	0.00	0.33	0.08	0.08	0.00	0.09	0.08	0.05	0.00	0.19	0.30	0.09	0.00	2.26
980	0.47	0.24	0.27	0.00	0.33	0.08	0.08	0.00	0.09	0.08	0.05	0.00	0.19	0.30	0.09	0.00	2.26
990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3-36 Summer SACTI Plume Length Frequency Results

Plume Length Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Summer

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	9.77	5.78	4.36	4.39	8.13	4.20	3.85	3.24	9.79	11.79	8.69	3.97	7.10	5.88	3.85	5.20	100.00
200	0.77	0.59	0.46	0.43	1.18	0.62	0.31	0.18	0.53	0.43	0.50	0.17	1.16	0.89	0.45	0.20	8.88
300	0.77	0.59	0.46	0.22	0.64	0.22	0.14	0.08	0.53	0.43	0.50	0.03	0.23	0.22	0.16	0.03	5.24
400	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
500	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
600	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
700	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
800	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
900	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1000	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1100	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1200	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1300	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1400	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1500	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1600	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1700	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1800	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
1900	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
2000	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
2100	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
2200	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
2300	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
2400	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
2500	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
2600	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
2700	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
2800	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95

Table 5.3-36 Summer SACTI Plume Length Frequency Results

Plume Length Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Summer

	******** Wind From ********																
Distance From Tower	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	******** Plume Headed ********																
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
2900	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3000	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3100	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3200	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3300	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3400	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3500	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3600	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3700	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3800	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
3900	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
4000	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
4100	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
4200	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
4300	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
4400	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
4500	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
4600	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
4700	0.36	0.27	0.22	0.22	0.64	0.20	0.14	0.08	0.28	0.20	0.12	0.03	0.23	0.20	0.16	0.03	3.37
4800	0.02	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
4900	0.02	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
5000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3-37 Summer SACTI Plume Height Frequency Results

Plume Height Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Summer

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
10	9.77	5.78	4.36	4.39	8.13	4.20	3.85	3.24	9.79	11.79	8.69	3.97	7.10	5.88	3.85	5.20	100.00
20	9.77	5.78	4.36	4.39	8.13	4.20	3.85	3.24	9.79	11.79	8.69	3.97	7.10	5.88	3.85	5.20	100.00
30	9.04	5.29	4.18	4.28	8.13	4.20	3.85	3.24	9.79	11.78	8.66	3.92	7.10	5.88	3.85	4.91	98.10
40	8.88	5.26	4.15	4.22	2.46	0.98	1.11	3.18	9.79	11.78	8.66	3.89	4.18	3.51	1.51	4.80	78.34
50	2.07	1.43	0.93	0.86	0.90	0.39	0.23	0.81	2.69	2.83	2.64	1.08	1.14	0.82	0.39	0.89	20.13
60	1.37	1.10	0.73	0.49	0.90	0.38	0.23	0.31	1.25	1.21	1.43	0.32	1.14	0.82	0.39	0.36	12.43
70	0.91	0.81	0.57	0.43	0.90	0.38	0.23	0.18	0.98	0.79	0.90	0.17	1.14	0.82	0.39	0.20	9.81
80	0.77	0.59	0.46	0.43	0.90	0.38	0.23	0.18	0.53	0.43	0.50	0.17	1.14	0.82	0.39	0.20	8.13
90	0.77	0.59	0.46	0.39	0.87	0.36	0.23	0.15	0.53	0.43	0.50	0.14	0.99	0.70	0.30	0.13	7.54
100	0.77	0.59	0.46	0.39	0.79	0.28	0.23	0.15	0.53	0.43	0.50	0.14	0.89	0.60	0.25	0.13	7.14
110	0.77	0.59	0.46	0.28	0.79	0.28	0.23	0.14	0.53	0.43	0.50	0.12	0.89	0.60	0.25	0.03	6.90
120	0.77	0.59	0.46	0.22	0.73	0.25	0.18	0.08	0.53	0.43	0.50	0.03	0.78	0.46	0.23	0.03	6.27
130	0.77	0.59	0.46	0.22	0.64	0.20	0.14	0.08	0.53	0.43	0.50	0.03	0.54	0.34	0.20	0.03	5.70
140	0.77	0.59	0.46	0.22	0.64	0.20	0.14	0.08	0.53	0.43	0.50	0.03	0.54	0.34	0.20	0.03	5.70
150	0.69	0.47	0.36	0.22	0.64	0.20	0.14	0.08	0.38	0.38	0.41	0.03	0.54	0.34	0.20	0.03	5.10
160	0.69	0.47	0.36	0.22	0.64	0.20	0.14	0.08	0.38	0.38	0.41	0.03	0.54	0.34	0.20	0.03	5.10
170	0.69	0.47	0.36	0.22	0.64	0.20	0.14	0.08	0.38	0.38	0.41	0.03	0.54	0.34	0.20	0.03	5.10
180	0.69	0.47	0.36	0.22	0.64	0.20	0.14	0.08	0.38	0.38	0.41	0.03	0.23	0.20	0.16	0.03	4.62
190	0.69	0.47	0.36	0.22	0.64	0.20	0.14	0.08	0.38	0.38	0.41	0.03	0.23	0.20	0.16	0.03	4.62
200	0.69	0.47	0.36	0.22	0.64	0.20	0.14	0.08	0.38	0.38	0.41	0.03	0.23	0.20	0.16	0.03	4.62
210	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
220	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
230	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
240	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
250	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
260	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
270	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
280	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95

Table 5.3-37 Summer SACTI Plume Height Frequency Results

Plume Height Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Summer

Distance From Tower	************ Wind From ************																
	N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	************ Plume Headed ************																
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
290	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
300	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
310	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
320	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
330	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
340	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
350	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
360	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
370	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
380	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
390	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
400	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
410	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
420	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
430	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
440	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
450	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
460	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
470	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
480	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
490	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
500	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
510	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
520	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
530	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
540	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
550	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
560	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95

Table 5.3-37 Summary SACTI Plume Height Frequency Results

Distance From Tower	Plume Height Frequency Table North Anna, Richmond (1998-2000), 52-Cell MDCT Season = Summer																
	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
570	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
580	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
590	0.62	0.42	0.36	0.22	0.64	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.95
600	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
610	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
620	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
630	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
640	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
650	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
660	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
670	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
680	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
690	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
700	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
710	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
720	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
730	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
740	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
750	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
760	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
770	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
780	0.62	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.92
790	0.60	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.91
800	0.60	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.91
810	0.60	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.91
820	0.60	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.91
830	0.60	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.91
840	0.60	0.42	0.36	0.22	0.61	0.20	0.14	0.08	0.28	0.22	0.14	0.03	0.23	0.20	0.16	0.03	3.91

Table 5.3-37 Summary SACTI Plume Height Frequency Results

Plume Height Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Summer

Distance From Tower	******** Wind From ********																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	******** Plume Headed ********																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
850	0.46	0.26	0.16	0.22	0.22	0.16	0.02	0.08	0.00	0.03	0.02	0.03	0.11	0.09	0.08	0.03	1.96
860	0.46	0.26	0.16	0.02	0.22	0.16	0.02	0.00	0.00	0.03	0.02	0.00	0.11	0.09	0.08	0.02	1.64
870	0.46	0.26	0.16	0.02	0.22	0.16	0.02	0.00	0.00	0.03	0.02	0.00	0.11	0.09	0.08	0.02	1.64
880	0.46	0.26	0.16	0.02	0.22	0.16	0.02	0.00	0.00	0.03	0.02	0.00	0.11	0.09	0.08	0.02	1.64
890	0.46	0.26	0.16	0.02	0.22	0.16	0.02	0.00	0.00	0.03	0.02	0.00	0.11	0.09	0.08	0.02	1.64
900	0.25	0.16	0.14	0.02	0.22	0.16	0.02	0.00	0.00	0.02	0.02	0.00	0.11	0.09	0.08	0.02	1.30
910	0.25	0.16	0.14	0.00	0.17	0.14	0.02	0.00	0.00	0.02	0.02	0.00	0.09	0.09	0.08	0.00	1.19
920	0.25	0.16	0.14	0.00	0.17	0.14	0.02	0.00	0.00	0.02	0.02	0.00	0.09	0.09	0.08	0.00	1.19
930	0.25	0.16	0.14	0.00	0.17	0.14	0.02	0.00	0.00	0.02	0.02	0.00	0.09	0.09	0.08	0.00	1.19
940	0.25	0.16	0.14	0.00	0.17	0.14	0.02	0.00	0.00	0.02	0.02	0.00	0.09	0.09	0.08	0.00	1.19
950	0.25	0.16	0.14	0.00	0.17	0.14	0.02	0.00	0.00	0.02	0.02	0.00	0.09	0.09	0.08	0.00	1.19
960	0.25	0.16	0.14	0.00	0.17	0.14	0.02	0.00	0.00	0.02	0.02	0.00	0.09	0.09	0.08	0.00	1.19
970	0.25	0.16	0.14	0.00	0.17	0.14	0.02	0.00	0.00	0.02	0.02	0.00	0.09	0.09	0.08	0.00	1.19
980	0.25	0.16	0.14	0.00	0.17	0.14	0.02	0.00	0.00	0.02	0.02	0.00	0.09	0.09	0.08	0.00	1.19
990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3-38 Fall SACTI Plume Length Frequency Results

Plume Length Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Fall

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	10.55	4.37	2.96	2.84	4.38	3.35	4.03	2.87	8.63	9.28	7.51	4.65	11.90	8.65	6.47	7.54	99.98
200	1.54	0.78	0.60	0.40	0.75	0.32	0.60	0.09	0.54	0.69	0.90	0.50	4.83	2.57	1.72	0.88	17.70
300	1.54	0.78	0.60	0.21	0.16	0.10	0.19	0.03	0.54	0.69	0.90	0.24	1.27	0.64	0.46	0.32	8.67
400	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
500	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
600	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
700	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
800	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
900	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1000	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1100	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1200	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1300	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1400	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1500	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1600	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1700	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1800	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
1900	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
2000	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
2100	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
2200	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
2300	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
2400	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
2500	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
2600	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
2700	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
2800	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98

Table 5.3-38 Fall SACTI Plume Length Frequency Results

Plume Length Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Fall

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
2900	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3000	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3100	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3200	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3300	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3400	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3500	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3600	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3700	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3800	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
3900	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
4000	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
4100	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
4200	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
4300	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
4400	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
4500	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
4600	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
4700	1.02	0.39	0.32	0.21	0.16	0.10	0.19	0.03	0.24	0.23	0.32	0.24	1.27	0.62	0.44	0.32	6.10
4800	0.08	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.15
4900	0.08	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.15
5000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3-39 Fall SACTI Plume Height Frequency Results

Plume Height Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Fall

Distance From Tower	Wind From: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
(M)	Plume Headed: S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
10	10.55	4.37	2.96	2.84	4.38	3.35	4.03	2.87	8.63	9.28	7.51	4.65	11.90	8.65	6.47	7.54	99.98
20	10.55	4.37	2.96	2.84	4.32	3.35	4.03	2.87	8.63	9.28	7.51	4.65	11.90	8.65	6.45	7.54	99.91
30	9.67	4.22	2.76	2.69	4.32	3.35	4.03	2.87	8.58	9.08	7.43	4.52	11.90	8.65	6.45	6.45	96.95
40	9.52	4.22	2.76	2.61	1.73	1.06	1.84	2.81	8.58	9.08	7.43	4.41	8.55	5.14	3.03	6.21	78.97
50	3.66	1.59	0.87	0.60	0.63	0.30	0.57	0.58	2.37	2.31	2.58	1.28	4.56	2.21	1.38	1.95	27.43
60	2.92	1.23	0.73	0.41	0.63	0.30	0.57	0.22	1.47	1.55	1.89	0.74	4.56	2.20	1.37	1.10	21.87
70	2.09	0.98	0.63	0.38	0.63	0.30	0.57	0.09	0.99	1.02	1.26	0.50	4.56	2.20	1.37	0.87	18.44
80	1.54	0.78	0.60	0.38	0.63	0.30	0.57	0.09	0.54	0.69	0.90	0.50	4.56	2.20	1.37	0.87	16.51
90	1.54	0.78	0.60	0.33	0.49	0.22	0.46	0.09	0.54	0.69	0.90	0.44	3.96	1.73	1.21	0.66	14.65
100	1.54	0.78	0.60	0.33	0.32	0.17	0.39	0.09	0.54	0.69	0.90	0.44	3.47	1.46	0.99	0.66	13.39
110	1.54	0.78	0.60	0.22	0.32	0.17	0.39	0.03	0.54	0.69	0.90	0.38	3.47	1.46	0.99	0.46	12.95
120	1.54	0.78	0.60	0.21	0.25	0.17	0.28	0.03	0.54	0.69	0.90	0.24	2.92	1.15	0.80	0.32	11.43
130	1.54	0.78	0.60	0.21	0.19	0.13	0.21	0.03	0.54	0.69	0.90	0.24	2.23	0.91	0.61	0.32	10.12
140	1.54	0.78	0.60	0.21	0.19	0.13	0.21	0.03	0.54	0.69	0.90	0.24	2.23	0.91	0.61	0.32	10.12
150	1.31	0.59	0.49	0.21	0.19	0.13	0.21	0.03	0.44	0.58	0.74	0.24	2.23	0.91	0.61	0.32	9.23
160	1.31	0.59	0.49	0.21	0.19	0.13	0.21	0.03	0.44	0.58	0.74	0.24	2.23	0.91	0.61	0.32	9.23
170	1.31	0.59	0.49	0.21	0.19	0.13	0.21	0.03	0.44	0.58	0.74	0.24	2.23	0.91	0.61	0.32	9.23
180	1.31	0.59	0.49	0.21	0.16	0.10	0.19	0.03	0.44	0.58	0.74	0.24	1.27	0.62	0.44	0.32	7.73
190	1.31	0.59	0.49	0.21	0.16	0.10	0.19	0.03	0.44	0.58	0.74	0.24	1.27	0.62	0.44	0.32	7.73
200	1.31	0.59	0.49	0.21	0.16	0.10	0.19	0.03	0.44	0.58	0.74	0.24	1.27	0.62	0.44	0.32	7.73
210	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
220	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
230	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
240	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
250	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
260	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
270	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
280	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98

Table 5.3-39 Fall SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Fall

Distance From Tower	************	************	************	************	************	************	************	************	Wind From	************	************	************	************	************	************	************	************
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	************	************	************	************	************	************	************	************	Plume Headed	************	************	************	************	************	************	************	************
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
290	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
300	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
310	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
320	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
330	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
340	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
350	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
360	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
370	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
380	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
390	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
400	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
410	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
420	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
430	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
440	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
450	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
460	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
470	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
480	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
490	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
500	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
510	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
520	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
530	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
540	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
550	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
560	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98

Table 5.3-39 Fall SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Fall

Distance From Tower	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
570	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
580	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
590	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.44	0.32	6.98
600	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
610	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
620	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
630	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
640	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
650	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
660	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
670	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
680	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
690	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
700	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
710	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
720	1.23	0.53	0.46	0.21	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.32	6.94
730	1.23	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.91
740	1.23	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.91
750	1.23	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.91
760	1.23	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.91
770	1.23	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.91
780	1.23	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.91
790	1.15	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.83
800	1.15	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.83
810	1.15	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.83
820	1.15	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.83
830	1.15	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.83
840	1.15	0.53	0.46	0.19	0.16	0.10	0.19	0.03	0.40	0.32	0.46	0.24	1.27	0.62	0.40	0.31	6.83

Table 5.3-39 Fall SACTI Plume Height Frequency Results

Plume Height Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Fall

Distance From Tower	* * * Wind From * * *																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	* * * Plume Headed * * *																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
850	0.62	0.30	0.22	0.19	0.08	0.10	0.09	0.03	0.17	0.19	0.19	.24	1.05	0.46	0.21	0.31	4.46
860	0.62	0.30	0.22	0.08	0.08	0.10	0.09	0.00	0.17	0.19	0.19	0.03	1.05	0.46	0.21	0.18	3.97
870	0.62	0.30	0.22	0.08	0.08	0.10	0.09	0.00	0.17	0.19	0.19	0.03	1.05	0.46	0.21	0.18	3.97
880	0.62	0.30	0.22	0.08	0.08	0.10	0.09	0.00	0.17	0.19	0.19	0.03	1.05	0.46	0.21	0.18	3.97
890	0.62	0.30	0.22	0.08	0.08	0.10	0.09	0.00	0.17	0.19	0.19	0.03	1.05	0.46	0.21	0.18	3.97
900	0.20	0.14	0.14	0.08	0.08	0.10	0.09	0.00	0.16	0.09	0.14	0.03	1.05	0.46	0.21	0.18	3.15
910	0.20	0.14	0.14	0.00	0.08	0.03	0.08	0.00	0.16	0.09	0.14	.00	0.52	0.24	0.14	0.00	1.96
920	0.20	0.14	0.14	0.00	0.08	0.03	0.08	0.00	0.16	0.09	0.14	.00	0.52	0.24	0.14	0.00	1.96
930	0.20	0.14	0.14	0.00	0.08	0.03	0.08	0.00	0.16	0.09	0.14	.00	0.52	0.24	0.14	0.00	1.96
940	0.20	0.14	0.14	0.00	0.08	0.03	0.08	0.00	0.16	0.09	0.14	.00	0.52	0.24	0.14	0.00	1.96
950	0.20	0.14	0.14	0.00	0.08	0.03	0.08	0.00	0.16	0.09	0.14	.00	0.52	0.24	0.14	0.00	1.96
960	0.20	0.14	0.14	0.00	0.08	0.03	0.08	0.00	0.16	0.09	0.14	.00	0.52	0.24	0.14	0.00	1.96
970	0.20	0.14	0.14	0.00	0.08	0.03	0.08	0.00	0.16	0.09	0.14	.00	0.52	0.24	0.14	0.00	1.96
980	0.20	0.14	0.14	0.00	0.08	0.03	0.08	0.00	0.16	0.09	0.14	.00	0.52	0.24	0.14	0.00	1.96
990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3-40 Annual SACTI Plume Length Frequency Results

Plume Length Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Annual

Distance From Tower	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100	10.14	5.24	3.95	3.43	5.71	3.60	3.39	2.59	8.67	10.26	8.17	4.36	8.71	8.29	6.80	6.70	100.00
200	2.44	1.31	0.95	0.67	1.43	0.62	0.58	0.24	0.82	0.97	0.91	0.48	3.13	3.07	2.30	1.21	21.15
300	2.44	1.31	0.95	0.41	0.67	0.26	0.22	0.10	0.82	0.97	0.91	0.22	0.91	0.99	0.78	0.64	12.62
400	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
500	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
600	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
700	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
800	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
900	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1000	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1100	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1200	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1300	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1400	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1500	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1600	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1700	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1800	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
1900	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
2000	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
2100	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
2200	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
2300	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
2400	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
2500	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
2600	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
2700	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
2800	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42

Table 5.3-40 Annual SACTI Plume Length Frequency Results

Plume Length Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Annual

Distance From Tower	****** Wind From ******																
	N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	****** Plume Headed ******																
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
2900	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3000	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3100	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3200	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3300	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3400	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3500	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3600	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3700	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3800	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
3900	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
4000	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
4100	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
4200	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
4300	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
4400	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
4500	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
4600	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
4700	1.52	0.73	0.60	0.41	0.66	0.26	0.22	0.10	0.35	0.45	0.39	0.22	0.89	0.94	0.74	0.64	9.12
4800	0.23	0.09	0.08	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.12	0.63
4900	0.23	0.09	0.08	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.12	0.63
5000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3-41 Annual SACTI Plume Height Frequency Results

Plume Height Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Annual

Distance From Tower	Wind From																
	N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	Plume Headed																
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
10	10.14	5.24	3.95	3.43	5.71	3.60	3.39	2.59	8.67	10.26	8.17	4.36	8.71	8.29	6.80	6.70	100.00
20	10.14	5.24	3.95	3.43	5.69	3.60	3.39	2.59	8.67	10.26	8.17	4.36	8.71	8.28	6.76	6.70	99.94
30	9.55	5.01	3.79	3.21	5.69	3.60	3.39	2.58	8.62	9.94	7.79	4.13	8.71	8.28	6.76	6.16	97.22
40	9.42	4.98	3.75	3.15	2.57	1.33	1.60	2.52	8.61	9.87	7.72	4.01	5.78	5.58	3.87	5.99	80.76
50	4.28	2.33	1.52	1.03	1.27	0.54	0.54	0.71	2.78	2.94	2.69	1.10	2.86	2.76	1.98	2.11	31.43
60	3.77	2.08	1.37	0.71	1.25	0.53	0.54	0.34	1.76	1.83	1.85	0.63	2.85	2.73	1.95	1.35	25.53
70	2.90	1.61	1.08	0.67	1.25	0.53	0.54	0.24	1.26	1.35	1.27	0.48	2.85	2.73	1.95	1.21	21.91
80	2.44	1.31	0.95	0.67	1.25	0.53	0.54	0.24	0.82	0.97	0.91	0.48	2.85	2.73	1.95	1.21	19.86
90	2.44	1.31	0.95	0.57	1.11	0.46	0.45	0.20	0.82	0.97	0.91	0.42	2.49	2.41	1.73	0.96	18.23
100	2.44	1.31	0.95	0.57	0.95	0.40	0.41	0.20	0.82	0.97	0.91	0.42	2.19	2.14	1.46	0.96	17.11
110	2.44	1.31	0.95	0.46	0.95	0.40	0.41	0.13	0.82	0.97	0.91	0.32	2.19	2.14	1.46	0.74	16.61
120	2.44	1.31	0.95	0.41	0.82	0.35	0.31	0.10	0.82	0.97	0.91	0.22	1.91	1.82	1.20	0.64	15.20
130	2.44	1.31	0.95	0.41	0.69	0.29	0.24	0.10	0.82	0.97	0.91	0.22	1.50	1.46	1.00	0.64	13.97
140	2.44	1.31	0.95	0.41	0.69	0.29	0.24	0.10	0.82	0.97	0.91	0.22	1.50	1.46	1.00	0.64	13.97
150	2.03	1.10	0.83	0.41	0.69	0.29	0.24	0.10	0.67	0.82	0.73	0.22	1.50	1.46	1.00	0.64	12.73
160	2.03	1.10	0.83	0.41	0.69	0.29	0.24	0.10	0.67	0.82	0.73	0.22	1.50	1.46	1.00	0.64	12.73
170	2.03	1.10	0.83	0.41	0.69	0.29	0.24	0.10	0.67	0.82	0.73	0.22	1.50	1.46	1.00	0.64	12.73
180	2.03	1.10	0.83	0.41	0.66	0.26	0.22	0.10	0.67	0.82	0.73	0.22	0.89	0.94	0.74	0.64	11.26
190	2.03	1.10	0.83	0.41	0.66	0.26	0.22	0.10	0.67	0.82	0.73	0.22	0.89	0.94	0.74	0.64	11.26
200	2.03	1.10	0.83	0.41	0.66	0.26	0.22	0.10	0.67	0.82	0.73	0.22	0.89	0.94	0.74	0.64	11.26
210	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
220	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
230	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
240	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
250	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
260	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
270	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
280	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42

Table 5.3-41 Annual SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Annual

Distance From Tower	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
290	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
300	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
310	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
320	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
330	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
340	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
350	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
360	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
370	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
380	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
390	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
400	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
410	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
420	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
430	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
440	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
450	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
460	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
470	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
480	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
490	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
500	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
510	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
520	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
530	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
540	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
550	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
560	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42

Table 5.3-41 Annual SACTI Plume Height Frequency Results

Plume Height Frequency Table
North Anna, Richmond (1998-2000), 52-Cell MDCT
Season = Annual

Distance From Tower	Wind From																
	N	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**All**
	Plume Headed																
(M)	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**SUM**
570	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
580	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
590	1.91	1.01	0.78	0.41	0.66	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.74	0.64	10.42
600	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
610	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
620	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
630	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
640	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
650	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
660	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
670	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
680	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
690	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
700	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
710	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
720	1.91	1.01	0.78	0.41	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.22	0.89	0.94	0.71	0.64	10.35
730	1.91	1.01	0.78	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	10.19
740	1.91	1.01	0.78	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	10.19
750	1.91	1.01	0.78	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	10.19
760	1.91	1.01	0.78	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	10.19
770	1.91	1.01	0.78	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	10.19
780	1.91	1.01	0.78	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	10.19
790	1.69	0.92	0.70	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	9.79
800	1.69	0.92	0.70	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	9.79
810	1.69	0.92	0.70	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	9.79
820	1.69	0.92	0.70	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	9.79
830	1.69	0.92	0.70	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	9.79
840	1.69	0.92	0.70	0.38	0.63	0.26	0.22	0.10	0.54	0.59	0.50	0.21	0.89	0.94	0.71	0.52	9.79

Table 5.3-41 Annual SACTI Plume Height Frequency Results

Plume Height Frequency Table

North Anna, Richmond (1998-2000), 52-Cell MDCT

Season = Annual

Distance From Tower	Wind From																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
	Plume Headed																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
850	0.88	0.51	0.36	0.38	0.35	0.18	0.12	0.10	0.27	0.28	0.24	0.21	0.67	0.68	0.33	0.52	6.09
860	0.88	0.51	0.36	0.15	0.35	0.18	0.12	0.01	0.27	0.28	0.24	0.06	0.67	0.68	0.33	0.15	5.25
870	0.88	0.51	0.36	0.15	0.35	0.18	0.12	0.01	0.27	0.28	0.24	0.06	0.67	0.68	0.33	0.15	5.25
880	0.88	0.51	0.36	0.15	0.35	0.18	0.12	0.01	0.27	0.28	0.24	0.06	0.67	0.68	0.33	0.15	5.25
890	0.88	0.51	0.36	0.15	0.35	0.18	0.12	0.01	0.27	0.28	0.24	0.06	0.67	0.68	0.33	0.15	5.25
900	0.39	0.28	0.18	0.15	0.35	0.18	0.12	0.01	0.20	0.14	0.11	0.06	0.67	0.68	0.33	0.15	4.00
910	0.39	0.28	0.18	0.00	0.17	0.08	0.07	0.00	0.20	0.14	0.11	0.00	0.33	0.30	0.17	0.00	2.42
920	0.39	0.28	0.18	0.00	0.17	0.08	0.07	0.00	0.20	0.14	0.11	0.00	0.33	0.30	0.17	0.00	2.42
930	0.39	0.28	0.18	0.00	0.17	0.08	0.07	0.00	0.20	0.14	0.11	0.00	0.33	0.30	0.17	0.00	2.42
940	0.39	0.28	0.18	0.00	0.17	0.08	0.07	0.00	0.20	0.14	0.11	0.00	0.33	0.30	0.17	0.00	2.42
950	0.39	0.28	0.18	0.00	0.17	0.08	0.07	0.00	0.20	0.14	0.11	0.00	0.33	0.30	0.17	0.00	2.42
960	0.39	0.28	0.18	0.00	0.17	0.08	0.07	0.00	0.20	0.14	0.11	0.00	0.33	0.30	0.17	0.00	2.42
970	0.39	0.28	0.18	0.00	0.17	0.08	0.07	0.00	0.20	0.14	0.11	0.00	0.33	0.30	0.17	0.00	2.42
980	0.39	0.28	0.18	0.00	0.17	0.08	0.07	0.00	0.20	0.14	0.11	0.00	0.33	0.30	0.17	0.00	2.42
990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

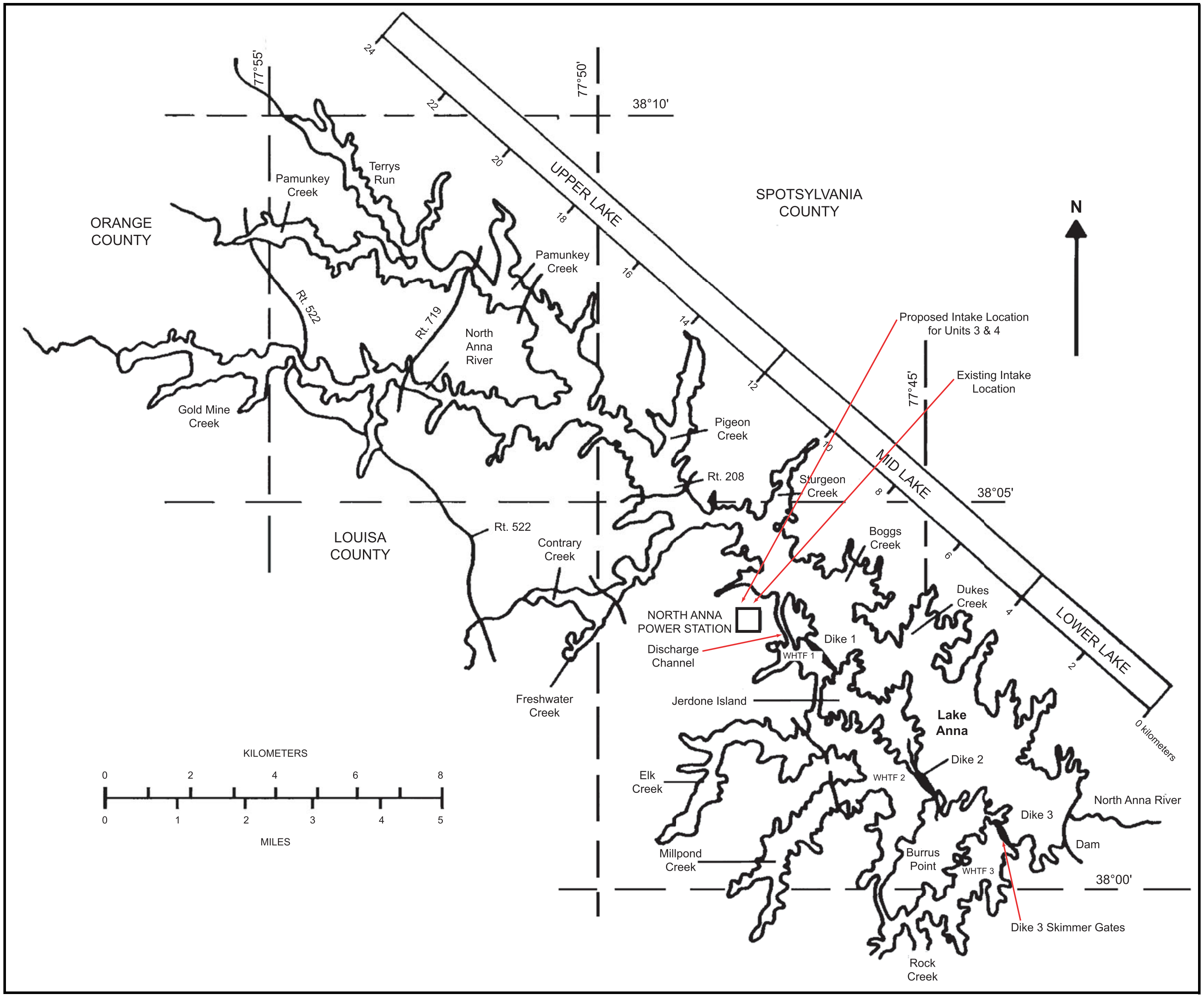

Figure 5.3-1 Generalized Map of North Anna Power Station Environs

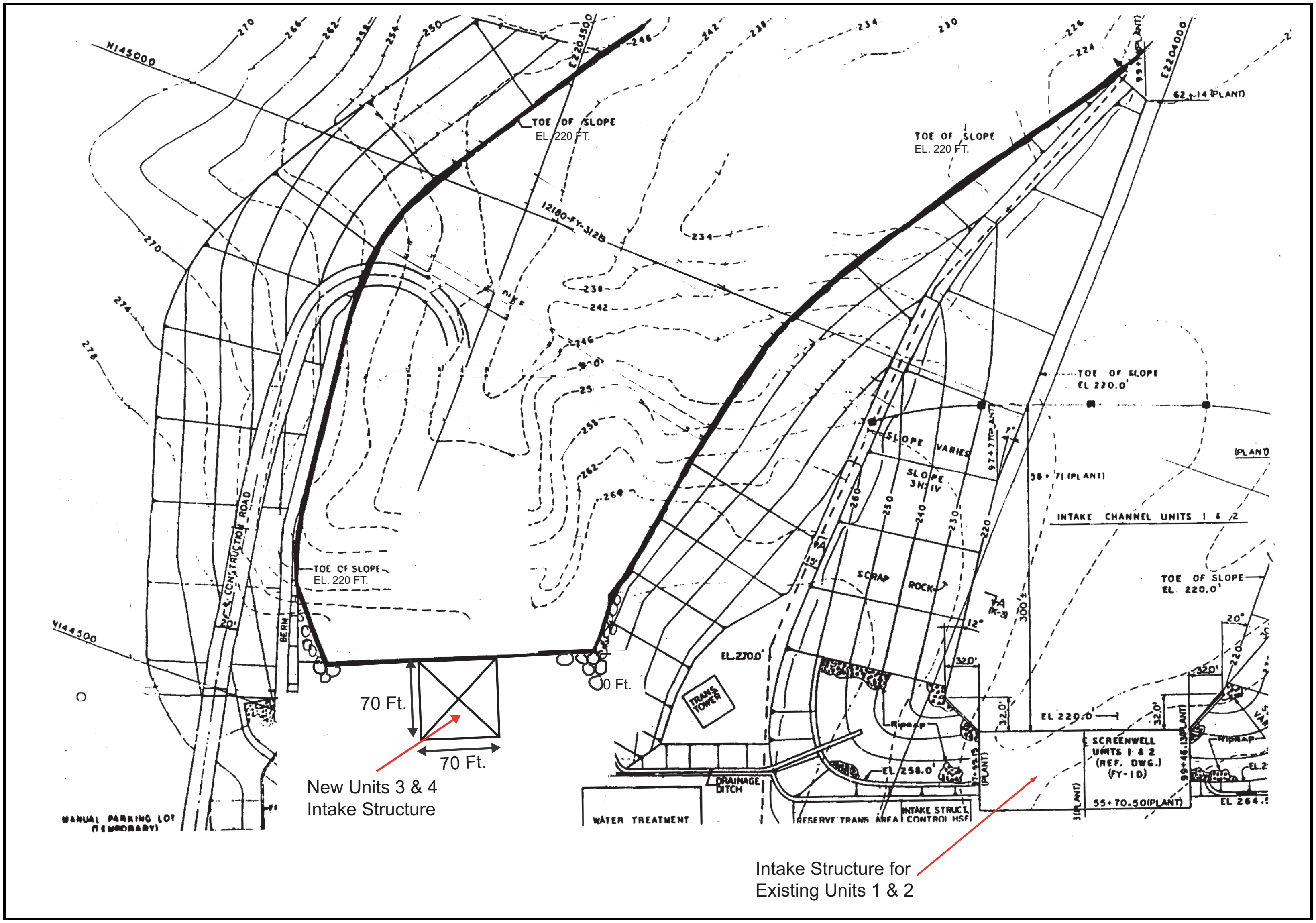

Figure 5.3-2 Intake Structure and Approach Channel for the New Units and the Existing Units

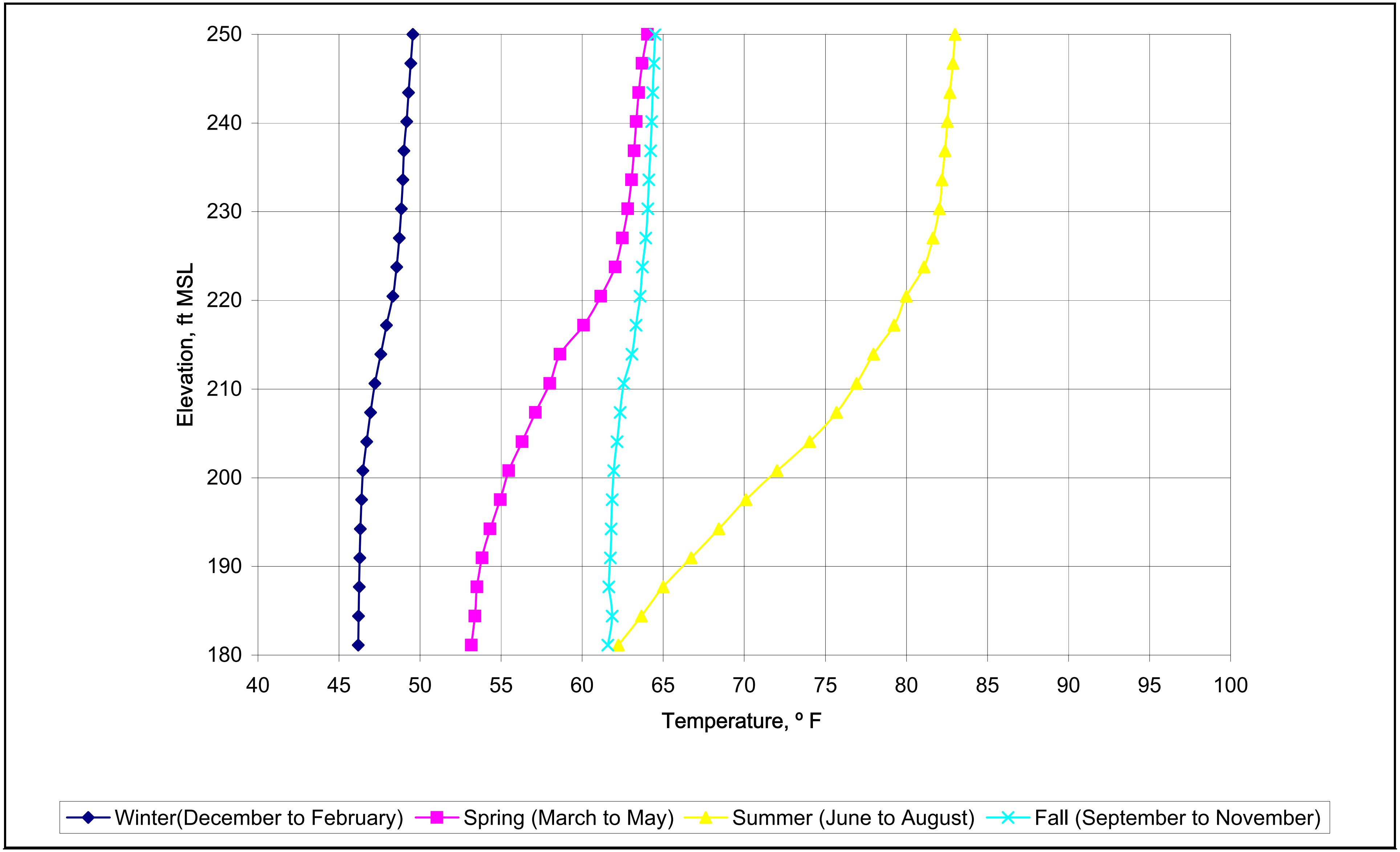

Figure 5.3-3 Observed Seasonal Average Vertical Temperature Profiles at Monitoring Station A Near North Anna Dam

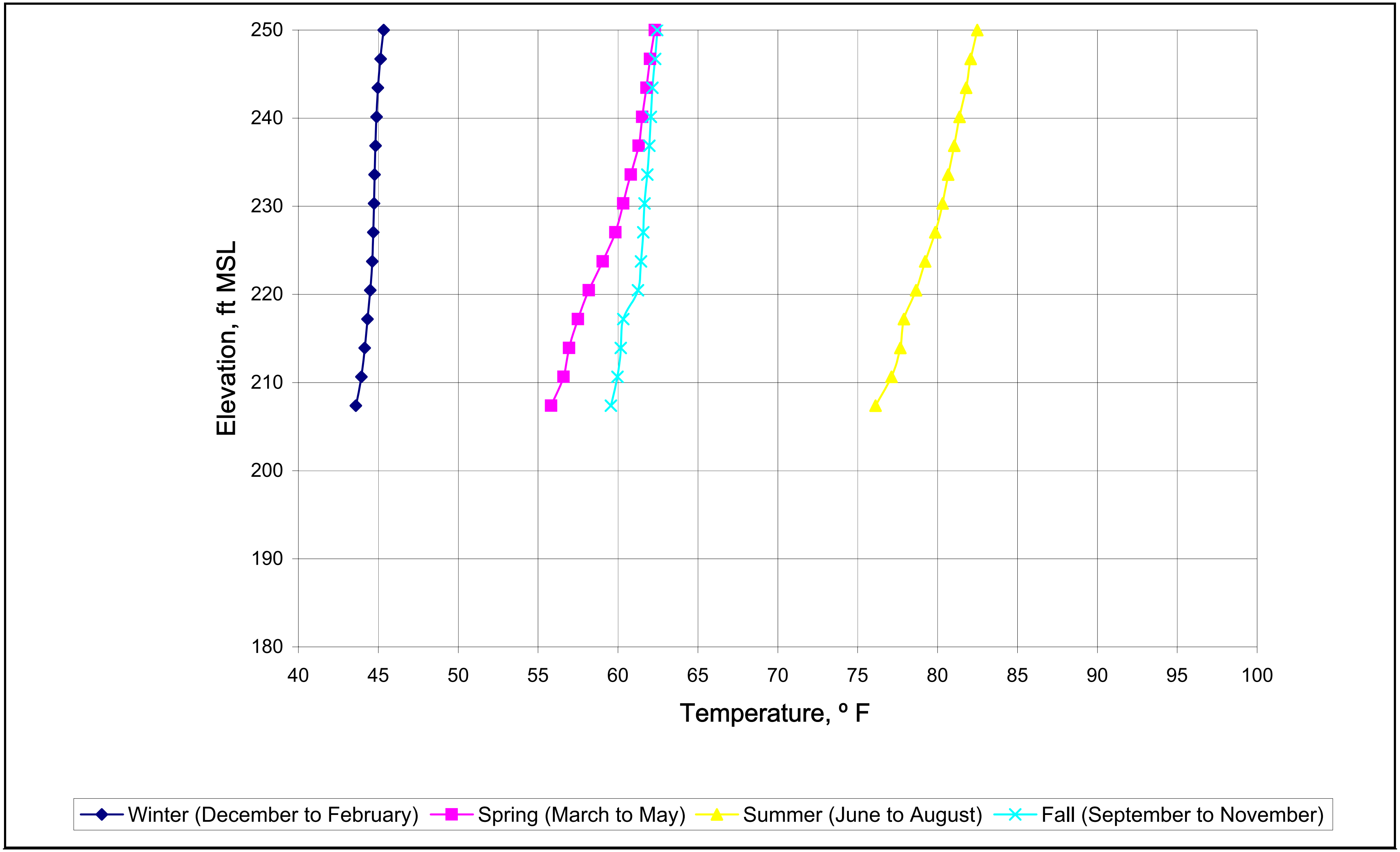

Figure 5.3-4 Observed Seasonal Average Vertical Temperature Profiles at Monitoring Station I Near the Intake

Figure 5.3-5 Deleted

Figure 5.3-6 Deleted

Figure 5.3-7 Deleted

Figure 5.3-8 Deleted

Figure 5.3-9 Deleted

Figure 5.3-10 Deleted

Figure 5.3-11 Deleted

Figure 5.3-12 Deleted

Figure 5.3-13 Deleted

Figure 5.3-14 Deleted

Figure 5.3-15 Deleted

Figure 5.3-16 Deleted

5.4 Radiological Impacts of Normal Operation

This section describes the radiological impacts of normal plant operation on members of the public and biota. Section 5.4.1 describes the exposure pathways by which radiation and radioactive effluents can be transmitted from the new units to organisms living near the plant. Section 5.4.2 estimates the maximum doses to the public from the operation of one new unit. Section 5.4.3 evaluates the impacts of these doses by comparing them to regulatory limits for one unit. In addition, the impact of two new units in conjunction with the two existing units is compared to the corresponding regulatory limit. Finally, Section 5.4.4 considers the impact to biota that appear along the exposure pathways or that are on endangered species lists.

5.4.1 Exposure Pathways

Small quantities of radioactive liquids and gases would be discharged to the environment during normal operation of the new units. The impact of these releases and any direct radiation to individuals, population groups, and biota in the vicinity of the new units was evaluated by considering the most important pathways from the release to the receptors of interest. The major pathways are those that could yield the highest radiological doses for a given receptor. The relative importance of a pathway is based on the type and amount of radioactivity released, the environmental transport mechanism, and the consumption or usage factors of the receptor.

The exposure pathways considered and the analytical methods used to estimate doses to the maximally exposed individual (MEI) and to the population surrounding the new units are based on RGs 1.109 and 1.111 (Reference 1 and Reference 2, respectively). A MEI is a hypothetical member of the public located to receive the maximum possible calculated dose. The MEI allows dose comparisons with established criteria for the public.

5.4.1.1 Liquid Pathways

The new units would release effluents to the WHTF through the discharge canal used for Units 1 and 2.

The LADTAP II computer program (Reference 3) was used to calculate the doses to the MEI, population groups, and biota. This program implements the radiological exposure models described in RG 1.109 for radioactivity releases in liquid effluent. The following exposure pathways are considered in LADTAP II:

- Ingestion of aquatic foods
- Ingestion of drinking water
- External exposure to shoreline sediments
- External exposure to water through boating and swimming

Irrigation was not considered as a pathway because the use of the water from Lake Anna for this purpose is negligible (Reference 4).

The input parameters for the liquid pathway are presented in Table 5.4-1 and Table 5.4-2. The dilution flow of 100,000 gpm is based on a plant effluent discharge rate of 100 gpm and a dilution factor of 1000, with no credit taken for the transit time from the release point to the receptors. The evaluation for the existing units is based on a dilution flow of approximately 430,000 gpm in the discharge canal (Reference 10, Table 11.2-20).

