2.0 SITE CHARACTERISTICS

2.1 <u>Geography and Demography</u>

2.1.1 Site Location and Description

2.1.1.1 Introduction

This section provides details about the site location and site area description for the VEGP site. The proposed ESP Units 3 and 4 would be built on the VEGP site adjacent to existing VEGP Units 1 and 2. The 3169-acre VEGP site is located on a coastal plain bluff southwest of the Savannah River in eastern Burke County. The site exclusion area boundary (EAB) is bounded by River Road, Hancock Landing Road, and 1.7 miles of the Savannah River. The site is approximately 30 river-miles above the U.S. Highway 301 bridge and directly across the river from the U.S. Department of Energy (DOE) Savannah River Site (SRS), in Barnwell County, South Carolina. The VEGP site is approximately 15 miles northeast of Waynesboro, Georgia, and 26 miles southeast of Augusta, Georgia, which is the nearest population center (with more than 25,000 residents).

2.1.1.2 Regulatory Basis

The acceptance criteria for site location and description are based on meeting the relevant requirements of 10 CFR 52.17, “Contents of applications,” and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the site location and area description:

- 10 CFR 52.17, as it relates to the applicant submitting information needed for evaluating factors involving the characteristics of the site environment, and describing the boundaries of the site and the proposed general location of each facility on the site.

- 10 CFR Part 100, Subpart B, as it relates to site acceptance being based on the consideration of factors relating to the proposed reactor design and the site characteristics.

Review Standard (RS)-002, “Processing Applications for Early Site Permits,” Section 2.1.1, specifies that an applicant has submitted adequate information if it satisfies the following criteria:

- Highways, railroads, and waterways which traverse the exclusion area are sufficiently distant from planned or likely locations of structures of a nuclear power plant or plants of specified type that might be constructed on the proposed site so that routine use of these routes is not likely to interfere with normal plant operation.

- The site location, including the exclusion area and the proposed location of a nuclear power plant or plants of specified type that might be constructed on the proposed site, are described in sufficient detail to allow a determination (in Sections 2.1.2, 2.1.3, and 15.0 of RS-002) that 10 CFR Part 100, Subpart B is met.

In addition to identifying specific acceptable criteria to meet the relevant requirements, RS-002 indicates the NRC staff's review of the site location and description typically involves reviewing the following:

- reactor location with respect to (1) latitude and longitude, and the Universal Transverse Mercator (UTM) coordinates, (2) political subdivisions (i.e., counties, cities, states, or their respective agencies), and (3) prominent natural and manmade features of the area for use in independent evaluations of the exclusion area authority and control, the surrounding population, and nearby manmade hazards

- the site area map containing the reactor and associated principal plant structures to determine (1) the distance from the reactor to the boundary lines of the EAB and (2) the location, distance, and orientation of plant structures with respect to highways, railroads, and waterways that traverse or lie adjacent to the exclusion area to ensure that they are adequately described to permit analyses of the possible effects of plant accidents on these transportation routes.

2.1.1.3 Technical Evaluation

Following the procedures described in RS-002, Section 2.1.1, the NRC staff reviewed Section 2.1.1 of the SSAR in the VEGP application regarding the site location and site area description, as well as the information the applicant provided in response to the NRC staff's RAI 2.1.1-2 and 2.1.1-3.

The applicant provided the following information regarding the site location and site area description:

- the site boundary for the proposed VEGP Units 3 and 4 to be built on the proposed ESP site with respect to the existing VEGP Units 1 and 2

- the site layout for the proposed VEGP Units 3 and 4 to be built on the proposed ESP site

- the site location with respect to political subdivisions and prominent natural and manmade features of the area within the 6-mile LPZ and the 50-mile population zone

- the topography and characteristics of the land surrounding the proposed ESP site

- the commercial, industrial, institutional, recreational, and residential structures located within the site area

- the distance from the proposed ESP site to the nearest EAB, including the direction and distance

- the potential radioactive release points and their locations for the proposed units

- the distance of the proposed Units 3 and 4 to be built on the proposed ESP site from regional U.S. and State highways

The proposed Units 3 and 4 would be located within the existing VEGP site adjacent to existing Units 1 and 2. The ESP site boundary, as shown in Figure 1-4 of the SSAR, is the same as the site boundary for the existing VEGP Units 1 and 2. This figure depicts both the existing units and the proposed units in addition to the site boundary, exclusion area boundary (EAB), protected area (PA) for the proposed units, visitor's center, and Plant Wilson, a six-unit oil-fueled combustion turbine facility owned by Georgia Power Company (GPC), which is also located on the VEGP site.

The NRC staff has verified the following latitude and longitude and UTM coordinates of the proposed units, as provided in the SSAR:

<u>UTM Coordinates</u>	<u>Latitude/Longitude</u> <u>Deg/Min/Sec</u>
Unit 3: Zone 17 3,667,170 m N; 428,320 m E	33 08 27 N; 81 46 07 W
Unit 4: Zone 17 3,667,170 m N; 428,070 m E	33 08 27 N; 81 46 16 W

The EAB for the VEGP, Units 1 and 2 will also apply to the proposed ESP VEGP Units 3 and 4. There are no residents in this exclusion area. The site EAB is bounded by River Road, Hancock Landing Road, and 1.7 miles of the Savannah River. The property boundary encompasses the entire EAB and extends beyond River Road in some areas. The nearest point to the EAB is located approximately 3400 feet southwest of the proposed VEGP Units 3 and 4 power block area. The applicant established this EAB to meet the siting and evaluation factors in Subpart B of 10 CFR Part 100, as well as the radiation exposure criterion "as low as is reasonably achievable," defined in 10 CFR Part 50.

The 3,169-acre proposed ESP site is located on a coastal plain bluff southeast of the Savannah River in eastern Burke County. The VEGP site is situated within three major resource areas: (1) the Southern Piedmont, (2) Carolina and Georgia Sand Hills, and (3) the Coastal Plain. These characteristics are typical of land forms that resulted from historical marine sediment deposits in central and eastern Georgia. There are no mountains in the general area.

The proposed ESP site is approximately 15 miles east-northeast of Waynesboro, Georgia, and 26 miles southeast of Augusta, Georgia, the nearest population center having more than 25,000 residents. It is also about 100 miles from Savannah, Georgia, and 150 river-miles from the mouth of the Savannah River. Burke County includes five incorporated towns (1) Waynesboro, (2) Girard, (3) Keysville, (4) Midville, and (5) Sardis. Of these five towns, only the town of Girard is within 10 miles of the ESP site. Girard has a population of 227 residents, according to the 2000 census.

Based on the NRC staff's review of the general site area and the information collected from the local officials during the site visit, the applicant's information with regard to the site location and area description is adequate and acceptable because it satisfies the acceptance criteria specified in RS-002, Section 2.1.1.

First, although the site is accessible by River Road via U.S. Highway 25 and Georgia Routes 56, 80, 24, and 23, and a railroad spur connects the site to the Norfolk Southern Savannah-to-Augusta track, there are no highways, railroads, or waterways that traverse the proposed ESP site EAB. Accordingly, because there are no highways, railroads, and waterways that traverse the exclusion area, routine use of these routes is not likely to interfere with normal plant operations.

Second, based on the NRC staff's review of the general site area and the information collected from the local officials during the site visit, the applicant's information with regard to the site location and area description is adequate and acceptable to allow the NRC to evaluate whether the applicant met the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff has verified that the EAB distance is consistent with the distance the applicant used in its radiological consequence analyses described in Chapter 15 and in Chapter 13.3 of the SSAR. The applicant stated that all areas outside the EAB will be unrestricted in the context of 10 CFR Part 20, "Standards for Protection Against Radiation," and the gaseous effluent release limits, per guidelines provided in 10 CFR Part 50, for the proposed ESP units, would apply to the EAB. Further information regarding the site location and site description is provided in Sections 2.1.2, 2.1.3, and 11 of this SER.

2.1.1.4 Conclusion

As set forth above, the applicant provided and substantiated information concerning the site location and description of site area. The NRC staff has reviewed the information provided and, for the reasons given above, concludes that the applicant established site characteristics that meet the requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff further concludes that the applicant provided sufficient details about the site location and description of the site area to allow the NRC staff to evaluate, as documented in Sections 2.1.2, 2.1.3, 11, 13.3, and 15 of this SER, whether the applicant met the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100.

2.1.2 Exclusion Area Authority and Control

2.1.2.1 Introduction

This section addresses the information concerning the legal authority to regulate any and all access and activity within the entire plant exclusion area for the proposed VEGP Units 3 and 4. Part 1, Chapter 3, of the SSAR provides general information pertaining to the owners/co-owners group. The applicant stated that GPC, for itself and as an agent for the other co-owners, has delegated complete authority to SNC to determine and regulate all activities within the designated exclusion area. "No Trespassing" signs are posted on the perimeter of the VEGP EAB on land and along the Savannah River, and indicate the actions to be taken in the event of emergency conditions at the plant.

2.1.2.2 Regulatory Basis

The acceptance criteria for exclusion area authority and control are based on meeting the relevant requirements of 10 CFR Part 100 with respect to the applicant's authority over the designated exclusion area.

- 10 CFR 100.3 states: Exclusion area means that area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to the facility as to interfere with normal operations of the facility and provided appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency, to protect the public health and safety. Residence within the exclusion area shall normally be prohibited. In any event, residents shall be subject to ready removal in case of necessity. Activities unrelated to operation of the reactor may be permitted in an exclusion area under appropriate limitations, provided that no significant hazards to the public health and safety will result.

As stated in RS-002, Section 2.1.2, specifies that an applicant has submitted adequate information if it satisfies the following criteria:

- The applicant demonstrates, prior to issuance of an ESP, that it has the authority within the exclusion area, as required by 10 CFR 100.3, or provides reasonable assurance that it will have such authority prior to start of construction of a proposed nuclear unit that might be located on the proposed ESP site.

- Activities unrelated to operation of a nuclear power plant or plants of specified type that might be constructed on the proposed site within the exclusion area are acceptable provided: (a) such activities, including accidents associated with such activities, represent no significant hazard to a nuclear power plant or plants of specified type that might be constructed on the proposed site, or are to be accommodated as part of the plant design basis at the COL stage. (See Section 2.2.3 of RS-002); (b) the applicant is aware of such activities and has made appropriate arrangements to evacuate persons engaged in such activities, in the event of an accident; and (c) there is reasonable assurance that persons engaged in such activities can be evacuated without receiving radiation doses in excess of the reference values of 10 CFR 50.34(a)(1).

RS-002, Section 2.1.2 also addresses review procedures that allow the NRC staff to determine whether the relevant requirements are met. This typically involves the NRC staff reviewing (1) the applicant's legal authority to determine all activities within the designated exclusion area, (2) the applicant's authority and control in excluding or removing personnel and property in the event of an emergency, and (3) proposed or permitted activities in the exclusion area which are unrelated to operation of the reactor to ensure that they do not result in a significant hazard to public health and safety.

2.1.2.3 Technical Evaluation

Following the procedures described in RS-002, Section 2.1.2, the NRC staff reviewed SSAR Chapter 2.1.2 of the VEGP ESP application regarding exclusion area authority and control, in addition to the applicant's responses to RAIs 2.1.2-1, 2.1.2-2, and 2.1.2-3.

In the SSAR Chapter 2.1.2, the applicant presented information concerning the following:

- complete legal authority to regulate any and all access and activity within the entire plant exclusion area

- identification of two facilities (the visitor's center and the GPC combustion turbine plant, Plant Wilson) within the EAB that have authorized activities unrelated to nuclear plant operations

- emergency planning, including arrangements for traffic control

Figure 1-4 of the SSAR depicts the boundary lines of the exclusion area for the proposed ESP site, which is the same as the EAB for the existing VEGP Units 1 and 2. The EAB is bounded by River Road, Hancock Landing Road, and 1.7 miles of the Savannah River. No state or county roads, railroads, or waterways traverse the VEGP exclusion area. The nearest point to the EAB is located approximately 3400 feet southwest of the proposed VEGP Units 3 and 4 ESP power block area.

The applicant stated that pursuant to the VEGP owner's agreement, GPC, for itself and as agent for the co-owners, has delegated to SNC (the applicant) complete authority to regulate any and all access and activity within the entire plant exclusion area. The applicant also stated that the perimeter of the VEGP EAB is adequately posted with "No Trespassing" signs on land and along the Savannah River, which indicate the actions to be taken in the event of emergency conditions at the plant. The applicant stated that it has complete authority to regulate any and all access and activity within the ESP EAB.

The NRC staff verified the applicant's description of exclusion area, the authority under which all activities within the exclusion area can be controlled, and the methods by which access and occupancy of the exclusion area can be controlled during normal operation and in the event of an emergency situation and concluded that the applicant has the required authority to control activities within the designated exclusion area.

The NRC staff verified for consistency the EAB the applicant considered for the radiological consequence evaluations in Chapters 15 and 13.3 of the SSAR.

The applicant stated that two facilities within the EAB have authorized activities unrelated to nuclear plant operations. These are the visitor's center and the GPC combustion turbine plant, Plant Wilson. The applicant also stated that the exclusion area outside the controlled area fence, including along the Savannah River, will be posted and closed to persons who have not received permission to enter the property.

The applicant stated that access to the visitor's center is controlled by security at the pavilion on the entrance road to the plant. Normally, only a few administrative personnel are located at the visitor's center, and the number of visitors at the center is minimal. In the event of emergency conditions at the plant, the emergency plan for the proposed Units 3 and 4 provides for notification of visitors to the center concerning the proper actions to be taken and evacuation instructions.

The applicant also stated that the VEGP staff control Plant Wilson, and locked gates limit access to the facility from New River Road. The emergency plan for the proposed Units 3 and 4 also provides for notification and evacuation of VEGP personnel at Plant Wilson. In addition, the applicant stated that SNC normally will not control passage or use of the Savannah River along the EAB. "No Trespassing" signs are posted near the river indicating the actions to be taken in the event of emergency conditions at the plant.

The NRC staff has evaluated and verified in Section 13.3 of this SER, the emergency plans and detailed information on the activities in the EAB as described above and in SSAR Chapter 13.3 to ensure that proper plans and procedures are in place. The NRC staff concludes that the specified activities unrelated to operation of a nuclear plant or plants that might be constructed on the proposed site within the exclusion area are acceptable.

2.1.2.4 Conclusion

As set forth above, the applicant appropriately described the exclusion area, the authority under which all activities within the exclusion area can be controlled, and the methods by which access and occupancy of the exclusion area can be controlled during normal operation and in the event of an emergency situation. In addition, the applicant has the required authority to control activities within the designated exclusion area, including the exclusion and removal of persons and property, and has established acceptable methods for control of the designated exclusion area. Therefore, the NRC staff concludes that the applicant's exclusion area is acceptable and meets the requirements of 10 CFR Part 100.

2.1.3 Population Distribution

2.1.3.1 Introduction

This section addresses the information provided by the applicant concerning the estimated population distribution surrounding the proposed ESP site up to a 50-mile radius, based on the year 2000 census. Data concerning the resident population distribution within the LPZ, the nearest population center, and population densities up to a 20-mile radius from the proposed site are provided by the applicant. The estimated transient population data out to 50 miles is also provided by the applicant. The cumulative population, including both the resident and transient population in 2000 within the LPZ, within 10 miles of the site, and within 50 miles from the center of the proposed ESP site is presented. The estimated population projections based on a 20-year (1980-2000) growth rate are also presented for the years 2010, 2020, 2030, 2040, and 2070. The established LPZ for the proposed Units 3 and 4 is the same as the LPZ for the existing VEGP, Units 1 and 2, falling within a 2-mile radius of the midpoint between the Units 1 and 2 containment buildings.

2.1.3.2 Regulatory Basis

The acceptance criteria for population distribution are based on the relevant requirements of 10 CFR 50.34, "Contents of Applications: Technical Information;" 10 CFR 52.17; and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the site location and area description:

- 10 CFR 52.17(a)(1)(ix) , insofar as it establishes the dose limits at the EAB and LPZ resulting from potential reactor accidents, as it relates to the requirements of 10 CFR 100.21(c).

- 10 CFR 52.17, insofar as it requires each applicant to provide a description of the existing and projected future population profile of the area surrounding the site.

- 10 CFR Part 100, insofar as it establishes the following requirements with respect to population.

  - 10 CFR 100.20(a), as it relates to population distribution and population density.

  - 10 CFR 100.21(a), which states that every site must have an exclusion area and an LPZ, as defined in 10 CFR 100.3.

- 10 CFR 100.21(b), which states that the population center distance, as defined in 10 CFR 100.3, must be at least one and one-third times the distance from the reactor to the outer boundary of the LPZ.

- 10 CFR 100.3, which defines exclusion area, LPZ, and population center distance.

RS-002, Section 2.1.3, specifies that an applicant has submitted adequate information if it satisfies the following criteria:

- Either there are no residents in the exclusion area, or if so, such residents are subject to ready removal, in case of necessity.

- The specified LPZ is acceptable if it is determined that appropriate protective measures could be taken on behalf of the enclosed populace in the event of a serious accident.

- The population center distance (as defined in 10 CFR 100.3) is at least one and one third times the distance from the reactor to the outer boundary of the LPZ.

- The population center distance is acceptable if there are no likely concentrations of greater than 25,000 people over the lifetime of a nuclear power plant or plants of specified type that might be constructed on the proposed site (plus the term of the ESP) closer than the distance designated by the applicant as the population center distance.

- The boundary of the population center shall be determined upon considerations of population distribution. Political boundaries are not controlling.

- The population data supplied by the applicant in the safety assessment are acceptable if (a) they contain population data for the latest census, projected year(s) of startup of a nuclear power plant or plants of specified type that might be constructed on the proposed site (such date or dates reflecting the term of the ESP) and projected year(s) of end of plant life; (b) they describe the methodology and sources used to obtain the population data, including the projections; (c) they include information on transient populations in the site vicinity; and (d) the population data in the site vicinity, including projections, are verified to be reasonable by other means such as U.S. Census publications, publications from State and local governments, and other independent projections.

- If the population density at the ESP stage exceeds the guidelines given in Position C.4 of Regulatory Guide (RG) 4.7 “General Site Suitability Criteria for Nuclear Power Stations,” Revision 2, issued April 1998, special attention to the consideration of alternative sites with lower population densities is necessary. A site that exceeds the population density guidelines of Position C.4 of RG 4.7 can nevertheless be selected and approved if, on balance, it offers advantages compared with available alternative sites when all of the environmental, safety, and economic aspects of the proposed and alternative sites are considered.

Position C.4 of RG 4.7 states that, preferably, a reactor would be located so that, at the time of initial site approval and within about 5 years thereafter, the population density, including weighted transient population, averaged over any radial distance out to 20 miles (cumulative population at a distance divided by the circular area at that distance), does not exceed 500 persons per square mile.

In addition to identifying specific acceptance criteria to meet the relevant requirements, RS-002 also indicates the NRC staff review of population distribution typically involves reviewing the following:

- data about the population in the site vicinity
- the population in the exclusion area
- the LPZ to determine whether appropriate protective measures could be taken on behalf of the populace in that zone in the event of a serious accident
- the nearest boundary of the closest population center containing 25,000 or more residents to determine whether this boundary is at least one and one-third times the distance from the reactor to the outer boundary of the LPZ
- the population density in the site vicinity, including weighted transient population at the time of initial site approval and within 5 years thereafter, to determine whether it exceeds 500 persons per square mile averaged over any radial distance out to 20 miles

2.1.3.3 Technical Evaluation

Following the procedures described in RS-002, Section 2.1.3, the NRC staff reviewed SSAR Chapter 2.1.3 regarding population distribution, as well as the applicant's responses to RAIs 2.1.3-1 through 2.1.3-6.

The NRC staff notes that there are no residents in the exclusion area.

In SSAR Chapter 2.1.3, the applicant estimated and provided the population distribution surrounding the ESP site, up to a 50-mile radius, based on the 2000 census. In this section, the applicant provided the resident population distribution within the LPZ, the nearest population center, and population densities up to a 20-mile radius from the site.

The NRC staff reviewed the population data presented by the applicant in the SSAR, to determine whether the exclusion area, LPZ, and population center distance for the proposed ESP site comply with the requirements of 10 CFR Part 100 and the acceptance criteria described in Section 2.1.3.2 of this SER. The NRC staff also evaluated whether, consistent with Regulatory Position C.4 of RG 4.7, the applicant should consider alternative sites with lower population densities. The NRC staff also reviewed whether appropriate protective measures could be taken on behalf of the enclosed populace within the EPZ, which encompasses the LPZ, in the event of a serious accident.

The NRC staff obtained the 1980 and 2000 U.S. Census Bureau (USCB) population data for the 16 counties in Georgia and the 12 counties in South Carolina that are within a 50-mile radius of the center of the ESP site. By accounting the percentage of each county falling within the 50-mile radius, the NRC staff was able to estimate the 2000 population within the 50-mile radius. The NRC staff also estimated the 1980 population within a 50-mile radius using the same approach. As a confirmatory check, the NRC staff compared the applicant's

2000 population data against the NRC staff's estimated 2000 population data. The NRC staff found that the staff's estimate was within 2 percent of the data that the applicant presented in the SSAR.

The NRC staff also reviewed the projected population data provided by the applicant. The NRC staff reviewed information pertaining to the cumulative populations, including the weighted transient populations, for the years 2010, 2020, 2030, 2040, and 2070. The population projections have been verified for consistency with the population projections presented in Section 13.3 of this SER as part of emergency planning and preparedness. The NRC staff also made confirmatory population projection estimates using annualized growth rates calculated for each county within 50 miles of the site based on data from the USCB Web site. The NRC staff-estimated population projections are slightly higher than the applicant's estimated projections, which may be because of the NRC staff's application of growth rate on a county basis, rather than on a census-block basis within each county. Therefore, the NRC staff deems the applicant's methodology for estimating population projections appropriate, reasonable, and acceptable. If the NRC staff were to approve and issue an ESP in 2010 (assuming a combined operating license (COL) application is submitted at the end of the ESP-approved period of 20 years), with a projected startup of new units in 2030 and an operational period of 40 years, the projected year for end of plant life is 2070. Accordingly, the NRC staff finds that the applicant's projected population data set covers an appropriate number of years and is reasonable.

The NRC staff reviewed the applicant's transient population data. The transient population within a 10-mile radius includes 200 hunters and fishermen at recreational areas along the Savannah River. The transient population between 10 and 50 miles from the VEGP site includes workers at and occupants of colleges, schools, hospitals, a military base, and the SRS. In addition, the thousands of people who visit Augusta and the surrounding area annually during the week of the Masters Tournament and for other annual events are included. Based on this information, the NRC staff finds that the applicant's estimate of the transient population to be reasonable.

The applicant estimated and provided the cumulative population, including a transient population of 50 hunters and fishermen, in the LPZ. No towns, recreational facilities, hospitals, schools, prisons, or beaches are within the LPZ, and River Road is the only road within the LPZ. The applicant evaluated representative design-basis accidents (DBAs) in Chapter 15 of the SSAR, and the NRC staff independently verified the applicant's evaluation in Chapter 15 of this SER to demonstrate that the radiological consequences of design-basis reactor accidents at the proposed ESP site are within the dose limits set forth in 10 CFR 52.17(a)(1)(ix).

The distance to Augusta, Georgia, the nearest population center, is about 26 miles and is well in excess of 2.67 miles (one and one third times the distance of 2 miles from the reactor to the outer boundary of the LPZ). In addition, the applicant, as well as the NRC staff, did not identify any other population center closer than the population center distance, as identified above. Therefore, the NRC staff concludes that the proposed site meets the population center distance requirement, as defined in 10 CFR Part 100, Subpart B. The NRC staff has also determined and concluded, based on the projected cumulative resident and transient population within 10 miles of the site, during the lifetime of plant, that there is no likelihood of a future population center of 25,000 people or more within 2.7 miles of the ESP site.

The NRC staff evaluated the site against the criterion in Regulatory Position C.4 of RG 4.7, Revision 2, regarding whether it is necessary to consider alternative sites with lower population densities. The evaluation included the review and verification of whether the population densities in the vicinity of the proposed site, including the weighted transient population, projected at the time of initial site approval and 5 years thereafter, would exceed the criteria of 500 persons per square mile averaged over a radial distance of 20 miles (cumulative population at a distance divided by the area at that distance). The NRC staff has independently determined population density for the lifetime of the plant based on the NRC staff's confirmatory population projection estimates discussed earlier, and has found that the population densities for the proposed site would be well below this criterion. Therefore, the NRC staff concludes that the site conforms to Regulatory Position C.4 in RG 4.7, Revision 2. Based on the applicant's projected population data and population densities, assuming initial approval of the ESP in 2010, construction beginning at the end of the term of 20 years of the ESP approval, and a plant operating life of 40 years, the NRC staff finds that the site also meets the guidance of RS-002 regarding population densities over the lifetime of facilities that might be constructed on the site. Specifically, the population density over that period is not expected to exceed 500 persons per square mile averaged out to 20 miles from the site.

Based on the information provided by the applicant in SSAR Chapter 13.3, the applicant's response to RAI 2.1.3-3, and the NRC staff's conclusions discussed in Section 13.3 of this SER, the NRC staff finds that appropriate protective measures could be taken on behalf of the populace in the LPZ in the event of a serious accident. Therefore, the NRC staff finds the applicant's response to be satisfactory.

2.1.3.4 Conclusion

As set forth above, the applicant provided an acceptable description of current and projected population densities in and around the site. The NRC staff concludes that the population data provided are acceptable and meet the applicable requirements of 10 CFR Part 52 and 10 CFR Part 100, Subpart B. This conclusion is based on the applicant having provided an acceptable description and safety assessment of the site, which contain present and projected population densities that are within the guidelines of Regulatory Position C.4 of RG 4.7. In addition, the applicant properly specified the LPZ and population center distance. The NRC staff has reviewed and confirmed, by comparison with independently obtained population data, the applicant's estimates of the present and projected populations surrounding the site, including transients. The applicant also evaluated the radiological consequences of DBAs at the proposed site in SSAR Chapter 15 and provided reasonable assurance that appropriate protective measures can be taken within the LPZ to protect the population in the event of a radiological emergency.

2.2 Nearby Industrial, Transportation, and Military Facilities and Descriptions

2.2.1-2.2.2 Identification of Potential Hazards in Site Vicinity

2.2.1.1-2.2.2.1 Introduction

For its ESP application, the applicant provided information on the relative location and separation distance of the site from industrial, military, and transportation facilities and routes in its vicinity. Such facilities and routes include air, ground, and water traffic; pipelines; and fixed manufacturing, processing; and storage facilities. The purpose of the review is to verify that the applicant has submitted sufficient information concerning the presence and magnitude of potential external hazards, so that the reviews and evaluations described in Sections 2.2.3 and 3.5.1.6 can be performed. Section 2.2 of the SSAR covers information concerning the industrial, transportation, and military facilities in the vicinity of the proposed ESP site. The NRC staff prepared Sections 2.2.3 and 3.5.1.6 of this SER using information presented in SSAR, Section 2.2, in accordance with the procedures described in RS-002.

2.2.1.2- 2.2.2.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17, with respect to the requirement that the application contain information on the location and description of any nearby industrial, military, or transportation facilities and routes.

- 10 CFR 100.20(b), which requires that the nature and proximity of man-related hazards (e.g., airports, dams, transportation routes, military and chemical facilities) be evaluated to establish site parameters for use in determining whether a plant design can accommodate commonly occurring hazards, and whether the risk of other hazards is very low.

- 10 CFR 100.21(e), which requires that the potential hazards associated with nearby transportation routes, industrial, and military facilities be evaluated and site parameters established such that potential hazards from such routes and facilities will not pose undue risk to the type of facility proposed to be located at the site.

RS-002, Section 2.2.1-2.2.2, specifies that an applicant has submitted adequate information to meet the above requirements, if the submitted information satisfies the following criteria:

- data in the site safety assessment adequately describes the locations and distances of industrial, military, and transportation facilities in the vicinity of the plant, a nuclear power plant or plants of specified type that might be constructed on the proposed site, and are in agreement with data obtained from other sources, when available.
- descriptions of the nature and extent of activities conducted at the site and nearby facilities, including the products and materials likely to be processed, stored, used, or transported, are adequate to permit identification of possible hazards.

- sufficient statistical data with respect to hazardous materials are provided to establish a basis for evaluating the potential hazard to a nuclear power plant or plants of specified type that may be constructed on the proposed site.

2.2.1.3-2.2.2.3 Technical Evaluation

Following the procedures detailed in RS-002, Sections 2.2.1-2.2.2, the NRC staff evaluated the potential for man-made hazards in the vicinity of the proposed ESP site by reviewing

- information the applicant provided in Section 2.2.1-2.2.2 of the SSAR,
- information the NRC staff obtained during a visit to the proposed ESP site and its surrounding vicinity,
- other publicly available reference material, such as U.S. Geological Survey (USGS) topographic maps, geographic information system (GIS) information, road and railroad maps, and electric transmission lines and natural gas pipeline maps, and
- information the NRC staff collected independently from such sources as state and local authorities.

In SSAR Chapters 2.2.1 and 2.2.2, the applicant identified and described the following facilities and routes, within a 5-mile radius of the existing VEGP site, which may generate potential hazards or which may engage in potentially hazardous activities:

- Georgia State Highway 23,
- the CSX Railroad,
- Plant Wilson, a combustion turbine electrical plant owned by the GPC,
- the SRS,
- a coal-fired steam electrical plant operated by Washington Savannah River Company in the D-Area of the SRS,
- VEGP Units 1 and 2,
- the Chem-Nuclear Systems radioactive disposal site (18 miles east of the proposed site) in South Carolina, and
- the Unitech Service Group Nuclear Laundry Facility (21 miles east of the proposed site) in South Carolina.

The applicant included maps that show the locations of these facilities and routes (along with airways and military operations) in comparison to the proposed ESP site (SSAR Figures 2.2.2 and 2.2.3). The applicant presented descriptions of these facilities and routes in SSAR Chapter 2.2.2.

In SSAR Chapter 2.2.2.3, the applicant described the roads within a 5-mile radius of the site. Segments of Georgia State Highways 23, 80, and 56 Spur are located within a 5-mile radius. The nearest highway with commercial traffic is Georgia State Highway 23. State Highway 23 serves as a major link between Augusta and Savannah. The heaviest truck traffic along State Highway 23, near the proposed site, consists primarily of timber and wood products and materials. In SSAR Table 2.2-3, the applicant provided available statistical data on personal injury accidents on these roads between 1999 and 2003.

SSAR Chapter 2.2.2.4 states that the CSX Railroad in South Carolina is the nearest railroad with commercial traffic and is approximately 4.5 miles northeast of the VEGP site. The CSX Railroad runs through and services the SRS. The railroad carries a number of major chemical substances, including cyclohexane, anhydrous ammonia, carbon monoxide, molten sulfur, and elevated temperature material liquids (ETMLs).

(Two local Norfolk Southern rail lines exist in Burke County, operated by Norfolk Southern, one through Waynesboro and one through Midville. These rail lines are approximately 12 miles west of the VEGP site.)

Plant Wilson is located approximately 6000 feet east-southeast from the proposed VEGP, Units 3 and 4. This combustion turbine plant is a GPC electrical peaking power station. The plant consists of six combustion turbines with a total rated capacity of 351.6 MW. The storage capacity of the fuel oil storage tanks at Plant Wilson is 9,000,000 gallons.

The SRS borders the Savannah River for approximately 17 miles opposite the VEGP site. It occupies an approximately circular area 310 square miles (198, 344 acres), encompassing parts of Aiken, Barnwell, and Allendale Counties in South Carolina. The SRS is owned by DOE and operated by an integrated team led by the Washington Savannah River Company. The site is a closed Government reservation except for through traffic on South Carolina Highway 125 and the CSX railroad. The current and near-term operating SRS facilities are engaged in various activities. The SRS processes and stores nuclear materials in support of the national defense and the U.S. non-proliferation efforts. This site also develops and deploys technologies to improve the environment and treat nuclear and hazardous wastes left from the Cold War. Because the SRS facilities are distant (i.e., more than 17 miles) from the proposed units, they are not considered to pose a viable threat to the safe operation of the proposed units.

Washington Savannah River Company operates the 70 megawatt coal-fired steam and electrical plant in the D-Area of SRS. This plant has been in operation since 1952 and supplies steam and electricity to several facilities throughout the SRS.

Chem-Nuclear Systems developed, constructed, and currently operates the largest radioactive waste disposal site in the country, near Barnwell, South Carolina. In addition, Unitech Services Nuclear laundry facility is located in the Barnwell County Industrial Park and provides radiological laundry and respirator services. However, these facilities are not considered to be an external hazard to the proposed nuclear units because of their distance (18 and 21 miles, respectively) from the VEGP site.

The existing VEGP Units 1 and 2, are located about 3600 feet and 3900 feet respectively, west of the Savannah River. Besides the activities at Plant Wilson, the only other activities unrelated to plant operations that may occur within the exclusion area are those associated with the operation of the visitor's center. VEGP has made arrangements to control and, if necessary, evacuate the exclusion area in the event of an emergency.

In SSAR Chapter 2.2.2.1, the applicant referenced the "Burke County Comprehensive Plan: 2010, Part 1," which forecasts a relatively slow, stable population growth pattern for Burke County, indicative of the fact that nearby industries have not significantly grown. The applicant stated that currently no major development of industrial, military, or transportation facilities is projected to occur within a 25-mile radius of the VEGP site, except for the development of proposed VEGP Units 3 and 4.

The applicant also identified and described in SSAR, Chapter 2.2.2, the nature, extent, and location of any:

- mining activities,
- commercially-traversable waterways,
- airports,
- airways,
- military-operation areas and routes,
- natural gas or petroleum pipelines,
- military facilities, and
- storage tanks and chemicals found on the current VEGP site.

In SSAR Chapter 2.2.2.2, the applicant stated that no mining activities occur within 5 miles of the VEGP site.

SSAR Chapter 2.2.2.5 states that the footprint of the proposed VEGP Units 3 and 4 is located about 4850 feet southwest of the Savannah River. The small amount of water traffic on the Savannah River that does exist is primarily composed of barge-tug tows moving up and down the river channel out of the Port of Savannah. There are no locks or dams in the vicinity of the proposed plant site. In 2004, only 13 commercial vessels were recorded on the Savannah River below Augusta. Within this section of the river, a total of less than 500 tons of nonexplosive residual fuel oil was transported near or past the VEGP site. Except for the residual fuel oil, there were no flammable or potentially explosive materials transported on this portion of the Savannah River. However, in its response to the NRC staff's RAI dated March 16, 2007, the applicant stated that fuel oil is no longer transported by barge past the VEGP site, and the barge hazard has been eliminated from additional consideration. The proposed intake structure is located approximately 1800 feet upstream of the existing VEGP Units 1 and 2 intake structures.

In SSAR Chapter 2.2.2.6.1, the applicant addressed nearby airports. There are no airports within 10 miles of the VEGP site. The closest airport, Burke County Airport, is approximately 16 miles west-southwest of the site. The average number of operations (landings and takeoffs) is about 57 per week. The closest commercial airport is the Augusta Regional Airport at Bush Field, which is located approximately 17 miles north-northwest of the VEGP site. Based on Federal Aviation Administration (FAA) information, 17 aircraft are based on the field, of which 10 are single-engine airplanes, 4 are multi-engine airplanes, and 3 are jet-engine airplanes. The average number of operations is about 91 per day. Approach and departure paths at Bush Field are not aligned with the VEGP site, and no regular air traffic patterns for Bush Field extend into the airspace over the VEGP site.

A small, un-improved grass airstrip is located immediately north of the VEGP site (north of Hancock Landing Road and west of the Savannah River). At its closest point, the airstrip is about 1.4 miles from the power block of the proposed new units. This privately owned and operated airstrip has a 1650-foot runway oriented east-west. Therefore, the takeoffs and landings are tangential to the site and oriented away from the plant. No FAA information is available for this airstrip. Informal communication with the owner and operator revealed that the airstrip is for personal use, and the associated traffic consists only of small single-engine aircraft. In addition, there is a small helicopter landing pad on the VEGP site. This facility exists for corporate use and for use in case of an emergency. The traffic associated with both of these facilities is characterized as sporadic.

In Section 2.2.2.6.2 of the SSAR, the applicant addresses airways. The applicant stated that the centerline of Airway V185 is approximately 1.5 miles west of the VEGP site. Additionally, Airway V417 is about 12 miles northeast of the VEGP site, and Airway V70 is approximately 20 miles south of the VEGP site. Because of its close proximity to the VEGP site, SSAR Chapter 3.5.1.6 evaluates hazards from air traffic along the V185 airway.

Section 2.2.2.6.3 of the SSAR describes military air training routes. The west edge of the Pointsett Military Operation Area (MOA) is about 75 miles east-northeast of the VEGP site. The east edge of the Bulldog MOAs is about 11 miles west of the VEGP site. Military aircraft in the Bulldog MOA come mainly from Shaw Air Force Base (about 32 miles east of Columbia, South Carolina) and McEntire Air National Guard Station (about 13 miles east-southeast of Columbia). Among the military training air routes, VR97-1059 is located closest to the VEGP site. The distance between the centerline of VR97-1059 and the VEGP site is about 18 miles. The maximum route width of VR97-1059 is 20 nautical miles; therefore, the width on either side of the route centerline is assumed to be 10 nautical miles (11.5 miles). The VEGP site is located more than 6 miles from the edge of this training route. The total number of military aircraft using route VR97-1059 is approximately 833 per year.

In Section 2.2.2.7 of the SSAR, the applicant addressed the existence of natural gas and petroleum pipelines nearby the VEGP site. The applicant stated that there are three natural gas pipelines within 25 miles of the VEGP site (However, none are located within 10 miles of the VEGP site):

- Pipeline 1 is located approximately 21 miles northeast of the VEGP site.
- Pipeline 2 is located approximately 19 miles southwest of the VEGP site.
- Pipeline 3 is located approximately 20 miles northwest of the VEGP site.

Section 2.2.2.8 of the SSAR describes any existing nearby military facilities. The applicant stated that no military facilities are within 5 miles of the VEGP site.

Section 2.2.2.9 of the SSAR addresses the existence of any storage tanks and chemicals currently held on the VEGP site. The list of such chemicals can be found in the SSAR on Table 2.2.5.

Based on its review of the information provided by the applicant in SSAR Chapter 2.2.1-2.2.2, as supplemented by responses to the NRC staff's RAI 2.2.2-1 and 2.2.2-2, and the information discussed above, the NRC staff did not identify any potential source of additional hazards beyond those that the applicant has identified and described.

2.2.1.4-2.2.2.4 Conclusion

As set forth above, the applicant provided information in the SSAR regarding potential site hazards in accordance with RS-002, such that compliance with the requirements of 10 CFR 52.17, 10 CFR 100.20(b) and 10 CFR 100.21(e) can be evaluated. In the SSAR, the applicant identified the facilities and reviewed the nature and extent of activities involving potentially hazardous materials on or in the vicinity of the site and identified hazards that might pose undue risk to the proposed nuclear facility. Based on the information presented in the SSAR, as well as information the NRC staff obtained independently, the NRC concludes that all potential hazards and potentially hazardous activities on and in the vicinity of the site have been identified. These potential hazards and potentially hazardous activities have been reviewed and are discussed in Sections 2.2.3 and 3.5.1.6 of this safety evaluation report (SER).

2.2.3 Evaluation of Potential Accidents

2.2.3.1 Introduction

In this section of the SER, Section 2.2.3, the NRC staff documents its review and evaluation of potential accident sequences on and in the vicinity of the proposed ESP site, such as an explosion of a flammable substance or a release of a toxic chemical. The NRC staff reviews the applicant's probability analyses of potential accident sequences involving hazardous materials or activities on the proposed ESP site and its vicinity to determine that appropriate data and analytical models have been utilized and to ensure that the calculated risks associated with potential accident sequences are sufficiently low.

2.2.3.2 Regulatory Basis

The acceptance criteria for the evaluation of potential accidents are based on meeting the relevant requirements of 10 CFR 52.17, 10 CFR 100.20 and 10 CFR 100.21, as they relate to factors considered in site evaluation. These requirements stipulate that individual and societal risk of potential plant accident sequences must be low. The NRC staff considered the following regulatory requirements in evaluating the potentiality and consequences of accident sequences:

- 10 CFR 52.17, with respect to the requirement that the application contain information on the location and description of any nearby industrial, military, or transportation facilities and routes.

- 10 CFR 100.20(b), which states that the nature and proximity of man-related hazards (e.g., airports, dams, transportation routes, military and chemical facilities) be evaluated to establish site parameters for use in determining whether a plant design can accommodate commonly occurring hazards, and whether the risk of other hazards is very low.

- 10 CFR 100.21(e), which requires that the potential hazards associated with nearby transportation routes, industrial, and military facilities be evaluated and site parameters established such that potential hazards from such routes and facilities will not pose undue risk to the type of facility proposed to be located at the site.

RS-002, Section 2.2.3 specifies that an application meets the above requirements, if the application satisfies the following criteria:

- None of the identified potential accidents are design basis events. A design basis event is defined as an accident that has a probability of occurrence on the order of 10^{-7} per year (or greater) and the expected rate of radiological exposure, as a postulated consequence of the accident, is in excess of 10 CFR 100.21 exposure standards.

If any of the identified potential accidents are considered design basis events, a detailed analysis is required, for each of the accidents so categorized, of the effects of the accident on the plant's safety-related structured and components. Because of the difficulty of assigning accurate numerical values to the expected rate of unprecedented potential hazards, on the probabilistic order of 10^{-7}, the NRC staff employed its judgment as to the acceptability of the overall risk calculated for a potential accident.

To evaluate the information provided in SSAR 2.2.1-2.2.2 per the above acceptance criteria, applicant applied the NRC-endorsed analytical methodologies found in the following:

- RG 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Revision 3, issued November 1978, which defines design basis events external to the nuclear plant as those accidents that have a probability of occurrence on the order of about 10^{-7} per year or greater.

- RG 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," issued December 2001.

- RG 1.91, "Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plant Sites," Revision 1, issued February 1978.

When independently assessing the applicant's analysis in SSAR Chapter 2.2.3, the NRC staff applied the same above-cited analytical methodologies.

2.2.3.3 Technical Evaluation

The NRC staff reviewed the information presented in SSAR Chapter 2.2.3 of the VEGP ESP application pertaining to potential accidents, as well as the applicant's responses to RAIs 2.2.3-1 through 2.2.3-16.

The applicant analyzed postulated accidents for various types, sources and locations:

- explosions and flammable vapor clouds
- release of hazardous chemicals
- fires
- radiological hazards

The applicant reviewed the existing analysis of potential hazards to VEGP Units 1 and 2 to determine its applicability to the proposed VEGP Units 3 and 4, in evaluating the postulated releases of flammable materials and toxic gases from transportation accidents or materials stored at industrial facilities within a 5-mile radius of the VEGP site. In addition, the applicant evaluated new chemicals identified for either VEGP Units 1 and 2, or VEGP Units 3 and 4, to determine their impact on the proposed VEGP Units 3 and 4. The NRC staff has reviewed the applicant's analyses and has made independent confirmatory checks and calculations to determine the applicant's conformance to the requirements and the applicant's reasonableness and approach in assessing these potential hazards.

2.2.3.3.1 Explosions and Flammable Vapor Clouds

Truck Traffic

The applicant analyzed the potential consequences of explosions postulated to occur on transportation routes near the proposed ESP site using the methodology given in RG 1.91. RG 1.91 details a method for determining distances from critical plant structures to a railway, highway, or navigable waterway beyond which any explosion that might occur on these transportation routes is not likely to have an adverse effect on plant operation or to prevent a safe shutdown. Under those conditions, a detailed review of the transport of explosives on those transportation routes would not be required. The RG 1.91 methodology is based on a level of peak positive incident over-pressure, below which no significant damage would be expected to plant structures. The NRC staff, in RG 1.91, conservatively chose 1 psi for this level. The calculation to determine the minimum safe distance at the chosen peak positive incident over-pressure (1 psi) is as follows:

$R > kW 1/3$, whereas R is the distance in feet from an exploding charge of W pounds of trinitrotoluene (TNT). When R is in feet and W is in pounds, k = 45. When R is in meters and W is in kilograms, k = 18.

The concept of TNT equivalence (i.e, finding the mass of substance in question that will produce the same blast effect as a unit mass of TNT) has long been used in establishing safe separation distances for solid explosives.

Based on the previous analysis done for VEGP Units 1 and 2, the applicant identified six chemicals as potential hazards when transported by truck. The applicant used the U.S. Environmental Protection Agency (EPA) Tier II reports for Burke and Richmond Counties in Georgia, along with the EPA Landview database to confirm and/or update the list of chemicals for the analysis. The applicant also performed a traffic corridor evaluation, which showed that even fewer chemicals pass by the site now than was previously assumed in the analysis for Units 1 and 2. The applicant concluded that the only hazardous chemicals likely transported by truck in the vicinity of the site are gasoline and diesel/fuel oil.

Georgia State Highway 23 is the closest ground route to the VEGP site, by which the previously-identified chemicals are being transported by truck. The nearest point from State Highway 23 to the center of VEGP Units 1 and 2, is 4.7 miles and to the center of VEGP, Units 3 and 4, 4.2 miles. The applicant concluded that, due to the distance between Highway 23 and the proposed ESP site, any explosions induced by flammable clouds of these chemicals will not adversely affect the safe operation of the proposed units. The NRC staff independently confirmed these findings using the methodology described in RG 1.91. For an explosion from a flammable cloud, the maximum distance that would result in a peak incident blast pressure of 1 psi is conservatively determined to be 2479 feet from the road.

For an 8500-gallon gasoline truck carrying a TNT equivalent of 56,165 pounds, the critical distance would be 1723 feet from the explosion point. Since the above calculated critical distances of 2479 feet and 1723 feet for the two types of explosions discussed, are much less than 4.2 miles, the distance between Highway 23 (at its closest point) and proposed

Units 3 and 4, the NRC staff concludes that the potential explosion of a gasoline truck would not adversely impact the safe operation of the plant.

In addition to the above-discussed highway transit, gasoline is delivered to the site by tank wagon containing a maximum volume of 4000 gallons. For an explosion from a 4000 gallon truck, the NRC staff calculated the critical distance (beyond which the blast pressure would be less than 1 psi) to be 1340 feet. For an explosion from a flammable cloud in the equivalent circumstances, the critical distance is 1658 feet. The closest distance from the site delivery route to the power block circle is approximately 2000 feet. That distance is greater than the above calculated critical distances. Therefore, the NRC staff concludes that the potential explosion of a gasoline delivery tank truck would not have an adverse impact on the safety of the plant operation. Because of its higher quantity and TNT equivalent and because it is more volatile than diesel fuel, gasoline impacts are considered bounding for the truck-borne hazards evaluation.

Pipelines and Mining Facilities

No natural gas pipeline or mining facilities are located within 10 miles of the VEGP site. Based on RG 1.70, because there are no pipelines or mining activities within 5 miles of the VEGP site, the applicant did not evaluate potential hazards from this source.

Waterway Traffic

The potential impact of barge traffic was analyzed for VEGP, Units 1 and 2. However, the current use of the Savannah River and the lack of commercial facilities and barge slips/docks upstream of the plant indicate that there is no current or projected barge traffic on the Savannah River past the VEGP site. Because the Savannah River is not being used to transport chemicals by barge, a hazard evaluation was not required.

Railroad Traffic

The nearest railroad to the VEGP site is the CSX Railroad, which is approximately 4.5 miles northeast of the center point of VEGP, Units 1 and 2. Based on the information obtained from CSX, the top four U.S. Department of Transportation (DOT) qualified hazardous chemicals are cyclohexane (64 percent), anhydrous ammonia (9 percent), carbon monoxide (3 percent), and ETML (3 percent). Because cyclohexane is both flammable and toxic, it was analyzed in detail to evaluate the potential for an explosion hazard from a railcar and from a flammable vapor cloud.

For the explosion from a railcar, the equivalent TNT mass of 117.5 pounds, based on an Upper Flammability Limit (UFL) of 8.34 percent of cyclohexane at the point of release, would produce a peak overpressure of 1 psi at a distance of 220 feet from the railroad. For an explosion from a flammable vapor cloud, the TNT-equivalent maximum distance beyond which the blast pressure would be less than 1 psi is calculated to be 1026 feet from the railcar. The separation distance between the railroad and the proposed units is 4.5 miles, which is far greater than the above calculated critical distances. Even for a maximum railcar load of 132,000 pounds, the critical distance that could cause a peak overpressure of 1 psi to safety-related structures from an explosion or flammable vapor-cloud-induced explosion is calculated to be 2293 ft. Since the amounts of chemicals transported are much lower than the maximum railcar load, and that the actual distance (approximately 4.5 miles) between the railroad and the VEGP site is greater than the critical distance of 2293 ft, the NRC staff has determined that if such an explosion were to occur, it would not pose a hazard to safety-related structures at the plant.

2.2.3.3.2 Release of Hazardous Chemicals

Using the methodology found in RG 1.78, the applicant analyzed the potential impacts of hazardous chemical releases on control room habitability. RG 1.78 provides guidance on the detailed evaluation of such release events and describes assumptions and criteria for screening out release events that need not be considered in the evaluation of control room habitability. RG 1.78 provides that chemicals stored or situated at distances greater than 5 miles from the plant need not be considered because, if a release occurs at such a distance, atmospheric dispersion will dilute and disperse the incoming plume to such a degree that either toxic limits will never be reached or there would be sufficient time for the control room operators to take appropriate action. In addition, the probability of a plume remaining within a given sector for a long period of time is small. Likewise, if hazardous chemicals are known or projected to be shipped by rail, water, or road routes outside a 5-mile radius of nuclear power plant, the shipments need not be considered further for evaluation.

As another screening criteria, for stationary sources of hazardous chemicals within the 5-mile radius of a nuclear power plant, a detailed analysis need only be performed if the hazardous chemicals are in quantities greater than the limits provided in RG 1.78 for a toxicity limit and stable meteorological conditions. Mobile sources, within the 5-mile radius, need not be considered further if the total shipment frequency for all hazardous chemicals (i.e., all hazardous chemicals considered as a singular cargo category without further distinction of the nature of those chemicals) does not exceed the specified number by traffic type (10 shipments per year for truck traffic, 30 per year rail traffic, or 50 per year for barge traffic - these frequencies are based on transportation accident statistics, conditional spill probability given an accident, and a limiting criterion for the number of spills or releases). Frequent shipments (i.e., shipments exceeding the specified number by traffic type) do not need to be considered in detailed analysis if the quantity of hazardous chemicals is less than the quantity provided in RG 1.78 (as adjusted for the appropriate toxicity limit, meteorology, and control room air exchange rate).

Since there are no manufacturing plants, chemical plants, storage facilities, or oil or gas pipelines are located within 5 miles of the VEGP site, only the following potential scenarios were evaluated:

<u>Release of Hazardous Chemicals from a Transportation Accident</u>

The applicant concluded that the only hazardous chemicals likely to be transported by truck in the vicinity of the VEGP site are gasoline and diesel/fuel oil. Therefore, the control room habitability analysis conducted by the applicant only included those two chemicals. Because gasoline is more volatile than diesel/fuel oil, the applicant applied the flammable properties of gasoline for the purposes of the analysis. Per the analytical methodology in RG 1.78, the calculated toxic vapor concentration of gasoline at the control room resulting from a release of gasoline from a 8500 gallon truck on Georgia State Highway 23 (4.2 miles from VEGP, Units 3 and 4) is 34.9 parts per million, and from a 4000 gallon tank wagon during delivery (2000 feet from the center of the power block for Units 3 and 4) is 95.1 parts per million. The calculated vapor concentrations are much smaller than the toxicity limit of 300 parts per million (American Conference of Governmental Industrial Hygienists Threshold Limit Value) and, therefore, the applicant asserted that no adverse impact on control room habitability from the accidental release of gasoline or diesel/fuel oil is expected. The NRC staff has reviewed and verified the applicant's information through independent analysis. The NRC staff has found the applicant's methodology to be acceptable and the results and conclusions to be reasonable. Based on the above information, the NRC staff concludes that the accidental release of gasoline or diesel/fuel oil by truck transportation would not cause concentrations of these chemicals to affect control room habitability at or above the corresponding toxicity limits.

The information obtained by the applicant from CSX revealed that the railroad carried four major hazardous chemicals in 2005: cyclohexane, anhydrous ammonia, carbon monoxide, and ETMLs. Accidental spills of carbon monoxide or ETMLs are not expected to create a vapor hazard for the site, as they are molten nonhazardous materials. Therefore, evaluations were performed for cyclohexane and anhydrous ammonia. Assuming a railcar capacity of 67 tons of cyclohexane (based on RG 1.91 limit of 132,000 pounds for a railcar load) and 26 tons of anhydrous ammonia (analyzed previously for VEGP Units 1 and 2), the vapor concentrations at the control room, which is approximately 4.5 miles from railroad, were estimated based on stable atmospheric conditions using a windspeed of 1 meter per second (m/s). The calculated vapor concentration of 34.3 parts per million for cyclohexane is much less than the toxicity limit of 1300 parts per million, and the calculated concentration of 112 parts per million for anhydrous ammonia is also less than the toxicity limit of 300 parts per million. The NRC staff reviewed the applicant's calculations of the concentrations of these chemicals and conducted independent confirmatory analyses using the methodology provided in RG 1.78. In light of the above evaluation and analyses, the NRC staff finds that the applicant's approach and calculations are reasonable and its conclusions acceptable. Based on these estimated toxic vapor concentrations for these chemicals, the NRC staff has determined that the potential hazard from these chemicals is minimal and will not affect the safe operation of the proposed units.

<u>Potential Hazard from Major Depots or Storage Areas</u>

The applicant stated that the only chemical storage areas within 5 miles of the VEGP site are located at the SRS and the Plant Wilson combustion turbine plant. The original analysis performed for VEGP, Units 1 and 2 discussed the storage at SRS "D-Area" (which is 4.5 miles from the center of Units 1 and 2) and of the chemicals chlorine and ammonia. Since these chemicals (or any others) are no longer used at D-Area, the analysis for VEGP Units 3 and 4 considered only the chemicals stored at Plant Wilson.

The chemicals stored at Plant Wilson (approximately 5500 feet from the new power block of Units 3 and 4) consist of three 3-million gallon tanks of fuel oil, sulfuric acid, and several other chemicals in small quantities. Because the sulfuric acid and the other chemicals are present in small quantities and have low volatility and toxicity, the applicant stated that they do not pose a potential hazard to control room habitability. Therefore, the applicant only analyzed one of the 3-million gallon fuel oil tanks, as a bounding case, for the toxic vapor concentration from potential accidental release. The applicant estimated the vapor concentration of fuel oil to be less than 50 parts per million at 5500 feet from the storage tank. Since the calculated concentration is much less than the toxicity limit of 300 parts per million, the applicant concluded that the Plant Wilson fuel oil storage tanks do not present a hazard to VEGP Units 3 and 4. The NRC staff conducted a confirmatory analysis and found that the calculated concentration is much less than the toxicity limit of 300 parts per million.

<u>Potential Hazard from Onsite Storage Tanks</u>

SSAR, Table 2.2-5 lists the chemicals that are stored at VEGP. Of the many chemicals listed that are stored and used on the site, only three chemicals, hydrazine, phosphoric acid, and methoxypropylamine (MPA), were evaluated by the applicant for potential hazard effects that would be bounding. Phosphoric acid and MPA are new chemicals that are being used at VEGP, Units 1 and 2. The applicant stated that the other listed chemicals were not considered for evaluation based on low volatility, low toxicity, or the relatively small quantities stored. In evaluating the control room habitability conditions, the applicant used the guidelines of NUREG-0570, "Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release," to determine the toxic concentrations of these chemicals at the control room intake.

Hydrazine is stored northeast of the VEGP Unit 1 reactor and is separated by a minimum distance of 1800 feet from Units 3 and 4. The applicant's analysis of the hydrazine for Units 1 and 2 showed that at least 2 minutes would be available between detection and the time the short-term toxicity limit (as defined in RG 1.78) would be reached. Since hydrazine storage is separated by 1800 feet for Units 3 and 4, the impact on the new units from an accidental release of hydrazine would be less than the impact on the existing VEGP Units 1 and 2. Due to the impact on control room habitability, these calculations will be evaluated at the time of the COL application. This is **COL Action Item 2.2-1**. When addressing this COL action item, Section 6.4 of the FSAR should also be taken into consideration.

Phosphoric acid is stored in a 5050-gallon tank at a distance of approximately 3200 feet from the air intake for the Unit 3 control room. The applicant calculated phosphoric acid concentration outside the control room intake under stable conditions (F stability) with 1 m/s windspeed to be 94 microgram/m^3, much lower than the 8-hour threshold limit value of 1 milligram/m^3 and the short-term exposure limit of 3 milligram/m^3.

The applicant had previously evaluated MPA for VEGP Units 1 and 2. The applicant calculated the MPA release concentration based on a 400-gallon release at 59 meters from the control room intake under atmospheric conditions of 2.5 m/s wind speed and G stability. Using these parameters, the applicant calculated the MPA concentration for VEGP Units 1 and 2 to be 1.5 parts per million, which is much lower than the short term exposure limit of 15 parts per million. Since VEGP Units 3 and 4 would be farther away from the MPA release point than VEGP Units 1 and 2, the MPA concentration at the new control room intake is expected to be lower than that calculated for VEGP Units 1 and 2.

SSAR Table 2.2-6 lists the chemicals that will be used at Units 3 and 4. However, the applicant did not provide the quantity of chemicals. Potential toxic concentrations of these chemicals based on their volatility, toxicity, and quantity, including their impact on control room habitability, will be evaluated at the time of the COL application. This is **COL Action Item 2.2-2**. When addressing this COL action item, Section 6.4 of the FSAR should also be taken into consideration.

The NRC staff used screening models (ALOHA, 2007; HPAC, 2005) to perform confirmatory analyses to independently determine the toxic concentrations of the above discussed chemicals. The NRC staff's estimated concentrations are comparable to those calculated by the applicant. Based on the NRC staff's confirmatory checks, the staff concludes that the applicant's assumptions, and its approach in determining the toxic concentrations of these chemicals at the control room intake, are reasonable and acceptable. Therefore, the NRC staff agrees with the applicant's conclusion that the control room will remain habitable for most release scenarios without any operator action. Furthermore, the applicant demonstrated that in the hydrazine release scenario, control room operators will have sufficient time to take emergency action (e.g., donning emergency breathing apparatus).

2.2.3.3.3 Fires

The preceding sections addressed the potential fire hazards associated with transportation accidents, industrial storage facilities, and onsite storage. The applicant considered the fire hazard from a forest fire resulting in release of potentially toxic chemicals CO, NO2, and CH4, and determined that such a scenario would produce only negligible concentrations outside the control room air intakes. In addition, because of the long distances separating the tree line from the control room, the NRC staff finds that there would be no adverse heat impact in the form of heat flux from the forest fire.

2.2.3.4 Radiological Hazards

Radiation monitoring of the main control room environment is provided by the radiation monitoring system. The habitability systems are capable of maintaining the main control room environment suitable for prolonged occupancy throughout the duration of postulated accidents that require protection from external fire, smoke, and airborne activity. In addition, safety related SSCs have been designed to withstand the efforts of radiological events and consequential releases. However, this site-specific information would be reviewed in Chapters 11 and 15 of a COL application.

2.2.3.5 Conclusion

The NRC staff has reviewed the applicant's potential accidents analysis using the procedures set forth in RS-002, Section 2.2.3. As discussed, the NRC staff has made confirmatory checks and calculations and has verified the applicant's evaluation of potential accidents by using screening models with conservative assumptions and comparing and verifying pertinent data available in the literature.

Based on these considerations, the NRC staff concludes that the potential accidents considered by the applicant would allow for a determination of whether a plant design is adequate to accommodate potential hazards in the site vicinity. Therefore, the NRC staff finds that, with respect to the hazards associated with evaluated potential accidents, the proposed site is acceptable for the planned units and the site meets the relevant requirements of 10 CFR 52.17, 10 CFR 100.20(b), and 10 CFR 100.21(e).

2.3 <u>Meteorology</u>

To ensure that a nuclear power plant or plants can be designed, constructed, and operated on an applicant's proposed ESP site in compliance with the Commission's regulations, the NRC staff evaluates regional and local climatological information, including climate extremes and severe weather occurrences that may affect the design and siting of a nuclear plant. The staff reviews information on the atmospheric dispersion characteristics of a nuclear power plant site to determine whether the radioactive effluents from postulated accidental releases, as well as routine operational releases, are within Commission guidelines. The staff has prepared Sections 2.3.1 through 2.3.5 of this SER in accordance with the review procedures described in RS-002, using information presented in Section 2.3 of the SSAR, responses to staff requests for additional information (RAIs), and generally available reference materials (as cited in applicable sections of RS-002).

2.3.1 Regional Climatology

2.3.1.1 Introduction

In Section 2.3.1 of the SSAR, the applicant presented information on the climatic conditions and regional meteorological phenomena (both the averages and extremes thereof) that could affect the design and operating bases of safety- and/or nonsafety-related SSCs for the proposed nuclear power plant. Specifically, the applicant provided the following information:

- data sources used to characterize the regional climatological conditions pertinent to the proposed site.

- a description of the general climate of the region with respect to types of air masses, synoptic features (high- and low-pressure systems), general airflow patterns (wind direction and speed), temperature and humidity, and precipitation (rain, snow, and sleet).

- frequencies and descriptions of severe weather phenomena that have affected the proposed site, including extreme wind, tornadoes, tropical cyclones, precipitation extremes, winter precipitation (hail, snowstorms, and ice storms), and thunderstorms (including lightning).

- a justification as to why the identification of meteorological conditions associated with the ultimate heat sink (UHS) maximum evaporation and drift loss of water and minimum water cooling is not necessary for a description of design-basis dry- and wet-bulb temperatures for the proposed site.

- a description of design-basis dry- and wet-bulb temperatures for the proposed site.

- the potentiality for restrictive air dispersion conditions and high air pollution at the proposed site.

Based on the above information, the applicant provided a table, SSAR Table 1-1, of proposed site characteristics. Site characteristics are the actual physical, environmental, and demographic features of a site and are used to verify the suitability of a proposed plant design for a site. The following are climatic site characteristics the applicant proposed to define the site:

- the maximum winter precipitation load (i.e., 100-year snowpack and 48-hour probable maximum winter precipitation (PMWP)) on the roofs of safety-related structures.

- tornado parameters, including maximum wind speed, maximum rotational and translational wind speed, the radius of maximum rotational wind speed, the maximum pressure drop, and the maximum rate of pressure drop.

- the 100-year return period straight-line (basic) wind speed.

- ambient air temperature and humidity extremes, including maximum dry-bulb (2-percent and 0.4-percent annual exceedance with concurrent mean wet-bulb temperatures; 100-year return period); minimum dry-bulb (99-percent and 99.6-percent annual exceedance; 100-year return period); and maximum wet-bulb (0.4-percent annual exceedance; 100-year return period).

- The site temperature basis for the AP1000, including the maximum safety dry-bulb temperature and coincident wet-bulb temperature; maximum safety noncoincident wet-bulb temperature; maximum normal dry-bulb temperature and coincident wet-bulb temperature; and maximum normal noncoincident wet-bulb temperature.

2.3.1.2 Regulatory Basis

The acceptance criteria for identifying regional climatological and meteorological information are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The staff considered the following regulatory requirements in reviewing the applicant's identification of regional climatological and meteorological information:

- 10 CFR 52.17(a), which requires that the application contain a description of the seismic, meteorological, hydrological, and geological characteristics of the proposed site.

- 10 CFR 100.20(c), which requires that the meteorological characteristics of the site, necessary for safety analysis or that may have an impact on plant design, be identified and characterized as part of the NRC's review of the acceptability of a site.

- 10 CFR 100.21(d), which requires that the physical characteristics of the site, including meteorology, geology, seismology, and hydrology be evaluated and site parameters established, such that the potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site.

The climatological and meteorological information assembled in compliance with the above regulatory requirements would be necessary to determine, at the COL stage, a proposed facility's compliance with the following requirements in Appendix A of 10 CFR Part 50:

- GDC 2, which requires that structures, systems and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

- GDC 4, "Environmental and Dynamic Effects Design Bases," which requires that SSCs important to safety be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, included loss-of-coolant accidents.

An ESP applicant, though, need not demonstrate compliance with the above GDC, with respect to regional climatology.

RS-002, Section 2.3.1 specifies that an application meets the above requirements, if the application satisfies the following criteria:

- The description of the general climate of the regions should be based on standard climatic summaries compiled by the National Oceanic and Atmospheric Administration (NOAA). Consideration of the relationships between regional synoptic-scale atmospheric processes and local (site) meteorological conditions should be based on appropriate meteorological data.

- Data on severe weather phenomena should be based on the standard meteorological records from nearby representative National Weather Service (NWS), military, or other stations recognized as standard installations which have long periods on record. The applicability of these data to represent site conditions during the expected period of reactor operation should be substantiated.

- Design basis straight-line wind velocity should be based on appropriate standards, with suitable corrections for local conditions.

- UHS meteorological data, as stated in RG 1.27, “Ultimate Heat Sink for Nuclear Power Plants,” should be based on long-period regional records which represent site conditions.

- Freezing rain estimates should be based on representative NWS station data.

- High air pollution potential information should be based on U.S. EPA studies.

- All other meteorological and air quality data used for safety-related plant design and operating bases should be documented and substantiated.

To the extent applicable to the above-outlined acceptance criteria, the applicant applied the NRC-endorsed meteorological information selection methodologies and techniques found in the following:

- RG 1.23, “Onsite Meteorological Programs,” which provides criteria for an acceptable onsite meteorological measurements program, which can be used to monitor regional meteorology site characteristics.

- RG 1.70, which describes the type of regional meteorological data that should be presented in SSAR Section 2.3.1.

- RG 1.76, “Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants,” which provides criteria for selecting the design-basis tornado parameters.

When independently assessing the veracity of the information presented by the applicant in SSAR Chapter 2.3.1, the NRC staff applied the same above-cited methodologies and techniques.

2.3.1.3 Technical Evaluation

The NRC staff reviewed the application, as supplemented by letters dated January 30, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML070330054);

March 26, 2007 (ADAMS Accession No. ML070880685); and March 30 2007 (ADAMS Accession No. ML070940221) to verify the accuracy, completeness, and sufficiency of the information presented by the applicant regarding regional climatology. In reviewing and evaluating this information, the staff used (or relied on) none of the applicant's proposed design parameters and site interface values presented in SSAR Section 1.3.

2.3.1.3.1 Data Sources

The applicant characterized the regional climatology of the proposed VEGP site's area using data from the National Climatic Data Center (NCDC), including the NWS station in Augusta, Georgia, and from nine other nearby cooperative observer stations. Five of these cooperative observer stations are located in Georgia counties, including Burke, Jefferson, Jenkins, Richmond, and Screven. The other four stations are located in the South Carolina counties, including Aiken, Bamberg, Barnwell, and Orangeburg. The regional climatic observation stations used by the applicant are included in the list presented in SER Table 2.3.1-1.

The applicant also obtained information on mean and extreme regional climatological phenomena from a variety of sources, such as publications by the NCDC, the Air Force Combat Climatology Center (AFCCC), the American Society of Civil Engineers (ASCE), the National Oceanic and Atmospheric Administration—Coastal Services Center (NOAA-CSC), and the Southeast Regional Climate Center (SERCC).

In RAI 2.3.1-1, the NRC staff asked the applicant to explain how it selected the observation stations it used to characterize regional climatology in SSAR Section 2.3.1. The applicant responded by revising its SSAR to enumerate the following selection criteria:

- The applicant chose stations in "proximity" to the site (i.e., within the general site area, less than or equal to 50 kilometers).

- The applicant attempted to select stations surrounding the site equally in all directions, to the greatest extent possible.

- Where more than one station exists in the same general direction from the site, the applicant selected the station that recorded a more extreme value for one or more meteorological conditions or phenomena (e.g., rainfall, snowfall, temperatures).

In addition to the ten climatic stations identified by the applicant, the NRC staff reviewed data from an additional seven climatic stations. Generally, the staff used data from stations within 50 miles (80 kilometers) and with a period of record greater than 10 years. SER Table 2.3.1-1 lists the observation stations used by the staff, in addition to those used by the applicant, to evaluate the regional climatology characteristics of the site.

During a site audit conducted on December 6, 2006, the staff asked the applicant to include all applicable stations which recorded the most extreme value for a particular meteorological condition or phenomena. The applicant responded by revising its SSAR to include data from the Louisville and Bamberg observation stations.

The NRC staff also used information reported by the NWS, NCDC, NOAA-CSC, Storm Prediction Center, National Severe Storms Laboratory (NSSL), National Hurricane Center (NHC), SERCC, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Structural Engineering Institute (SEI), AFCCC, and ASCE.

2.3.1.3.2 General Climate

The applicant described the proposed VEGP site's general climate as mild with short winters. The region often experiences long periods of mild weather in the autumn and spring, coupled with long hot summers. The predominant air mass over the region is maritime tropical. In the winter, continental polar air, associated with high-pressure systems that move southeastward out of Canada, periodically affects the region. However, in general, down sloping and land modification warm the cold air that reaches the proposed site.

The regional climate is primarily influenced by the Azores high-pressure system. During the summer, the Bermuda High and the Gulf High have the strongest influence on Georgia's precipitation and temperature patterns. These circulation patterns are less defined in the transitional seasons and winter months, because of the passage of synoptic and meso-scale weather systems.

The applicant stated that monthly precipitation exhibits a cyclical pattern, with one maximum during the winter into early spring and a second maximum during late spring into summer. These two precipitation maxima are related to eastward moving low-pressure systems and thunderstorm activity, respectively. During the summer and early autumn, heavy precipitation can also be associated with tropical cyclones.

The staff agrees with the applicant's description of the general climate of the region, which is consistent with the NCDC narrative, "Annual Summary with Comparative Data for Augusta, Georgia;" the NCDC climatic data summary for Augusta shows an annual mean wind speed of 6.1 miles per hour (mi/h) and an annual prevailing wind direction from the west-southwest.

2.3.1.3.3 Severe Weather

2.3.1.3.3.1 Extreme Wind

Estimating wind loading on plant structures involves identifying the site's "basic" wind speed, which is defined by ASCE/SEI 7-02, "Minimum Design Loads for Buildings and Other Structures," as the "3-second gust speed at 33 feet (10 meters) above the ground in Exposure Category C".[6] Using linear interpolation on a plot of basic wind speeds presented in ASCE/SEI 7-02 for the portion of the United States that includes the proposed VEGP site, the applicant defined the basic wind speed for the proposed site as 97 mi/h. This value is associated with a mean recurrence interval of 50 years. Using a conversion factor listed in ASCE/SEI 7-02, the applicant derived a 100-year return period 3-second gust wind speed site characteristic value of 104 mi/h, as presented in SER Table 2.3.1-4.

Based on Section C6.0 of ASCE/SEI 7-02, the ratio of the 100-year to 50-year mean recurrence interval values is typically 1.07, which means that the 50-year return period basic wind speed value of 97 mi/h corresponds to a 100-year return period basic wind speed value of 104 mi/h. Therefore, the staff concludes that a site characteristic 3-second gust basic wind speed value of 104 mi/h is acceptable.

2.3.1.3.3.2 Tornadoes

The applicant used an approximate 55-year period of tornado reports (January 1950 through April 2005) from the NCDC to calculate the probability of a tornado strike near the proposed VEGP site. The applicant stated that 348 tornadoes have been reported to have touched down in the vicinity (i.e., within a 2-degree latitude and longitude area) of the proposed ESP site. Following the methodology presented in WASH-1300, "Technical Basis for Interim Regional Tornado Criteria," issued May 1974, the applicant used the following formula to calculate the probability that a tornado will strike a particular location during any one year period:

$$Ps = n(a/A)$$

where:

Ps = mean tornado strike probability per year
n = average number of tornadoes per year in the area being considered
a = average individual tornado area
A = total area being considered

The applicant calculated the probability of a tornado strike in the vicinity of the proposed ESP site of 774×10^{-7} per year, or, put differently, a recurrence interval of once every 12,920 years. The staff verified the applicant's probabilistic calculation, using the same tornado database, "Storm Events for Georgia and South Carolina, Tornado Event Summaries," from NCDC.

---

7 Exposure Category C is defined as open terrain with scattered obstructions, having heights generally less than 30 feet (9.1 meters). This category includes flat open country, grasslands, and all water surfaces in hurricane-prone regions.

The applicant chose the tornado site characteristics based on the proposed Revision 1 to RG 1.76 (Draft Regulatory Guide DG-1143). DG-1143 provides design basis tornado characteristics for three tornado intensity regions throughout the United States, each with a 10-7 probability of occurrence. The proposed VEGP site is adjacent to both tornado intensity regions I and II. The applicant chose to use the more conservative design-basis tornado region (region I) and, correspondingly, proposed the following tornado site characteristics:

Maximum Wind speed	300 mi/h
Maximum Translational Speed	60 mi/h
Rotational Speed	240 mi/h
Radius of Maximum Rotational Speed	150 feet
Pressure Drop	2.0 lbf/in.2
Rate of Pressure Drop	1.2 lbf/in.2/s

In March, 2007, revision 1 to RG 1.76 was issued. Revision 1 reconfirmed that the design-basis tornado wind speeds for new reactors should correspond to the exceedance frequency of 10-7 per year. The design-basis tornado wind speeds presented in Revision 1 to RG 1.76 are based on the Enhanced-Fujita (EF) scale, which relates the degree of damage from a tornado to the tornado's maximum wind speed. The original versions of RG 1.76 and DG-1143 were based on the original Fujita scale. The applicant's design-basis tornado site characteristics conservatively bound those presented in Revision 1 to RG 1.76. For example, Revision 1 to RG 1.76 suggests a design-basis tornado wind speed of 230 mi/h for the proposed VEGP site, whereas the applicant chose a site characteristic design-basis wind speed of 300 mi/h.

Because the applicant's design-basis tornado site characteristics conservatively bound those presented in Revision 1 to RG 1.76, the staff concludes that the applicant has chosen acceptable tornado site characteristics. SER Table 2.3.1-4 presents the tornado site characteristics for the proposed VEGP site in the list of regional climatic site characteristics.

2.3.1.3.3.3 Tropical Cyclones

According to information presented by the applicant, during the period of time between 1851 and 2004, 102 tropical cyclones centers passed within a 100-nautical mile (185-kilometer) radius of the proposed VEGP site. The applicant used the NOAA-CSC historical tropical database to derive these results. Using the same database, the staff was able to verify the statistics presented by the applicant. SER Table 2.3.1-3 presents the storm classifications and respective frequencies of tropical cyclones passing within 100 nautical miles of the site during the 154-year period tracked by the NOAA-CSC database.

Since 1850, only nine hurricanes of category 2 strength or greater, which had sustained (i.e., 1-minute average) winds greater than 96 mi/h, have impacted the 100-nautical mile area surrounding the proposed VEGP site. This translates to a recurrence interval of 0.06 years, or one hurricane of category 2 strength or greater every 17.1 years. Six of these category 2 and 3 storms that affected the 100-nautical mile area surrounding proposed site did so before 1900. No category 2 or 3 storms have affected the region since 1959.

The strongest recorded hurricane to pass within 100 nautical miles of the site was hurricane Gracie on September 29, 1959. Hurricane Gracie had sustained wind speeds of 120 mi/h as it crossed the Atlantic coastline approximately 100 nautical miles southeast of the proposed VEGP site. The forward speed of the storm, as it crossed the coastline, was about 12 mi/h, as reported by the NHC. Based on its forward speed, hurricane Gracie would have needed to travel approximately 7 hours overland to reach the proposed VEGP site, approximately 88 miles (142 kilometers) from the coast. The storm's sustained wind speeds had weakened to 70 mi/h within 6 hours after it crossed the coastline. Assuming the storm took a direct track over the proposed VEGP site, the maximum projected sustained winds at the site would have been 70 mi/h. The Hurricane Research Division, a specialized division of NOAA, recommends multiplying sustained winds by a factor of 1.3 to obtain 3-second gust estimates. This would have resulted in a 3-second gust wind speed of approximately 91 mi/h, well below the chosen 3-second gust basic wind speed site characteristic of 104 mi/h.

Although tropical systems generally weaken significantly before impacting the proposed VEGP site, they still can cause significant amounts of rainfall. The applicant reported that tropical cyclones produced at least 12 separate 24-hour and monthly rainfall records at eight NWS cooperative observer network stations in the vicinity of the proposed site's area. The staff has independently confirmed these statistics.

2.3.1.3.3.4 Precipitation Extremes

The applicant used historical climate data from 10 nearby observing stations, as listed in SER Table 2.3.1-1, to identify precipitation extremes (rainfall and snowfall) observed near the proposed VEGP site. Based on the similarity of precipitation extremes and a real distribution of the observing stations around the site, these data can be used to adequately represent precipitation extremes that might be expected to occur at the site.

In SSAR Table 2.3-3, the applicant provided a climatic summary for each of the utilized observation stations, including the ones with the maximum 24-hour rainfall and maximum monthly rainfall. The staff independently verified each of these rainfall records, using the NCDC "Cooperative Summary of the Day—Daily Surface Data (TD 3200/3210)" and confirmed that the statistics provided by the applicant are correct.

During a site audit conducted on December 6, 2006, the staff asked why the applicant did not use as input to SSAR Table 2.3-3 the monthly rainfall value of 22.16 inches at Louisville in October 1990, as reported in the NCDC "Climatology of the United States No. 20." The applicant responded in a letter dated January 30, 2007, that this value is suspect and most likely an error. The applicant used the NCDC "Cooperative Summary of the Day" and climate summaries from SERCC to show that the actual value should be 14.34 inches. The staff agrees with the applicant that the 22.16 inches is an error and accepts the overall highest monthly total of 17.32 inches, which occurred at Springfield.

Although most of the recorded precipitation extremes were associated with the occurrence of tropical cyclones, the overall highest 24-hour rainfall total and overall highest monthly rainfall total were not. On April 16, 1969, the 24-hour rainfall record in the area surrounding the proposed site was set at the Aiken 4NE Station, when 9.68 inches fell. The overall highest monthly total of 17.32 inches occurred during June 1973 in Springfield.

According to the applicant, the disruptive effects of any winter storm accompanied by frozen precipitation in the proposed VEGP site area can be significant. However, storms that produce significant amounts of snow are infrequent. With one exception, all of the 24-hour and monthly record snowfall totals around the proposed site were associated with a storm that occurred early in February 1973. The applicant originally reported that the highest daily and monthly snowfall totals were both 17.0 inches and occurred at the Blackville station in South Carolina (Most other surrounding stations recorded similar amounts, ranging from 14.0 to 16.0 inches). The staff found larger values of 19.0 inches and 22.0 inches for the daily and monthly snowfall records near the site--these occurred in

February 1973 at Bamberg, South Carolina. During a site audit conducted on December 6, 2006, the staff asked the applicant to justify not including Bamberg as one of the cooperative observation stations considered in the SSAR. The applicant responded by adding climatic data from Bamberg to the SSAR and using data recorded by the Bamberg station to help characterize the regional climatology of the proposed VEGP site.

The staff notes that large snowfalls are very rare in the vicinity of the proposed site. At Waynesboro, the climatic observation station closest to the proposed site, maximum monthly snowfall totals from 1940 through 2006 (except for 1973) annually have ranged between 2 and 4 inches; only 5 years in the 66-year period have had months with snowfall greater than 2 inches at the Waynesboro cooperative observation site.

The staff concludes that the applicant has adequately identified precipitation extremes that might be expected to occur at or around the site. SER Table 2.3.1-2 lists the highest precipitation extremes that have occurred in the vicinity of the site.

2.3.1.3.3.5 Winter Precipitation Loads

The methodology for assessing the potential winter precipitation load on the roofs of safety-related structures considers two climate-related components, the weight of the 100-year return period ground-level snowpack, and the weight of the 48-hour PMWP. Consistent with the staff's branch position on winter precipitation loads (NRC memorandum dated March 24, 1975, from Harold R. Denton to R.R. Maccary), the winter precipitation loads included in the combination of normal live loads considered in the design of a nuclear power plant that might be constructed on a proposed ESP site should be based on the weight of the 100-year snowpack or snowfall, whichever is greater, recorded at ground level. Likewise, the winter precipitation loads included in the combination of extreme live loads considered in the design of a nuclear power plant that might be constructed on a proposed ESP site should be based on the weight of the 100-year snowpack at ground level plus the weight of the 48-hour PMWP at ground level for the month corresponding to the selected snowpack. A COL or CP applicant may choose to justify an alternative method for defining the extreme winter precipitation load by demonstrating that the 48-hour PMWP could neither fall nor remain on top of the snowpack and/or building roofs.

The applicant identified a 100-year return period ground-level snowpack value of 10-pounds-force per square foot (lbf/ft^2) for the proposed VEGP site, which was determined in accordance with ASCE/SEI 7-02. The applicant estimated the 48-hour PMWP as 28.3 inches (water equivalent) of precipitation. The applicant derived this PMWP estimate by using the guidance provided in the NOAA Hydrometeorological Report No. 53 (HMR 53), "Seasonal Variation of 10-Square-Mile Probable Maximum Precipitation Estimates—United States East of the 105th Meridian."

Between February 9 and 11, 1973, heavy snowfall impacted the proposed VEGP site. Snowfall totals recorded at most of the surrounding climatic data stations ranged from 14.0 to 17.0 inches, with the highest recorded snowfall of 22.0 inches occurring at Bamberg. The storm produced the most snowfall in the climatic period of record for the region. Precipitation records from SERCC, "Period of Record Daily Climate Summary for Bamberg, SC," indicate the amount of liquid equivalent (i.e., liquid depth if all the snow melted) was 7.79 inches for this event. An inch of liquid water is equivalent to 5.2 lbf/ft^2, and, correspondingly, 7.79 inches of liquid water yields a snowpack of 40.5 lbf/ft^2.

In RAI 2.3.1-2, the staff asked the applicant to justify the adequacy of the proposed snowpack site characteristic, 10 lbf/ft^2, in consideration of the effects of the previously-discussed February 1973 storm. The applicant responded that the liquid equivalent value from SERCC is most likely bad datum and should have been removed. The applicant also stated that Section C7, Table C7-1, of the ASCE standard specifically lists the Augusta NWS location as having a maximum observed ground snow load of 8 lbf/ft^2 over a period of 40 years. The NRC staff accepts the applicant's response, and the applicant's proposed snowpack site characteristic of 10 lbf/ft^2, because other liquid equivalent estimates from other stations for the February 9–11, 1973 event are much smaller (less than 2.40 inches for most stations). The following is a list of the total snowfall and liquid equivalent, as recorded by NCDC in its Summary of the Day publications, for several surrounding climatic stations for the February 1973 storm:

STATION	SNOWFALL	LIQUID EQUIVALENT
Augusta	14.0 inches	2.13 inches
Louisville	14.8 inches	1.55 inches
Midville	10.0 inches	1.97 inches
Millen	14.0 inches	2.30 inches
Waynesboro	14.0 inches	2.39 inches

The staff, thus, agrees with the applicant that the 7.79 inches liquid equivalent value from SERCC is most likely incorrect.

The applicant has identified the 48-hour PMWP site characteristic of 28.3 inches using data from HMR-53. The applicant determined its 48-hour PMWP site characteristic value by using linear interpolation between the 24- and 72-hour probable maximum precipitation (PMP) values for December (Figures 35 and 45 of HMR-53), which had the largest values among the winter months December–February. The value of 28.3 inches converts to an estimated weight of the 48-hour PMWP of 147 lbf/ft^2, assuming that 1 inch of liquid water is equivalent to 5.2 lbf/ft^2. Using the same data from HMR-53, the staff found that the applicant has adequately identified an appropriate estimate of the 48-hour PMWP.

SER Table 2.3.1-4 presents the staff-accepted winter precipitation site characteristics for the proposed VEGP site as part of the list of regional climatic site characteristics.

2.3.1.3.3.6 Hail, Freezing Rain, and Sleet

The following discussion on hail, freezing rain, and sleet is intended to provide a general climatic understanding of the severe weather phenomena in the site region but does not result in the generation of site characteristics for use as design or operating bases.

Hail can accompany severe thunderstorms and can be a major weather hazard, causing significant damage to crops and property. The applicant used the NOAA "Climate Atlas of the United States" to estimate that around the proposed VEGP site area, specifically to the northwest of the site, the annual mean number of days with hail of 0.75 inches or greater in diameter is approximately 1 to 2 per year. The applicant also stated that an extreme hailstorm event (i.e., hail with a diameter greater than 2.75 inches) was observed only once, on May 21, 1964, about 43 miles southeast of the proposed site.

The NCDC Storm Event Database, "Storm Events for Georgia, Query Results, Hail Event(s) Reported in Burke County, Georgia Between 01/01/1950 and 07/31/2006," reports that a total of 28 hail events with hail 0.75 inches or greater occurred in Burke County from January 1971 through May 2006. In four of those events, the hail had a diameter of 1.75 inches or greater.