5.4.1.2 **Gaseous Pathways**

The GASPAR II computer program (Reference 5) was used to calculate the doses to the MEI, population groups, and biota. This program implements the radiological exposure models described in RG 1.109 to estimate the radioactivity releases in gaseous effluent and the subsequent doses. The following exposure pathways are considered in GASPAR II:

- External exposure to airborne plume
- External exposure to contaminated ground
- Inhalation of airborne activity
- Ingestion of contaminated agricultural products

The input parameters for the gaseous pathway are presented in Table 5.4-3 and Table 5.4-5, and the receptor locations are shown in Table 5.4-4.

5.4.1.3 **Direct Radiation from Station Operation**

Contained sources of radiation at the new units would be shielded. An evaluation of all operating plants by the NRC states that:

> "…because the primary coolant of an LWR is contained in a heavily shielded area, dose rates in the vicinity of light water reactors are generally undetectable and are less than 1 mrem/year at the site boundary. Some plants [mostly BWRs] do not have completely shielded secondary systems and may contribute some measurable off-site dose."

The NRC concludes that the direct radiation from normal operation results in "small contributions at site boundaries" (Reference 6, Section 4.6.1.2). Since the advanced reactor designs being considered are expected to provide shielding that is at least as effective as existing light water reactors, direct dose contribution from the new units would be negligible

5.4.2 **Radiation Doses to Members of the Public**

In this section, doses to MEIs from liquid and gaseous effluents from one new unit are estimated using the methodologies and parameters specified in Section 5.4.1. Additionally, based on the available data on the reactor designs being considered, the maximum annual occupational dose is estimated to be 150 person-rem. This maximum dose would be verified in the COL application when a reactor design is selected.

5.4.2.1 **Liquid Pathway Doses**

Based on the parameters shown in Table 5.4-1 and Table 5.4-2, the LADTAP II computer program was used to calculate doses to the MEI via the following activities:

- Eating fish and invertebrates caught near the point of discharge
- Drinking water from Lake Anna
- Boating, swimming, and using the shoreline for recreational purposes

The liquid activity releases (source terms) are shown in Table 5.4-6. For all isotopes except tritium, these are bounding, composite activities for a single new unit, obtained by taking the maximum activity for each isotope from multiple reactor designs, based on the approach presented in Section 3.1.6. The activity concentrations of liquid effluents from the new units are calculated using the composite activity releases with the methodology presented in the NAPS Updated Final Safety Analysis Report (UFSAR) (Reference 10, Section 11.2.5.1). The concentrations from the existing units are obtained from UFSAR Table 11.2-14. Table 5.4-6 shows the total activity concentrations from the new and existing units and compares them to the effluent concentration limits (ECLs) in 10 CFR 20, Appendix B, Table 2, Column 2 (Reference 13). The sum of the fractions of ECLs is within unity, in conformance with 10 CFR 20. The calculated annual doses to the total body, the thyroid, and the maximally exposed organ are presented in Table 5.4-8. The maximum annual dose of 2.5 mrem would be received by the bone of the maximally exposed child. These calculations are conservative and do not represent actual doses near the ESP site.

5.4.2.2 **Gaseous Pathway Doses**

Based on the parameters in Table 5.4-3 and Table 5.4-5, the GASPAR II computer program was used to calculate doses to the maximally exposed adult, teenager, child, and infant at the following locations:

- Nearest site boundary
- Nearest vegetable garden
- Nearest residence
- Nearest meat cow

The gaseous activity releases (source terms) are shown in Table 5.4-7. These are bounding, composite activities for a single new unit, obtained by taking the maximum activity for each isotope from multiple reactor designs, based on the approach presented in Section 3.1.6. Table 5.4-7 also shows the maximum activity concentrations at the site boundary from the new and existing units and compares them to the ECLs in 10 CFR 20, Appendix B, Table 2, Column 1 (Reference 13). The gaseous effluent concentrations are calculated based on the composite activity releases for the new units and the activity releases from the existing units from UFSAR Table 11.3-2 and the respective atmospheric dispersion factors at the site boundary. The sum of the fractions of ECLs is within unity, in conformance with 10 CFR 20. The calculated annual total body, thyroid, and skin doses are presented in Table 5.4-9. These calculations are conservative and do not represent actual doses to individuals near the ESP site.

5.4.3 Impacts to Members of the Public

In this section, the radiological impacts to individuals and population groups from liquid and gaseous effluents are estimated using the methodologies and parameters specified in Section 5.4.1.

Table 5.4-10 shows the total body and organ doses to the MEI from liquid effluents and from gaseous releases from a new unit. The calculated doses for both sources are within the design objectives of 10 CFR 50, Appendix I (Reference 7). The total site liquid and gaseous effluent doses from the two existing units and two new units would be well within the regulatory limits of 40 CFR 190 (Reference 8), as shown in Table 5.4-11. As indicated in NUREG-1555 (Reference 9), demonstration of compliance with the limits of 40 CFR 190 is considered to be in compliance with 0.1 rem limit of 10 CFR 20.1301. Table 5.4-12 shows the population doses attributable to the new units for the population within 50 miles of the ESP site.

5.4.4 Impacts to Biota Other than Members of the Public

Radiation exposure pathways to biota were examined to determine if the pathways could result in doses to biota greater than those predicted for humans. This assessment used surrogate species that provide representative information about the various dose pathways potentially affecting broader classes of living organisms. Surrogates were used since important attributes of these species are well defined and are accepted as a method for judging doses to biota.

Important biota considered are federally- and state-listed species that are endangered or threatened, commercially and recreationally valuable species, and species important to the local ecosystem. Table 5.4-13 identifies the important species near the ESP site and the assigned surrogates employed in the assessment of radiation doses. The aquatic species listed in the table are those that may potentially exist in the counties immediately adjacent to Lake Anna, the North Anna River upstream or downstream of Lake Anna, and tributary streams crossed by transmission lines. The terrestrial species listed are those that exist or may potentially exist within the ESP site or the associated transmission line rights-of-way. The doses are calculated using pathway models adopted from RG 1.109.

5.4.4.1 Liquid Pathway

The LADTAP II computer program was used to calculate doses to the biota via the following exposure pathways:

- Fish, 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, 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

Food consumption rates, body masses, and effective body radii used in the dose calculations are shown in Table 5.4-14, while the residence times for swimming and shoreline exposure are shown in Table 5.4-15. In determining shoreline doses, adjustments were made for the fact that biota would be closer to any potential shoreline contamination than humans. Other biota parameters are taken from RG 1.109 and NUREG/CR-4013 (Reference 3).

5.4.4.2 **Gaseous Pathway**

Gaseous effluents contribute to the terrestrial doses. Immersion and ground deposition doses are largely independent of organism size, and the doses for the MEI, as described in Section 5.4.2, can be applied to biota. However, the external ground deposition doses, as calculated by GASPAR II, were increased by a factor of two to account for the closer proximity of terrestrial organisms to the ground, similar to the adjustments made for biota exposures to shoreline sediments in LADTAP II.

5.4.4.3 **Biota Doses**

Maximum calculated doses to biota from liquid and gaseous effluents are shown in Table 5.4-16. Assuming mrem and mrad to be approximately equivalent, the maximum calculated doses to all biota, except fish, exceed the regulatory limit (40 CFR 190) for humans of 25 mrem/yr. Although there are no regulatory limits specifically for biota, there is no scientific evidence that chronic dose rates below 100 mrad/day are harmful to plants and animals (Reference 9). The biota doses in Table 5.4-16 are all less than 1 mrad/day.

Section 5.4 References

1. Regulatory Guide 1.109, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I*, Revision 1, U. S. Nuclear Regulatory Commission, October 1977.
2. Regulatory Guide 1.111, *Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors*, Revision 1, U. S. Nuclear Regulatory Commission, July 1977.

3. NUREG/CR-4013, *LADTAP II – Technical Reference and User Guide*, Prepared for the U. S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, April 1986.

4. Virginia Agricultural Statistics Service website, www.nass.usda.gov/va/va.pdf.

5. NUREG/CR-4653, *GASPAR II – Technical Reference and User Guide*, Prepared for the U. S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, March 1987.

6. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, U. S. Nuclear Regulatory Commission, May 1996.

7. 10 CFR 50, Appendix I, *Code of Federal Regulations*, "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."

8. 40 CFR 190, *Code of Federal Regulations*, "Environmental Radiation Protection Standards for Nuclear Power Operations."

9. NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, October 1999.

10. *North Anna Power Station Updated Final Safety Analysis Report*, Revision 38.

11. *Annual Radioactive Effluent Release Report, North Anna Power Station (January 01, 2001 to December 31, 2001)*, Virginia Electric and Power Company, 2002.

12. NRP Report No. 94, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, National Council on Radiation Protection and Measurements, 1987.

13. 10 CFR 20, Appendix B, *Code of Federal Regulations*, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage."

Table 5.4-1 Liquid Pathway Parameters

Parameter	Value
Release source terms	Table 5.4-6
Effluent discharge rate	100 gpm
Site-specific dilution flow rate	1.0E+05 gpm
Transit time to receptor	0
Impoundment reconcentration model	None
Population distribution	Table 2.5-8
Sport fishing harvest in 2040	2.7E+05 kg/yr

Table 5.4-2 Liquid Pathway Consumption Factors for Maximally Exposed Individual

	Annual Rate			
Consumption Factor	Adult	Teen	Child	Infant
Fish consumption (kg/yr)	21	16	6.9	0
Invertebrate consumption (kg/yr)	5	3.8	1.7	0
Drinking water consumption (l/yr)	730	510	510	330
Shoreline usage (hr/yr)	300	300	300	300
Swimming exposure (hr/yr)	200	200	200	200
Boating usage (hr/yr)	500	500	500	500

Source: Reference 1 (Table E-5) and Reference 10 (Section 11B.4.1).

Table 5.4-3 Gaseous Pathway Parameters

Parameter	Value
Release source terms	Table 5.4-7
Population distribution	Table 2.5-8
Milk production rate within 50 miles	7.2E+08 l/yr
Meat production rate within 50 miles	1.7E+09 kg/yr
Vegetable/fruit production rate within 50 miles	5.4E+08 kg/yr
Atmospheric dispersion factors	Table 2.7-17 to Table 2.7-19
Ground deposition factors	Table 2.7-20

Note: Production rates are projected for year 2040.

Table 5.4-4 Gaseous Pathway Receptor Locations

Receptor	Direction	Distance (miles)
Nearest site boundary	ESE	0.88
Nearest vegetable garden	NE	0.94
Nearest residence	NNE	0.96
Nearest meat animal	SE	1.37

Note: This data is taken from Table 2.7-14. There are no milk cows or goats within 5 miles of the plant (see Table 2.7-13).

Table 5.4-5 Gaseous Pathway Consumption Factors for Maximally Exposed Individual

	Annual Rate			
Consumption Factor	Adult	Teen	Child	Infant
Leafy vegetable consumption (kg/yr)	64	42	26	0
Meat consumption (kg/yr)	110	65	41	0
Milk consumption (l/yr)	310	400	330	330
Vegetable/fruit consumption (kg/yr)	520	630	520	0

Source: Reference 1, Table E-5.

Table 5.4-6 Release of Activities in Liquid Effluent

Isotope	Release (Ci/yr)	Concentration (µCi/ml)	ECL (µCi/ml)	Fraction of ECL
H-3	8.5E+02	2.0E-05	1.0E-03	2.0E-02
C-14	4.4E-04	7.7E-12	3.0E-05	2.6E-07
Na-24	3.5E-03	3.5E-11	5.0E-05	7.1E-07
P-32	6.6E-04	6.7E-12	9.0E-06	7.4E-07
Cr-51	2.1E-02	2.4E-10	5.0E-04	4.8E-07
Mn-54	2.8E-03	7.6E-11	3.0E-05	2.5E-06
Mn-56	4.2E-03	4.2E-11	7.0E-05	6.0E-07
Fe-55	6.4E-03	9.6E-11	1.0E-04	9.6E-07
Fe-59	2.0E-04	2.8E-11	1.0E-05	2.8E-06
Co-56	5.7E-03	6.1E-11	6.0E-06	1.0E-05
Co-57	7.9E-05	9.9E-13	6.0E-05	1.7E-08
Co-58	3.4E-03	7.8E-10	2.0E-05	3.9E-05
Co-60	1.0E-02	2.2E-10	3.0E-06	7.4E-05
Ni-63	1.5E-04	2.7E-12	1.0E-04	2.7E-08
Cu-64	8.2E-03	8.3E-11	2.0E-04	4.1E-07
Zn-65	7.5E-04	9.3E-12	5.0E-06	1.9E-06
Zn-69m	6.0E-04	6.0E-12	6.0E-05	1.0E-07
Br-83	7.5E-05	7.5E-13	9.0E-04	8.4E-10
Br-84	2.0E-05	2.0E-13	4.0E-04	5.0E-10
Rb-88	2.7E-04	2.7E-12	4.0E-04	6.8E-09
Rb-89	4.8E-05	4.8E-13	9.0E-04	5.4E-10
Sr-89	3.6E-04	1.1E-10	8.0E-06	1.4E-05
Sr-90	3.8E-05	1.3E-11	5.0E-07	2.5E-05
Sr-91	9.8E-04	2.9E-11	2.0E-05	1.4E-06
Sr-92	8.8E-04	8.8E-12	4.0E-05	2.2E-07
Y-90	3.4E-06	1.3E-11	7.0E-06	1.9E-06
Y-91m	1.0E-05	1.0E-13	2.0E-03	5.0E-11
Y-91	2.4E-04	1.3E-10	8.0E-06	1.7E-05

Table 5.4-6 Release of Activities in Liquid Effluent

Isotope	Release (Ci/yr)	Concentration (μCi/ml)	ECL (μCi/ml)	Fraction of ECL
Y-92	6.6E-04	6.6E-12	4.0E-05	1.6E-07
Y-93	9.8E-04	9.9E-12	2.0E-05	4.9E-07
Zr-95	1.0E-03	3.2E-11	2.0E-05	1.6E-06
Nb-95	1.9E-03	4.2E-11	3.0E-05	1.4E-06
Mo-99	3.9E-03	9.9E-08	2.0E-05	5.0E-03
Tc-99m	5.1E-03	8.5E-08	1.0E-03	8.5E-05
Ru-103	4.9E-03	5.1E-11	3.0E-05	1.7E-06
Ru-105	1.0E-04	1.0E-12	7.0E-05	1.4E-08
Ru-106	7.4E-02	9.7E-10	3.0E-06	3.2E-04
Rh-103m	4.9E-03	5.0E-11	6.0E-03	8.3E-09
Rh-106	7.4E-02	7.4E-10	—	—
Ag-110m	1.1E-03	1.3E-11	6.0E-06	2.2E-06
Ag-110	1.4E-04	1.4E-12	—	—
Sb-124	6.8E-04	7.2E-12	7.0E-06	1.0E-06
Te-129m	1.4E-04	1.4E-12	7.0E-06	2.0E-07
Te-129	1.5E-04	1.5E-12	4.0E-04	3.8E-09
Te-131m	1.0E-04	1.0E-12	8.0E-06	1.3E-07
Te-131	3.0E-05	3.0E-13	8.0E-05	3.8E-09
Te-132	2.4E-04	4.8E-09	9.0E-06	5.3E-04
I-131	1.4E-02	5.6E-08	1.0E-06	5.6E-02
I-132	2.8E-03	8.5E-09	1.0E-04	8.5E-05
I-133	2.4E-02	6.2E-08	7.0E-06	8.9E-03
I-134	1.9E-03	1.2E-09	4.0E-04	3.0E-06
I-135	8.2E-03	3.7E-09	3.0E-05	1.2E-04
Cs-134	9.9E-03	1.8E-08	9.0E-07	2.0E-02
Cs-136	1.2E-03	2.6E-09	6.0E-06	4.4E-04
Cs-137	1.3E-02	1.2E-07	1.0E-06	1.2E-01
Cs-138	2.1E-04	2.1E-12	4.0E-04	5.2E-09

Table 5.4-6 Release of Activities in Liquid Effluent

Isotope	Release (Ci/yr)	Concentration (µCi/ml)	ECL (µCi/ml)	Fraction of ECL
Ba-137m	1.2E-02	1.3E-10	—	—
Ba-139	2.5E-05	2.5E-13	2.0E-04	1.3E-09
Ba-140	5.5E-03	1.5E-10	8.0E-06	1.8E-05
La-140	7.4E-03	1.2E-10	9.0E-06	1.4E-05
La-142	2.5E-05	2.5E-13	1.0E-04	2.5E-09
Ce-141	1.3E-04	1.3E-12	3.0E-05	4.5E-08
Ce-143	1.9E-04	1.9E-12	2.0E-05	9.5E-08
Ce-144	3.2E-03	5.8E-11	3.0E-06	1.9E-05
Pr-143	1.4E-04	1.4E-12	2.0E-05	6.9E-08
Pr-144	3.2E-03	3.2E-11	6.0E-04	5.3E-08
W-187	2.1E-04	2.1E-12	3.0E-05	7.1E-08
Np-239	1.4E-02	1.4E-10	2.0E-05	6.9E-06
Total w/o H-3	3.7E-01	4.7E-07		2.1E-01
Total w/ H-3	8.5E+02	2.0E-05		2.3E-01

Note: The releases are composite, bounding values for a new single unit based on multiple reactor designs. For all isotopes except H-3, the composite values are based on ABWR, AP1000, ACR-700, and ESBWR, with ABWR activities scaled up to 4300 MWt and ESBWR activities increased by 25 percent. The H-3 concentration is based on a release of 850 Ci/yr. The concentrations are the total liquid effluents from the two new units and the two existing units. No ECLs are provided in 10 CFR 20 for Rh-106, Ag-110, and Ba-137m.

Table 5.4-7 Release of Activities in Gaseous Effluent

Isotope	Release (Ci/yr)	Concentration (μCi/ml)	ECL (μCi/ml)	Fraction of ECL
H-3	3.5E+03	8.3E-10	1.0E-07	8.3E-03
C-14	1.2E+01	2.8E-12	3.0E-09	9.3E-04
Na-24	4.4E-03	1.0E-15	7.0E-09	1.5E-07
P-32	1.0E-03	2.4E-16	5.0E-10	4.7E-07
Ar-41	3.0E+02	7.1E-11	1.0E-08	7.1E-03
Cr-51	3.8E-02	9.0E-15	3.0E-08	3.0E-07
Mn-54	5.9E-03	1.4E-15	1.0E-09	1.4E-06
Mn-56	3.8E-03	9.0E-16	2.0E-08	4.5E-08
Fe-55	7.1E-03	1.7E-15	3.0E-09	5.6E-07
Fe-59	8.9E-04	2.1E-16	5.0E-10	4.2E-07
Co-57	8.2E-06	1.9E-18	9.0E-10	2.1E-09
Co-58	2.3E-02	5.4E-15	1.0E-09	5.4E-06
Co-60	1.4E-02	3.3E-15	5.0E-11	6.7E-05
Ni-63	7.1E-06	1.7E-18	1.0E-09	1.7E-09
Cu-64	1.1E-02	2.6E-15	3.0E-08	8.6E-08
Zn-65	1.2E-02	2.8E-15	4.0E-10	7.1E-06
Kr-83m	1.3E-03	3.0E-16	5.0E-05	5.9E-12
Kr-85m	3.6E+01	7.9E-11	1.0E-07	7.9E-04
Kr-85	4.1E+03	2.2E-09	7.0E-07	3.2E-03
Kr-87	4.9E+01	5.1E-11	2.0E-08	2.6E-03
Kr-88	7.4E+01	1.4E-10	9.0E-09	1.6E-02
Kr-89	4.7E+02	1.1E-10	1.0E-09	1.1E-01
Kr-90	4.2E-04	9.9E-17	1.0E-09	9.9E-08
Rb-89	4.7E-05	1.1E-17	2.0E-07	5.6E-11
Sr-89	6.2E-03	1.5E-15	2.0E-10	7.3E-06
Sr-90	1.2E-03	2.8E-16	6.0E-12	4.7E-05
Sr-91	1.1E-03	2.6E-16	5.0E-09	5.1E-08
Sr-92	8.6E-04	2.0E-16	9.0E-09	2.2E-08

Table 5.4-7 Release of Activities in Gaseous Effluent

Isotope	Release (Ci/yr)	Concentration (µCi/ml)	ECL (µCi/ml)	Fraction of ECL
Y-90	5.0E-05	1.2E-17	9.0E-10	1.3E-08
Y-91	2.6E-04	6.2E-17	2.0E-10	3.1E-07
Y-92	6.8E-04	1.6E-16	1.0E-08	1.6E-08
Y-93	1.2E-03	2.8E-16	3.0E-09	9.5E-08
Zr-95	1.7E-03	4.1E-16	4.0E-10	1.0E-06
Nb-95	9.2E-03	2.2E-15	2.0E-09	1.1E-06
Mo-99	6.5E-02	1.5E-14	2.0E-09	7.6E-06
Tc-99m	3.3E-04	7.6E-17	2.0E-07	3.8E-10
Ru-103	3.8E-03	9.0E-16	9.0E-10	1.0E-06
Ru-106	7.8E-05	1.8E-17	2.0E-11	9.2E-07
Rh-103m	1.2E-04	2.8E-17	2.0E-06	1.4E-11
Rh-106	2.1E-05	4.9E-18	1.0E-09	4.9E-09
Ag-110m	2.2E-06	5.1E-19	1.0E-10	5.1E-09
Sb-124	2.0E-04	4.6E-17	3.0E-10	1.5E-07
Sb-125	6.1E-05	1.4E-17	7.0E-10	2.0E-08
Te-129m	2.4E-04	5.6E-17	3.0E-10	1.9E-07
Te-131m	8.3E-05	1.9E-17	1.0E-09	1.9E-08
Te-132	2.1E-05	4.9E-18	9.0E-10	5.4E-09
I-131	5.1E-01	3.5E-13	2.0E-10	1.7E-03
I-132	2.4E+00	6.1E-13	2.0E-08	3.0E-05
I-133	1.9E+00	7.2E-13	1.0E-09	7.2E-04
I-134	4.1E+00	9.9E-13	6.0E-08	1.6E-05
I-135	2.6E+00	7.3E-13	6.0E-09	1.2E-04
Xe-131m	1.8E+03	4.2E-10	2.0E-06	2.1E-04
Xe-133m	8.7E+01	1.2E-10	6.0E-07	2.0E-04
Xe-133	4.6E+03	1.0E-08	5.0E-07	2.1E-02
Xe-135m	7.7E+02	1.9E-10	4.0E-08	4.7E-03
Xe-135	8.2E+02	4.0E-10	7.0E-08	5.7E-03

Table 5.4-7 Release of Activities in Gaseous Effluent

Isotope	Release (Ci/yr)	Concentration (µCi/ml)	ECL (µCi/ml)	Fraction of ECL
Xe-137	9.8E+02	2.3E-10	1.0E-09	2.3E-01
Xe-138	7.8E+02	2.1E-10	2.0E-08	1.0E-02
Xe-139	5.3E-04	1.2E-16	1.0E-09	1.2E-07
Cs-134	6.8E-03	1.6E-15	2.0E-10	8.0E-06
Cs-136	6.5E-04	1.5E-16	9.0E-10	1.7E-07
Cs-137	1.0E-02	2.4E-15	2.0E-10	1.2E-05
Cs-138	1.9E-04	4.4E-17	8.0E-08	5.5E-10
Ba-140	3.0E-02	6.9E-15	2.0E-09	3.5E-06
La-140	2.0E-03	4.6E-16	2.0E-09	2.3E-07
Ce-141	1.0E-02	2.4E-15	8.0E-10	2.9E-06
Ce-144	2.1E-05	4.9E-18	2.0E-11	2.4E-07
Pr-144	2.1E-05	4.9E-18	2.0E-07	2.4E-11
W-187	2.1E-04	4.9E-17	1.0E-08	4.9E-09
Np-239	1.3E-02	3.1E-15	3.0E-09	1.0E-06
Total w/o H-3	1.5E+04	1.5E-08		4.2E-01
Total w/ H-3	1.8E+04	1.5E-08		4.2E-01

Note: The releases are composite, bounding values for a single new unit based on multiple reactor designs. The composite values are based on the ABWR, AP1000, ACR-700, and ESBWR, with ABWR activities scaled up to 4300 MWt and ESBWR activities increased by 25 percent. The concentrations are the total at the site boundary from the new units and the two existing units.

Table 5.4-8 Liquid Pathway Doses for Maximally Exposed Individuals at Lake Anna

	Dose (mrem/yr)		
Pathway	**Total Body**	**Thyroid**	**Bone**
Fish	5.1E-01	0.0E+00	2.3E+00
Invertebrate	6.6E-02	0.0E+00	1.5E-01
Drinking	2.0E-01	6.5E-01	2.7E-02
Shoreline	3.0E-02	3.0E-02	3.0E-02
Swimming	3.2E-04	3.2E-04	3.2E-04
Boating	4.0E-04	4.0E-04	4.0E-04
Total	8.1E-01	6.8E-01	2.5E+00
Age group receiving maximum dose	Adult	Infant	Child

Note: Doses are from one new unit. Bone of the child is the organ receiving the maximum dose.

Table 5.4-9 Gaseous Pathway Doses for Maximally Exposed Individuals

		Dose (mrem/yr)		
Location	**Pathway**	**Total Body**	**Thyroid**	**Skin**
Nearest Site Boundary (0.88 mi ESE)	Plume	2.1E+00	0.0E+00	6.2E+00
	Inhalation			
	Adult	3.0E-01	1.6E+00	0.0E+00
	Teen	3.1E-01	2.0E+00	0.0E+00
	Child	2.7E-01	2.3E+00	0.0E+00
	Infant	1.6E-01	2.0E+00	0.0E+00
Nearest Garden (0.94 mi NE)	Vegetable			
	Adult	4.4E-01	4.9E+00	0.0E+00
	Teen	5.7E-01	6.6E+00	0.0E+00
	Child	1.1E-00	1.3E+01	0.0E+00
Nearest Residence (0.96 mi NNE)	Plume	1.4E+00	0.0E+00	4.0E+00
	Inhalation			
	Adult	2.0E-01	1.0E+00	0.0E+00
	Teen	2.0E-01	1.3E+00	0.0E+00
	Child	1.8E-01	1.5E+00	0.0E+00
	Infant	1.0E-01	1.3E+00	0.0E+00
Nearest Meat Cow (1.37 mi SE)	Meat			
	Adult	6.7E-02	1.5E-01	0.0E+00
	Teen	4.9E-02	1.1E-01	0.0E+00
	Child	7.9E-02	1.7E-01	0.0E+00

Note: Doses are from one new unit. There are no milk cows or goats within 5 miles (SeeTable 2.7-13). There are no infant doses for the vegetable and meat pathways because infants do not consume these foods (See Table 5.4-5).

Table 5.4-10 Comparison of Maximally Exposed Individual Doses with 10 CFR 50, Appendix I Criteria

Type of Dose	Location	Annual Dose per Unit Calculated	Annual Dose per Unit Limit
Liquid Effluent			
Total Body (mrem)	Lake Anna	0.81	3
Maximum Organ - Bone (mrem)	Lake Anna	2.5	10
Gaseous Effluent			
Gamma Air (mrad)	Site Boundary	3.2	10
Beta Air (mrad)	Site Boundary	4.8	20
Total Body (mrem)	Site Boundary	2.4	5
Skin (mrem)	Site Boundary	6.2	15
Iodines and Particulates (All Effluents)			
Maximum Organ - Thyroid (mrem)	Lake Anna/ Nearest Garden	12	15

Note: Doses are from one new unit.

Table 5.4-11 Comparison of Maximally Exposed Individual Doses with 40 CFR 190 Criteria

	Dose (mrem/yr)					
	Two New Units			Existing Units	Site Total	Regulatory Limit
	Liquid	Gaseous	Total			
Total Body	1.6E+00	4.8E+00	6.4E+00	3.2E-01	6.8E+00	2.5E+01
Thyroid	1.4E+00	2.5E+01	2.7E+01	4.6E-01	2.7E+01	7.5E+01
Other Organ - Bone	5.0E+00	6.5E+00	1.1E+01	4.6E-01	1.2E+01	2.5E+01

Note: Doses for existing units are from Reference 11.

Table 5.4-12 Collective Total Body Doses Within 50 Miles

	Dose (person-rem/yr)	
	Each New Unit	Both Units
Liquid	8.6E+00	1.7E+01
Noble Gases (Gaseous)	3.5E+00	7.0E+00
Iodines and Particulates (Gaseous)	1.4E+00	2.8E+00
H-3 and C-14 (Gaseous)	1.4E+01	2.9E+01
Total	2.8E+01	5.6E+01
Natural Background	9.2E+05	9.2E+05

Note: Natural background dose is based on a dose rate of 325 mrem/person-yr (Reference 10, Table 11B-8, and Reference 12, Table 9.7) and a population of 2.8E+06 (Table 2.5-8). Occupational workforce doses are not shown.

Table 5.4-13 Important Biota Species and Analytical Surrogates

Ecology	Specie Type	Species	Status	Surrogate Species
Terrestrial	Bird	Bald eagle	Federal threatened, State threatened	Heron
		Loggerhead shrike	State threatened	Heron
Aquatic	Invertebrate	Dwarf wedgemussel	Federal endangered, State endangered	Invertebrate
		Slippershell mussel	State endangered	Invertebrate
		Fluted kidneyshell mussel	Candidate for federal listing	Invertebrate
	Fish	Various	Recreationally valuable	Fish

Source: Section 2.4.1 and Section 2.4.2.

Table 5.4-14 Terrestrial Biota Parameters

Biota	Effective Body Radius (cm)	Body Mass (kg)	Consumption of Food (g/day)	Food Organism
Muskrat	6	1	100	Aquatic plants
Raccoon	14	12	200	Invertebrates
Heron	11	4.6	600	Fish
Duck	5	1	100	Aquatic plants

Source: NUREG/CR-4013 (Reference 3).

Table 5.4-15 Parameters for Shoreline and Swimming Exposure to Biota

	Exposure Time (hr/yr)	
Biota	Shoreline	Swimming
Fish	4380	8760
Invertebrates	8760	8760
Algae	NA	8760
Muskrat	2922	2922
Raccoon	2191	Not Applicable
Heron	2922	2920
Duck	4383	4383

Source: NUREG/CR-4013 (Reference 3).

Table 5.4-16 Biota Doses from Liquid and Gaseous Effluents

	Dose (mrad/yr)			
Biota	Liquid Effluent	Gaseous Effluent	Total	Dose (mrad/day)
Fish	9.7E+00	0.0E+00	9.7E+00	2.7E-02
Invertebrates	4.6E+01	0.0E+00	4.6E+01	1.3E-01
Algae	5.4E+01	0.0E+00	5.4E+01	1.5E-01
Muskrat	4.3E+01	3.4E+01	7.7E+01	2.1E-01
Raccoon	4.9E+00	3.4E+01	3.9E+01	1.1E-01
Heron	5.4E+01	3.4E+01	8.8E+01	2.4E-01
Duck	4.3E+01	3.4E+01	7.7E+01	2.1E-01

5.5 Environmental Impact of Waste

This section describes the environmental impacts that could result from the operation of the non-radioactive waste system and from storage and disposal of mixed wastes. As defined in the Atomic Energy Act (AEA) of 1954, as amended, (42 USC 2011 et seq.), mixed waste contains hazardous waste and a low-level radioactive source, special nuclear material, or byproduct material. Federal regulations governing generation, management, handling, storage, treatment, disposal, and protection requirements associated with these wastes are contained in 10 CFR (NRC regulations) and 40 CFR (EPA regulations). The section is divided into two subsections: non-radioactive waste system impacts and mixed waste impacts.

5.5.1 **Nonradioactive-Waste-System Impacts**

Descriptions of the existing units' waste systems and waste systems for the new units' non-radioactive wastes are presented in Section 3.6.

All non-radioactive wastes generated at the NAPS site, including those from the new units (i.e., solid wastes, liquid wastes, air emissions) would continue to be managed in accordance with applicable federal, Virginia, local laws and regulations, and permit requirements. Management practices would be the same as those implemented for the existing units and would include the following:

- Non-radioactive solid waste (e.g., office waste, glass bottles, scrap wood) would be collected temporarily on the NAPS site and disposed of at offsite licensed commercial waste disposal site(s).
- Debris (e.g., vegetation) collected on trash screens at the water intake structure(s) would be disposed of off site as solid waste, in accordance with the existing VPDES Permit. (Reference 1)
- Scrap metal would be collected temporarily on the NAPs site and transported to an offsite permitted recycling facility.
- Water from wet cooling tower blowdown and auxiliary systems would be discharged through the WHTF to the North Anna Reservoir via Dike 3.
- Wastewater treatment sludge would be taken to the Louisa County Sewage Treatment Plant for further processing and disposal.
- Used oil and antifreeze would be collected temporarily on the NAPS site and recycled through an offsite environmental services contractor.

For further descriptions of plant systems generating non-radioactive wastes, refer to Section 3.6. There would be no other site-specific waste disposal activities unique to the new units. The assessment of potential impacts resulting from the discharge of non-radioactive wastes is presented in the following subsections.

5.5.1.1 Discharge Constituents and Characteristics

Non-radioactive wastewater discharges to surface water would increase as a result of several aspects of new units' operation, such as blowdown from the Unit 3 wet cooling tower, new auxiliary systems, and storm water runoff from new impervious surfaces. The Bounding Site-Specific PPE (Table 3.1-9) lists typical constituents along with estimates of constituent concentrations in the cooling and auxiliary system discharges. The estimates of constituent concentrations are based on conservative assumptions of system operation (e.g., flow rates, cycles of concentration, chemical addition, etc.) and on historical data on water quality for the North Anna Reservoir (the source of cooling tower make-up). Suspended solids which may exist in the cooling tower make-up water would also be discharged by way of blowdown from Unit 3 at a higher concentration. Section 3.6 contains a list of some typical chemicals that may be present in the plant's permitted discharge, including chemicals used in the new units' cooling systems, and information regarding the engineering controls that would prevent or minimize the release of harmful levels of constituents to Lake Anna. Concentrations of constituents in the cooling tower blowdown water discharge would be diluted and would reach a concentration upon entering the North Anna Reservoir not significantly different from that in the reservoir (see Section 5.3.2.2). Cooling towers would be constructed of materials that would not have the potential for leaching of hazardous chemicals.

Smaller volume discharges associated with plant auxiliary systems would be discharged in accordance with the applicable VPDES water quality standards. Therefore, potential impacts from constituents in the cooling tower blowdown water and plant auxiliary systems' discharges from the new units would be small.

With regard to changes in volume and constituent concentrations in storm water discharge, Dominion would coordinate with Virginia Power to revise the existing units' SWPPP which is required by the VPDES permit to prevent or minimize the release of harmful levels of pollutants within the storm water discharge. Impacts from increases in volume or pollutants in the storm water discharge would be small.

5.5.1.2 Impacts of Discharges to Land

Operation of the new units would result in an increase in the total volume of solid waste generated at the NAPS site. However, no new solid waste streams would be generated. All applicable federal, Virginia, and local requirements and standards would be met with regard to the handling, transportation, and offsite land disposal of the solid waste. All non-radioactive solid waste would be reused or recycled to the extent possible. Solid wastes appropriate for recycling (e.g., used oil, antifreeze, scrap metal) would be managed through use of approved and appropriately licensed contractors. All non-radioactive solid waste destined for offsite land disposal would be disposed of at approved and licensed offsite commercial waste disposal site(s). Therefore, potential impacts from land disposal of non-radioactive solid wastes would be small.

5.5.1.3 Impacts of Discharges to Air

Operation of the new units would increase small amounts of gaseous emissions to the air, primarily from equipment associated with plant auxiliary systems (e.g., diesel engines). Dry and wet cooling tower impacts on terrestrial ecosystems are addressed in Section 5.3.3.2. Potential impacts associated with Unit 3 wet cooling towers and Units 3 and 4 dry cooling towers would be small and restricted within the NAPS site boundary. Other minor air emission sources associated with the new units would be operated in accordance with federal, Virginia, and local air quality control laws and regulations. Impacts to air would be small.

5.5.1.4 Sanitary Waste

The existing units' sanitary waste treatment system (see Section 3.6) would be modified to accommodate the increases in sanitary wastes generated as a result of the operation of the new units. Sanitary wastes would be managed on site and disposed of off site in compliance with applicable laws, regulations, and permit conditions imposed by federal, Virginia, and local agencies. Potential impacts associated with increases in sanitary waste from operation of the new units would be small.

5.5.2 Mixed Waste Impacts

The term "mixed waste" refers specifically to waste that is regulated as both radioactive and hazardous waste. Radioactive materials at nuclear power plants are regulated by the NRC under the Atomic Energy Act (AEA) (Reference 2). Hazardous wastes are regulated by the EPA or an Authorized State (a state authorized by the EPA to regulate those portions of the federal act) under the Resource Conservation and Recovery Act (RCRA) (Reference 3).

Mixed waste generated on site is assessed based on the following regulatory guidance. The radioactive component of mixed waste must satisfy the definition of low-level radioactive waste in the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985 (Reference 4). The hazardous component must exhibit at least one of the hazardous waste characteristics identified in 40 CFR 261, Subpart C, or be listed as a hazardous waste in 40 CFR 261, Subpart D (Reference 5). Entities who generate, treat, store, or dispose of mixed wastes are subject to the requirements of the Atomic Energy Act, the Solid Waste Disposal Act of 1965 as amended by the RCRA in 1976, and the Hazardous and Solid Waste Amendments, which amended the RCRA in 1984. The federal agencies responsible for ensuring compliance with these statutes are the NRC and the EPA.

5.5.2.1 Plant Systems Producing Mixed Waste

Proper chemical handling techniques, pre-job planning, and compliance with an approved facility waste minimization plan would ensure that only small quantities of mixed waste would be generated by the new units. For example, the Westinghouse AP1000 would produce (Reference 6):

- Expected generation of 15 ft^3/yr mixed liquid waste and 5 ft^3/yr of mixed solid waste
- Maximum generation of 30 ft^3/yr mixed liquid waste and 10 ft^3/yr of mixed solid waste

These quantities represent less than 1 percent of the total waste generation for the AP1000 design, and they are consistent with the experience at existing operating plants, where the volume of mixed waste accounts for less than 3 percent of the annual low-level waste generated (Reference 7).

A 1990 survey by the NRC identifies the following types of mixed low-level waste at reactor facilities (Reference 8):

- Waste oil from pumps and other equipment
- Chlorinated fluorocarbons (CFC) resulting from cleaning, refrigeration, degreasing, and decontamination activities
- Organic solvents, reagents, and compounds, and associated materials such as rags and wipes
- Metals such as lead from shielding applications and chromium from solutions and acids
- Metal-contaminated organic sludges and other chemicals
- Aqueous corrosives consisting of organic and inorganic acids

Primary importance would be placed on source reduction efforts to prevent pollution and eliminate or reduce the generation of mixed waste. Potential pollutants and wastes that cannot be eliminated or minimized would be evaluated for recycling. Treatment for reducing the quantity, toxicity, or mobility of the mixed waste before storage or disposal would be considered only when prevention or recycling is not possible or practical. A waste minimization plan is described in Section 5.5.2.4.

5.5.2.2 **Mixed Waste Storage and Disposal Plans**

The volume of mixed waste could be reduced or eliminated by one or more of the following treatments prior to disposal: decay, stabilization, neutralization, filtration, or chemical or thermal destruction by an offsite vendor.

Some small quantities of mixed waste must be temporarily stored onsite due to the lack of treatment options or disposal sites. For this reason, impacts resulting from occupational exposure to chemical hazards and radiological doses could be higher than otherwise expected. Occupational chemical and radiological exposures could occur during the testing of mixed wastes to determine if the constituents are chemically hazardous.

Potential disposal facilities for mixed waste that would be shipped for treatment and disposal rather than stored would be identified. Dominion would identify one disposal facility as the primary facility and a second as an alternate.

5.5.2.3 **Environmental Impacts**

Minimal environmental impacts would result from storage or shipment of mixed wastes. In the event of a spill, emergency procedures would be implemented to limit any onsite impacts. Emergency response personnel would be properly trained and would maintain a current facility inventory, which would include types of waste, volumes, locations, hazards, control measures, and precautionary measures to be taken in the event of a spill.

Generation and temporary storage of mixed waste could expose workers to hazards associated with the chemical component(s) of the mixed waste matrix from leaks and spills. 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.

Offsite shipment, treatment, and disposal options depend on the hazard levels and radiological characteristics of the mixed waste. Because personnel performing packaging and shipping could be exposed to radiation from the mixed waste, appropriate controls would be implemented to ensure that ALARA goals are not exceeded. EPA mandates that waste storage containers in temporary storage be inspected weekly and certain aboveground portions of waste storage tanks be inspected daily. The purpose of these inspections is to detect leakage from, or deterioration of, containers (Reference 9). The NRC recommends that waste in storage be inspected at least quarterly (Reference 10). Waste inspection methods could include direct visual monitoring or remote monitoring for detecting leakage or deterioration. Additionally, measures would be provided to promptly locate and segregate or mitigate leaking containers.

5.5.2.4 **Waste Minimization Plan**

A waste minimization program would be developed and implemented. The following would be some of the key elements of such a program:

- Inventory Management – Inventory management or control techniques would be used to reduce the amount of excess or out-of-date chemicals or hazardous substances. Techniques would be used to reduce the inventory of hazardous chemicals and the size of the containers, and also monitor inventory turnover.
- Maintenance Program – Equipment maintenance programs would be periodically reviewed to establish improvements in corrective and preventive maintenance that would reduce equipment failures that could generate mixed waste. Maintenance procedures would be reviewed to determine which were contributing to the production of waste in the form of process materials, scrap, and cleanup residue. In addition, the need for revising operational procedures, modifying equipment, and segregating and recovering the mixed waste source would be determined.

- Recycling and Reuse – Recycling of waste would be considered. Opportunities for reclamation and reuse of waste materials would be used whenever feasible. Tools, equipment, and materials would be decontaminated for reuse or recycle whenever possible to minimize the amount of waste for disposal. Impediments to recycling, whether regulatory or procedural, would be challenged to enable generators to recycle whenever possible.
- Segregation – If radiological or hazardous waste is generated, proper handling, containerization, and separation techniques would be employed. This would minimize cross contamination and the unnecessary generation of mixed waste.
- Decay in Storage – Some portion of the mixed waste would be radionuclides with relatively short half-lives. The NRC generally allows facilities to store waste containing radionuclides with half-lives of less than 65 days until 10 half-lives have elapsed and the radiation emitted from the unshielded surface of the waste is indistinguishable from background levels. The waste could then be disposed of as a nonradioactive waste. Radioactive waste could also be stored for decay under certain circumstances in accordance with 10 CFR 20. For mixed waste, storage for decay would be particularly advantageous, because the waste could be managed solely as a hazardous waste after the radionuclides decayed to background levels, thus simplifying the management and regulation of these wastes.
- Work Planning – Pre-job planning would be performed to determine what materials and equipment would be needed to perform the anticipated work. One objective of this planning would be to prevent pollution and minimize the amount of mixed waste that may be generated and to use only the resources necessary to accomplish the work. Planning would also prevent mixing of materials or waste types.
- Tracking Systems – A tracking system would be developed, if required, to identify waste generation data and waste minimization opportunities. This would provide essential feedback to successfully guide future efforts. The data collected by the system would be used for internal reporting. The tracking system would provide feedback on the progress of the waste minimization program, including the results of the implementation of pollution prevention technologies. In addition, it would facilitate reporting pollution prevention data to the NRC and EPA.
- Training and Awareness Programs – A successful waste minimization program requires employee commitment. By educating employees in the principles and benefits of such a program, solutions to current and potential environmental management problems would be found. The broad objective of the waste minimization program would be to educate employees in the environmental aspects of activities occurring at the plant and in their community.

5.5.3 Conclusions

Minimal chemical constituents would be discharged to the water or air from operation of the new units. Waste minimization programs would reduce the amount of wastes, including mixed wastes, generated by operation of the new units. No new waste streams would be generated. Impacts of waste generation would be small and would not warrant mitigation.

Section 5.5 References

1. VPDES Permit. Permit Number: VA0052451. January 2001.

2. 42 USC 2011 et seq., *United States Code*, Title 42, Chapter 23, “Development and Control of Atomic Energy,” (Atomic Energy Act of 1954).

3. 42 USC 6901 et seq., *United States Code*, Title 42, Chapter 82, “Solid Waste Disposal,” (Resource Conservation and Recovery Act of 1976).

4. 42 USC 2021b et seq., *United States Code*, Title 42, Chapter 23, “Development and Control of Atomic Energy,” (Low-Level Radioactive Waste Policy Amendments Act of 1985).

5. 40 CFR 261, *Code of Federal Regulations*, “Identification and Listing of Hazardous Waste.”

6. AP1000 Document No. APP-GW-GL-700, *AP1000 Design Control Document*, Tier 2 Material, Westinghouse, Revision 2, 2002.

7. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Vol. 1, U. S. Nuclear Regulatory Commission, April 1996.

8. NUREG/CR-5938, *National Profile on Commercially Generated Low-Level Radioactive Mixed Waste*, U. S. Nuclear Regulatory Commission, December 1992.

9. 40 CFR 264, *Code of Federal Regulations*, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.”