The NRC staff notes that hailstorm events are point observations, which are often dependent on population density. Estimates of hail size can range widely based on the surrounding area population density and years considered. The applicant stated that Burke County can expect, on average, hail with a diameter of 0.75 inches or greater about 1 day per year and hail with a diameter of 1.0 inches or greater less than 1 day per year. The applicant also stated that the annual mean number of days reported with hail equal to or greater than 0.75 inches ranges from 1 to 2 days per year in the nearby, more populated counties of Richmond, Columbia, Aiken, and Edgefield. The annual mean number of days reported with hail equal to or greater than 1.0 inches ranges up to 1 day per year in those same counties. The staff verified the hail frequencies presented by the applicant from "The Climate Atlas of the United States." Based on the NSSL "Severe Thunderstorm Climatology, Total Threat," the staff finds that, considering data from 1980 through 1999, the total number of days per year with hail greater than 0.75 inches ranges from 2 to 4.

The applicant estimated that the highest average frequency of ice storms (i.e., sleet and freezing rain) occurs to the northeast, east, and southeast of the proposed VEGP site in South Carolina. These areas can expect an average of 3 to 5 days of freezing precipitation per year. Ice accumulations typically have a thickness of less than 1 inch.

The staff has independently confirmed and accepts the hail and ice storm frequencies provided by the applicant. The NCDC Storm Event Database, "Storm Events for Georgia, Query Results, Snow & Ice Event(s) Reported in Burke County, Georgia, Between 01/01/1950 and 07/31/2006," lists four ice events for Burke County in the period January 2002 through January 2005. "The Climate Atlas of the United States" estimates 3 to 5 days per year with freezing rain around the proposed VEGP site area. The staff notes that cold air damming events can bring cold air and an increased probability of ice storms during the winter months. In Jones, et al. (2002), the NCDC reports a 50-year return period uniform radial ice thickness of 0.75 inches because of freezing rain, with a concurrent 3-second gust wind speed of 30 mi/h for the proposed site area.

2.3.1.3.3.7 Thunderstorms

The following discussion on thunderstorms is intended to provide a general climatic understanding of the severe weather phenomena in the site region but does not result in the generation of site characteristics for use as design or operating bases.

The applicant estimated that, on average, approximately 52 days with thunderstorm occurrences happen per year in the site area. This frequency is taken from the NCDC local climatological data, annual summary with comparative data, for Augusta. The majority of thunderstorms recorded (60 percent) occurred between late spring and midsummer (i.e., from June through August). The applicant estimated that approximately 16 flashes to earth per square mile (6.2 flashes to earth per square kilometer) per year occur around the site. The staff finds this number appropriate based on similar values from "The Climate Atlas of the United States" (4.8–6 flashes to earth per square kilometer), a 5-year flash density map from Vaisala (4–8 flashes to earth per square kilometer), and a 1999 paper by G. Huffines and R.E. Orville, titled "Lightning Ground Flash Density and Thunderstorm Duration in the Continental United States: 1989-96" (3–7 flashes to earth per square kilometer). Assuming the size of the potential reactor area for the proposed Vogtle units is bounded by an area of 0.068 square miles (0.176 square kilometers), an approximate average of 1 lightning strike per year will occur in the reactor area.

2.3.1.3.4 Ultimate Heat Sink

The applicant has chosen a reactor design that does not use a cooling tower to release heat to the atmosphere following a loss-of-coolant accident. Instead, a passive containment cooling system (PCS) would provide the safety-related UHS. The applicant stated that the PCS is not significantly influenced by local weather conditions. If, at the COL or CP stage, the applicant chooses an alternative plant design that requires the use of a UHS cooling tower, the applicant will need to identify the appropriate meteorological site characteristics (i.e., maximum evaporation and drift loss and minimum water cooling conditions) used to evaluate the design of the chosen UHS cooling tower. At the time of the COL or CP, the staff will verify the design type and characteristics of the UHS. This is COL Action Item 2.3-1.

2.3.1.3.5 Temperatures

The applicant based its ambient air temperature and humidity site characteristics (e.g., the 0.4-percent, 2-percent, 99-percent, and 99.6-percent annual exceedance dry-bulb temperatures[8] and 0.4-percent annual exceedance wet-bulb temperature) on 1973–1996 Augusta data published by AFCCC in its 1999 long-term, engineering-related climatological data summaries. The values for the 0.4-percent, 2-percent, 99-percent, and 99.6-percent annual exceedance dry-bulb temperatures are 97 °F, 92 °F, 25 °F, and 21 °F, respectively. The staff performed an independent analysis for a longer period of record (1961–2006) using hourly data from Augusta, obtained from the NCDC "Integrated Surface Hourly Observations" data compilation. The staff calculated the same values as the applicant. Consequently, the staff finds the proposed site characteristics for ambient air temperature and humidity appropriate.

---

8 The data presented by the applicant as minimum 1-percent and 0.4-percent annual exceedance values are referred to by the staff as 99-percent and 99.6-percent annual exceedance values throughout the SE.

The applicant based the mean coincident wet-bulb temperatures associated with the annual 2-percent and 0.4-percent exceedance dry-bulb temperatures on data in the AFCCC report "Engineering Weather Data." The staff has confirmed that the mean coincident wet-bulb temperatures of 75 °F and 76 °F associated with the 2-percent and 0.4-percent exceedance probabilities are appropriate based on values presented in the AFCCC report.

To determine the site characteristic 0.4-percent annual exceedance maximum wet-bulb temperature value, the applicant selected a value of 79 °F from the AFCCC report for Augusta based on data from 1973 through 1996. The staff evaluated Augusta wet-bulb data from 1961 through 2006 and produced the same exceedance value. Thus, the staff finds the applicant's value of 79 °F appropriate for the 0.4-percent annual exceedance maximum wet-bulb temperature site characteristic.

To calculate 100-year return maximum and minimum dry-bulb temperatures, the applicant performed linear regression using daily maximum and minimum dry-bulb temperatures from Augusta from the 30-year period between 1966 and 1995. The staff used a methodology presented in the 2001 ASHRAE Handbook ("Fundamentals") to check the applicant's 100-year return values. The ASHRAE methodology is based on the assumption that the annual maxima and minima are distributed according to the Gumbel (Type 1 Extreme Value) distribution. Based on techniques presented in Chapter 27 of the Handbook, the staff calculated 100-year return values of maximum dry-bulb temperature for Waynesboro, Augusta, and Louisville; and 100-year return values of minimum dry-bulb temperature for Waynesboro, Augusta, and Aiken. The staff included Aiken and Louisville in its analysis because those are the two observation stations where the all-time maximum (112 °F) and minimum (−4 °F) temperatures occurred in the vicinity of the proposed VEGP site. Louisville data are available for the past 77 years, and Aiken data are available for the past 94 years; thus, a reasonably extensive record exists on which to base climate records. Based on techniques in the ASHRAE handbook, the staff calculated 100-year return maximum and minimum dry-bulb temperature values which are bounded by the applicant's proposed 100-year return period maximum and minimum dry-bulb temperature site characteristic values of 115 °F and −8 °F, respectively. The applicant's proposed 100-year return period maximum and minimum dry-bulb temperature site characteristic values also bound the all-time maximum and minimum temperatures observed in the area surrounding the proposed VEGP site (i.e., 112 °F at Aiken, and −4 °F at Louisville). Therefore, the staff finds that the applicant's values of 115 °F and −8 °F are appropriate for the 100-year return period maximum and minimum dry-bulb temperature site characteristics.

The applicant used a linear regression technique on 1966–1995 data from Augusta to estimate the 100-year return period maximum wet-bulb temperature of 88 °F. The staff conducted a similar linear regression technique, and, in addition, used the technique presented in the ASHRAE handbook, as previously discussed above, to calculate a similar 100-year return value using 1961–2006 data from the Augusta NWS site. The maximum hourly wet-bulb temperature recorded at Augusta from 1961 through 2006 was 86 °F. Based on these results, the staff believes that the applicant's 100-year return maximum wet-bulb temperature site characteristic value of 88 °F is appropriate.

The applicant based many of the proposed site characteristics on data from Augusta. The staff accepts this approach because meteorological conditions at Augusta tend to be representative of the proposed VEGP site. In SER Section 2.3.3, the staff shows a comparison between onsite meteorological data and corresponding Augusta data. Temperature, dew point, wind speed, and wind direction measurements are very similar between the two observation stations.

At the time of any COL application, the applicant would have to compare site characteristics presented in the ESP against the corresponding site parameters listed in the design certification document (DCD).

The site characteristics discussed above are meant to encompass many potential designs and corresponding site parameters. Since the applicant has expressed an interest in using the AP1000 design in any future COL application, the applicant has identified additional site characteristics that directly correspond to temperature site parameters in the AP1000 DCD. The applicant provided the following definitions for the AP1000 DCD temperature site parameters:

- <u>Maximum Safety Dry-Bulb Temperature and Coincident Wet-Bulb Temperature</u>: These site parameter values represent a maximum dry-bulb temperature that exists for 2 hours or more, combined with the maximum wet-bulb temperature that exists in that population of dry-bulb temperatures.

- <u>Maximum Safety Noncoincident Wet-Bulb Temperature</u>: This site parameter value represents a maximum wet-bulb temperature that exists within a set of hourly data for a duration of 2 hours or more.

- <u>Maximum Normal Dry-Bulb Temperature and Coincident Wet-Bulb Temperature</u>: The dry-bulb temperature component of this site parameter pair is represented by a maximum dry-bulb temperature that exists for 2 hours or more, excluding the highest 1 percent of the values in an hourly data set. The wet-bulb temperature component is similarly represented by the highest wet-bulb temperature excluding the highest 1 percent of the data, although there is no minimum 2-hour persistence criterion associated with this wet-bulb temperature.

- <u>Maximum Normal Noncoincident Wet-Bulb Temperature</u>: This site parameter value represents a maximum wet-bulb temperature, excluding the highest 1 percent of the values in an hourly data set (i.e., a 1 percent exceedance), that exists for 2 hours or more.

The applicant identified the following AP1000 specific temperature site characteristics:

- a maximum safety dry-bulb temperature of 115 °F with a coincident wet-bulb temperature of 77.7 °F.

- a maximum safety noncoincident wet-bulb temperature of 83.9 °F.

- a maximum normal dry-bulb temperature of 94 °F with a coincident wet-bulb temperature of 78 °F.

- a maximum normal noncoincident wet-bulb temperature of 78 °F.

Initially, the applicant used a 30-year period of record, 1966 through 1995, from Augusta to define these site characteristics. In Open Item 2.3-1, the staff asked the applicant to base the AP1000 specific maximum safety dry-bulb and maximum safety wet-bulb temperatures on a more conservative 100-year return period. The applicant responded to Open Item 2.3-1 by providing a 100-year return period maximum safety dry-bulb temperature with a coincident wet-bulb temperature and maximum safety noncoincident wet-bulb temperature.

As previously discussed above, the staff has independently confirmed and accepts the applicant's 100-year dry-bulb temperature site characteristic of 115 °F. Since this value is based on a linear regression technique, there is no discrete measurement of the coincident wet-bulb temperature. The applicant estimated the safety coincident wet-bulb temperature based on the relationship between concurrent dry- and wet-bulb temperatures at Augusta from 1949 through 1995. The staff performed a similar analysis using hourly data from Augusta from 1961 through 2006 and believes the applicant's estimate is accurate.

The applicant calculated the 100-year return period maximum safety noncoincident wet-bulb temperature based on a linear regression technique. The staff used the technique presented in the ASHRAE handbook, as previously discussed above, to calculate a similar 100-year return value (i.e., ± 1°F) using 1961–2006 hourly data from the Augusta NWS site. Thus, the staff believes the applicant's maximum safety noncoincident wet-bulb temperature estimate is appropriate for the site.

The maximum safety noncoincident wet-bulb temperature of 83.9 °F is lower than the previously discussed 100-year return period maximum wet-bulb temperature of 88 °F because, as defined above, it is based on a two hour persistence criteria; whereas, the 88 °F wet-bulb temperature is based on a one hour persistence criteria.

Since the applicant has determined a maximum safety dry-bulb temperature with a coincident wet-bulb temperature and a maximum safety noncoincident wet-bulb temperature based on a 100-year return period, the staff considers Open Item 2.3-1 closed.

As previously discussed above, the staff finds the applicant's estimates of 2-percent and 0.4-percent exceedance dry-bulb temperature and coincident wet-bulb temperature and 0.4-percent exceedance non-coincident wet-bulb temperature appropriate. The AP1000 specific maximum normal dry-bulb and wet-bulb temperatures are based on a 1-percent exceedance. The values are consistent with those previously discussed and thus acceptable to the staff.

2.3.1.3.6 Stagnation Potential

Large-scale episodes of atmospheric stagnation are not common in the region of the proposed site. Based on the 50-year period from 1948 through 1998, high-pressure stagnation conditions, usually accompanied by light and variable wind conditions, can be expected at the proposed VEGP site about 20 days per year, or about four cases per year with the mean duration of each case being about 5 days (Wang and Angell). Stagnation conditions usually occur during the months from May through October, with a peak in September. Winds are usually weakest in September due to influence from the Bermuda High pressure system.

The applicant also noted that, from a climatological standpoint, the lowest morning mixing heights occur in the autumn and are the highest during the winter. Conversely, afternoon mixing heights reach a seasonal minimum in the winter and a maximum during the summer, which is expected because of more intense summer heating. The applicant presented mixing height data from Athens, Georgia, which the applicant claims is reasonably representative of conditions at the proposed VEGP site.

The staff confirmed the information presented by the applicant regarding restrictive dispersion conditions as correct. Section 2.3.2 of this SER discusses the proposed VEGP site air quality conditions for design- and operating-basis considerations. Sections 2.3.4 and 2.3.5 of this SER discuss atmospheric dispersion site characteristics used to evaluate short-term post-accident airborne releases and long-term routine airborne releases, respectively.

2.3.1.3.7 Climate Change

As specified in RS-002, the applicability of data used to discuss severe weather phenomena that may impact the proposed ESP site during the expected period of reactor operation should be substantiated.

Long-term environmental changes and changes to the region resulting from human or natural causes may affect the applicability of the historical data for describing the site's climate characteristics. Although there is no scientific consensus regarding the issue of climate change, the staff believes current climate trends should be analyzed for the potential for ongoing environmental changes.

During a site audit conducted on December 6, 2006, the staff asked the applicant to evaluate trends in temperature and precipitation extremes in the proposed VEGP site vicinity and discuss whether such trends may be indicative of climatic change. In a letter dated January 30, 2007, the applicant stated that initial investigations showed no consistent long-term climate change in the proposed site area. The applicant also revised its SSAR to include a discussion of long-term climatic changes.

The applicant analyzed trends in temperature and rainfall normals / standard deviations over a 70-year period for successive 30-year intervals based on the NCDC "Climatography of the United States." The applicant stated that average temperature has increased only slightly (i.e., 0.2 to 0.3 °F) over the latest 30-year period and rainfall, on average, has increased by 1.5 inches over the same period.

The staff has confirmed and accepts the numbers provided by the applicant. The staff analyzed 1-year, 10-year, and 20-year trends in annual average daily maximum and minimum temperatures, annual extreme maximum and minimum temperatures, annual average precipitation, and annual extreme daily precipitation at Waynesboro and Augusta for potential indications of climate change using data from 1951 through 2004. The trends over 20 years show that annual extreme minimum temperatures have increased 2 °F and average annual precipitation has increased about 1.5 to 2.5 inches over the period of record. All other meteorological parameters showed no discernible signs of climate change.

The Intergovernmental Panel on Climate Change (IPCC) issued its Fourth Assessment Report on Climate Change in February 2007. The staff considered Chapter 11 in "Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the 4th Assessment Report of the Intergovernmental Panel on Climate Change," regarding the southeastern portion of the United States. The IPCC models projecting potential future climate change depend on human activity and land use. To account for this, the IPCC uses different global scenarios as input to the models. Chapter 11 of the IPCC report discusses the following three scenarios:

- (A2) "A more divided world with self-reliant, independently operating nations"
- (A1B) "A more integrated world with an emphasis on all energy sources"
- (B1) "A world more integrated and ecologically friendly" (i.e., less energy consumption and more cooperating nations)

During the 100-year period under the A1B scenario (i.e., 1980–1999 as compared to 2080–2099), the IPCC projection estimates that the proposed VEGP site may see an increase in average annual temperature of 3 °C and an increase in precipitation of 0 to 5 percent. Under the more and less extreme scenarios, increases in annual average temperature may range from 2 °C to 7.5 °C. The projection also shows a general decrease in snow depth as a result of delayed autumn snowfall and earlier spring snow melt.

The staff also analyzed climate-change-induced hurricane trends within 100 nautical miles of the site and found no discernible trends in hurricane frequency or intensity. The "Summary for Policymakers" based on the February 2007 IPCC report makes the following statement concerning tropical cyclones:

> Based on a range of models, it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures. (IPCC Sections 3.8, 9.5, and 10.3)

However, the question of whether hurricanes are becoming more destructive because of global warming is a contested issue in the scientific debate over climate change. A number of academic papers have been published either supporting or debunking the idea that warmer temperatures linked to human activity have created more intense storms, and the issue is currently unresolved (Dean; Eilperin; Kerr; Witze). Based on the current amount of scientific uncertainty regarding this subject, the staff believes the applicant has adequately addressed the issue of hurricanes and provided conservative site characteristics.

The applicant stated that the number of recorded tornado events has increased, in general, since detailed records were routinely kept beginning around 1950. However, some of this increase is attributable to a growing population, greater public awareness and interest, and technological advances in detection. These changes are superimposed on normal year-to-year variations. Consequently, the number of observations recorded within a 2-degree latitude and longitude square centered on the VEGP site reflects these effects. The staff has confirmed and accepts the applicant's statements regarding tornadoes. The "Summary for Policymakers" based on the February 2007 IPCC report states, "there is insufficient evidence to determine whether trends exist in small scale phenomena such as tornadoes, hail, lightning, and dust storms." (IPCC Sections 3.8 and 5.3).

In conclusion, the staff acknowledges that long-term climatic change resulting from human or natural causes may introduce changes into the most severe natural phenomena reported for the site. However, no conclusive evidence or consensus of opinion is available on the rapidity or nature of such changes. If in the future, the ESP site is no longer in compliance with the terms and conditions of the ESP (e.g., if new information shows that the climate has changed and that the climatic site characteristics no longer represent extreme weather conditions), the staff may seek to modify the ESP or impose requirements on the site in accordance with the provisions of 10 CFR 52.39, "Finality of Early Site Permit Determinations."

2.3.1.4 Conclusion

The NRC staff has evaluated the relevant sections of the application, as supplemented by letters dated January 30, 2007, March 26, 2007, and March 30, 2007, pursuant to the acceptance criteria described RS-002, Section 2.3.1 and applicable regulatory requirements of 10 CFR Part 52 and 10 CFR Part 100. The applicant has presented and substantiated information relative to the regional meteorological conditions. The staff has reviewed the information presented by the applicant and concludes that the identification and consideration of the regional and site meteorological characteristics meet the requirements of 10 CFR 52.17(a)(1), 10 CFR 100.20(c), and 10 CFR 100.21(d).

Table 2.3.1-1 - Regional Climatic Observation Stations

STATION NAME	COUNTY	STATE CLIMATIC DIVISION	DISTANCE FROM ESP SITE (km)	DIRECTION FROM ESP SITE	STATION ELEV. (m)	DIFF. FROM ESP SITE ELEV. (m)	YEARS OF DATA
Appling 2NW 1	Columbia	GA-6	69	NW	113	46	46
Augusta Bush Field 2	Richmond	GA-6	32	NW	40	-27	57
Augusta 1	Richmond	GA-6	41	NW	40	-27	13
Louisville 1 E 2	Jefferson	GA-6	59	SW	98	31	77
Midville Exp. Station 2	Burke	GA-6	51	SW	85	18	50
Millen 4 N 2	Jenkins	GA-6	36	SSW	59	-8	68
Newington 2	Screven	GA-6	65	SSE	64	-3	43
Sylvania 2 SSE 1	Screven	GA-6	47	SE	76	9	13
Waynesboro 2 S 2	Burke	GA-6	25	WSW	82	15	67
Allendale 2 NW 1	Allendale	SC-7	44	ESE	55	-12	26
Bamberg 2	Bamberg	SC-7	70	ENE	50	-17	57
Blackville 3W 2	Barnwell	SC-7	47	NE	99	32	93
Hampton 1 S 1	Hampton	SC-7	68	SSE	29	38	55
Aiken 5 SE 2	Aiken	SC-5	41	N	150	83	94
Clarks Hill 1 W 1	McCormick	SC-5	71	NW	116	49	56
Trenton 1 NNE 1	Edgefield	SC-5	68	NNE	189	122	47
Springfield 2	Orangeburg	SC-5	60	NNE	91	24	58

1 Climatic stations used by the staff only
2 Climatic stations used by both the staff and applicant

Data Reference: NCDC, "Local Weather Observation Station Record," October 2006.

Table 2.3.1-2 Climatic Precipitation Extremes within 50 Miles of the ESP Site

PARAMETER	SITE EXTREMES	STATION
Maximum 24-hr Rainfall	9.68 in.	Aiken 5SE
Maximum Monthly Rainfall	17.32 in.	Springfield
Minimum Monthly Rainfall	0 in.	Multiple
Maximum 24-hr Snowfall	19 in.	Bamberg
Maximum Monthly Snowfall	22 in.	Bamberg
Maximum Daily Snow Depth	19 in.	Bamberg

Table 2.3.1-3 - Tropical Cyclone Frequency within a 100-Nautical Mile Radius of the Proposed VEGP Site between 1851 and 2004

CLASSIFICATION	NUMBER OF OCCURRENCES	MAXIMUM SUSTAINED (1-MIN AVG) WIND SPEED RANGE
Saffir-Simpson Category 5 Hurricanes	0	>155 mi/h
Saffir-Simpson Category 4 Hurricanes	0	131–155 mi/h
Saffir-Simpson Category 3 Hurricanes	5	111–130 mi/h
Saffir-Simpson Category 2 Hurricanes	4	96–110 mi/h
Saffir-Simpson Category 1 Hurricanes	16	74–95 mi/h
Tropical Storms	46	39–73 mi/h
Tropical Depressions	23	<39 mi/h
Subtropical Storms	1	<74 mi/h
Subtropical Depressions	2	<39 mi/h
Extra-Tropical Storms	5	N/A

Table 2.3.1-4 - Regional Climatology Site Characteristics

SITE CHARACTERISTIC	VALUE		DESCRIPTION
Ambient Air Temperature and Humidity			
Maximum Dry-Bulb Temperature	2 percent annual exceedance	92 ºF / 75 ºF	The ambient dry-bulb temperature (and mean coincident wet-bulb temperature) that will be exceeded 2 percent of the time annually
	0.4 percent annual Exceedance	97 ºF / 76 ºF	The ambient dry-bulb temperature (and mean coincident wet-bulb temperature) that will be exceeded 0.4 percent of the time annually
	100-year return Period	115 ºF	The ambient dry-bulb temperature that has a 1 percent annual probability of being exceeded (100-year mean recurrence interval)
Minimum Dry-Bulb Temperature	99 percent annual exceedance	25 ºF	The ambient dry-bulb temperature below which dry-bulb temperatures will fall 1 percent of the time annually
	99.6 percent annual exceedance	21 ºF	The ambient dry-bulb temperature below which dry-bulb temperatures will fall 0.4% of the time annually
	100-year return period	-8 ºF	The ambient dry-bulb temperature for which a 1 percent annual probability of a lower dry-bulb temperature exists (100-year mean recurrence interval)
Maximum Wet-Bulb Temperature	0.4 percent annual exceedance	79 ºF	The ambient wet-bulb temperature that will be exceeded 0.4 percent of the time annually
	100-year return period	88 ºF	The ambient wet-bulb temperature that has a 1% annual probability of being exceeded (100-year mean recurrence interval)
Site Temperature Basis for AP1000			
Maximum Safety Dry-Bulb and Coincident Wet-Bulb	115 ºF / 77.7 ºF		These AP1000 specific site characteristics values represent a maximum dry-bulb temperature that exists for 2 hours or more, combined with the maximum wet-bulb temperature that exists in that population of dry-bulb temperatures.

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Maximum Safety Wet-Bulb (Non-Coincident)	83.9 ºF	This AP1000 specific site characteristic value represents a maximum wet-bulb temperature that exists within a set of hourly data for a duration of 2 hours or more.
Maximum Normal Dry-Bulb and Coincident Wet-Bulb	94 ºF / 78 ºF	The dry-bulb temperature component of this AP1000 specific site characteristics pair is represented by a maximum dry-bulb temperature that exists for 2 hours or more, excluding the highest 1 percent of the values in an hourly data set. The wet-bulb temperature component is similarly represented by the highest wet-bulb temperature excluding the highest 1 percent of the data, although there is no minimum 2-hour persistence criterion associated with this wet-bulb temperature.
Maximum Normal Wet-Bulb (Non-Coincident)	78 ºF	This AP1000 specific site characteristic value represents a maximum wet-bulb temperature, excluding the highest 1 percent of the values in an hourly data set (i.e., a 1 percent exceedance), that exists for 2 hours or more.
Basic Wind Speed		
3-Second Gust	104 mi/h	The 3-second gust wind speed to be used in determining wind loads, defined as the 3-second gust wind speed at 33 feet above the ground that has a 1 percent annual probability of being exceeded (100-year mean recurrence interval)
Tornado		
Maximum Wind Speed	300 mi/h	Maximum wind speed resulting from passage of a tornado having a probability of occurrence of 10^{-7} per year
Maximum Translational Speed	60 mi/h	Translation component of the maximum tornado wind speed

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Rotational Speed	240 mi/h	Rotation component of the maximum tornado wind speed
Radius of Maximum Rotational Speed	150 feet	Distance from the center of the tornado at which the maximum rotational wind speed occurs
Pressure Drop	2.0 $lbf/in.^2$	Decrease in ambient pressure from normal atmospheric pressure resulting from passage of the tornado
Rate of Pressure Drop	1.2 $lbf/in.^{2/s}$	Rate of pressure drop resulting from the passage of the tornado
Winter Precipitation		
100-Year Snowpack	10 lb/sq ft	Weight of the 100-year return period snowpack (to be used in determining normal precipitation loads for roofs)
48-Hour Probable Maximum Winter Precipitation	28.3 inches of water	PMP during the winter months (to be used in conjunction with the 100-year snowpack in determining extreme winter precipitation loads for roofs)

2.3.2 Local Meteorology

2.3.2.1 Introduction

In Section 2.3.2 of the SSAR, the applicant presented information on local (site) meteorological parameters. Specifically, the applicant provided the following information:

- a description of the local (site) meteorology in terms of airflow, atmospheric stability, temperature, water vapor, precipitation, fog, and air quality.

- an assessment of the influence on the local meteorology of construction and operation of the nuclear power plant that is planned to be constructed on the proposed site and its facilities, including the effects of plant structures, terrain modification, and heat and moisture sources resulting from plant operation.

- a topographical description of the site and its environs, as modified by the structures of the nuclear power plant that is planned to be built on the proposed site.

This section verifies that the applicant has identified and considered the meteorological and topographical characteristics of the site and the surrounding area, as well as changes that may result to those characteristics because of the construction and operation of the proposed facility.

2.3.2.2 Regulatory Basis

The acceptance criteria for identifying local meteorological parameters are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The staff considered the following regulatory requirements in reviewing the applicant's identification of local meteorological parameters:

- 10 CFR 52.17(a), which requires that the application contain a description of the seismic, meteorological, hydrological, and geological characteristics of the proposed site.

- 10 CFR 100.20(c), which requires that the meteorological characteristics of the site, necessary for safety analysis or that may have an impact on plant design, be identified and characterized as part of the NRC's review of the acceptability of a site.

- 10 CFR 100.21(c), which requires that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that (1) radiological effluent release limits associated with normal operation from the type of facility to be located at the site can be met for any individual located offsite; and (2) radiological dose consequences of postulated accidents shall meet the criteria set forth in 10 CFR 50.34(a)(1) for the type of facility proposed to be located at the site.

- 10 CFR 100.21(d), which requires that the physical characteristics of the site, including meteorology, geology, seismology, and hydrology be evaluated and site parameters established, such that the potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site.

The local meteorological information assembled in compliance with the above regulatory requirements would be necessary to determine, at the COL stage, a proposed facility's compliance with the following requirements in Appendix A, "General Design Criteria for Nuclear Power Plants," of 10 CFR Part 50:

- GDC 2, which requires that structures, systems and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions; and further requires that consideration be given to the most severe local weather phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

An ESP applicant, though, need not demonstrate compliance with the above GDC, with respect to local meteorology.

RS-002, Section 2.3.2 specifies that an application meets the above requirements, if the application satisfies the following criteria:

- Local meteorological data, based on onsite measurements and data from nearby NWS stations or other standard installations, should be presented in the format specified in RG 1.70.

- A complete topographical description of the site and environs set out to a distance of 50 miles from the site should be provided.

- A discussion and evaluation of the influence of a nuclear power plant of the type proposed to be constructed on the site on local meteorological and air quality conditions should be provided.

To the extent applicable to the above-outlined acceptance criteria, the applicant applied the NRC-endorsed meteorological information selection methodologies and techniques found in the following:

- RG 1.23, which provides criteria for an acceptable onsite meteorological measurements program to be used to monitor local (onsite) meteorology site characteristics.

- RG 1.70, which describes the type of local meteorological data that should be presented in SSAR Section 2.3.2.

When independently assessing the veracity of the information presented by the applicant in SSAR Chapter 2.3.2, the NRC staff applied the same above-cited methodologies and techniques.

2.3.2.3 Technical Evaluation

Using the approaches and methodologies described in RS-002 Section 2.3.2, the NRC staff reviewed the application, as supplemented by letters dated January 30, 2007, March 26, 2007, and March 30, 2007. In reviewing and evaluating the applicant's site meteorology, the staff used (or relied on) none of the applicant's proposed design parameters and site interface values presented in SSAR Section 1.3.

2.3.2.3.1 Local Meteorology Description

The applicant used data from the existing Vogtle meteorological monitoring program and 10 surrounding NWS observation stations (as listed in SSAR Section Table 2.3.1-2 and repeated in

SER Section 2.3.1) to describe local meteorology. The applicant used data from the onsite meteorological monitoring program to describe wind speed, wind direction, and atmospheric stability conditions; surrounding offsite observation stations were data sources for temperature, atmospheric moisture, precipitation, and fog conditions.

The applicant presented means and historical extremes of temperature, rainfall, and snowfall data from the 10 offsite observation stations listed in SSAR Section 2.3.1. SER Table 2.3.2-1 summarizes the overall extremes from those stations, as compiled by the applicant.

The staff evaluated the information regarding local meteorological conditions submitted by the applicant using data from the Vogtle onsite meteorological monitoring system, as well as climatic data reported in "Monthly Station Climate Summaries," "U.S. Monthly Climate Normals," and "Daily Surface Data" (all from NCDC) and "Period of Record Daily Climate Summaries for Georgia and South Carolina" from SERCC. The staff has confirmed the normal and extreme values presented by the applicant in SSAR Tables 2.3-3 and 2.3-5, respectively.

2.3.2.3.1.1 Airflow

The applicant presented hourly wind data from the Vogtle onsite meteorological monitoring program, as described in SSAR Section 2.3.3, from 1998 through 2002. The applicant also provided annual and seasonal wind roses based on 10-meter and 60-meter observation heights. The NRC staff confirmed that the wind directions from both levels are fairly similar. The prevailing annual wind direction for the site is generally from the southwest. Winds from the southwest predominate during the spring and summer, westerly winds predominate during the winter, and northeasterly winds predominate during the autumn months.

The applicant stated that annual average wind speeds at the 10- and 60-meter observation levels are 2.5 m/s and 4.6 m/s, respectively. This is consistent with the 6.1-meter measurement height annual average wind speed at Augusta, Georgia, of 2.7 m/s. The annual frequencies of calm wind conditions are 0.44 and 0.07 percent of the time for the 10-meter and 60-meter observation levels at the proposed VEGP site.

The staff reviewed the Vogtle onsite meteorological wind data from 1998 through 2002 for completeness and consistency. The wind measurements provided by the applicant had at least 95-percent data recovery. Initially, the staff did have concerns about the consistency of the data. The staff, having compared the 1998–2002 annual data used by the applicant to the 1972–1973, 1977-1978, 1978–1979, and 1980–1981 meteorological data presented in the original final safety analysis report (FSAR) for Vogtle Units 1 and 2, discovered that there were discrepancies between the two sets of data. During a site audit conducted on December 6, 2006, the staff asked the applicant to explain the differences in wind direction frequency at 60 meters and 10 meters during the spring, summer, and winter seasons, when comparing the submitted VEGP wind data to the original FSAR data for Vogtle Units 1 and 2. In its letter dated January 30, 2007, the applicant explained that while the winds are somewhat uniform (in that the overall peak sector for both the original FSAR data and the 1998–2002 data is the same (west)), there is some variability among the annual data due to the relatively low wind speeds at the site. The staff has confirmed that the wind speeds are typically light at the site and thus some degree of variability can be expected. When winds are light they are typically not produced by a large-scale pressure gradient (e.g., synoptic scale), rather by smaller, more random and turbulent motions (e.g., meso-scale).

During the December 2006 site audit, the staff also asked the applicant to explain the amount of variability in summer wind direction frequency between the two onsite observation heights of 10 and

60 meters. The applicant stated in its letter dated January 30, 2007 that it was revising the wind roses for the summer season to correct an error and would include the corrected wind roses in the next revision of the SSAR. In a letter dated March 26, 2007, the applicant also provided a revised onsite 1998–2002 database, in which periods of bad data were removed and coded as such. Based on an independent review of the revised onsite meteorological data, the staff accepts the changes and concludes that the onsite meteorological wind data from 1998 through 2002 are both complete and consistent.

The staff agrees with the applicant that the winds for the proposed VEGP site are predominately from the southwest through west sectors. The staff also agrees with the annual average wind speeds of 2.5 m/s and 4.6 m/s at 10 and 60 meters as presented by the applicant. The staff's conclusions are based on a comparison between the Vogtle onsite meteorological wind data and nearby Augusta climatological data, as presented in the NCDC 2004 "Local Climatological Data."

2.3.2.3.1.2 Atmospheric Stability

The applicant classified atmospheric stability in accordance with the guidance provided in the proposed Revision 1 to RG 1.23. Atmospheric stability is a critical parameter for estimating dispersion characteristics in SSAR Sections 2.3.4 and 2.3.5. Dispersion of effluents is greatest for extremely unstable atmospheric conditions (i.e., Pasquill stability class A) and decreases progressively through extremely stable conditions (i.e., Pasquill stability class G). The applicant primarily based its stability classification on temperature change with height (i.e., delta-temperature or $\Delta T/\Delta Z$) between the 60-meter and 10-meter height, as measured by the Vogtle onsite meteorological monitoring program between 1998 and 2002.

The applicant provided seasonal and annual frequencies of atmospheric stability classes for the 5-year period of record for the onsite data from 1998–2002. According to the applicant, there is a predominance of slightly stable (Pasquill stability class E) and neutral stability (Pasquill stability class D) conditions at the proposed VEGP site, ranging from 50 to 60 percent of the time, on a seasonal and annual basis. Extremely unstable conditions (Pasquill stability class A) occur most frequently during spring and summer, and extremely stable conditions (Pasquill stability class G) occur most frequently during the fall and winter months. Based on past experience with stability data at various sites, a predominance of slightly stable (Pasquill stability class E) and neutral (Pasquill stability class D) conditions at the proposed site is generally consistent with expected meteorological conditions.

During a site audit conducted on December 6, 2006, the staff asked the applicant to explain the decrease in frequency of extremely unstable conditions (Pasquill stability class A) from 1998-2000 to 2001–2002, and the increase in frequency of slightly stable conditions (Pasquill stability class E) from 2000 to 2001. The staff also asked the applicant to explain a decrease in the number of occurrences of unstable conditions (Pasquill stability classes A–C) in 2001 and 2002, as compared to 1998 through 2000. The applicant responded, in its letter dated January 30, 2007, that there has been a slight decreasing trend in stability class A over the past 5 years; however, when individual stability classes are combined into the following three basic stability categories, (1) unstable (A-C), (2) neutral (D-E), and (3) stable (F-G) the decreasing trend is not as significant. The applicant stated that the increase in stability class E frequency was due to a data error. This error was corrected in the revised meteorological database. The staff reviewed the revised meteorological database and has concluded that its concerns regarding stability class frequencies have been resolved.

As a qualitative check of the hourly stability data provided by the applicant, the staff created plots of stability class as a function of time of day for each individual year, and, additionally, the 5 years together. SER Figure 2.3.2-1 is a plot of the proposed VEGP site 1998–2002 hourly stability class data as a function of time of day. Unstable conditions (Pasquill stability classes A–C) generally occurred during the day, and stable conditions (Pasquill stability classes F–G) generally occurred during the night, as expected due to daytime heating and nighttime cooling.

During a site audit conducted on December 6, 2006, the staff asked the applicant to explain a daytime increase in the number of occurrences of stable conditions (Pasquill stability classes F and G) in 2001, which is not seen in the other years. The applicant responded, in its letter dated January 30, 2007, that this could be attributed to a data error. This error was corrected in the revised meteorological database. The staff has confirmed that this problem has been fixed.

Frequency of occurrence for each stability class is one of the inputs to the dispersion models used in SSAR Sections 2.3.4 and 2.3.5. The applicant included these data in the form of a joint frequency distribution (JFD) of wind speed and direction data as a function of stability class. A comparison of a JFD developed by the staff from the hourly data submitted by the applicant with the JFD developed by the applicant showed reasonable agreement.

The staff accepts the 5 years of stability data presented by the applicant in SSAR Section 2.3.2 as complete and adequate. The staff believes that these data are appropriate to use as input to the dispersion models discussed in SER Sections 2.3.4 and 2.3.5.

2.3.2.3.1.3 Temperature

The applicant characterized normal and extreme temperatures for the site based on the 10 surrounding observation stations listed in SSAR Section 2.3.1.1. The extreme maximum temperature recorded near the site is 112 °F, and the extreme minimum temperature recorded near the site is −4 °F. Annual average temperatures for the 10 surrounding observation stations in the site vicinity (which are based on the average of the daily mean maximum and minimum temperatures) range from 63.1 °F to 65.0 °F. The applicant stated that the annual average diurnal (day-to-night) temperature differences in the site vicinity range from 21.9 °F to 26.3 °F.

Using data from NCDC and SERCC, the staff reviewed the daily mean temperatures, the extreme temperatures, and the diurnal temperature ranges presented by the applicant. The staff confirmed the temperature characterizations, as presented in SSAR Section 2.3.2, and accepts them as correct.

2.3.2.3.1.4 Water Vapor

The applicant presented wet-bulb temperature, dew point temperature, and relative humidity data summaries from the Augusta NWS observation station to characterize the typical atmospheric moisture conditions near the proposed VEGP site.

Based on a 49-year period of record, the applicant indicated that the mean annual wet-bulb temperature is 56.7 °F. The highest monthly mean wet-bulb temperature is 72.7 °F during July, and the lowest monthly mean wet-bulb temperature is 40.3 °F during January. According to the applicant, the mean annual dew point temperature at Augusta is 51.9 °F, which also reaches its maximum during summer and minimum during winter. The applicant gives the highest monthly mean dew point temperature as 69.7 °F during July, and the lowest monthly mean dew point temperature as 34.4 °F during January.

Based on a 30-year period of record, the applicant indicates that relative humidity averages 72 percent on an annual basis. The average early morning relative humidity levels exceed 90 percent during August, September, and October. Typically, the relative humidity values reach their diurnal maximum in the early morning and diurnal minimum during the early afternoon.

The staff has verified and accepts as correct and appropriate the wet-bulb temperature, dew point temperature, and relative humidity data presented by the applicant. The staff reviewed the data listed in the NCDC “Augusta, Georgia, 2004 Local Climatological Data, Annual Summary with Comparative Data.” Because of the proximity of Augusta to the proposed VEGP site and because of the similarity of topographic features at both locations (i.e., gently rolling terrain, adjacent to the Savannah River, and location within the broad river valley), the Augusta atmospheric moisture data should be typical of the atmospheric moisture conditions in the proposed site region. SER Section 2.3.1 discusses the wet-bulb site characteristics more quantitatively.

2.3.2.3.1.5 Precipitation

Based on data from the 10 surrounding observation stations, the applicant provided that the average annual precipitation (water equivalent) totals generally range from 43.85 to 48.57 inches. The highest average annual precipitation is 52.43 inches, which occurs at the Aiken 4NE Station.

According to the applicant, snowfall is infrequent, with normal annual totals ranging from 0.1 to 1.4 inches. SER Section 2.3.1 discusses in greater detail snowfall in the vicinity of the proposed VEGP site.

Using daily snowfall and rainfall data from NCDC and SERCC, the staff has independently verified the precipitation statistics presented in SSAR Section 2.3.2 and accepts them as accurate.

2.3.2.3.1.6 Fog

Augusta is the closest station to the proposed VEGP site that makes fog observations. The applicant stated that, based on a 54-year period of record, Augusta averages about 35.1 days per year of heavy fog conditions (e.g., visibility is reduced to one-quarter mile or less).

According to the applicant, the frequency of typical fog conditions at Augusta is expected to be similar to that at the proposed VEGP site because of the proximity and similarity of topographic features between the two locations. Both sites are located in gently rolling terrain, adjacent to the Savannah River, and are situated in a broad river valley.

The staff confirmed the applicant's assertion that the Augusta NWS station reports 35.1 days per year with heavy fog observations. The staff agrees that the frequency of fog conditions at Augusta is expected to be similar to that at the proposed VEGP site because of the proximity and similarity of topographic features at both locations.

2.3.2.3.1.7 Air Quality

The applicant provided that the proposed VEGP site is located in the Augusta—Aiken Interstate Air Quality Control Region. The counties within this region, including Burke County, have been designated as being in attainment or unclassified for all EPA criteria air pollutants (i.e., ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead) (40 CFR 81.311, "Georgia," and 40 CFR 81.34, "Metropolitan Dayton Intrastate Air Quality Control Region").

According to the applicant, the proposed nuclear steam supply system (NSSS) and other radiological systems related to the proposed facility will not be sources of criteria pollutants or other hazardous air pollutants. Other proposed supporting equipment such as diesel generators, fire pump engines, auxiliary boilers, emergency station-blackout generators, and other nonradiological emission-generating sources are not expected to be, in the aggregate, a significant source of criteria pollutant emissions. The staff agrees with this assessment because these systems will be used on an infrequent basis.

Because the EPA has designated the proposed VEGP site area as being in attainment or unclassified for all criteria air pollutants and the new facility is not expected to be a significant source of air pollutants, the staff finds that the VEGP site air quality conditions should not be a significant factor in the design and operating bases for the facility.

2.3.2.3.2 Impacts on Local Meteorology

The applicant stated that the associated paved, concrete, or other improved surfaces resulting from the construction of the proposed nuclear facility are insufficient to generate discernible, long-term effects to local- or micro-scale meteorological conditions. Wind flow may be altered immediately adjacent to and downwind of larger site structures, but these effects will likely dissipate within 10 structure heights downwind. SER Section 2.3.3 discusses the effects of these larger structures on wind flow.

Although temperature may increase above altered surfaces, the effects will be too limited in their vertical profile and horizontal extent to alter local- or regional-scale ambient temperature changes. Any water vapor releases from the proposed 600-foot-high natural draft cooling towers will have insignificant effects on local meteorology because of the high release height of thermal/water vapor plumes.

Because of the limited and localized nature of the expected modifications associated with the proposed plant structures and the associated improved surfaces, the staff agrees with the applicant that the proposed facility will not have significant impact on local meteorological conditions to affect plant design and operation.

The use of natural draft cooling towers could create visible plumes under certain atmospheric conditions, which could cause shadowing of nearby lands and salt deposition. Ground-level icing would be insignificant, though, because of the low probabilities of ground-level plumes and freezing conditions. The staff finds that these projected atmospheric impacts will not have significant impact on local meteorological conditions to affect plant design and operation.

During a site audit conducted on December 6, 2006, the staff asked the applicant to clarify whether any terrain modifications are expected to result from construction of the proposed facility and how they may affect the local meteorological characteristics of the site. The applicant responded in its letter dated January 30, 2007, that although there will be excavation, landscaping, site leveling, and clearing associated with the construction of the new units, these alterations to the site terrain would be localized and would not represent a significant alteration to the flat-to-gently-rolling topographic character of the area and region around the site. Therefore, the overall meteorological characteristics of the site will not be affected. The staff agrees that these activities are too small-scale to impact the local meteorological characteristics of the site.

2.3.2.3.3 Topographic Description of the Site

The proposed VEGP site is located in Burke County, Georgia, west of the Savannah River on approximately 3169 acres of land. The applicant provided maps of topographic features within a 5-mile radius of the site. The applicant also provided terrain elevation profiles along each of the 16 standard 22.5-degree compass radials out to a distance of 50 miles. Based on these profiles, the applicant characterized the proposed site terrain as flat to gently rolling. The only significant nearby topographic feature mentioned by the applicant is the broad Savannah River valley. The staff agrees with this terrain characterization based on topography data from the USGS and a site visit. The staff concludes that the applicant provided all the necessary topographic information.

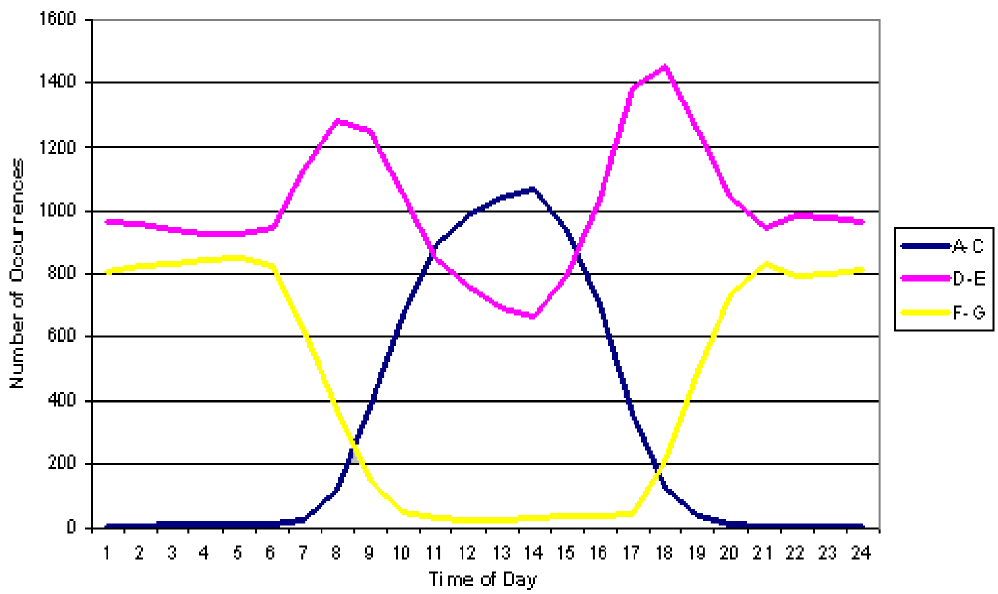
2.3.2.4 Conclusion

The NRC staff has evaluated the relevant sections of the application, as supplemented by letters dated January 30, 2007, March 26, 2007, and March 30, 2007, pursuant to the acceptance criteria of RS-002 Section 2.3.2 and applicable regulatory requirements of 10 CFR Part 52 and 10 CFR Part 100. As discussed above, the applicant has identified and provided acceptable consideration of the meteorological and topographical characteristics of the site and the surrounding area, including the potential impact on plant design and operation due to changes in local meteorology caused by plant construction and operation. Therefore, the staff finds that the applicant has provided the information required to address 10 CFR 52.17(a), 10 CFR 100.20(c), 10 CFR 100.21(c), and 10 CFR 100.21(d).

Table 2.3.2-1 - Offsite Temperature and Precipitation Extremes

PARAMETER	VALUE (DATE)	LOCATION
Maximum Temperature	112 °F (7/24/52)	Louisville 1E
Minimum Temperature	−4 °F (1/21/85)	Aiken 4NE
Maximum 24-hr Rainfall	9.68 in. (4/16/69)	Aiken 4NE
Maximum Monthly Rainfall	17.32 in. (6/73)	Springfield
Maximum 24-hr Snowfall	19.0 in. (2/10/73)	Bamberg
Maximum Monthly Snowfall	22.0 in. (2/73)	Bamberg

Figure 2.3.2-1 Vogtle 1998-2002 Hourly Stability Class Frequency



2.3.3 Onsite Meteorological Measurements Program

2.3.3.1 Introduction

In Section 2.3.3 of the SSAR, the applicant presented information concerning the onsite meteorological measurements program in support of its ESP application. Specifically, the applicant provided the following information:

- A description of meteorological instrumentation, including siting of sensors, sensor performance specifications, methods and equipment for recording sensor output, the QA program for sensors and recorders, and data acquisition and reduction procedures.

- Hourly meteorological data, including consideration of the period of record and amenability of the data for use in characterizing atmospheric dispersion conditions.

This section verifies that the applicant successfully implemented an appropriate onsite meteorological measurements program and that data from this program provide an acceptable basis for estimating atmospheric dispersion for DBA and routine releases from a nuclear power plant of the type specified by the applicant.

2.3.3.2 Regulatory Basis

The acceptance criteria for the development and implementation of an onsite meteorological program are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The staff considered the following regulatory requirements in reviewing the applicant's development and implementation of an onsite meteorological program:

- 10 CFR 52.17(a), which requires that the application contain a description of the seismic, meteorological, hydrological, and geological characteristics of the proposed site.

- 10 CFR 100.20(c), which requires that the meteorological characteristics of the site, necessary for safety analysis or that may have an impact on plant design, be identified and characterized as part of the NRC's review of the acceptability of a site.

- 10 CFR 100.21(c), which requires that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that (1) radiological effluent release limits associated with normal operation from the type of facility to be located at the site can be met for any individual located offsite; and (2) radiological dose consequences of postulated accidents shall meet the criteria set forth in
- 10 CFR 50.34(a)(1) for the type of facility proposed to be located at the site.

- 10 CFR 100.21(d), which requires that the physical characteristics of the site, including meteorology, geology, seismology, and hydrology be evaluated and site parameters established, such that the potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site.

The assessment and conclusions made in this section, regarding the site-specific adequacy of onsite meteorological instrumentation (including siting of sensors, sensor performance specifications, methods and equipment for recording sensor output, the QA program for sensors and recorders, and data acquisition and reduction procedures), are pertinent to the staff's evaluation, in SER Chapter 13, of the applicant's proposed emergency plan, in accordance with the following requirements of 10 CFR 50.47, "Emergency Plans," and 10 CFR Part 50, Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities":

- 10 CFR 50.47(b), which requires that the onsite emergency response plan have adequate methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences of a radiological emergency condition.

- 10 CFR Part 50, Appendix E, which requires emergency plans to have adequate provisions for equipment for determining the magnitude of and for continuously assessing impact of the release of radioactive materials to the environment.

The development and implementation of an onsite meteorological program is necessary for the collection of onsite meteorological information, so as to be able to demonstrate compliance, at the COL stage, with the numerical guides for doses contained in 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and limiting Conditions for Operation to Meet the Criterion 'As Low as Reasonable Achievable' for Radioactive material in Light-Water-Cooled Nuclear Power Reactor Effluents."

RS-002, Section 2.3.3 specifies that an application meets the above requirements, if the application satisfies the following criteria:

- The onsite meteorological measurements programs should produce data that describe the meteorological characteristics of the site and its vicinity for the purpose of making atmospheric dispersion estimate for both postulated accidental and expected routine airborne releases of effluents and for comparison with offsite sources to determine the appropriateness of climatological data used for design considerations. The criteria for an acceptable onsite meteorological measurements program are documented in the Regulatory Position, Section C, "Meteorological Monitoring Programs for Nuclear Power Plants," of RG 1.23.

To the extent applicable to the above-outlined acceptance criteria, the applicant applied the NRC-endorsed methodologies and parameters found in the following:

- RG 1.23, which provides criteria for an acceptable onsite meteorological measurements program, data from which are used as input to atmospheric dispersion models.

- RG 1.70, which provides guidance on information appropriate for presentation regarding an onsite meteorological measurements program.

- RG 4.2, "Preparation of Environmental Reports for Nuclear Power Stations," which states that the meteorological description of the site and its surrounding area should include data from the onsite meteorological program.

When independently assessing the sufficiency of the information presented by the applicant in SSAR Chapter 2.3.3, the NRC staff applied the same above-cited methodologies and parameters.

2.3.3.3 Technical Evaluation

Using the approaches and methodologies described in RS-002 Section 2.3.3, the NRC staff reviewed the application, as supplemented by letters dated January 30, 2007, March 26, 2007, and March 30, 2007. In reviewing and evaluating the applicant's onsite meteorological program, the staff used (or relied on) the following design parameters and site interface values proposed by the applicant in SSAR Section 1.3: building height, cooling tower height, cooling tower base diameter, and cooling tower diameter at the top.

The applicant used the existing onsite meteorological measurements program at the Vogtle facility (Units 1 & 2) to collect data for the proposed VEGP site and plans to continue to use this monitoring program to support operation of the proposed facility. If any changes are made to the monitoring program, the COL applicant should update the description of the proposed operational onsite meteorological measurements program at the time of the COL application in accordance with Section C.III.2.2.3.3 of RG 1.206, "Combined License Applications for Nuclear Power Plants."

2.3.3.3.1 Instrument Description

The Vogtle meteorological monitoring program began operation in 1979. Instruments for measuring pertinent meteorological parameters were mounted on a 45-meter tower located on a cleared area on the site. The facility updated the meteorological monitoring program in 1984 to meet the criteria of NUREG-0654, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans [RERP] and Preparedness in Support of Nuclear Power Plants." The updated monitoring equipment has observation heights at 10 and 60 meters above ground level. Measured data include wind speed and direction at 10 and 60 meters, temperature at 10 meters, differential temperature between 60 and 10 meters, dew point temperature at 10 meters, precipitation at the tower base, and sigma theta (wind direction standard deviation) at 10 and 60 meters. Currently, the original 45-meter tower is used as a backup meteorological monitoring system during periods of equipment failure on the 60-meter tower. The backup system can measure wind speed, wind direction, temperature, and sigma theta at the 10-meter level.

The meteorology tower is located about 4525 feet south of the proposed power block area. The applicant stated that the closest major structures to the meteorological measurement tower would be the proposed Unit 3 and 4 reactor buildings and proposed natural draft cooling towers. The cooling towers would be the largest structures in the vicinity of the meteorology tower and would have the greatest potential to influence the accuracy of future measurements because of the postulated downwind wake created by these structures.

The applicant stated that the region potentially affected by wake from the proposed cooling towers will extend about 1650 feet downwind. It based this value on the EPA 1981 version of the "Guideline for Determination of Good Engineering Practice Stack Height," which states that the distance downwind affected by the wake of a hyperbolically shaped natural draft cooling tower is about five times the width of the tower at the top of the structure. Since the closest cooling tower will be 3025 feet from the primary meteorological tower, the applicant determined that the primary meteorology tower will be outside of the potential wake zone.

RG 1.23 indicates that obstructions to flow (such as buildings) should be located at least 10 obstruction heights from the meteorological tower to prevent adverse building wake effects. Since the height of the proposed tallest power block structure is 234 feet above plant grade, the zone of turbulent flow created by the reactor buildings will be limited to about 2340 feet downwind. The staff concludes that building wake from the proposed reactor buildings will not cause any adverse affects on measurements because the meteorology tower is located 4525 feet south of the proposed power block area.

The 10-building-height distance of separation is typically applied to square or rectangular structures, whereas rounded and sloping structures such as hyperbolic natural draft cooling towers can be expected to produce a smaller wake zone. According to the applicant, the preliminary design for the natural draft cooling towers calls for them to be about 600 feet high, with a base diameter of 550 feet and a top diameter of 330 feet. In RAI 2.3.3-2, the staff asked the applicant to include the proposed natural draft cooling tower height and width as part of SSAR Table 1-1, which lists postulated design parameters, since this information is used to determine the potential wake effects from these towers. The applicant complied with this request.

Section 123 of the Clean Air Act as amended in 1990 defines good engineering practice stack height as the height necessary to ensure that emissions from a stack do not result in excessive concentrations of any air pollutant in the immediate vicinity of a source as a result of atmospheric downwash, eddies, and wakes which may be created by the source itself, by nearby structures, or by nearby terrain obstacles. The EPA defines “nearby structures” in its regulations (40 CFR 51.100(jj)(1)) as that distance up to five times the lesser of the height or the width dimension of a structure; that is, the downwind distance in which a structure is presumed to have a significant influence as a result of downwash, eddies, and wakes extends downwind approximately five times either the height or width (whichever is less) of the structure. The EPA regulatory guidance document for determining good engineering practice stack heights (EPA-450-4/80/023R, June 1985) also states that this area of influence becomes significantly smaller as the height to width ratio of a structure increases. Based on the EPA guidance for this type of structure, which will have a maximum width of 550 feet, the outermost boundary of influence exerted by the proposed cooling towers is estimated to be no more than 2750 feet. Since this distance is shorter than the 3025-foot separation between the proposed cooling towers and the primary meteorological tower, the staff concludes that the proposed natural draft cooling towers will not adversely affect measurements made at the primary meteorological tower. The staff calculated a larger area that may be affected by cooling tower wake because the updated 1985 EPA guidance used by the staff recommends using the maximum width of the structure, whereas the 1981 EPA guidance used by the applicant recommended using the width at the top of the structure for calculating potential wake influences.

The base of the primary tower is at an elevation similar to plant grade for the proposed facility, and the ground cover at the base of the tower is primarily native grass. The applicant stated that it evaluated minor structures in the vicinity of the primary meteorological tower as having no adverse effect on the measurements taken at the meteorological measurement tower. After conducting a site audit on December 6, 2006, the staff agrees with the applicant that the meteorology towers are sited in an appropriate area and these minor structures will have no adverse impact on the accuracy of measurements. The staff also noted during its site audit that the meteorology towers are located far enough from the surrounding tree line to prevent adverse effects on measurements.
SER Figure 2.3.3-1 shows the proposed layout of the VEGP site.

The primary meteorological equipment is mounted on a 200-foot Unarco-Rohn, Inc., Model 55G tower. All instrumentation (primary and backup) is mounted on a Tower Systems, Inc., Model TS-2500 instrument elevator system. The instruments are standard Climatronics products. The applicant uses Yokogawa digital equipment to receive the observations, which are displayed using the Meteorological Information and Dispersion Assessment System (MIDAS). The Climatronics Signal Conditioning Equipment is powered by dual (redundant) Hewlett Packard Model 6291A direct current power supplies.

During a site audit conducted on December 6, 2006, the staff reviewed the applicant's meteorology equipment calibration procedures in detail and found them to be adequate to ensure a reliable meteorological measurements program in accordance with RG 1.23. For example, the delta temperature calibration involves temperature baths using reference temperatures of 32 °F and 100 °F; the applicant checks to ensure on a regular basis that the delta-temperature instrumentation is taking accurate measurements. The applicant uses similar procedures for the other meteorological measurement equipment.

The applicant monitors the meteorology instruments at least once a week. Maintenance is performed in accordance with instrument manuals and is intended to maintain, at least, a 90-percent data recovery. From 1998–2002, the average data recovery rates are well above the RG 1.23 90-percent threshold.

Although all of the 5-year average recovery rates were still above 90 percent, the staff computed slightly different values for some of the annual data recovery rates. During a site audit conducted on December 6, 2006, the staff asked the applicant to verify the validity of the yearly data recovery statistics presented in the application. In a letter dated January 30, 2007, the applicant agreed with the values presented by the staff and stated that the hourly meteorological database was going to be updated. In RAI 2.3.3-1, the staff asked the applicant to provide the NRC with a copy of the updated hourly meteorological database. The applicant complied with this request. After receiving the updated and revised meteorological data, the staff was able to produce the same data recovery statistics as the applicant.

The applicant provided system performance specifications for the meteorological monitoring program, which are listed in SER Table 2.3.3-1. These values are consistent with RG 1.23 and thus accepted by the staff. Meteorological data samples are taken every 5 seconds and recorded as 15- and 60-minute averages. The 15-minute averages are used for emergency planning purposes, while the January 1998 through December 2002 hourly averages were used to compute the short-term and long-term diffusion estimates presented in SSAR Sections 2.3.4 and 2.3.5.

The description of meteorological instrumentation, including siting of sensors, sensor performance specifications, methods and equipment for recording sensor output, the QA program for sensors and recorders, and data acquisition and reduction procedures are in compliance with the guidelines of RG 1.23. Thus, the staff considers the meteorological instrumentation to be acceptable.

2.3.3.3.2 Meteorological Data

The applicant used the existing onsite meteorological measurements program from the Vogtle facility (Units 1 & 2) to collect hourly meteorological data. The applicant provided seasonal and annual summaries of onsite meteorological data in the SSAR, based on hourly measurements, from instrumentation mounted on the primary tower, taken over the 5-year period from 1998 through 2002. The applicant provided a copy of this 1998–2002 hourly database to the staff.

The staff performed a quality review of the 1998–2002 hourly meteorological database using the methodology described in NUREG-0917, "Nuclear Regulatory Commission Staff Computer Programs for Use with Meteorological Data," issued July 1982. The staff used computer spreadsheets to perform further review. During a site audit conducted on December 6, 2006, the staff notified the applicant that it had identified a few inconsistencies in the data (such as overly persistent wind directions or stability classes, temperature observations switching between degrees Celsius (°C) and Fahrenheit (°F), or delta-temperature measurements exceeding the auto-convective lapse rate) and asked the applicant for an explanation. The applicant responded in a letter dated January 30, 2007, that it would revise the onsite meteorological database to address these concerns. The staff reviewed a copy of this revised database and finds that the applicant has addressed all of the above concerns; a comparison between the JFD used by the applicant as input to the PAVAN and XOQDOQ atmospheric dispersion computer codes and a staff-generated JFD from the hourly database provided by the applicant shows that the two JFDs are similar.

To further check the validity and accuracy of the onsite meteorology data, the staff compared hourly data from the VEGP application to concurrent data obtained from the NCDC integrated hourly surface observations for Augusta. SER Table 2.3.3-2 compares 1998–2002 annual temperature, atmospheric moisture, wind speed, and wind direction statistics between the VEGP onsite data and the Augusta NWS data. The comparison of the 1998–2002 onsite temperature, atmospheric moisture, wind speed, and wind direction data with similar data recorded at Augusta for the same period of record shows that the Vogtle onsite data are reasonable.

Because of the reasonable correlation between the Augusta and Vogtle data, long-term temperature and atmospheric moisture data from Augusta are appropriate for determining the ambient air temperature and humidity site characteristics presented in SSAR Section 2.3.1. The Augusta annual maximum and minimum temperatures tend to be slightly more extreme than the Vogtle data. This implies that using Augusta data to characterize the extreme temperatures expected onsite is a conservative approach.

Based on an independent analysis of the onsite meteorological data and a comparison with hourly data from the Augusta NWS station, the staff accepts the 5 years of onsite data provided by the applicant as being representative of the site and an acceptable basis for estimating atmospheric dispersion for DBA and routine releases in SSAR Sections 2.3.4 and 2.3.5.

2.3.3.4 Conclusion

The NRC staff evaluated the relevant sections of the application, as supplemented by letters dated January 30, 2007, March 26, 2007, and March 30, 2007, pursuant to the acceptance criteria of RS-002 Section 2.3.3 and applicable regulatory requirements of 10 CFR Part 52 and 10 CFR Part 100. Based on the preceding discussion, the staff concludes that the applicant has successfully implemented an appropriate onsite meteorological measurements program and that data from this program provide an acceptable basis for estimating atmospheric dispersion for DBA and routine releases from a nuclear power plant of the type specified by the applicant. Therefore, the staff finds that the applicant has provided the information required to address 10 CFR 52.17(a)(1), 10 CFR 100.20(c), and 10 CFR 100.21(d). The staff also finds that analysis and conclusions regarding the site-specific adequacy of onsite meteorological instrumentation are sufficient to support the staff's evaluation of the applicant's proposed emergency plan, in SER Chapter 13, per 10 CFR 50.47 and 10 CFR Part 50, Appendix E.

Table 2.3.3-1 - Onsite Meteorological Monitoring Program Specifications

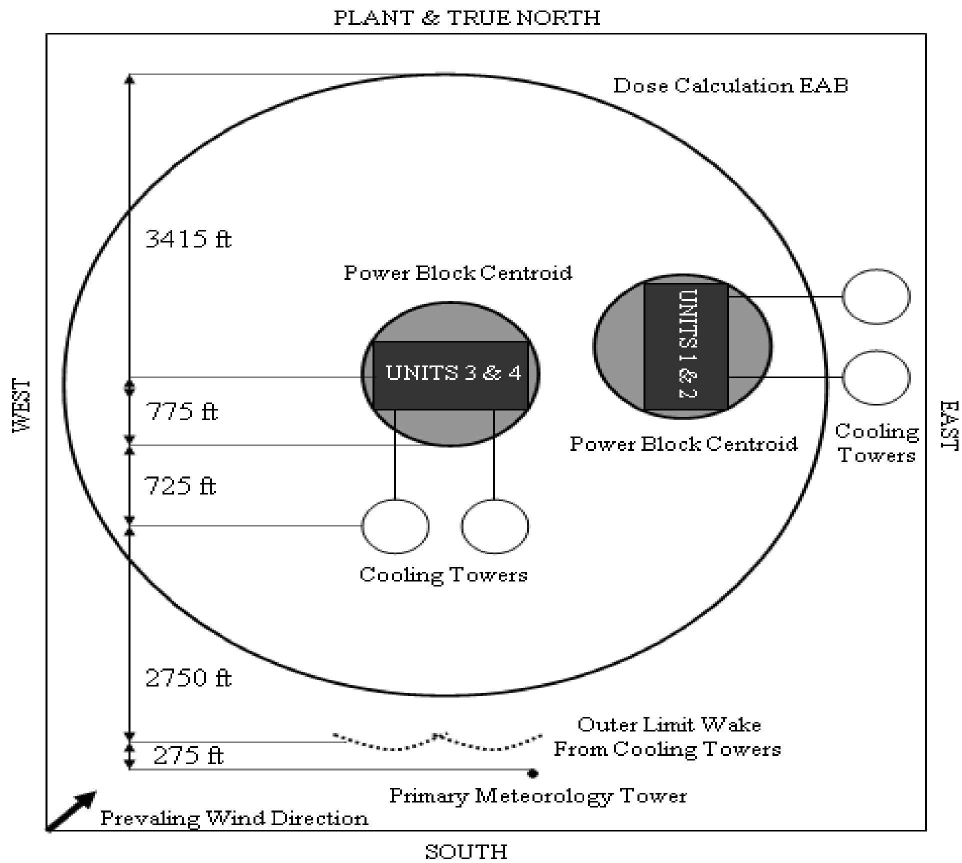
PARAMETER	RANGE	SYSTEM ACCURACY
Wind speed	0 - 100 mi/h	± 0.5 mi/h
Wind Direction	0 ° – 360 °	± 5 °
Ambient Temperature	-10 ° – 120 °F	± 0.9 °F
Differential Temperature	-5 ° – 10 °F	± 0.27 °F

Table 2.3.3-2 - Comparison of Augusta NWS and Vogtle Meteorology Observations

	ANNUAL AVERAGE TEMPERATURE		EXTREME MAXIMUM ANNUAL TEMPERATURE		EXTREME MINIMUM ANNUAL TEMPERATURE	
	AUGUSTA	VOGTLE	AUGUSTA	VOGTLE	AUGUSTA	VOGTLE
1998	65 °F	66 °F	103 °F	102 °F	19 °F	25 °F
1999	64 °F	65 °F	107 °F	104 °F	13 °F	17 °F
2000	63 °F	63 °F	101 °F	98 °F	13 °F	17 °F
2001	64 °F	64 °F	97 °F	94 °F	12 °F	20 °F
2002	64 °F	65 °F	101 °F	96 °F	16 °F	17 °F

	ANNUAL AVERAGE DEWPOINT		ANNUAL AVERAGE WIND SPEED		ANNUAL PREVAILING WIND DIRECTION	
	AUGUSTA	VOGTLE	AUGUSTA	VOGTLE	AUGUSTA	VOGTLE
1998	53 °F	53 °F	4.9 mi/h	5.1 mi/h	WSW	WSW
1999	51 °F	50 °F	5.3 mi/h	5.1 mi/h	WSW	SW
2000	52 °F	49 °F	5.1 mi/h	5.3 mi/h	WSW	SW
2001	52 °F	50 °F	5.1 mi/h	5.5 mi/h	WSW	W
2002	53 °F	51 °F	5.3 mi/h	5.2 mi/h	WSW	W

Figure 2.3.3-1 - Proposed Layout for VEGP Site



2.3.4 Short-Term Diffusion Estimates

2.3.4.1 Introduction

In Section 2.3.4 of the SSAR, the applicant presented information on atmospheric dispersion estimates for postulated accidental airborne releases of radioactive effluents to the EAB and the outer boundary of the LPZ. The applicant provided the following specific information:

- Atmospheric transport and diffusion models to calculate dispersion estimates (atmospheric dispersion factors, relative concentrations, or χ/Q values) for postulated accidental radioactive releases.

- Meteorological data summaries used as input to dispersion models.

- Diffusion parameters.

- Determination of χ/Q values used for assessment of consequences of postulated radioactive atmospheric releases from design-basis and other accidents.

This section verifies that the applicant has used appropriate atmospheric dispersion models and meteorological data to calculate relative concentrations at appropriate distances and directions from postulated release points for the evaluation of accidental airborne releases of radioactive material.

2.3.4.2 Regulatory Basis

The acceptance criteria for calculating atmospheric dispersion estimates for postulated accidental airborne releases of radioactive effluents are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The staff considered the following regulatory requirements in reviewing the applicant's calculation of atmospheric dispersion estimates for postulated accidental airborne releases of radioactive effluents

- 10 CFR 100.20(c), which requires that the meteorological characteristics of the site, necessary for safety analysis or that may have an impact on plant design, be identified and characterized as part of the NRC's review of the acceptability of a site.

- 10 CFR 100.21(c)(2), which requires that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that radiological dose consequences of postulated accidents shall meet the criteria set forth in 10 CFR 50.34(a)(1) for the type of facility proposed to be located at the site.

The applicant also originally identified Appendix E to 10 CFR Part 50 as applicable to SSAR Section 2.3.4. In RAI 2.3.4-2, the staff asked the applicant to explain how Appendix E applies to the development of the short-term (accidental release) atmospheric dispersion estimates presented in SSAR Section 2.3.4. The applicant responded by deleting the reference to Appendix E to 10 CFR Part 50 in SSAR Section 2.3.4.

RS-002, Section 2.3.4 specifies that an application meets the above requirements, if the application provides the following information:

- A description of the atmospheric dispersion models used to calculate relative concentrations (χ/Q values) in air resulting from accidental releases of radioactive material to the atmosphere. The models should be documented in detail and substantiated within the limits of the model so that the staff can evaluate their appropriateness to site characteristics, plant characteristics (to the extent known), and release characteristics.

- Meteorological data used for the evaluation (as input to the dispersion models) which represent annual cycles of hourly values of wind direction, wind speed, and atmospheric stability for each mode of accidental release.

- The variation of atmospheric diffusion parameters used to characterize lateral and vertical plume spread as a function of distance, topography, and atmospheric conditions, as related to measured meteorological parameters. The methodology for establishing these relationships should be appropriate for estimating the consequences of accidents within the range of distances which are of interest with respect to site characteristics and established regulatory criteria.

- Cumulative probability distributions of relative concentrations (χ/Q values) describing the probabilities of these χ/Q values being exceeded. These cumulative probability distributions should be presented for appropriate distances and time periods as specified in Section 2.3.4.2 of RG 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." The methods of generating these distributions should be adequately described.

- Relative concentrations used for assessment of consequences of atmospheric radioactive releases from design-basis and other accidents.

To the extent applicable to the above-outlined acceptance criteria, the applicant applied the NRC-endorsed analytical methodologies, models and parameters found in the following:

- RG 1.23, which provides criteria for an acceptable onsite meteorological measurements program, data from which are used as input to atmospheric dispersion models.

- RG 1.70, which states that the SSAR should provide atmospheric estimates at the EAB and outer boundary of the LPZ for appropriate time periods up to 30 days after an accident based on the most representative meteorological data and potential impacts of topography on atmospheric dispersion site characteristics.

- RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," which provides acceptable methods for characterizing annual average atmospheric transport and diffusion conditions for evaluating the consequences of radiological releases at the EAB and outer boundary of the LPZ.

- RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," which provides acceptable methods for characterizing atmospheric dispersion conditions for appropriate time periods up to 30 days for evaluating the consequences of DBA radiological releases to the EAB and outer boundary of the LPZ.

- RG 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," which provides criteria on the use of alternative radiological source terms for evaluating the consequences of DBAs.

- RG 4.7, which provides criteria on the amount of meteorological data necessary to ensure the generation of representative atmospheric dispersion site characteristics.

The applicant originally identified RG 1.78 as applicable to SSAR Section 2.3.4. In RAI 2.3.4-3, the staff asked the applicant to explain how RG 1.78 applies to the development of the short-term (accidental release) atmospheric dispersion site characteristics presented in SSAR Section 2.3.4. The applicant responded by deleting the reference to RG 1.78 for SSAR Section 2.3.4.

When independently assessing the veracity of the information presented by the applicant in SSAR Chapter 2.3.4, the NRC staff applied the same above-cited methodologies, models and parameters.

2.3.4.3 Technical Evaluation

Using the approaches and analytic methodologies described in RS-002 Section 2.3.4, the NRC staff reviewed the application, as supplemented by letters dated January 30, 2007, March 26, 2007, and March 30, 2007. In reviewing and evaluating the applicant's short-term atmospheric dispersion estimates, the staff used (or relied on) only the elevation of the post-accident release point from the design parameters and site interface values presented by the applicant in SSAR Section 1.3.

2.3.4.3.1 Atmospheric Dispersion Mode

The applicant used the computer code PAVAN (NUREG/CR-2858, "PAVAN: An Atmospheric Dispersion Program for Evaluating Design-Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations,") to estimate χ/Q values at the EAB and at the outer boundary of the LPZ for potential accidental releases of radioactive material. The PAVAN model implements the methodology outlined in RG 1.145.

The PAVAN code estimates χ/Q values for various time-average periods ranging from 2 hours to 30 days. The meteorological input to PAVAN consists of a joint frequency distribution (JFD) of hourly values of wind speed and wind direction by atmospheric stability class. In response to RAI 2.3.4-5, the applicant provided a copy of the input file used to compute the χ/Q values listed in SSAR Section 2.3.4. The staff used this input file, as well as the hourly meteorological data, to verify the χ/Q values presented by the applicant, as discussed in SER Section 2.3.4.3.4.

The χ/Q values calculated through PAVAN are based on the theoretical assumption that material released to the atmosphere will be normally distributed (Gaussian) about the plume centerline. A straight-line trajectory is assumed between the point of release and all distances for which χ/Q values are calculated.

For each of the 16 downwind direction sectors (e.g., N, NNE, NE, ENE), PAVAN calculates χ/Q values for each combination of wind speed and atmospheric stability at the appropriate downwind distance (i.e., the EAB and the outer boundary of the LPZ). The χ/Q values calculated for each sector are then ordered from greatest to smallest and an associated cumulative frequency distribution is derived based on the frequency distribution of wind speed and stabilities for each sector. The smallest χ/Q value in a distribution will have a corresponding cumulative frequency equal to the wind direction frequency for that particular sector. PAVAN determines for each sector an upper envelope curve based on the derived data (plotted as χ/Q versus probability of being exceeded), such that no plotted point is above the curve. From this upper envelope, the χ/Q value, which is equaled or exceeded 0.5 percent of the total time, is obtained. The maximum 0.5 percent χ/Q value from the 16 sectors becomes the 0–2 hour "maximum sector χ/Q value."

Using the same approach, PAVAN also combines all χ/Q values independent of wind direction into a cumulative frequency distribution for the entire site. An upper envelope curve is determined, and the program selects the χ/Q value which is equaled or exceeded 5.0 percent of the total time. This is known as the 0–2 hour "5-percent overall site χ/Q value."

The larger of the two χ/Q values, either the 0.5-percent maximum sector value or the 5-percent overall site value, is selected to represent the χ/Q value for the 0–2 hour time interval (note that this resulting χ/Q value is based on 1-hour averaged data but is conservatively assumed to apply for 2 hours).

To determine χ/Q values for longer time periods (i.e., 0–8 hour, 8–24 hour, 1–4 days, and 4-30 days), PAVAN performs a logarithmic interpolation between the 0–2 hour χ/Q values and the annual average (8760-hour) χ/Q values for each of the 16 sectors and overall site. For each time period, the highest among the 16 sector and overall site χ/Q values is identified and becomes the short-term site characteristic χ/Q value for that time period.

2.3.4.3.2 Meteorological Data Input

The meteorological input to PAVAN used by the applicant consisted of a JFD of wind speed, wind direction, and atmospheric stability based on hourly onsite data from January 1998 through December 2002. The wind data were obtained from the 10-meter level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-temperature) measurements taken between the 60-meter and 10-meter levels on the onsite meteorological tower.

As discussed in SER Section 2.3.3, the staff considers the 1998–2002 onsite meteorological database suitable for input to the PAVAN model.

2.3.4.3.3 Diffusion Parameters

The applicant chose to implement the diffusion parameter assumptions outlined in RG 1.145, as a function of atmospheric stability, for its PAVAN model runs. The staff evaluated the applicability of the PAVAN diffusion parameters and concluded that no unique topographic features (such as rough terrain, restricted flow conditions, or coastal or desert areas) preclude the use of the PAVAN model for the VEGP site. Therefore, the staff finds that the applicant's use of diffusion parameter assumptions, as outlined in RG 1.145, was acceptable.

2.3.4.3.4 Relative Concentration for Accident Consequences Analysis

The applicant modeled one ground-level release point and did not take credit for building wake effects. Ignoring building wake effects for a ground-level release decreases the amount of atmospheric turbulence assumed to be in the vicinity of the release point, resulting in higher (more conservative) χ/Q values. A ground-level release assumption is therefore acceptable to the staff.

The applicant defined a "dose calculation" EAB as a circle that extends 0.5 mile beyond the power block area.[9] Consequently, the applicant executed PAVAN using a distance from release point to the

[9] Because the power block area is defined as being within a 775-foot-radius circle centered on a point between the two proposed AP1000 units, the dose calculation EAB can also be defined as a circle with a radius of 3,415 feet from the proposed power block centroid.

dose calculation EAB of 0.5 mile (800 meters) for all downwind sectors. The applicant stated that because the dose calculation EAB is circumscribed the “true” (actual) EAB for the site, any χ/Q values produced by PAVAN will be conservative estimates. The staff verified that the dose calculation EAB is within the true EAB for the site and is therefore acceptable to the staff.

The outer boundary of the LPZ for the proposed facility is a 2-mile-radius circle centered on the existing power block. The applicant chose to use a downwind distance of 1.4 miles (2304 meters) for all direction sectors for calculating LPZ χ/Q values because this is the shortest distance in any direction from the proposed power block area boundary to the predefined LPZ. The use of the shortest distance results in higher (more conservative) χ/Q values and is therefore acceptable to the staff.

SER Table 2.3.4-1 lists the short-term atmospheric dispersion estimates for the dose calculation EAB and the outer boundary of the LPZ that the applicant derived from its PAVAN modeling run results. The applicant identified these χ/Q values as site characteristics in SSAR Table 1-1 because these are the atmospheric dispersion site characteristics used by the applicant to demonstrate compliance with the terms of 10 CFR 100.21(c)(2) for the radiological dose consequences of postulated accidents.

The applicant originally identified the 0.5-percent maximum sector EAB χ/Q value as being larger than the 5-percent overall site EAB χ/Q value. In contrast, by way of confirmatory analysis, the staff found the 5-percent overall site χ/Q value to be the larger of the two values. In RAI 2.3.4-4, the staff asked the applicant to confirm which of the two χ/Q values is more limiting for the site. The applicant responded that a new PAVAN run, using the revised meteorological database discussed in SER Section 2.3.3, verified the staff’s results: the 5-percentile overall site EAB χ/Q value did indeed bound the 0.5-percentile maximum sector EAB χ/Q value.

The staff confirmed the applicant’s atmospheric dispersion estimates by running the PAVAN computer model and obtaining similar results (i.e., plus or minus 4 percent).

In light of the foregoing, the staff accepts the short-term χ/Q values presented by the applicant. The staff will include the short-term χ/Qs listed in SER Table 2.3.4-1 as site characteristics in any ESP that the NRC may issue for the VEGP site.

2.3.4.4 Conclusion

The NRC staff has evaluated the relevant sections of the application, as supplemented by letters dated January 30, 2007, March 26, 2007, and March 30, 2007, pursuant to the acceptance criteria described in RS-002 Section 2.3.4 and the applicable regulatory requirements of 10 CFR Part 52 and 10 CFR Part 100. As discussed above, the applicant provided meteorological data and an atmospheric dispersion model that are appropriate for the characteristics of the site. Therefore, the staff concludes that representative atmospheric transport and diffusion conditions have been calculated at the EAB and the outer boundary of the LPZ, and, thus, that the applicant has provided the information required to comply with the applicable provisions of 10 CFR Part 52 and 10 CFR 100.21(c)(2).

Table 2.3.4-1 - Short-Term (Accidental Release) Atmospheric Dispersion Site Characteristics

SITE CHARACTERISTIC	VALUE	DEFINITION
0–2 hr χ/Q value @ EAB	3.49×10^{-4} s/m^3	The atmospheric dispersion coefficients used in the design safety analysis to estimate dose consequences of accidental airborne releases.
0–8 hr χ/Q value @ LPZ outer boundary	7.04×10^{-5} s/m^3	
8–24 hr χ/Q value @ LPZ outer boundary	5.25×10^{-5} s/m^3	
1–4 day χ/Q value @ LPZ outer boundary	2.77×10^{-5} s/m^3	
4–30 day χ/Q value @ LPZ outer boundary	1.11×10^{-5} s/m^3	

2.3.5 Long-Term Diffusion Estimates

2.3.5.1 Introduction

In Section 2.3.5 of the SSAR, the applicant presented its atmospheric dispersion estimates for routine releases of radiological effluents to the atmosphere. Specifically, the applicant provided the following information:

- atmospheric dispersion models used to calculate concentrations in air and the amount of material deposited as a result of routine releases of radioactive material to the atmosphere.
- points of routine release of radioactive material to the atmosphere, the characteristics of each release mode, and the location of potential receptors for dose computations.
- meteorological data used as input to dispersion models.
- diffusion parameters.
- relative concentration factors (χ/Q values) and relative deposition factors (D/Q values) used to assess the consequences of routine airborne radioactive releases.

This section verifies that the applicant has used appropriate atmospheric dispersion models and meteorological data to calculate relative concentration and relative deposition at appropriate distances and directions from postulated release points for the evaluation of routine airborne releases of radioactive material.

2.3.5.2 Regulatory Basis

The acceptance criteria for calculating atmospheric dispersion estimates for routine releases of radiological effluents are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The staff considered the following regulatory requirements in reviewing the applicant's calculation of atmospheric dispersion estimates for routine releases of radiological effluents:

- 10 CFR 100.20(c), which requires that the meteorological characteristics of the site, necessary for safety analysis or that may have an impact on plant design, be identified and characterized as part of the NRC's review of the acceptability of a site.
- 10 CFR 100.21(c)(1), which requires that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that radiological effluent release limits associated with normal operation from the type of facility to be located at the site can be met for any individual located offsite.

Characterization of atmospheric transport and diffusion conditions is necessary for estimating the radiological consequences of routine releases of radioactive materials to the atmosphere, so as to demonstrate compliance, at the COL stage, with the numerical guides for doses contained in 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and limiting Conditions for Operation to Meet the Criterion 'As Low as Reasonable Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents."

The applicant originally identified in its application Appendix E to 10 CFR Part 50 as applicable to SSAR Section 2.3.5. In RAI 2.3.5-3, the staff asked the applicant to explain how Appendix E applies to the development of the long-term (routine release) atmospheric dispersion estimates presented in SSAR Section 2.3.5. The applicant responded by deleting the reference to Appendix E to 10 CFR Part 50 in SSAR Section 2.3.5.

RS-002, Section 2.3.5 specifies that an application meets the above requirements, if the application provides the following information:

- A description of the atmospheric dispersion models used to calculate concentrations in air and the amount of material deposited as a result of routine releases of radioactive material to the atmosphere. The models should be sufficiently documented and substantiated to allow a review of their appropriateness for site characteristics, plant characteristics (to the extent known), and release characteristics.