10. 10 CFR 20, *Code of Federal Regulations*, “Standards for Protection Against Radiation.”

5.6 Transmission System Impacts

This section discusses the environmental impacts of the transmission system during operation of the new units. As described in Section 3.7, based on an initial evaluation, the current ESP site transmission lines and corridors appear to have sufficient capacity for the total output of the existing and new units.

The current corridor maintenance activities are in compliance with applicable federal, state, and local laws and regulations, and applicable permit requirements. Section 5.6.1 and Section 5.6.2 discuss the terrestrial and aquatic impacts associated with current maintenance activities. Current maintenance practices would continue if two new units were built at the ESP site. Section 5.6.3 discusses the current potential impacts to members of the public.

5.6.1 **Terrestrial Ecosystems**

Refer to Section 2.2.2 for a description of the terrestrial ecology along the existing units' transmission corridors. In addition to the information presented in this application, Section 2.4 and Section 2.5 of the ER prepared for the North Anna License Renewal application provide further detail of the activities summarized below and more detail regarding terrestrial ecosystems. (Reference 1)

5.6.1.1 **Impacts of Routine Maintenance Practices**

As part of a three-year cycle for maintenance, slow helicopter inspections are conducted to support more detailed surveys of facilities and rights-of-way (Reference 1, Sections 2.4 and 2.5). Impacts of helicopter inspections are primarily air emission and noise from the aircraft.

Aircraft engines emit carbon dioxide, oxides of nitrogen, oxides of sulphur, water vapor, hydrocarbons and particulates. Noise generated by the fly-overs may cause local fauna to become nervous, startled, or temporarily displaced. These impacts are short-term and limited to a localized area; there are no long-term impacts. Impact(s) associated with helicopter inspections would be small.

The transmission corridors are managed (e.g., brush cutting and tree trimming) to prevent woody growth from encroaching on the transmission lines and potentially causing disruption in service or be a general safety hazard. As part of a three-year maintenance cycle, transmission lines and corridors are inspected from the ground and monitored for clearance at locations of concern identified during fly-overs. These inspections involve the use of light equipment (e.g., saws, mowers), herbicides, and hand tools. Mowing is the primary method for maintaining the corridors. Tree and brush trimming is performed in accordance with the Commonwealth of Virginia's tree trimming policy (Reference 2). In areas where mowing is impractical or undesirable, hand cutting and/or non-restricted herbicides are used. In areas where the ground is saturated (e.g., wetlands or wet areas), hand-cutting is the preferred alternative. These activities are regulated by federal and state laws as well as applicable permit conditions and landowner agreements and have been incorporated into corridor management plans. (Reference 1, Sections 2.4 and 2.5)

Keeping the corridors free of woody vegetation can provide suitable habitat for protected plant species (e.g., rare, threatened, endangered) that depend on open conditions. Virginia Power has cooperated with the VDCR Natural Heritage Program in rare plant surveys within transmission corridors. Although several rare plant species have been located along transmission corridors, no threatened or endangered plant species have been identified or recorded. Locations of rare or sensitive plant species are marked on cutting sketches that Virginia Power maintains for its transmission lines. These cutting sketches, along with specifications and guidelines regarding herbicide use and brush cutting, are provided to corridor maintenance contractors so that adverse impacts on the environment can be avoided. (Reference 1, Sections 2.4 and 2.5)

The bald eagle and the loggerhead shrike (*Lanius ludovicianus*), are known to exist in central Virginia Piedmont areas (see Section 2.4.1), however, no federally and/or state-listed species designated as endangered or threatened are known to exist along the transmission corridors. Therefore, no special protection measures for such species is incorporated in the existing corridor system maintenance procedures.

The use of light equipment (e.g., pick-up trucks, farm tractors with mower attachments, small-engine hand tools) could result in incidental spills of fuel and/or lubricants. Whenever these materials are taken into the field, adequate spill response materials are immediately available to clean-up any such occurrences. Additionally, personnel are trained in how to respond to, clean-up, and report a spill, if one should occur. Contaminated material is managed and disposed of in accordance with federal and state laws and regulations.

Herbicides are handled and applied by specialty contractors in accordance with manufacturer specifications and guidance from jurisdictional regulatory agencies. Contractors are appropriately trained and licensed to perform such work. Herbicide applications are scheduled at appropriate times of the year (e.g., late summer when plants senesce). Furthermore, to prevent environmental impacts from herbicides, their use is prohibited:

- within 100 feet of a river or highway crossing or within 50 feet of a stream crossing
- on protected flora or habitats identified as being environmentally or commercially sensitive to the use of herbicides
- on desirable groundcover (e.g., dogwood, redbud, holly, rhododendron, wax myrtle)
- during high or unfavorable winds, when the risk of an uncontrolled application is increased
- on wild cherry trees growing in pasture lands or areas where livestock may be present.

5.6.1.2 Impacts of Special Maintenance Practices

Special maintenance practices are sometimes necessary for important habitats or wildlife-management requirements not addressed by applicable laws, regulations, or permit requirements. No areas designated by the USFWS as “critical habitat” for endangered species have been identified along or adjacent to NAPS transmission lines. The transmission corridors do not cross state or federal parks, wildlife refuges, or wildlife management areas (Reference 1, Sections 2.4 and 2.5).

5.6.1.3 Conclusion

Potential impacts associated with corridor maintenance activities would be small.

5.6.2 Aquatic Ecosystems

Refer to Section 2.2.2 for a description of the aquatic ecology along the existing units’ transmission corridors. In addition to the information presented in application, Section 2.4 and Section 2.5 of the ER prepared for the North Anna License Renewal application, provide further details of the activities summarized below and more detail regarding aquatic ecosystems. (Reference 1, Sections 2.4 and 2.5)

5.6.2.1 Impacts of Routine Maintenance Practices

Routine maintenance practices in and near wetlands and other water bodies are performed in accordance with the practices described in Section 5.6.1.1. As noted in Section 5.6.1.1, tree trimming and brush cutting is done by hand in aquatic resource areas. Herbicide applications are prohibited within 50 feet of a stream crossing or where winds are likely to increase the risk of misapplication to aquatic resources.

5.6.2.2 Impacts of Special Maintenance Practices

Special maintenance practices are sometimes necessary for important habitats or wildlife management requirements not addressed by applicable laws, regulations, or permit requirements. No threatened or endangered aquatic species have been identified in the water bodies crossed by the NAPS transmission corridors.

Based on the VDGIF Fish and Wildlife Information Service Database (Reference 3), two state- and federally-listed freshwater mussel species [i.e., green floater (*Lasmigona subviridis),* and yellow lance *(Elliptio lanceolata)*] could exist in watercourses that the transmission corridors cross. Neither of these mussel species has been observed in the watercourses crossed by the transmission corridors. They have, been collected from other locations in the counties through which the transmission corridors run.

A third mussel species, the fluted kidney shell mussel (*Ptychobranchus subtentum*), has been reported within the vicinity of the ESP site. This mussel is a candidate for federal listing, and the database referenced above lists this species as existing in a stream or streams in Louisa County, but not on the ESP site. All confirmed accounts of this species are confined to mountain streams in southwestern Virginia. (Reference 3) These streams comprise part of the Tennessee River watershed, and it is unlikely that fluted kidney shell mussel populations in such streams would be impacted, either directly or indirectly, by maintenance practices on the transmission line corridors, most of which cross streams in watersheds flowing toward the Atlantic Ocean.

5.6.2.3 Conclusion

Impacts of routine and special maintenance procedures for transmission corridors on aquatic resources would be small.

5.6.3 Impacts to Members of the Public

This section discusses the potential impacts on members of the public from electrical shock, electromagnetic field (EMF) exposure, noise, and aesthetics associated with the existing NAPS site transmission lines. Four transmission lines currently originate from the NAPS site. Three of the lines are 500 kV-transmission lines designed and built in the late 1970s in accordance with the National Electrical Safety Code (NESC) and industry guidance that was current at the time. The fourth line is a 230 kV line to South Anna, designed and built in 1984 in accordance with the NESC and industry guidance that was current at the time. (Reference 1, Section 4.13)

5.6.3.1 Electrical Shock

Virginia Power analyzed the potential impacts of electrical shock for the transmission lines in its environmental report for the existing units operating licenses renewal application. This analysis would be unaffected by the new units. The analysis of the induced current along the transmission lines began with the identification of the limiting case for each transmission line. By definition, the limiting case is the configuration along each transmission line where the potential for current-induced shock would be greatest. Because transmission corridors leaving the NAPS site contain only one transmission line per corridor, the limiting case was defined primarily by ground clearance and tower configuration of a single-line corridor. (Reference 4)

Once the limiting case was identified, the electrostatic field strength and the associated induced current for each transmission line was calculated using a computer algorithm (ENG01814), developed by Cincinnati Gas & Electric Company, and used by Virginia Power since 1978. The input parameters for ENG01814 included the design features of the limiting-case scenario, a calculated line sag at 120°F conductor temperature (i.e., NESC requirement and based on design clearances), and an assumed maximum vehicle size under the lines of a tractor-trailer (i.e., 55 ft x 8 ft x 11 ft). Model results were then field-verified through actual electric field measurements under energized transmission lines.

The computer analysis, confirmed by field verification, concluded that none of the four transmission lines have the capacity to induce more than 5 milliamperes in a vehicle parked beneath the lines. Therefore, the four transmission line designs conform to the NESC provisions for preventing electric shock from induced current. The analysis results for each transmission line are provided in Table 5.6-1. Impacts to members of the public from existing transmission lines would be small.

Table 5.6-1 Results of Induced Current Analysis

Transmission Line	Voltage (kV)	Limiting Case Electric Field Strength (kV/meter)	Limiting Case Induced Current (mA)
South Anna NUG (255)	230	4.35	3.10
Morrisville (573)	500	6.95	4.95
Ladysmith (575)	500	6.40	4.56
Midlothian (576)	500	6.68	4.77

5.6.3.2 Electromagnetic Field Exposure

In 1996, after 17 years of research that examined more than 500 studies, the National Research Council released the results of a study that stated, “The findings to date do not support claims that EMFs are harmful to a person’s health.” Furthermore the report added there is no conclusive evidence that EMF plays a role in the development of cancer, or reproductive or other abnormalities in humans. (Reference 5) Impacts to members of the public attributable to EMF exposure would be small.

5.6.3.3 Noise

Noise emitted from high-voltage lines is caused by the discharge of energy that occurs when the electrical field strength on the conductor surface is greater than the breakdown strength (i.e., the field intensity necessary to start a flow of electric current) of the surrounding air. The energy loss is known as corona loss. The higher voltages at which modern transmission lines operate have increased the nuisance noise problem.

The intensity of the noise, is affected by two conditions:

- Ambient weather conditions (e.g., humidity, air density, wind, precipitation)
- Irregularities on the conductor surface (e.g., sharp points)

Aging or weathering of the conductor surface typically reduces the significance of these factors. To limit corona activity, transmission lines are constructed and maintained so that during dry weather they operate below the corona-inception voltage. However, during wet weather, the likelihood of corona loss increases, contributing to nuisance noise. Corona-induced noise levels along the existing transmission system are low and do not pose a health risk to humans. Additionally, Virginia Power has not received any reports from the public of nuisance noise due to transmission lines. Impacts to members of the public attributable to noise from the transmission lines would be small.

5.6.3.4 **Visual Impacts**

Visual impacts to members of the public from the transmission system were addressed qualitatively during the development of the Final Environmental Impact Statement (FEIS) for the existing units (Reference 6). The FEIS notes that the visual impact of the transmission lines would be diminished by several techniques including use of russet-brown tower structures that blend with the rural landscape and gray-painted H-frame structures to support conductor spans over the North Anna reservoir. The FEIS also notes that the route of transmission lines would, in most locations, be along existing ground contours thereby partially concealing the lines and eliminating long views of the line through woods and up slopes. In addition, the FEIS recommended that natural vegetation be retained, where possible, at road crossings to help minimize ground-level visual impacts. This specific recommendation from the FEIS has been incorporated into transmission corridor routine maintenance practices for vegetation control. Contractors performing routine vegetation control activities on the transmission lines are instructed to maintain a screen of natural vegetation in the right-of-way on each side of major highways and rivers unless otherwise directed. Based on the design conditions and ongoing routine vegetation control practices, the visual impact to members of the public from the transmission system would be small.

5.6.3.5 **Conclusions**

Potential impacts from electric shock, EMF exposure, noise or visual impacts from the existing NAPS site transmission lines would be small.

Section 5.6 References

1. *North Anna Power Station, Units 1 and 2 Application for Renewed Operating Licenses Environmental Report*, (Appendix E) Dominion, May 2001.

2. Policy for Tree and Brush Trimming, Virginia Department of Transportation, as seen on the TLC for Trees Project, www.tlcfortrees.info/virginia_department_of_transport.htm, accessed July 29, 2003.

3. Virginia Department of Game & Inland Fisheries' Fish and Wildlife Information Service Database, Website address: vafwis.org/perl/vafwis.pl/vafwis Online database accessed on February 26, 2003.

4. *Transmission Line Electric Shock Analysis, Virginia Power Bulk Power Delivery Transmission Lines*, Donald Koonce, Director, Transmission O&M Support. Virginia Power, December 1999.

5. Possible Health Effects of Exposure to Residential Electric and Magnetic Fields, National Research Council, October 1996.

6. Atomic Energy Commission (AEC), Docket Nos. 50-338 and 50-339, Final Environmental Impact Statement (FEIS) Section 4.1, “Effect on Land Use,” Virginia Electric and Power Company, April 1973.

5.7 Uranium Fuel Cycle Impacts

This section addresses the uranium fuel cycle environmental impacts and is divided into two main subsections. The first subsection addresses the LWR designs presently being considered. The second subsection addresses the gas-cooled reactor designs also being considered. This split addresses the regulatory distinction made in 10 CFR 51.51 for LWRs.

5.7.1 **Light-Water-Cooled Reactors**

10 CFR 51.51(a) states 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 waste 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.”

Table S-3 of 10 CFR 51.51 is reproduced in its entirety herein as Table 5.7-3. Specific categories of natural-resource use included in the table relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic and high- and low-level wastes, and radiation doses from transportation and occupational exposures. The contributions in the table for reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle); that is, the cycle that results in the greater impact is used.

Dominion’s analysis of environmental effects of the uranium fuel cycle for North Anna’s ESP application included a review of impact considerations due to radon-222 (Ra-222) and technetium-99 (Tc-99). This assessment took advantage of previous analyses documented in NUREG-1437, Section 6.2, including Tables 6.1 through 6.4, as well as a review of known impacts from experience with these isotopes in the fuel cycle. The analysis in NUREG-1437, Section 6.2 is incorporated by reference in the North Anna ESP application.

As described in NUREG-1437, Chapter 6, the data on environmental impacts of the uranium fuel cycle presented in Table S-3 (which didn’t address the impacts of Ra-222 and Tc-99) was supplemented to extend the coverage of assessed impacts to include those isotopes. In NUREG-1437 it states that “Principal radon releases occur during mining and milling operations and as emissions from mill tailings, whereas principal Tc-99 releases occur from gaseous diffusion enrichment facilities.” In accordance with the guidance provided in NUREG-1555 (Section 5.7, Appendix A) and the NEPA evaluation process, Dominion determined that there was no new significant information relevant to the impacts of those isotopes for the North Anna ESP site. Since the principal fuel cycle and impact evaluations for new reactor technologies are bounded by the existing LWR impact assessment, Dominion concluded that the overall significance of contribution from Ra-222 and Tc-99 would remain small. In addition, calculated operational aspects of the fuel cycle associated with supporting new units at the North Anna site would only contribute to an extremely low percentage of the natural total body dose to the public. Furthermore, the EPA has found that current emissions from power plants were at levels that provided an ample margin of safety. Therefore, since uranium fuel cycle facilities must comply with federal and state regulatory limits, dose contribution to the public would also be considered small. In addition, the non-radiological impacts of the uranium fuel cycle are acceptable.

The LWR technologies being considered to demonstrate site suitability include the ABWR, the ESBWR, the AP1000 (Advanced Passive PWR), the IRIS, and the ACR-700 (Advanced light-water-cooled version of the CANDU Reactor). The standard configuration for each of these reactor technologies is as follows. The ABWR is a single-unit, 4300 MWt, nominal 1500 MWe reactor. The ESBWR is a similar BWR: single-unit, 4500 MWt, nominal 1520 MWe. The AP1000 is a single-unit, 3400 MWt, nominal 1117–1150 MWe PWR. The IRIS is a three-module PWR configuration for a total of 3000 MWt and nominal 1005 MWe. And the ACR-700 is a twin-unit, 3964 MWt, nominal 1462 MWe, light-water-cooled CANDU reactor.

These reactor technologies are all LWRs with uranium dioxide fuel and therefore Table S-3 of 10 CFR 51.51(b) provides the basis for evaluating the environmental effects from the uranium fuel cycle for these reactor technologies. The Table S-3 values are normalized for a 1000 MWe reference LWR. Since the ESP site may be used for up to 3200 MWe, the fuel cycle impacts resulting from operation of new LWRs at the ESP site would be no more than 3.2 times the Table S-3 values.

5.7.2 **Gas-cooled Reactors**

5.7.2.1 **Introduction and Background**

This section provides an assessment of the environmental impacts of the fuel cycle, as related to the operation of the gas-cooled reactor technologies, based on a comparison of the key parameters that were used to generate the impacts listed in 10 CFR 51.51, Table S-3 (and repeated in Table 5.7-3). The key parameters are energy usage, material involved, number of shipments, etc. associated with the major fuel cycle activities. The major fuel cycle activities are mining and milling, uranium hexafluoride conversion, enrichment, fuel fabrication, and radioactive waste disposal. Basically, the premise is that if less energy is needed, if fewer shipments are required, and if less material is involved in the process, then with all other things being equal, the overall impacts are less.

There are two gas-cooled reactor technologies being considered at this time. The GT-MHR is a four-module, 2400 MWt, nominal 1140 MWe reactor that operates at a unit capacity of 88 percent.

The PBMR is an eight module, 3200 MWt, nominal 1320 MWe reactor operating at a 95 percent unit capacity.

A key reference is NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants,* May 1996, which provides a very detailed look at the impacts to the environment from the nuclear fuel cycle. The document also looks at the sensitivity of the changes to the nuclear fuel cycle on the impacts to the environment.

Table 5.7-1 was prepared to succinctly capture the major features of the reference LWR fuel cycle that were used to develop Table S-3 and compare these same features with the gas-cooled reactor technologies being considered. This comparison can then help to demonstrate that the previously accepted environmental impacts identified in Table S-3 are comparable to the impacts for these gas-cooled technologies. The premise is that if the values of the major contributors to the health and environmental impacts that were used for the reference LWR fuel cycle are greater than those comparable values for the gas-cooled reactor technologies, then the published, previously accepted impacts would also be greater than the impacts from the new reactor technologies. It is important to point out that even though the contributors are being examined individually, it is the overall impact that is of concern. As such, there can be increases in individual contributors, yet the total impacts can still be bounded, if offset by decreases in other contributors.

The information to conduct the comparison was taken from 10 CFR 51.51, Table S-3 “Uranium Fuel Cycle Environmental Data,” WASH-1248, *Environmental Survey of the Uranium Fuel Cycle*, and Supplement 1 to WASH-1248, (also known as NUREG-0116) *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*. The “reference LWR” refers to the model 1000 MWe LWR used as a basis for studying annual fuel related requirements as described in WASH-1248. For the gas-cooled reactor technologies, information was gathered from the reactor vendors, United States Enrichment Corporation (USEC) and ConverDyn.

5.7.2.2 **Analytic Approach**

The major activities of the reference LWR fuel cycle that were considered in the WASH-1248 report were uranium mining, uranium milling, uranium hexafluoride production, uranium enrichment, fuel fabrication, irradiated fuel reprocessing, radioactive waste management which includes decontamination and decommissioning, and transportation. Three comments pertinent to this analysis are: 1) the WASH-1248 report and this evaluation only address the uranium fuel cycle (other fuel cycles such as thorium and plutonium are not part of this effort), 2) irradiated fuel reprocessing is not being considered by any of the new reactor technologies and is not included in this analysis, and 3) the transportation impacts are addressed based on the following premise - if the quantity of material required by the new gas-cooled reactor technologies at each major step of the fuel cycle is less than the reference plant, then the transportation impacts are also less. Comparing only the number of shipments of material is appropriate since there is little if any radioactivity in the fuel cycle shipments considered by Table S-3.

The main features of the major activities of the reference LWR fuel cycle that were identified as being the primary contributors to the health and environmental impacts are as follows. For the mining operation, annual ore supply is the major determinant of environmental and health impacts. Less ore would necessitate less energy, fewer emissions, less water usage, and less land disturbed. Secondarily, the mining technique can play a significant role in any impacts. Open pit mining has by far the most environment impact, followed by underground mining, with *in situ* leaching being the most environmentally benign.

For the milling operation, annual yellowcake (U_3O_8) production is the metric of interest. If a plant requires less U_3O_8 than the reference plant, then there would be less energy needed, fewer emissions, and less water usage. This is especially true if *in situ* leaching was used to obtain the ore, because the major milling steps of crushing and grinding are not required.

For the uranium conversion process, annual uranium hexafluoride (UF_6) production is the primary determinant of environmental impacts. If the new technology requires less UF_6 than the reference plant, then there would be less energy required, fewer emissions and less water used. As with the mining step, the conversion process (wet versus dry) is also a consideration. However, NUREG-1437 states that in either case “the environmental releases are so small that changing from 100 percent use of one process to 100 percent of the other would make no significant difference in the totals given in Tables S-3 or S-4.”

For the enrichment operation, there are two quantities of interest. The first quantity is the separative work units (SWU) needed to enrich the fuel, and the second quantity is the amount of enriched UF_6. The SWU is a measure of energy required to enrich the fuel. More SWUs would indicate not only more energy required but also more emissions associated with the production of the energy needed and with that more water usage. However, this assumes the same technology is used to achieve the enrichment. As presented in NUREG-1437, the centrifuge process uses 90 percent less energy than the gaseous diffusion process. Since the major environmental impacts for the entire fuel cycle are from the emissions from the fossil fueled plants needed to supply the energy demands of the gaseous diffusion plant, this reduction in energy requirements results in a fuel cycle with much less environmental impact. With regard to the amount of enriched UF_6 produced, the major effect would be the number of shipments. More UF_6 would necessitate more shipments, while less UF_6 would require fewer shipments. Slight increases or decreases would probably result in the same number of shipments.

For the fuel fabrication process, the quantity of UO_2 produced is the value of interest. This is really equivalent to the annual fuel loading in MTU, which would also be evaluated. Here again, the production of more UO_2 would require more energy, greater emissions, and increased water usage. New reactor technologies with an annual fuel loading less than the reference LWR plant would have less environmental impact, requiring less energy, fewer emissions and less water usage.

The last activity to be addressed is radioactive waste management. There are two aspects of radioactive waste that are considered as part of Table S-3: operations and reactor decontamination and decommissioning (D&D). For these activities, curies of low-level waste (LLW) from annual operations and Ci of LLW from reactor (D&D) are the measures to consider. Curies by themselves are not a direct indicator of the potential environmental impacts. The radionuclide, its half-life and type of emission, and its physical and chemical form are the main contributors to risk. While we recognize this distinction, for this bounding analysis we will use curies as was done in the WASH-1248. More curies generally indicate the potential for greater impacts, while fewer curies indicate lesser impacts.

One of the clearest ways to conduct this comparison between the reference LWR and the gas-cooled reactor technologies is to start with the annual fuel loading in MTU for each of the reactor technologies. The other activities more accurately originate from the need for a certain amount of fuel. Using annual fuel loading as the starting point, the analysis will proceed in the reverse direction for the fuel cycle until the mining has been addressed, then the radioactive waste will be addressed. Before beginning this comparison, it is important to recognize that the plants being considered are a different size, have a different electrical rating and have a different capacity factor from the reference LWR. The reference LWR is a 1000 MWe plant with a capacity factor of 80 percent. In order to make a proper comparison, we need to evaluate the activities based on the same criterion. In this case, electrical generation is the metric of choice. Electrical generation is why the plants are being built and we want to know if these new reactor technologies, for the same electrical output, have a greater or lesser impact on human health and environment. Based on this, the reactor technologies will be normalized to 800 MWe using plant specific electrical rating and capacity factor.

5.7.2.3 Analysis and Discussion

5.7.2.3.1 Fuel Fabrication/Operations

The reference LWR required 35 MTU on an annual basis. This is equivalent to 40 MT of enriched UO_2, the annual output needed from the fuel fabrication plant. In comparison, the normalized annual fuel needs for the new gas-cooled reactor technologies ranged from 4.3 MTU to 5.3 MTU, approximately 88 percent to 85 percent lower than the reference plant. Similarly, the annual output needed from the fuel fabrication plant range from a low of 4.89 MT of UO_2 to 6.0 MT of UO_2, again approximately 88 percent to 85 percent lower than the reference plant. The specific breakdowns are shown on Table 5.7-1. One important distinction is that the fuel form for the gas-cooled reactors is also different. For the GT-MHR, the fuel is a two-phase mixture of enriched UO_2 AND UC_2, usually referred to as UCO. For the PBMR the fuel kernel is UO_2. Both fuels are then TRISO coated. For the GT-MHR these TRISO fuel particles are blended and bonded together with a carbonaceous binder. These fuel compacts are then stacked within a graphite block. For the PMBR, the fuel unit is a 6 cm diameter graphite sphere containing approximately 15000 fuel particles.

Before concluding the potential impacts from the fuel fabrication process are less, the gas-cooled reactors require a different fuel fabrication process altogether. The TRISO coated fuel kernel is quite different from the UO_2 sintered fuel pellet and as such would require a different type of facility. Ideally, to verify the environmental impacts of this change in fabrication process are bounded by the reference LWR fuel fabrication plant, a comparison of the land use, energy demand, effluents, etc., is in order. However, because there are no planned or currently operating plants in the United States, a direct comparison cannot be made at this time. Therefore, we have provided information on the reference fuel fabrication plant along with conceptual design information for a TRISO fabrication plant that was planned for the New Production Reactor and conceptual design information received from one of the gas-cooled reactor vendors.

From WASH-1248, the reference LWR fuel fabrication plant produced fuel for 26 plants ($\approx$910 MTU), was located on a site of about 100 acres, required 5.2 million gallons of water per annual fuel requirement of 35 MTU, and required 1,700 MW-hours of electricity per 35 MTU. The WASH-1248 report also states that nearly all of the airborne chemical effluents resulted from the combustion of fossil fuels to produce electricity to operate the fabrication plant. These numbers represented a very small portion of the overall fuel cycle. For example, the electrical usage represented less than 0.5 percent of that needed for the enrichment process, and the water use was less than 2 percent of the overall fuel cycle.

The fuel fabrication facility for the New Production Reactor was for a modular high temperature gas reactor (MHTGR) design and was sized for just one plant, so the much larger reference LWR fuel fabrication plant are not readily comparable. The dimensions for the fuel fabrication building were 230 ft x 150 ft. The annual production was about 2 MTU. The plant required 960 kW of electrical power and 45 liters per minute of water. Effluents consisted of 60 m^3/yr of miscellaneous non-combustible solids and filters; 50 m^3/yr of combustible solids; 50 m^3/yr of process off-gas and HVAC filters; 2.0 m^3/yr of tools and failed equipment; and process off-gases of 900,000 m^3/yr. The process off-gases consisted of 74 percent N_2, 12 percent O_2, 7.2 percent Ar, 6.4 percent CO_2, 0.2 percent CO, and 0.02 percent CH_3CCl_3. The activity associated with this off-gas: 0.01 pCi alpha/m^3, and 0.01 pCi beta/m^3.

The information gathered from one of the current reactor vendors was for a plant producing 6.3 MTU, about 19 percent more than the annual reload of 5.31 MTU for its reactor. Again this plant was sized for just one reactor. This plant would require 10 MW of electrical power with an annual electrical usage of 35,000 MW-hr. The gaseous emissions consist of 80 MT of nitrogen, 52 MT of argon, 22.4 MT of CO, 22 MT of hydrogen and 3.7 MT of CO_2. The solid waste totals about 84 m^3 of LLW, 3 m^3 of intermediate level waste, and the remainder sanitary/industrial wastes. The liquid processing system would generate an additional 3.8 m^3 of LLW, would discharge about 3700 m^3 of low activity aqueous effluent, and would discharge about 45,000 m^3 of industrial cooling water.

Because of the differences in scale and the state of design of the facilities, it is not possible or appropriate to make a direct comparison of the impacts. Obviously, there are economies of scale and design improvements that would occur for a plant comparable in size to the reference plant. Regardless, the projected impacts of a TRISO fuel plant based on the two conceptual designs are not inconsistent with the reference plant and would be operated within existing air, water, and solid waste regulations. Furthermore, like the impacts associated with the sintered UO_2 pellet plant, the impacts from a TRISO fuel plant would still be a minor contributor to the overall fuel cycle impacts. By characterizing the impacts as “not inconsistent,” it is meant that while certain parameters such as electrical usage for fuel fabrication might be higher for the gas-cooled plants on an annual fuel loading basis, the environmental impacts from the TRISO plants as conceptualized would still be bounded by the overall LWR fuel cycle impacts.

5.7.2.3.2 **Uranium Enrichment**

In order to produce the 40 MT of enriched UO_2 for the reference LWR, the enrichment plant needed to produce 52 MT of UF_6, which required 127 MT of SWU. The normalized enriched UF_6 needs for the new gas-cooled reactor technologies ranged from 6.38 MT of UF_6 to 7.9 MT of UF_6, approximately 88 percent to 85 percent lower. To produce these quantities of UF_6 requires from 124 MT of SWU to 163 MT of SWU, slightly lower to 28 percent higher. The enrichment SWU calculation for the new reactor technologies was performed using the USEC SWU calculator and assumes a 0.30 percent tails assay, the same value as for the reference LWR. Using this calculator for the reference LWR plant yielded 126 MT of SWU versus the NUREG value of 127. This is very close indicating that this latest version of the USEC SWU calculator is appropriate for use in this computation. Table 5.7-2 gives the details of the computations.

The 28 percent increase in the MTU of SWU would by itself indicate greater environmental impacts. However, a close look at the original WASH-1248 analysis shows that the environmental impacts are almost totally from the electrical generation needed for the gaseous diffusion process. These impacts result from the emissions from the electrical generation that is assumed to be from coal plants and from the associated water to cool the plants. Today, and in the future, the enrichment process is and will be different. A significant fraction of the enrichment services to U.S. utilities today is provided from European facilities using centrifuge technology rather than the fifty-year-old gaseous diffusion technology. For the future, two private companies, United States Enrichment Corporation and Louisiana Energy Services, are planning to develop centrifuge technology in the U.S. In fact, NRC has just recently accepted United States Enrichment Corporation’s centrifuge license application for technical review. Centrifuge technology requires less than 10 percent of the energy needed for the gaseous diffusion process and as such the environmental impacts associated with the electrical generation would be correspondingly less. This tremendous reduction in energy and the associated environmental impacts more than offsets a 28 percent increase in SWU.

5.7.2.3.3 Uranium Hexafluoride Production

In order to provide the feed needed for the reference LWR to the enrichment plant, the uranium hexafluoride plant needed to produce 360 MT of UF_6. The normalized feed needed for the new gas-cooled reactor technologies, the output from the uranium hexafluoride plant, ranged from 241 to 303 MT of UF_6, well below the reference plant. The feed calculations were performed using the USEC SWU calculator. Using this calculator for the reference LWR yielded 353 MT of UF_6 versus 360 MT specified for the reference LWR in NUREG-0166. Again this value is very close (<2 percent) to the published value.

5.7.2.3.4 Uranium Milling

To produce the 360 MT of UF_6 for the reference LWR, 293 MT of yellowcake (U_3O_8) from the mill was required. The normalized new gas-cooled reactor technologies needs ranged from 193 MT of U_3O_8 to 243 U_3O_8, well below the reference plant. These yellowcake numbers were generated using the relationship 2.61285 lb of U_3O_8 to 1 kg of UF_6. This conversion factor was obtained from ConverDyn.

5.7.2.3.5 Uranium Mining

The raw ore needed to produce the 293 MT of yellowcake (U_3O_8) for the reference LWR was 272,000 MT. Now assuming a 0.1 percent ore body and a 90 percent recovery efficiency, the normalized new gas-cooled reactor technologies ore requirements ranged from 215,000 to 270,000 MT of ore, both below the reference plant. Of note, the value of 272,000 MT specified for the reference LWR in NUREG-0116 should be about 325,600 using the same assumptions. In any case, the gas-cooled reactor technologies are below the published reference plant value.

Uranium mining completes the front end of the fuel cycle. However, there are two areas on the down stream cycle to be considered. These are the LLW generated by operations and the LLW generated as part of the D&D process. As mentioned earlier, spent fuel reprocessing is not germane to this analysis, and therefore, not discussed.

5.7.2.3.6 Solid Low-Level Radioactive Waste - Operations

For the reference LWR, 10 CFR 51.51, Table S-3, Table of Uranium Fuel Cycle Environmental Data, states that there are 9,100 Ci of LLW generated annually from operations. The range of activity of LLW generated annually projected by the new gas-cooled reactor technologies is 65.4 Ci to 1,100 Ci, far below the reference LLW. This decrease would also suggest many fewer shipments to the disposal facility and less worker exposure.

5.7.2.3.7 Solid Low-Level Radioactive Waste – Decontamination and Decommissioning

10 CFR 51.51, Table S-3, states 1,500 Ci per Reactor Reference Year (RRY) “comes from reactor decontamination and decommissioning – buried at land burial facilities.” Based on this small quantity and the modifying phrase “buried at land burial facilities” it is clear that only waste suitable for shallow land burial was being considered as a basis for the Table S-3 line item. At this time, only

general conclusions can be drawn to indicate these gas-cooled reactor technologies would generate less D&D LLW than the reference plant. The new plants would operate much cleaner than the reference LWR as evidenced by the annual generation of much less LLW. Improvements in fuel integrity and differences in fuel form as well as the use of the chemically and radiologically inert helium as the coolant are responsible for this reduction and also should contribute to both a lower level and less overall contamination to be managed during the D&D process. The plants higher thermal efficiency and higher fuel burnup would produce less heavy metal radioactive waste. Lastly, the plants, with the exception of the reactor core, are typically more compact than the reference LWR contributing to less D&D waste. For these reasons, it is expected that the D&D LLW generation from the gas-cooled reactor designs would be comparable or less than that associated with the reference LWR.

The key areas of impact from D&D LWR for the gas-cooled reactor are expected to be identical to those of the reference LWR, namely transportation and land use supporting waste disposal. As presented in WASH-1248, the contributions from the D&D LLW to the overall environmental impacts are relatively quite small. WASH-1248 points out that by far the major environmental impacts are dominated by the front end phases (mining, milling, enrichment) of the fuel cycle, e.g., land use from mining and power consumption to support enrichment, related water usage, and power plant emissions.

As noted above, the D&D LLW impacts related to the gas-cooled reactor designs are expected to be comparable or less than that of the reference LWR. However, even if the gas-cooled reactor D&D LLW activities and/or volumes were larger, the overall reference LWR fuel cycle impacts would continue to be bounding.

5.7.2.4 **Summary and Conclusion**

To recap, there are only two instances where any part of the uranium fuel cycle is/might be exceeded by the new gas-cooled reactor technologies. These fuel cycle steps are enrichment, a 28 percent increase and possibly D&D. As presented above, the enrichment requirement for SWU, while slightly larger, can be conducted in a much more environmentally benign manner, centrifuge versus gaseous diffusion, from current overseas sources or expected new domestic facilities. The net effect would be that the environmental and health impacts would be less than those identified in Table S-3. The second area, decontamination and decommissioning, is a minor contributor to the fuel cycle impacts. While definitive D&D LLW information was not readily available for the gas-cooled reactor technologies, for several qualitative reasons, the impacts are expected to be comparable or less than the reference LWR. However, even an increase in the D&D LLW impacts would be more than offset by the significant decreases in the impacts due to reduction in fuel needs and changes in the enrichment process and mining technique.

In conclusion, this detailed comparison of the underpinnings of Table S-3 show qualitatively that the existing WASH-1248 environmental and health effects are conservative and appropriate for use by these new gas-cooled reactor technologies. Collectively, improvements in both past practices as well as changes in technology have resulted in a fuel cycle with lower environmental impact.

5.7.3 **Methodology Assessment**

The selection of a reactor design to be used for the ESP Facility is still under consideration. Selection of a reactor to be used at the ESP site may not be limited to those considered above. However, the methodology utilized above is appropriate to evaluate the final selected reactor. Further, should the selected design be shown to be bounded by the above evaluation, then the selected design would be considered to be within the acceptable fuel cycle environmental impacts considered for this ESP.

Section 5.7 References

1. 10 CFR 51.51, Table S-3, Table of Uranium Fuel Cycle Environmental Data.
2. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants,* May 1996.
3. WASH-1248, *Environmental Survey of the Uranium Fuel Cycle*, April 1974.
4. Supplement 1 to WASH-1248, also known as NUREG-0116, *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*, October 1976.
5. EGG-NPR-8522, Rev. B, *NPR-MHTGR Generic Reactor Plant Description and Source Terms*, March 1991.

Table 5.7-1 Gas-Cooled Fuel Cycle Impact Evaluation

Reactor Technology Facility/Activity	**Reference LWR** (Single unit) (≈1000 MWe) 80% Capacity	**GT-MHR** (4 Modules) (2400 MWt total) (≈1150 MWe total) 88% Capacity	**PBMR** (8 Modules) (3200 MWt total) (≈1280 MWe total) 95% Capacity
Mining Operations			
Annual ore supply MT	272,000	337140	337140
Normalized annual ore supply MT	272,000	269712	214739
Fraction of reference LWR	1	0.99	0.79
Calculated number	314,011	269712	214739
Milling Operations			
Annual yellowcake MT	293	303	303
Normalized annual yellowcake MT	293	243	193
Fraction of reference LWR	1	0.83	0.66
Calculated number	283	243	193
UF_6 Production			
Annual UF_6 MT	360	379	379
Normalized annual UF_6 MT	360	303	241
Fraction of reference LWR	1	0.84	0.67
Calculated number	353	303	241
Enrichment Operations			
Enriched UF_6 (MT)	52	8.0	12.3
Normalized enriched UF_6 (MT)	52	6.38	7.9
fraction of reference LWR	1	0.12	0.15
Calculated number	52	6.38	7.9
Annual SWU (MT)	127	204	194
Normalized annual SWU (MT)	127	163	124
fraction of reference LWR	1	1.29	0.97
Calculated number	126	163	124

Table 5.7-1 Gas-Cooled Fuel Cycle Impact Evaluation

Reactor Technology Facility/Activity	**Reference LWR** (Single unit) (≈1000 MWe) 80% Capacity	**GT-MHR** (4 Modules) (2400 MWt total) (≈1150 MWe total) 88% Capacity	**PBMR** (8 Modules) (3200 MWt total) (≈1280 MWe total) 95% Capacity
Fuel Fabrication Plant Operations			
Enriched UO_2 (MT)	40	6.11	9.5
Normalized enriched UO_2 (MT)	40	4.89	6.0
fraction of reference LWR	1	0.12	0.15
Calculated number	40	4.89	6.0
Annual Fuel Loading (MTU)	35	5.39	8.34
Normalized annual fuel loading (MTU)	35	4.3	5.31
fraction of reference LWR	1	0.12	0.15
Reprocessing Plant Operations			
Annual spent fuel reprocessing MTU	35	0	0
Solid Radioactive Waste			
Annual LLW from reactor operations Ci	9,100	1100 Ci; 98 m^3	65.4 Ci; 800 drums
fraction of reference LWR	1	0.12	0.01
LLW from Reactor Decontamination & Decommissioning Ci per RRY	1,500	Data not available	Data not available
TRU and HLW Ci	1.1×10^7	Reprocessing is not considered in this evaluation.	Reprocessing is not considered in this evaluation.
Yellow indicates a value larger than Table S-3.			

References:

1. 10 CFR 51.51, Table S-3 Table of Uranium Fuel Cycle Environmental Data
2. 10 CFR 51.51, Table S-3 Table of Uranium Fuel Cycle Environmental Data

Table 5.7-1 Gas-Cooled Fuel Cycle Impact Evaluation

Reactor Technology Facility/Activity	**Reference LWR** (Single unit) (≈1000 MWe) 80% Capacity	**GT-MHR** (4 Modules) (2400 MWt total) (≈1150 MWe total) 88% Capacity	**PBMR** (8 Modules) (3200 MWt total) (≈1280 MWe total) 95% Capacity

Notes:

1. The enrichment SWU calculation was performed using the USEC SWU calculator and assumes a 0.30% 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.
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 MWe 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 kgs of U 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. Co-60 with a 5.26 year half-life and Fe-55 with a 2.73 year half-life are the main nuclides listed for the PBMR D&D waste.

Table 5.7-2 SWU and Feed Calculation Results

Reactor Technology	kg Uranium Product	Weight Percent U_{235}	SWU Quantity	kg of U Feed Required	Tails Assay
ABWR	32,760	4.5	204,127.56	334,774.44	0.30%
ESBWR	32,760	4.5	204,127.56	334,774.44	0.30%
AP1000	24,400	4.51	152,500.00	249,929.20	0.30%
IRIS	18,800	4.85	129,851.60	208,134.8	0.30%
ACR-700	66,200	2.00	112,341.40	273,803.20	0.30%
GT-MHR	5,394	19.80	204373.27	255,918.33	0.30%
PBMR	8,340	12.90	194,413.74	255,679.38	0.30%
NUREG-0116	35,000	3.10	126,175	238,455	0.30%
WASH-1248	35,000	3.20	147,280	223,965	0.25%

Notes:

1. The reactor vendor supplied the kg uranium product and weight percent U_{235}.
2. The tails assay was assumed to be 0.3% to match NUREG-0116 with the exception of WASH-1248 which used a tail assay of 0.25%.
3. The SWU Quantity and kg Feed Required were calculated using the USEC SWU Calculator.
4. The results have not been normalized to equivalent electrical generation.

Table 5.7-3 10 CFR 51.51, Table S-3- of Uranium Fuel Cycle Environmental Data[a]
[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]
[See Footnotes at end of this table]

Environmental Considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
Natural Resource Use		
Land (acres)		
Temporarily committed[b]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to a 110 MWe coal-fired power plant.
Permanently committed	13	
Overburden moved (millions of MT)	2.8	Equivalent to 95 MWe coal-fired power plant.
Water (millions of gallons)		
Discharged to air	160	=2% of model 1,000 MWe LWR with cooling tower.
Discharged to water bodies	11,090	
Discharged to ground	127	
Total	11,377	<4% of model 1,000 MWe LWR with once through cooling.
Fossil Fuel:		
Electrical energy (thousands of MW-hour)	323	<5% of model 1,000 MWe output
Equivalent coal (thousands of MT)	118	Equivalent to the consumption of a 45 MWe coal-fired power plant.
Natural gas (millions of scf)	135	<0.4% of model 1,000 MWe energy output.
Effluents-Chemical (MT)		
Gases (including entrainment)[c]		
SO_x	4,400	
NO_x[d]	1,190	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	

Table 5.7-3 10 CFR 51.51, Table S-3- of Uranium Fuel Cycle Environmental Data[a]

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]
[See Footnotes at end of this table]

Environmental Considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
Other gases		
F	0.67	Principally from UF_6, production, enrichment, and reprocessing. Concentration within range of state standards- below level that has effects on human health.
HCl	0.014	
Liquids		
$SO\text{-}_4$	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.
$NO\text{-}_3$	25.8	
Fluoride	12.9	
CA^{++}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
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	

Table 5.7-3 10 CFR 51.51, Table S-3- of Uranium Fuel Cycle Environmental Data[a]

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]
[See Footnotes at end of this table]

Environmental Considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
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 the environment.
Ra-226	0.0034	From UF_6 production.
Th-230	.0015	
Th-234	.01	From fuel fabrication plants-- concentration 10 percent of 10 CFR 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	9,100 Ci comes from low level reactor wastes and 1,5000 Ci comes from reactor decontamination and decommissioning -- buried at land burial facilities. 600 Ci comes from mills -- included in tailing 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
Effluents-- thermal (billions of British thermal units)	4,063	<5 percent of model 1,000 MWe LWR.
Transportation (person-rem):		
Exposure of workers and general public	2.5	

Table 5.7-3 10 CFR 51.51, Table S-3- of Uranium Fuel Cycle Environmental Data[a]

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]
[See Footnotes at end of this table]

Environmental Considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
Occupational exposure	22.6	From reprocessing and waste management.

[49FR9381, Mar. 12, 1984; 49FR10922, Mar. 23, 1984]

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 Reprocessing and Waste Management Portion of the LWR Fuel Cycle," NUREG-0116 (Supp. 1 to WASH-1248); 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): and in the record of 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 fuel 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 §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, since 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.

5.8 Socioeconomic Impacts

Section 5.8 describes the socioeconomic impacts of operating the new units. For this ER, socioeconomic impacts include potential impacts on individual communities, the surrounding region, and minority and low-income populations. This section has been segregated into three subsections:

- Physical impacts
- Social and economic impacts
- Environmental justice impacts

5.8.1 Physical Impacts of Station Operation

This section describes the assessment of the potential physical impacts on the nearby communities due to operation of the new units. Potential impacts include noise, odors, exhausts, thermal emissions, and visual intrusions. These physical impacts would be managed to comply with applicable federal, state and local environmental regulations and would not significantly affect the ESP site and its vicinity.