- A discussion of the relationship between atmospheric diffusion parameters, such as vertical plume spread, and measured meteorological parameters. Use of these parameters should be substantiated as to their appropriateness for use in estimating the consequences of routine releases from the site boundary to a radius of 50 miles from the plant site.

- Meteorological data used as input to the dispersion models. Data used for this evaluation should represent hourly average values of wind speed, wind direction, and atmospheric stability which are appropriate for each mode of release. The data should reflect atmospheric transport and diffusion conditions in the vicinity of the site throughout the course of a year.

- Relative concentration (χ/Q) and relative deposition (D/Q) values used for assessment of consequences of routine radioactive gas releases.

- Points of routine release of radioactive material to the atmosphere, the characteristics of each release mode, and the location of potential receptors for dose computations.

To the extent applicable to the above-outlined acceptance criteria, the applicant applied the NRC-endorsed analytical methodologies, models and parameters found in the following:

- RG 1.23, which provides criteria for an acceptable onsite meteorological measurements program, data from which are used as input to atmospheric dispersion models.

- RG 1.70, which states that the SSAR should provide realistic estimates of annual average atmospheric transport and diffusion characteristics out to a distance of 50 miles from the plant, including a detailed description of the model used and a calculation of the maximum annual average χ/Q value at or beyond the site boundary for each venting location.

- RG 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,” which presents identification criteria to be used for specific receptors of interest.

- RG 1.111, which provides acceptable methods for characterizing atmospheric transport and diffusion conditions for evaluating the consequences of routine effluent releases.

- RG 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors," which provides criteria for identifying release points and release characteristics.

When independently assessing the veracity of the information presented by the applicant in SSAR Chapter 2.3.5, the NRC staff applied the same above-cited methodologies, models and parameters.

2.3.5.3 Technical Evaluation

Using the approaches and analytic methodologies described in RS-001 Section 2.3.5, the NRC staff reviewed the application, as supplemented by letters dated January 30, 2007, March 26, 2007, and March 30, 2007. In reviewing and evaluating the applicant's long-term atmospheric dispersion estimates, the staff used (or relied on) none of the applicant's proposed design parameters and site interface values presented in SSAR Section 1.3, but did rely on the routine release point elevation, containment building minimum cross-sectional area, and the equivalent structural height values presented by the applicant in SSAR Section 2.3.5.

2.3.5.3.1 Atmospheric Dispersion Model

The applicant used the NRC-sponsored computer code XOQDOQ (described in NUREG/CR-2919, "XOQDOQ Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations,") to estimate χ/Q and D/Q values resulting from routine releases. The XOQDOQ model implements the methodology outlined in RG 1.111.

The XOQDOQ model is a straight-line Gaussian plume model based on the theoretical assumption that material released to the atmosphere will be normally distributed (Gaussian) about the plume centerline. In predictions of χ/Q and D/Q values for long time periods (i.e., annual averages), the plume's horizontal distribution is assumed to be evenly distributed within the downwind direction sector (e.g., "sector averaging").

Because geographic features such as hills, valleys, and large bodies of water can potentially influence dispersion and airflow patterns, terrain recirculation factors can be used to adjust the results of a straight-line trajectory model such as XOQDOQ to account for terrain-induced flows, recirculation, or stagnation. In RAI 2.3.5-5, the staff asked the applicant to explain why it did not use terrain recirculation factors, which were used in Chapter 8 of Revision 21 of the VEGP Offsite Dose Calculation Manual (ODCM, dated October 1, 2003), in developing the long-term χ/Qs presented in the VEGP SSAR. The applicant responded that the topographic features in the site vicinity do not require the use of terrain recirculation factors and that the analyses reported in the Unit 1/Unit 2 FSAR did not use these factors. The applicant also stated that most terrain recirculation factors used in the ODCM for ground-level releases are about 1. Based on SSAR Figure 2.3-15, topographical descriptions in SSAR Section 2.3.1, and a site audit conducted on December 6, 2006, the staff agrees with the applicant that the site can be characterized as having open terrain with gently rolling hills. Thus, the staff concludes that XOQDOQ modeling results are applicable to the site and no unique topographic features (such as valley, desert, or overall water trajectories) preclude the use of the model for the proposed VEGP site.

2.3.5.3.2 Release Characteristics and Receptors

The applicant modeled one ground-level release point, assuming a minimum building cross-sectional area of 2,926 square meters and a containment "equivalent" structure height of 65.6 meters. The staff asked the applicant in RAI 2.3.5-1 to provide the basis for the calculation of the containment building minimum cross-sectional area and equivalent structural height. In its response, the applicant stated that the equivalent structure height was determined by dividing the building cross-sectional area by the width of the proposed reactor containment at the bottom.

A ground-level release is a conservative assumption resulting in higher χ/Q and D/Q values when compared to a mixed-mode (e.g., part-time ground, part-time elevated) release or a 100-percent elevated release, as discussed in RG 1.111. A ground-level release assumption is therefore acceptable to the staff.

The applicant executed XOQDOQ using a distance from the release point to the dose calculation EAB of 0.5 mile (800 meters) for all downwind sectors as discussed in SSAR Section 2.3.4.3. The applicant also placed receptors of interest (i.e., resident, meat animal, and vegetable garden) in all compass directions at a downwind distance of 1,071 meters. This distance is based on the closest of these receptors (the nearest resident in the west-southwest sector), as identified in the VEGP "Annual Radiological Environmental Operating Report (AREOP) for 2004," produced by Southern Company (ADAMS Accession No. ML051380059). This is a conservative assumption and is therefore acceptable to the staff. SER Table 2.3.5-1 compares the AREOP distances and the distances used as input to the XOQDOQ model.

2.3.5.3.3 Meteorological Data Input

The meteorological input to XOQDOQ consists of a JFD of wind speed, wind direction, and atmospheric stability based on hourly onsite data from January 1998 through December 2002. The wind data were obtained from the 10-meter level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-temperature) measurements taken between the 60-meter and 10-meter levels on the onsite meteorological tower.

As discussed in SER Section 2.3.3, the staff considers the 1998–2002 onsite meteorological database suitable for input to the XOQDOQ model.

2.3.5.3.4 Diffusion Parameters

The applicant chose to implement the diffusion parameter assumptions outlined in RG 1.111, as a function of atmospheric stability, for its XOQDOQ model runs. The staff evaluated the applicability of the XOQDOQ diffusion parameters and concluded that no unique topographic features (such as valley, desert, or over water trajectories) preclude the use of the XOQDOQ model for the VEGP site. Therefore, the staff finds that the applicant's use of diffusion parameter assumptions, as outlined in RG 1.111, was acceptable.

2.3.5.3.5 Resulting Relative Concentration and Relative Deposition Factors

SER Table 2.3.5-2 lists the long-term atmospheric dispersion and deposition estimates for the dose calculation EAB and special receptors of interest that the applicant derived from its XOQDOQ modeling results. The applicant identified these χ/Q and D/Q values as site characteristics in SSAR Table 1-1 because these are the atmospheric dispersion site characteristics used by the applicant to demonstrate compliance with the terms of 10 CFR 100.21(c)(1) for the radiological dose consequences related to routine operation.

In response to RAI 2.3.5-6, the applicant provided long-term atmospheric dispersion and deposition estimates for all 16 radial sectors from the site boundary, to a distance of 50 miles from the proposed facility, in SSAR Table 2.3-18. The COL applicant will need to use this information to show that the proposed plant's gaseous radiological waste systems include all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, can, for a favorable cost-benefit ratio, effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor, in accordance with the requirements of Section II.D of Appendix I to 10 CFR Part 50.

The χ/Q values presented in SER Table 2.3.5-2 reflect several plume radioactive decay and deposition scenarios. Section C.3 of RG 1.111 states that radioactive decay and dry deposition should be considered in radiological impact evaluations of potential annual radiation doses to the public, resulting from routine releases of radioactive materials in gaseous effluents. Section C.3.a of RG 1.111 states that an overall half-life of 2.26 days is acceptable for evaluating the radioactive decay of short-lived noble gases and an overall half-life of 8 days is acceptable for evaluating the radioactive decay for all iodines released to the atmosphere.

Definitions for the χ/Q categories listed in the headings of SER Table 2.3.5-2 are as follows:

- Undepleted/No Decay χ/Q values are χ/Qs used to evaluate ground-level concentrations of long-lived noble gases, tritium, and carbon-14. The plume is assumed to travel downwind, without undergoing dry deposition or radioactive decay.

- Undepleted/2.26-Day Decay χ/Q values are χ/Qs used to evaluate ground-level concentrations of short-lived noble gases. The plume is assumed to travel downwind, without undergoing dry deposition, but is decayed, assuming a half-life of 2.26 days, based on the half-life of xenon-133m.

- Depleted/8.00-Day Decay χ/Q values are χ/Qs used to evaluate ground-level concentrations of radioiodine and particulates. The plume is assumed to travel downwind, with dry deposition, and is decayed, assuming a half-life of 8.00 days, based on the half-life of iodine-131.

The applicant provided a copy of its XOQDOQ input file in response to RAI 2.3.5-4. Using this information as well as the updated meteorological data provided by the applicant in its March 30, 2007 letter, the staff confirmed the applicant's χ/Q and D/Q values by running the XOQDOQ computer code and obtaining the same results.

In light of the foregoing, the staff accepts the long-term χ/Q and D/Q values presented by the applicant. The staff will include the long-term atmospheric dispersion and deposition factors listed in SER Table 2.3.5-2 as site characteristics in any ESP that the NRC might issue for the VEGP site.

2.3.5.4 Conclusion

The NRC staff evaluated the relevant sections of the application, as supplemented by letters dated January 30, 2007, March 26, 2007, and March 30, 2007, pursuant to the acceptance criteria of RS-002 Section 2.3.5 and applicable regulatory requirements of 10 CFR Part 52 and 10 CFR Part 100. As discussed above, the applicant has provided meteorological data and an atmospheric dispersion model that are appropriate for the characteristics of the site and release points. Therefore, the staff concludes that the applicant has calculated representative atmospheric transport and diffusion conditions for 16 radial sectors from the site boundary to a distance of 50 miles and for the specific receptor locations.

Therefore, the applicant has provided the information required to address 10 CFR 52.17(a), 10 CFR 100.20, and 10 CFR 100.21(c)(1). The staff also concludes that the applicant's characterization of long-term atmospheric transport and diffusion conditions would be appropriate, at the COL stage, for use in demonstrating compliance with the numerical guides for doses contained in Appendix I to 10 CFR Part 50.

Table 2.3.5-1 - Distances between the Proposed Units 3 and 4 Power Block and Receptors of Interest[10]

RECEPTOR	DOWNWIND DIRECTION SECTOR	DISTANCE COMPILED FROM THE AREOP	DISTANCE USED
Nearest Resident	N	2032 m	1071 m
	NNE	>8045 m	1071 m
	NE	>8045 m	1071 m
	ENE	>8045 m	1071 m
	E	>8045 m	1071 m
	ESE	7118 m	1071 m
	SE	7327 m	1071 m
	SSE	7410 m	1071 m
	S	6835 m	1071 m
	SSW	7068 m	1071 m
	SW	3633 m	1071 m
	WSW	1071 m	1071 m
	W	5024 m	1071 m
	WNW	2069 m	1071 m
	NW	>8045 m	1071 m
	NNW	1946 m	1071 m
Meat Animal	N	>8045 m	1071 m
	NNE	>8045 m	1071 m
	NE	>8045 m	1071 m
	ENE	>8045 m	1071 m
	E	>8045 m	1071 m
	ESE	>8045 m	1071 m
	SE	>8045 m	1071 m
	SSE	7414 m	1071 m
	S	>8045 m	1071 m
	SSW	6736 m	1071 m
	SW	7155 m	1071 m
	WSW	6366 m	1071 m
	W	6170 m	1071 m
	WNW	>8045 m	1071 m
	NW	2400 m	1071 m
	NNW	>8045 m	1071 m
Vegetable Garden	N	>8045 m	1071 m
	NNE	>8045 m	1071 m
	NE	>8045 m	1071 m
	ENE	>8045 m	1071 m
	E	>8045 m	1071 m
	ESE	>8045 m	1071 m
	SE	>8045 m	1071 m
	SSE	>8045 m	1071 m
	S	>8045 m	1071 m
	SSW	>8045 m	1071 m
	SW	>8045 m	1071 m
	WSW	4273 m	1071 m
	W	>8045 m	1071 m
	WNW	4458 m	1071 m
	NW	5899 m	1071 m
	NNW	>8045 m	1071 m

10 Note that 2004 AREOP did not report any milk-giving animals (either cows or milk) within a 5-mile radius of the proposed VEGP site.

Table 2.3.5-2 - Long-Term (Routine Release) Atmospheric Dispersion Site Characteristics

SITE CHARACTERISTIC	VALUE	DEFINITION
Annual Average Undepleted/No Decay χ/Q Value @ EAB, northeast, 0.5 mile	5.5×10^{-6} s/m^3	The maximum annual average EAB undepleted/no decay atmospheric dispersion factor (χ/Q value) for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Undepleted/2.26-Day Decay χ/Q Value @ EAB, northeast, 0.5 mile	5.5×10^{-6} s/m^3	The maximum annual average EAB undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Depleted/8.00-Day Decay χ/Q Value @ EAB, northeast, 0.5 mile	5.0×10^{-6} s/m^3	The maximum annual average EAB depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average D/Q Value @ EAB, northeast and east-northeast, 0.5 mile	1.7×10^{-8} 1/m^2	The maximum annual average EAB relative deposition factor (D/Q value) for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Resident, northeast, 0.67 mile	3.4×10^{-6} s/m^3	The maximum annual average resident undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Undepleted/2.26-Day Decay χ/Q Value @ Nearest Resident, northeast, 0.67 mile	3.4×10^{-6} s/m^3	The maximum annual average resident undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Depleted/8.00-Day Decay χ/Q Value @ Nearest Resident, northeast, 0.67 mile	3.0×10^{-6} s/m^3	The maximum annual average resident depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average D/Q Value @ Nearest Resident, northeast, east-northeast, and east, 0.67 mile	1.0×10^{-8} 1/m^2	The maximum annual average resident D/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Meat Animal, northeast, 0.67 mile	3.4×10^{-6} s/m^3	The maximum annual average meat animal undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Undepleted/2.26-Day Decay χ/Q Value @ Nearest Meat Animal, northeast, 0.67 mile	3.4×10^{-6} s/m^3	The maximum annual average meat animal undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Depleted/8.00-Day Decay χ/Q Value @ Nearest Meat Animal, northeast, 0.67 mile	3.0×10^{-6} s/m^3	The maximum annual average meat animal depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average D/Q Value @ Nearest Meat Animal, northeast, east-northeast, and east, 0.67 mile	1.0×10^{-8} 1/m^2	The maximum annual average meat animal D/Q value for use in determining gaseous pathway doses to the maximally exposed individual.

SITE CHARACTERISTIC	VALUE	DEFINITION
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Vegetable Garden, northeast, 0.67 mile	3.4×10^{-6} s/m^3	The maximum annual average vegetable garden undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Undepleted/2.26-Day Decay χ/Q Value @ Nearest Vegetable Garden, northeast, 0.67 mile	3.4×10^{-6} s/m^3	The maximum annual average vegetable garden undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average Depleted/8.00-Day Decay χ/Q Value @ Nearest Vegetable Garden, northeast, 0.67 mile	3.0×10^{-6} s/m^3	The maximum annual average vegetable garden depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual.
Annual Average D/Q Value @ Nearest Vegetable Garden, northeast, east-northeast, and east, 0.67 mile	1.0×10^{-8} 1/m^2	The maximum annual average vegetable garden D/Q value for use in determining gaseous pathway doses to the maximally exposed individual.

2.4 <u>Hydrologic Engineering</u>

2.4.1 Hydrologic Description

2.4.1.1 Introduction

Attachment 2 of RS-002 [Review Standard] discusses the site characteristics that could affect the safe design and siting of proposed plant or plants. Section 2.4 of the applicant's SSAR describes the hydrological setting and the data used in the applicant's safety conclusions regarding hydrology. The NRC staff's review of the SSAR covers: (1) interface of the plant with the hydrosphere; (2) hydrological causal mechanisms; (3) surface and ground water use; (4) data that forms the basis of the applicant's analysis and conclusions; (5) alternate conceptual models; (6) consideration of other site-related evaluation criteria; and (7) additional information for applications under 10 CFR Part 52.

The VEGP site is located on the southwest side of the Savannah River (SNC 2007). The VEGP site currently hosts two nuclear power plants, VEGP Units 1 and 2. The VEGP application proposed the addition of two new nuclear power reactors at the VEGP site (SNC 2007).

2.4.1.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.20(c), addresses the hydrologic characteristics of a proposed site that may affect the consequences of an escape of radioactive material from the facility. Applicants should determine factors important to hydrologic radionuclide transport, described in 10 CFR 100.20(c)(3), by using onsite measurements. 10 CFR 100.20(c) also requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

Section 2.4.1 of RS-002 provides the following criteria that was used by the NRC staff to evaluate this SSAR section.

- To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the applicant's SSAR should describe the surface and subsurface hydrologic characteristics of the site and region. This description should be sufficient to assess the acceptability of the site and the potential for those characteristics to influence the design of the SSCs of a nuclear unit(s) that might be constructed on the proposed site.

- Meeting Section 2.4.1 of RS-002 provides reasonable assurance that the hydrologic characteristics of the site and potential hydrologic phenomena will pose no undue risk to the type of facility proposed for the site. Further, it provides reasonable assurance that such a facility will pose no undue risk of radioactive contamination to surface or subsurface water from either normal operations or as the result of a reactor accident.

- To meet the requirements of the hydrologic aspects of 10 CFR Part 52 and 10 CFR Part 100, the applicant's SSAR should form the basis for the hydrologic engineering analysis with respect to subsequent sections of the application for an ESP. Therefore, completeness and clarity are of paramount importance. Maps should be legible and adequate in their coverage to substantiate applicable data. Site topographic maps should be of good quality and of sufficient scale to allow independent analysis of preconstruction drainage patterns. Data on surface water users, location with respect to the site, type of use, and quantity of surface water used are necessary. Inventories of surface water users should be consistent with regional hydrologic inventories reported by applicable Federal and State agencies. The description of the hydrologic characteristics of streams, lakes, and shore regions should correspond to those of the USGS, NOAA, Soil Conservation Service (SCS), USACE, or appropriate State and river basin agencies. Applicants should describe all existing or proposed reservoirs and dams (both upstream and downstream) that could influence conditions at the site. Descriptions may be obtained from reports of USGS, U.S. Bureau of Reclamation (USBR), USACE, and others. Generally, reservoir descriptions of a quality similar to those contained in pertinent datasheets of a standard USACE hydrology design memorandum are adequate. Tabulations of drainage areas, types of structures, appurtenances, ownership, seismic and spillway design criteria, elevation-storage relationships, and short- and long-term storage allocations should be provided.

2.4.1.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the applicant's technical information presented in the SSAR; and (2) NRC staff's technical evaluation of the hydrology near the site, including appropriateness of the data used by the applicant in its SSAR.

2.4.1.3.1 Technical Information Presented by the Applicant

In Section 2.4 of the SSAR, the applicant described the site area and the facilities that currently exist on the proposed site, including the hydrological and geological setting. In addition, the description included the hydrologic characteristics of the Savannah River Basin along with the major dams and multipurpose projects that manage water supply and provide flood control within the basin. The applicant described that the VEGP site is located on the southeast side of the Savannah River, approximately 15 miles east-northeast of Waynesboro, Georgia, 26 miles southeast of Augusta, Georgia, and 100 miles north-northwest of Savannah, Georgia (SNC, 2006). The VEGP site is located approximately 150 river miles upstream of the mouth of the Savannah River. Elevations in the Savannah River basin range from sea level at the mouth to 5030 ft mean sea level (MSL) at Little Bald Peak in North Carolina. The Savannah River system drains a total of 10,577 square miles. The contributing watershed area of the Savannah River near the VEGP site is approximately 8304 square miles. There are 14 dams in the Savannah River Basin upstream of the VEGP site (SNC, 2006) owned and operated by the U.S. Army Corps of Engineers (USACE) or one of several power generation companies in Georgia and South Carolina. The entire 312-mile reach of the Savannah River is regulated by three major USACE multipurpose projects. The three reservoirs created by these projects are

Hartwell Lake and Dam, Richard B. Russell Lake and Dam, and J. Strom Thurmond Lake and Dam (also known as Clarks Hill Lake and Dam).

The applicant mentioned that the average daily discharge at the USGS gauge 02197320, Savannah River near Jackson, SC, which is located approximately six river miles upstream of the VEGP site, based on 31 years of data is 8913 cubic feet per second (cfps) (SNC, 2006). Based on the same record, the average discharge at this location varies from 7216 cfps in September to 11,347 cfps in March.

The applicant described that the VEGP site is located on a high bluff on the west bank of the Savannah River and has an area of approximately 3169 acres (SNC, 2006). The grade elevations of proposed Units 3 and 4 will be 220 feet MSL or higher. Approximately 4 miles from the VEGP site, Georgia State Highway 23 runs along a topographic ridgeline. The ridgeline separates drainages that generally flow northeast towards the Savannah River from drainages that generally flow to the southwest.

The applicant also detailed the local site drainage at the VEGP site, the current water uses within the Savannah River Basin, and the proposed water consumption for the two new units. A storm water drainage system exists on the VEGP site. This system was developed during construction of existing Units 1 and 2 and provides drainage away from the site. Surface runoff from the high ground where Units 1 and 2 are located is collected in four major drainage channels that are aligned with access roads and railroad facilities (SNC, 2006). The outfall of the drainage channels is to the north, the south, the east, and the west of the site.

The applicant described that annual peak discharges in the Savannah River at Augusta, Georgia, reported by the USGS based on observed streamflow at gauge 02197000, located approximately 48.7 miles upstream of the VEGP site, are presented in the SSAR (SNC, 2006). The annual peak discharges were estimated by USGS for water years (October 1 of the previous calendar year through September 30 of current year) 1796, 1840, 1852, 1864, 1865, and 1876. The maximum annual peak discharge in the period of record is 350,000 cfps, observed on October 2, 1929. The oldest annual peak discharge, on January 17, 1796, was estimated from reported river stages using slope-conveyance methods. The estimated values of the peak discharge on this date vary from 280,000 cfps for a reported stage of 38 feet to 360,000 cfps for a reported maximum flood stage of 40 feet. Based on the elevation of the USGS gauge 02197000 being 96.58 feet MSL, the maximum historic flood elevation of the Savannah River at Augusta, Georgia is estimated between 134.6 and 136.6 feet MSL (SNC, 2006).

Average daily and annual peak discharge data for nine streamflow gauges maintained by the USGS on the Savannah River were used in preparation of SSAR Sections 2.4.11 and 2.4.2, respectively.

Unregulated annual peak discharge values for the period after 1952 were estimated by modeling using the 1990 reservoir operation rules and the stage-storage-discharge characteristics of the three major USACE projects. Estimates of regulated peak discharge values for the period prior to 1952 were also generated using the same approach. Four USGS topographic quadrangles were used to create a map of the topography at the VEGP site. Cross-section profiles of the Savannah River at several locations were used in the SSAR. Air temperature records from eight NWS meteorological stations were used to analyze historical air temperature variations in the SSAR.

2.4.1.3.2 NRC Staff's Technical Evaluation

The NRC staff reviewed the description of the site region, general location and hydrologic interfaces of the VEGP site, and the description of the local site drainage provided by the applicant. The NRC staff independently obtained descriptions and maps of the general region surrounding the VEGP site. The NRC staff created Figure 2.4.1-1 that shows a map of the region where the VEGP site is located. The estimated distances from the VEGP site to the Georgia cities of Augusta, Waynesboro, and Savannah, are 25.7, 14.8, and 83.2 miles, respectively.

The Savannah River Basin straddles the State boundary between Georgia and South Carolina (Figure 2.4.1-2). The NRC staff created the map shown in Figure 2.4.1-2 by using USGS hydrologic unit codes geographical information system (GIS) coverages from the Natural Resources Conservation Service Geospatial Data Gateway. The Savannah River Basin consists of 9 level 4 and 312 level 6 hydrologic unit codes (Seaber et al., 1987), with a total area of 10,218 square miles. The area of the Savannah River Basin estimated from the GIS coverages is 3.4 percent less (10,218 square miles versus 10,577 square miles) than that reported by SNC (2006). The NRC staff's research indicated that the Nature Conservancy (2007) reports the area of the Savannah River Basin as 10,577 square miles. The contributing drainage area at the streamflow gauge at Hardeeville, South Carolina, about 10 miles above the mouth of the Savannah River, is approximately 10,250 square miles (Cooney et al., 2005). The differences in the reported drainage areas for the Savannah River Basin are minor and are not expected to result in any significant differences in estimation of the probable maximum participation (PMP) or the probable maximum flood (PMF) for the Savannah River Basin. The estimation of the drainage area is an intermediate step in the determination of the probable maximum flood in streams and rivers.

Based on its independent assessment, the NRC staff concluded that the applicant presented sufficient information related to hydrologic description in SSAR Section 2.4.1. Later sections of this SER describe the NRC staff's review of hydrological causal mechanisms, water uses, data, and conceptual models.

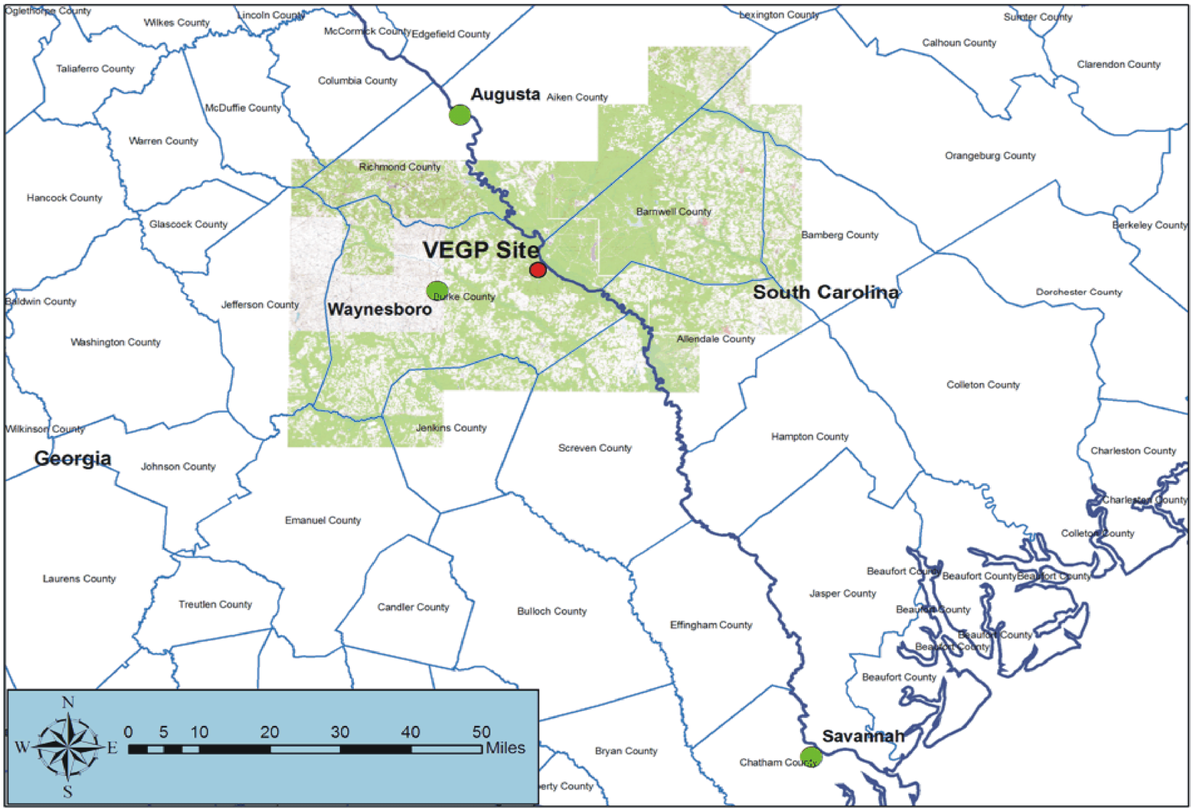


Figure 2.4.1-1 - Location map of the VEGP site

The cities of Augusta, Waynesboro, and Savannah are 25.7, 14.8, and 83.2 miles from the site, respectively. The Savannah River marks the state boundary between South Carolina and Georgia near the VEGP site.

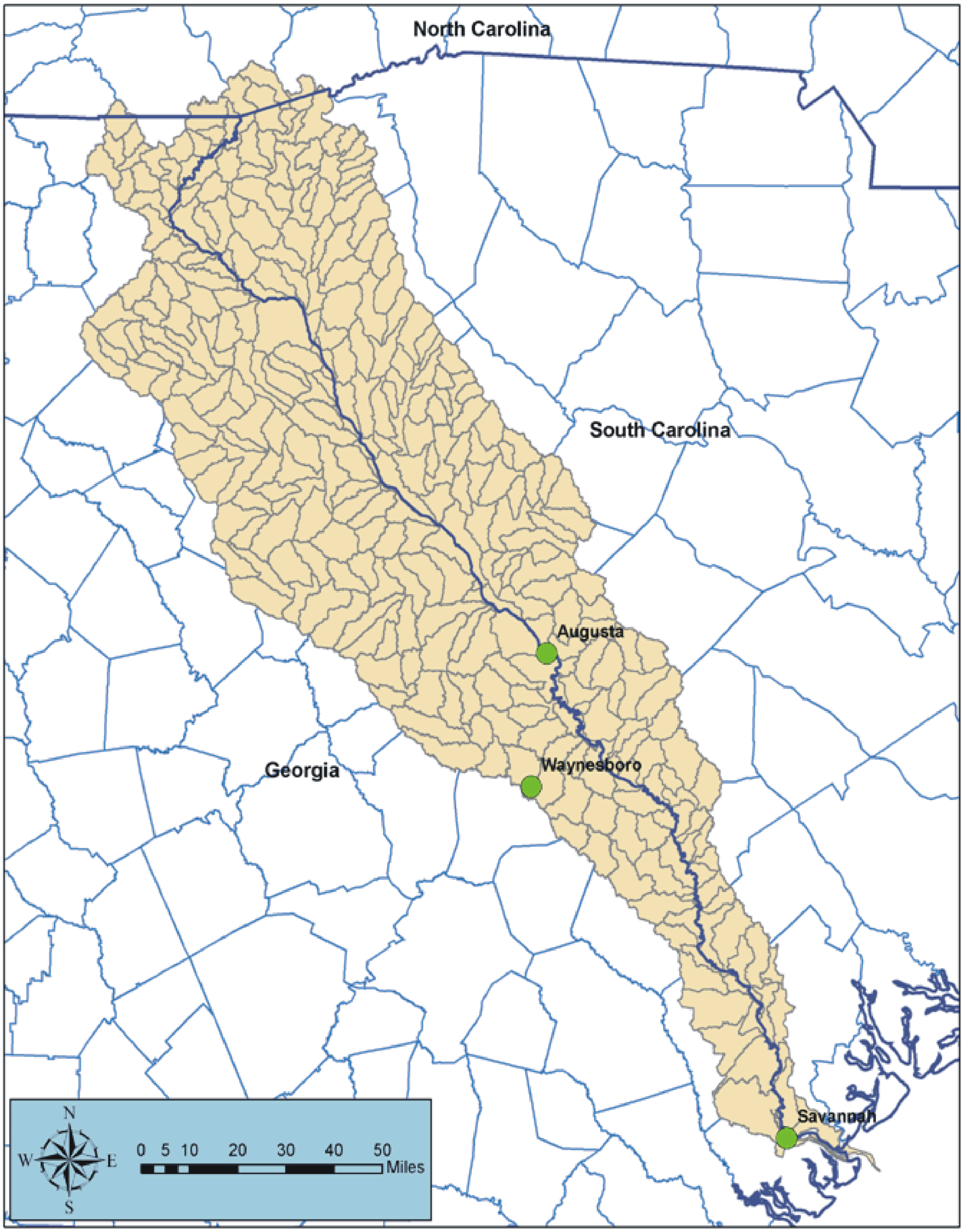


Figure 2.4.1-2 - The Savannah River Basin that straddles the state boundary between Georgia and South Carolina. Portions of the headwaters lie in North Carolina.

2.4.1.4 Conclusion

As set forth above, the applicant has presented and substantiated sufficient information pertaining to the hydrologic description at the proposed site. Section 2.4.1 of RS-002 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the hydrology in the vicinity of the site and site regions, including interface of the plant with the hydrosphere, hydrological causing mechanisms, surface and ground water uses, spatial and temporal data sets, and alternate conceptual models of site hydrology.

Therefore, the NRC staff concludes that the identification and consideration of the hydrological setting of the site set forth above are acceptable and meet the applicable requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d). In view of the above, the NRC staff finds the applicant's proposed site characterization related to the hydrological setting for the ESP application to be acceptable.

2.4.2 Floods

Section 2.4.2 of the SSAR identified historical flooding (defined as occurrences of abnormally high water stage or overflow from a stream, floodway, lake, or coastal area) at the proposed site or in the region of the site. The applicant, in Section 2.4.2 of the SSAR, summarized and identified the individual types of flood-producing phenomena, and combinations of flood-producing phenomena, considered in establishing the flood design bases for safety-related plant features. In addition, the SSAR covered the potential effects of local intense precipitation. Although topical information may appear in SSAR Sections 2.4.3 through 2.4.7 and Section 2.4.9, the types of events considered and the controlling event are reviewed in this section of the SER.

The NRC staff reviews the flood history and the potential for flooding for the sources and events listed below. Factors affecting potential runoff (such as urbanization, forest fire, or change in agricultural use), erosion, and sediment deposition are considered in the NRC staff's review. In addition to describing flood history, the applicant also determined the local intense precipitation on the site in order to estimate local flooding. Local intense precipitation is reported as a site characteristic used in site grading design. The NRC staff's review of the SSAR covered¨ (1) local flooding on the site and drainage design; (2) stream flooding; (3) surges; (4) seiches; (5) tsunami; (6) seismically induced dam failures (or breaches); (7) flooding caused by landslides; (8) effects of ice formation in water bodies; (9) combined events criteria; (10) consideration of other site-related evaluation criteria; and (11) additional information for 10 CFR Part 52 applications.

2.4.2.1 Introduction

The VEGP site is located on the southeast side of the Savannah River, approximately 15 miles east-northeast of Waynesboro, Georgia, 26 miles southeast of Augusta, Georgia, and 100 miles north-northwest of Savannah, Georgia (SNC, 2006). The VEGP site is located approximately

150 river miles upstream of the mouth of the Savannah River. Elevations in the Savannah River basin range from sea level at the mouth to 5030 feet MSL at Little Bald Peak in North Carolina. The Savannah River system drains a total of 10,577 square miles. The contributing watershed area of the Savannah River near the VEGP site is approximately 8304 square miles.

There are 14 dams in the Savannah River Basin upstream of the VEGP site (SNC, 2006), which are owned and operated by the USACE or one of several power generation companies in Georgia and South Carolina. The three major USACE multipurpose projects regulate the entire 312-mile reach of the Savannah River. The three reservoirs created by these projects are Hartwell Lake and Dam, Richard B. Russell Lake and Dam, and J. Strom Thurmond Lake and Dam (also known as Clarks Hill Lake and Dam).

The VEGP site is located on a high bluff on the west bank of the Savannah River and has an area of approximately 3169 acres (SNC, 2006). The grade elevations of the proposed Units 3 and 4 will be 220 feet MSL or higher. Approximately 4 miles from the VEGP site, Georgia State Highway 23 runs along a topographic ridgeline. The ridgeline separates drainages that generally flow northeast toward the Savannah River from drainages that generally flow to the southwest.

Potential causes of floods at the VEGP site are local runoff from intense point-rainfall near the site and flooding in the Savannah River caused by precipitation in the river basin or floods from cascading failure of upstream dams on the river. The VEGP site is located approximately 150 river miles inland from the ocean; therefore, flooding caused by surges, seiches, and oceanic tsunamis is unlikely to occur. Section 2.4.7 of the SERs addresses Ice-related events that may result in flooding.

2.4.2.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.20(c), also requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

Section 2.4.2 of RS-002 provides the review guidance that the NRC staff used to evaluate this SSAR section.

- To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of the surface and subsurface hydrologic characteristics of the site and region and an analysis of the PMF. This description should be sufficient to assess the acceptability of the site and the potential for those characteristics to influence the design of plant SSCs important to safety. Meeting this guidance provides reasonable assurance that the hydrologic characteristics of the site and potential hydrologic phenomena will pose no undue risk to the type of facility proposed for the site.

As stated in Section 2.4.2 of RS-002, to judge whether the applicant has met the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the NRC uses the following criteria:

- For SSAR Section 2.4.2.1 (Flood History), the NRC staff compares the potential flood sources and flood response characteristics of the region and site identified in its review (as described in the review procedures) to those identified by the applicant. If similar, the NRC staff accepts the applicant's conclusions. If, in the NRC staff's opinion, significant discrepancies exist, the applicant must provide additional data, reestimate the effects on a nuclear unit(s) of a specified type that might be constructed on the proposed site, or revise the applicable flood design bases, as appropriate.

- For SSAR Section 2.4.2.2 (Flood Design Considerations), the applicant's estimate of controlling flood levels is acceptable if it is no more than 5 percent less conservative than the NRC staff's independently determined (or verified) estimate. If the applicant's SSAR estimate is more than 5 percent less conservative, the applicant should fully document and justify its estimate of the controlling level. Alternatively, the applicant may accept the NRC staff's estimate.

- For SSAR Section 2.4.2.3 (Effects of Local Intense Precipitation), the applicant's estimates of the local PMP and the capacity of site drainage facilities (including drainage from the roofs of buildings and site ponding) are acceptable if the estimates are no more than 5 percent less conservative than the corresponding NRC staff assessment. Similarly, conclusions relating to the potential for any adverse effects of blockage of site drainage facilities by debris, ice, or snow should be based upon conservative assumptions of the storm and vegetation conditions likely to exist during storm periods. If a potential hazard does exist (e.g., the elevation of ponding exceeds the elevation of plant access openings), the applicant should document and justify the local PMP basis.

- The NRC staff used the appropriate sections of several documents to determine the acceptability of the applicant's data and analyses in meeting the requirements of 10 CFR Part 52 and 10 CFR Part 100. RG 1.59, Revision 2, "Design Basis Floods for Nuclear Power Plants," issued August 1977, provides guidance for estimating the design-basis flooding considering the worst single phenomenon, as well as combinations of less severe phenomena. The NRC staff used the publications of USGS, NOAA, SCS, USACE, applicable State and river basin authorities, and other similar agencies to verify the applicant's data relating to the hydrologic characteristics and extreme events in the region.

2.4.2.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the applicant's technical information presented in the SSAR; and (2) the NRC staff's technical evaluation to determine the potential for site flooding due to various flooding mechanisms.

2.4.2.3.1 Technical Information Presented by the Applicant

Flood History

In Section 2.4.2 of the SSAR, the applicant characterized the historical flooding in streams near the VEGP site using the discharge record at the USGS gauge 02197000, located on the Savannah River at Augusta, Georgia, approximately 48.7 river miles upstream of the site (SNC, 2006). The maximum annual peak flood discharge of 350,000 cfps was reported on October 2, 1929. The discharge on January 17, 1796 was estimated to be between 280,000 cfps for a reported stage of 38 feet (USGS, 2006; gauge datum at 96.58 feet MSL) and 360,000 cfps for a reported stage of 40 feet (USGS, 1990). Based on an elevation of 96.58 feet MSL for the Augusta, Georgia stream gauge datum, the applicant concluded that the historical maximum stage of the Savannah River near the VEGP site is, therefore, between 134.6 and 136.6 feet MSL.

The applicant noted that the average annual peak discharges have declined since the three dams were constructed on the Savannah River (SNC, 2006).

Design-Basis Flood

The applicant selected the design-basis flood from several flooding scenarios including an approximate estimate of the PMF, flooding caused by local intense precipitation on local drainages, and potential dam-failure-generated floods with coincident wind setup and wave runup (SNC, 2006). Flooding from storm surges, seiches, and tsunamis was not considered since the VEGP site is located approximately 150 river miles inland from the Atlantic Coast (SNC, 2006).

The applicant determined that the design-basis flood for the VEGP site is a flood generated by an upstream breach of dams with coincident wind setup and wave runup. SSAR Section 2.4.4 provides a detailed estimation of this flooding event, which was reviewed by the NRC staff in Section 2.4.4 below.

Local Intense Precipitation

The local intense precipitation was estimated from the recommendations of Hydrometeorological Report Nos. 51 and 52 (SNC, 2006). The 6-hour, 10-square miles PMP depth was estimated from Hydrometeorological Report No. 51 for the location of the VEGP site. A multiplier for the VEGP site was estimated from Hydrometeorological Report No. 52 that, when applied to the 6-hour, 10-square miles PMP depth, yielded the 1-hour, 1-square mile PMP depth. Another set of multipliers for the VEGP site was also obtained from Hydrometeorological

Report No. 52. This set of multipliers was applied to the 1-hour, 1-square mile PMP depth to obtain PMP depths at 30, 15, and 5 minutes. The applicant's local intense precipitation is presented in Table 2.4.2-1.

Table 2.4.2-1 - Local Intense Precipitation Depths for Various Durations at the VEGP Site

Duration	Area (square miles)	Multiplier	Applied to	Local Intense Precipitation (inches)
6 hours	10	NA	NA	31.0
1 hour	1	0.620	6-hour, 10-square miles value	19.2
30 minutes	1	0.736	1-hour, 1-square mile value	14.1
15 minutes	1	0.509	1-hour, 1-square mile value	9.8
5 minutes	1	0.323	1-hour, 1-square mile value	6.2

2.4.2.3.2 NRC Staff's Technical Evaluation

The NRC staff's technical evaluation consisted of a review of the data and methods presented in the applicant's SSAR. Sections 2.4.2 through 2.4.7, and 2.4.9 of the SER describe the NRC staff's review of various flooding mechanisms. Based on these reviews, the NRC staff verified that the design-basis flooding scenario at the VEGP site consisted of a domino-type dam-failure scenario-generated flood, and coincident wind setup and wave runup scenario.