5.8.1.1 Plant Site and Vicinity

There are no residential areas located within the NAPS site boundary. Lake Anna, which was created to meet the cooling supply needs of the station, has public access and is the nearest recreational facility to the ESP site.

The region surrounding the lake is covered with forest and brushwood interspersed with occasional farmland. The population immediately surrounding the lake is about 980 and about 2940 between 2.5 and 5 miles from the ESP site (see Section 2.5.1). The town of Mineral, located about 7 miles southwest of the ESP site, is a small rural community that includes small businesses, houses, and farm buildings. Mineral has a population of 424, according to the Year 2000 census. Because of Mineral’s distance from the ESP site, its residents would not experience any physical impacts from operation of the new units.

5.8.1.2 Noise

The new units would produce noise from the operation of pumps, wet and dry cooling tower fans, water cascading down the wet cooling towers, transformers, turbines, generators, and switchyard equipment. The noise levels would be controlled in accordance with applicable local county regulations. As described in Section 5.3.4, Virginia has no state regulations or guidelines regarding noise limits. The nearby counties (Louisa and Spotsylvania) maintain county ordinances to prohibit unnecessary, unreasonable, or disturbing noise (Reference 1) (Reference 2).

Most equipment would be located inside structures reducing the outdoor noise level. Noise would be further attenuated by distance to the NAPS site boundary. Wet and dry cooling towers would be located outdoors and would generate more significant noise levels.

Closed-cycle, combination dry and wet cooling towers would be used for heat dissipation for Unit 3. Wet cooling towers would remove the heat by spraying the water into a forced or induced air stream. Motor-driven fans would be used to drive air flow. The noise level from the wet cooling towers would be most dominant and would be greater than the near-field noise from fans for the dry towers for Unit 3 and Unit 4. The sound level at the nearest point on the EAB, at approximately 700 feet to the west of proposed cooling tower location, would be less than 65 dBA.

The sound levels were evaluated using vendor-supplied data for typical wet and dry cooling towers. This data, along with an assumed physical configuration of the cooling towers, were modeled using the commercially available “CADNA/A” noise propagation software package. The noise propagation algorithm used in the CADNA/A software is based on ISO 9613, part 2, “Acoustics – Attenuation of sound during propagation outdoors”. Neutral atmospheric conditions were assumed, and with no credit taken for sound attenuation due to structures (other than the cooling towers themselves), vegetation, or changes in terrain. In general, a flat plane was assumed, with a moderate ground absorption coefficient of 0.5. Aside from the cooling tower fans, motors, and water noise, no other sources (e.g., plant pumps, motors, transformers) were modeled and no background noise was included in the evaluation. This is appropriate since, at the closest point on the EAB, the sound levels will be dominated by noise from the cooling towers. For the modeling of the dry cooling towers, the total free field sound power level of each fan was modeled, assuming that half of the power radiates downward from the bottom of the fan deck and most of the remainder radiating from the top of the units. Both the top and bottom of the towers were represented as horizontal area sources encompassing the combined noise from all the individual fans. For the wet cooling towers, the fan discharge power level for each fan was modeled as a point source located just above the top of the fan stack. The wet towers were modeled as three banks of cells, distributed within the area allocated for the cooling towers; two banks with 19 cells and one bank with 14 cells. The water noise from each side of each bank of cells is shown in the table below. The model considered the directional dependence of the source (with one side from each bank of cells facing the general direction of the EAB and the other side facing away from the EAB.) The following noise source sound power levels were used in the assessment:

	Sound Power Level relative to 1 Pico-Watt, dBA	Quantity	Total Sound Power Level relative to 1 Pico-Watt, dBA
Dry Tower Unit 3 Fan Intake	98.5	100	118.5
Dry Tower Unit 3 Fan Discharge	96.8	100	116.8
Dry Tower Unit 4 Fan Intake	83.2	100	103.2
Dry Tower Unit 4 Fan Discharge	81.4	100	101.4
Wet Tower Intake per side (for two 19-cell rows)	119.4	4 (2 sides facing the near-side EAB and 2 sides facing away from the near-side EAB)	—
Wet Tower Intake per side (for one 14-cell row)	118.1	2 (1 side facing toward the near-side EAB and 1 side facing away from the near-side EAB)	—
Wet Tower Discharge	102.6	52	119.8
Service Water Tower Intake per side	113.1	2 (1 side facing toward the near-side EAB and 1 side facing away from the near-side EAB)	—
Service Water Tower Fan Discharge	100.8	4	106.8

The result from this evaluation is lower than the NRC-defined significant level (65 dBA) at the EAB (See Section 5.3.4). The nearest residence is about 3000 feet to the north of the planned cooling tower location (see Figure 5.8-1). Noise levels below 65 dBA are considered to be of small significance (Reference 3). Therefore, the noise impact at the nearest residence would be small and no mitigation would be warranted.

Dry towers would be used for heat dissipation for the new Unit 3 and Unit 4. In order to dissipate enough heat and to minimize the generation of local air turbulence, fans used for dry towers are large and slow. As noted above, noise from the Unit 3 wet cooling towers would be most dominant. However, during operation of dry towers only, the fan noise will be the main noise source at the EAB. At the time of the COL (when design details are known), a confirmatory evaluation will be performed to show that the current analysis of cooling tower noise (conducted as part of this ESP application) remains bounding.

Ambient noise heard by recreational users of Lake Anna under normal conditions includes noise from the existing units. The noise level generated by the operation of the new units would not affect the recreational use of the lake (see Section 5.3.4).

Commuter traffic would be controlled by speed limits. The access roads to the ESP site would be paved. Good road conditions and appropriate speed limits would minimize the noise level generated by the work force commuting to the ESP site.

Section 2.7 of RG 4.2 requires an assessment of the ambient noise level within 5 miles of the ESP site. Particular attention is directed toward obtaining acoustic levels associated with high voltage transmission lines (Reference 4). As presented in Section 3.7.1, 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 and after a decision has been made to proceed with the new capacity. This evaluation would include assessment of noise impacts.

5.8.1.3 **Air**

The new units would have standby diesel generators and auxiliary power systems. Air permits acquired for these generators would ensure that air emissions comply with regulations. In addition, standby diesel generators would be operated on a limited short-term basis. The impact of the operation of the new units on air quality would be small, and would not warrant any mitigation.

Good access roads and appropriate speed limits would minimize the amount of dust generated by the commuting work force.

During normal plant operation, the new units would not use a large amount of chemicals that would generate odors exceeding the odor threshold value.

5.8.1.4 **Thermal Emissions**

Heat dissipation to the atmosphere from operation of the Unit 3 dry and wet cooling towers and Unit 4 dry towers is described in Section 5.3.3.1. Because any increase in overall atmosphere temperature would be very localized to the NAPS site, and there is no residential area within the NAPS site boundary, there would be no heat impacts on nearby communities.

5.8.1.5 **Visual Intrusions**

The nearest residential area is about 3000 feet north of the ESP site and is shielded by forested land. Further, the ESP and cooling tower site grade will be lower than the surrounding terrain, except in the direction of Lake Anna. Given this distance and relative elevations, residents near the site would not have a clear view of the new units. 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 in their view.

The existing units' Turbine Building is about 100 feet above grade and the existing units' containment buildings are about 130 feet above grade. Because the new units' containment building could be approximately 230 feet above grade, the Unit 3 wet and dry towers would be less than 180 feet tall and Unit 4 dry towers would be less than 150 feet tall, small visual impacts from the plant structures would result. Use of these maximum cooling tower structural heights in the evaluation of the visual impacts conservatively maximizes the prediction of that environmental impact.

The use of wet cooling towers for Unit 3 may result in the generation of a vapor plume that would 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 evaluation shows that on an annual average basis, the plume would extend more than 650 feet above the tower, or extend more than 0.25 mile in length approximately 10 percent of the time the wet towers are operating. A description of the plume evaluation, including seasonal average frequency of visible plume, plume height, and plume length, is provided in Section 5.3.3.2.1. As is discussed in Section 5.3.3.2.1, for the plume analysis, in order to conservatively maximize the prediction of the environmental impact due to visible plume, fogging, icing, and salt deposition, a lower profile (74 feet) non-plume-abated wet cooling tower was modeled. Seventy-four feet is the maximum expected non-plume-abated wet tower height.

The reactor design and ancillary facilities have not yet been selected. Depending on the design selected, a visual impact study would be performed and described in the COL application.

5.8.1.6 Other Related Impacts

Water withdrawal and the associated discharge of heated water from the new Unit 3 would be conducted in accordance with federal, state and local regulations that govern water quality. As described in Section 3.4.1, new Unit 3 would use closed-cycle, combination dry and wet cooling towers with the North Anna Reservoir as the make-up water supply and the wet cooling tower blowdown would be discharged to the WHTF. The new Unit 4 would use a dry tower system for heat dissipation.

Roads within the vicinity of the ESP site would experience a temporary increase in traffic at the beginning and the end of the workday period. However, the current road network has sufficient capacity to accommodate the increase, as detailed in Section 5.1.1.1. Therefore, no significant congestion would result from operation of the new units.

5.8.2 Social and Economic Impacts of Station Operation

The social and economic impacts from the operation of new units at the ESP site would be associated with activities related to the daily operation of the new units, and with the social and economic demands on the surrounding region.

Approximately 720 workers would be required for the operation of the new units, about the same as currently required for the existing units. These 720 workers would relocate into the area with their families and, therefore, would represent both a source of income to the community and a potential demand on community services, such as schools and police protection. These 720 employees would translate into an increase in population of about 2900 to the region, assuming each new employee represents a family of four and relocates into the region.

The expected number of permanent workers needed to operate the new units, and their families, would be a small fraction of the total projected population growth in the region. Assuming that the geographic distribution of new employees would be the same as for the existing units, about 200 would settle in Louisa County, 157 in Spotsylvania County, and 102 in Orange County. The remaining 261 would settle in Henrico and Hanover Counties and the City of Richmond.

5.8.2.1 Economic Impacts

The main economic impacts of the new workers and their families on the area would be related to taxes, housing, and purchase of goods and services. Economic impacts related to the operation of the new units would be associated mainly with payment of the plant property taxes.

5.8.2.1.1 Potential Non-Income Taxes related to Operation of New Unit(s)

In Virginia, counties and towns collect most of their tax revenue through property taxes and sales taxes.

The assessed value of the new units would exceed that of the existing units, which have depreciated with time. It is not possible to estimate the actual taxes that would be paid to the regional governments or of the expenditures that the regional governments would incur to accommodate the workforce, at this time. The expenditures by the regional governments would, in part, be related to the size and age distribution of the families of the new employees. Based on the assumption that the new employees would come from outside the region, the regional governments would experience both outflows and inflows of monies as a result of the operation of the new units. Expenditures would be related to the impacts on the local and regional infrastructure due to the increased usage of the school, recreational, medical, fire and police, and transportation systems. The types of non-income taxes and their bases can be addressed and are presented below.

a. **Sales and Use Taxes**

   The Commonwealth of Virginia and Louisa County would experience an increase in the amount of sales and use taxes associated with the operation of the new units, as will other, more developed counties, such as Spotsylvania.

   Additional sales and use tax revenues would also be generated by retail expenditures (restaurants, hotels, and merchant sales) by the new employees and by their families. It is estimated that about half of the day-to-day expenditures during operation would occur in the region.

   The current combined sales and use tax rate in counties adjoining the ESP site is 4.5 percent. Of the 4.5 percent tax rate, 3.5 percent would be paid to the Commonwealth, and 1 percent to the locality.

b. **Property Taxes**

The surrounding counties about the ESP site and the City of Richmond would benefit from additional property tax revenues from two sources associated with the new units: the new units and the new employees through their purchase of housing.

Property taxes would be levied for the increase in value of the NAPS site due to the new units. The property tax payments to Louisa County are presented in Section 2.5.2 and identified as a large beneficial impact for Louisa County. The addition of the new units to the NAPS site would substantially increase the property tax payments.

The existing units have contributed more than 50 percent of the property taxes paid to Louisa County over the past decade, which has allowed the property tax assessment rates within the county to remain substantially below those of neighboring counties. The construction and operation of the new units would serve to maintain the very high percent of the property taxes paid by the various DRI subsidiaries. Overall, the property taxes paid to Louisa County by Virginia Power amounted to about 22.5 percent of the total budget for the County during the 1995–2000 time period. Operation of the NAPS site will continue to be a major benefit to Louisa County when the new units start operating.

The GEIS (Reference 5) points out that the potential effects of electric utility deregulation within Virginia are not known. However, it is reasonable to conclude that the operation of new units should result in a substantial increase in property tax payments.

5.8.2.1.2 Housing

A review of Table 2.5-22 shows that the number of housing units for sale in the region could easily accommodate the expected permanent workforce of 720 new employees. Furthermore, as presented in Section 4.4.2.1.2, the counties in the vicinity of the NAPS site and within the region are addressing the needs of the projected increases in population in their Comprehensive Plans. Because the new workforce income would be good relative to other incomes in the region, it can be expected that the housing purchases would be on the high end of the price range. However, as is presented in more detail in Section 5.8.2.2, the new workers and their families are a small percentage of the populations that the VEC has projected for the Counties and the City of Richmond over the next thirty years. Therefore, the impact of the property taxes paid for housing by these families would be a positive, but not necessarily a very large, benefit to the Counties and the City of Richmond.

Currently, the planned outages of each existing unit (approximately every 18 months per unit) are staggered so that only about 700 to 1000 additional workers per unit would be onsite for a period of 30 to 40 days per outage. It is expected planned outages for each new unit could involve the same numbers of additional workers and would be scheduled so that multiple units would not be worked on simultaneously. This would also reduce the potential for demand exceeding the availability of short-term housing in the immediate vicinity of the NAPS site.

As presented in Section 4.4.2, within the region — particularly in the City of Richmond and Henrico County — there are sufficient numbers of housing units available for rent, if needed, to accommodate the total workforce required in the event there are simultaneous outages of two or more units.

5.8.2.2 **Social Impacts**

The communities with the greatest potential for social impact associated with the installation and operation of new units at the NAPS site are in Henrico, Hanover, Louisa, Orange, and Spotsylvania Counties, and in the City of Richmond. The permanent new employees, would relocate with their families to the region. Depending on the number of families that move into a given area and the number of children and their ages, it is possible that social impacts would be recognized locally.

The VEC has developed for the counties and some cities in Virginia preliminary local population projections for years 2000 to 2030. These projections are presented in Table 5.8-1 for the counties within a 50-mile radius around the ESP site and for the City of Richmond (Reference 6). The population of the City of Richmond is projected to remain flat from year 2000 to 2020 and then to increase by about 13,000 between 2020 and 2030, while Henrico County will grow about 15 percent over the 30-year period for a total increase in population of 41,900. Hanover and Spotsylvania Counties are projected to have the greatest sustained growth over this period with Spotsylvania doubling in population and Hanover increasing by 53,014, about a 60 percent increase in population. Louisa and Orange Counties are projected to grow by 10,587 (41 percent increase) and 12,723 (49 percent increase), respectively, over the thirty years, with fairly steady growth projected to occur over the entire time period.

Table 5.8-1 VEC Preliminary Local Population Projections, 2000–2030

County	2000	2010	2020	2030	Total Increase
Louisa County	25,627	29,123	32,565	36,214	10,587
Hanover County	86,320	105,934	122,751	139,334	53,014
Spotsylvania County	90,395	124,933	153,032	181,394	90,999
Orange County	25,881	30,414	34,384	38,604	12,723
Henrico County	262,300	271,632	281,059	304,200	41,900
Richmond City	197,790	198,390	199,329	212,337	14,547

If, as assumed, the distribution of the permanent work force would be about the same as the current distribution, then the increase in operating personnel would have a small impact on the infrastructure or social services in the vicinity or in the general region of the ESP site.

The estimated peak workforce of 5000 over a 5-year construction period would have a moderate effect on the transportation network in the vicinity and region. However, permanent mitigation measures to reduce or eliminate this effect would be implemented, as necessary, during, or prior to, construction. These permanent measures would also effectively reduce or eliminate any such impacts during operation because the total operating workforce for the existing and new units is not expected to exceed 1500 workers.

Implementation of the permanent transportation mitigation measures proposed for the construction of the new units would also result in small transportation-related impacts during operation of the new units.

5.8.2.2.1 Schools and Recreational Areas

a. **Schools**

As presented in Section 2.5.2, only Louisa and Orange Counties currently have potential limits to the number of students that could be assimilated by their systems into each grade level if a sudden large influx of families were to relocate into these areas. However, it is reasonable to conclude that the future updates to the County Comprehensive Plans for these counties would include funding for new schools, given the projected increases in their populations. Therefore, an increase of 200 families in Louisa County and about 157 families in Orange County should have a small impact on the school system.

b. **Recreational Areas**

Recreational areas are described in Section 2.5.2. By the year 2020, Louisa County population is projected to increase by about 7,000. Of these, only about 800 would be due to the new employees and their families (i.e., 200 workers and their families) relocating into the county. The numbers of new workers relocating with their families into the counties other than Louisa County or into the City of Richmond would be less than those relocating into Louisa County.

The population increase in the potentially impacted counties other than Louisa County is expected to be equal to or greater than that the increase in Louisa County. To accommodate these increases in population, the surrounding counties would need to address and fund new recreational areas as they update their Comprehensive Plans.

The GEIS concludes that impacts of the existing employees and their families on the parks and other recreational areas within the region are small. This would also apply to the employees of the new units and their families who would relocate to the area because they represent a small fraction of the projected population growth for the area.

5.8.2.2.2 Public Services

Public services addressed include water supply, sewer systems, transportation network, and police, fire and medical facilities. The baseline for these services is provided in Section 2.5.2.

a. **Water and Sewer Systems**

As presented in Section 2.5.2, water supply would not be a problem for Henrico County, the City of Richmond, Spotsylvania County, or Hanover County, because they currently have sufficient water sources and are expanding their water systems. Except for the towns in Louisa and Orange Counties, groundwater is the source of water for the residents and there is no concern about the availability of such groundwater for future growth in the two counties, as identified in the SEIS.

Sewer systems in the more urbanized counties and the City of Richmond are expected to accommodate their projected population growths. The residents in the more rural counties normally have individual septic systems, which are expected to be able to accommodate the projected population growth. Only a few towns in these rural counties have connections to a sewer system with a publicly-owned treatment works, and these towns are not currently planning major expansions of their sewer systems.

For Louisa County and Orange County, the projected growth in population between 2000 and 2010 is 3,496 and 4,533, respectively; values that greatly exceed the projected number of new employees and their families. These projections for population growth and their possible impacts on the local infrastructure, including water and sewer services, have been incorporated into the comprehensive land use plans for both counties. Although there are plans to construct new treatment plants or to expand existing facilities in the towns of Louisa County and Orange County, these are not expected to accommodate many new houses. The limited number of sewer and water hookups that will be available would serve to restrict the number of new homes that will be built in the existing towns.

Louisa County is planning for construction of about 300 houses per year for the foreseeable future. New employees who wish to relocate their families to Louisa County should have sufficient new housing in the County. However, because most of this housing would be outside the towns, the relocated families' impacts on these water and sewer systems would be small.

b. **Transportation Network**

Section 4.4.2 discusses a number of permanent changes to the regional and local transportation network that would reduce any potential adverse impacts generated by the influx of 5,000 construction workers during construction of the new units. These permanent changes would also reduce or eliminate any potential adverse impacts that could be generated by the operating workforce of about 720 for the new units who have relocated with their families into the region.

c. **Police, Fire, and Medical Facilities** Section 2.5.2

Section 2.5.2 addresses police, fire, and medical facilities.

The police and fire departments within ten miles of the NAPS site are part of the existing emergency response plan for the existing units. The police departments are responsible for the proper evacuation of the area in the event of an emergency at the NAPS site. This would continue to be the case when the new units become operational.

Medical facilities generally consist of local physicians' offices in the surrounding counties. However, there are major medical facilities in Fredericksburg, Charlottesville, Mechanicsville, and the City of Richmond that are readily accessible to the counties' residents.

A review of the Comprehensive Plans for the counties reveals that the need for additional medical, fire, and police facilities is being assessed. Where the planners assess that the demands of the growth in population would create a need, the intent of the various county plans is to add new facilities or expand existing facilities. The increase of 720 new employees and their families would represent a small fraction of the expected population growth in the vicinity and region around the NAPS site. Therefore, no unforeseen demands would result from the operation of the new units.

5.8.2.3 **Impacts on Lake Anna Recreational Area**

Lake Anna is a recreational area that attracts year-round residents (including both commuters and retirees) as well as visitors during the summer and early fall months. Any impacts that would reduce the number of visitors in the area due to the operation of the new units could have a socioeconomic impact on the local area.

Section 5.8.1 assesses the relative physical impacts on the environment created by the operation of the new units and concludes that these impacts would be small. Since the types of reactor and ancillary facilities have not yet been selected, there is the potential for an aesthetic impact on the users of Lake Anna. The potential heights of the containment (reactor) building and of cooling towers are larger than the sizes of the existing structures, which have the potential to result in a visual impact. The cooling system design would take into consideration the need to minimize the visual impact of any cooling towers to the extent reasonable and practicable. Based on the design selected, a visual impact study would be performed and described in the COL application. The study would assess the physical layout on the site of the reactor and ancillary facilities with respect to the existing facilities that would reduce the potential aesthetic impact of the new units on the users of the lake to the extent reasonable and practicable.

Although not expected to be a major issue, a noise study may be appropriate prior to final design of the cooling system. If a noise study determines that the incremental increase in noise created by the operation of the new units is intrusive to continued recreational enjoyment of the lake, then commonly applied mitigation measures would be considered to determine if they are effective in reducing the noise and if they are reasonable and practicable at the ESP site.

In addition to potential aesthetic and noise impacts on the ESP site, Dominion evaluated shoreline areas in an effort to assess, in general, various impacts of raising normal operating lake level 6 inches to 12 inches above 250 ft msl, if a Virginia permitting agency process determined the need for such an action. Raising normal operating lake level is not being proposed to demonstrate site suitability. VDEQ 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.

Dominion's evaluations included:

- a review of the US FWS National Wetlands Inventory, and various Lake Anna topographical maps;
- a physical survey by boat of the best estimate of areas that could be impacted; and
- an aerial survey of uplake, low gradient tributaries.

Because of the generally steep shoreline topography, the conclusion is that a rise in water level of 6 inches to 12 inches would result in minimal changes to the types and amounts of wetlands other than to shift the prevailing vegetation in gradually sloping tributaries in an upland direction.

In many of the headwater lake tributaries, with gradually sloping shoreline, a successional shift, or movement in wetland vegetation in an upland direction with forest shrub/scrub transitioning to emergents, and emergents to submersed, would be expected. Typical vegetation included rushes and sedges with river birch grading to yellow poplar with increases in elevation. These shifts would likely develop over several years and depend on conditions such as soil type, water clarity and extent of canopy cover.

Rushes were observed intermittently in these areas. Due to the altered shoreline in some areas along Contrary Creek, the lateral extent of flooding and resulting changes to the types and amounts of wetlands appear to be less than in the neighboring headwater, Freshwater Creek.

Along the main lake channel toward the dam, both upstream and downstream, some shoreline topography had relatively steep banks. Some of these banks were nearly vertical gradients due to the effect of wind and wave action undercutting the banks. Several points and coves on either shoreline toward the dam confirmed that a lake level rise would likely result in little lateral or upland change within these areas. Much of the main lake shoreline is more exposed to wind and wave action and would unlikely contain rooted vegetation.

Uplake, near the southern shore about one mile above the Route 208 bridge, there is an elevated area of cleared and gently sloping land which would not be flooded by the postulated water level increase. There appeared to be dormant water willow in a protected area adjacent to this land.

A helicopter survey of the upper lake followed a boat survey, specifically to view the low gradient tributaries in both the North Anna and Pamunkey arms. The survey confirmed that changes associated with an increased water level would be most evident in these areas and result in the likely shift of wetland vegetation in an upland direction. Beaver activity was observed throughout these upper tributaries, with their dams already acting to flood and alter the wetland landscape. A direct result of the aerial survey was an identification of about 15 areas, ranging in size of approximately one-half acre to 25 acres, which could be impacted as described.

As a result of the evaluations described above, including ground-truthing points around the lake, the conclusion is that a 6 inches to 12 inches water level increase above the normal 250 ft msl, depending on seasonal variation in precipitation and lake management, over time, would most likely result in little to no net loss of wetland areas impacted, with many areas remaining largely unchanged. Other areas, most notably the gradually sloping headwater tributaries, would exhibit an upland shift in the vegetation community concurrent with any sustained increase in normal water level.

In addition to wetland impacts, raising the lake level could increase localized flooding potential and downstream flows, and would likely affect usage of some residential and marina boat ramps and docks, including Lake Anna State Park. These might need some modification to avoid impacting the year-round and seasonal recreational usage of the lake.

5.8.3 Environmental Justice Impacts

This section addresses the potential for disproportionately high and adverse human health or environmental impacts during the operation of the new units on minority or low-income populations who reside within a 50-mile radius of the new units at the ESP site.

5.8.3.1 New Unit(s) at the North Anna Power Station Site

The geographic distribution of minority and low-income populations within 80 km (50 miles) of the NAPS site are those that were determined for Section 2.5.4, that is, for purposes of this section, the distribution of such populations within the region is assumed to remain the same as, or about the same as, that identified in the 2000 Census. The analysis for Section 2.5.4 is based on data from the 2000 Census and applies the following definitions:

A minority population or low-income population exists if either of the following criteria are met:

1. A “minority population” is considered to be present if: 1) the minority population in the census block group or environmental impact site exceeds 50 percent, or 2) the minority population percentage of the environmental impact area is significantly greater (typically at least 20 percentage points) than the minority population percentage in the geographic area chosen for the comparative analysis, for example, the county or State, or

2. A “low-income population” is considered to be present if: 1) the low-income population in the census block group or the environmental impact area exceeds 50 percent, or 2) the percentage of households below the poverty level in an environmental impact area is significantly greater (typically at least 20 percentage points) than the low-income population percentage in the geographic area chosen for the comparative analysis.

As presented in Section 2.5.4, the census tracts with at least 50 percent of their area within the 80-km (50-mile) distance from the NAPS site were included in the analysis. The distribution of minority and low-income populations is presented in the text and is graphically presented in Figure 2.5-14 and Figure 2.5-15.

The assessment of the potential for environmental justice impacts associated with the operation of the new units at the ESP site was based on the following information:

- The results of the analyses of the physical impacts of operation presented in Section 5.8.1 and the social and economic impact analyses presented in Section 5.8.2.
- The DBA analyses presented in Section 7.1.
- There are relatively few minority and low-income populations in the environmental impact area and none in proximity to the ESP site. The nearest minority or low-income populations are 20 km (about 12 miles) from the ESP site.

Section 5.8.1 identifies no large or moderate physical impacts from the operation of the new units at the ESP site. Therefore, there could be no large or moderate physical impacts on the minority or low-income populations.

Socioeconomic impacts identified in Section 5.8.2 would be beneficial throughout the region. The potential does exist for adverse visual and/or noise impacts related to the size of the new units and associated ancillary equipment. However, these potential adverse social impacts would be small and restricted to the immediate area of the site. Socioeconomic impacts would, therefore, not be an issue at the distance of the nearest minority or low-income populations.

The calculated environmental doses due to radiological impacts from DBAs are analyzed in Section 7.1. The analyses demonstrated that the evaluated dose consequences of such accidents would be within the regulatory limits. These doses are calculated at the EAB and the LPZ using NRC-approved methodology. The EAB is 5000 feet and the LPZ is six miles from the existing units, much closer to the ESP site than the nearest minority or low-income populations.

Given the distances to the nearest minority or low-income populations, the calculated low environmental doses from the DBA analyses at the EAB and LPZ, and the small potential socioeconomic impacts, no disproportionately high or adverse human health or environmental impacts on minority or low-income populations would arise from operation of the new units, alone or in combination with the existing units at the NAPS site.

Section 5.8 References

1. Louisa County Ordinance, Section 51-3, Louisa County, Virginia.

2. Spotsylvania County Ordinance, Section 14-14, Spotsylvania County, Virginia.

3. NUREG-1555, Standard Review Plan for Environmental Reviews for Nuclear Power Plants, U.S. Nuclear Regulatory Commission, October 1999.

4. Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations, U.S. Nuclear Regulatory Commission, Revision 2, July 1976.

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

6. Virginia Employment Commission (VEC) Website, www.vec.state.va.us, accessed on March 28, 2003.

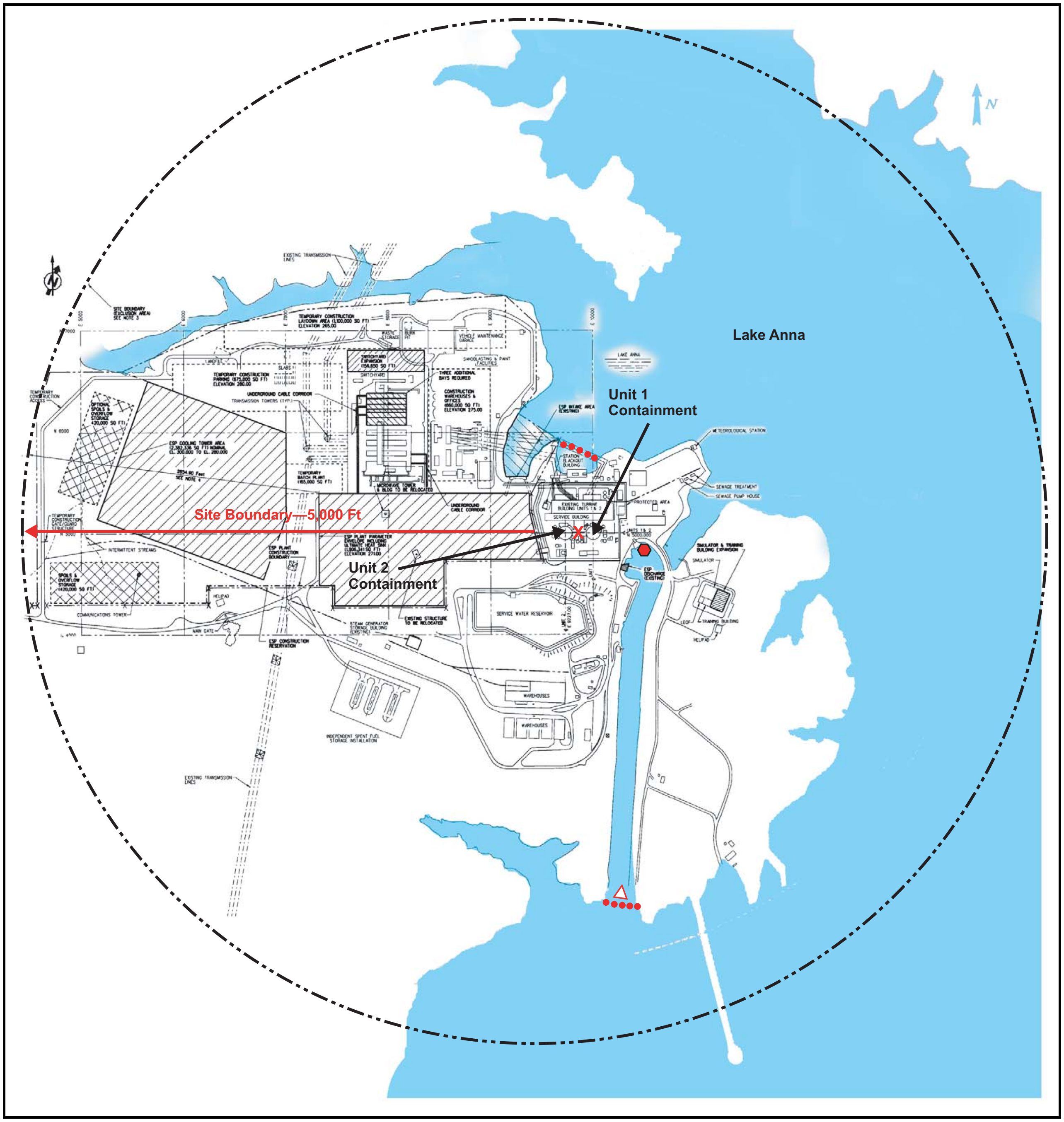

Figure 5.8-1   Site Boundary and Cooling Tower Envelope Area

5.9 Decommissioning

According to Section 5.9 of NUREG-1555 (Reference 1), studies of social and environmental effects of decommissioning large commercial power generating units have not identified any significant impacts beyond those considered in the Final Generic Environmental Impact Statement (GEIS) on decommissioning (Reference 2). The GEIS evaluates the environmental impact of the following three decommissioning methods:

- DECON – The equipment, structures, and portions of the facility and site that contain radioactive contaminants are removed or decontaminated to a level that permits termination of the license shortly after cessation of operations.
- SAFSTOR – The facility is placed in a safe stable condition and maintained in that state until it is subsequently decontaminated and dismantled to levels that permit license termination. During SAFSTOR, a facility is left intact, but the fuel has been removed from the reactor vessel and radioactive liquids have been drained from systems and components and then processed. Radioactive decay occurs during the SAFSTOR period, thus reducing the quantity of contaminated and radioactive material that must be disposed of during the decontamination and dismantlement.
- ENTOMB – This alternative involves encasing radioactive structures, systems, and components in a structurally long-lived substance, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level that permits termination of the license.

NRC regulations do not require an ESP applicant to select one of these decommissioning alternatives or to prepare definite plans for decommissioning. These plans are required by 10 CFR 50.82 after a decision has been made to cease operations. General decommissioning environmental impacts are summarized in this section, since detailed plans or a selection of alternatives is not required for an ESP.

Decommissioning of a nuclear facility that has reached the end of its useful life has a positive environmental impact (Reference 2). The major environmental impact, regardless of the specific decommissioning option selected, is the commitment of small amounts of land for waste burial in exchange for the potential re-use of the land where the facility is located (Reference 2).

Dominion would control radiological doses during decommissioning with appropriate work procedures, shielding, and other occupational dose control measures similar to those used during plant operation. Experience with decommissioned power plants has shown that the occupational exposures during the decommissioning period are comparable to those associated with refueling and plant maintenance when it is operational (Reference 2). Each potential decommissioning alternative would have radiological impacts from the transport of materials to their disposal sites. The expected impact from this transportation activity would not be significantly different from normal operations(Reference 1, Section 5.9).

NRC regulations do not require the establishment of decommissioning financial assurances to support an ESP application (Reference 1, Section 5.9). Therefore, this environmental report does not discuss decommissioning financial assurances.

Section 5.9 References

1. NUREG-1555, *Environmental Standard Review Plan*, U.S. Nuclear Regulatory Commission, March 2000.

2. NUREG-0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities,* U.S. Nuclear Regulatory Commission, October 2001.

5.10 Measures and Controls to Limit Adverse Impacts During Operation

This section summarizes the potential adverse impacts, along with the measures and controls to be used to minimize those impacts as identified in Section 5.1 through Section 5.9.

The following measures and controls would be used in limiting adverse environmental impacts:

- Compliance with the applicable federal, Virginia, and local laws, ordinances, and regulations that prevent or minimize environmental impacts (e.g., solid waste management, erosion and sediment control, air emission control, noise control, storm water management, spill response and cleanup, hazardous material management).
- Compliance with applicable requirements of permits and licenses required for operation (e.g., VPDES Permit, Operating License).
- Compliance with Virginia Power procedures applicable to environmental control and management.

The measures and controls presented above would be implemented in concert with the specific measures and controls shown in Table 5.10-1. These measures and controls are considered feasible from both a technical and economic standpoint. In addition, they are expected to be adequate to avoid or mitigate the identified potential adverse impacts associated with operation of the new units.

The columns in Table 5.10-1 listed under the “Potential Impact Significance” are those elements listed in NUREG-1555, Section 5.10, relating to the various issues addressed in the operational impact assessment sections of the Environmental Report (i.e., Sections 5.1 – 5.9). The significance rating (i.e., [S]mall, [M]oderate, or [L]arge) provided for each element in the table has been determined by viewing the potential impact in terms of its significance following implementation of the associated mitigation measures and controls.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Feasible and Adequate Measures/Controls**
5.1 Land-Use Impacts																
5.1.1 The Site and Vicinity			S	S											• The NAPS site is zoned by Louisa County as “industrial.” This designation would not change due to operation of the new units. • The change in temperature at the discharge point of WHTF due to operation of new units would be negligible and would not impact recreational use. • The impact of heat and moisture dissipation from new wet and dry cooling towers on overall atmospheric temperature is limited to NAPS site boundary. • Increased traffic loads on existing network from workforce during operations	• Comply with VPDES permit requirements imposed on water discharges from operation of the new units. • No new public roads needed for operation of the new units. Potential increases in traffic would be mitigated through effective traffic management.
5.1.2 Transmission Corridors and Offsite Areas															• The existing transmission lines and corridors have sufficient capacity for the total output of the existing and new units.	None
5.1.3 Historic Properties														S	• No impacts identified beyond those associated with construction of the proposed new units.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Feasible and Adequate Measures/Controls**
5.2 Water-Related Impacts																
5.2.1 Hydrologic Alterations and Plant Water Supply									S						• Reduction in the volume of water available to be released from the North Anna Dam • Reductions in Lake Anna water levels from current values during periods of extended drought	• Practices to minimize the hydrologic alterations may be implemented. • During periods of extended drought, dry cooling towers would be put into service to dissipate a portion of waste heat from Unit 3 to minimize the make-up water requirements.
5.2.2 Water-Use Impacts									S						• Reduction in the volume of water available to be released from the North Anna Dam • Reductions in Lake Anna water levels from current values during periods of extended drought • There would be no appreciable water quality impacts due to blowdown from the Unit 3 wet cooling towers. There would be no blowdown from the Unit 3 and Unit 4 dry cooling towers.	• During periods of extended drought, dry cooling towers would be put into service to dissipate a portion of waste heat from Unit 3 to minimize the make-up water requirements.
5.3.1 Intake System															The make-up water intake system for Unit 3 would consist of a new intake structure and located in a cove on the south shore of Harris Creek to withdraw water from North Anna Reservoir. The area to be occupied by this intake system, originally planned for the intake of the previously abandoned Units 3 and 4, is adjacent to the cove that houses the intake of the existing units.	

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Potential Impact Significance [a, b] Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.3.1.1 Hydrodynamic Descriptions and Physical Impacts															• Evaluation concludes that the potential for scouring of the lake bottom, erosion of the shoreline, increased turbidity, and increased siltation from operation of the new units would be small.	• Stabilizing the banks of the channel to the screen house and pump house would be considered.
5.3.1.2 Aquatic Ecosystems															• Increase in impingement of fish from new water intake system. Increases in impingement by important species would represent only a small percentage of the estimated standing crop in Lake Anna. Any increased impingement would be offset by natural compensation due to a stable, healthy, and diverse fish population. • Increase in entrainment of larval fish from new make-up water intake system would be very small. Mortality rates for eggs and larval fish of important species in Lake Anna due to natural causes are extremely high. In spite of this, the fishery in Lake Anna has remained stable, healthy, and productive. Any slight increases in mortality due to entrainment from the additional intake systems would have a negligible impact on the Lake Anna fishery.	• The intake structure for the new Unit 3 at the ESP site would meet Section 316(b) of the Clean Water Act and the implementing regulations, as applicable. • A fish return system based on the latest technology available during detailed engineering would be considered for incorporation into the intake system.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.3.2 Discharge System															Blowdown from Unit 3 wet cooling towers would be sent via the WHTF to the North Anna Reservoir for heat dissipation. The blowdown discharge volume from Unit 3 is very small when compared with the discharge volume from the existing Units. The increase in water temperature due to operation of new units would be negligible.	
5.3.2.1 Thermal Description and Physical Impacts															• The blowdown discharge volume from Unit 3 is very small when compared with the discharge volume from the existing units. The increase in water temperature due to operation of new units would be negligible. • Assuming new Unit 3 on closed-cycle, combination dry and wet cooling tower system and new Unit 4 on a closed-cycle dry tower system, there are no expected impacts such as scouring of the lakebed or erosion of the shoreline at the current discharge point (i.e., Dike 3) from operation of the existing units in combination with the new units. No mitigation measures or control are proposed beyond overall cooling system design. • Evaluation concludes that the potential for scouring of the lake bottom, erosion of the shoreline, increased turbidity, and increased siltation from operation of the new units would be very small.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.3.2.2 Aquatic Ecosystems															• Negligible impact from scouring and sediment transport due to increased water discharge flows.	• Maintain compliance with VPDES water quality standards and permitted discharge limits for cooling water discharges to the North Anna Reservoir.
															• The addition of new Unit 3 would cause no thermally-induced impact on the fish population in Lake Anna. Sudden changes in discharge temperature are typically minimal with a nuclear power facility since units do not come on and off-line regularly. This limits the potential for heat or cold shock to fish.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference	**Noise**	**Erosion and Sediment**	**Air Quality**	**Traffic**	**Wastes**	**Surface Water**	**Groundwater**	**Land-Use**	**Water-Use**	**Terrestrial Ecosystems**	**Aquatic Ecosystems**	**Socioeconomic**	**Radiation Exposure**	**Other (site-specific)**	**Impact Description or Activity**	**Feasible and Adequate Measures/Controls**
5.3.3 Heat-Discharge System															N/A	
5.3.3.1 Heat Dissipation to the Atmosphere															• Operation of Unit 3 wet cooling towers may produce visible plume, salt drift and steam fog. Salt deposition rates would be below threshold value beyond the site boundary at ground levels. • Most of the fogging from the wet cooling towers would occur within site boundary in winter and spring. No icing would be anticipated within or beyond the site boundary • There would be no plume associated with the Unit 3 and Unit 4 dry cooling towers, and consequently no potential interaction with other permitted air emission sources at the existing units (e.g., standby diesel generators and auxiliary power systems) at the site.	None
5.3.3.2 Terrestrial Ecosystems	S													S	• Predicted noise from heat dissipation system would be similar to or less than NAPS site current operating levels. • Potential for avian collisions with dry and wet cooling towers would be small.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

	Potential Impact Significance [a, b]															
Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.3.4 Impacts to Members of the Public	S				S	S	S		S						• Thermal effluent discharge from Unit 3 wet cooling tower systems would not alter the temperature regime in Lake Anna. Assessed temperature increases due to addition of Units 3 and 4 would be insignificant and would not contribute to an environment conducive to the reproduction and growth of thermophilic micro-organisms in the WHTF or alter the recreational uses of Lake Anna. • The recently upgraded on-site sewage treatment plant at the NAPS site includes disinfection to reduce coliform bacteria and other micro-organism to levels that meet Virginia water quality standards. • Small potential for offsite noise impacts from wet and dry cooling tower system operation. Modeled peak noise levels from operation of the composite cooling system would be below threshold levels.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference		Potential Impact Significance [a, b]															
		Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.4	Radiological Impacts of Normal Operation																
5.4.1	Exposure Pathways			S			S	S	S	S	S	S	S	S		• Potential for small discharges of radioactive liquids and gases to the environment. • Direct dose contribution from the new units would be negligible.	• Sources of radiation at the new units would be contained similar to the existing units.
5.4.2	Radiation Doses to Members of the Public													S		See Section 5.4.3 for discussion of impacts to members of the public.	
5.4.3	Impacts to Members of the Public													S		• Potential doses to the public from liquid radwaste effluent releases to the discharge canal and WHTF and gaseous pathway releases. Calculated doses to public through liquid and gaseous pathways are within the design objectives of 10 CFR 50 Appendix I and within regulatory limits of 40 CFR 190.	None
5.4.4	Impacts to Biota Other than Members of the Public													S		• Potential doses to biota from liquid and gaseous effluents. Although there are no acceptance criteria specifically for biota, there is no scientific evidence that chronic dose rates below 100 mrad/day are harmful to plants and animals. The biota doses are all less than 1 mrad/day.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Potential Impact Significance [a, b]: Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.5 Environmental Impact of Waste																
5.5.1 Nonradioactive-Waste-System Impacts			S		S	S			S		S				• Increased volume of discharged effluent. • Increased chemicals and other pollutants in the discharge effluent. • Increased storm water discharge • Increase in total volume of solid waste generated. • Potential increase in gaseous emissions. • Increase in total volume of sanitary waste generated.	• Water availability issues regarding the North Anna River are addressed via regulated releases from the North Anna Dam. • Comply with applicable VPDES water quality standards for any discharge from Dike 3. • Prepare and implement a new operational Storm Water Pollution Prevention Plan to avoid and/or minimize releases of contaminated storm water. • Use approved transporters and offsite landfills for disposal of solid waste. Continue existing units' program for reuse and recycling of nonradwastes. • Operate any new minor air emission sources in accordance with applicable regulations and permits. • Modify (if necessary) existing sanitary waste treatment systems to accommodate increased volume.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Potential Impact Significance [a, b] Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
5.5.2 Mixed Waste Impacts					S	S	S		S				S	S	• Expected annual generation of between 15–30 cubic feet of mixed liquid waste and 5–10 cubic feet of mixed solid waste. • Potential chemical hazardous and occupational exposure to radiological materials during handling and storage onsite. • Potential exposures to onsite workers and emergency response personnel during accidental releases and cleanup activities.	• Limit need to manage and dispose of mixed waste through: 1) source reduction; 2) recycling options; 3) treatment. • Develop a Waste Minimization Program, to address mixed waste inventory management; equipment maintenance; recycling and reuse; segregation; treatment (decay in storage); work planning; waste tracking; and awareness training. • Implement a program to manage wastes stored onsite in compliance with applicable EPA and NRC regulatory requirements. • Implement spill prevention and response plans and procedures to address hazards associated with managing mixed wastes. Include in plans and procedures measures for response personnel training and protective equipment.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Potential Impact Significance [a, b]														Impact Description or Activity	Feasible and Adequate Measures/Controls
	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)		
5.6 Transmission System Impacts																
5.6.1 Terrestrial Ecosystems	S		S							S					• Air emissions and nuisance noise from use of helicopter to maintain transmission corridors. Virginia Power's current maintenance activities for the transmission corridors are infrequent and limited to the localized areas of the corridor. No new maintenance practices are expected for the new units.	None
5.6.2 Aquatic Ecosystems											S				• Potential impacts to mussel species from maintenance of transmission corridors. Although some mussel species occur in Louisa County, there are no confirmed accounts of mussels in watercourses crossed by existing transmission lines. There are no mitigation measures since there are no planned changes to transmission corridor maintenance practices for the proposed new units.	None
5.6.3 Impacts to Members of the Public	S													S	• Based on an initial evaluation, the existing transmission lines and corridors have sufficient capacity for the total output of the existing and new units. Mitigation of potential impacts from electric shock, EMF exposure, noise, or visual impacts would be unchanged.	None

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference		Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
		Potential Impact Significance [a, b]															
5.7	Uranium Fuel Cycle Impacts																
5.7	Uranium Fuel Cycle Impacts (i.e., relative to the reference LWR)			S			S							S		• Yellowcake production and uranium conversion impacts such as energy required, emissions, and water. • Air emissions from fossil fuel plants supplying the gaseous diffusion plant. • Production of UO_2 during fuel fabrication • Radioactive waste management from operations, and decontamination and decommissioning.	• Select mining techniques that minimize potential impacts. • Consider use of new technology that requires less uranium hexafluoride. • Consider use of centrifuge process over gaseous diffusion process, which can significantly reduce energy requirements and environmental impacts. • Consider use of new technologies with less fuel loading to reduce energy, emissions and water usage. Projected impacts of TRISO fuel plant would be less than existing air, water, and solid waste regulations. • Consider use of new gas-cooled reactor technologies that can result in generation of far less low-level wastes.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
	Potential Impact Significance [a, b]															
5.8 Socioeconomic Impacts																
5.8.1 Physical Impacts of Station Operation	S		S	S				S						S	• Noise associated with dry and wet cooling towers would be below level considered nuisance to public at the nearest residence. • Potential impacts from air emissions associated with diesel generators and auxiliary power systems • Potential visual impacts to surrounding areas due to new buildings, and wet and dry cooling towers. • Local roads would experience increased operations traffic but have sufficient capacity without implementation of additional mitigation measures or controls.	• Comply with applicable VDEQ permit limits and regulations when installing and operating air emission sources. • Perform noise study as part of final design for dry cooling towers. • Perform visual impact study for new structures on site, including dry and wet cooling towers, as part of final design.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Section Reference		Noise	Erosion and Sediment	Air Quality	Traffic	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/Controls
		Potential Impact Significance [a, b]															
5.8.2	Social and Economic Impacts of Station Operation												S		S	• Increase need for community services up to 2900 persons. Overall impact to services in the surrounding counties would be small. Predicted workforce is a small fraction of the total projected population growth in the region. • Revenue from sales and use taxes would be beneficial to Louisa County. • Property taxes paid by new workers in the region would be beneficial but small relative to those already obtained from the regional population. • Potential aesthetic impacts (e.g., visual, noise) to residences and recreational users of Lake Anna	• Perform noise study as part of final design for dry and wet cooling towers. • Perform visual impact study for new structures on site, including dry and wet cooling towers, as part of final design.
5.8.3	Environmental Justice Impacts															• No disproportionatly high impacts on minority or low-income populations resulting from operation of the proposed new units.	None
5.9	Decommissioning																
5.9	Decommissioning															• Potential radiation exposure related to decommissioning, including transportation of materials to disposal sites. • Decommissioning methods are expected to produce impacts equivalent to operations.	• The significance of the impacts is unknown because the decommissioning methods have not been chosen. No mitigation measures or controls are proposed at this time.

a. The assigned significance levels [(S)mall, (M)oderate, or (L)arge are based on the assumption that for each impact, the associated proposed mitigation measures and controls (or equivalents) would be implemented.

b. A blank in the elements column denotes “no impact” on that specific element due to the assessed impacts.

Chapter 6 Environmental Measurements and Monitoring Programs

This chapter describes the environmental measurement and monitoring programs for the new units. Some of the programs at the existing units would constitute the primary monitoring efforts that would be relied on if a decision to add additional capacity at the ESP site was made.

The discussion of environmental measurements and monitoring programs is divided into the following sections:

- Thermal Monitoring (Section 6.1)
- Radiological Monitoring (Section 6.2)
- Hydrological Monitoring (Section 6.3)
- Meteorological Monitoring (Section 6.4)
- Ecological Monitoring (Section 6.5)
- Chemical Monitoring (Section 6.6)
- Summary of Monitoring Programs (Section 6.7)

Monitoring details (e.g., sampling equipment, constituents, parameters, frequency, and locations) for each specific phase of the overall program are described in each of these sections.

6.1 Thermal Monitoring

This section describes the thermal monitoring program that would be implemented to monitor the effects of new units at the ESP site.

6.1.1 Existing Thermal Monitoring Program

Thermal monitoring is currently being conducted in Lake Anna in accordance with VPDES permit number VA-0052451, which was established by VDEQ for the existing units (Reference 1). The permit limits the total maximum rejected heat load from the existing units to 1.354×10^{10} Btu per hour and requires reporting of the daily rejected heat, measured as a percentage of the combined rated power level. The permit also prescribes a thermal monitoring program that consists of taking two sets of water temperature measurements in the cooling lake system: a) continuous water temperature monitoring; and b) water temperature profiling (thermal plume survey). The temperature monitoring program is described in more detail below.

Fixed water temperature recorders continuously record water temperatures at 11 locations: 10 in the North Anna Reservoir and WHTF areas, and one in the North Anna River downstream of the dam (Table 6.1-1 and Figure 6.1-1) (Reference 1). Temperature measurements at all stations, except NALST10, are taken near the water surface. At station NALST10, the water temperature measurement is taken at 3 m below the water surface. Temperature readings are reported in degrees Celsius in accordance with the VPDES permit on the following basis: 1) monthly maximum daily temperature, and 2) monthly mean of daily high, daily mean, and daily low.

During water temperature profiling, water temperatures are recorded during daylight hours from the surface to the bottom at one-meter intervals at Stations A to N (Figure 6.1-2) (Reference 1). The temperature profiling is conducted during at least two quarters per year, such that one measurement quarter is always during the July-to-September quarter, and the remaining quarter is alternated every year.

6.1.2 **Pre-Application, Pre-Operational, and Operational Thermal Monitoring**

The current thermal monitoring plan has provided sufficient thermal data to establish baseline conditions prior to any construction. This program would be continued for pre-operational monitoring of the new units (while under construction) to establish a baseline for identifying and assessing the environmental impacts resulting from operation of the new units. The same program would continue to be used for operational monitoring of the new and existing units.

Section 6.1 References

1. VPDES Permit No. VA 0052451, *Authorization to Discharge Under the Virginia Pollutant Discharge Elimination System and The Virginia State Water Control Law*, Commonwealth of Virginia, Department of Environmental Quality, January 11, 2001.

Table 6.1-1 Water Temperature Recorder Station Locations

Station	Site Description	Monitoring Depth
NALST10	Lake Anna: Mid-level in Lake in the flow through Lake Anna Dike 3	At 3 m water depth
NALBRPT	Lake Anna: near Burruss Point	Surface
NALTHIS	Lake Anna: near Thurman Island	Surface
NALIN	Lake Anna: at North Station intakes	Surface
NAL208	Lake Anna: Route. 208 Bridge	Surface
NADISC1	At end of station discharge in Lagoon (Pond) 1	Surface
NAWHTF2	Lagoon (Pond) 2	Surface
NAWHTF3	Lagoon (Pond) 3	Surface
NAL719S	North Anna River arm of Lake Anna at Route 719 bridge	Surface
NAL719N	Pamunkey Creek arm of Lake Anna at Route 719 bridge	Surface
NARIV601	Route 601 crossing	Surface

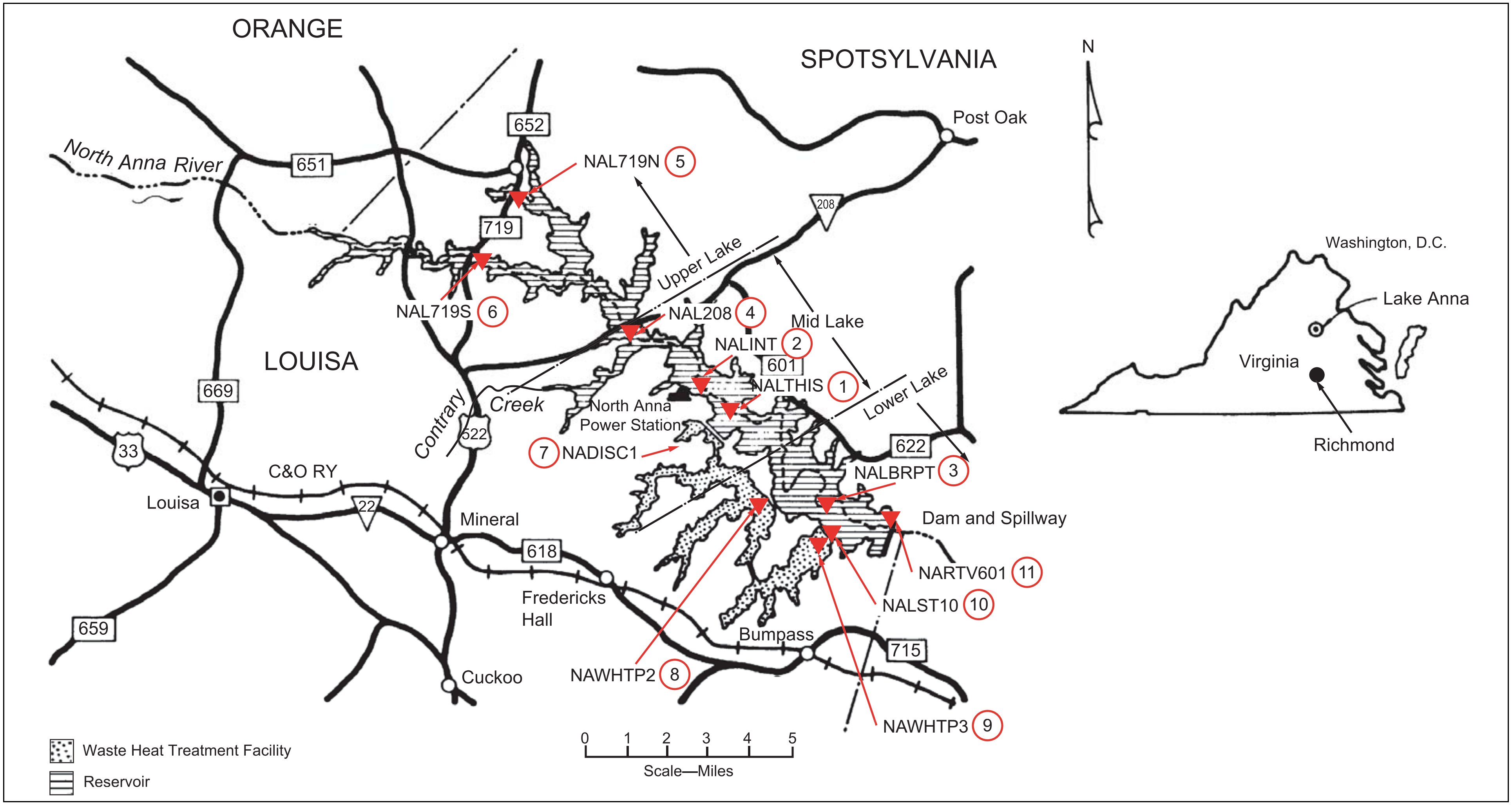

Figure 6.1-1 Locations of Water Temperature Monitoring Stations

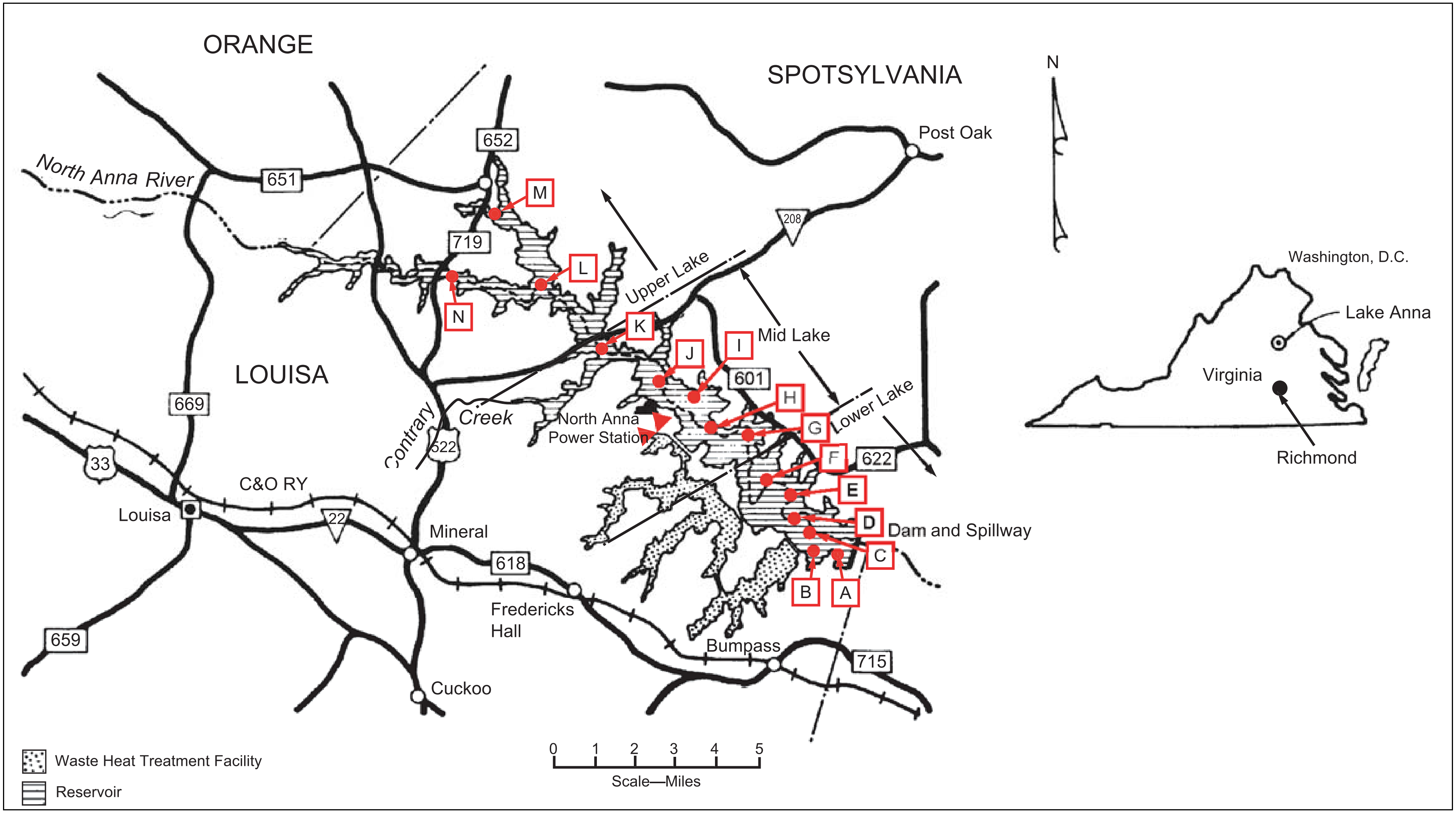

Figure 6.1-2 Temperature Profiling Stations A Through N

6.2 Radiological Monitoring

This section presents the basis, contents, reporting, and quality assurance of the ESP site Radiological Environmental Monitoring Program.

6.2.1 Radiological Environmental Monitoring Program Basis

The Radiological Environmental Monitoring Program (REMP) for the ESP site would be based on NUREG-0472 Revision 3 (Reference 1) and the NRC's Branch Technical Position Paper, *Acceptable Radiological Environmental Monitoring Program*, Revision 1 (Reference 2). The structure of the ESP site 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 (Reference 2). It would be implemented through the existing units' Offsite Dose Calculation Manual (ODCM), and via administrative and technical procedures.

6.2.2 Radiological Environmental Monitoring Program Contents

The pre-operational and operational radiological monitoring program incorporates measurements to evaluate the possible effects from plant operation and to ensure that changes in environmental radioactivity can be detected. Pre-operational data provided a baseline for the existing units and the current REMP data would provide a baseline for the new units. The measurement of radiation levels, concentrations (including surface area), and/or other quantities of radioactive material, are used to evaluate potential exposures and doses to members of the public and the environment.

The following exposure pathways to radiation would be monitored.

- Direct (including dosimeters)
- Airborne (including iodine and particulates)
- Waterborne (including ground and precipitation)
- Aquatic (including tissue analysis)
- Ingestion (including milk and crops)
- Vegetation (including soil)

Sampling results and locations can be evaluated to determine effects from seasonal yields and variations. Figure 6.2-1 shows existing sampling locations for the REMP which would apply for the ESP site and expanded program. Table 6.2-1 provides details of the radiation exposure pathways monitored and the monitoring frequencies for those pathways. Sensitivity analyses provide information regarding changes in background levels and determine the adequacy of analysis techniques in light of program results and changes in technology, when compared to baseline measurements. Changes in program implementation (including sampling techniques, frequencies and locations) may be added in response to monitoring results.

6.2.3 Radiological Environmental Monitoring Program Reporting

An annual Radiological Environmental Operating Report for the NAPS site would be written and submitted in accordance with the existing units Technical Specifications. Results from REMP implementation and evaluation would be compared to the previous years' results for measurement trends, methodology consistency, and indications that program changes are needed.

An Inter-laboratory Comparison Program exists to verify correctness of vendor results of samples sent for their analysis of radioactive materials. These results would be reported in an Annual Radiological Environmental Monitoring Report.

A land use census would be conducted within a designated distance of the NAPS site, currently 5 miles, to determine sampling yields and locations, and to ascertain if changes to the Radiological Environmental Monitoring Program are warranted. Parameters that have been reported include locations of nearest residence, milk production yield, and broad leaf vegetation.

6.2.4 Quality Assurance Program

Quality assurance is provided in the existing NRC-approved Radiological Environmental Monitoring Program through quality training, program implementation by periodic tests, the Inter-laboratory Comparison Program, and administrative and technical procedures. In addition, the existing units' Technical Specifications direct an audit of the REMP and its results under cognizance of the offsite Management Safety Review Committee.

Quality and credibility in the ESP Radiological Environmental Monitoring Program would be consistent with existing program components, regulatory guidance, and best management practices.

Section 6.2 References

1. NUREG-0472, Revision 3, *Standard Radiological Effluent Technical Specifications for Pressurized Water Reactors*, U.S. Nuclear Regulatory Commission, January 1983.

2. Branch Technical Position Paper, Revision 1, *Acceptable Radiological Environmental Monitoring Program*, U.S. Nuclear Regulatory Commission, November 1979.

3. Updated Final Safety Analysis Report, North Anna Power Station, Units 1 and 2, Revision 38.

Table 6.2-1 Radiation Pathway Monitoring

Radiation Exposure Pathways Monitored	Parameters	Frequency
Direct	Radiation Levels	Quarterly
Airborne, including Gaseous, Particulate, and Iodine	Radiation Levels Concentrations Radioactive Material Quantities	Continuous Weekly Quarterly
Waterborne, including Surface, Ground, and Sediment	Concentrations Radioactive Material Quantities	Monthly, Quarterly, Semi-annually
Ingestion, including Milk, Aquatic, Vegetation, and Food products	Concentrations Radioactive Material Quantities	Monthly Semi-annually

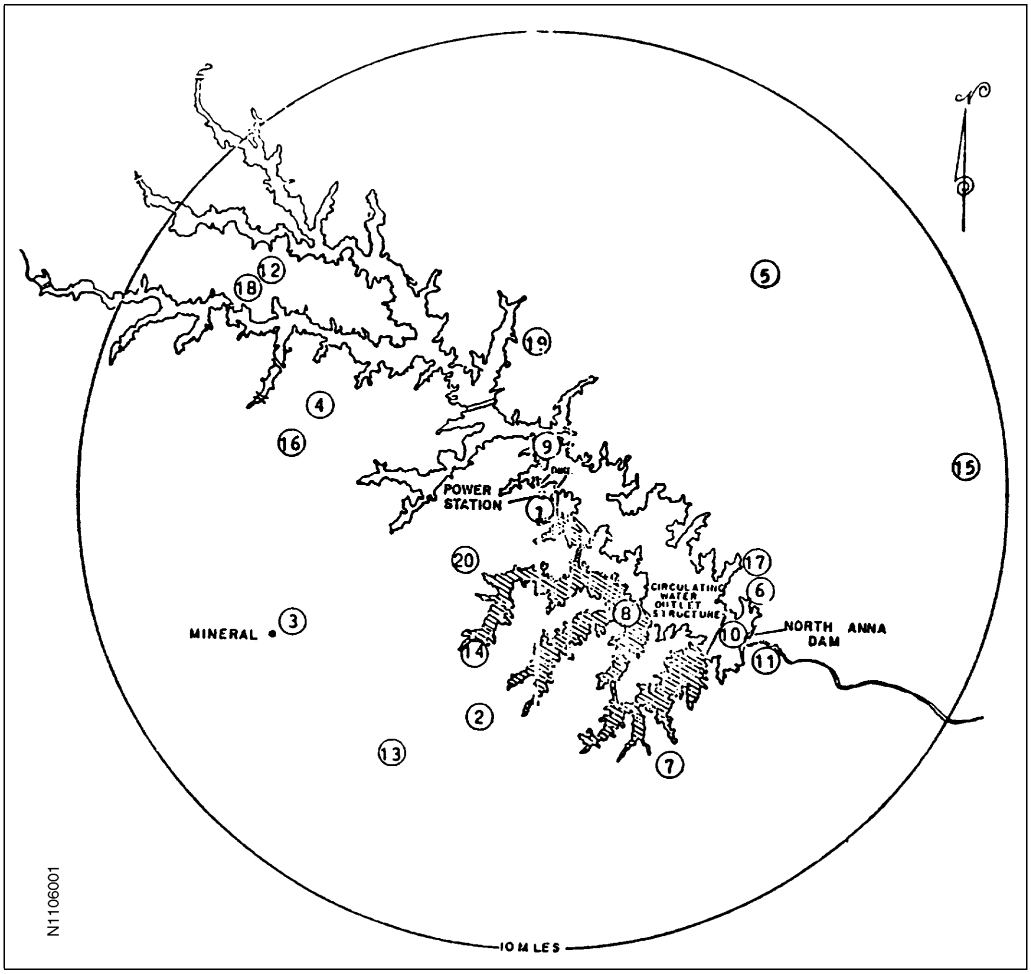

Figure 6.2-1 Preoperational Radiological Environmental Sampling Program Sample Station Locations

6.3 Hydrological Monitoring

This section discusses the hydrological monitoring program that would be implemented to monitor the effects of the new units at the ESP site, including monitoring of flow rates, water levels, sediment loads, and groundwater levels.

6.3.1 Existing Hydrological Monitoring

Presently, Virginia Power conducts hydrological monitoring in accordance with VPDES Permit No. VA0052451 (Reference 1). The hydrological measurements required by this permit are shown in Table 6.3-1. In addition to the flow measurements required for the VPDES permit, hourly lake water level readings are recorded at the North Anna Dam for use in regulating outflow from the dam.

Groundwater levels are the subject of an ongoing monitoring program at the ESP site. Nine groundwater observation wells were installed at the ESP site during November and December 2002 to determine groundwater levels, flow paths, and gradients. Tests were performed in these wells to determine the permeability of the subsurface materials. These wells, together with nine existing monitoring wells around the SWR for the existing units and one monitoring well at the ISFSI, are being used to measure groundwater levels on a quarterly basis to observe seasonal variations. Wells around the existing SWR are monitored every six months to evaluate the reservoir for leakage, assess the effectiveness of horizontal drains beneath the existing units pump house, and determine the flow rate and clarity of the associated discharge water.

6.3.2 Construction and Pre-Operational Monitoring

The VPDES Permit monitoring and lake water level monitoring would continue through the construction phase and prior to operation of the new units. This monitoring, in addition to the groundwater monitoring currently ongoing, would establish the baseline hydrological conditions for both Lake Anna and groundwater near the ESP site. Although no significant impacts to Lake Anna or groundwater aquifers are anticipated during construction, continual monitoring, as described in Section 6.3.1, would provide a means of detecting any unanticipated changes should they occur.

Also, prior to construction of the new units, an approved Erosion and Sediment Control Plan would be developed and implemented in accordance with state and local regulations (Reference 2). The Erosion and Sediment Control Plan would require periodic visual inspection of erosion and sediment control best management practices that have been implemented. If erosion or sediment deposition is discovered outside the defined limits of disturbance, measures would be implemented to correct the problem. Additionally, any hydrological monitoring required in conjunction with permits associated with construction of the make-up water intake structure or removal of the existing coffer dam at the intake location would be implemented via a specific construction monitoring plan, if necessary.

6.3.3 **Operational Monitoring**

An operational monitoring program would be developed in coordination with the VDEQ to establish a new or amended VPDES discharge permit. Since the permitted site is a nuclear power station, it is anticipated that the monitoring requirements of the new/amended permit would be similar to the existing permit. Monitoring of the Lake Anna water levels at North Anna Dam would continue during plant operation.

The NAPS site groundwater use is currently less than 100 gpm, and it is not expected to increase significantly after the addition of the new units. No changes to existing groundwater monitoring programs would be necessary.

Section 6.3 References

1. VPDES Permit No. VA0052451, *Authorization to Discharge Under the Virginia Pollutant Discharge Elimination System and The Virginia State Water Control Act, Effective January 11, 2002, Expiration January 11, 2006*, Department of Environmental Quality, Commonwealth of Virginia.

2. Virginia Erosion and Sediment Control Handbook, 3rd Edition, Division of Soil and Water Conservation, Virginia Department of Conservation, 1992.

Table 6.3-1 VPDES Hydrological Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
001 - Discharge of Condenser Cooling Water from Heat Treatment Facility at Dike 3	Flow (mgd)	1/month	Calculated
103 - Process Waste Clarifier	Flow (mgd)	2/month	Estimate
104 - Oil Water Separator and Storm Water	Flow (mgd)	2/month	Estimate
105 - Bearing Cooling Tower Blowdown	Flow (mgd)	1/month	Estimate
107 - Bearing Cooling Tower System Discharge-Lake to Lake Operation	Flow (mgd)	1/month	Estimate
108 - Service Water Overflow	Flow (mgd)	1/month	Estimate
109 & 110 - Hot Well Drains	Flow (mgd)	1/month	Estimate
111 - Sewage	Flow (mgd)	1/day	Estimate
112 & 113 - Steam Generator Blowdown Units 1 & 2	Flow (mgd)	1/month	Estimate
114 - Service Water Pipe Vault Drain	Flow (mgd)	1/month	Estimate
115 - Service Water System Blowdown	Flow (mgd)	1/month	Estimate
009 - Ground Water, Storm Water, Backwash from Sand Filters and RO Units	Flow (mgd)	1/month	Estimate
013 - Turbine Building Sump #1 and Storm Water	Flow (mgd)	1/month	Estimate
014 - Turbine Building Sump #2 and Storm Water	Flow (mgd)	1/month	Estimate
016 - Intake Screen Wash Water	Flow (mgd)	1/year	Estimate
020 - RO Reject	Flow (mgd)	2/month	Estimate
021 - RO Drain Line	Flow (mgd)	1/month	Estimate
022 – 026 - Storm Water Outfalls	Flow	1/storm event	Estimate

Data Source: Reference 1

6.4 Meteorological Monitoring

6.4.1 General Description – Onsite Meteorological Monitoring Program

Dominion plans to use the existing NAPS meteorological monitoring program for the ESP site. The existing program is described in the NAPS UFSAR, Section 2.3 (Reference 1). The existing program is suited for the ESP-required onsite meteorological measurements because the ESP site is adjacent to the existing units within the existing NAPS site. Additionally, the ESP site is relatively flat and free of elevated terrain features that generate complex airflows. Therefore, the airflow patterns throughout the site area would be similar.

The current onsite NAPS meteorological measurements program conforms to the requirements of 10 CFR 50.47 (Reference 2) and the guidance criteria set forth in NUREG-0696 (Reference 3), NUREG-0737 (Reference 4), NUREG-0654, Appendix 2 (Reference 5), Section C.4 of RG 1.111 (Reference 6), RG 1.21 (Reference 7), and RG 1.23 (Reference 10). System accuracy conforms to RG 1.23, Proposed Revision 1 (Reference 8).

The meteorological program has the following basic functions:

- Collecting meteorological data
- Generating real-time predictions of atmospheric effluent transport and diffusion
- Providing the appropriate organizations access (remote interrogation) to the atmospheric measurements and predictions

Meteorological measurements are available from both a primary tower and a backup tower, as required in 10 CFR 50, Appendix E (Reference 9). The backup system is designed to function even when the primary system is out of service, thus providing assurance that basic meteorological information would be available during and immediately following an accidental airborne radioactivity release.

Descriptions of the onsite meteorological monitoring program are from the NAPS UFSAR, unless otherwise indicated. The primary meteorological monitoring site at the NAPS site consists of a Rohn Model 80, guyed, 160-ft (48.8-m) tower, approximately 1750 ft (580 m) east of the Unit 1 containment building. Sensors are located at the 32.8-ft (10-m) level, the 158.9-ft (48.4-m) level, and ground level. Wind speed, wind direction, horizontal wind direction fluctuation, ambient temperature, one-half of differential temperature, and dew point temperature are measured at the 10-m elevation. Wind speed, wind direction, horizontal wind direction fluctuation, and one-half of the differential temperature are measured at the 48.4-m elevation. Precipitation is monitored at the ground level. Signal cables are routed through conduit from each location into the instrument shelter at the base of the tower. Inside the shelter, the signals are routed to the appropriate signal-conditioning equipment. The equipment outputs are directed to digital data recorders and to an interface with the intelligent remote multiplex system.

The backup meteorological monitoring site consists of a Rohn Model 25, freestanding 32.8-ft (10-m) tower. This tower is approximately 1300 ft (396 m) northeast of the Unit 1 containment building. A sensor at the top of the mast monitors wind speed, wind direction, and horizontal wind direction fluctuation. The signal path, instrument shelter and data recording are similar to those at the primary tower. All parameters are interfaced to the intelligent remote multiplexing system.

Because of the proximity of the ESP site to the existing units, meteorological parameters collected at the onsite primary and backup towers are representative of the dispersion conditions at the ESP site.

6.4.1.1 **Location, Elevation, and Exposure of Instruments**

The location of the primary meteorological tower is shown on the topographical map, Figure 2.7-1. Distances and bearings to ground features in the vicinity of the tower are shown on Figure 2.7-2. Onsite structures have been evaluated as having no adverse structural influence on the measurements taken at the tower. Trees in the immediate vicinity of the tower have been topped to heights of 10-15 ft (3-4.6 m). The nearest contiguous tree line is more than 500 ft (152 m) away from the tower and those tree heights are 40 to 50 ft (12 to 15 m).

Ground cover at the location is native grasses. Comparable cover is maintained at the base of the tower.

The Bounding Site-Specific PPE shows that the highest structure for new units at the ESP site would not be more than 234 ft (71.3 m) above grade level. Both the existing primary and backup towers are located more than 10 building heights away from the tallest expected structure within the ESP site plant envelope area. Therefore, these structures would not have any influence on the meteorological measurements.

6.4.1.2 **Wind System**

The wind sensors at both towers are positioned such that the tower does not influence the prevailing south-southwest wind flow detected by the sensors. The wind speed, wind direction, and horizontal wind direction fluctuation sensors are mounted on booms longer than the tower face width. Wind speed, wind direction, and horizontal wind direction fluctuation are measured at both the lower and upper tower levels. Electro-mechanical instruments are used to measure wind speed and wind direction. Horizontal wind direction fluctuation is calculated by the digital data acquisition system.

For the primary meteorological monitoring site, wind speed, wind direction, and horizontal wind direction fluctuation are measured at the 32.8-ft (10-m) level and at the 158.9-ft (48.4-m) level. The wind speeds are recorded with an accuracy of ±0.22 m/s (0.5 mph) for speeds less than 11.13 m/s (25 mph), with a starting threshold of less than 0.45 m/s (1 mph). The wind direction is measured with an accuracy of at least ±5 degrees of azimuth with a starting threshold of less than 0.45 m/s

(1.0 mph). Wind speed accuracy, wind direction, and starting threshold values conform to the guidance of RG 1.23, Proposed Revision 1.

The backup meteorological monitoring sensor at the top of the mast monitors wind speed, wind direction, and horizontal wind direction fluctuation to the same accuracy as the primary monitoring system.

6.4.1.3 **Temperature Systems**

At the primary meteorological monitoring site, temperature is measured at the 32.8-ft (10-m) level and differential temperature is measured between the 32.8-ft (10-m) and 158.9-ft (48.4-m) levels. The system consists of two temperature sensors. One single-element, high-precision, platinum resistance temperature sensor located at the 158.9-ft (48.4-m) level measures temperature in support of the differential temperature calculation. The other single-element, precision, platinum resistance sensor located at 32.8-ft (10-m) level measures ambient temperature and provides input to the differential temperature calculation. The sensors' signals are input into a temperature/delta temperature processor to provide output signals proportional to one ambient and one differential (ΔT) temperature. The temperature sensors record the data with an accuracy of at least ±0.5°C (0.9°F). The temperature difference is recorded with an accuracy of at least ±0.15°C (0.27°F) per 164 ft (50-m) height interval. These accuracy levels meet the guidance presented in RG 1.23, Proposed Revision 1.

Temperature and differential temperature sensors are housed in motor-aspirated shields to insulate them from thermal radiation. These shields support temperature measurement, which have less than 0.2°F (0.11°C) error, assuming maximum solar radiation of 1.6 gm-cal/cm^2/min). The backup tower does not measure differential temperature. The temperature sensor of the backup tower is also housed in a motor-aspirated shield.

6.4.1.4 **Dew Point Systems**

At the primary meteorological monitoring site, a lithium chloride dew point sensor measures dew point temperature at the 32.8-ft (10-m) level. The sensor signals are input into a dew point processor, which provides output signals proportional to the ambient dew point temperatures. The dew point levels are recorded to an accuracy of at least ±1.5°C (2.7°F), in accordance with RG 1.23, Proposed Revision 1.

Dew point temperature sensors are housed in motor-aspirated shields to insulate them from thermal radiation. These shields support temperature measurement with less than 0.2°F (0.11°C) error, assuming maximum solar radiation of 1.6 gm-cal/cm^2/min. The backup tower does not collect dew point temperature.

6.4.1.5 Precipitation Systems

At the primary meteorological monitoring site, precipitation is monitored at the ground level. The precipitation is measured with a recording rain gauge that has a resolution of 0.25 mm (0.01 in.). The accuracy is at least ±10 percent of the total accumulated catch, in accordance with RG 1.23, Proposed Revision 1. The backup tower does not collect precipitation.

6.4.2 Instrument Calibration and Maintenance

The meteorological monitoring system is calibrated at least semi-annually at both the primary and backup towers. Inspection, service, and maintenance are performed, as necessary, to ensure not less than 90 percent data recovery in accordance with the guidance of RG 1.23, Proposed Revision 1. Site-based instrument technicians have the requisite expertise to service and, in the event of a system failure, to repair the monitoring equipment.

In the event of a system outage, an inventory of spare sensors and parts is maintained for the replacement of major components. Redundant recording systems are incorporated into the program to further minimize data loss due to recorder failure. As an example, for this ESP application, the data recovery rates for more recent observations are presented in Table 6.4-1. Those data recovery rates for meteorological parameters (wind direction, wind speed, and atmospheric stability class) used for the dispersion analyses, as presented in Section 2.7, are very high and exceed the 90 percent guidance criteria in RG 1.23, Proposed Revision 1.

6.4.3 Data Recording Systems

6.4.3.1 Control Room Systems

Table 6.4-2 and Table 6.4-3 list each meteorological input parameter collected by the current system and the location to which the data are transmitted for the primary tower and backup tower, respectively. Parameters provided in Table 6.4-2 and Table 6.4-3 are available for remote interrogation at any time. During emergency conditions, selected meteorological parameters can be made available to the NRC through the ERF system.

6.4.3.2 Tower Base Shelter Systems

A nominally 8 ft x 8 ft x 18 ft (2.4 m x 2.4 m x 5.5 m) shelter is located at the primary and backup tower bases. The shelter is insulated. A thermostatically controlled heat and air conditioning system maintains the shelter interior temperature within a range appropriate for proper equipment operation. The enclosure is located so as to minimize any micrometeorological effects on the tower instrumentation. Equipment and circuitry for two separate data recording systems are housed in the shelter.

Microprocessor-based data acquisition systems are the primary method of data acquisition. The sensor analog signals are collected, processed, and telemetered to a system computer. The data acquisition systems have a built-in battery, which maintains the time and date and initialized parameters. In addition to the power-up diagnostic checks, memory diagnostic tests are continually performed to insure data integrity. The instruments and data acquisition systems as detailed herein are consistent with the current level of technology for meteorological monitoring and the accuracy of the components meets the guidance of RG 1.23, Proposed Revision 1.

6.4.4 Meteorological Data Analysis Procedure

The collected data are used to generate a sequential file of 1-hour values for each parameter. The average values are calculated by the digital data collection system.

In addition to being transmitted real-time to the ERF system, the data are telemetered daily to a computer in the corporate office. Virginia Power personnel check the data for representativeness and reasonableness. The data are compared with data collected from other offsite meteorological towers as well as with the real-time data received at the Virginia Power Meteorological Operations Center. The data is maintained on computers and is used as the database for data summaries and historical calculations.

Routine data summaries are generated for each day, each calendar month, and each calendar year for certain meteorological parameters recorded on strip charts in the existing units control room. Annual summaries of this data are provided within Virginia Power.

The format of the onsite data summaries conforms to the recommended format found in Reference 10, Table 1, and RG 1.21. To facilitate comparison, these summaries include joint frequency distributions of wind speed and wind direction for each stability class, as defined by horizontal wind sigma and differential temperature.

6.4.5 Preoperational and Operational Monitoring

Per the guidance of NUREG-0654, Appendix 2 (Reference 5), all meteorological data systems should have the capability of being remotely interrogated. Also, the guidance of NUREG-1555, Section 6.4 (Reference 11) states that the meteorological monitoring program should establish a baseline for identifying and assessing environmental impacts during pre-operational and operational stages. As stated in NAPS UFSAR (Reference 1, Section 2.3.3.2.6), the meteorological data collected onsite are transmitted on real-time basis to the ERF, the data are telemetered daily to a computer in the corporate office. This satisfies the guidance provided in NUREG-0654.

In conclusion, the current NAPS meteorological monitoring program would serve as the preoperational monitoring program for the new units. The existing database adequately establishes a baseline for identifying and assessing environmental impacts that would result from operation of the new units. This database satisfies the guidance specified in RG 1.111, Section C.4, for providing representative meteorological data for evaluating environmental impacts.

Because the existing onsite meteorological monitoring program is conducted in accordance with the guidance criteria of RG 1.23 and the system accuracy specified in RG 1.23, Proposed Revision 1, the current system would serve as the basis for the operational monitoring program for any new units at the ESP site. Additional data links to the existing and new facilities would be required for the new units. After selection of a specific reactor design, actual data recording system designs would be defined in the COL application.

Section 6.4 References

1. *Updated Final Safety Analysis Report,* North Anna Power Station Units 1 and 2, Revision 38.

2. 10 CFR 50.47, *Emergency Plans,* January 19, 2001.

3. NUREG-0696, *Functional Criteria for Emergency Response Facilities, Final Report,* U.S. Nuclear Regulatory Commission, 1981.

4. NUREG-0737, *Clarification of TMI Plan Requirements,* U.S. Nuclear Regulatory Commission, 1980.

5. NUREG-0654, *FEMA-REP-1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants,* Rev. 1, U.S. Nuclear Regulatory Commission, 1996.

6. Regulatory Guide 1.111, *Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,* Rev. 1, U.S. Nuclear Regulatory Commission, 1977.

7. Regulatory Guide 1.21, *Measuring, Evaluating, and Reporting Radioactivity in Solid Waste and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants,* Rev. 1, U.S. Nuclear Regulatory Commission, 1974.

8. Regulatory Guide 1.23, *Meteorological Programs in Support of Nuclear Power Plants,* Proposed Revision 1, U.S. Nuclear Regulatory Commission, September 1980.

9. 10 CFR 50, Appendix E, *Emergency Planning and Preparedness for Production and Utilization Facilities (Integrated),* Code of Federal Regulations, June 14, 1996.

10. Regulatory Guide 1.23, *Onsite Meteorological Programs,* U.S. Nuclear Regulatory Commission, February 1972.

11. NUREG-1555, *Standard Review Plan for Environmental Reviews for Nuclear Power Plants,* U.S. Nuclear Regulatory Commission, October 1999.

Table 6.4-1 Meteorological Data Recovery Rates (percent) (North Anna, January 1, 1996–December 31, 2001)

	Delta T Included		Delta T Not Included	
Year	**33-ft Wind Data**	**150-ft Wind Data**	**33-ft Wind Data**	**150-ft Wind Data**
1996	98.88	99.30	98.92	99.48
1997	98.96	90.09	99.36	99.20
1998	99.12	99.34	99.21	99.43
1999	98.91	98.90	99.45	99.44
2000	98.73	98.76	99.23	99.24
2001	98.88	91.78	99.76	92.59

Note: Data in this table are for the primary site.

Table 6.4-2 Primary Tower Meteorological Parameters

	Transmitted Locations		
Parameter	**ERF Data Base**	**Control Room**	**Remote Interrogation**
Wind Direction (upper)	X	X	X
Wind Speed (upper)	X	X	X
Sigma theta (upper) (S_t)			X
Wind Direction (lower)	X	X	X
Wind Speed (lower)	X	X	X
Sigma theta (lower) (S_t)			X
Ambient Temperature (lower)	X	X	X
Dew point (lower)			X
Delta Ambient Temperature (upper-lower)	X	X	X
Precipitation			X

Note: All parameters going to the ERF database are available for printout in the existing TSC and EOF. The Units 1 & 2 control room parameters are hardwired.

Source: Reference 1

Table 6.4-3 Backup Tower Parameters

Parameter	ERF Data Base	Control Room	Remote Interrogation
Wind Speed	X	X	X
Wind Direction	X	X	X
Sigma Theta (S_t)	X	X	X

Note: All parameters going to the ERF database are available for printout in the existing TSC and EOF. The Units 1 & 2 control room parameters are hardwired.

Source: Reference 1

6.5 Ecological Monitoring

NUREG-1555 recommends that ecological monitoring programs encompass the elements of the ecosystems for which a causal relationship is established or strongly suspected between the construction or operation of a new unit and adverse change (Reference 1, Section 6.5).

Ecological monitoring programs have been conducted at the NAPS site on a periodic basis since the early 1970s. The data collected under these programs is summarized in Section 2.4. The existing ecological monitoring programs and associated databases would be supplemented, as necessary, to support new units.

6.5.1 Terrestrial Ecology and Land Use

The following sections describe the prescribed pre-application, construction/pre-operational, and operational monitoring programs for terrestrial ecology and land use of the ESP site and transmission corridors that may be impacted by the new units.

6.5.1.1 Pre-Application Monitoring

The pre-application monitoring program has two objectives: 1) to provide supplemental information that aids in assessing the suitability of the ESP site, and 2) to support the assessment of potential impacts on the terrestrial environment that could result from construction and operation of the new units. The pre-application monitoring program comprises the existing NAPS terrestrial ecological database and the ongoing NAPS-based ecological monitoring programs.

The existing units terrestrial monitoring program was initiated in 1973 to monitor the local wildlife and vegetation communities in response to the expected major changes in the terrestrial environment associated with the creation of Lake Anna and NAPS. The program was designed to provide baseline data about existing ecological communities. The program specifically identified vegetation types around Lake Anna, compiled an inventory of wildlife in the area, and evaluated local land use patterns. (Reference 2) Some of the terrestrial monitoring programs continued to monitor the variations within existing communities during the construction and operation of the existing units.

The following sections describe the vegetation, avian, and mammalian community monitoring programs performed to date, highlight the present status of “important” related ecological species and habitats, and identify the on-going related monitoring programs.