The NRC staff independently estimated the local intense precipitation for the VEGP site in order to verify applicant's submission in SSAR Section 2.4.2. Hydrometeorological Report No. 52 recommends that local intense precipitation or point precipitation be estimated as a 1-hour, 1-square mile PMP event. Hydrometeorological Report No. 52 presents a set of maps of estimated PMP depths for several durations ranging from 6 to 72 hours and several areas ranging from 10 to 20,000 square miles. The PMP approach only addressed areas 10 square miles and larger and durations of 6 hours and greater. In order to estimate PMP depths at a point (essentially a 1 square mile area) and for durations of 1 hour and less, Hydrometeorological Report No. 52 recommends the use of a set of multipliers to first estimate the 1-hour, 1-square mile PMP depth from the 6-hour, 10-square miles PMP depth followed by the application of the multipliers to the 1-hour, 1-square mile PMP depth to obtain shorter-duration PMP depths for a 1-square mile area.

The 6-hour, 10-square miles PMP for the VEGP site location was estimated from the PMP depth map corresponding to 6-hour duration and 10-square miles drainage area. Hydrometeorological Report No. 52 maps of multipliers were used to obtain the set of multipliers for the VEGP site. Table 2.4.2-2 shows the NRC staff's estimate of the local intense precipitation.

Table 2.4.2-2 - The NRC Staff-estimated Local Intense Precipitation Depths for Various Durations at the VEGP Site

Duration	Area (square miles)	Multiplier	Applied to	Local Intense Precipitation (inches)
6 hours	10	NA	NA	31.0
1 hour	1	0.621	6-hour, 10-square miles value	19.3
30 minutes	1	0.738	1-hour, 1-square mile value	14.2
15 minutes	1	0.509	1-hour, 1-square mile value	9.8
5 minutes	1	0.323	1-hour, 1-square mile value	6.2

The NRC staff concluded that the local intense precipitation values reported by the applicant in the SSAR are essentially identical (less than 5% different) to those independently estimated by the NRC staff and, thus, are acceptable. The local intense precipitation values reported by the applicant in Table 2.4.2-3 of the SSAR will be used as a site characteristic for the VEGP site.

2.4.2.4 Conclusion

The NRC staff independently confirmed the local intense precipitation values estimated and presented by the applicant in SSAR Section 2.4.2. The local intense precipitation values reported by the applicant in Table 2.4.2-3 of the SSAR will be used as a site characteristic for the VEGP site. As discussed in Section 2.4.4 of this SER, the NRC staff also verified that the controlling flood for the VEGP site consists of a domino-type dam failure scenario-generated flood and coincident wind setup and wave runup scenario.

The applicant has presented and substantiated sufficient information pertaining to the local intense precipitation, flooding causal mechanisms, and the controlling flooding mechanism at the proposed site. RS-002, Section 2.4.2 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the local intense precipitation, flooding causal mechanisms, and the controlling flooding mechanism in the vicinity of the site and site regions. The applicant considered the most severe natural phenomena that have been historically reported for the site and surrounding area, and reasonable combinations of these phenomena in establishing the design-basis information pertaining to the local intense precipitation, flooding causal mechanisms, and the controlling flooding mechanism. The applicant's analysis contained sufficient margin for the limited accuracy, quantity, and period of time in which the historical data has been accumulated. As documented in SERs for previous licensing actions, the NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in these site characteristics. Accordingly, the NRC staff concludes that the use of these methodologies results in site characteristics containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. The site characteristics previously identified are acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

Therefore, the NRC staff concludes that the identification and consideration of the local intense precipitation, flooding causal mechanisms, and the controlling flooding mechanism set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d).

In view of the above, the NRC staff finds the applicant's proposed site characteristics related to the local intense precipitation for inclusion for the ESP application to be acceptable.

2.4.3 Probable Maximum Flood (PMF) On Streams And Rivers

In this section of the SSAR, the applicant developed the hydrometeorological design basis to determine the extent of any flood protection required for those SSC necessary to ensure the capability to shut down the reactor and maintain it in a safe shutdown condition. The NRC staff's review of the SSAR covers: (1) design bases for flooding in streams and rivers; (2) design bases for site drainage; (3) consideration of other site-related evaluation criteria; and (4) additional information for 10 CFR Part 52 applications.

2.4.3.1 Introduction

The VEGP site is located on the southeast side of the Savannah River, approximately 15 miles east-northeast of Waynesboro, Georgia; 26 miles southeast of Augusta, Georgia; and 100 miles north-northwest of Savannah, Georgia (SNC, 2006). The VEGP site is located approximately 150 river miles upstream of the mouth of the Savannah River. The Elevations in the Savannah River basin range from sea level at the mouth to 5030 feet MSL at Little Bald Peak in North Carolina. The Savannah River system drains a total of 10,577 square miles. The contributing watershed area of the Savannah River near the VEGP site is approximately 8304 square miles.

A PMP in the watershed of the Savannah River can cause a flood near the site. The NRC staff's evaluation in this section consisted of verifying the applicant's approach for estimating the PMF in the Savannah River near the VEGP site and independently estimating the PMF.

2.4.3.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.20(c), also requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

To evaluate the information provided in SSAR 2.4 per the above acceptance criteria, applicant applied the NRC-endorsed analytical methodologies found in RG 1.59, Revision 2, issued August 1977.

Section 2.4.3 of RS-002 provides the review guidance used by the NRC staff to evaluate this SSAR section.

- To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of the hydrologic characteristics of the site and region and an analysis of the PMF. This description should be sufficient to assess the acceptability of the site and the potential for those characteristics to influence the design of SSCs important to safety for a nuclear unit(s) of a specified type that might be constructed on the proposed site. Meeting this guidance provides reasonable assurance that any hydrologic phenomena of severity up to and including the PMF will pose no undue risk to the type of facility proposed for the site.

- To judge whether the applicant has met the requirements of the hydrologic aspects of 10 CFR Part 52 and 10 CFR Part 100, the NRC uses specific criteria.

- The PMF, as defined in RG 1.59, has been adopted as one of the conditions to be evaluated in establishing the applicable stream and river flooding design basis referenced in GDC 2. PMF estimates are needed for all adjacent streams or rivers and site drainage (including the consideration of PMP on the roofs of safety-related structures). The criteria for accepting the applicant's PMF-related design basis depend on one of the following three conditions:

    1. The elevation attained by the PMF (with coincident wind waves) establishes a necessary protection level to be used in the design of the facility.

    2. The elevation attained by the PMF (with coincident wind waves) is not controlling; the design-basis flood protection level is established by another flood phenomenon (e.g., the probable maximum hurricane (PMH)).

    3. The site is "dry"; that is, the site is well above the elevation attained by a PMF (with coincident wind waves).

- When condition (1) is applicable, the NRC staff will assess the flood level. The NRC staff may perform this assessment independently from basic data, by detailed review and checking of the applicant's analyses, or by comparison with estimates made by others that have been reviewed in detail. The applicant's estimates of the PMF level and the coincident wave action are acceptable if the estimates are no more than 5 percent less conservative than the NRC staff estimates. If the applicant's estimates of discharge are more than 5 percent less conservative than the NRC staff's, the applicant should fully document and justify its estimates or accept the NRC staff estimates.

- When condition (2) or (3) applies, the NRC staff analyses may be less rigorous. For condition (2), acceptance is based on the protection level estimated for another flood-producing phenomenon exceeding the NRC staff estimate of PMF water levels. For condition (3), the site grade should be well above the NRC staff assessment of PMF water levels. The evaluation of the adequacy of the margin (difference in flood and site elevations) is generally a matter of engineering judgment. Such judgment is based on the confidence in the flood-level estimate and the degree of conservatism in each parameter used in the estimate.

- The NRC staff used the appropriate sections of several documents to determine the acceptability of the applicant's data and analyses. RG 1.59 provides guidance for estimating the PMF design basis. Publications by NOAA and USACE may be used to estimate PMF discharge and water level conditions at the site, as well as coincident wind-generated wave activity.

2.4.3.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the applicant's technical information presented in the SSAR; and (2) NRC staff's technical evaluation to determine the potential for site flooding due to PMF.

2.4.3.3.1 Technical Information Presented by the Applicant

The proposed site grade for the new units is 220 feet MSL. The applicant reviewed studies and analysis that were performed for the existing VEGP units to verify that its conclusions are valid for proposed units. The applicant also performed an approximate PMF estimation as described in RG 1.59 to alternatively estimate the maximum flood stage in the Savannah River near the VEGP site.

Previous Studies

For the original VEGP Units 1 and 2, the applicant used two approaches in determining the PMF in the Savannah River near the VEGP site.

- The first approach used PMP values estimated from Hydrometeorological Report Nos. 51 and 52 and routed the PMP using the U.S. Army Corps of Engineers (USACE) HEC-1 Flood Hydrograph Computer Program. The watershed that was upstream of the Thurmond Dam was characterized by NWS-estimated unit hydrographs of 10 subbasins. The applicant used the USACE DAMBRK computer program to model separately the valley storage below the Thurmond Dam. The peak PMF discharge at the VEGP site was reported as 895,000 cfps when ignoring valley storage and as 540,000 cfps when accounting for valley storage. The associated flood water surface elevations were 136 feet MSL and 126 feet MSL, respectively. The flood water surface elevation with coincident wind wave action was reported as 163 feet MSL and 153 feet MSL.

- In the second approach, the USACE DAMBRK computer program was used to route the USACE-derived PMF outflow hydrograph from the Thurmond Dam to the VEGP site and combining the PMF outflow hydrograph with the PMF discharge of the drainage area downstream of this dam. The PMF discharge in the Savannah River near the VEGP site was estimated as 710,000 cfps with a corresponding water surface elevation of 138 feet MSL. The PMF water surface elevation with coincident wind wave action was estimated as 165 feet MSL.

Approximate PMF Estimation

The applicant used the alternative method for estimation of the PMF described in RG 1.59. The PMF values corresponding to 100, 500, 1000, 5000, 10,000, and 20,000 square miles of contributing areas were obtained from PMF isoline maps given in RG 1.59. The applicant estimated a best-fit power curve to this data and used the estimated power curve to predict the PMF in the Savannah River near the VEGP site. The applicant estimated that the PMF at the VEGP site corresponding to a contributing area of 8,304 square miles is 920,000 cfps.

In SSAR Section 2.4.4, the applicant simulated floods caused by dam failure to determine the flood water surface elevation that corresponded to the PMF discharge from a stage-discharge relationship obtained from a steady-state backwater analysis for the Savannah River. The flood water surface elevation corresponding to the peak PMF discharge was 138.8 feet MSL.

As described in SSAR Section 2.4.4, the applicant used a 50 miles per hour windspeed over a fetch of 11 miles to estimate the wind setup and wave runup. The estimated wind setup and wave runup was 11.3 feet. The PMF water surface elevation with coincident wind wave action was estimated as 150.1 feet MSL, 69.9 feet below the proposed site grade. As such, the applicant concluded that the VEGP site is a dry site.

2.4.3.3.2 NRC Staff's Technical Evaluation

NRC staff's technical evaluation consisted of reviewing the data and methods presented in the applicant's SSAR. The NRC staff independently estimated the PMF and performed an assessment of impacts for flooding on the VEGP site.

In order to verify the applicant's submittal related to PMF in the Savannah River near the VEGP site, the NRC staff carried out an independent and conservative estimate of the PMF. The NRC staff first estimated the PMP in the Savannah River Basin, as described in Hydrometeorological Report Nos. 51 and 52. The cumulative PMP depths for 6, 12, 24, 48, and 72 hours were obtained from the PMP maps in Hydrometeorological Report No. 51 for drainage areas of 10, 200, 1000, 5000, 10,000, and 20,000 square miles (Table 2.4.3-1). The NRC staff plotted a set of depth-area-duration curves for the PMP values (Figure 2.4.3-1).

Table 2.4.3-1 - PMP Depths for Various Drainage Areas and Durations near the VEGP Site

Area (square miles)	Duration (hours)				
	6	12	24	48	72
10	31.0	37.0	43.8	48.2	51.0
200	23.0	27.9	35.0	38.0	42.0
1000	16.9	22.5	28.5	33.5	35.2
5000	9.7	14.0	19.3	23.8	27.5
10000	7.4	11.1	15.8	20.0	23.3
20000	5.4	8.8	12.5	16.2	19.2

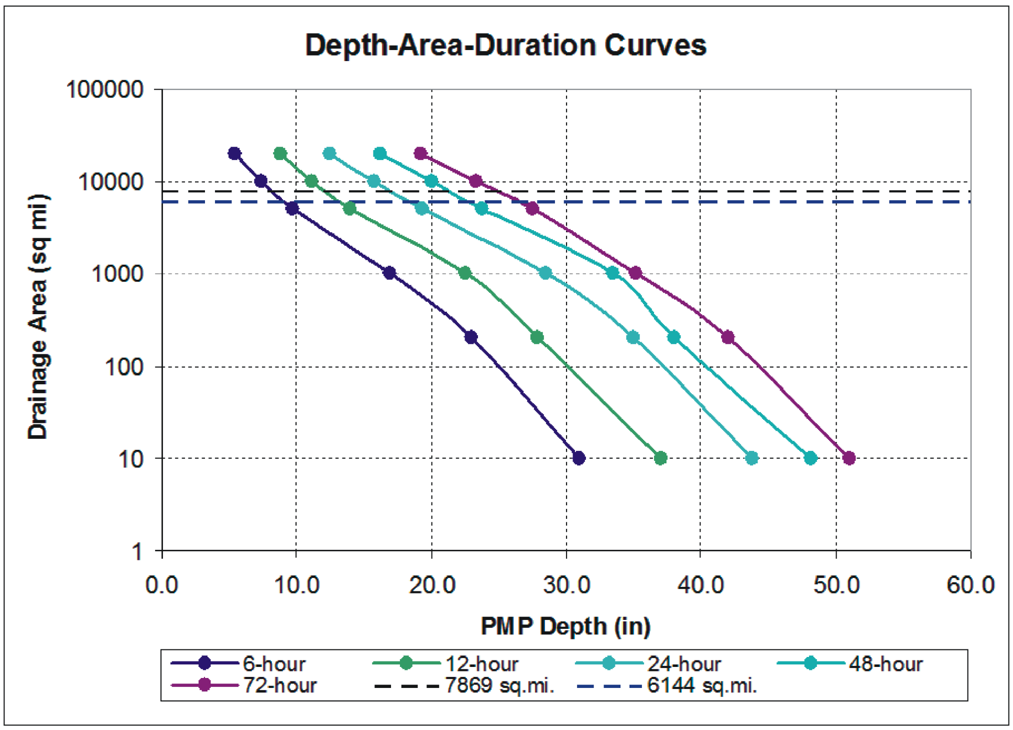


Figure 2.4.3-1 - PMP Depth-Area-Duration Curves Near the VEGP site

The drainage area at the VEGP site was estimated from the hydrologic unit codes that drain areas upstream of the site. The NRC staff estimated the drainage area at the VEGP site to be 7869 square miles. The cumulative PMP values for durations of 6, 12, 24, 48, and 72 hours were then estimated for the corresponding drainage area of the Savannah River near the VEGP site from the depth-area-duration plot (Table 2.4.3-2).

Table 2.4.3-2 - Cumulative PMP for the Savannah River Drainage Area Upstream of the VEGP Site

Area (square miles)	Duration (hours)				
	6	12	24	48	72
7869	8.2	12.1	17.1	21.3	24.9

The incremental PMP depths were calculated from the estimated cumulative PMP depths and the recommended procedure of the American National Standards Institute/American Nuclear Society (ANSI/ANS) Standard 2.8-1992 to estimate the time distribution of the 72-hour PMP storm at 6-hour increments (Table 2.4.3-3).

Table 2.4.3-3 - Incremental 6-hourly PMP Values of the 72-hour PMP Storm for the Savannah River Drainage Near the VEGP Site

6-hr period	Depth (inches)	Group	ANSI/ANS-2.8-1992 Rearrange	PMP Depth (inches)	Time (hour)
1	8.20	1	2.50	1.05	6
2	3.90		3.90	1.05	12
3	2.50		8.20	1.05	18
4	2.50		2.50	1.05	24
5	1.05	2	1.05	2.50	30
6	1.05		1.05	3.90	36
7	1.05		1.05	8.20	42
8	1.05		1.05	2.50	48
9	0.90	3	0.90	0.90	54
10	0.90		0.90	0.90	60
11	0.90		0.90	0.90	66
12	0.90		0.90	0.90	72

In order to estimate the flooding hazard at the VEGP site from a PMF in the Savannah River, the NRC staff adopted a bounding approach. The NRC staff started with a very conservative scenario under which the PMF is obtained by assuming that no losses occur during the PMP event and all of the runoff generated within the drainage area of the Savannah River upstream of the VEGP site is instantaneously delivered to the river near the VEGP site. Under this extremely conservative scenario of PMF generation, the NRC staff estimated the peak PMF discharge in the Savannah River near the VEGP site as 6.94 million cfps by multiplying the drainage area with the precipitation depth during the 6–hour period with maximum estimated PMP precipitation. Then the volume of water thus obtained was converted to an average discharge during that 6-hour period. The stage-discharge relationship estimated during the review of dam failure-generated floods, described in Section 2.4.4 of this report, indicated that the water surface elevation corresponding to a discharge of 6.94 million cfps would exceed the site grade. The NRC staff determined that this first PMF estimation approach was unnecessarily conservative. Therefore the NRC staff refined its approach for estimating the PMF in the Savannah River near the VEGP site.

In this new approach, the NRC staff estimated the PMF inflow into the Thurmond Lake and then the routed outflow from the Thurmond Dam to the VEGP site. The NRC staff estimated the PMP storm over the 6144 square miles of contributing area for Thurmond Lake, following the same procedure described above for estimation of the PMP storm for the 7689 square miles contributing area at the VEGP site. The NRC staff estimated the maximum depth of PMP for any 6-hour duration in the PMP storm for the contributing area of the Thurmond Lake to be 8.9 inches. In addition, the NRC staff estimated the corresponding maximum PMF inflow into Thurmond Lake assuming no losses and instantaneous translation as 5.9 million cfps. The NRC staff postulated that this inflow will then be released from the Thurmond Dam and flow downstream to the VEGP site. In Section 2.4.4, the NRC staff computed the flood from the cascading failure of the Russell Dam located upstream of the Thurmond Dam followed by the failure of the Thurmond Dam itself. The inflow into the Thurmond Lake due to the upstream failure of the Russell Dam was 6.5 million cfps. The NRC staff estimated the corresponding peak discharge as 2.5 million cfps and the corresponding water surface elevation as 170.1 feet MSL in the Savannah River near the VEGP site after being attenuated along the 70-mile river reach between the Thurmond Dam and the site. The PMF generated by a PMP in the drainage area of the Thurmond Lake would produce an inflow (5.9 million cubic feet per second) less severe than that generated by the postulated failure of the Russell Dam upstream of the Thurmond Lake (6.5 million cfps). Therefore, the NRC staff concluded that the PMF inflow into the Thurmond Lake is bounded by inflow into the Thurmond Lake caused by the postulated breach of the Russell Dam.

The NRC staff postulated that the outflow from the Thurmond Dam would combine with the flood response from the contributing area downstream of the dam and upstream of the VEGP site during the PMP event. This contributing area is 1545 square miles in size (7689 square miles contributing area at the VEGP site – 6144 square miles contributing area for the Thurmond Lake). The NRC staff estimated the peak PMF runoff from this contributing area by conservatively assuming that no losses occur during the PMP event, that the runoff generated anywhere in this area is instantaneously translated to the VEGP site, and that the timing of the peak flow from this area coincides with that of the peak flow of the discharge from the Thurmond Lake routed to the VEGP site. The NRC staff estimated the peak discharge from the 1545 square miles contributing area downstream of the Thurmond dam as approximately 1.4 million cfps (8.2 inches of excess rainfall over 1545 square miles of drainage area converted to average discharge over a duration of six hours).

The NRC staff conservatively estimated the combined peak discharge in the Savannah River near the VEGP site by adding the bounding peak discharge of 2.5 million cfps near the VEGP site to the peak PMF discharge of 1.4 million cfps from the 1545 square miles of contributing area downstream of the Thurmond Dam and upstream of the VEGP site. The bounding peak PMF discharge in the Savannah River near the VEGP site is thus estimated as 3.9 million cfps. This peak discharge is less than the 5.9 million cfps needed to raise the stillwater elevation in the Savannah River to inundate the proposed site grade of 220 feet MSL.

The NRC staff estimated the maximum wind wave runup at the VEGP site corresponding to an ANSI/ANS-2.8-1992-recommended windspeed of 50 miles per hour and a maximum fetch of 11 miles, as approximately 19 feet (see Section 2.4.4 of this SER). The NRC staff also estimated the stillwater elevation corresponding to a discharge of 3.9 million cfps in the

Savannah River near the VEGP site using the stage-discharge function estimated in Section 2.4.4 of this SER. The NRC staff-estimated stillwater elevation corresponding to a discharge of 3.9 million cfps was 194.8 feet MSL. The bounding maximum water surface elevation accounting for wind wave action was, therefore, 213.8 feet MSL (194.8 feet MSL + 19 feet). The staff emphasizes that this NRC-estimated bounding value is very conservative (beyond any scenario that would be plausibly expected), and the staff does consider the applicant's model and calculated PMF value to be acceptable. The NRC staff concluded, therefore, that the VEGP site will remain dry during a bounding PMF event in the Savannah River watershed. This conclusion meets the criterion (3) described above in Section 2.4.3.2.

2.4.3.4 Conclusion

The VEGP site is a dry site with respect to floods in rivers and streams. All safety-related SSC will be placed above the highest flood water surface elevation.

As set forth above, the applicant has presented and substantiated sufficient information pertaining to the PMF on streams and rivers at the proposed site. RS-002, Section 2.4.3 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the PMF on streams and rivers. Furthermore, the applicant considered local flooding of the site drainage under local intense precipitation in establishing design-basis information pertaining to flooding, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in this analysis, as documented in SERs for previous licensing actions. Accordingly, the NRC staff concludes that the use of these methodologies results in an analysis containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the applicant's analysis is acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

Therefore, the NRC staff concludes that the identification and consideration of the probable maximum floods on streams and rivers set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d).

In view of the above, the NRC staff finds the applicant's analysis related to the PMF on streams and rivers for the ESP application to be acceptable.

2.4.4 Potential Dam Failures

In this section of the site SSAR (SSAR), the hydrological design basis is developed to ensure that any potential hazard to the safety-related facilities resulting from the failure of onsite, upstream, and downstream water control structures are considered in plant design. The NRC staff's review of the SSAR covers: flood waves from severe breaching of an upstream dam; domino-type or cascading dam failures; dynamic effects of dam-failure induced flood waves on structures; loss of water supply at the plant due to failure of a downstream dam; effects of sediment deposition and erosion; failure of onsite water control or storage structures; potential effects of seismic and non-seismic information on the postulated design bases and how they relate to dam failures in the vicinity of the site and the site region; and additional information for 10 CFR Part 52 applications.

2.4.4.1 Introduction

The VEGP Site is located at Savannah River mile 150.9, and three large dams lie upstream of the site. Hartwell Dam, located 138 miles upstream of the VEGP site; Richard B. Russell Dam, located 108 miles upstream of the site; and J. Strom Thurmond Dam, located 71 miles upstream of the VEGP site, respectively (USACE 1996). Floods initiated by a domino-type failure of these upstream dams were found to produce a peak discharge and peak stage at the site that was larger than flood waves discussed in Section 2.4.3 of this SER (i.e., waves induced by rainfall events alone).

2.4.4.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.20(c), also requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.23, “Geologic and Seismic Siting Criteria,” as it relates to establishing the design-basis flood resulting from seismic dam failure.

To evaluate the information provided in SSAR 2.4 per the above acceptance criteria, the applicant applied the NRC-endorsed analytical methodologies found in the following:

- RG 1.70, Revision 3, issued November 1978

- RG 1.29, “Seismic Design Classification”

- RG 1.59, Revision 2, issued August 1977

- RG 1.102, Revision 1, “Flood Protection for Nuclear Power Plants,” issued September 1976.

Section 2.4.4 of RS-002 provides the review guidance that the NRC staff used to evaluate this SSAR section.

- The regulations at 10 CFR Part 52 and 10 CFR Part 100 apply to SSAR Section 2.4.4 because it addresses the site's physical characteristics, including hydrology, considered by the Commission when determining its acceptability to host a nuclear unit(s). To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of the hydrologic characteristics of the region and an analysis of potential dam failures. The description should be sufficient to assess the acceptability of the site and the potential for those characteristics to influence the design of SSCs important to safety. Meeting this criterion provides reasonable assurance that the effects of high water levels resulting from the failure of upstream dams, as well as those of low water levels resulting from the failure of a downstream dam, will pose no undue risk to the type of facility proposed for the site.

- The regulation at 10 CFR 100.23 requires consideration of geologic and seismic factors in determining site suitability. Specifically, 10 CFR 100.23(c) requires an investigation of the geologic and seismic site characteristics to permit evaluation of seismic effects on the site. Such an evaluation must consider seismically induced floods, including failure of an upstream dam during an earthquake.

- The regulation at 10 CFR 100.23 applies to SSAR Section 2.4.4 because it requires investigation of seismic effects on the site. Such effects include seismically induced floods or low water levels, which constitute one element in the Commission's consideration of the suitability of proposed sites for nuclear power plants. RG 1.70 provides more detailed guidance on the investigation of seismically induced floods, including results for seismically induced dam failures and antecedent flood flows coincident with the flood peak. Meeting this guidance provides reasonable assurance that, given the geologic and seismic characteristics of the proposed site, a nuclear unit(s) of a specified type could be constructed and operated on the proposed site without undue risk to the health and safety of the public, with respect to those characteristics.

- To judge whether the applicant has met the requirements of 10 CFR Part 52, 10 CFR Part 100, and 10 CFR 100.23 as they relate to dam failures, the NRC uses the following criteria:

    - The NRC staff will review the applicant's analyses and independently assess the coincident river flows at the site and at the dams being analyzed. ANSI/ANS-2.8-1992 provides guidance on acceptable river flow conditions to be assumed coincident with the dam failure event. To be acceptable, the applicant's estimates of the flood discharge resulting from the coincident events (which may include landslide-induced failures) should be no more than 5 percent less conservative than the NRC staff estimates. If the applicant's estimates differ by more than 5 percent, the applicant should fully document and justify its estimates or accept the NRC staff estimates.

    - The applicant should identify the location of dams and potentially likely or severe modes of failure, as well as dams or embankments built to impound water for a nuclear unit(s) that might be constructed on the proposed site. The applicant should discuss the potential for multiple, seismically induced dam failures and the domino failure of a series of dams. Approved USACE and Tennessee Valley Authority models should be used to predict the downstream water levels resulting from a dam breach. First-time use of other models will necessitate complete model description and documentation. The NRC staff will review the model theory, available verification, and application to determine the acceptability of the model and subsequent analyses. For cases that assume something other than instantaneous failure, the conservatism of the rate of failure and shape of the breach should be well documented. The applicant should present a determination of the peak flow rate and water level at the site for the worst possible combination of dam failures, a summary analysis that substantiates the condition as the critical permutation, and a description of and the bases for all coefficients and methods used. In addition, the effects of other concurrent events on plant safety, such as blockage of the river and waterborne missiles, should be considered.

- The effects of coincident and antecedent flood flows (or low flows for downstream structures) on initial pool levels should be considered. Depending upon estimated failure modes and the elevation difference between plant grade and normal river levels, it may be acceptable to use conservative, simplified procedures to estimate flood levels at the site. For cases in which calculated flood levels employing simplified methods are at or above plant grade and use assumptions which cannot be demonstrated as conservative, it will be necessary to use unsteady flow methods to develop flood levels at the site. The methods described in RS-002 (ADAMS Accession No. ML040700094), are acceptable to the NRC staff; however, other criteria could be acceptable with proper documentation and justification. Applications should summarize the computations, coefficients, and methods used to establish the water level at the site for the most critical dam failures. Coincident wind-generated wave activity should be considered in a manner similar to that discussed in Section 2.4.3 of RS-002.

2.4.4.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the information provided by the applicant; and (2) the NRC staff's technical evaluation to determine the potential for site flooding resulting from dam failure.

2.4.4.3.1 Technical Information Presented by the Applicant

In the SSAR, the applicant presented the potential for a domino-type failure of Russell and Thurmond dams to induce flooding at the VEGP site. The applicant performed the calculation using the USACE developed Hydrologic Engineering Center River Analysis System (HEC-RAS) numerical model (2005a). The NRC staff obtained the related input files though a RAI 2.4.1-1 (Enclosure Attachment 2). The applicant's simulation conservatively estimated the volume of the dams upstream of Russell Reservoir, and placed the entire flood volume of these dams in Russell Reservoir at the start of the simulation.

The applicant stated in the SSAR that Russell Dam was breached by overtopping in the HEC-RAS model. After investigating the applicant's model input files, the NRC staff determined that the dam was actually breached by a piping-type failure placed midway up the dam (elevation 420 feet MSL). The dam was assumed to breach 2 hours after the start of the simulation.

The SSAR describes how the applicant chose its breach parameters, and how the selection process applied references from the relevant technical literature. The applicant selected methods that were described in the US Bureau of Reclamation (USBR), Department of Interior (1998) Predication of Embankment Dam Breach Parameters: A Literature Review and Needs Assessment, Dam Safety Office, Water Resources Research Laboratory. These USBR methods are accepted current engineering practices. Breaches of both dams extend the full height of the each dam, and the HEC-RAS model defined them using three parameters: bottom width of the breach, left and right side slope, and breach formation time. For the Russell Dam, the bottom width was 750 feet, the side slopes were 2, and the breach time was 1.0 hour. For the Thurmond Dam, the bottom width was 755 feet, the side slopes were 2, and the breach time was 1.0 hour.

The SSAR states that the applicant assigned the initial water surface elevation in Thurmond Reservoir to be 344.7 feet MSL. After reviewing the applicant's HEC-RAS input files, the NRC staff determined that the actual initial elevation assumed in the model analysis was 342.1 feet MSL. The applicant correctly described elevation 342.1 feet MSL to be the Standard Project Flood (SPF) elevation for Thurmond Reservoir (USACE 1996).

The applicant's computed results for the unsteady dam beach and routing analysis was a peak water surface elevation of 166.8 feet MSL at the VEGP site. The computed peak flow at the VEGP site was approximately 2.3 million cfps. The applicant also computed the wave runup due to the maximum wave height. Based on ANS/ANSI 2.8 (1992), a 50 miles per hour wind was applied to the longest fetch (11.1 miles) during passage of the flood wave. The resulting maximum wave height was 7.5 feet, with a corresponding maximum runup height of 11.3 feet. After combining the runup height and the peak flood stage, the applicant computed the maximum flood level at the VEGP site as 178.1 feet MSL. This elevation is 41.9 feet below site grade.

2.4.4.3.2 NRC Staff's Technical Evaluation

NRC staff independently reviewed the applicant's estimate of the flood water height at the VEGP site resulting from a domino-type failure of upstream dams. This evaluation consisted of a steady flow analysis, used to compute the Savannah River discharge necessary for the water surface elevation at the site to reach the site grade, and (b) an unsteady flow analysis, used to compute the maximum stage and discharge in the Savannah River should an upstream domino-type dam failure occur.

Steady Flow Analysis

The NRC staff performed a steady flow analysis to compute the stage versus discharge rating curve at the VEGP site. The analysis used the current public release of HEC-RAS, version 4.0, which is a numerical model developed by the USACE HEC (HEC-RAS, 2006).

In response to RAI 2.4.1-1, the applicant provided electronically the initial geometric description of Russell and Thurmond dams and the Savannah River cross-sections between river miles 259.2 and 99.4. The applicant stated in SSAR Section 2.4.4.2 that these data were supplied in HEC-RAS format directly from the USACE, Savannah River District. The NRC staff's analysis utilized the latest public release of HEC-RAS, a numerical model developed by the HEC, USACE (HEC-RAS 2006). The NRC staff independently confirmed the geometric description of the dams and cross-sections using USACE (1996) and a 30-meter digital elevation model (DEM) data from the USGS.

The applicant-developed HEC-RAS model was modified by the NRC staff to remove cross-sections and reservoirs upstream of Thurmond Dam tailrace for the steady-state flow analysis. The NRC staff then applied a series of constant flow upstream boundary conditions ranging between 3,800 and 6,400,000 cfps to compute the rating curve for the Savannah River adjacent to the site. Based on this rating curve, the river discharge at the site necessary for the static water surface elevation to reach elevation 220 feet MSL is approximately 5.9 million cfps. This discharge is greater than 2.5 times the peak unsteady-flow discharge computed by the applicant as passing at the VEGP site during the dam break analysis. However, as discussed below, the discharge conservatively estimated by the NRC staff, using the unsteady flow analysis, did not exceed 5.9 million cfps.

Unsteady Flow Analysis

The NRC staff performed an unsteady flow analysis to examine the sensitivity of the applicant's model parameters. Using the model input files provided by the applicant, this analysis used a bounding assumption to simplify the distribution of impounded water in the Savannah River basin upstream of Thurmond Dam. This assumption assigned, as an initial condition of the model, the volume of water impounded in Russell Reservoir to be equal to the maximum volume of water impounded by all dam upstream, including Russell Dam. In other words, the initial Russell Reservoir volume assigned by the applicant, and used by the NRC staff in the unsteady-flow analysis, was 8,022,500 acre-ft. As shown in Table 2.4.4.1, this initial impounded volume was greater than the cumulative impounded volume of all reservoirs in the Savannah River watershed upstream of Russell Dam.

The NRC staff's analysis was similar to the applicant's in that Russell Dam was assumed to breach early in the simulation, followed by an overtopping breach of Thurmond Dam downstream. Both the applicant's and the NRC staff's analyses excluded all bridges and dams downstream of Thurmond Dam, which could constrict the flow of the flood wave and hence attenuate the flood at the VEGP site. The NRC staff assumed that the initial water surface elevation in Thurmond Reservoir was at the SPF level (elevation of 342.1 feet). The initial Savannah River discharge passing through Thurmond Dam before the breach and downstream, including at the VEGP Site, was 560,000 cfps. This discharge represents the SPF maximum estimated outflow at Thurmond Dam (USACE 1996).

Table 2.4.4.1 - Storage Volumes of Reservoirs Upstream of Russell Dam

Dam	River System	River Mile above Savannah River Mouth (1)	Maximum Storage (acre-feet) (2)
Bad Creek	Keowee	368.6	33,892
Jocassee	Keowee	366.5	1,287,788
Keowee	Keowee	351.5	955,586
Burton	Tallulah	381.4	108,000
Nacoochee	Tallulah	377.1	8,100
Mathis-Terrora	Tallulah	362.8	31,000
Tallulah Falls	Tallulah	359.9	2,400
Tugaloo	Tugaloo	358.1	42,200
Yonah	Tugaloo	354.9	11,700
Hartwell	Savannah	288.9	3,438,700
Russell	Savannah	259.1	1,488,166
Total			7,407,532

(1) From USACE (1996)
(2) From NID (2007)

The Russell Dam breach simulated by the applicant extended from the thalweg (elevation 345 feet) and to the top of the dam. The final bottom width of the breach was 750 feet, and the breach side slope was 2, resulting in a top width of 1350 feet. These breach parameters are reasonable, and fall within the range suggested by USBR (1998). However, to test the sensitivity of the model to these selected values, the NRC staff increased the total breach area by 50 percent (a more conservative assumption). Specifically, the breach bottom width was increased to 975 feet, the side slope was increased to 4, and the top width was increased to 2175 feet. The impact of this 50 percent increase in total breach area was to increase the peak discharge from Russell Dam, from 4.5 million cfps to 6.5 million cfps (approximately 45 percent increase in peak discharge).

The Thurmond Dam breach occurred approximately 2.5 hours after the Russell Dam breach, when the water surface elevation exceeded the top of the dam by 0.1 feet (i.e., elevation 351.1 feet). The applicant’s Russell Dam breach parameters were that the final dam breach extended from the top to the bottom (elevation 200 feet) of the dam, with a bottom width of 755 feet, top width of 1359 feet, and side slopes of 2. These breach parameters are reasonable, and fall within the range suggested by USBR (1998). However, to test the sensitivity of the model to these selected values, the NRC staff increased the breach area by 50 percent (a more conservative assumption). NRC staff assigned the breach bottom width to be 981.5 feet, top width of 2189.5 feet, and side slopes of 4. The impact of this 50 percent increase in breach area was to increase the peak discharge issuing from Thurmond Dam. Under this scenario, with both Russell and Thurmond dam breach areas increased by 50 percent, the increase in peak Thurmond Dam discharge was from 5.5 million cfps to

7.8 million cfps (approximately 41 percent increase). The peak water surface elevation at Thurmond Dam also increased from 352.4 feet to 353.0 feet.

After the peak flood wave passed Thurmond Dam, the peak was attenuated because of the large overbank areas between Thurmond Dam and the VEGP site. Much of the overbank lengths in this region are very broad, with some overbank areas extending laterally from the river for more than 5 miles.

The NRC staff's evaluation mentioned above assumes that the time for the full breach to develop was 1.0 hour. As described in USBR (1998), the breach formation time could take anywhere from 0.1 to 1.0 hour for engineered, compacted earth dams, using the 1987 Engineering Guidelines for the Evaluation of Hydropower Projects, FERC 0119-1, Office of Hydropower Licensing, Federal Energy Regulatory Commission (FERC) method. The sensitivity of the HEC-RAS model to this parameter was tested by decreasing the parameter to 0.1 hour. The simulation results show that the Russell Dam discharge increased to 6.7 million cfps. However, the overtopping breach at Thurmond Dam did not increase with the decrease in breach formation time. Maximum breach discharge is a function of maximum water surface elevation at the dam, and, due to the rapidity of the breach, the maximum stage at the dam was lowered by 2.4 feet (350.6 feet versus 353.0 feet). As expected, the maximum stage adjacent to the VEGP site was also lower with the 0.1 hour (169.9 feet) versus the 1.0 hour breach formation time. Therefore, the 1.0 hour breach formation time parameter was used for the NRC staff's final analysis.

The NRC staff computed the peak discharge at the VEGP site, after it was attenuated along the 70 miles between Thurmond Dam and the site, with approximately 2.5 million cfps. The hydrograph of water surface elevation in the Savannah River near the VEGP site is shown in Figure 2.4.4-1 of the SER. The applicant computed the peak static water surface elevation at the VEGP site as 166.8 feet (Southern 2007). The NRC staff's analysis, with a 50 percent increase in breach area, produced a peak water surface elevation of 170.1 feet at the site, an increase in peak flood stage of 3.3 feet.

In order to satisfy the combined effects guidance in ANS/ANSI 2.8 (1992), the maximum wave height and associated maximum wave runup were computed and added to the peak flood wave elevation. The windspeed for the site was assumed to be 50 miles per hour following the guidelines in ANS/ANSI 2.8 (1992). Based on an estimated fetch of 11.2 miles, the maximum wave height was computed to be 9.8 feet using procedures discussed in USACE (2006). In Section 2.4.4 of the SSAR, the applicant stated that the embankment slope near the site will be 2H:1V. Given this slope value and the maximum wave height, the maximum wave runup at the VEGP site was determined to be 19 feet. Combining this value with the peak static water surface elevation determined with the NRC staff's more conservative breach parameters results in a maximum flood elevation at the VEGP site of 189.1 feet MSL. Even with a more conservative estimate of breaching parameters, the peak flood wave is 30.9 feet below the plant grade (elevation 220 feet MSL). Therefore, the NRC staff concludes that the VEGP site will not be affected by the potential failure of dams upstream of the site. The NRC staff did not apply the "no more than 5% less conservative" criterion to determine the agreement between the NRC staff's estimate of the maximum flood discharge and the corresponding water surface elevation and that of the applicant's from dam-break flooding in the Savannah River. The NRC staff only applies this criterion to compare agreement between the results obtained by the applicant and the results from the NRC staff's independent analysis when the complexity and the conservativeness of the two analyses are the same. Since the NRC staff's independent analysis of the dam-break flooding in the Savannah River is a bounding analysis that is more conservative than the analysis performed by the applicant, the NRC staff did not apply the above-mentioned criterion. The NRC staff, based on its independent analysis of dam-break flooding in the Savannah River, determined that the VEGP site would not flood during the postulated dam-break scenario. Thus the NRC staff agrees with the applicant that the VEGP site is "dry."

2.4.4.4 Conclusion

It is possible that dams upstream of the VEGP site could fail and potentially cause a domino-type cascading failure of multiple dams. However, this failure of upstream dams would not affect the VEGP site. The analysis performed by the applicant follows methods accepted in current engineering practice. The NRC staff reviewed these results by first computing the rating curve at the site, and determining that the peak flood wave discharge that was necessary to reach plant grade was more than 2.5 times the peak flood computed by the applicant. The NRC staff then adjusted the breach parameters in the applicant's HEC-RAS model to examine the sensitivity of model results. Although the peak wave could be increased using more conservative values than standard engineering practice, the resulting peak flood wave passing the VEGP site was still below the site grade by more than 30 feet. Therefore, NRC staff concludes the site is dry, and that safe operation and/or shutdown of the plant will not be affected by failure of dams upstream of the site.

As set forth above, the applicant has presented and substantiated sufficient information pertaining to the effects of dam failures at the proposed site. RS-002, Section 2.4.4 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the effects of dam failures. Furthermore, the applicant considered dam failures in establishing design-basis information pertaining to flooding and safety-related water supply, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in these site characteristics, as documented in SERs from previous licensing actions. Accordingly, the NRC staff concludes that the use of these methodologies results in site characteristics containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the site characteristics identified in this section are acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

Therefore, the NRC staff concludes that the identification and consideration of the dam failures set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d). The NRC staff finds the applicant's proposed site characteristics related to the maximum flood elevation, wind run-up, and combined effects maximum flood elevation associated with dam failures for the ESP application to be acceptable.

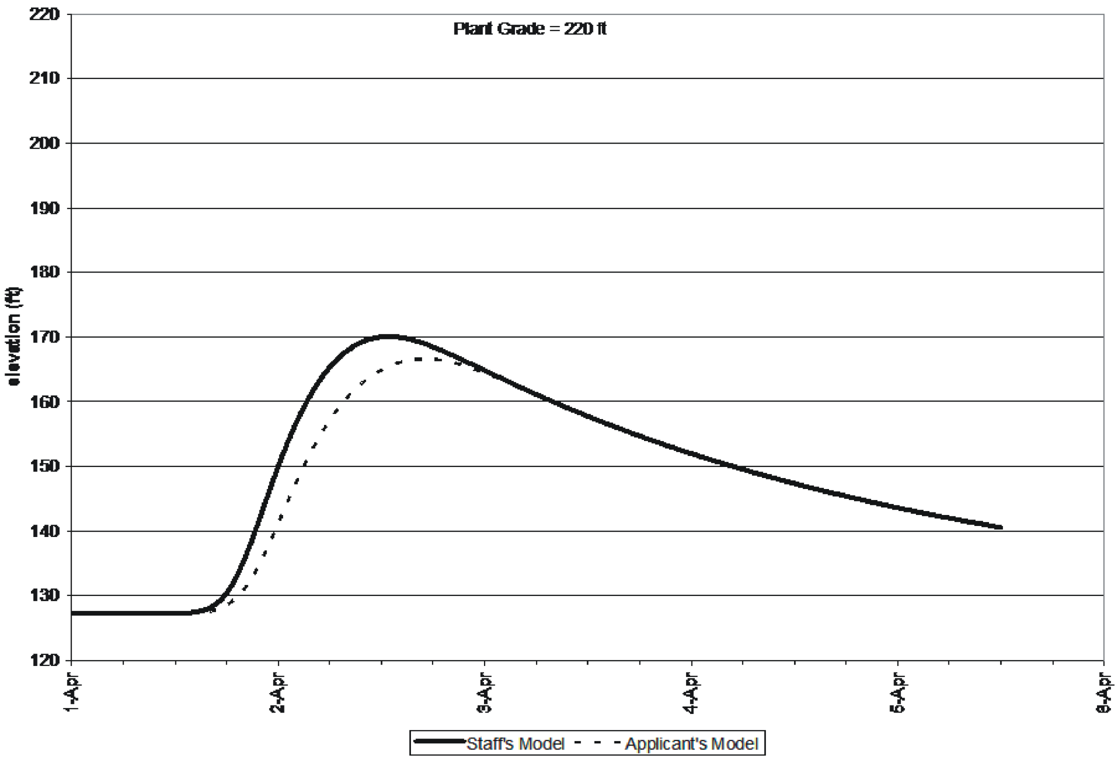


Figure 2.4.4-1 - Stage hydrograph at the VEGP Site

2.4.5 Probable Maximum Surge And Seiche Flooding

In this section of the SSAR, the hydrometeorological design basis is developed to ensure that any potential hazard to the safety-related facilities due to the effects of probable maximum surge and seiche is considered in plant design. The NRC staff's review of the SSAR covers: (1) probable maximum hurricane; (2) probable maximum wind storm; (3) seiche and resonance; (4) wave runup; (5) effects of sediment erosion and deposition; (6) consideration of other site-related evaluation criteria; and (7) additional information for 10 CFR Part 52 applications.

2.4.5.1 Introduction

The VEGP site is located on the southeast side of the Savannah River, approximately 15 miles east-northeast of Waynesboro, Georgia, 26 miles southeast of Augusta, Georgia, and 100 miles north-northwest of Savannah, Georgia (SNC, 2006). The VEGP site is located approximately 150 river miles upstream of the mouth of the Savannah River. The grade elevation of the existing VEGP units and the new proposed units is 220 feet MSL.

The Savannah River is the only large body of water that could potentially flood the VEGP site due to surge and seiche effects. Section 2.4.4 discuss the increase in water surface elevation along one bank from the wind blowing across the river's surface.

2.4.5.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.20(c), also requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

To evaluate the information provided in SSAR 2.4 per the above acceptance criteria, applicant applied the NRC-endorsed analytical methodologies found in the following:

- RG 1.70, Revision 3, issued November 1978

- RG 1.29

- RG 1.59, Revision 2, issued August 1977

- RG 1.102, Revision 1, issued September 1976

- RG 1.125, Revision 1, "Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants," issued October 1978

Section 2.4.5 of RS-002 provides the review guidance used by the NRC staff to evaluate this SSAR section.

- To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the applicant's safety assessment should contain a description of the surface and subsurface hydrologic characteristics of the region and an analysis of the potential for flooding caused by surges or seiches. This description should be sufficient to assess the acceptability of the site and the potential for a surge or seiche to influence the design of SSCs important to safety for a nuclear unit(s) of a specified type that might be constructed on the proposed site. Meeting this requirement provides reasonable assurance that the most severe flooding likely to occur as a result of storm surges or seiches will not pose an undue risk to the type of facility proposed for the site.

- If it has been determined that surge and seiche flooding estimates are necessary to identify flood design bases, the NRC will consider the applicant's analysis to be complete and acceptable if it addresses the following areas and if the NRC staff can independently and comparably evaluate them based on the applicant's submission.

- All reasonable combinations of PMH, moving squall line, or other cyclonic windstorm parameters are investigated, and the most critical combination is selected for use in estimating a water level.

- Models used in the evaluation are verified or have been previously approved by the NRC staff.

- Detailed descriptions of bottom profiles are provided (or are readily obtainable) to enable an independent NRC staff estimate of surge levels.

- Detailed descriptions of shoreline protection and safety-related facilities are provided to enable an independent NRC staff estimate of wind-generated waves, runup, and potential erosion and sedimentation.

- Ambient water levels, including tides and sea level anomalies, are estimated using NOAA and USACE publications, as described below.

- Combinations of surge levels and waves that may be critical to the design of a nuclear unit(s) of a specified type that might be constructed on the proposed site are considered, and adequate information is supplied to allow a determination that no adverse combinations have been omitted.

- This section of the SSAR may also state with justification that surge and seiche flooding estimates are not necessary to identify the flood design basis (e.g., the site is not near a large body of water).

- Hydrometeorological estimates and criteria for the development of PMHs for East and Gulf Coast sites, squall lines for the Great Lakes, and severe cyclonic windstorms for all lake sites by USACE, NOAA, and the NRC staff are used for evaluating the conservatism of the applicant's estimates of severe windstorm conditions, as discussed in RG 1.59. USACE and NOAA criteria call for variation of the basic meteorological parameters within given limits to determine the most severe combination that could result. The applicant's hydrometeorological analysis should be based on the most critical combination of these parameters.

- Data from publications by NOAA, USACE, and other sources (such as tide tables, tide records, and historical lake level records) are used to substantiate antecedent water levels. These antecedent water levels should be as high as the 10-percent exceedance monthly spring high tide, plus a sea-level anomaly based on: (1) the maximum difference between recorded and predicted average water levels for durations of 2 weeks or longer for coastal locations; or (2) the 100-year recurrence interval high water for the Great Lakes. In a similar manner, the NRC staff independently analyzes the storm track, wind fields, effective fetch lengths, direction of approach, timing, and frictional surface and bottom effects to ensure that the applicant selected the most critical values. Models used to estimate surge hydrographs that the NRC staff has not previously reviewed and approved are verified by reproducing historical events, with any discrepancies in the model being on the conservative (i.e., high) side.

- The NRC staff uses USACE criteria and methods, as generally summarized in RS-002, as a standard to evaluate the applicant's estimate of coincident wind-generated wave action and runup.

- The NRC staff uses USACE criteria and methods, as generally summarized in RS-002, and other standard techniques to evaluate the potential for oscillation of waves at natural periodicity.

2.4.5.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the technical information provided by the applicant; and (2) NRC staff's technical evaluation to determine the potential for site flooding due to surge and seiche.

2.4.5.3.1 Technical Information Presented by the Applicant

The proposed site grade for the new units is 220 feet MSL. The applicant reported three major hurricanes, defined as those of Category 3 or larger (Saffir/Simpson Hurricane Scale) that have affected the Atlantic coast of Georgia between 1841 and 2004 (SNC, 2006). The most severe observed hurricane with a landfall location within 100 miles of the Savannah River estuary was

Hurricane Hugo, which made landfall near Charleston, South Carolina (SNC, 2006). The applicant reported that Hurricane Hugo produced a 20-ft storm surge in the Cape Romain-Bulls Bay area in South Carolina.

The applicant estimated the probable maximum surge height at the mouth of the Savannah River using the RG 1.59 values of 28.2 feet mean low water (MLW) at Folly Island, South Carolina, and 33.9 feet MLW at Jekyll Island, Georgia, which are located northeast and southwest of the Savannah River estuary, respectively (SNC, 2006). The applicant obtained from ANSI/ANS-2.8 (1992) the 10 percent exceedance high tide at the Savannah River estuary as 9.0 feet MLW with MLW at the entrance to Savannah River being at 1.2 feet below MSL. The applicant estimated the probable maximum surge water surface elevation with a coincident 10 percent exceedance high tide at the mouth of the Savannah River as 32.3 feet MLW or 31.1 feet MSL (SNC, 2006).

The applicant noted that probable maximum surge data from RG 1.59 do not include hurricanes after 1975. Inclusion of the more recent hurricane data in RG 1.59 could have slightly altered the probable maximum surge estimate (SNC, 2006).

The applicant postulated that a probable maximum surge at the mouth of the Savannah River would only have an insignificant effect near the VEGP site because the surge height would dissipate before reaching the VEGP site, which is located approximately 151 river miles inland from the mouth, and the proposed site grade is 220 feet MSL (SNC, 2006).

2.4.5.3.2 NRC Staff's Technical Evaluation

The NRC staff's technical evaluation consisted of a review of the data, the references, and the methods presented in the applicant's SSAR.

The NRC staff reviewed the references provided by the applicant in the SSAR and agreed that three hurricanes exceeding Category 3 have been reported by Blake et al. (2007) on the Georgia coastline within 100 miles of Savannah, Georgia. The NRC staff downloaded historical hurricane track data for the Atlantic basin from the NOAA Coastal Services Center (2007) and created a map of these hurricane tracks in the vicinity of the VEGP site (Figure 2.4.5-1). The NRC staff determined from this map that three Category 4 hurricanes and five Category 3 hurricanes have come within 150 miles and 100 miles of the VEGP site, respectively. One Category 1 and one Category 2 hurricane came within 50 miles of the VEGP site. Within a 25 mile-radius of the Savannah River Estuary (Figure 2.4.5-2), four Category 3 hurricanes have been observed. Within a 50 mile-radius of the Savannah River Estuary, six Category 3 and one Category 4 hurricane have occurred (Figure 2.4.5-2). Based on these historical data, the NRC staff concluded that storm surges caused by severe hurricanes that exceed Category 4 can occur in the vicinity of the Savannah River Estuary.

The NRC staff reviewed the probable maximum surge estimation performed by the applicant. The NRC staff concluded that the applicant appropriately applied the method described in Appendix C of RG 1.59 to the Savannah River estuary location. In addition, the NRC staff finds that the applicant's estimate of total probable maximum surge height of 32.3 feet MLW or 31.1 feet MSL is acceptable.

The NRC staff reviewed the location of the VEGP site in relation to the Savannah River Estuary, and concluded that effects of storm surge and seiche at the site would likely be small. To quantitatively bound these effects, the NRC staff used the HEC-RAS model described in Section 2.4.4 of this SER. The downstream boundary condition, applied at river mile 99.4, of the NRC staff's unsteady flow analysis was modified to a constant stage height. The selected height for this analysis was elevation 119.7 feet MSL. This elevation is the sum of the peak flood stage at the model's boundary during the dam break simulation (elevation 88.6 feet MSL) and the computed maximum storm surge occurring at the mouth of the Savannah River using RG 1.59 (31.1 feet). This estimate of storm surge at river mile 99.4 does not take into account attenuation of the surge that would occur between the mouth and the model boundary. The peak stage at the site computed during the domino-type failure of the upstream dams using this revised downstream boundary condition was elevation 172.1 feet MSL, which is 47.9 feet below the site grade. Wind blowing along the water surface could increase the water surface elevation along one bank. These effects were computed in Section 2.4.4 to be approximately 19 feet. Combining these effects results in a water surface elevation of 191.1 feet MSL, which is 28.9 feet below the site grade. Therefore, the NRC staff concluded that the probable maximum surge and seiche will not affect the VEGP site.

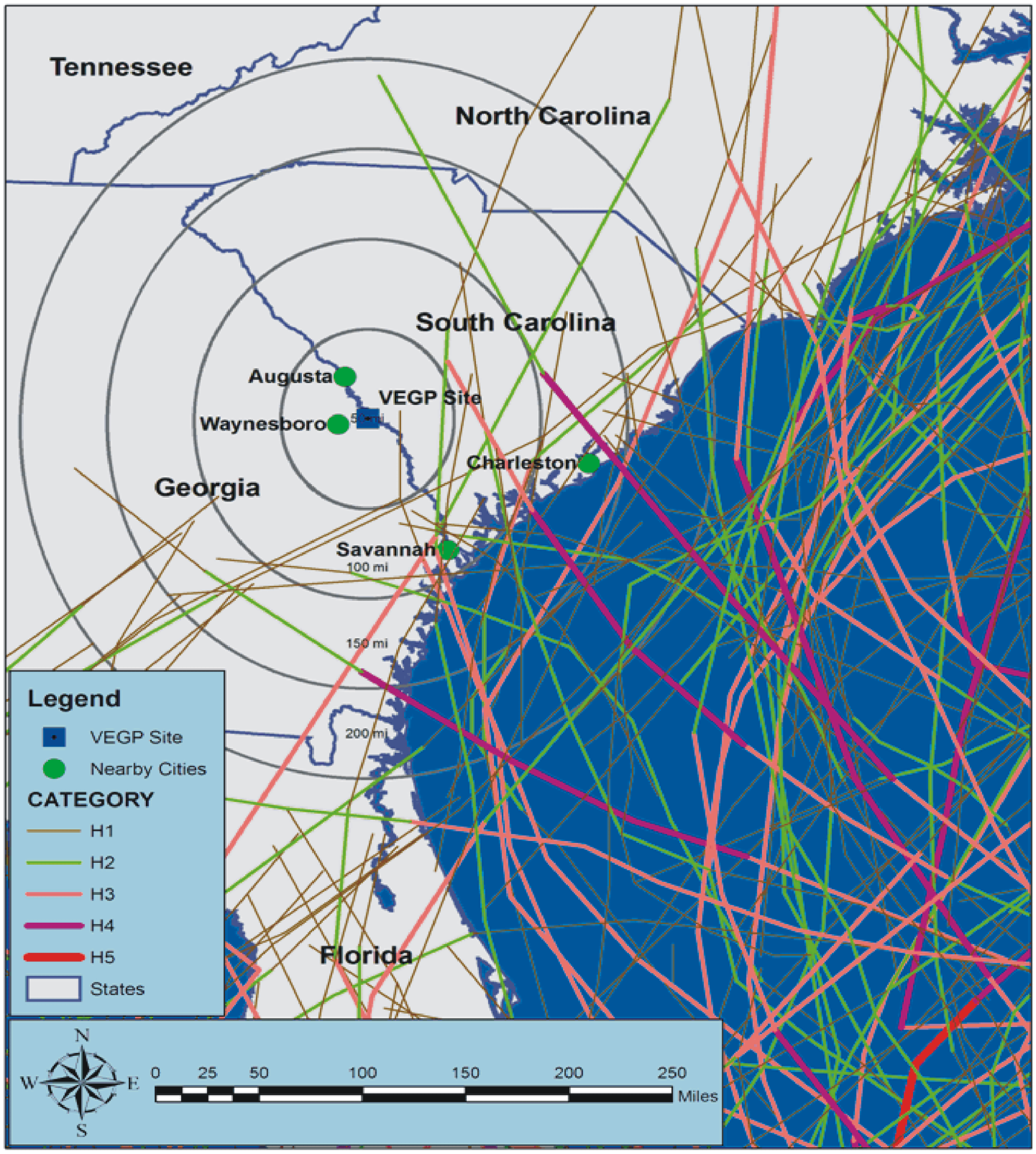


Figure 2.4.5-1 - Hurricane tracks near the VEGP site. The hurricane track data was downloaded from the NOAA Coastal Services Center and all hurricanes (Category H1 through H5) from the dataset were selected to show on the map.

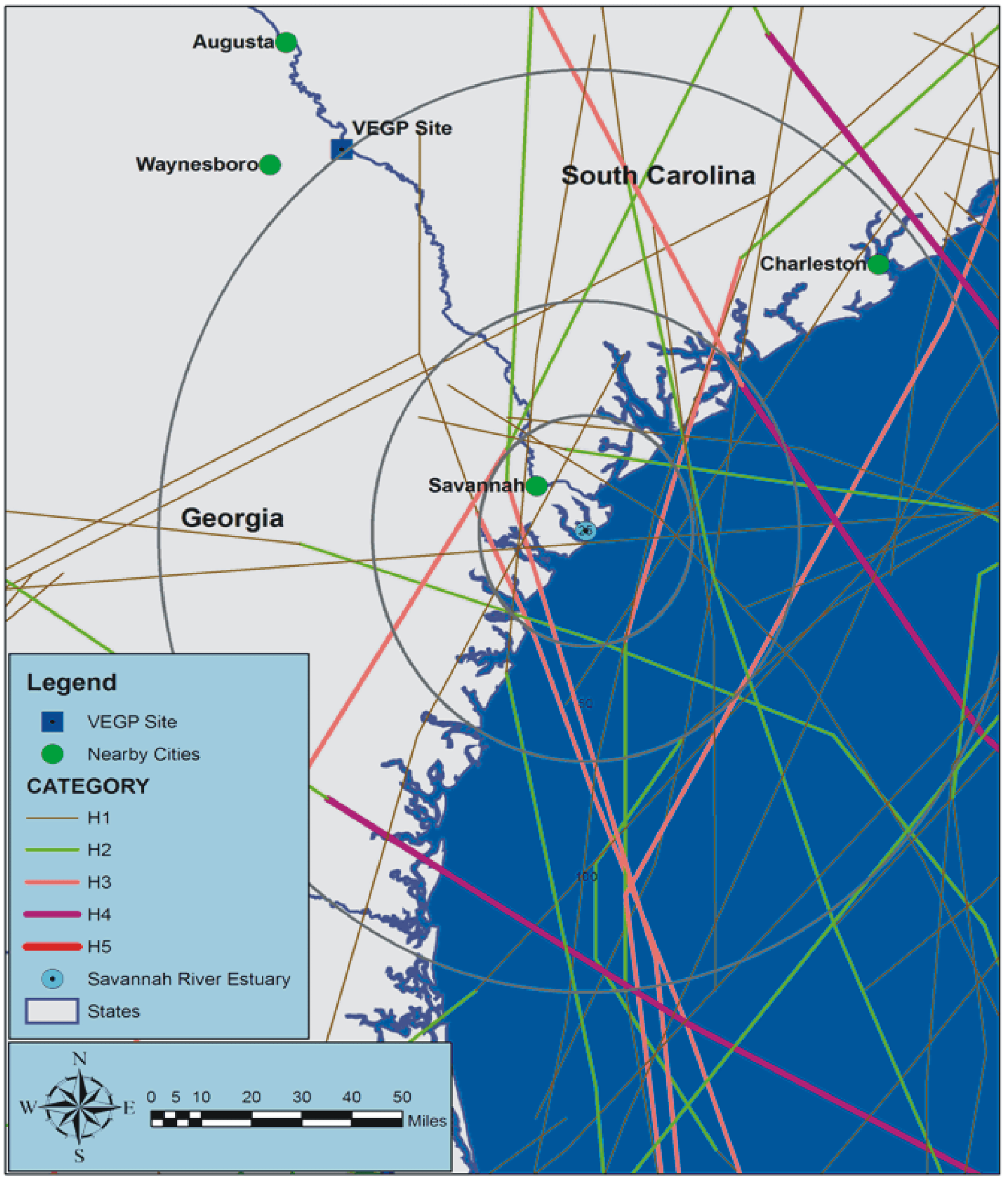


Figure 2.4.5-2 - Hurricane tracks near the Savannah River Estuary. The hurricane track data was downloaded from the NOAA Coastal Services Center and all hurricanes (Category H1 through H5) from the data set were selected to show on the map.

2.4.5.4 Conclusion

A probable maximum surge in the Savannah River Estuary can occur. However, this probable maximum surge does not affect the VEGP site. The VEGP site is also not affected by seiche because the site is located approximately 150 river miles inland from the ocean and there are no large bodies of water in the vicinity. All safety-related SSC will be placed above the highest flood water surface elevation that is controlled by flooding in the Savannah River resulting from cascading upstream dam failures.

As set forth above, the applicant has presented and substantiated sufficient information pertaining to the effects of storm surge and seiche at the proposed site. Section 2.4.5 of RS-002 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the effects of storm surge and seiche. Furthermore, the applicant considered the most severe natural phenomena that have been historically reported for the site and surrounding area while describing the effects of surge and seiche near the site, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in this analysis, as documented in SERs for previous licensing actions. Accordingly, the NRC staff concludes that the use of these methodologies results in an analysis containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the applicant's analysis is acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

Therefore, the NRC staff concludes that the identification and consideration of surge and seiche phenomena set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d). The NRC staff finds the applicant's analysis related to surge and seiche for the ESP application to be acceptable.

2.4.6 Probable Maximum Tsunami Hazards

In this section of the SSAR, the geohydrological design basis is developed to ensure that any plant design considers potential hazards to the safety-related facilities due to the effects of probable maximum tsunami. The NRC staff's review of the SSAR covers: (1) historical tsunami data; (2) probable maximum tsunami; (3) tsunami propagation models; (4) wave runup, inundation, and drawdown; (5) hydrostatic and hydrodynamic forces; (6) debris and water-borne projectiles; (7) effects of sediment erosion and deposition; (8) consideration of other site-related evaluation criteria; and (9) additional information for 10 CFR Part 52 applications.

2.4.6.1 Introduction

The VEGP site is located on the southeast side of the Savannah River, approximately 15 miles east-northeast of Waynesboro, Georgia; 26 miles southeast of Augusta, Georgia; and 100 miles north-northwest of Savannah, Georgia (SNC, 2006). The VEGP site is located approximately 150 river miles upstream of the mouth of the Savannah River. The grade elevation of the existing VEGP units and the proposed new units is 220 feet MSL.

A probable maximum tsunami can be caused near the mouth of the Savannah River by a tsunamigenic source in the Atlantic Ocean. There are no large inland bodies of water near the VEGP site in which a tsunami may be generated.

2.4.6.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.20(c), also requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.23, as it relates to investigating the tsunami potential at the site.

To evaluate the information provided in SSAR 2.4 per the above acceptance criteria, applicant applied the NRC-endorsed analytical methodologies found in the following:

- RG 1.70, Revision 3, issued November 1978
- RG 1.29
- RG 1.59, Revision 2, issued August 1977
- RG 1.102, Revision 1, issued September 1976
- RG 1.125, Revision 1, issued October 1978

Section 2.4.6 of RS-002 provides the following review guidance used by the NRC staff to evaluate this SSAR section. The acceptance criteria for this section are based on meeting the requirements of the following regulations:

- The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the NRC take into account the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit(s). The regulations at

10 CFR Part 52 and 10 CFR Part 100 apply to RS-002, Section 2.4.6, because they address the physical characteristics, including hydrology, considered by the Commission when determining the acceptability of the proposed site. To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of the hydrologic characteristics of the coastal region in which the proposed site is located and an analysis of severe seismically induced waves. The applicant's description should be sufficient to assess the site's acceptability and the potential for a tsunami to influence the design of SSCs important to safety for a nuclear unit(s) of specified type that might be constructed on the proposed site. Meeting this requirement provides reasonable assurance that the most severe flooding likely to occur as a result of a tsunami will pose no undue risk to the type of facility proposed for the site.

- The regulation at 10 CFR 100.23(c) requires that the NRC consider the geologic and seismic factors when determining suitability of the site. Pursuant to 10 CFR 100.23(c), an investigation must be completed to obtain geologic and seismic data necessary for evaluating seismically induced floods and water waves. This regulation also applies to RS-002, Section 2.4.6, because it requires the investigation of distantly and locally generated waves or tsunamis that have affected or could affect a proposed site, including available evidence regarding the runup or drawdown associated with an historic tsunami in the same coastal region and local features of coastal topography that might modify runup or drawdown. RG 1.70 provides more detailed guidance on the investigation of seismically induced flooding.

- Though not required at the ESP stage, the applicant for a COL must demonstrate compliance with general design criteria [GDC] 2 as it relates to designing SSCs important to safety to withstand the effects of a tsunami.

- To judge whether the applicant has met the requirements of 10 CFR Part 52, 10 CFR Part 100, and 10 CFR 100.23 with respect to tsunamis and the analysis thereof, the NRC uses the following criteria:

- If it has been determined that tsunami estimates are necessary to identify flood or low-water design bases, the NRC will consider the applicant's analysis to be complete if it addresses the following areas and if the NRC staff can independently and comparably evaluate them based on the applicant's submission:

    - All potential distant and local tsunami generators, including volcanoes and areas of potential landslides, are investigated, and the most critical ones are selected.

    - Conservative values of seismic characteristics (source dimensions, fault orientation, and vertical displacement) for the tsunami generators selected are used in the analysis.

    - The NRC staff previously approved or verified all models used in the analysis. RG 1.125 provides guidance in the use of physical models of wave protection structures.

    - Bathymetric data are provided (or are readily obtainable).

- Detailed descriptions of shoreline protection and safety-related facilities are provided for wave runup and drawdown estimates. RG 1.102 provides guidance on flood protection for nuclear power plants.

- Ambient water levels, including tides, sea level anomalies, and wind waves, are estimated using NOAA and USACE publications, as described below.

- If the applicant adopts RG 1.59, Position 2, the design basis for tsunami protection of all safety-related facilities identified in RG 1.29 should be shown at the COL stage to be adequate in terms of the time necessary for implementation of any emergency procedures.

- The applicant's estimates of tsunami runup and drawdown levels are acceptable if the estimates are no more than 5 percent less conservative than the NRC staff's estimates. If the applicant's estimates are more than 5 percent less conservative (based on the difference between normal water levels and the maximum runup or drawdown levels) than the NRC staff's, the applicant should fully document and justify its estimates or accept the NRC staff's estimates.

- This section of the SSAR will also be acceptable if it states that the criteria used to determine that tsunami flooding estimates are not necessary to identify the flood design basis (e.g., the site is not near a large body of water).

2.4.6.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the applicant's technical information presented in the SSAR; and (2) NRC staff's technical evaluation to determine the potential for tsunami hazards at the site.

2.4.6.3.1 Technical Information Presented by the Applicant

The applicant stated in SSAR Section 2.4.6 that since the VEGP site is not located on an open ocean coast of a large body of water, a tsunami would not produce maximum water level at the site (SNC, 2006).

The Atlantic Ocean is subject to infrequent seismic and volcanic activities that have resulted in few recorded tsunamis. The most notable Atlantic tsunami was generated by the Great Lisbon Earthquake of 1755. The earthquake generated a tsunami that traveled across the Atlantic and produced waves 10 to 15 feet in height on the Caribbean coasts and computer models suggested a wave height of 10 feet along the east coast of the U.S.

The applicant estimated that effects of any tsunami with similar height approaching the Savannah River estuary would be dissipated before reaching the VEGP site, which is located approximately 151 river miles inland and has a grade elevation of 220 feet MSL (SNC, 2006).

2.4.6.3.2 NRC Staff's Technical Evaluation

The NRC staff's technical evaluation consisted of a review of the data and the references presented in the applicant's SSAR. The NRC staff also carried out a hierarchical review of tsunamis near the VEGP site.

The NRC staff carried out a search of the National Geophysical Data Center (NGDC) Tsunami Runup Database to locate all reported tsunami runups on the U.S. east coast. This search returned reported tsunami runup events in the general region of the Savannah River estuary that are shown on the map below (Figure 2.4.6-1).

The NGDC database did not contain the actual runup heights for several of the runup locations shown on the map (Figure 2.4.6-1). The NGDC database reported an observed runup height less than 1 foot at Charleston, South Carolina, near the Savannah River Estuary resulting from the 1929 Grand Banks submarine landslide-generated tsunami. The NGDC database lists the 1886 earthquake in Charleston, South Carolina as having generated three runup events in Copper River, South Carolina and Jacksonville and Mayport in Florida. Runup heights at the three locations are not available. The event description in the NGDC database lists extensive damage to Charleston, South Carolina by a "mighty tidal," presumably the tsunami wave (NGDC, 2007a).

The NGDC tsunami runup database lists the tsunami caused by the 1755 Great Lisbon Earthquake as resulting in runups on the east coast of the U.S. However, the NGDC database does not include runup heights on the east coast of the U.S. (NGDC, 2007b). A computer modeling of the tsunami wave generated by the 1755 Great Lisbon Earthquake suggested runups of approximately 10 feet on the U.S. east coast (Mader, 2001).

Based on the historical tsunami data near the Savannah River estuary, the NRC staff concluded that the region is subject to tsunamis but there is not enough historical data to ascertain the severity of runups near the Savannah River estuary. In order to determine whether tsunamis pose a hazard to the VEGP site, the NRC staff adopted a bounding approach.

Figure 2.4.6-1 - Locations of Tsunami Runups Reported in the NGDC Tsunami Runup Database near the Savannah River Estuary

The NRC staff evaluated three metrics related to the geographical and topographical location of the site in relation to tsunami wave inundation: (1) distance of the site from the shoreline; (2) upriver distance of the site from the shoreline; and (3) elevation of the site relative to the shoreline. These three metrics specifically address: (1) if the site is located within the horizontal extent of the tsunami wave inundation zone; (2) if the tsunami wave can produce a bore in the Savannah River that may travel upstream to the site; and (3) if the tsunami wave can run up to site grade.

The NRC staff's search of the NGDC tsunami database revealed that the maximum observed horizontal distance of inundation during a tsunami is approximately 3.4 miles. The accounts from the 2004 Sumatra tsunami indicated the maximum extent of horizontal distance could be 5.0 miles from the shoreline on the island of Sumatra, Indonesia. The VEGP site is located more than 100 miles inland from the east coast of the U.S. Since the distance of the site from the shoreline is an order of magnitude more than the maximum observed horizontal inundation distance from a tsunami, the NRC staff concluded that a tsunami arriving at the Savannah River Estuary from the Atlantic Ocean will not inundate the VEGP site.

The NRC staff's search of the NGDC tsunami database revealed that the maximum observed tsunami runup, defined as the highest ground elevation the waters from a tsunami reached, is 1720 feet caused by the giant Lituya Bay subaerial landslide on July 10, 1958. There have been other tsunamis caused by landslides in Lituya Bay on October 27, 1936, on an unspecified day in 1853, and on September 10, 1899, which had reported runups of 490 feet, 394 feet, and 200 feet, respectively. The NGDC tsunami database also reports runups of 820 feet and 738 feet on May 18, 1980 in Spirit Lake located in the Washington State, which was caused by the catastrophic collapse of the north flank of the Mount St. Helens dome and the subsequent pyroclastic flow into the lake. The NGDC tsunami database also contains a few observed runups exceeding 150 feet (Table 2.4.6-1).

The tsunami events that caused runups exceeding 150 feet have properties that are not similar to those at the Savannah River Estuary. The Lituya Bay tsunami events are characterized by subaerial landslides in a very narrow inlet bay flanked by steep and high slopes. The Spirit Lake events were cause by the catastrophic failure of the north flank of the Mount St. Helens volcano. The 1674 tsunami runups on Ambon Island, Indonesia were caused by a near-field tsunamigenic earthquake in the Banda Sea. The events in Japan and Russia and those in Alaska were generated by tsunamigenic sources in the Pacific Ocean. The NRC staff concluded that none of these runup events can be considered representative of tsunamigenic conditions that may affect the Savannah River Estuary. Therefore, the NRC staff carried out a search for tsunami runups with tsunamigenic sources located in the Atlantic Ocean and in the Caribbean Sea, the most likely locations of tsunamigenic sources relevant to the Savannah River Estuary. Table 2.4.6-2 shows the results of this search.

Table 2.4.6-1 - Tsunami Runups Exceeding 150 Feet in the NGDC Tsunami Database

Date			Cause*	Country	Location	Runup (feet)
Year	Month	Day				
1958	7	10	3	USA	Lituya Bay, Alaska	1720
1980	5	18	6	USA	Spirit Lake West, Washington	820
1980	5	18	6	USA	Spirit Lake East, Washington	738
1936	10	27	8	USA	Lituya Bay, Alaska	490
1853	--	--	8	USA	Lituya Bay, Alaska	394
1674	2	17	1	Indonesia	Ceyt, Ambon Island	328
1674	2	17	1	Indonesia	Hila, Ambon Island	328
1674	2	17	1	Indonesia	Hitu Peninsula, Ambon Island	328
1674	2	17	1	Indonesia	Lima, Ambon Island	328
1741	8	29	5	Japan	Sado Island	295
1788	7	21	1	USA	Unga Island, Alaska	289
1788	8	6	1	USA	Unga Island, Alaska	289
1771	4	24	1	Japan	Ishigaki Island	280
1899	9	10	3	USA	Lituya Bay, Alaska	200
1737	10	17	0	Russia	Bering and Commander Islands	197
1771	4	24	1	Japan	Shiraho	197
1771	4	24	1	Japan	Ara	185
1792	5	21	5	Japan	Shimbara	180
1964	3	28	3	USA	Valdez Inlet, Alaska	170
2004	12	26	1	Indonesia	Labuhan, NW Coast of Sumatra	167
1650	9	29	6	Greece	West Coast Patmos	164
2004	12	26	1	Indonesia	Rhiting, Aceh, Sumatra	160
1771	4	24	1	Japan	Nobaruzaki	153

* Cause Codes:

0: Unknown
1: Earthquake
2: Questionable Earthquake
3: Earthquake and Landslide
4: Volcano and Earthquake
5: Volcano, Earthquake, and Landslide
6: Volcano
7: Volcano and Landslide
8: Landslide
9: Meteorological
10: Explosion
11: Astronomical Tide

Table 2.4.6-2 - Runups Exceeding 30 Feet Caused by Tsunamigenic Sources in the Atlantic Ocean and the Caribbean Sea

Date			Cause*	Country	Location	Runup (feet)
Year	Month	Day				
1755	11	1	1	Portugal	Lagos	98
1954	10	--	0	Greenland	Aputiteq Point	60
1755	11	1	1	Portugal	Lisbon	40
1894	11	21	6	Ireland	West Coast	40
1867	11	18	1	Guadeloupe	Deshaies	33
1867	11	18	1	Guadeloupe	Sainte-Rose	33
1900	10	29	1	Venezuela	Puerto Tuy	33

The 1755 Great Lisbon Earthquake, the only known great teletsunami in the Atlantic basin, produced runups of nearly 100 feet in Lagos, Portugal and approximately 40 feet in Lisbon, Portugal. According to the NGDC tsunami database, reported runups at Saint Martin harbor and Samana Bay in the Dominican Republic, both in the Caribbean Sea, were approximately 15 feet and 12 feet, respectively. Computer modeling of the tsunami waves generated by the 1755 Great Lisbon Earthquake, Mader (2001) estimated the runup heights on the east coast of the U.S. to be approximately 10 feet.

Based on the above data, the NRC staff concluded that all known tsunami runups on the Atlantic coast of the U.S. have been at least an order of magnitude less than the elevation of the site grade of the proposed new units at the VEGP site.

A tidal bore is a solitary, non-linear, shallow-water undular wave (Chen, 2003) that is caused by a large tide and typically propagates upstream in a slowly flowing estuary. The tidal bore is hydraulically similar to a traveling hydraulic jump characterized by supercritical flow upstream of the estuary. The formation of supercritical flow in the estuary is a necessary condition for the formation of a tidal bore (Chen, 2003). Supercritical flow is described by the Froude number, the ratio of inertial to gravity forces in open channel flow (Chow, 1959), exceeding 1.0. The Froude number is expressed by

$$Fr = V/(gL)^{1/2} \qquad (1)$$

where V is the velocity of flow, g is the acceleration due to gravity, and L is a characteristic length taken as the hydraulic depth for open channels. The hydraulic depth is defined as the ratio of the cross sectional area of discharge normal to the direction of flow to the top width of the free surface (Chow, 1959). For wide rectangular channels, therefore

$$Fr = V / (gh)^{1/2} \qquad (2)$$

where h is the depth of flow. Therefore, the criteria for supercritical flow in wide, rectangular channels, Fr >= 1.0, can also be stated as

$$V \geq (gh)^{1/2} \qquad (3)$$

The right hand side of equation (3) is the celerity, or speed, of a shallow-water wave. Therefore, when the Froude number exceeds 1.0, the velocity of flow exceeds shallow-water wave celerity.

Tidal bores are rare occurrences. Bartsch-Winkler and Lynch (1988) presented a catalog of worldwide occurrences and characteristics of tidal bores. This catalog listed 67 known locations where tidal bores occur. The only documented occurrences of tidal bores in the U.S. are those in the Knik and Turnagain Arms of Cook Inlet in Alaska (Bartsch-Winkler and Lynch, 1988). The NRC staff's additional search did not find any reference to the formation of a tidal bore in the Savannah River Estuary. The NRC staff concluded that a tsunami-induced bore traveling upstream from the mouth of the Savannah River would not occur.

A tsunami that causes a runup near the mouth of the Savannah River would have to reach an elevation of 220 feet MSL more than 100 miles inland in order to inundate the VEGP site. Both these metrics are an order of magnitude greater than the maximum estimated tsunami runup on the Atlantic coast near the site and the maximum reported horizontal extent of tsunami inundation anywhere, respectively. Based on the data pertaining to the geographical and topographical location of the VEGP site as it relates to tsunamis, the NRC staff concluded that a tsunami at the mouth of the Savannah River would not affect the VEGP site, which is located more than 100 miles from the mouth and at a grade elevation of 220 feet MSL.

2.4.6.4 Conclusion

The VEGP site is not affected by probable maximum tsunami. All safety-related SSC will be placed above the highest flood water surface elevation that is controlled by flooding in the Savannah River resulting from to cascading upstream dam failures.

As set forth above, the applicant has presented and substantiated sufficient information pertaining to the effects of probable maximum tsunami hazards at the proposed site. RS-002, Section 2.4.6 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the effects of probable maximum tsunami hazards. Furthermore, the applicant considered the most severe natural phenomena that have been historically reported for the site and surrounding area while describing the probable maximum tsunami hazards, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in this analysis, as documented in SERs for previous licensing actions. Accordingly, the NRC staff concludes that the use of these methodologies results in an analysis containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the applicant's analysis is acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

Therefore, the NRC staff concludes that the identification and consideration of the probable maximum tsunami hazards set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d). The

NRC staff finds the applicant's proposed analysis related to probable maximum tsunami hazards for the ESP application to be acceptable.

2.4.7 Ice Effects

This section of the applicant's SSAR develops the hydrometeorological design basis to ensure that ice-induced hazards do not affect safety-related facilities and water supply. The applicant is responsible for providing site characteristics and other hydrometeorological parameters related to ice formation at or near the site to the organization responsible for review of the SSCs to ascertain whether the mechanical or structural design basis for the plant properly considers ice effects on potentially affected SSC. The review covers: (1) historical ice accumulation; (2) high and low water levels; (3) ice sheet formation; (4) ice-induced forces and blockages; (5) consideration of other site-related evaluation criteria; and (6) additional information for 10 CFR Part 52 applications.

2.4.7.1 Introduction

The VEGP site is located on the southeast side of the Savannah River, approximately 15 miles east-northeast of Waynesboro, Georgia, 26 miles southeast of Augusta, Georgia, and 100 miles north-northwest of Savannah, Georgia (SNC 2007). The VEGP site is located approximately 150 river miles upstream of the mouth of the Savannah River. The grade elevation of the existing VEGP units and the new proposed units is 220 feet MSL.

The site may be affected by icing in the Savannah River near the site. There are no large inland bodies of water near the VEGP site and no water reservoirs are proposed for safety-related use.

2.4.7.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.20(c), also requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

To evaluate the information provided in SSAR 2.4 per the above acceptance criteria, applicant applied the NRC-endorsed analytical methodologies found in the following:

- RG 1.59, Revision 2, issued August 1977.

- The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the NRC take into account the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability for hosting a nuclear power reactor(s). To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of any icing phenomena with the potential to result in adverse effects to the intake structure or other safety-related facilities for a nuclear unit(s) of a specified type that might be constructed on the proposed site. Applicants should describe ice-related characteristics historically associated with the site and region, and they should perform an analysis to determine the potential for flooding, low water, or ice damage to safety-related SSCs. The analysis should be sufficient to evaluate the site's acceptability and to assess the potential for those characteristics to influence the design of SSCs important to safety for a nuclear unit(s) of a specified type that might be constructed on the proposed site. Meeting this guidance provides reasonable assurance that the effects of potentially severe icing conditions will pose no undue risk to the type of facility proposed for the site.

- Publications by NOAA, USGS, USACE, and other sources are used to identify the history and potential for ice formation in the region. The historical maximum depths of icing should be noted, as well as mass and velocity of any large, floating ice bodies. The phrase, "historical low water ice affected," or similar phrases in streamflow records (USGS and State publications) will alert the reviewer to the potential for ice effects. The following items should be considered and evaluated, if necessary:

  - The regional ice and ice jam formation history should be described to enable an independent determination of the need for including ice effects in the design basis.

  - If the potential for icing is severe, based on regional icing history, it should be shown that water supplies capable of meeting safety-related needs are available from under the ice formations postulated and that safety-related equipment could be protected from icing. If this cannot be shown, it should be demonstrated that alternate sources of water are available that could be protected from freezing and that the alternate source would be capable of meeting safety-related requirements in such situations.

  - If floating ice is prevalent, based on regional icing history, potential impact forces on safety-related intakes should be considered. The structural design basis should include dynamic loading caused by floating ice. (This item will be addressed at the COL or CP stage.)

  -If ice blockage of the river or estuary is possible, it should be demonstrated that the resulting water level in the vicinity of the site has been considered. If this water level would adversely affect the intake structure or other safety-related facilities of a nuclear unit(s) of a specified type that might be constructed on the proposed site, it should be demonstrated that it would not also adversely affect an alternate safety-related water supply.

- The applicant's estimates of potential ice flooding or low flows are acceptable if the estimates are no more than 5 percent less conservative than the NRC staff estimates. If the applicant's estimates are more than 5 percent less conservative than the NRC staff's, the applicant should fully document and justify its estimates or accept the NRC staff estimates.

2.4.7.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the applicant's technical information presented in the SSAR; and (2) NRC staff's technical evaluation to determine the potential for ice-related hazards at the site.

2.4.7.3.1 Technical Information Presented by the Applicant

The applicant used air temperature records from eight locations, including seven cooperative stations, around the VEGP site to analyze historical extreme air temperature variations (SNC 2007). The applicant also used air temperature data from onsite measurements.