6.5.1.1.1 Vegetation

As described in Section 2.4.1, much of the NAPS site consists of existing generation and maintenance facilities, parking lots, roads, cleared areas, and mowed grass. Hardwood forests exist in areas that have not been cleared for the construction and operation of the existing units. These wooded areas are remnants of forests that were used for timber production, prior to the land acquisition by Virginia Power, and are dominated by a variety of oak, yellow poplar, sweet gum, and red maples. Scattered loblolly pines, Virginia pines, and short-leaf pines exist in some wooded areas. (Reference 3, Sections 2.4 and 2.5) (Reference 4, Section 2.2.6)

The transmission corridors are regularly managed by Virginia Power to prevent woody growth from reaching the transmission lines. The removal of woody species can provide outstanding grassland and bog-like habitat for many rare plant species dependent on open conditions. No endangered or threatened plants have been recorded along the transmission corridors. (Reference 3, Sections 2.4 and 2.5)

Virginia Power currently conducts a transmission corridor rare plant survey program in cooperation with the VDCR's Natural Heritage Program (see Section 2.2.2 and Section 5.6.1). The Natural Heritage Program prepares annual reports from these surveys.

No additional monitoring would be performed for the new units.

6.5.1.1.2 **Avian Communities**

Common bird species recorded in upland areas on and near the ESP site include the American crow, blue jay, Carolina chickadee, mourning dove, black vulture, turkey vulture, European starling, song sparrow, white-throated sparrow, dark-eyed junco, Northern cardinal, house finch, tufted titmouse, red-bellied woodpecker, downy woodpecker, and Northern flicker.

Several species of residential and migratory wading birds and waterfowl use Lake Anna. Virginia Power biologists have documented breeding at Lake Anna by mallards, wood ducks, and Canada geese. 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. Belted kingfishers, great blue herons, and green-backed herons are present at Lake Anna throughout the year and presumably nest on or near the Lake Anna shoreline (see Section 2.4.1.4).

Even though the bald eagle and loggerhead shrike have been observed in the local area, terrestrial species that are listed by the federal and/or the Commonwealth of Virginia governments as endangered or threatened species are not known to exist at the NAPS site or along the transmission corridors. No areas designated by the USFWS as "critical habitat" for endangered species exist at or near the NAPS site or associated transmission lines. In addition, the transmission corridors do not cross any Commonwealth or federal parks, wildlife refuges, or wildlife management areas.

Virginia Power annually has participated with the National Audubon Society in conducting the "Christmas Bird Counts" during either December or January (see Section 2.4.1.3). Bird species were recorded in upland areas on and near the NAPS site during this count.

6.5.1.1.3 **Small Mammals**

Wildlife species resident in the forested portions of the NAPS site are typical of those found in upland Piedmont forests of north-central Virginia. As presented in Section 2.4.1.2, frequently observed mammals such as the white-tailed deer, raccoon, opossum, gray squirrel, and gray fox occur on site, as do smaller mammals such as moles, shrews, and a variety of mice and voles. Woodchucks exist in grassy areas near the forest edges of the NAPS site, and beavers exist in Lake Anna and its tributaries. Various birds, reptiles (e.g., snakes, lizards), and amphibians (e.g., frogs, salamanders) exist in uplands and along the edge of Lake Anna.

No areas designated by the USFWS as “critical habitat” for endangered species exist at the NAPS site or along/adjacent to transmission corridors. In addition, the transmission corridors do not cross any Commonwealth or federal parks, wildlife refuges, or wildlife management areas.

No additional mammal-related monitoring would be performed for the new units.

6.5.1.2 **Construction and Pre-Operational Monitoring**

Construction of the new units would result in the removal of substantial portions of the existing forested habitat on the NAPS site. The construction site and support areas do not contain any old growth timber, unique or sensitive plants, or unique or sensitive plant communities. Therefore, construction would not significantly reduce the local or regional diversity of plants or plant communities. As the potentially impacted forested habitat on site represents a small portion of the available undeveloped land in the region of the NAPS site, the displacement and construction-related mortality of wildlife would be small, relative to wildlife populations in the region.

Noise-related impacts and bird collisions due to construction activities and equipment would be negligible. Section 2.4.1 and Section 4.3.1 conclude that while there is potential for bird collisions with the buildings and equipment during the facility construction phase, the additional impact of construction-related structures would be small, given the proximity of existing units structures and the relative absence of evidence of previous avian collisions with these structures. Finally, no federal or Commonwealth threatened or endangered plants or animals are known to exist in the construction site and support areas, and these areas do not contain any designated critical habitats. Thus, construction would not adversely impact any threatened or endangered species, or trigger the need to conduct additional terrestrial monitoring.

6.5.1.3 **Operational Monitoring**

Operation of the new units would not pose any additional impacts to areas outside those previously disturbed by NAPS site or new unit construction. New unit operation would not impact critical habitats, or important, threatened, or endangered species. Thus, additional terrestrial monitoring would not be warranted.

6.5.2 **Aquatic Ecology**

The following sections describe the pre-application, construction/pre-operational, and operational monitoring programs for aquatic ecology. These programs would support any required assessments of aquatic impacts associated with new unit construction and operation.

6.5.2.1 **Pre-Application Monitoring**

The objective of the pre-application aquatic monitoring program is to provide information that aids in the assessment of site suitability and supports the assessment of potential impacts on the aquatic environment that would result from the construction and operation of the new units. This monitoring program comprises the existing NAPS aquatic ecological database and the related ongoing NAPS aquatic monitoring programs. The following subsections summarize the previous aquatic monitoring programs, the current status of “important” aquatic species and habitats, and the nature of ongoing aquatic monitoring programs.

6.5.2.1.1 **Previous Aquatic Ecology Monitoring Programs**

The earliest aquatic monitoring program was initiated by Virginia Power in the early 1970s, prior to the creation of Lake Anna and the construction of the existing units. This program was designed to provide baseline data about the ecology of the North Anna River basin, to support the evaluation of impacts from dam construction on the North Anna River and the upper section of the Pamunkey River. This aquatic monitoring program was followed in the summer of 1972 by a more intensive post-impoundment aquatic ecological monitoring program. This program collected biological samples at 10 stations distributed upstream and downstream of the North Anna dam. Epiphytes, macrobenthic fauna, and fish were collected during the summer months of 1972. Later in the year, following the filling of Lake Anna, a new aquatic ecology monitoring program was initiated, which sampled phytoplankton, zooplankton, benthos, and fishes at stations in the Lake. Prior to the construction and operation of the existing units, this program generated a database that characterized the newly formed Lake Anna biota. (Reference 2, Section 6.1) Supplemental studies of phytoplankton, zooplankton, and benthic organisms followed from 1973 through 1985 (see Section 2.4.2.2).

Section 2.4.2.2 discusses fish community studies. From 1975 through 1985, Virginia Power evaluated the abundance and distribution of adult fish using a variety of sampling methods. Virginia Power also conducted larval fish studies, creel surveys, and a number of special studies, focusing on the reproduction and growth of important recreational species, such as largemouth bass (*Micropterus salmoides*). Using ultrasonic tags, Virginia Power investigated the seasonal movement and habitat preferences of striped bass (*Morone saxatilis*). (Reference 3, Sections 2.4 and 2.5)

6.5.2.1.2 **Important, Threatened, and Endangered Species**

As described in Section 2.4.2.2, from 1975 through 1985, 39 species of fish (representing 12 families) were found in Lake Anna. The species include those historically found in the North Anna River, those in local farm ponds inundated by the new lake, and nine species (four non-natives) introduced by the VDGIF. (Reference 4, Section 2.2.5) Section 2.4.2.2 also reports that fish monitoring conducted over a more recent six-year period (1995–2000) shows a balanced reservoir fish community of healthy top-of-the-food-chain predators (e.g., largemouth bass and striped bass), the forage species on which they feed (e.g., threadfin shad, and gizzard shad), pan fish (e.g., bluegill, red ear sunfish, redbreast, crappie), and catfish.

No Commonwealth of Virginia or federally-listed (e.g., endangered, threatened, species of concern) fish species or critical habitats are found in Lake Anna or the North Anna River (see Section 2.4.2.2.5 and Section 2.4.2.3.5). No Commonwealth or federally-listed fish species have been collected in any surveys or operational monitoring studies. While VDGIF ecological databases indicate that three Commonwealth and federally-listed species – the Commonwealth freshwater mussel species dwarf wedge mussel *(Alasmidonta heterodon*), the Atlantic pig toe (*Fusonaia mason*), and James spiny mussel (*Pleurobema collina*) – could occur in local streams, none have been observed or collected in local streams. A fourth mussel species, the kidney mussel (*Ptychobranchus subtentum*), a candidate for federal listing, has been reported to have been observed in the vicinity of the ESP site. However, these observations may be in error, since confirmed observations limit this species to more western mountain streams that drain to the Gulf of Mexico. (Reference 3, Sections 2.4 and 2.5) (Reference 4, Section 2.2.5)

6.5.2.1.3 **Current Monitoring Programs**

Virginia Power has monitored fish populations in Lake Anna since 1986. Virginia Power conducts quarterly electro-fishing sampling at nine stations (five stations in the North Anna Reservoir, four in the WHTF, and six gillnetting stations (four in the reservoir 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 via direct (snorkel) observation. The biologists swim established transects, counting and categorizing (by size) all bass that are observed, and noting the type of cover being used. Other fish abundance and distribution information in the North Anna River is collected by electro-fishing at 4 stations, 3 times per year.

In response to NRC Generic Letter 89-13, Virginia Power initiated a semi-annual sampling program in the fall of 1990 to monitor Asiatic clams (*Corbicula flumenia)* in the North Anna Reservoir, the WHTF, and the SWR. Virginia Power continues to collect replicate samples at two North Anna Reservoir stations (i.e., Intake and Mid-Lake), two WHTF stations, and a single station in the SWR, and they report the total number and density of clams at the stations and discuss population trends in semi-annual reports. In the course of monitoring *Corbicula* populations, Virginia Power assesses the micro-fouling potential of Asiatic clams and looks for evidence that the exotic zebra mussel (*Dreissena polymorpha*) has invaded Lake Anna. As of the end of 2002, Virginia Power had observed no zebra mussels in Lake Anna.

Virginia Power biologists have also conducted studies in the North Anna River in response to reduced flow due to drought conditions. The studies included physical habitat measurements at different flows, dissolved oxygen, temperature, 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, Hydrilla verticillata is conducted.

As presented in Section 2.4.2.2.3, the 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, two species that are highly esteemed by local anglers. Other species, such as black crappie, walleye, channel catfish, and gizzard and threadfin shad, are monitored by VDGIF.

6.5.2.2 **Construction and Pre-Operational Monitoring**

Construction of the new units would result in minor temporary disruptions of some aquatic habitats. The addition of a new Lake Anna intake structure for Unit 3 wet cooling tower make-up and removal of the existing intake cofferdam would contribute to temporary increases in the turbidity of the water in these disturbed areas. The land clearing and earthwork associated with construction of the new units could similarly result in temporary increases in the turbidity in adjacent surface water bodies. As appropriate, soil erosion and sedimentation controls and construction-phase storm water management practices would be employed to minimize the sediment-related impacts to these surface water resources. Therefore, new unit construction would not reduce the local or regional diversity of aquatic species.

No federally or Commonwealth-listed threatened or endangered aquatic plants or important species are known to live in areas that would be impacted by construction of the new units, nor do these areas contain any designated critical habitats. Therefore, construction of the new units would not adversely impact any threatened or endangered aquatic species.

The Virginia Power aquatic ecology monitoring programs (i.e., quarterly fish surveys, semi-annual shellfish surveys, Hydrilla inspections) and the VDGIF-sponsored annual fish monitoring program would continue. Therefore, construction of the new units would not require additional aquatic ecology monitoring programs or efforts.

6.5.2.3 **Operational Monitoring**

While the addition of the new units would increase water withdrawal rates (to provide make-up water for the cooling towers) and, very slightly, the water discharge rates (due to cooling tower blowdown), operation with the new units would be fundamentally similar to operation with the existing units. The impact of these changes on lake temperature would be negligible. Therefore, operation with the new units is not predicted to have any impact or to cause habitat reductions for striped bass. Likewise, other aquatic species are predicted to not be affected. Consequently, the operational-phase aquatic ecological monitoring program for the new units would be an extension of the ongoing Virginia Power and VDGIF monitoring programs.

Section 6.5 References

1. NUREG-1555, *Standard Review Plans for Environmental Review for Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, October 1999.

2. *North Anna Power Station Final Environmental Statement,* United States Atomic Energy Commission, April 1973.

3. *North Anna Station Application for Renewed Operating Licenses (Appendix E – Environmental Report)*, Dominion Energy, May 2001.

4. NUREG-1437*, Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants, Supplement 7*, U.S. Nuclear Regulatory Commission, November 2002.

6.6 Chemical Monitoring

The following section describes the chemical monitoring program for surface water and groundwater quality, which includes the following topics:

- Pre-application monitoring that supports the baseline environmental hydrologic and water quality descriptions in Chapter 2 and Chapter 3.
- Construction/pre-operational monitoring that would evaluate anticipated impacts from site preparation and new unit construction and that would establish a baseline for identifying and assessing environmental impacts from operation of the new units.
- Operational monitoring that would identify impacts from operation of the new units.

The proposed chemical monitoring programs contain the elements necessary to evaluate potential impacts on water quality in accordance with the guidance of NUREG-1555 (Reference 1, Section 6.6).

6.6.1 **Pre-Application Monitoring**

The objective of the pre-application monitoring program is to provide information that aids in the assessment of site suitability and supports the assessment of potential impacts that could result from the construction and operation of the new units. The pre-application monitoring program is composed of the existing NAPS water quality database and the ongoing VPDES permit-mandated surface water and NAPS groundwater monitoring programs

6.6.1.1 **Surface Water Monitoring**

A series of pre-operational water quality programs were initiated for the NAPS site in the early 1970s. Lake Anna was created to supply plant cooling water for the power station. The initial pre-impoundment program focused on evaluating the local water quality effects of pyrite-mine drainage from Contrary Creek and its tributaries. A post-impoundment water quality monitoring program began in the summer of 1971. During this monitoring period, temperature, total solids, turbidity, flow rate, dissolved oxygen (DO), salinity, biological oxygen demand (BOD), alkalinity, pH, iron, magnesium, manganese, copper, zinc, mercury, lead, nitrates, and sulfates were measured bi-monthly at 10 monitoring stations located downstream of the North Anna Dam and the upper Pamunkey River. A 3-year pre-operational water quality monitoring program was initiated in March 1972 to monitor temperature, DO, pH, conductivity, alkalinity, nutrients, iron, magnesium, copper, strontium, calcium, manganese, chromium, aluminum, zinc, and potassium at 12 locations in the recently fully developed Lake Anna. In addition, Secchi disk and radiological analyses were conducted at these stations. All of these measurements were conducted monthly, except during the summer months, when they were performed bi-weekly. (Reference 2, Section 6.1)

As part of the NAPS CWA Section 316(a) Demonstration in 1985, a revised temperature-monitoring program was initiated at seven local monitoring stations. Temperatures were recorded hourly at most of these stations through 1985 (Reference 3, Section 2.2).

Virginia Power continues to measure Lake Anna water temperatures at a number of monitoring stations in the Lake in accordance with VPDES permit conditions (Reference 4). Specific monitoring details (location, parameters, frequency) of this ongoing permit-based water quality and temperature monitoring program are provided in Table 6.6-1 and Figure 6.6-1, Figure 6.2-3, and Figure 6.6-2.

Dominion would continue to conduct the water quality monitoring program mandated by the VPDES permit.

6.6.1.2 Groundwater Monitoring

NAPS groundwater use is currently less than 100 gpm. Operation of the new units would not significantly increase groundwater use (see Section 2.3.2.2.1). Given the regular and small usage of groundwater at the NAPS site, the quality of the groundwater has not been the subject of any recent systematic monitoring efforts. Current groundwater use would not change during new unit construction, pre-operational periods, or operating periods. Therefore, groundwater impacts will continue to be viewed as minimal, and mitigation and related water quality monitoring measures are not warranted. (Reference 5, Section 4.5)

Groundwater levels have been, and continue to be, the subject of an on-going monitoring program. Nine groundwater observation wells were installed (November and December 2002) at the ESP site to determine water elevations, flow paths, and gradients. Tests have been performed in these wells to determine the permeability of the subsurface materials. These wells, together with 9 existing monitoring wells around the SWR and one monitoring well at the ISFSI, are used to measure groundwater elevations on a quarterly basis for one year to determine seasonal variations. Virginia Power would continue to monitor wells around the SWR to evaluate the SWR for leakage, to assess the effectiveness of horizontal drains beneath the existing units pump house, and to determine the flow rate and clarity of the water discharge. An existing well at the NAPS metrology lab is also being monitored quarterly for radiological purposes.

6.6.2 Construction and Pre-Operational Monitoring

The VPDES-mandated temperature and water quality monitoring program and the groundwater level monitoring program for the existing units would continue. Construction of the new units would require Dominion to seek a permit for storm water discharges from construction activities. This permit would not trigger the need to conduct additional storm water-related monitoring beyond that required for the existing units. The ongoing surface and groundwater monitoring programs for the existing units would provide the data necessary to assess potential changes in water quality associated with construction of the new units. These ongoing programs would also provide a baseline for the identification and measurement of water quality impacts from operation of the new units.

6.6.3 Operational Monitoring

An operational monitoring program would be implemented to identify any changes in water quality that may result from the operation of the new units and to assess the effectiveness of the related effluent treatment systems. The specific elements of the operational monitoring program would be developed in consultation with the VDEQ during the process to revise the existing VPDES permit. Given that the new units would represent an expansion of the existing nuclear power generation facilities, any new monitoring would be similar to that described in the current VPDES-mandated program.

Section 6.6 References

1. NUREG-1555, *Environmental Standard Review Plan*, U.S. Nuclear Regulatory Commission, October 1999.

2. *North Anna Power Station Final Environmental Statement,* United States Atomic Energy Commission, April 1973.

3. *North Anna Station Application for Renewed Operating Licenses* (Appendix E – Environmental Report), Dominion Energy, May 2001.

4. Virginia Discharge Elimination System Permit No. VA0052451, Virginia Department of Environmental Quality, July 11, 2001.

5. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants*, Supplement 7, U.S. Nuclear Regulatory Commission, November 2002.

Table 6.6-1 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
001 - Discharge of Condenser Cooling Water from Heat Treatment Facility at Dike 3 (Note 1)	Flow (mgd)	1/month	Calculated
	pH	1/year	Grab
	Heat Rejected ($\times 10^9$ Btu/hr)	1/day	Calculated
	Total Residual Chlorine (mg/l)	1/month	Grab
	Copper	1/5 years beginning 2004	Grab
	Nickel	1/5 years beginning 2004	Grab
	Acute and Chronic Toxicity Test	August/September 2004 or 2005 1/3 months if test fails for one year. Annually thereafter	48-hour static test using *Ceriodaphnia dubia* to determine No Observable Adverse Effects Concentration (NOAEC).
103 – Process Waste Clarifier (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Oil and Grease (mg/l)	1/3 months	Grab
104 – Oil Water Separator and Storm Water (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Oil and Grease (mg/l)	1/3 months	Grab

Data Source: Reference 4
Notes: 1. See Figure 6.6-2 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.2-3 for location.

Table 6.6-1 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
105 – Bearing Cooling Tower Blowdown (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Free Available Chlorine	1/month	Grab
	Priority Pollutants (mg/l) Note: 126 Priority Pollutants contained in cooling tower treatment chemicals except for total chromium and total zinc)	1/3 months	Grab
	Total Chromium (mg/l)	1/3 months	Grab
	Total Zinc (mg/l	1/3 months	Grab
107 - Bearing Cooling Tower System Discharge-Lake to Lake Operation (Note 1)	Flow (mgd)	1/month	Estimate
	Total Residual Chlorine (mg/l)	1/month	Grab
108 – Service Water Overflow (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
109 & 110 – Hot Well Drains (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
111 - Sewage (Note 1)	Flow (mgd)	1/day	Estimate
	pH	1/month	Grab
	BOD - 5-day (mg/l)	1/6 months	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Total Residual Chlorine (mg/l) or Fecal Coliform (n/100 ml)	1/day 1/week	Grab Grab

Data Source: Reference 4

Notes: 1. See Figure 6.6-2 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.2-3 for location.

Table 6.6-1 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
112 & 113 – Steam Generator Blowdown Units 1 & 2 (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/6 months	Grab
	Oil and Grease (mg/l)	1/6 months	Grab
114 – Service Water Pipe Vault Drain (Note 1)	Flow (mgd)	1/month	Estimate
115 – Service Water System Blowdown (Note 1)	Flow (mgd)	1/month	Estimate
009 – Groundwater, Storm Water, Backwash form Sand Filters and RO Units (Note 1)	Flow (mgd)	1/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
013 - Turbine Building Sump #1 and Storm Water (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
014 - Turbine Building Sump #2 and Storm Water (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
016 – Intake Screen Wash Water (Note 1)	Flow (mgd)	1/year	Estimate
020 – RO Reject (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Total Residual Chlorine	2/month	Grab

Data Source: Reference 4

Notes: 1. See Figure 6.6-2 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.2-3 for location.

Table 6.6-1 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
021 – RO Drain Line (Note 1)	Flow (mgd)	1/month	Estimate
022 to 026 Storm Water Associated with Industrial Activities (Note 1)	Total Recoverable Iron	2/year for years 2005 and 2006, immediately after applicable storm event (> 0.1 inch)	Grab
	Visual Inspection	1/3 months immediately following applicable storm event (> 0.1 inch)	Visual observation
Station 1 – 9 & 11 (Note 2)	Temperature (°C)	Hourly during summer quarter and one other alternating quarter of year	Automated surface measurement
Station 10 (Note 2)	Temperature (°C)	Hourly during summer quarter and one other alternating quarter of year	Automated 3 meter deep measurement
Stations A – N (Note 3)	Temperature (°C)	Hourly measurements during daylight hours	Automated surface to bottom measurements at one meter intervals

Data Source: Reference 4
Notes: 1. See Figure 6.6-2 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.2-3 for location.

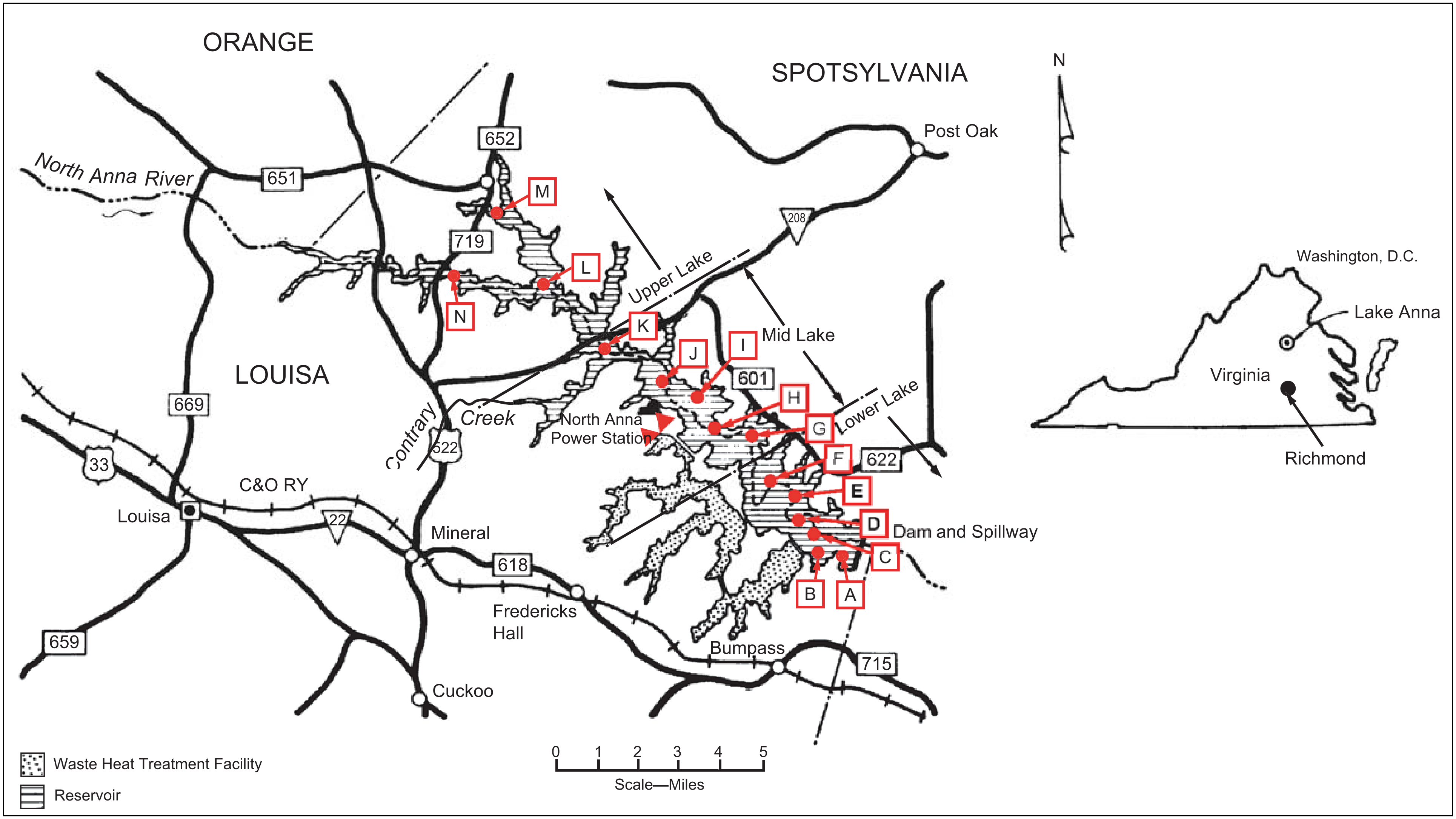

Figure 6.2-3 Location of Thermal Plume Sampling Stations – Lake Anna

Data source: Reference 4

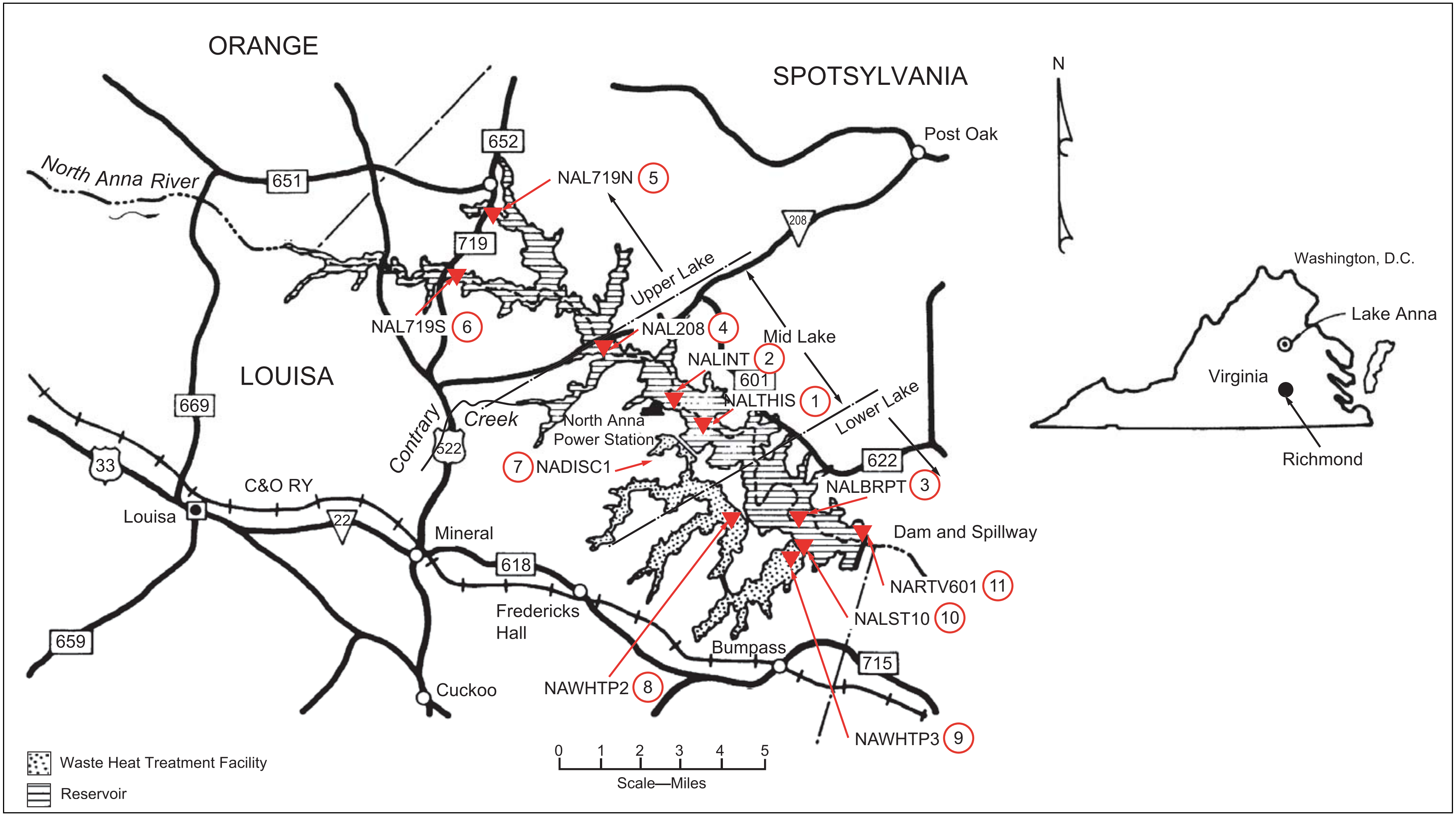

Figure 6.6-1 Location of Temperature Sensors – Lake Anna

Data source: Reference 4

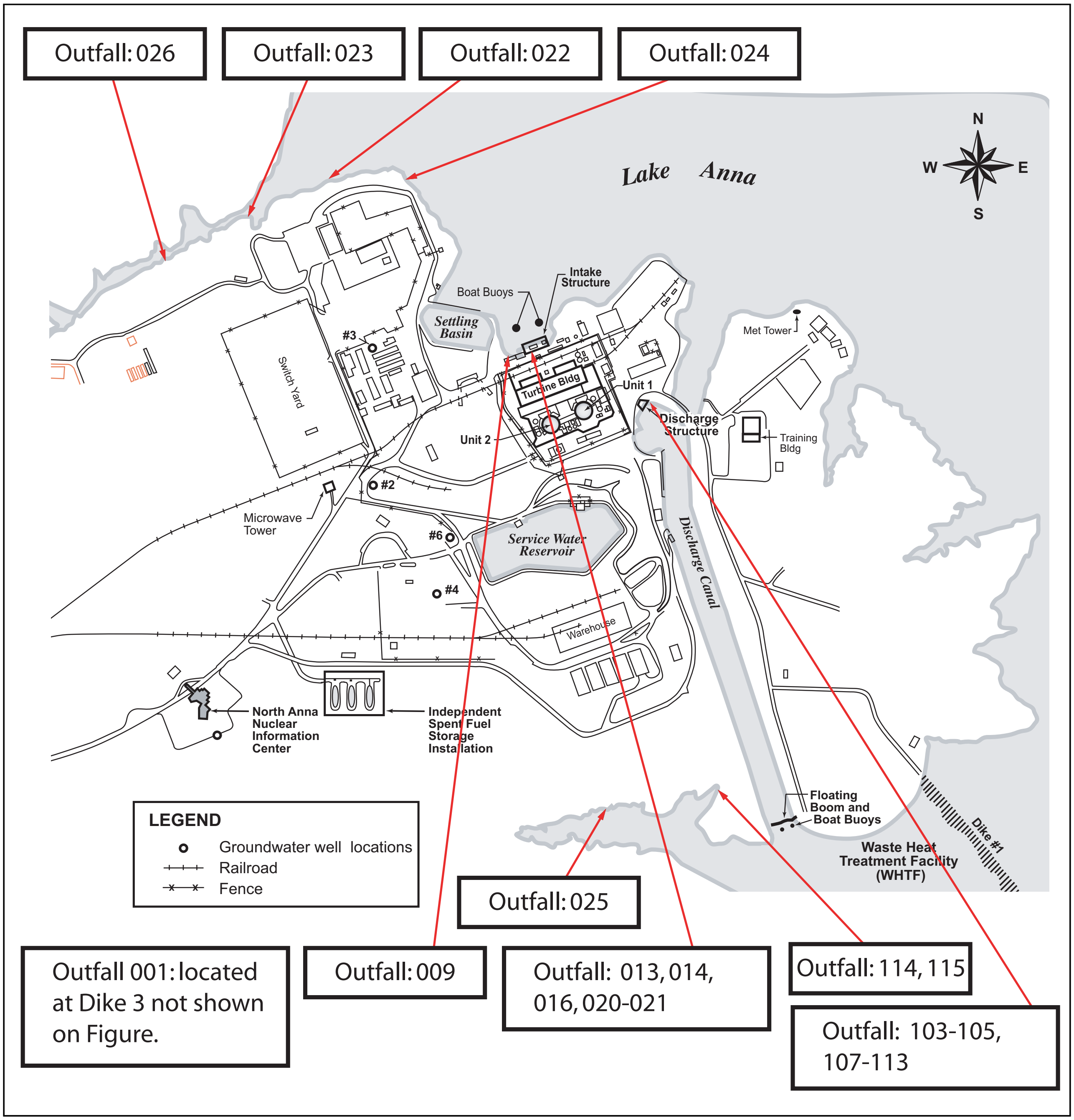

Figure 6.6-2 Location of Monitored VPDES Permit Outfalls

6.7 Summary of Monitoring Programs

This section summarizes all of the environmental monitoring programs described in Chapter 6. The summary is divided into three sections:

- Pre-application monitoring
- Construction and Pre-Operational monitoring
- Operational monitoring

6.7.1 Pre-Application Monitoring

Table 6.7-1 through Table 6.7-6 summarize the pre-application monitoring programs. These programs represent continuations of the thermal, radiological, hydrological, meteorological, ecological, and chemical monitoring programs currently being performed at the NAPS site.

6.7.2 Construction and Pre-Operational Monitoring

The current thermal, radiological, hydrological, meteorological, ecological, and chemical monitoring programs for the existing units would be continued through the construction and pre-operational phases of the new units. Table 6.7-1 through Table 6.7-6 reflect this continuation.

6.7.3 Operational Monitoring

While specific operational monitoring requirements and programs for the new units have not been established at this time, they would be similar to those monitoring programs outlined in Table 6.7-1 through Table 6.7-6. The operational monitoring programs may be modified as a result of future consultations with appropriate VDEQ and other Commonwealth of Virginia and municipal authorities. The need for further modifications (e.g., changes in monitoring locations, parameters, collection, or analytical procedures) would be assessed prior to and during the course of operation.

Section 6.7 References

None

Table 6.7-1 Pre-Application, Construction/Pre-Operational, and Operational Thermal Monitoring Program

Sites	Monitoring Location	Sampling Methodology	Sampling Frequency
NALST10	Lake Anna: Mid-level in Lake in the flow through Lake Anna Dike 3	Mid-level depth at 3 m water depth	2/year
NALBRPT	Lake Anna: near Burruss Point	Surface	2/year
NALTHIS	Lake Anna: near Thurman Island	Surface	2/year
NALIN	Lake Anna: at North Station intakes	Surface	2/year
NAL208	Lake Anna: Route. 208 Bridge	Surface	2/year
NADISC1	At end of station discharge in Lagoon (Pond) 1	Surface	2/year
NAWHTF2	Lagoon (Pond) 2	Surface	2/year
NAWHTF3	Lagoon (Pond) 3	Surface	2/year
NAL719S	North Anna River arm of Lake Anna at Route 719 bridge	Surface	2/year
NAL719N	Pamunkey Creek arm of Lake Anna at Route 719 bridge	Surface	2/year
NARIV601	Route 601 crossing	Surface, at Route 601 crossing	4/year

Table 6.7-2 Pre-Application, Construction/Pre-Operational, and Operational Radiological Monitoring Program

Radiation Exposure Pathways Monitored	Parameters	Frequency
Direct	Radiation Levels	Quarterly
Airborne, including Gaseous, Particulate, and Iodine	Radiation Levels Concentrations Radioactive Material Quantities	Continuous, Weekly, Quarterly
Waterborne, including Surface, Ground, and Sediment	Concentrations Radioactive Material Quantities	Monthly, Quarterly, Semi-annually
Ingestion, including Milk, Aquatic, Vegetation, and Food products	Concentrations Radioactive Material Quantities	Monthly, Semi-annually

Table 6.7-3 Pre-Application, Construction/Pre-Operational, and Operational Hydrological Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
001 - Discharge of Condenser Cooling Water from Heat Treatment Facility at Dike 3	Flow (mgd)	1/month	Calculated
103 - Process Waste Clarifier	Flow (mgd)	2/month	Estimate
104 - Oil Water Separator and Storm Water	Flow (mgd)	2/month	Estimate
105 - Bearing Cooling Tower Blowdown	Flow (mgd)	1/month	Estimate
107 - Bearing Cooling Tower System Discharge - Lake to Lake Operation	Flow (mgd)	1/month	Estimate
108 - Service Water Overflow	Flow (mgd)	1/month	Estimate
109 & 110 - Hot Well Drains	Flow (mgd)	1/month	Estimate
111 - Sewage	Flow (mgd)	1/day	Estimate
112 & 113 - Steam Generator Blowdown Units 1 & 2	Flow (mgd)	1/month	Estimate
114 - Service Water Pipe Vault Drain	Flow (mgd)	1/month	Estimate
115 - Service Water System Blowdown	Flow (mgd)	1/month	Estimate
009 - Ground Water, Storm Water, Backwash from Sand Filters and RO Units	Flow (mgd)	1/month	Estimate
013 - Turbine Building Sump #1 and Storm Water	Flow (mgd)	1/month	Estimate
014 - Turbine Building Sump #2 and Storm Water	Flow (mgd)	1/month	Estimate
016 - Intake Screen Wash Water	Flow (mgd)	1/year	Estimate
020 - RO Reject	Flow (mgd)	2/month	Estimate
021 - RO Drain Line	Flow (mgd)	1/month	Estimate
022 – 026 - Storm Water Outfalls	Flow	1/storm event	Grab

Table 6.7-4 Pre-Application, Construction/Pre-Operational, and Operational Meteorological Monitoring Program

Primary Tower Meteorological Parameters

Parameter	Transmitted Locations: ERF Data Base	Transmitted Locations: Control Room	Transmitted Locations: Remote Interrogation
Wind Direction (upper)	X	X	X
Wind Speed (upper)	X	X	X
Sigma theta (upper)			X
Wind Direction (lower)	X	X	X
Wind Speed (lower)	X	X	X
Sigma theta (lower)			X
Ambient Temperature (lower)	X	X	X
Dew point (lower)			X
Delta Ambient Temperature (upper-lower)	X	X	X
Precipitation			X
Backup Tower Meteorological Parameters			
Wind Speed	X	X	X
Wind Direction	X	X	X
Sigma Theta	X	X	X

Note: All parameters are continuously monitored. All parameters going to the ERF database would be available for printout in the existing TSC and EOF. The Units 1 & 2 control room parameters are hardwired.

Table 6.7-5 Pre-Application, Construction/Pre-Operational, and Operational Ecological Monitoring Program

Category	Monitoring Location	Summary	Sampling Methodology	Sampling Frequency
Ecological (Terrestrial)	Site property and immediate vicinity	Bird count in December or January	Visual observation	Variable
Ecological (Terrestrial)	Transmission line corridors	Rare plant survey (National Heritage Program)	Ground-base inspection	Variable
Ecological (Aquatic)	Lake Anna, WHTF	Fish surveys (species, numbers, size distributions)	Electro-fishing, gillnetting	4/year
Ecological (Aquatic)	North Anna River	Smallmouth and largemouth bass abundance survey	Snorkel observations along transects	6/year
Ecological (Aquatic)	Lake Anna, WHTF, and Service Water Reservoir	Shellfish surveys	Virginia Power biologist collection of replicate samples	2/year
Ecological (Aquatic)	North Anna River	Benthic macro-invertebrate studies	Virginia Power biologist collection	Periodic in drought conditions
Ecological (Aquatic)	Lake Anna	Hydrilla inspections	Aerial and ground-based inspection	
Ecological (Aquatic)	Lake Anna	VDGIF-sponsored fish monitoring program		1/year
Ecological (Aquatic)	North Anna River	Monitor fin fish population	Electro-fishing	3/year

Table 6.7-6 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
001 - Discharge of Condenser Cooling Water from Heat Treatment Facility at Dike 3 (Note 1)	Flow (mgd)	1/month	Calculated
	pH	1/year	Grab
	Heat Rejected ($\times 10^9$ Btu/hr)	1/day	Calculated
	Total Residual Chlorine (mg/l)	1/month	Grab
	Copper	1/5 years beginning 2004	Grab
	Nickel	1/5 years beginning 2004	Grab
	Acute and Chronic Toxicity Test	August/September 2004 or 2005 1/3 months if test fails for one year. Annually thereafter.	48-hour static test using Ceriodaphnia dubia to determine No Observable Adverse Effects Concentration (NOAEC).
103 – Process Waste Clarifier (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Oil and Grease (mg/l)	1/3 months	Grab
104 – Oil Water Separator and Storm Water (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Oil and Grease (mg/l)	1/3 months	Grab
105 – Bearing Cooling Tower Blowdown (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Free Available Chlorine	1/month	Grab
	Priority Pollutants (mg/l) Note: 126 Priority Pollutants contained in cooling tower treatment chemicals except for total chromium and total zinc.	1/3 months	Grab
	Total Chromium (mg/l)	1/3 months	Grab
	Total Zinc (mg/l	1/3 months	Grab

Table 6.7-6 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
107 - Bearing Cooling Tower System Discharge-Lake to Lake Operation (Note 1)	Flow (mgd)	1/month	Estimate
	Total Residual Chlorine (mg/l)	1/month	Grab
108 – Service Water Overflow (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
109 & 110 – Hot Well Drains (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
111 - Sewage (Note 1)	Flow (mgd)	1/day	Estimate
	pH	1/month	Grab
	BOD _ 5day (mg/l)	1/6 months	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Total Residual Chlorine (mg/l) or Fecal Coliform (n/100 ml)	1/day 1/week	Grab Grab
112 & 113 – Steam Generator Blowdown Units 1 & 2 (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/6 months	Grab
	Oil and Grease (mg/l)	1/6 months	Grab
114 – Service Water Pipe Vault Drain (Note 1)	Flow (mgd)	1/month	Estimate
115 – Service Water System Blowdown (Note 1)	Flow (mgd)	1/month	Estimate
009 – Groundwater, Storm Water, Backwash form Sand Filters and RO Units (Note 1)	Flow (mgd)	1/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab

Table 6.7-6 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
013 - Turbine Building Sump #1 and Storm Water (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
014 - Turbine Building Sump #2 and Storm Water (Note 1)	Flow (mgd)	1/month	Estimate
	pH	1/month	Grab
	Suspended Solids (mg/l)	1/month	Grab
	Oil and Grease (mg/l)	1/month	Grab
016 – Intake Screen Wash Water (Note 1)	Flow (mgd)	1/year	Estimate
020 – RO Reject (Note 1)	Flow (mgd)	2/month	Estimate
	pH	2/month	Grab
	Suspended Solids (mg/l)	1/3 months	Grab
	Total Residual Chlorine	2/month	Grab
021 – RO Drain Line (Note 1)	Flow (mgd)	1/month	Estimate
022 to 026 Storm Water Associated with Industrial Activities (Note 1)	Total Recoverable Iron	2/year for years 2005 and 2006, immediately after applicable storm event (>0.1 inch)	Grab
	Visual Inspection	1/3 months immediately following applicable storm event (>0.1 inch)	Visual observation
Station 1 – 9 & 11 (Note 2)	Temperature (°C)	Hourly during summer quarter and one other alternating quarter of year	Automated surface measurement.
Station 10 (Note 2)	Temperature (°C)	Hourly during summer quarter and one other alternating quarter of year	Automated 3 m deep measurement

Table 6.7-6 VPDES Water Quality Monitoring Program

Monitoring Location	Constituent (units)	Frequency	Sample Type
Stations A – N (Note 3)	Temperature (°C)	Hourly measurements during daylight hours	Automated surface to bottom measurements at one meter intervals

Data Source: VPDES Permit

Notes:
1. See Figure 6.6-2 for location.
2. See Figure 6.6-1 for location.
3. See Figure 6.2-3 for location.

Chapter 7 Environmental Impacts of Postulated Accidents Involving Radioactive Materials

The purpose of this section is to assess the environmental impacts of postulated accidents involving radioactive materials. Section 7.1 evaluates DBAs, Section 7.2 considers the impact of severe accidents, Section 7.3 addresses severe accident mitigation alternatives (SAMA), and Section 7.4 pertains to transportation accidents.

7.1 Design Basis Accidents

7.1.1 Selection of Accidents

The radiological consequences of accidents are assessed to demonstrate that new units could be constructed and operated at the ESP site without undue risk to the health and safety of the public. The assessment uses site-specific accident meteorology with the radiological analyses in selected reactor designs to analyze the suitability of the ESP site. The assessment uses a robust and conservative set of surrogate DBAs that is representative of the range of reactor designs being considered for the ESP site. The DBAs include a spectrum of events, including those of relatively greater probability of occurrence as well as those that are less probable but have greater severity.

The set of accidents selected focuses on three light water reactor (LWR) designs: AP1000, ABWR, and ESBWR. These three designs have been chosen because these are standard designs that have recognized bases for postulated accident analyses. The accidents for some of the newer reactor types being considered are not as well defined as those for these LWRs and, hence, the accepted analytical methodologies and assumptions applied to LWRs may not apply to these newer reactors. However, because of their greater potential for inherent safety, the accident radiological consequences of the other reactors being considered for the site are expected to be bounded by the AP1000, the ABWR, and the ESBWR. If one of these other designs is eventually selected for the ESP site, the COL application would verify that the AP1000, ABWR, and ESBWR doses are bounding or provide a complete evaluation of accident radiological consequences compared with regulatory limits.

The following LWR accidents are identified in NUREG-1555, Section 7.1, Appendix A (Reference 1), as those that should be considered for radiological consequences, based on the SRP, NUREG-0800 (Reference 2):

- SRP Section 15.1.5, PWR Main Steam Line Break
- SRP Section 15.2.8, Feedwater System Pipe Break
- SRP Section 15.3.3, Locked Rotor Accident
- SRP Section 15.3.4, Reactor Coolant Pump Shaft Break
- SRP Section 15.4.9, BWR Control Rod Drop Accident

- SRP Section 15.6.2, Failure of Small Lines Carrying Primary Coolant Outside Containment
- SRP Section 15.6.3, PWR Steam Generator Tube Failure
- SRP Section 15.6.5, Loss-of-Coolant Accident
- SRP Section 15.7.4, Fuel Handling Accident

RG 1.183 (Reference 3) includes the following additional accidents:

- PWR Rod Ejection Accident (corresponds to SRP Section 15.4.8)
- BWR Main Steam Line Break (corresponds to SRP Section 15.6.4)

In addition, a cleanup water line break is evaluated for the ABWR and the ESBWR. The radiological consequences from the above DBAs are analyzed. This set of accidents provides a reasonable basis for evaluating the suitability of the ESP site.

7.1.2 Evaluation Methodology

Doses for the representative DBAs are evaluated at the EAB and the LPZ. These doses must meet the site acceptance criteria in 10 CFR 50.34 and 10 CFR 100 (Reference 4 and Reference 5, respectively). Although the emergency safety features are expected to prevent core damage and mitigate releases of radioactivity, the loss-of-coolant accidents (LOCAs) analyzed presume substantial core melt with the release of significant amounts of fission products. The postulated LOCAs are expected to more closely approach 10 CFR 50.34 limits than the other DBAs of greater probability of occurrence but lesser magnitude of activity releases. For these accidents, the calculated doses are compared to the acceptance criteria in RG 1.183 and NUREG-0800, to demonstrate that the consequences of the postulated accidents are acceptable.

The evaluations use short-term accident atmospheric dispersion factors (χ/Q). The χ/Qs are calculated using the methodology of RG 1.145 (Reference 6) and site-specific meteorological data. The following site-specific 50th percentile χ/Q values from Section 2.7.5.2 are used in these evaluations, per NUREG-1555:

- EAB – 3.34E-5 sec/m^3
- LPZ – 2.17E-6 sec/m^3

The accident dose calculations are performed using the activity releases for the following time intervals:

- EAB – 0 to 2 hours
- LPZ – 0 to 8 hours, 8 to 24 hours, 24 to 96 hours, and 96 to 720 hours

The accident doses are expressed as TEDE, consistent with 10 CFR 50.34. The TEDE consists of the sum of the committed effective dose equivalent (CEDE) from inhalation and either the deep dose equivalent (DDE) or the effective dose equivalent (EDE) from external exposure. The CEDE is determined using the dose conversion factors in Federal Guidance Report 11 (Reference 7), while the DDE and the EDE are based on dose conversion factors in Federal Guidance Report 12 (Reference 8).

7.1.3 **Source Terms**

Doses are calculated based on the time-dependent activities released to the environment during each DBA. The activities are based on the analyses used to support the reactor standard safety analysis reports. Different reactor technologies use different source terms and approaches in defining the activity releases. The ABWR source term is based on TID-14844 (Reference 9). Environmental releases are calculated using the guidance in the NUREG-0800 and RGs 1.3 and 1.25 (Reference 10 and Reference 11, respectively). The AP1000 and ESBWR source terms, methodologies, and assumptions are based on the alternative source term methods outlined in RG 1.183. The activity releases and doses for the AP1000, the ABWR, and the ESBWR are based on 102 percent of core thermal power.

The ABWR activity releases are scaled up from a power level of 4005 MWt (102 percent of 3926 MWt, as specified in the design certification) to 4386 MWt (102 percent of 4300 MWt, the power proposed for a new ABWR unit at the ESP site), an adjustment factor of 1.10. Because the ESBWR design has not yet been certified by the NRC, the ESBWR design control document activity releases are increased by 25 percent to allow for uncertainty.

The IRIS and ACR-700 source term information are preliminary, but the AP1000 LOCA is expected to bound the worst-case accident releases for these advanced reactor concepts.

The advanced gas reactor designs (GT-MHR and PBMR) use mechanistic accident source terms and postulate relatively small environmental releases, compared with the water reactor technologies. The activity releases to the environment are typically provided by the reactor vendors as part of their standard design packages.

7.1.4 **Radiological Consequences**

For the AP1000 and ABWR accidents identified in Section 7.1.1, site-specific doses are calculated by multiplying the design certification doses by the ratio of site χ/Qs to design certification χ/Qs. Using the EAB and LPZ site χ/Qs of 3.34E-5 and 2.17E-6 sec/m^3, respectively, from Section 7.1.2, with the design certification χ/Qs (Reference 12 and Reference 13), the following ratios are obtained:

Table 7.1-1 Design Certification χ/Q Values and Ratios to Site χ/Q Values

		χ/Q (sec/m^3)		Ratio (Site/DC)	
	Time (hr)	**AP1000**	**ABWR**	**AP1000**	**ABWR**
EAB	0–2	6.00E-04	1.37E-03	5.57E-02	2.44E-02
LPZ	0–8	1.35E-04	1.56E-04	1.61E-02	1.39E-02
	8–24	1.00E-04	9.61E-05	2.17E-02	2.26E-02
	24–96	5.40E-05	3.36E-05	4.02E-02	6.46E-02
	96–720	2.20E-05	7.42E-06	9.86E-02	2.92E-01

Details about the methodology and assumptions pertaining to each of the accidents, such as activity release paths and the credited mitigation features, may be found in the design certification documents for the AP1000 (Reference 12), the ABWR (Reference 13), and the ESBWR (Reference 14).

As the ABWR design certification document presents whole body and thyroid doses, an equivalent TEDE value is estimated by multiplying the thyroid dose by 0.03 and adding the product to the whole body dose in accordance with RG 1.183. Also, consistent with the activity releases in Section 7.1.3, the ABWR doses are scaled up by a factor of 1.10 from a power level of 4005 MWt (102 percent of 3926 MWt, as specified in the design certification) to 4386 MWt (102 percent of 4300 MWt, the power proposed for a new ABWR unit at the ESP site).

As the ESBWR design has not yet been certified by the NRC, the doses are calculated based on activity releases, which include a margin of 25 percent to allow for uncertainty. The TEDE dose from an isotope for a given time period is calculated by adding the CEDE from inhalation and the EDE from external exposure. The CEDE is calculated by multiplying the isotopic activity by the site χ/Q value, the breathing rate of the individual located offsite, and the effective inhalation dose conversion factor from Federal Guidance Report 11. The EDE is calculated by multiplying the isotopic activity by the site χ/Q value and the effective submersion dose conversion factor from Federal Guidance Report 12.

A summary of the resulting accident doses is presented in Table 7.1-2. This table also compares the environmental doses to the recommended limits in RG 1.183 and NUREG-0800 and shows that the evaluated dose consequences are within the recommended limits.

The TEDE dose limits in Table 7.1-2 are taken from RG 1.183, Table 6, for all accidents except PWR Reactor Coolant Pump Shaft Break (SRP Section 15.3.4) and Failure of Small Lines Carrying Primary Coolant Outside Containment (SRP Section 15.6.2). For these two accidents, NUREG-0800 indicates that the dose limit is a “small fraction” or 10 percent of the 10 CFR 100 guideline of 25 Rem, meaning a limit of 2.5 Rem.

The doses summarized in Table 7.1-2 are based on the time-dependent doses presented in Table 7.1-3 to Table 7.1-32 for each of the accidents. In addition to doses, the latter tables also show the activities released to the environment.

Section 7.1 References

1. NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants*, NRC, October 1999.

2. NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*, NRC, 1987.

3. Regulatory Guide 1.183, *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors*, NRC, July 2000.

4. 10 CFR 50.34, *Code of Federal Regulations*, “Contents of applications; technical information.”

5. 10 CFR 100, *Code of Federal Regulations*, “Reactor Site Criteria.”

6. Regulatory Guide 1.145, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*, Revision 1, NRC, November 1982.

7. Federal Guidance Report 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, U. S. Environmental Protection Agency, EPA-520/1-88-020, 1988.

8. Federal Guidance Report 12, *External Exposure to Radionuclides in Air, Water, and Soil*, U. S. Environmental Protection Agency, EPA-402-R-93-081, 1993.

9. TID-14844, *Calculation of Distance Factors for Power and Test Reactor Sites*, U. S. Atomic Energy Commission, March 1962.

10. Regulatory Guide 1.3, *Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors*, Revision 2, NRC, June 1974.

11. Regulatory Guide 1.25 (Safety Guide 25), *Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors*, NRC, March 1972.

12. AP1000 Document No. APP-GW-GL-700, *AP1000 Design Control Document*, Tier 2 Material, Westinghouse, Revision 2, 2002.

13. Document 23A6100, *ABWR Standard Safety Analysis Report*, General Electric, Revision 8.

14. Document 26A6642, *ESBWR Design Control Document*, Tier 2 Material, General Electric, Revision 1.

Table 7.1-2 Summary of Design Basis Accident Doses

SRP Section	Accident	Reactor	TEDE (Rem) EAB	TEDE (Rem) LPZ	TEDE (Rem) Limit
15.1.5	PWR Main Steam Line Break				
	Pre-Existing Iodine Spike	AP1000	3.9E-02	1.1E-02	25
	Accident-Initiated Iodine Spike	AP1000	4.5E-02	4.5E-02	2.5
15.2.8	Feedwater System Pipe Break	AP1000	See Note 1		2.5
		ABWR	See Note 2		2.5
		ESBWR	6.8E-06	4.4E-07	2.5
15.3.3	Reactor Coolant Pump Rotor Seizure (Locked Rotor Accident)	AP1000	1.4E-01	9.6E-03	2.5
		ABWR/ESBWR	Not Postulated		2.5
15.3.4	Reactor Coolant Pump Shaft Break	AP1000	See Note 3		2.5
		ABWR/ESBWR	Not Postulated		2.5
15.4.8	PWR Rod Ejection Accident	AP1000	1.7E-01	3.1E-02	6.3
15.4.9	BWR Control Rod Drop Accident	ABWR/ESBWR	Not Postulated		6.3
15.6.2	Failure of Small Lines Carrying Primary Coolant Outside Containment	AP1000	7.2E-02	4.8E-03	2.5
		ABWR	6.4E-03	4.1E-04	2.5
		ESBWR	4.5E-03	6.8E-04	2.5
15.6.3	PWR Steam Generator Tube Rupture				
	Pre-Existing Iodine Spike	AP1000	1.7E-01	5.7E-03	25
	Accident-Initiated Iodine Spike	AP1000	8.4E-02	4.5E-03	2.5
15.6.4	BWR Main Steam Line Break				
	Pre-Existing Iodine Spike	ABWR	7.6E-02	4.9E-03	25
	Equilibrium Iodine Spike	ABWR	3.7E-03	2.4E-04	2.5
	Pre-Existing Iodine Spike	ESBWR	3.1E-01	2.0E-02	25
	Equilibrium Iodine Spike	ESBWR	1.6E-02	1.0E-03	2.5
15.6.5	Loss-of-Coolant Accident	AP1000	1.4E+00	2.0E-01	25
		ABWR	2.6E-01	1.7E+00	25
		ESBWR	2.1E-01	2.0E-01	25

Table 7.1-2 Summary of Design Basis Accident Doses

SRP Section	Accident	Reactor	TEDE (Rem) EAB	TEDE (Rem) LPZ	TEDE (Rem) Limit
15.7.4	Fuel Handling Accident	AP1000	1.3E-01	9.6E-03	6.3
		ABWR	9.2E-02	6.0E-03	6.3
		ESBWR	1.8E-01	1.2E-02	6.3
	Cleanup Water Line Break	ABWR	4.7E-04	3.0E-05	2.5
		ESBWR	2.6E-02	1.7E-03	2.5

Notes:

1. The AP1000 design certification indicates that the doses for the feedwater system pipe break are bounded by the main steam line break (Reference 12, Section 15.2.8.3).
2. The ABWR design certification indicates that the doses for the feedwater system pipe break are bounded by the cleanup water line break (Reference 13, Section 15.2.8).
3. The AP1000 design certification indicates that the doses for the reactor coolant pump shaft break are bounded by the reactor coolant pump rotor seizure (Reference 12, Section 15.3.4.2).
4. The ABWR design certification indicates that there are no radiological consequences for the reactor coolant pump rotor seizure, the reactor coolant pump shaft break, and the control rod drop accident (Reference 13, Sections 15.3.3.5, 15.3.4.5, and 15.4.10.6).
5. The ESBWR design certification indicates that there are no radiological consequences for the reactor coolant pump rotor seizure, the reactor coolant pump shaft break, and the control rod drop accident (Reference 14).

Table 7.1-3 Activity Releases for AP1000 Main Steam Line Break, Pre-Existing Iodine Spike

	Activity Release (Ci)				
Isotope	**0–2 hr**	**2–8 hr**	**8–24 hr**	**24–72 hr**	**Total**
Kr-85m	2.30E-01	3.82E-01	2.26E-01	2.03E-02	8.58E-01
Kr-85	9.47E-01	2.83E+00	7.47E+00	2.17E+01	3.29E+01
Kr-87	9.24E-02	4.49E-02	1.76E-03	2.84E-07	1.39E-01
Kr-88	3.77E-01	4.59E-01	1.34E-01	2.72E-03	9.73E-01
Xe-131m	4.28E-01	1.27E+00	3.26E+00	8.78E+00	1.37E+01
Xe-133m	5.31E-01	1.51E+00	3.45E+00	6.69E+00	1.22E+01
Xe-133	3.95E+01	1.15E+02	2.87E+02	7.03E+02	1.14E+03
Xe-135m	1.02E-02	4.44E-05	0.00E+00	0.00E+00	1.02E-02
Xe-135	1.04E+00	2.31E+00	2.78E+00	1.11E+00	7.24E+00
Xe-138	1.34E-02	3.81E-05	0.00E+00	0.00E+00	1.34E-02
I-130	4.98E-01	4.74E-01	6.95E-01	4.36E-01	2.10E+00
I-131	3.37E+01	4.05E+01	1.03E+02	2.67E+02	4.44E+02
I-132	4.02E+01	1.39E+01	2.68E+00	2.16E-02	5.68E+01
I-133	6.03E+01	6.35E+01	1.17E+02	1.30E+02	3.71E+02
I-134	8.24E+00	5.47E-01	4.77E-03	1.50E-08	8.79E+00
I-135	3.56E+01	2.73E+01	2.51E+01	5.60E+00	9.36E+01
Cs-134	1.91E+01	6.52E-01	1.72E+00	5.00E+00	2.65E+01
Cs-136	2.84E+01	9.57E-01	2.47E+00	6.69E+00	3.85E+01
Cs-137	1.38E+01	4.70E-01	1.24E+00	3.61E+00	1.91E+01
Cs-138	1.02E+01	3.41E-03	1.48E-06	0.00E+00	1.02E+01
Total	2.93E+02	2.72E+02	5.58E+02	1.16E+03	2.28E+03

Table 7.1-4 Doses for AP1000 Main Steam Line Break, Pre-Existing Iodine Spike

	AP1000 TEDE (Rem)		χ/Q Ratio	Site TEDE (Rem)	
Time	**EAB**	**LPZ**	**(Site/AP1000)**	**EAB**	**LPZ**
0–2 hr	7.00E-01		5.57E-02	3.90E-02	
0–8 hr		2.40E-01	1.61E-02		3.86E-03
8–24 hr		8.00E-02	2.17E-02		1.74E-03
24–96 hr		1.30E-01	4.02E-02		5.22E-03
96–720 hr		0.00E+00	9.86E-02		0.00E+00
Total	7.00E-01	4.50E-01		3.90E-02	1.08E-02
Limit				25	25

Table 7.1-5 Activity Releases for AP1000 Main Steam Line Break, Accident-Initiated Iodine Spike

	Activity Release (Ci)				
Isotope	**0-2 hr**	**2-8 hr**	**8-24 hr**	**24-72 hr**	**Total**
Kr-85m	2.30E-01	3.82E-01	2.26E-01	2.03E-02	8.58E-01
Kr-85	9.47E-01	2.83E+00	7.47E+00	2.17E+01	3.29E+01
Kr-87	9.24E-02	4.49E-02	1.76E-03	2.84E-07	1.39E-01
Kr-88	3.77E-01	4.59E-01	1.34E-01	2.72E-03	9.73E-01
Xe-131m	4.28E-01	1.27E+00	3.26E+00	8.78E+00	1.37E+01
Xe-133m	5.31E-01	1.51E+00	3.45E+00	6.69E+00	1.22E+01
Xe-133	3.95E+01	1.15E+02	2.87E+02	7.03E+02	1.14E+03
Xe-135m	1.02E-02	4.44E-05	0.00E+00	0.00E+00	1.02E-02
Xe-135	1.04E+00	2.31E+00	2.78E+00	1.11E+00	7.24E+00
Xe-138	1.34E-02	3.81E-05	0.00E+00	0.00E+00	1.34E-02
I-130	6.84E-01	3.33E+00	5.27E+00	3.30E+00	1.26E+01
I-131	3.92E+01	1.92E+02	5.18E+02	1.35E+03	2.10E+03
I-132	9.12E+01	3.26E+02	7.46E+01	6.00E-01	4.92E+02
I-133	7.75E+01	3.81E+02	7.54E+02	8.34E+02	2.05E+03
I-134	3.03E+01	6.23E+01	8.85E-01	2.78E-06	9.35E+01
I-135	5.57E+01	2.59E+02	2.61E+02	5.82E+01	6.34E+02
Cs-134	1.91E+01	6.52E-01	1.72E+00	5.00E+00	2.65E+01
Cs-136	2.84E+01	9.57E-01	2.47E+00	6.69E+00	3.85E+01
Cs-137	1.38E+01	4.70E-01	1.24E+00	3.61E+00	1.91E+01
Cs-138	1.02E+01	3.41E-03	1.48E-06	0.00E+00	1.02E+01
Total	4.09E+02	1.35E+03	1.92E+03	3.00E+03	6.68E+03

Table 7.1-6 Doses for AP1000 Main Steam Line Break, Accident-Initiated Iodine Spike

	AP1000 TEDE (Rem)		χ/Q Ratio	Site TEDE (Rem)	
Time	EAB	LPZ	(Site/AP1000)	EAB	LPZ
0–2 hr	8.00E-01		5.57E-02	4.45E-02	
0–8 hr		6.40E-01	1.61E-02		1.03E-02
8–24 hr		4.20E-01	2.17E-02		9.11E-03
24–96 hr		6.30E-01	4.02E-02		2.53E-02
96–720 hr		0.00E+00	9.86E-02		0.00E+00
Total	8.00E-01	1.69E-00		4.45E-02	4.47E-02
Limit				2.5	2.5

Table 7.1-6a Activity Releases for ABWR Cleanup Water Line Break

	Activity Release (Ci)
Isotope	0–2 hr
I-131	2.40E+00
I-132	5.62E+00
I-133	6.80E+00
I-134	9.46E+00
I-135	7.39E+00
Total	3.17E+01

Table 7.1-6b Doses for ABWR Cleanup Water Line Break

	ABWR EAB Dose (S_v)			χ/Q Ratio	Site TEDE (Rem)	
Time	W. Body	Thyroid	TEDE	(Site/ABWR)	EAB	LPZ
0–2 hr	1.70E-04	1.70E-04	1.75E-04	2.44E-02	4.68E-04	
0–8 hr	1.70E-04	1.70E-04	1.75E-04	1.58E-03		3.04E-05
8–24 hr						0.00E+00
24–96 hr						0.00E+00
96–720 hr						0.00E+00
Total	1.70E-04	1.70E-04	1.75E-04		4.68E-04	3.04E-05
Limit					2.5	2.5

Note: The ABWR TEDE is whole body dose plus 3% of thyroid dose. Since the ABWR design certification document does not include an LPZ dose for this accident, the site LPZ dose is obtained by multiplying the ABWR EAB dose by the ratio of site LPZ χ/Q to ABWR EAB χ/Q. The site doses include a multiplier of 1.10 for power adjustment.

Table 7.1-6c Activity Releases for ESBWR Feedwater System Pipe Break

	Activity Release (Ci)
Isotope	0–2 hr
I-131	4.39E-03
I-132	4.05E-02
I-133	2.94E-02
I-134	7.43E-02
I-135	4.05E-02
Total	1.89E-01

Table 7.1-6d Doses for ESBWR Feedwater System Pipe Break

	Site TEDE (Rem)	
Time	**EAB**	**LPZ**
0–2 hr	6.85E-06	
0–8 hr		4.45E-07
8–24 hr		0.00E+00
24–96 hr		0.00E+00
96–720 hr		0.00E+00
Total	6.85E-06	4.45E-07
Limit	2.5	2.5

Table 7.1-7 Activity Releases for AP1000 Locked Rotor Accident

Isotope	Activity Release (Ci) 0–2 hr
Kr-85m	4.09E+02
Kr-85	3.77E+01
Kr-87	6.05E+02
Kr-88	1.05E+03
Xe-131m	1.87E+01
Xe-133m	1.02E+02
Xe-133	3.33E+03
Xe-135m	1.63E+02
Xe-135	8.01E+02
Xe-138	6.48E+02
I-130	4.15E+00
I-131	1.83E+02
I-132	1.33E+02
I-133	2.31E+02
I-134	1.44E+02
I-135	2.04E+02
Cs-134	5.83E+00
Cs-136	1.85E+00
Cs-137	3.42E+00
Cs-138	3.05E+01
Rb-86	6.69E-02
Total	8.11E+03

Table 7.1-8 Doses for AP1000 Locked Rotor Accident

	AP1000 TEDE (Rem)		χ/Q Ratio	Site TEDE (Rem)	
Time	EAB	LPZ	(Site/AP1000)	EAB	LPZ
0–2 hr	2.50E+00		5.57E-02	1.39E-01	
0–8 hr		6.00E-01	1.61E-02		9.64E-03
8–24 hr		0.00E+00	2.17E-02		0.00E+00
24–96 hr		0.00E+00	4.02E-02		0.00E+00
96–720 hr		0.00E+00	9.86E-02		0.00E+00
Total	2.50E+00	6.00E-01		1.39E-01	9.64E-03
Limit				2.5	2.5

Table 7.1-9 Activity Releases for AP1000 Rod Ejection Accident

	Activity Release (Ci)					
Isotope	**0–2 hr**	**2–8 hr**	**8–24 hr**	**24–96 hr**	**96–720 hr**	**Total**
Kr-85m	2.85E+02	6.48E+01	3.87E+01	3.53E+00	5.01E-05	3.92E+02
Kr-85	1.24E+01	5.60E+00	1.49E+01	6.70E+01	5.71E+02	6.71E+02
Kr-87	4.86E+02	2.60E+01	1.03E+00	1.67E-04	0.00E+00	5.13E+02
Kr-88	7.49E+02	1.18E+02	3.49E+01	7.18E-01	1.68E-08	9.03E+02
Xe-131m	1.22E+01	5.46E+00	1.42E+01	5.72E+01	2.31E+02	3.20E+02
Xe-133m	6.62E+01	2.81E+01	6.49E+01	1.69E+02	1.06E+02	4.34E+02
Xe-133	2.18E+03	9.58E+02	2.40E+03	8.53E+03	1.68E+04	3.09E+04
Xe-135m	2.18E+02	5.30E-02	4.33E-09	0.00E+00	0.00E+00	2.18E+02
Xe-135	5.39E+02	1.72E+02	2.09E+02	8.69E+01	3.58E-01	1.01E+03
Xe-138	8.89E+02	1.38E-01	3.19E-09	0.00E+00	0.00E+00	8.89E+02
I-130	5.93E+00	7.28E+00	4.32E+00	4.06E-01	5.88E-04	1.79E+01
I-131	1.64E+02	2.45E+02	2.31E+02	6.20E+01	3.33E+01	7.35E+02
I-132	1.90E+02	9.94E+01	9.85E+00	1.65E-02	0.00E+00	2.99E+02
I-133	3.29E+02	4.40E+02	3.18E+02	4.56E+01	4.81E-01	1.13E+03
I-134	2.18E+02	2.85E+01	1.37E-01	8.96E-08	0.00E+00	2.47E+02
I-135	2.91E+02	2.97E+02	1.19E+02	4.79E+00	1.46E-04	7.12E+02
Cs-134	3.15E+01	6.22E+01	6.03E+01	1.55E+01	1.03E+01	1.80E+02
Cs-136	8.98E+00	1.75E+01	1.67E+01	4.10E+00	1.31E+00	4.86E+01
Cs-137	1.83E+01	3.62E+01	3.51E+01	9.04E+00	6.05E+00	1.05E+02
Cs-138	1.13E+02	7.05E+00	1.68E-03	0.00E+00	0.00E+00	1.20E+02
Rb-86	3.70E-01	7.27E-01	6.96E-01	1.73E-01	6.79E-02	2.03E+00
Total	6.81E+03	2.62E+03	3.57E+03	9.06E+03	1.78E+04	3.98E+04

Table 7.1-10 Doses for AP1000 Rod Ejection Accident

	AP1000 TEDE (Rem)		χ/Q Ratio	Site TEDE (Rem)	
Time	**EAB**	**LPZ**	**(Site/AP1000)**	**EAB**	**LPZ**
0–2 hr	3.00E-00		5.57E-02	1.67E-01	
0–8 hr		1.40E+00	1.61E-02		2.25E-02
8–24 hr		2.60E-01	2.17E-02		5.64E-03
24–96 hr		4.60E-02	4.02E-02		1.85E-03
96–720 hr		1.20E-02	9.86E-02		1.18E-03
Total	3.00E-00	1.72E+00		1.67E-01	3.12E-02
Limit				6.3	6.3

Table 7.1-11 Doses for AP1000 Failure of Small Lines Carrying Primary Coolant Outside Containment

	AP1000 TEDE (Rem)		χ/Q Ratio	Site TEDE (Rem)	
Time	**EAB**	**LPZ**	**(Site/AP1000)**	**EAB**	**LPZ**
0–2 hr	1.30E+00		5.57E-02	7.24E-02	
0–8 hr		3.00E-01	1.61E-02		4.82E-03
8–24 hr		0.00E+00	2.17E-02		0.00E+00
24–96 hr		0.00E+00	4.02E-02		0.00E+00
96–720 hr		0.00E+00	9.86E-02		0.00E+00
Total	1.30E+00	3.00E-01		7.24E-02	4.82E-03
Limit				2.5	2.5

Note: No activity release information is available for this accident.

Table 7.1-12 Activity Releases for ABWR Failure of Small Lines Carrying Primary Coolant Outside Containment

	Activity Release (Ci)		
Isotope	**0–2 hr**	**2–8 hr**	**Total**
I-131	2.01E+00	2.16E+00	4.17E+00
I-132	1.76E+01	1.76E+01	3.52E+01
I-133	1.36E+01	1.43E+01	2.79E+01
I-134	2.93E+01	2.69E+01	5.62E+01
I-135	1.95E+01	2.01E+01	3.96E+01
Total	8.20E+01	8.11E+01	1.63E+02

Table 7.1-13 Doses for ABWR Failure of Small Lines Carrying Primary Coolant Outside Containment

	ABWR EAB Dose (Sv)			χ/Q Ratio	Site TEDE (Rem)	
Time	**W. Body**	**Thyroid**	**TEDE**	**(Site/ABWR)**	**EAB**	**LPZ**
0–2 hr	9.40E-04	4.80E-02	2.38E-03	2.44E-02	6.36E-03	
0–8 hr	9.40E-04	4.80E-02	2.38E-03	1.58E-03		4.13E-04
8–24 hr						0.00E+00
24–96 hr						0.00E+00
96–720 hr						0.00E+00
Total	9.40E-04	4.80E-02	2.38E-03		6.36E-03	4.13E-04
Limit					2.5	2.5

Note: The ABWR TEDE is whole body dose plus 3% of thyroid dose. Since the ABWR design certification document does not include an LPZ dose for this accident, the site LPZ dose is obtained by multiplying the ABWR EAB dose by ratio of site LPZ χ/Q to ABWR EAB χ/Q. The site doses include a multiplier of 1.10 for power adjustment.

Table 7.1-13a Activity Releases for ESBWR Failure of Small Lines Carrying Primary Coolant Outside Containment

	Activity Release (Ci)		
Isotope	0–2 hr	2–8 hr	Total
I-131	6.13E+00	1.05E+01	1.66E+01
I-132	8.03E+00	7.35E+00	1.54E+01
I-133	1.51E+01	2.35E+01	3.86E+01
I-134	8.78E+00	4.60E+00	1.34E+01
I-135	1.39E+01	1.85E+01	3.24E+01
Total	5.19E+01	6.45E+01	1.16E+02

Table 7.1-13b Doses for ESBWR Failure of Small Lines Carrying Primary Coolant Outside Containment

	Site TEDE (Rem)	
Time	EAB	LPZ
2–4 hr	4.49E-03	
0–8 hr		6.84E-04
8–24 hr		0.00E+00
24–96 hr		0.00E+00
96–720 hr		0.00E+00
Total	4.49E-03	6.84E-04
Limit	2.5	2.5

Note: The maximum EAB dose occurs between 2 and 4 hours.

Table 7.1-14 Activity Releases for AP1000 Steam Generator Tube Rupture, Pre-Existing Iodine Spike

	Activity Release (Ci)			
Isotope	0–2 hr	2–8 hr	8–24 hr	Total
Kr-85m	5.67E+01	1.91E+01	2.50E-02	7.58E+01
Kr-85	2.25E+02	1.07E+02	4.44E-01	3.32E+02
Kr-87	2.46E+01	3.56E+00	3.02E-04	2.82E+01
Kr-88	9.44E+01	2.61E+01	1.80E-02	1.21E+02
Xe-131m	1.02E+02	4.82E+01	1.96E-01	1.50E+02
Xe-133m	1.26E+02	5.83E+01	2.19E-01	1.85E+02
Xe-133	9.37E+03	4.41E+03	1.75E+01	1.38E+04
Xe-135m	3.61E+00	5.78E-03	0.00E+00	3.62E+00
Xe-135	2.51E+02	1.00E+02	2.35E-01	3.51E+02
Xe-138	4.78E+00	4.99E-03	0.00E+00	4.78E+00
I-130	1.81E+00	6.12E-02	2.90E-01	2.16E+00
I-131	1.22E+02	5.97E+00	3.32E+01	1.61E+02
I-132	1.43E+02	8.53E-01	2.08E+00	1.46E+02
I-133	2.19E+02	8.68E+00	4.41E+01	2.72E+02
I-134	2.78E+01	5.16E-03	4.57E-03	2.78E+01
I-135	1.28E+02	3.06E+00	1.26E+01	1.44E+02
Cs-134	1.65E+00	6.35E-02	2.27E-01	1.94E+00
Cs-136	2.45E+00	9.30E-02	3.30E-01	2.87E+00
Cs-137	1.19E+00	4.58E-02	1.64E-01	1.40E+00
Cs-138	5.71E-01	3.07E-06	6.00E-07	5.71E-01
Total	1.09E+04	4.79E+03	1.12E+02	1.58E+04

Table 7.1-15 Doses for AP1000 Steam Generator Tube Rupture, Pre-Existing Iodine Spike

	AP1000 TEDE (Rem)		χ/Q Ratio	Site TEDE (Rem)	
Time	EAB	LPZ	(Site/AP1000)	EAB	LPZ
0–2 hr	3.00E-00		5.57E-02	1.67E-01	
0–8 hr		3.20E-01	1.61E-02		5.14E-03
8–24 hr		2.60E-02	2.17E-02		5.64E-04
24–96 hr		0.00E+00	4.02E-02		0.00E+00
96–720 hr		0.00E+00	9.86E-02		0.00E+00
Total	3.00E-00	3.46E-01		1.67E-01	5.71E-03
Limit				25	25

Table 7.1-16 Activity Releases for AP1000 Steam Generator Tube Rupture, Accident-Initiated Iodine Spike

	Activity Release (Ci)			
Isotope	0–2 hr	2–8 hr	8–24 hr	Total
Kr-85m	5.67E+01	1.91E+01	2.50E-02	7.58E+01
Kr-85	2.25E+02	1.07E+02	4.44E-01	3.32E+02
Kr-87	2.46E+01	3.56E+00	3.02E-04	2.82E+01
Kr-88	9.44E+01	2.61E+01	1.80E-02	1.21E+02
Xe-131m	1.02E+02	4.82E+01	1.96E-01	1.50E+02
Xe-133m	1.26E+02	5.83E+01	2.19E-01	1.85E+02
Xe-133	9.37E+03	4.41E+03	1.75E+01	1.38E+04
Xe-135m	3.61E+00	5.78E-03	0.00E+00	3.62E+00
Xe-135	2.51E+02	1.00E+02	2.35E-01	3.51E+02
Xe-138	4.78E+00	4.99E-03	0.00E+00	4.78E+00
I-130	7.30E-02	1.19E-02	3.13E-02	1.16E-01
I-131	4.90E+00	1.15E+00	3.55E+00	9.60E+00
I-132	5.79E+00	1.75E-01	2.30E-01	6.20E+00
I-133	8.79E+00	1.68E+00	4.73E+00	1.52E+01
I-134	1.12E+00	1.18E-03	5.21E-04	1.12E+00
I-135	5.15E+00	6.01E-01	1.36E+00	7.11E+00
Cs-134	1.65E+00	6.35E-02	2.27E-01	1.94E+00
Cs-136	2.45E+00	9.30E-02	3.30E-01	2.87E+00
Cs-137	1.19E+00	4.58E-02	1.64E-01	1.40E+00
Cs-138	5.71E-01	3.07E-06	6.00E-07	5.71E-01
Total	1.03E+04	4.78E+03	2.93E+01	1.51E+04

Table 7.1-17 Doses for AP1000 Steam Generator Tube Rupture, Accident-Initiated Iodine Spike

	AP1000 TEDE (Rem)		χ/Q Ratio	Site TEDE (Rem)	
Time	EAB	LPZ	(Site/AP1000)	EAB	LPZ
0–2 hr	1.50E+00		5.57E-02	8.35E-02	
0–8 hr		1.80E-01	1.61E-02		2.89E-03
8–24 hr		7.20E-02	2.17E-02		1.56E-03
24–96 hr		0.00E+00	4.02E-02		0.00E+00
96–720 hr		0.00E+00	9.86E-02		0.00E+00
Total	1.50E+00	2.52E-01		8.35E-02	4.46E-03
Limit				2.5	2.5

Table 7.1-18 Activity Releases for ABWR Main Steam Line Break

	Activity Release (Ci)	
Isotope	**Pre-Existing**	**Equilibrium Activity**
I-131	4.32E+01	2.16E+00
I-132	4.20E+02	2.10E+01
I-133	2.95E+02	1.48E+01
I-134	8.25E+02	4.14E+01
I-135	4.32E+02	2.16E+01
Kr-83m	7.22E-02	1.20E-02
Kr-85m	1.27E-01	2.12E-02
Kr-85	4.02E-04	6.68E-05
Kr-87	4.35E-01	7.22E-02
Kr-88	4.38E-01	7.27E-02
Kr-89	1.75E+00	2.92E-01
Kr-90	4.58E-01	7.54E-02
Xe-131m	3.13E-04	5.20E-05
Xe-133m	6.03E-03	1.00E-03
Xe-133	1.69E-01	2.80E-02
Xe-135m	5.15E-01	8.55E-02
Xe-135	4.79E-01	7.98E-02
Xe-137	2.19E+00	3.64E-01
Xe-138	1.67E+00	2.79E-01
Xe-139	7.66E-01	1.28E-01
Total	2.02E+03	1.02E+02

Table 7.1-19 Doses for ABWR Main Steam Line Break, Pre-Existing Iodine Spike

	ABWR EAB Dose (Sv)			χ/Q Ratio	Site TEDE (Rem)	
Time	W. Body	Thyroid	TEDE	(Site/ABWR)	EAB	LPZ
0–2 hr	1.30E-02	5.10E-01	2.83E-02	2.44E-02	7.56E-02	
0–8 hr	1.30E-02	5.10E-01	2.83E-02	1.58E-03		4.91E-03
8–24 hr						0.00E+00
24–96 hr						0.00E+00
96–720 hr						0.00E+00
Total	1.30E-02	5.10E-01	2.83E-02		7.56E-02	4.91E-03
Limit					25	25

Note: The ABWR TEDE is whole body dose plus 3% of thyroid dose. Since the ABWR design certification document does not include an LPZ dose for this accident, the site LPZ dose is obtained by multiplying the ABWR EAB dose by the ratio of site LPZ χ/Q to ABWR EAB χ/Q. The site doses include a multiplier of 1.10 for power adjustment.

Table 7.1-20 Doses for ABWR Main Steam Line Break, Equilibrium Iodine Activity

	ABWR EAB Dose (Sv)			χ/Q Ratio	Site TEDE (Rem)	
Time	W. Body	Thyroid	TEDE	(Site/ABWR)	EAB	LPZ
0–2 hr	6.20E-04	2.60E-02	1.40E-03	2.44E-02	3.74E-03	
0–8 hr	6.20E-04	2.60E-02	1.40E-03	1.58E-03		2.43E-04
8–24 hr						0.00E+00
24–96 hr						0.00E+00
96–720 hr						0.00E+00
Total	6.20E-04	2.60E-02	1.40E-03		3.74E-03	2.43E-04
Limit					2.5	2.5

Note: The ABWR TEDE is whole body dose plus 3% of thyroid dose. Since the ABWR design certification document does not include an LPZ dose for this accident, the site LPZ dose is obtained by multiplying the ABWR EAB dose by the ratio of site LPZ χ/Q to ABWR EAB χ/Q. The site doses include a multiplier of 1.10 for power adjustment.

Table 7.1-20a Activity Releases for ESBWR Main Steam Line Break

	Activity Release (Ci)	
Isotope	Pre-Existing	Equilibrium Activity
I-131	1.96E+02	9.79E+00
I-132	1.86E+03	9.45E+01
I-133	1.35E+03	6.75E+01
I-134	3.38E+03	1.72E+02
I-135	1.92E+03	9.45E+01
Kr-85m	1.72E-02	1.72E-02
Kr-85	6.75E-05	6.75E-05
Kr-87	5.74E-02	5.74E-02
Kr-88	5.74E-02	5.74E-02
Xe-133	2.46E-02	2.46E-02
Xe-135	6.75E-02	6.75E-02
Total	8.70E+03	4.39E+02

Table 7.1-20b Doses for ESBWR Main Steam Line Break, Pre-Existing Iodine Spike

	Site TEDE (Rem)	
Time	EAB	LPZ
0–2 hr	3.13E-01	
0–8 hr		2.03E-02
8–24 hr		0.00E+00
24–96 hr		0.00E+00
96–720 hr		0.00E+00
Total	3.13E-01	2.03E-02
Limit	25	25

Table 7.1-20c Doses for ESBWR Main Steam Line Break, Equilibrium Iodine Activity

	Site TEDE (Rem)	
Time	**EAB**	**LPZ**
0–2 hr	1.57E-02	
0–8 hr		1.02E-03
8–24 hr		0.00E+00
24–96 hr		0.00E+00
96–720 hr		0.00E+00
Total	1.57E-02	1.02E-03
Limit	2.5	2.5

Table 7.1-21 Activity Releases for AP1000 Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	**0–2 hr**	**2–8 hr**	**8–24 hr**	**24–96 hr**	**96–720 hr**	**Total**
Kr-85m	6.31E+02	3.14E+03	1.87E+03	1.71E+02	2.43E-03	5.82E+03
Kr-85	3.22E+01	2.64E+02	7.05E+02	3.17E+03	2.70E+04	3.12E+04
Kr-87	6.87E+02	1.26E+03	4.97E+01	8.11E-03	0.00E+00	1.99E+03
Kr-88	1.50E+03	5.76E+03	1.70E+03	3.49E+01	8.16E-07	8.99E+03
Xe-131m	3.20E+01	2.62E+02	6.79E+02	2.74E+03	1.11E+04	1.48E+04
Xe-133m	1.74E+02	1.37E+03	3.15E+03	8.21E+03	5.15E+03	1.80E+04
Xe-133	5.71E+03	4.62E+04	1.16E+05	4.11E+05	8.10E+05	1.39E+06
Xe-135m	3.33E+01	2.62E+00	2.14E-07	0.00E+00	0.00E+00	3.59E+01
Xe-135	1.31E+03	8.33E+03	1.01E+04	4.21E+03	1.73E+01	2.40E+04
Xe-138	1.14E+02	6.83E+00	1.58E-07	0.00E+00	0.00E+00	1.20E+02
I-130	3.22E+01	4.58E+01	2.96E+00	1.11E+00	1.99E-02	8.21E+01
I-131	9.13E+02	1.45E+03	1.56E+02	3.74E+02	1.12E+03	4.01E+03
I-132	8.77E+02	7.93E+02	7.64E+00	2.29E-02	0.00E+00	1.68E+03
I-133	1.81E+03	2.70E+03	2.16E+02	1.63E+02	1.62E+01	4.91E+03
I-134	7.16E+02	3.04E+02	1.26E-01	1.07E-07	0.00E+00	1.02E+03
I-135	1.53E+03	1.97E+03	8.31E+01	9.55E+00	4.95E-03	3.59E+03
Cs-134	1.46E+02	2.16E+02	8.06E+00	1.88E-01	1.59E+00	3.72E+02
Cs-136	4.15E+01	6.13E+01	2.25E+00	4.72E-02	2.03E-01	1.05E+02
Cs-137	8.50E+01	1.26E+02	4.70E+00	1.10E-01	9.39E-01	2.17E+02
Cs-138	2.67E+02	5.25E+01	6.92E-04	0.00E+00	0.00E+00	3.19E+02
Rb-86	1.72E+00	2.54E+00	9.37E-02	2.03E-03	1.05E-02	4.37E+00
Sb-127	1.10E+01	2.01E+01	7.13E-01	1.16E-02	1.60E-02	3.18E+01
Sb-129	2.63E+01	3.65E+01	4.83E-01	1.01E-04	1.00E-09	6.33E+01
Te-127m	1.42E+00	2.64E+00	9.83E-02	2.27E-03	1.77E-02	4.18E+00
Te-127	9.83E+00	1.59E+01	3.65E-01	5.63E-04	2.72E-06	2.61E+01
Te-129m	4.85E+00	9.00E+00	3.33E-01	7.47E-03	4.79E-02	1.42E+01
Te-129	1.35E+01	9.71E+00	8.54E-03	7.27E-10	0.00E+00	2.32E+01
Te-131m	1.46E+01	2.60E+01	8.29E-01	6.86E-03	1.60E-03	4.14E+01

Table 7.1-21 Activity Releases for AP1000 Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	0–2 hr	2–8 hr	8–24 hr	24–96 hr	96–720 hr	Total
Te-132	1.46E+02	2.68E+02	9.42E+00	1.44E-01	1.60E-01	4.24E+02
Sr-89	4.16E+01	7.74E+01	2.87E+00	6.54E-02	4.60E-01	1.22E+02
Sr-90	3.59E+00	6.68E+00	2.48E-01	5.82E-03	4.97E-02	1.06E+01
Sr-91	4.64E+01	7.52E+01	1.74E+00	2.76E-03	1.44E-05	1.23E+02
Sr-92	3.80E+01	4.50E+01	3.26E-01	1.06E-05	0.00E+00	8.33E+01
Ba-139	3.64E+01	2.98E+01	4.73E-02	2.03E-08	0.00E+00	6.63E+01
Ba-140	7.35E+01	1.36E+02	5.00E+00	1.05E-01	4.41E-01	2.15E+02
Mo-99	9.77E+00	1.78E+01	6.19E-01	8.79E-03	7.72E-03	2.82E+01
Tc-99m	7.30E+00	1.10E+01	1.94E-01	1.08E-04	2.73E-08	1.85E+01
Ru-103	7.82E+00	1.45E+01	5.38E-01	1.21E-02	8.11E-02	2.30E+01
Ru-105	4.19E+00	5.87E+00	7.97E-02	1.82E-05	2.40E-10	1.01E+01
Ru-106	2.57E+00	4.79E+00	1.78E-01	4.16E-03	3.46E-02	7.58E+00
Rh-105	4.71E+00	8.45E+00	2.76E-01	2.64E-03	8.48E-04	1.34E+01
Ce-141	1.76E+00	3.26E+00	1.21E-01	2.71E-03	1.72E-02	5.16E+00
Ce-143	1.59E+00	2.84E+00	9.20E-02	8.29E-04	2.34E-04	4.51E+00
Ce-144	1.32E+00	2.47E+00	9.19E-02	2.14E-03	1.77E-02	3.91E+00
Pu-238	4.13E-03	7.70E-03	2.86E-04	6.71E-06	5.73E-05	1.22E-02
Pu-239	3.63E-04	6.77E-04	2.52E-05	5.90E-07	5.04E-06	1.07E-03
Pu-240	5.34E-04	9.92E-04	3.69E-05	8.65E-07	7.39E-06	1.57E-03
Pu-241	1.19E-01	2.23E-01	8.30E-03	1.94E-04	1.66E-03	3.52E-01
Np-239	2.04E+01	3.72E+01	1.27E+00	1.67E-02	1.17E-02	5.89E+01
Y-90	3.68E-02	6.70E-02	2.32E-03	3.25E-05	2.75E-05	1.06E-01
Y-91	5.35E-01	9.94E-01	3.69E-02	8.43E-04	6.09E-03	1.57E+00
Y-92	4.18E-01	5.46E-01	5.77E-03	5.86E-07	0.00E+00	9.70E-01
Y-93	5.81E-01	9.48E-01	2.25E-02	4.05E-05	2.91E-07	1.55E+00
Nb-95	7.20E-01	1.34E+00	4.95E-02	1.11E-03	7.23E-03	2.12E+00
Zr-95	7.17E-01	1.33E+00	4.94E-02	1.13E-03	8.29E-03	2.11E+00
Zr-97	6.66E-01	1.15E+00	3.26E-02	1.38E-04	7.58E-06	1.84E+00

Table 7.1-21 Activity Releases for AP1000 Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	**0–2 hr**	**2–8 hr**	**8–24 hr**	**24–96 hr**	**96–720 hr**	**Total**
La-140	7.66E-01	1.38E+00	4.58E-02	4.84E-04	1.97E-04	2.19E+00
La-141	5.37E-01	7.26E-01	8.69E-03	1.31E-06	0.00E+00	1.27E+00
La-142	3.47E-01	3.06E-01	6.67E-04	6.96E-10	0.00E+00	6.53E-01
Nd-147	2.79E-01	5.16E-01	1.89E-02	3.88E-04	1.49E-03	8.16E-01
Pr-143	6.28E-01	1.16E+00	4.27E-02	9.01E-04	3.95E-03	1.84E+00
Am-241	5.40E-05	1.00E-04	3.74E-06	8.75E-08	7.48E-07	1.59E-04
Cm-242	1.27E-02	2.37E-02	8.81E-04	2.04E-05	1.64E-04	3.75E-02
Cm-244	1.56E-03	2.91E-03	1.08E-04	2.53E-06	2.16E-05	4.61E-03
Total	1.72E+04	7.52E+04	1.35E+05	4.30E+05	8.54E+05	1.51E+06

Table 7.1-22 Doses for AP1000 Loss-of-Coolant Accident

	AP1000 TEDE (Rem)		χ/Q Ratio	Site TEDE (Rem)	
Time	**EAB**	**LPZ**	**(Site/AP1000)**	**EAB**	**LPZ**
0–2 hr	2.48E+01		5.57E-02	1.38E+00	
0–8 hr		9.20E+00	1.61E-02		1.48E-01
8–24 hr		3.30E-01	2.17E-02		7.16E-03
24–96 hr		3.10E-01	4.02E-02		1.25E-02
96–720 hr		2.90E-01	9.86E-02		2.86E-02
Total	2.48E+01	1.01E+01		1.38E+00	1.96E-01
Limit				25	25

Table 7.1-23 Activity Releases for ABWR Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	**0–2 hr**	**2–8 hr**	**8–24 hr**	**24–96 hr**	**96–720 hr**	**Total**
I-131	2.84E+02	1.25E+02	1.01E+03	9.52E+03	6.80E+04	7.90E+04
I-132	3.85E+02	3.63E+01	3.55E+01	0.00E+00	0.00E+00	4.57E+02
I-133	5.92E+02	2.21E+02	1.29E+03	3.64E+03	7.39E+02	6.48E+03
I-134	5.62E+02	1.17E+00	0.00E+00	0.00E+00	0.00E+00	5.63E+02
I-135	5.62E+02	1.45E+02	3.63E+02	1.83E+02	0.00E+00	1.25E+03
Kr-83m	3.57E+02	5.09E+02	1.66E+02	0.00E+00	0.00E+00	1.03E+03
Kr-85	4.47E+01	3.38E+02	2.40E+03	2.38E+04	3.13E+05	3.40E+05
Kr-85m	9.24E+02	3.17E+03	4.78E+03	7.69E+02	0.00E+00	9.64E+03
Kr-87	1.31E+03	1.07E+03	1.01E+02	0.00E+00	0.00E+00	2.48E+03
Kr-88	2.32E+03	5.48E+03	3.76E+03	3.25E+02	0.00E+00	1.19E+04
Kr-89	1.98E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E+02
Xe-131m	2.33E+01	1.65E+02	1.22E+03	1.04E+04	6.80E+04	7.98E+04
Xe-133	8.35E+03	5.85E+04	4.12E+05	3.04E+06	9.20E+06	1.27E+07
Xe-133m	3.28E+02	2.38E+03	1.51E+04	8.31E+04	7.95E+04	1.80E+05
Xe-135	1.01E+03	5.02E+03	1.66E+04	1.28E+04	0.00E+00	3.55E+04
Xe-135m	5.33E+02	8.87E-02	0.00E+00	0.00E+00	0.00E+00	5.33E+02
Xe-137	5.62E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.62E+02
Xe-138	2.19E+03	1.48E-01	0.00E+00	0.00E+00	0.00E+00	2.19E+03
Total	2.05E+04	7.72E+04	4.59E+05	3.18E+06	9.73E+06	1.35E+07

Table 7.1-24 Doses for ABWR Loss-of-Coolant Accident

	ABWR EAB Dose (Sv)			ABWR LPZ Dose (Sv)			χ/Q Ratio (Site/ ABWR)	Site TEDE (Rem)	
Time	W. Body	Thyroid	TEDE	W. Body	Thyroid	TEDE		EAB	LPZ
0–2 hr	4.10E-02	1.90E+00	9.80E-02				2.44E-02	2.62E-01	
0–8 hr				1.00E-02	3.10E-01	1.93E-02	1.39E-02		2.94E-02
8–24 hr				8.00E-03	2.00E-01	1.40E-02	2.26E-02		3.46E-02
24–96 hr				1.10E-02	7.90E-01	3.47E-02	6.46E-02		2.45E-01
96–720 hr				9.00E-03	1.10E+00	4.20E-02	2.92E-01		1.35+00
Total	4.10E-02	1.90E+00	9.80E-02	3.80E-02	2.40E+00	1.10E-01		2.62E-01	1.65E+00
Limit								25	25

Note: The ABWR TEDE is whole body dose plus 3% of thyroid dose. The site doses include a multiplier of 1.10 for power adjustment.

Table 7.1-24a Activity Releases for ESBWR Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	0–2 hr	2–8 hr	8–24 hr	24–96 hr	96–720 hr	Total
Co-58	2.28E-03	2.22E-02	3.89E-02	4.18E-02	2.61E-02	1.31E-01
Co-60	2.19E-03	2.16E-02	3.76E-02	4.10E-02	2.89E-02	1.31E-01
Kr-85	6.59E+00	3.23E+02	2.72E+03	2.08E+04	5.31E+04	7.70E+04
Kr-85m	1.14E+02	3.01E+03	5.21E+03	8.50E+02	0.00E+00	9.19E+03
Kr-87	1.17E+02	8.60E+02	1.08E+02	0.00E+00	0.00E+00	1.09E+03
Kr-88	2.68E+02	5.12E+03	4.30E+03	1.63E+02	0.00E+00	9.85E+03
Rb-86	1.38E-01	1.00E+00	1.72E+00	1.79E+00	8.25E-01	5.48E+00
Sr-89	3.53E+00	3.46E+01	6.01E+01	6.43E+01	3.88E+01	2.01E+02
Sr-90	3.48E-01	3.42E+00	5.98E+00	6.51E+00	4.63E+00	2.09E+01
Sr-91	3.95E+00	3.06E+01	2.63E+01	5.00E+00	0.00E+00	6.58E+01
Sr-92	3.18E+00	1.45E+01	2.88E+00	1.25E-01	0.00E+00	2.06E+01
Y-90	6.34E-03	1.70E-01	9.06E-01	2.51E+00	4.25E+00	7.84E+00
Y-91	4.59E-02	4.70E-01	8.96E-01	1.03E+00	6.38E-01	3.08E+00
Y-92	4.89E-01	1.01E+01	8.31E+00	3.75E-01	0.00E+00	1.93E+01
Y-93	4.94E-02	3.87E-01	3.45E-01	7.25E-02	0.00E+00	8.54E-01

Table 7.1-24a Activity Releases for ESBWR Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	**0–2 hr**	**2–8 hr**	**8–24 hr**	**24–96 hr**	**96–720 hr**	**Total**
Zr-95	6.39E-02	6.26E-01	1.09E+00	1.18E+00	7.25E-01	3.68E+00
Zr-97	6.16E-02	5.28E-01	6.10E-01	2.25E-01	0.00E+00	1.43E+00
Nb-95	6.43E-02	6.30E-01	1.11E+00	1.20E+00	8.25E-01	3.83E+00
Mo-99	8.30E-01	7.86E+00	1.23E+01	9.88E+00	1.00E+00	3.19E+01
Tc-99m	7.46E-01	7.24E+00	1.19E+01	1.01E+01	8.75E-01	3.09E+01
Ru-103	6.66E-01	6.52E+00	1.13E+01	1.21E+01	6.88E+00	3.75E+01
Ru-105	3.48E-01	2.09E+00	8.88E-01	3.75E-02	0.00E+00	3.36E+00
Ru-106	2.33E-01	2.28E+00	3.99E+00	4.34E+00	3.04E+00	1.39E+01
Rh-105	4.05E-01	3.88E+00	5.85E+00	3.74E+00	1.25E-01	1.40E+01
Sb-127	9.09E-01	8.69E+00	1.40E+01	1.23E+01	1.75E+00	3.76E+01
Sb-129	2.18E+00	1.30E+01	5.25E+00	1.25E-01	0.00E+00	2.05E+01
Te-127	9.29E-01	8.96E+00	1.49E+01	1.39E+01	3.13E+00	4.18E+01
Te-127m	1.22E-01	1.20E+00	2.09E+00	2.29E+00	1.54E+00	7.24E+00
Te-129	2.41E+00	1.62E+01	1.15E+01	6.75E+00	3.50E+00	4.04E+01
Te-129m	4.09E-01	4.02E+00	6.98E+00	7.35E+00	4.13E+00	2.29E+01
Te-131m	1.22E+00	1.11E+01	1.53E+01	8.75E+00	2.50E-01	3.66E+01
Te-132	1.24E+01	1.19E+02	1.88E+02	1.59E+02	1.88E+01	4.96E+02
I-131	6.66E+01	5.13E+02	9.33E+02	1.44E+03	7.00E+02	3.65E+03
I-132	7.88E+01	3.44E+02	2.45E+02	1.89E+02	2.25E+01	8.79E+02
I-133	1.31E+02	9.10E+02	1.22E+03	7.63E+02	1.25E+01	3.04E+03
I-134	4.96E+01	5.10E+01	3.75E-01	0.00E+00	0.00E+00	1.01E+02
I-135	1.11E+02	6.07E+02	4.16E+02	5.38E+01	0.00E+00	1.19E+03
Xe-133	1.08E+03	5.19E+04	4.08E+05	2.51E+06	1.20E+06	4.18E+06
Xe-135	3.68E+02	1.40E+04	5.13E+04	3.80E+04	0.00E+00	1.04E+05
Cs-134	1.16E+01	8.50E+01	1.48E+02	1.63E+02	1.14E+02	5.21E+02
Cs-136	4.03E+00	2.92E+01	5.00E+01	5.05E+01	2.00E+01	1.54E+02
Cs-137	7.54E+00	5.52E+01	9.60E+01	1.05E+02	7.50E+01	3.39E+02
Ba-139	2.96E+00	7.50E+00	3.00E-01	0.00E+00	0.00E+00	1.08E+01

Table 7.1-24a Activity Releases for ESBWR Loss-of-Coolant Accident

	Activity Release (Ci)					
Isotope	0–2 hr	2–8 hr	8–24 hr	24–96 hr	96–720 hr	Total
Ba-140	6.26E+00	6.10E+01	1.04E+02	1.06E+02	4.00E+01	3.18E+02
La-140	1.40E-01	4.41E+00	2.37E+01	5.83E+01	4.35E+01	1.30E+02
La-141	4.50E-02	2.56E-01	9.13E-02	2.50E-03	0.00E+00	3.95E-01
La-142	2.84E-02	8.09E-02	4.50E-03	0.00E+00	0.00E+00	1.14E-01
Ce-141	1.49E-01	1.46E+00	2.54E+00	2.69E+00	1.46E+00	8.30E+00
Ce-143	1.35E-01	1.23E+00	1.75E+00	1.05E+00	2.50E-02	4.19E+00
Ce-144	1.21E-01	1.19E+00	2.08E+00	2.26E+00	1.55E+00	7.20E+00
Pr-143	5.46E-02	5.40E-01	9.68E-01	1.06E+00	4.63E-01	3.09E+00
Nd-147	2.38E-02	2.31E-01	3.94E-01	3.95E-01	1.39E-01	1.18E+00
Np-239	1.69E+00	1.59E+01	2.44E+01	1.88E+01	1.38E+00	6.21E+01
Pu-238	2.98E-04	2.93E-03	5.11E-03	5.54E-03	4.00E-03	1.79E-02
Pu-239	3.59E-05	3.53E-04	6.19E-04	6.80E-04	4.75E-04	2.16E-03
Pu-240	4.65E-05	4.56E-04	7.98E-04	8.75E-04	6.13E-04	2.79E-03
Pu-241	1.35E-02	1.33E-01	2.31E-01	2.53E-01	1.78E-01	8.08E-01
Am-241	6.08E-06	5.97E-05	1.06E-04	1.15E-04	9.25E-05	3.79E-04
Cm-242	1.43E-03	1.40E-02	2.44E-02	2.65E-02	1.76E-02	8.39E-02
Cm-244	6.91E-05	6.77E-04	1.19E-03	1.29E-03	9.13E-04	4.14E-03
Total	2.46E+03	7.82E+04	4.76E+05	2.58E+06	1.25E+06	4.39E+06

Table 7.1-24b Doses for ESBWR Loss-of-Coolant Accident

	Site TEDE (Rem)	
Time	**EAB**	**LPZ**
2–4 hr	2.08E-01	
0–8 hr		4.38E-02
8–24 hr		4.24E-02
24–96 hr		7.91E-02
96–720 hr		3.81E-02
Total	2.08E-01	2.03E-01
Limit	25	25

Note: The maximum EAB dose occurs between 2 and 4 hours.

Table 7.1-25 Activity Releases for AP1000 Fuel Handling Accident

	Activity Release (Ci)
Isotope	**0–2 hr**
Kr-85m	2.68E-03
Kr-85	1.10E+03
Xe-131m	5.36E+02
Xe-133m	1.29E+03
Xe-133	6.94E+04
Xe-135m	4.37E-01
Xe-135	1.32E+02
I-130	3.52E-02
I-131	2.90E+02
I-132	1.54E+02
I-133	1.91E+01
I-135	1.36E-02
Total	7.29E+04

Table 7.1-26 Doses for AP1000 Fuel Handling Accident

	AP1000 TEDE (Rem)		χ/Q Ratio	Site TEDE (Rem)	
Time	EAB	LPZ	(Site/AP1000)	EAB	LPZ
0–2 hr	2.40E+00		5.57E-02	1.34E-01	
0–8 hr		6.00E-01	1.61E-02		9.64E-03
8–24 hr		0.00E+00	2.17E-02		0.00E+00
24–96 hr		0.00E+00	4.02E-02		0.00E+00
96–720 hr		0.00E+00	9.86E-02		0.00E+00
Total	2.40E+00	6.00E-01		1.34E-01	9.64E-03
Limit				6.3	6.3

Table 7.1-27 Activity Releases for ABWR Fuel Handling Accident

Isotope	Activity Release (Ci) 0–2 hr
I-131	1.35E+02
I-132	1.66E+02
I-133	1.39E+02
I-134	6.74E-06
I-135	2.25E+01
Kr-83m	7.04E+00
Kr-85m	9.34E+01
Kr-85	5.23E+02
Kr-87	1.35E-02
Kr-88	2.66E+01
Kr-89	8.90E-11
Xe-131m	9.14E+01
Xe-133m	1.20E+03
Xe-133	3.08E+04
Xe-135m	2.42E+02
Xe-135	6.98E+03
Xe-137	2.27E-10
Xe-138	4.70E-10
Total	4.04E+04

Table 7.1-28 Doses for ABWR Fuel Handling Accident

	ABWR EAB Dose (Sv)			χ/Q Ratio (Site/ABWR)	Site TEDE (Rem)	
Time	W. Body	Thyroid	TEDE		EAB	LPZ
0–2 hr	1.20E-02	7.50E-01	3.45E-02	2.44E-02	9.21E-02	
0–8 hr	1.20E-02	7.50E-01	3.45E-02	1.58E-03		5.99E-03
8–24 hr						0.00E+00
24–96 hr						0.00E+00
96–720 hr						0.00E+00
Total	1.20E-02	7.50E-01	3.45E-02		9.21E-02	5.99E-03
Limit					6.3	6.3

Note: The ABWR TEDE is whole body dose plus 3% of thyroid dose. The site LPZ dose is obtained by multiplying ABWR EAB dose by ratio of site LPZ χ/Q to ABWR EAB χ/Q. The site doses include a multiplier of 1.10 for power adjustment.

Table 7.1-29 Activity Releases for ESBWR Fuel Handling Accident

	Activity Release (Ci)
Isotope	0–2 hr
I-131	3.00E+02
I-132	2.43E+02
I-133	1.92E+02
I-134	1.05E-05
I-135	3.17E+01
Kr-85m	2.77E+02
Kr-85	1.01E+03
Kr-87	4.39E-02
Kr-88	8.78E+01
Xe-133	8.10E+04
Xe-135	2.13E+04
Total	1.04E+05

Table 7.1-30 Doses for ESBWR Fuel Handling Accident

	Site TEDE (Rem)	
Time	**EAB**	**LPZ**
0–2 hr	1.84E-01	
0–8 hr		1.19E-02
8–24 hr		0.00E+00
24–96 hr		0.00E+00
96–720 hr		0.00E+00
Total	1.84E-01	1.19E-02
Limit	6.3	6.3

Table 7.1-31 Activity Releases for ESBWR Cleanup Water Line Break

	Activity Release (Ci)
Isotope	**0–2 hr**
I-131	3.48E+01
I-132	7.05E+01
I-133	9.28E+01
I-134	1.22E+02
I-135	9.59E+01
Total	4.16E+02

Table 7.1-32 Doses for ESBWR Cleanup Water Line Break

	Site TEDE (Rem)	
Time	**EAB**	**LPZ**
0–2 hr	2.59E-02	
0–8 hr		1.68E-03
8–24 hr		0.00E+00
24–96 hr		0.00E+00
96–720 hr		0.00E+00
Total	2.59E-02	1.68E-03
Limit	2.5	2.5

7.2 Severe Accidents

This section describes the probabilities and consequences of accidents of greater severity than the DBAs. As a class, they are considered less likely to occur, but because their consequences could be more severe, they are considered important both in terms of impact to the environment and off-site costs. These severe accidents can be distinguished from DBAs in two primary respects:

1. They involve substantial physical deterioration of the fuel in the reactor core, including overheating to the point of melting.

2. They involve deterioration of the capability of the containment system to perform its intended function of limiting the release of radioactive materials to the environment.

In NUREG-1437 (NRC 1996), the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), the NRC generically assesses the impacts of severe accidents during license renewal periods, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period (Reference 1). This methodology is used as a basis for evaluating the severe accident environmental impacts of new units at the ESP site.

7.2.1 **Applicability of Existing Generic Severe Accident Studies**

NUREG-1437, Section 5.3.3, presents a thorough assessment by the NRC staff of the impacts of severe accidents during the license renewal period. Methodologies are developed therein to evaluate each of the dose pathways by which a severe accident may result in adverse environmental impacts and to estimate the off-site costs of severe accidents. This assessment methodology and the resulting conclusions are considered, for reasons presented below, broadly applicable beyond the license renewal context, including evaluation of severe accident impacts associated with determining site suitability for a nuclear power plant. The three NUREG-1437 pathways for release of radioactive material to the environment from severe accidents (atmospheric, air to surface water, and groundwater to surface water) are presented in this section. The economic impacts from severe accidents are also comparatively evaluated in this section.

The GEIS evaluations and conclusions are based on existing assessments of severe accident impacts presented in numerous Final Environmental Statements (FES) published after 1980 and for a representative set of U.S. plants and sites in NUREG-1150 (Reference 2). The GEIS results are expressed as a range of values in terms of risk of severe accident impact per reactor-year of operation. The NRC confirms, in 61 FR 28480, that “the analyses performed for the GEIS represent adequate, plant-specific estimates of the impacts from severe accidents…” (Reference 3).

As described in the GEIS, the purpose of the evaluation of severe accidents is “to use, to the extent possible, the available severe accident results, in conjunction with those factors that are important to risk and that change with time to estimate the consequences of nuclear plant accidents for all plants for a time period that exceeds the time frame of existing analyses." This estimation process is completed by predicting increases or decreases in consequences as the plant lifetime is extended past the normal license period by considering the projected changes in the risk factors. The primary assumption in this analysis is that regulatory controls ensure that the physical plant condition, which affects the predicted probability of and radioactive releases from an accident, is maintained at a constant level during the renewal period; therefore, the frequency and magnitude of a release remains relatively constant. In other words, significant changes in consequences would result only from changes in the plant's external environment. The logical approach, then, would be to incorporate the most significant environmental factors into calculations of consequences for subsequent correlation with existing analyses, which use the consequence computer codes.

The NRC staff concludes in NUREG-1437 that the primary factors affecting risk are the site population, which reflects the number of people potentially at risk to severe accident exposure, and wind direction, which reflects the likelihood of exposure. Secondary factors – such as terrain, rainfall, and wind stability – also have some effect on risk, but their impact is judged to be much smaller than the effects of population and wind direction. These factors are included in the FES analyses whose results are the bases for the GEIS analyses. Consequently, their effects are indirectly considered in the prediction of future risks and are reflected within the uncertainty bounds generated by the regression of the FES risk values. To ensure that the existing FES analyses cover a range of secondary factors representative of the total population of plants, the more significant secondary factors are also examined in the GEIS. Variations in these factors (precipitation, 50-mile population, 50-mile population in the direction of highest wind frequency, general terrain, and emergency planning) are found to be enveloped by the FES analyses and thus reasonably accounted for in the GEIS evaluation of severe accidents.

Detailed evaluations of severe accident consequences such as early and latent fatalities and total dose are not available for all plants considered in the GEIS. Therefore, a predictor for these consequences is developed using correlations based upon the calculated results from the existing FES severe accident analyses. This predictor is then used to infer the future consequence level of all individual nuclear plants. Correlations are developed using two environmental parameters that are available for all plants. This correlation process is well described in NUREG-1437.

While NUREG-1437 discussions deal with the environmental impacts of accidents during operation after license renewal, the primary assumption for this evaluation is that the frequency or likelihood of occurrence of an accident at a given plant would not increase during the plant lifetime, inclusive of the license renewal period, because regulatory controls ensure that the plant's licensing basis is maintained and improved, where warranted. The GEIS use of severe accident risk per reactor-year of operation as the principal metric for evaluating severe accident environmental impacts and the assumption that this risk remains constant over the life of the plant are equally applicable and appropriate in the license renewal context as in the ESP and COL contexts. Therefore, the thorough generic analysis of severe accident impacts presented in the GEIS also provides an appropriate basis and method for evaluating severe accident impacts for early site permitting.

It is recognized, however, that the changing environment around the plant is not subject to regulatory controls and introduces the potential for changing risk. Consequently, the site-specific environmental considerations (population and meteorology) are evaluated in the GEIS and are considered in the following sections.

Specifically, the following evaluation of the significant factors associated with the environment shows these factors for the ESP site are not substantially different from those factors identified for previously analyzed sites. Thus, it follows that the environmental impacts for the ESP site would not be substantially different from the acceptable environmental impacts identified for the previously analyzed sites. Furthermore, the NRC's severe accident policy statement about new reactors (Reference 4) reinforces the concept that the results of the existing severe accident analyses would bound the consequences of the advanced reactor designs being considered for the ESP site.

7.2.2 **Evaluation of Site-Specific Potential Severe Accident Releases**

The significance of the impacts associated with each issue is identified as either small, moderate, or large, consistent with the criteria that the NRC established in Appendix B to Subpart A of 10 CFR 51, Table B-1, Footnote 3 as follows (Reference 4):

- Small – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.
- Moderate – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attribute of the resource.
- Large – Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

In accordance with NEPA practice, ongoing and potential additional mitigations are considered in proportion to the significance of the impact to be addressed, meaning that impacts that are small receive less mitigative consideration than impacts that are large.

Dominion bases its evaluation of potential environmental consequences of severe accidents on the evaluation of potential consequences of severe accidents for current generation reactors presented in NUREG-1437, and on source term parameters provided from the ABWR, AP1000, and ESBWR reactor designs. Three release 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. The MACCS2 computer code was utilized to evaluate the potential offsite consequences of severe accidents. Three types of consequences were assessed: 1) human health, 2) economic costs, and 3) land area affected by contamination.

7.2.2.1 Evaluation of Potential Releases via Atmospheric Pathway

The site-specific significant factors of demography and meteorology are considered in the evaluation of the atmospheric exposure pathway for new units at the ESP site. For this evaluation, NUREG-1437 calculates an exposure index (EI) for use in comparing the relative risk for the current fleet of nuclear power plants. NUREG-1437 provides the following discussion of EI:

> Population, which changes over time, defines the number of people within a given distance from the plant. Wind direction, which is assumed not to change from year to year, helps determine what proportion of the population is at risk in a given direction, because radionuclides are carried by the wind. Therefore, an EI relationship was developed by multiplying the wind direction frequency (fraction of the time per year) for each of 16 (22.5 degrees) compass sectors times the population in that sector for a given distance from the plant and summing all products. … Population varies with population growth and movement, and with the distance from any given plant. As the population changes for that plant, the EI also changes (the larger the EI, the larger the number of people at risk). Thus, EI is proportional to risk and an EI for a site for a future year can be used to predict the risk to the population around that site in that future year.

Thus, the EI is a function of population surrounding the site, weighted by the site-specific wind direction frequency, and is, therefore, a site-specific parameter. Because meteorological patterns, including wind direction frequency, tend to remain constant over time, the site meteorology would not be significantly different for the ESP site than that considered in NUREG-1437 for the NAPS site and only population can significantly affect the resulting risk in any given year of reactor operation.

Two EI values are evaluated in NUREG-1437. A 10-mile EI is found to best correlate with early fatalities and a 150-mile EI is found to best correlate with latent fatalities and total dose. Using these indices, it is determined that the risk of early and latent fatalities from individual nuclear power plants is small and represents only a small fraction of the risk to which the public is exposed from other sources.

NUREG-1437 indicates a 10-mile EI for the NAPS site of 704 for the year 2030, while the 10-mile EI for the current generation of nuclear power plant sites ranges from 96 to 18,959 (Reference 1, Table 5.7). Using the US Census Bureau population data (circa 2000) projected to years 2040 and 2065 with the best available wind direction frequency information (1996–1998), 10-mile EI values of 4200 and 5700 are calculated for the ESP site for the years 2040 and 2065, respectively. For both years, the ESP site 10-mile EI is within the range of risk calculated for the existing fleet of nuclear power plants.

NUREG-1437 indicates a 150-mile EI for the NAPS site of 876,587 for the year 2030, while the 150-mile EI for the current generation of nuclear power plant sites ranges from 132,195 to 2,863,844 (Reference 1, Table 5.8). Using the US Census Bureau population data (circa 2000) projected to years 2040 and 2065 with the best available wind direction frequency information (1996–1998), 150-mile EI values of 1.1E6 and 1.4E6 are calculated for the ESP site for the years 2040 and 2065, respectively. For both years, the ESP site 150-mile EI is within the range of risk calculated for the existing fleet of nuclear power plants.

Thus, the risks for new units at the ESP site for the atmospheric exposure pathway would be within the range of those considered in NUREG-1437 as “small.” NUREG-1437, Section 5.5.2.1, indicates that these predicted effects of a severe accident “are not expected to exceed a small fraction of that risk to which the population is already exposed.”

Results for dose and economic costs from MACCS2 runs for the atmospheric pathway are presented in Table 7.2-1 and Table 7.2-2, respectively.

Table 7.2-1 ESBWR Population Dose

	Sieverts					
STC	**Case1A 98MET**	**Case2A 97MET**	**Case3A 96MET**	**Case4A 5500MWt**	**Case5B Plume = 1.0E6W**	**Category Frequency Prob/yr**
BOC	9.33E+04	8.55E+04	8.77E+04	9.79E+04	8.84E+04	<1E-12
BYP	8.68E+04	7.96E+04	8.22E+04	9.11E+04	8.28E+04	4E-12
CCID	7.17E+04	6.48E+04	6.65E+04	7.16E+04	6.71E+04	2.9E-11
CCIW	1.24E+04	1.09E+04	1.18E+04	1.30E+04	1.20E+04	2.9E-10
DCH	6.29E+04	5.74E+04	5.73E+04	6.41E+04	5.76E+04	<1E-12
EVE	7.72E+04	6.90E+04	7.18E+04	7.70E+04	7.27E+04	2.5E-10
FR	3.15E+02	2.64E+02	2.98E+02	3.60E+02	3.02E+02	2.3E-10
OPVB	3.12E+04	2.83E+04	2.91E+04	3.30E+04	2.93E+04	<1E-12
OPW1	5.52E+04	5.13E+04	5.21E+04	5.73E+04	5.27E+04	<1E-12
OPW2	2.87E+04	2.68E+04	2.76E+04	2.96E+04	2.78E+04	1.4E-11
TSL	2.43E+02	2.02E+02	2.29E+02	2.73E+02	2.32E+02	2.8E-8

Table 7.2-2 ESBWR Offsite Cost

	Cost, $					
STC	Case1A 98MET	Case2A 97MET	Case3A 96MET	Case4A 5500MWt	Case5B Plume = 1.0E6W	Category Frequency Prob/yr
BOC	1.36E+10	1.27E+10	1.41E+10	1.63E+10	1.43E+10	<1E-12
BYP	1.34E+10	1.25E+10	1.38E+10	1.58E+10	1.41E+10	4E-12
CCID	1.51E+10	1.36E+10	1.42E+10	1.62E+10	1.44E+10	2.9E-11
CCIW	8.19E+08	6.24E+08	7.54E+08	1.06E+09	7.80E+08	2.9E-10
DCH	9.46E+09	8.50E+09	9.20E+09	1.01E+10	9.37E+09	<1E-12
EVE	1.59E+10	1.44E+10	1.50E+10	1.70E+10	1.52E+10	2.5E-10
FR	2.48E+06	1.93E+06	2.51E+06	3.25E+06	2.47E+06	2.3E-10
OPVB	4.15E+09	3.45E+09	3.95E+09	4.38E+09	4.04E+09	<1E-12
OPW1	9.13E+09	8.11E+09	8.63E+09	9.63E+09	8.74E+09	<1E-12
OPW2	4.58E+09	3.84E+09	4.25E+09	4.93E+09	4.35E+09	1.4E-11
TSL	1.64E+06	1.47E+06	1.74E+06	2.60E+06	1.68E+06	2.8E-8

7.2.2.2 **Evaluation of Potential Releases via Atmospheric Fallout onto Open Bodies of Water**

This section examines radiation exposure risk for new reactors at the ESP site in the event of a severe reactor accident in which radioactive contaminants are released into the atmosphere and subsequently deposited onto open bodies of water. In the GEIS, the drinking water pathway is treated separately, while the aquatic food, swimming, and shoreline pathways are addressed collectively. Population dose estimates for both the drinking water and aquatic food pathways are then compared with estimates from the atmospheric pathway.

As reported in NUREG-1437, analyses for both the drinking water and aquatic food pathways are performed with and without considering interdiction. In the case of the drinking-water pathway, the Great Lakes and the estuarine sites are bound by a previous site evaluation (i.e., Fermi) while small river sites with relatively low annual flow rates, long residence times, and large surface-area-to-volume ratios may potentially not be bounded by a previous analysis. In all cases, however, interdiction can reduce relative risk to levels at or below that of the previous acceptable analysis and significantly below that for the atmospheric pathway. River sites that may have relatively high concentrations of contaminants, but which remove contaminants within short periods of time (hours to several days), are amenable to short-term interdiction. A similar level of reduced risk can be achieved at those sites with longer residence times (months) by more extensive interdictive measures.

Lake Anna is the major surface water body in the vicinity of the North Anna ESP site, and is used for recreational activities including swimming and fishing. However, the North Anna ESP site is classified as being on a small river. NUREG-1437 provides an estimate of typical population exposure risk for the aquatic food pathway for power stations located on small rivers. In the event of a large release of radioactive material, access to Lake Anna could be controlled. This control would reduce human exposures through the surface water pathways.

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. After considering the water ingestion dose estimates, the NUREG-1437 evaluations, and controlled access to Lake Anna, impacts as a result of the surface water exposure pathway would be expected to be small.

For the aquatic food pathway, the population dose and the population exposure per reactor-year are directly related to aquatic food harvest. For river sites, the population exposure for the un-interdicted pathway is lower than that for the atmospheric pathway by orders of magnitude. For Great Lakes sites, the un-interdicted population exposure is a substantial fraction of that predicted for the atmospheric pathway but is reduced significantly by interdiction. For estuarine sites with large annual aquatic food harvests, dose reduction of a factor of 2 to 10 through interdiction provides essentially the same population exposure estimates as the atmospheric pathway.

For these reasons, population dose for the drinking-water pathway is found to be a small fraction of that for the atmospheric pathway. Risk associated with the aquatic food pathway is found to be small relative to the atmospheric pathway for most sites and essentially the same as the atmospheric pathway for the few sites with large annual aquatic food harvests.

Environmental parameters important for input in performing the above analyses, and for use in analyses of additional sites, are: 1) the surface area of the receiving body, 2) the volume of water in the body, and 3) the flow rate. In the absence of rigorous site-specific analyses, these data can provide estimates of the extent of contamination in the receiving water body and the residence time of the contaminant in the affected water body. Comparing these estimates and site environmental parameters with those for the previously evaluated site (i.e., Fermi) can provide an indication of the comparative hazard associated with drinking contaminated surface water among sites and the need for site-specific analyses. Accounting for population and meteorological data in the comparison can provide further indication of relative risk among sites.

The environmental parameters listed above have been identified in the GEIS for the NAPS site (Reference 1, Table 5.14a). These parameters are applicable for new units at the ESP site, since these parameters are generally constant for a given site, and no major changes have been identified that would impact these parameters. Thus, the drinking-water pathway and the aquatic food, swimming, and shoreline pathways for the ESP site are comparable to those considered in the GEIS evaluation. Therefore, the risk from air fallout to a water body exposure pathway generally compares favorably with the risk to the population from atmospheric releases. The risks for new units at the ESP site for the water body exposure pathway would also be within the range of those considered in NUREG-1437 as “small.”

7.2.2.3 Evaluation of Potential Releases to Groundwater

This section discusses the potential for radiation exposure from the groundwater pathway as the result of postulated severe accidents for new units at the ESP site. Severe accidents are the only accidents capable of producing significant groundwater contamination.

As identified in NUREG-1437, groundwater contamination due to severe accidents has been evaluated generically in NUREG-0440, Liquid Pathway Generic Study (LPGS) (Reference 5). The LPGS evaluates the consequences assuming a core melt with subsequent basemat melt-through. The LPGS examines six generic sites using typical or comparative assumptions about geology, adsorption factors, etc.

According to NUREG-1437, “the LPGS results are believed to provide generally conservative uninterdicted population dose estimates in the six generic plant-site categories. Five of these categories are site groupings in common locations adjacent to small rivers, large rivers, the Great Lakes, oceans, and estuaries. In a severe accident, contaminated groundwater could reach nearby surface water bodies and the population could be exposed to this source of contamination through drinking of surface water, ingestion of finfish and shellfish, and shoreline contact. Exposure by drinking contaminated groundwater is considered to be minor or nonexistent in these five categories because of a limited number of drinking-water wells. The sixth category is a “dry” site located either at a considerable distance from surface water bodies or where groundwater flow is away from a nearby surface water body. In this case, the only population exposure results from drinking contaminated groundwater.” (Reference 1, Section 5.3.3.4.1)

NUREG-1437 concludes that the risk from the groundwater exposure pathway generally contributes only a small fraction of that risk attributable to the population from the atmospheric pathway but in a few cases may contribute a comparable risk.

In the GEIS analysis, site-specific data of groundwater travel time; retention-adsorption coefficients; distance to surface water; and soil, sediment, and rock characteristics are compared with previous groundwater contamination analyses (Reference 1, Section 5.3.3.4). Previous analyses are contained in the LPGS and site-specific FESs. These environmental parameters have been identified in the GEIS for the NAPS site. These same parameters are applicable to new units at the ESP site, since these environmental parameters are generally constant for a given site, and no major changes have been identified that would impact these parameters. Thus, the groundwater pathway for the ESP site is comparable to that considered in the GEIS evaluation. Therefore, the risk from the groundwater exposure pathway generally compares favorably with the risk to the population from atmospheric releases. The risks for new units at the ESP site for the groundwater exposure pathway would also be within the range of those considered in NUREG-1437 as “small.”

7.2.3 Evaluation of Economic Impacts of Severe Accidents

This section discusses the potential economic impact that could result from postulated severe accidents at the ESP site. Similar to Section 7.2.2.1, the EI is used as a predictor of cost because, as identified in the GEIS, the cost should be dependent on the economic impact in the same way and for the same reason that population dose estimates are dependent on the EI values.

As noted in NUREG-1437, FES analyses use the Calculation of Reactor Accident Consequences (CRAC) computer code to calculate off-site severe accident costs for the area contaminated by the accident. The off-site costs that are considered relate to avoidance of adverse health effects and are categorized as follows:

- Evacuation costs
- Value of crops contaminated and condemned
- Value of milk contaminated and condemned
- Costs of decontamination of property where practical
- Indirect costs resulting from the loss of use of property and incomes derived therefrom, including interdiction to prevent human injury

For those FES analyses that address severe accidents, the off-site accident costs are estimated to be as high as $6 billion to $8 billion in 1994 dollars; however, the accident probabilities are extremely low (1E-6 per year), as would be expected for this class of events. Because key variables used in the FES cost analyses are strongly related to population density, NUREG-1437 further evaluates the FES results using normalization techniques and the 150-mile EI values. This evaluation, which includes the NAPS site, demonstrates that the FES cost predictions remain valid, even considering population changes represented by the EI values.

In addition, NUREG-1437 generically predicts that conditional land contamination is small (10 acres per year at most). This is consistent with WASH-1400 (Reference 6) and NUREG/CR-2239 (Reference 7). NUREG/CR-2239 is a 1982 study on siting criteria that predicts small conditional land contamination values. The GEIS concludes that land contamination values for the evaluated plants can be considered representative of all plants, since they cover the major vendor and containment types and include sites at the upper end of annual rainfall. However, even considering that land contamination values can vary at other sites, predicted land contamination from plants at other sites are expected to vary more than one or two orders of magnitude from the values listed above and, therefore, there would still be a small impact.

Based on the evaluations of the expected economic costs and land contamination as a result of a severe accident, the GEIS concludes in Section 5.5.2.4 that the conditional impacts in both cases are of small significance for all plants. As with other aspects of the GEIS evaluation of severe accident impacts, this evaluation and conclusion are broadly applicable beyond the license renewal context. Thus the economic impacts and land contamination resulting from postulated severe accidents at new units on the ESP site would be comparable as well, falling within the range of those considered in NUREG-1437 as having a “small” impact.

7.2.4 Consideration of Commission Severe Accident Policy

In 1985, the NRC adopted a Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants (Reference 8), which stated the following:

> “The Commission fully expects that vendors engaged in designing new standard (or custom) plants will achieve a higher standard of severe accident safety performance than their prior designs. This expectation is based on:
>
> - The growing volume of information from industry and government-sponsored research and operating reactor experience has improved our knowledge of specific severe accident vulnerabilities and of low-cost methods for their mitigation. Further learning on safety vulnerabilities and innovative methods is to be expected.
> - The inherent flexibility of this Policy Statement (that permits risk-risk trade-offs in systems and sub-systems design) encourages thereby innovative ways of achieving an improved overall systems reliability at a reasonable cost.
> - Public acceptance, and hence investor acceptance, of nuclear technology is dependent on demonstrable progress in safety performance, including the reduction in frequency of accident precursor events as well as a diminished controversy among experts as to the adequacy of nuclear safety technology.”

Thus, based on the informed expectations of the Commission’s Severe Accident Policy, it is reasonable to conclude that the environmental impact of new units at the ESP site would be within the range of risk previously determined to be “small.”

A significant factor in the risk associated with plant design is the frequency of the considered accident sequences. As indicated above, the designs certified in accordance with 10 CFR 52 are expected to exhibit a “higher standard of severe accident safety performance than the prior designs.” The ABWR is a currently certified design under 10 CFR 52, Appendix A (Reference 9), and is considered to be representative of advanced light water reactor standard designs. The NRC Safety Evaluation Report for the ABWR states, “the ABWR design and the submittals made for the ABWR in the SSAR meet the intent of the Commission’s Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants.” Similar findings have been made for the other currently certified designs, namely System 80+ and AP-600. Thus, the Severe Accident Policy Statement expectations have been met for each of the three advanced standard designs considered to date by the NRC and are expected to continue to be met for future design certifications and COL application approvals.

7.2.5 Conclusion

The GEIS concludes, based on the generic evaluations presented, that the probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts from severe accidents are “small” for all plants.

As described above, the methodology and evaluations of the GEIS are applicable to the consideration of new plants in the ESP and COL application context. Evaluation of site-specific factors for purposes of this application have shown that the ESP site is within the range of sites considered in the GEIS. Thus, the GEIS conclusion is applicable to the ESP site.

Use of pertinent site specific information to confirm the applicability of existing generic analyses is consistent with NRC staff plans for addressing severe accident environmental impacts at the ESP, as identified in SECY-91-041 (Reference 11).

In summary, the environmental impacts considered in NUREG-1437 evaluations include potential radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. The consequences of these accidents could be severe, but due to their low likelihood of occurrence, the impacts are judged to be small. This conclusion is based on: 1) considerable experience gained with the operation of similar facilities without significant degradation of the environment, 2) the requirement that in order to obtain a license the applicant must comply with the applicable Commission regulations and requirements, and 3) a previously analyzed assessment of the risk of design-basis and severe accidents (Reference 10).

Specifically, based on the NRC and industry implementation of the 1985 policy statement, the generic NUREG-1437 risk evaluations, and the ESP site specific demography and meteorology, the radiological consequences and the societal and economic impacts of severe accidents for new units at the ESP site would be “small.”

Section 7.2 References

1. NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Vol. 1, U. S. Nuclear Regulatory Commission, April 1996.

2. NUREG-1150, *Severe Accident Risks: An Assessment for Five U. S. Nuclear Power Plants*, U. S. Nuclear Regulatory Commission, December 1990.

3. 61 FR 28467 – 28497, *Final Rule*, “Environmental Review for Renewal of Nuclear Power Plant Operating Licenses,” U. S. Nuclear Regulatory Commission, June 5, 1996.

4. 10 CFR 51, *Code of Federal Regulations*, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions,” U. S. Nuclear Regulatory Commission.

5. NUREG-0440, *Liquid Pathway Generic Study: Impacts of Accidental Radioactive Releases to the Hydrosphere from Floating and Land-Based Nuclear Power Plants*, U. S. Nuclear Regulatory Commission, February 1978.

6. WASH-1400 (NUREG-75/014), *Reactor Safety Study: An Assessment of the Accident Risks in U.S. Commercial Nuclear Power Plants*, U. S. Nuclear Regulatory Commission, October 1975.

7. NUREG/CR-2239, *Technical Guidance for Siting Criteria Development*, Prepared for U. S. Nuclear Regulatory Commission by Sandia National Laboratories, December 1982.

8. 50 FR 32138 – 32150, *Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants*, U. S. Nuclear Regulatory Commission, August 8, 1985.

9. 10 CFR 52, *Code of Federal Regulations*, “Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants,” U. S. Nuclear Regulatory Commission.

10. NUREG-1503, *Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design*, U. S. Nuclear Regulatory Commission, July 1, 1994.

11. SECY-91-0041, *Early Site Permit Review Readiness*, U. S. Nuclear Regulatory Commission, February 13, 1991.

7.3 Severe Accident Mitigation Alternatives

The purpose of SAMA is to review and evaluate plant-design alternatives that could significantly reduce the radiological risk from a severe accident by preventing substantial core damage or by limiting releases from containment in the event that substantial core damage does occur.

SAMAs depend on design issues evaluated during the development and review of standard design certifications and COL applications. The design of the reactor and analyses of projected severe accidents are major contributing factors in the determination of SAMAs. To determine whether mitigation alternatives are cost beneficial, severe accident analyses must be included in these evaluations. SAMA would be evaluated for the new units in the COL application.

Section 7.3 References

None

7.4 Transportation Accidents

The assessment of transportation accidents is provided in Section 3.8, Transportation of Radioactive Materials.

Section 7.4 References

None