The climate at the VEGP site consists of short, mild winters and long, humid summers (SNC 2007). At the Augusta, Georgia station, based on 129 years of records, January is the coldest month with a mean temperature of 46.8 ºF. Among the eight stations, the lowest air temperature was -4.0 ºF at Aiken, South Carolina in January 1985. During the same period, the air temperature at the VEGP site was -0.1 ºF, with air temperatures remaining below freezing (32 ºF) for approximately 50 hours (SNC 2007). Onsite measurements from 1984 to 2002 showed that mean daily air temperature remained below freezing for a maximum of three consecutive days (SNC 2007).

Historical water temperature data from five USGS gauging stations located on the Savannah River covering an area that includes the VEGP site showed that the minimum water temperature is observed in the month of February and varies from 39.2 ºF and 42.8 ºF (SNC 2007).

Based on historical air and water temperature records, the applicant concluded that it is very unlikely that surface or frazil ice formation would occur in the Savannah River in the vicinity of the proposed intake location of the new VEGP units (SNC 2007).

The applicant reported in SSAR Section 2.4.7 that the USACE Ice Jam Database includes no recorded ice jam events in the lower reaches of the Savannah River. The existence of dams and reservoirs on the Savannah River upstream of the VEGP site reduce the possibility of any surface ice or ice floes moving downstream (SNC 2007). Since the water temperature in the lower reach of the Savannah River consistently remains above freezing, the applicant concluded that formation of frazil ice or ice jams is very unlikely at the proposed intake location for the new VEGP units.

The proposed VEGP units would use a closed-cycle cooling system with cooling towers for the circulating water system cooling (SNC 2007). Makeup water for the circulating water system cooling towers will be supplied from the Savannah River using a new intake system comprising of an intake canal and a pump intake structure located upstream of the existing river intake system for VEGP Units 1 and 2 (SNC 2007).

The reactors for the proposed VEGP units will use passive UHS systems that do not require any safety-related water supply (SNC 2007). The proposed reactors would have a non-safety related auxiliary heat sink service water system that will be used for shutdown, normal operations, and anticipated operational events (SNC 2007). The makeup water to the service water system will be supplied from groundwater wells or an onsite water storage tank (SNC 2007). No water will be necessary from the Savannah River or any other open surface water source for the proposed reactors' UHS (SNC 2007). The applicant concluded, therefore, that any ice event in the Savannah River will not have an impact on the safe operation of the proposed units (SNC 2007).

2.4.7.3.2 NRC Staff's Technical Evaluation

The NRC staff's technical evaluation consisted of a review of the data and the references presented in the applicant's SSAR.

The NRC staff carried out a review of historical air temperature data near the VEGP site. The stations used by the NRC staff and their periods of record are shown in Table 2.4.7-1.

Table 2.4.7-1 - Meteorological stations near the VEGP site used by the NRC staff

Name (State)	COOP ID	Start Date	End Date
Augusta Bush Field Airport (Georgia)	090495	03/01/1949	04/30/2007
Louisville 1E (Georgia)	095314	01/01/1893	03/31/2007
Midville Experiment Station (Georgia)	095863	06/01/1957	03/31/2007
Millen 4N (Georgia)	095882	11/01/1891	12/31/1998
Newington (Georgia)	096323	09/01/1956	02/28/2003
Waynesboro 2S (Georgia)	099194	11/01/1893	02/28/2007
Aiken 5SE (South Carolina)	380074	01/01/1893	03/31/2007
Bamberg (South Carolina)	380448	08/01/1951	01/31/2007
Blackville 3W (South Carolina)	380764	06/01/1894	07/31/2002

In reviewing the daily minimum air temperature record at these stations, the NRC staff determined that the lowest daily minimum air temperature, -4 ºF, was observed at the Aiken 5SE station on January 21, 1985. The range of the lowest daily minimum air temperatures at all stations was 0 ºF to -4 ºF. The NRC staff estimated the mean daily minimum air temperature during the winter months, December through March, for all stations (see Table 2.4.7-2). None of these temperatures was below freezing.

Table 2.4.7-2 - Mean Daily Minimum Air Temperatures During the Months of December Through March for All Stations Used in the NRC Staff's Review

Name (State)	Mean Daily Minimum Air Temperature (ºF)			
	December	January	February	March
Augusta Bush Field Airport (Georgia)	34.7	33.5	35.8	42.3
Louisville 1E (Georgia)	49.2	49.9	55.7	62.4
Midville Experiment Station (Georgia)	37.1	35.5	38.3	45.2
Millen 4N (Georgia)	38.1	37.6	39.8	45.9
Newington (Georgia)	38.8	36.4	39.4	45.5
Waynesboro 2S (Georgia)	42.3	41.5	45.5	52.5
Aiken 5SE (South Carolina)	39.0	37.8	40.7	47.3
Bamberg (South Carolina)	37.4	35.5	37.9	43.8
Blackville 3W (South Carolina)	52.1	54.4	59.4	67.8

The NRC staff also identified the longest consecutive period during which the mean daily air temperature (estimated as the average of the daily minimum and maximum temperatures) was below freezing at each of the stations (see Table 2.4.7-3). The longest duration, that of nine days, of mean daily air temperature below freezing was observed at the Aiken station from January 13 to January 21, 1893.

According to USACE (2002), frazil ice forms in turbulent, supercooled water that is not covered by an ice layer. The NRC staff identified the maximum number of consecutive days that mean daily air temperature falls below 18 ºF for each of the stations (Table 2.4.7-3a). Two consecutive days of mean daily air temperatures below 18 ºF were observed twice at Waynesboro 2S and once at Blackville 3W. At all other stations experienced only 1 consecutive day with the mean air temperature below 18 ºF.

In response to NRC staff's RAI 2.4.1-1, the applicant provided water temperature data at the Shell Bluff Landing site, which is located approximately 11 river miles upstream of the VEGP site. The NRC staff reviewed water temperature data supplied by the applicant. The period of record for these monthly water temperatures was from January 30, 1973 to August 13, 1996. From these data, the NRC staff computed the following water temperature statistics: the minimum water temperature was 41.0 °F, the average water temperature was 63.4 °F, the median water temperature was 64.4 °F, and the maximum water temperature was 81.0 °F.

Based on its independent review of air temperature data near the VEGP site, the NRC staff concluded that the occurrenceS of air temperatures below freezing at and near the VEGP site are brief and infrequent. Although air temperature could fall below 18 ºF in the vicinity of the VEGP site, the duration of such a freezing spell would be unlikely to exceed two days. Since the water temperatures in the Savannah River near the site have never approached freezing (minimum water temperature estimated from 13 years of monthly data was 41.0 ºF), the NRC staff concluded that the VEGP site would not support the formation of frazil ice.

Table 2.4.7-3 - Longest Consecutive Period of Mean Daily Air Temperature below Freezing for All Stations Used in the NRC Staff's Review

Name (State)	Longest Consecutive Period of Mean Daily Air Temperature Below Freezing	
	Duration (days)	Dates
Augusta Bush Field Airport (Georgia)	6	01/10/1982 – 01/15/1982, 12/30/2000 – 04/01/2001
Louisville 1E (Georgia)	8	01/14/1893 – 01/21/1893
Midville Experiment Station (Georgia)	4	02/16/1958 – 02/19/1958, 01/08/1970 – 01/11/1970, 12/23/1989 – 12/26/1989
Millen 4N (Georgia)	5	01/13/1912 – 01/17/1912, 01/25/1940 – 01/29/1940
Newington (Georgia)	5	01/16/1977 – 01/20/1977
Waynesboro 2S (Georgia)	6	12/30/1917 – 01/04/1918, 01/11/1982 – 01/16/1982
Aiken 5SE (South Carolina)	9	01/13/1893 – 01/21/1893
Bamberg (South Carolina)	5	02/01/1980 – 02/05/1980, 12/31/2000 – 01/04/2001
Blackville 3W (South Carolina)	5	12/30/1899 – 01/03/1900

Table 2.4.7-3a - Number of Days with Minimum Daily Temperature at or below 18 ºF

Name (State)	Longest Consecutive Period of Mean Daily Air Temperature Below 18 ºF
Augusta Bush Field Airport (Georgia)	1
Louisville 1E (Georgia)	1
Midville Experiment Station (Georgia)	1
Millen 4N (Georgia)	1
Newington (Georgia)	1
Waynesboro 2S (Georgia)	2
Aiken 5SE (South Carolina)	1
Bamberg (South Carolina)	1
Blackville 3W (South Carolina)	2

The proposed units at the VEGP site have no safety-related water requirement and would not use any safety-related intakes. Consequently, formation of ice sheets, forces induced by ice, and blockages caused by ice are not areas of concern for this review.

The NRC staff searched the USACE Ice Jam Database for ice jam events reported in the states of Georgia, North Carolina, and South Carolina (CRREL, 2007a; 2007b; 2007c). The Ice Jam Database contains no ice jams reported in Georgia and South Carolina (CRREL, 2007d; 2007f). There are two ice jams reported in North Carolina (CRREL 2007e), one on the Neuse River and the other on the Missouri River. Based on these search results, the NRC staff concluded that ice jams in the Savannah River near the VEGP site are not likely.

The NRC staff proposed a site characteristic related to frazil ice that states that hydrometeorologic conditions at the VEGP site do not support formation of frazil ice.

2.4.7.4 Conclusion

Based on its review and independent analysis of data available publicly and those provided by the applicant, the NRC staff concluded that icing in the vicinity of the VEGP site is unlikely. Since the proposed units have no requirement other than initial filling and occasional makeup purposes, for continuous safety-related water supply, no safety-related water reservoirs or canals, intakes, and structures will be used. Therefore, the NRC staff concluded that ice effects will not affect safety of the proposed units.

As set forth above, the applicant has presented and substantiated sufficient information pertaining to the identification and evaluation of ice effects at the proposed site. Section 2.4.7 of RS-002 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating ice effects at the site. Furthermore, the applicant considered the most severe natural phenomena that have been historically reported for the site and surrounding area while describing the hydrologic interface of the plant with the site, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in this site characteristic, as documented in SERs for previous licensing actions. Accordingly, the NRC staff concludes that the use of these methodologies results in a site characteristic containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the site characteristic previously identified is acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

Therefore, the NRC staff concludes that the identification and consideration of the site characteristic related to ice effects set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d). The NRC staff finds the applicant's proposed site characteristic related to ice effects for the ESP application to be acceptable.

2.4.8 Cooling Water Canals and Reservoirs

This section of the applicant's SSAR develops the hydraulic design basis for canal and reservoirs used to transport and impound water supplied to the safety-related structures, systems, and components (SSCs). The NRC staff's review of the SSAR covers (1) hydraulic design bases for protection of structures, (2) hydraulic design bases of canals, (3) hydraulic design bases of reservoirs, (4) consideration of other site-related evaluation criteria, and (5) 10 CFR Part 50, Appendix A, GDC 44, for CP and OL applications, as it relates to providing a UHS for normal operating and accident conditions.

2.4.8.1 Introduction

The VEGP site is located on the southwest side of the Savannah River (SNC 2008a). The two proposed plant units will use a closed-cycle cooling system with cooling towers. The Savannah River will provide makeup water for the cooling towers' evaporative and other losses using a new intake system consisting of a 200-foot-long intake canal and an intake structure.

The proposed units at the VEGP site will not rely on external sources of safety-related UHS cooling water. The applicant has not proposed any safety-related cooling water supply canals and reservoirs.

2.4.8.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in the site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit

- 10 CFR 100.20(c), with respect to the requirement that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit

To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the applicant's SSAR should describe the cooling water canals and reservoirs for a nuclear power plant of the specified type that might be constructed on the proposed site. The analysis related to cooling water canals and reservoirs should be sufficient to evaluate the site's acceptability and to assess the potential for those characteristics to influence the design of SSCs important to safety for a nuclear power plant of the specified type that might be constructed on the proposed site. Meeting this requirement provides reasonable assurance that the capacities of cooling water canals and reservoirs are adequate.

2.4.8.3 Technical Evaluation

The technical evaluation consists of (1) a review of the technical information presented in the application, and (2) the NRC staff's technical evaluation to determine the acceptability of the design bases for canals and reservoirs.

2.4.8.3.1 Technical Information Presented by the Applicant

The proposed VEGP units will use a closed-cycle cooling system with cooling towers for condenser heat removal during normal operation (SNC 2008a). To replenish the water losses from evaporation, drift, and blowdown, the Savannah River will supply makeup water at a maximum rate of approximately 57,784 gallons per minute (SNC 2008a). The makeup water intake system for the proposed units will be located upstream of the intake for the existing units (SNC 2008a).

The proposed plants for the new VEGP units use a passive UHS with in-plant storage of safety-related cooling water (SNC 2008a). The proposed plant design does not require an external water-cooled UHS (SNC 2008a). The makeup water intake that will supply water to the condenser heat removal system will not be safety related (SNC 2008a). Because the proposed VEGP units will not rely on the Savannah River for safety-related water supply, low-water conditions in the river will not affect safety-related SSCs (SNC 2008a).

2.4.8.3.2 Technical Evaluation

The NRC staff's technical evaluation consisted of a review of the data and the references presented in the applicant's SSAR in its various revisions. The ESP SER with Open Items was based on SSAR, Revision 2 (SNC 2007), and this final ESP SER is based on SSAR, Revision 4 (SNC 2008a) and Revision 4S-2 (SNC 2008b).

On the basis of its initial review of the information presented in the SSAR, the NRC staff concluded that, as proposed in the application, the new VEGP Units 3 and 4 would not rely on any external water source for safety-related cooling water. The applicant did not propose any safety-related canals or reservoirs as a source for cooling water. However, safety-related water would be needed for initial filling and occasional makeup purposes. In this regard, the applicant did not provide design parameters for these values. This omission was designated Open Item 2.4-1.

The NRC staff identified in Section 2.4.8 of the ESP SER with Open Items a permit condition stating that VEGP Units 3 and 4 will not rely on any external water source for safety-related cooling water other than initial filling and occasional makeup water. This permit condition precluded the use of onsite surface and ground water for safety-related water supply except for initial filling and occasional makeup water.

The NRC staff discussed these issues with the applicant and reviewed the water components of the passive containment cooling system of a nuclear power reactor design that fits within the bounding parameters provided in the proposed permit application. The applicant stated that storage volume for each of the two water tanks would be approximately 800,000 gallons (SNC 2007g). The applicant also stated that the VEGP Units 3 and 4 water storage tanks will require initial filling and occasional makeup water to these tanks. For the VEGP site, the applicant proposes to use ground water as the source of water for the tanks, as described in SSAR Section 2.4.12.2 and Table 2.4.12-12 (SNC 2008b). The NRC staff determined that the capacity of the three existing and two proposed deep ground-water wells at the VEGP site under the current groundwater use permit issued by the State of Georgia Environmental Protection Division to SNC for 5.5 million gallons a day (MGD) annual average flow will be sufficient for initial filling and occasional makeup water supply, due to evaporative losses, to the two tanks providing water to the passive containment cooling system. The staff determined that neither the initial filling of the two tanks and occasional makeup involves reliance on external sources of safety-related UHS cooling water. Apart from the water stored in these two tanks to supply water to the passive containment cooling system, no other water is required by any safety-related system. Therefore, Open Item 2.4-1 is now closed, and the permit condition stated above is not required.

2.4.8.4 Conclusion

As proposed, VEGP Units 3 and 4 will not rely on any external water source for safety-related cooling water except for initial filling and makeup water. The units will not use any safety-related canals or reservoirs. The SSAR should address the requirements of 10 CFR Part 52 and 10 CFR Part 100 as they relate to identifying and evaluating design bases of canals and reservoirs at the site. As set forth above, the applicant presented and substantiated sufficient information pertaining to the design bases of canals and reservoirs at the proposed site.

Therefore, the NRC staff concludes that the identification and consideration of the safety-related canals and reservoirs set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d). The NRC staff finds the applicant's site characterization related to canals and reservoirs acceptable for the ESP application.

2.4.9 Channel Diversions

In this section of the applicant's SSAR, the geohydrologic design basis is developed to ensure that the plant and essential water supplies will not be adversely affected. This review includes stream channel diversions away from the site (which may lead to loss of safety related water) and stream channel diversions towards the site (which may lead to flooding). Additionally, in such an event, the applicant needs to show that alternate water supplies are available to safety-related equipment. The NRC staff's review of the SSAR covers: (1) historical channel diversions; (2) regional topographic evidence; (3) ice causes; (4) flooding of site due to channel diversion; (5) human-induced causes of channel diversion; (6) alternate water sources; (7) consideration of other site-related evaluation criteria; and (8) additional information for 10 CFR Part 52 applications.

2.4.9.1 Introduction

The VEGP site is located on the southwest side of the Savannah River (SNC 2007). The site is located on a plateau with natural drainages that drain water away from the site in all directions. The proposed site grade for the new units is 220 feet MSL. The two proposed units will use a closed-cycle cooling system with cooling towers. Make-up water for the cooling towers' evaporative and other losses will be supplied from the Savannah River using a new intake system consisting of a canal and an intake structure.

The proposed units at the VEGP site will not rely on safety-related cooling water from the Savannah River. The highest water surface elevation caused by flooding in the Savannah River is 178.1 feet MSL, more than 30 feet below the proposed site grade.

2.4.9.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.20(c) and 10 CFR 100.20(d), also requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

Section 2.4.9 of RS-002 provides the following criteria that were used by the NRC staff to evaluate this SSAR section.

- Channel diversion or realignment poses the potential for flooding or for an adverse effect on the supply of cooling water for a nuclear unit(s) of a specified type that might be constructed on the proposed site. Therefore, it is one physical characteristic that must be evaluated pursuant to 10 CFR 100.21(d). The consideration of the 10 CFR 100.21(d) criteria in this evaluation provides reasonable assurance that the effects of flooding caused by channel diversion resulting from severe natural phenomena will pose no undue risk to the type of facility proposed for the site.

- To judge whether the applicant has met the requirements of 10 CFR Part 52 and 10 CFR Part 100 as they relate to channel diversion, the NRC uses the following criteria:

    - A description of the applicability (potential adverse effects) of stream channel diversions is necessary.

    - Historical diversions and realignments should be discussed.

    - The topography and geology of the basin and its applicability to natural stream channel diversions should be addressed.

    - If applicable, the safety consequences of diversion and the potential for high or low water levels caused by upstream or downstream diversion to adversely affect safety-related facilities, water supply, or the UHS should be addressed. RG 1.27 provides guidance on acceptable UHS criteria.

2.4.9.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the technical information presented in the application; and (2) NRC staff's technical evaluation to determine the effects of potential channel diversions near the site.

2.4.9.3.1 Technical Information Presented by the Applicant

The applicant provided information related to physiographic, topographic, hydrologic, and geologic characteristics of the region within which the VEGP site is located (SNC, 207). Based on these data, the applicant concluded that it could not completely discount diversion of the river channel in this region (SNC 2007).

The applicant stated that although meandering of the river channel upstream and downstream of the VEGP site can be observed on topographic maps, the Savannah River near the VEGP site has a relatively straight and stable reach from River Mile 143 to River Mile 152 and the river plan-form did not change between 1965 and 1989 as inferred from USGS topographic maps (SNC 2007). The applicant also stated that the flow in the Savannah River is controlled by upstream multipurpose projects in the Savannah River system (SNC 2007). The effect of the control on the Savannah River results in lowering of peak flows and augmentation of low flows with an associated reduction in the morphological activity of the river (SNC 2007). The applicant concluded that it is unlikely the river will be diverted away from the VEGP site due to natural causes.

2.4.9.3.2 NRC Staff's Technical Evaluation

The NRC staff's technical evaluation consisted of a review of the approach presented in the applicant's SSAR.

As proposed in the application, the new VEGP Units 3 and 4 will not rely on any external water source for safety-related cooling water. The applicant did not propose any safety-related intakes for cooling water from the Savannah River. The NRC staff concluded that diversion of the Savannah River away from the VEGP site for any cause would not adversely affect the safety of the proposed VEGP Units 3 and 4.

The topographic elevations within the floodplain adjacent to the Savannah River northeast of the VEGP site are approximately 90 feet MSL and lower. The proposed grade elevation of the VEGP Units 3 and 4 is 220 feet MSL. In order to cause flooding at the VEGP site, the Savannah River would have to erode through more than 100 feet of terrain. Upstream dams regulate peak flood discharges in the Savannah River near the VEGP site and the river plan-form near the VEGP site is relatively straight. Based on these topographic, morphologic, and hydrologic characteristics, the NRC staff concluded that it is unlikely that flooding at the VEGP site can occur due to the Savannah River diverting towards the VEGP site.

2.4.9.4 Conclusion

As proposed, VEGP Units 3 and 4 will not rely on any external water source for safety-related cooling water. The NRC staff concluded that diversion of the Savannah River away from the VEGP site for any reason would not result in an adverse effect on safety of proposed VEGP Units 3 and 4. Based on topographic, morphologic, and hydrologic characteristics of the Savannah River, the NRC staff concluded that flooding of the VEGP site due to the river diverting towards the site is unlikely.

As set forth above, the applicant has presented and substantiated sufficient information pertaining to the identification and evaluation of channel diversions at the proposed site. Section 2.4.9 of RS-002 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating channel diversions affecting the site. Furthermore, the applicant considered the most severe natural phenomena that have been historically reported for the site and surrounding area while describing the hydrologic interface of the plant with the site, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in this analysis, as documented in SERs for previous licensing actions. Accordingly, the NRC staff concludes that the use of these methodologies results in an analysis containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the applicant's analysis is acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

Therefore, the NRC staff concludes that the identification and consideration of the channel diversion characterization set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d).

In view of the above, the NRC staff finds the applicant's site characterization related to channel diversions to be acceptable for the ESP application.

2.4.10 Flooding Protection Requirements

In this section of the applicant's SSAR, the locations and elevations of safety-related facilities and those of structures and components required for protection of safety-related facilities are compared with design-basis flood conditions to determine if flood effects need to be considered in plant design or in emergency procedures. The NRC staff's review of the SSAR covers: (1) safety-related facilities exposed to flooding; (2) type of flooding protection; (3) emergency procedures; (4) consideration of other site-related evaluation criteria; and (5) additional information for 10 CFR Part 52 applications.

2.4.10.1 *Introduction*

The VEGP site is located on the southwest side of the Savannah River (SNC 2007). The proposed site grade for the new units is 220 feet MSL. The proposed units at the VEGP site will not rely on safety-related cooling water from the Savannah River.

2.4.10.2 *Regulatory Basis*

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in site vicinity:

- 10 CFR 52.17(a), with respect to the requirement that the application contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

- 10 CFR 100.20(c), also requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s).

The regulation at 10 CFR 100.20(c) requires estimation of the PMF using historical data. Meeting this requirement provides reasonable assurance that the effects of flooding or a loss of flooding protection resulting from severe natural phenomena will pose no undue risk to the type of facility proposed for the site.

To judge whether the applicant has met the requirements of 10 CFR Part 52 and 10 CFR Part 100 as they relate to flooding protection, the NRC uses the following criteria:

- The applicability (potential adverse effects) of a loss of flooding protection should be described.

- Historical incidents of shore erosion and flooding damage should be discussed.

- The topography and geology of the basin and its applicability to damage as a result of flooding should be addressed.

If applicable, the safety consequences of a loss of flooding protection and the potential to adversely affect safety-related facilities, water supply, or the UHS should be addressed. RG 1.27 provides guidance on acceptable UHS criteria.

2.4.10.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the technical information presented in the application; and (2) NRC staff's technical evaluation to determine flooding protection requirements.

2.4.10.3.1 Technical Information Presented by the Applicant

The applicant stated that entrances and openings of all safety-related SSCs will be placed at or above the proposed site grade of 220 feet MSL (SNC 2007). The design-basis flood elevation in the Savannah River is 178.1 feet MSL (SNC 2007). The applicant concluded that safety-related SSC of the proposed VEGP Units 3 and 4 will not be exposed to flooding from the Savannah River.

The applicant stated that the effects of local intense precipitation will be considered in the design of site drainage system (SNC 2007). The applicant committed to designing the site drainage system such that all safety-related SSC would be safe from flooding from local intense precipitation (SNC 2007). All drainage structures such as culverts, storm drains, and bridges would be assumed to be blocked during the local intense precipitation event (SNC 2007).

2.4.10.3.2 NRC Staff's Technical Evaluation

In the preceding sections of this report, the NRC staff estimated the highest water surface elevation due to flooding in the Savannah River and concluded that it is well below the proposed site grade. The NRC staff concluded that protection from flooding in the Savannah River is not needed for a safety-related SSC if its entrances and openings are located above the proposed site grade of 220 feet MSL.

2.4.10.4 Conclusion

The proposed site grade of 220 feet MSL is safe from flooding in the Savannah River. The entrances and openings of all safety-related SSC that are located above the proposed site grade would be safe from flooding.

As set forth above, the applicant has presented and substantiated sufficient information pertaining to the flood protection measures at the proposed site. RS-002, Section 2.4.10 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating flood protection measures at the site. Furthermore, the applicant considered the most severe natural phenomena that have been historically reported for the site and surrounding area while describing the flooding protection requirements at the site, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in this analysis, as documented in SERs for previous licensing actions. Accordingly, the NRC staff concludes that the use of these methodologies results in an analysis containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the applicant's analysis previously identified are acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

Therefore, the NRC staff concludes that the identification and consideration of the flooding protection requirement analysis set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d). In view of the above, the NRC staff finds the applicant's analysis related to flooding protection requirements to be acceptable for the ESP application.

2.4.11 Low Water Considerations

In this section of the applicant's SSAR, natural events that may reduce or limit the available safety-related cooling water supply, are identified and the applicant ensures that an adequate water supply will exist to shut down the plant under conditions requiring safety-related cooling. The NRC staff's review of the SSAR covers: (1) low water from drought; (2) low water from other phenomena; (3) effect of low water on safety-related water supply; (4) water use limits; (5) consideration of other site-related evaluation criteria; and (6) additional information for 10 CFR Part 52 applications.

2.4.11.1 Introduction

The VEGP site is located on the southwest side of the Savannah River (SNC 2007). The proposed units at the VEGP site will not rely on safety-related cooling water from any external source, including the Savannah River and groundwater.

2.4.11.2 Regulatory Basis

The acceptance criteria for this section relate to the following regulations:

- 10 CFR Part 52 and 10 CFR Part 100 require that hydrologic characteristics be considered in the site evaluation.

- 10 CFR 100.23 requires that siting factors to be evaluated must include the cooling water supply.

Section 2.4.11 of RS-002 provides the following criteria that were used by the NRC staff to evaluate this SSAR section.

- The regulations at 10 CFR Part 52 and 10 CFR Part 100 require that the evaluation of a nuclear power plant site consider the hydrologic characteristics. To satisfy the requirements of 10 CFR Part 52 and 10 CFR Part 100, the applicant's SSAR should describe the surface and subsurface hydrologic characteristics of the site and region. In particular, the UHS for the cooling water system may consist of water sources that could be affected by the site's hydrologic characteristics that may reduce or limit the available supply of cooling water for safety-related SSCs, such as those resulting from river blockage or diversion, tsunami runup and drawdown, and dam failure.

- Meeting the requirements of 10 CFR Part 52 and 10 CFR Part 100 provides reasonable assurance that severe hydrologic phenomena, including low-water conditions, will pose no undue risk to the type of facility proposed for the site.

- As required by 10 CFR 100.23, siting factors, including cooling water supply, must be evaluated for a nuclear unit. The evaluation of the emergency cooling water supply for a nuclear power plant(s) of a specified type that might be constructed on the proposed site should consider river blockages, diversions, or other failures that may inhibit the flow of cooling water, tsunami runup and drawdown, and dam failures.

- The regulation at 10 CFR 100.23 applies to this section because the UHS for the cooling water system consists of water sources that are subject to natural events that may reduce or limit the available supply of cooling water (i.e., the heat sink). Natural events such as river blockages, diversions, or other failures that may inhibit the flow of cooling water, tsunami runup and drawdown, and dam failures should be conservatively estimated to assess the potential for these characteristics to influence the design of those SSCs important to safety for a nuclear unit(s) of a type specified by the applicant that might be constructed on the proposed site. The available water supply should be sufficient to meet the needs of the unit(s) to be located at the site. Specifically, those needs include the maximum design essential cooling water flow, as well as the maximum design flow for normal plant needs at power and at shutdown.

- The specific criteria discussed in the paragraphs below assess the applicant's ability to meet the requirements of the hydrologic aspects of the above regulations. Acceptance is based primarily on the adequacy of the UHS to supply cooling water for normal operation, anticipated operational occurrences, safe shutdown, cooldown (first 30 days), and long-term cooling (periods in excess of 30 days) during adverse natural conditions.

Low Flow in Rivers and Streams

- For essential water supplies, the low-flow/low-level design for the primary water supply source is based on the probable minimum low flow and low level resulting from the most severe drought that can reasonably be considered for the region. The low-flow/low-level site parameters for operation should not allow shutdowns caused by inadequate water supply to trigger the frequent use of emergency systems.

- Low Water Resulting from Surges, Seiches, or Tsunami

- For coastal sites, the applicant should postulate the appropriate PMH wind fields at the ESP stage to estimate the maximum winds blowing offshore, thus creating a probable minimum surge level. Low-water levels on inland ponds, lakes, and rivers caused by surges should be estimated based on the probable maximum winds oriented away from the plant site. The same general analysis methods discussed in Sections 2.4.3, 2.4.5, and 2.4.6 of RS-002 apply to low-water estimates resulting from the various phenomena discussed. If the site is susceptible to such phenomena, minimum water levels resulting from setdown (sometimes called runout or rundown) from hurricane surges, seiches, and tsunamis should be verified at the COL or CP stage to be higher than the intake design basis for essential water supplies.

<u>Historical Low Water</u>

- If historical flows and levels are used to estimate design values by inference from frequency distribution plots, the data used should be presented to allow for an independent determination. The data and methods of NOAA, USGS, SCS, USBR, and USACE are acceptable.

<u>Future Controls</u>

- This section is acceptable if water use and discharge limitations (both physical and legal), which are already in effect or under discussion by the responsible Federal, State, regional, or local authorities and which may affect the water supply for a nuclear unit(s) of a type specified by the applicant that might be constructed on the proposed site, have been considered and are substantiated by reference to reports of the appropriate agencies. The design basis should identify and take into account the most adverse possible effects of these controls to ensure that essential water supplies are not likely to be negatively affected in the future.

2.4.11.3 Technical Evaluation

The technical evaluation consists of: (1) a review of the technical information presented in the application; and (2) NRC staff's technical evaluation to determine effects of low water conditions.

2.4.11.3.1 Technical Information Presented by the Applicant

The applicant stated that proposed VEGP Units 3 and 4 will not use any external water sources for safety-related cooling water supply (SNC 2007).

2.4.11.3.2 NRC Staff's Technical Evaluation

The applicant stated that proposed VEGP Units 3 and 4 will not need any external water sources for safety-related cooling water supply for continuous use. While, the NRC staff determined that initial filling and occasional makeup water requirements for two water storage tanks exist, as described in Section 2.4.8.3.2 of this report, the NRC staff determined that low water conditions will not affect any safety-related SSCs.

2.4.11.4 Conclusion

The proposed VEGP Units 3 and 4 will not rely on any external source of water supply for safety-related cooling on a continuous basis; therefore, low water conditions will not affect any safety-related SSCs. RS-002, Section 2.4.11 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating low water conditions affecting the site. As set forth above, the applicant has presented and substantiated sufficient information pertaining to the identification and evaluation of low water conditions at the proposed site.

Therefore, the NRC staff concludes that the identification and consideration of the low water conditions set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d). In view of the above, the NRC staff finds the applicant's site characterization related to low water considerations for inclusion in an ESP for the applicant's site to be acceptable.

2.4.12 Ground Water

2.4.12.1 Introduction

This section of the applicant's SSAR evaluates the hydrogeological characteristics of the site and describes the effects of ground water on the plant foundations and the reliability of safety-related water supply and dewatering systems. The NRC staff's review of the SSAR covers: (1) local and regional ground-water characteristics and use; (2) effects on plant foundations and other safety-related SSCs; (3) reliability of ground-water resources and systems used for safety-related purposes; (4) reliability of dewatering systems; and (5) consideration of other site-related evaluation criteria.

The proposed VEGP Units 3 and 4 are to be located on a topographic ridge perpendicular to the Savannah River that forms a boundary between two watersheds. The watershed to the northwest is dominated by Mallard Pond and an unnamed drainage creek from it that discharges to the Savannah River. The watershed to the southeast is dominated by Daniels Branch, Telfair Pond, and Beaverdam Creek. Beaverdam Creek discharges to the Savannah River. Construction of the proposed facilities may alter the topography of the site and alter recharge to the unconfined aquifer in the immediate vicinity of the proposed units. Ground water has no safety-related role in the operation of the proposed VEGP units; however, the three existing and two proposed deep groundwater wells at the VEGP site will be sufficient for initial filling and occasional makeup water supply to the two tanks providing water to the passive containment cooling system.

Section 2.4.13 of this SER provides a complete discussion and evaluation of accidental radioactive releases (i.e., the release, migration, and the resulting hazard).

2.4.12.2 Regulatory Basis

The acceptance criteria for this section relate to the following regulations:

- 10 CFR Part 52 and 10 CFR Part 100 requires the site evaluation to consider hydrologic characteristics.

- 10 CFR 100.23 sets forth the criteria to determine the suitability of design bases for a nuclear unit of specified type that might be constructed on the proposed site with respect to its seismic characteristics. This section also requires applicants to ensure the adequacy of the cooling water supply for emergency and long-term shutdown decay heat removal, taking into account information concerning the physical, including hydrological, properties of the materials underlying the site.

As specified in 10 CFR 100.20(c), the NRC must consider the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit.

The regulation at 10 CFR 100.20(c)(3) requires that the NRC address factors important to hydrologic radionuclide transport using onsite characteristics. To satisfy the hydrologic requirements of 10 CFR Part 100, the staff's review of the applicant's SSAR should verify the description of ground-water conditions at the proposed site and the effect of the construction and operation of a nuclear unit of specified type that might be constructed on the site on those conditions. Meeting this requirement provides reasonable assurance that the release of radioactive effluents from a unit of specified type that might be constructed on the proposed site will not significantly affect the ground water at or near the site.

The regulation at 10 CFR 100.23 requires that the evaluation consider geologic and seismic factors when determining the suitability of the site and the acceptability of the design for each nuclear power plant. In particular, 10 CFR 100.23(d)(4) requires consideration of the physical properties of materials underlying the site when designing a system to supply cooling water for emergency and long-term shutdown decay heat removal.

Though not required at the ESP stage, the applicant for a COL must demonstrate compliance with GDC 2 as it relates to designing SSCs important to safety to withstand the effects of natural phenomena.

To judge whether the applicant has met the requirements of the hydrologic aspects of 10 CFR Part 52 and 10 CFR Part 100, the NRC used the following criteria:

- Section 2.4.12.1 of the SSAR must fully describe regional and local ground-water aquifers, sources, and sinks. In addition, it must describe the type of ground-water use, wells, pump, storage facilities, and the flow needed for the proposed plants of specified type that might be constructed on the site. If ground water is to be used as an essential source of water for safety-related equipment, the design basis for protection from natural and accident hazard phenomena must be compared to RG 1.27 guidelines. This section must adequately describe and reference the bases and data sources.

- Section 2.4.12.2 of the SSAR must describe present and projected local and regional ground-water use. This section must discuss and tabulate existing uses, including amounts, water levels, location, drawdown, and source aquifers. It must also indicate flow directions, gradients, velocities, water levels, and the effects of potential future use on these parameters, including any possibility for reversing the direction of ground-water flow. In addition, SSAR Section 2.4.12.2 must identify any potential ground-water recharge area within the influence of the proposed plants of specified type that might be constructed on the site, as well as the effects of construction, including dewatering. This section must also discuss the influence of existing and potential future wells with respect to ground water beneath the site and describe and reference the bases and data sources. RS-002 discusses certain studies concerning ground-water flow problems.

- Section 2.4.12.3 of the SSAR must discuss the need for and extent of procedures and measures, including monitoring programs, to protect present and projected ground-water users. These items are site specific and will vary with each application.

To evaluate whether the applicant has met the requirements of 10 CFR 50.55, "Conditions of Construction Permits," the NRC uses the following criteria:

- SSAR Section 2.4.12.4 should describe the design bases (and development thereof) for ground-water-induced loadings on subsurface portions of safety-related SSCs at the COL stage. If a permanent dewatering system is employed to lower design-basis ground-water levels, the applicant must provide the bases for the design of the system and determination of the design basis for ground-water levels. The application must provide information regarding the following:

  — all structures, components, and features of the system

  — the reliability of the system as related to available performance data for similar systems used at other locations

  — the various soil parameters (such as permeability, porosity, and specific yield) used in the design of the system

  — the bases for determination of ground-water flow rates and areas of influence to be expected

  — the bases for determination of time available to mitigate the consequences of system failure where system failure could cause design bases to be exceeded

  — the effects of malfunctions or failures (such as a single failure of a critical active component or failure of circulating water system piping) on system capacity and subsequent ground-water levels

  — a description of the proposed ground-water level monitoring program and outlet flow monitoring program

- If wells are proposed for safety-related purposes, the applicant must describe the hydrodynamic design bases (and development thereof) for protection against seismically induced pressure waves, which should be consistent with site characteristics.

2.4.12.3 Technical Evaluation

This section reviews the applicant's information and evaluates the effects of ground water.

2.4.12.3.1 Technical Information Presented by the Applicant

In Section 2.4.12 of the SSAR, both Revision 4 (SNC 2008a) and Revision 4-S2 (SNC 2008b), Southern Nuclear Operating Company (Southern) presented information and data describing the local and regional ground-water systems and use, monitoring or safeguard requirements, and design basis for subsurface hydrologic loading. Much of the information and data was available in Revision 2 of the SSAR (SNC 2007) and was described in the ESP SER with Open Items; however, a substantial body of work on groundwater models and modeling of the VEGP site was included in Revision 4-S2 (SNC 2008b) and the responses to the additional RAIs (SNC 2008c).

The VEGP site is located on a ridge perpendicular to the Savannah River which lies to the northeast. This ridge separates two drainages. Mallard Pond and an unnamed drainage stream lie to the northwest, and Red Branch, Daniels Branch, Telfair Pond, and Beaverdam Creek lie to the southeast (SNC 2008a, Part 2, Section 2.4.1.2.2).

The applicant described the hydrogeology in Section 2.4.12.1.1 of the SSAR (SNC 2008b). The thickness of Coastal Plain sediments varies from less than 200 feet at the fall line to 4000 feet at the coastline, and is approximately 1000 feet thick at the site (SNC 2008b, Section 2.4.12.1.1). A surface topography of gently rolling hills ranges in elevation from 80 feet above MSL to nearly 300 feet above MSL in the immediate vicinity of the VEGP site (SNC 2008a, Part 3, Sections 2.4.1 and 2.6.1). Developed portions of the site have ground surface elevations of approximately 220 feet MSL (SNC 2008b, Section 2.4.12, pg. 2.4.12-1, and Figure 2.4.12-1). The Savannah River has incised the Coastal Plain sediments and formed steep bluffs exhibiting topographic relief of nearly 150 feet from the river to the developed portions of the existing VEGP site (SNC 2008a, Part 3, Section 2.6.1).

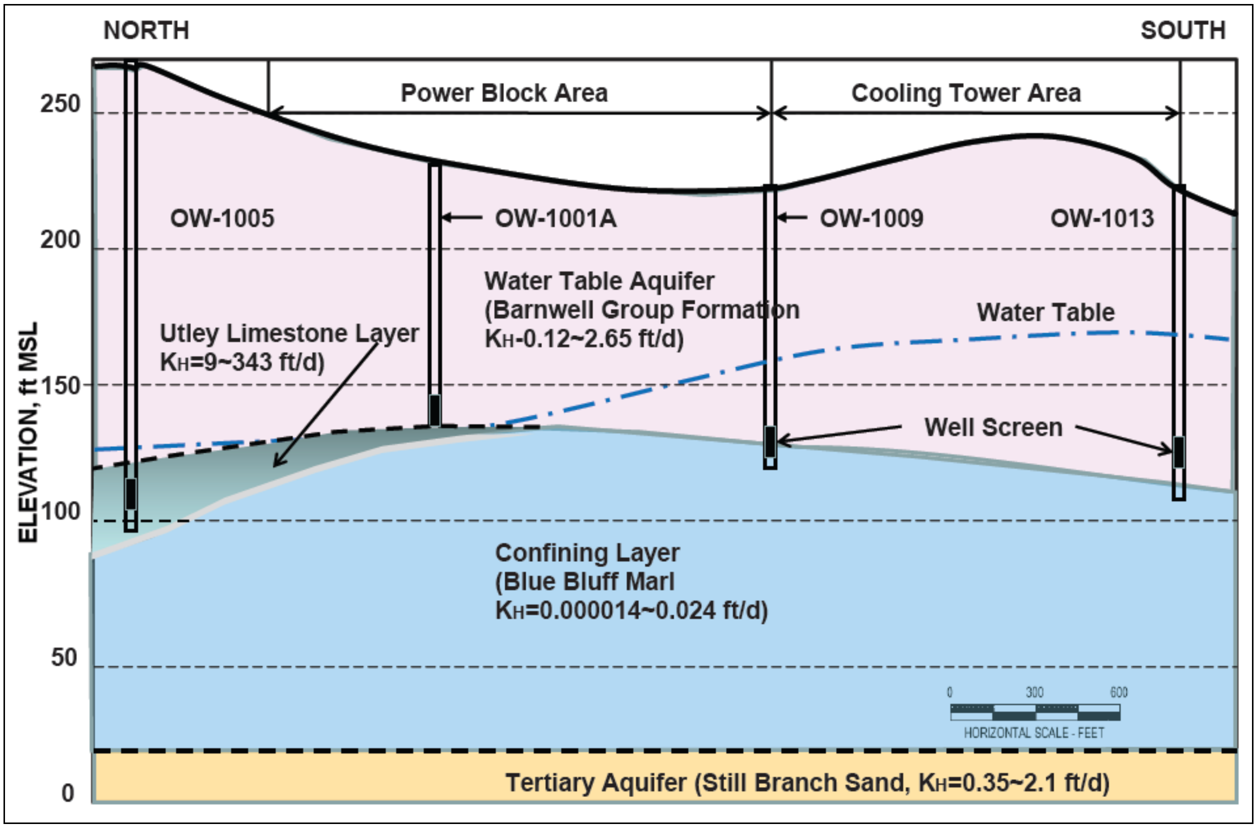


Figure 2.4.12-1 Hydrogeologic cross-section of the Water Table aquifer at the Vogtle site (KH is the horizontal hydraulic conductivity)

Precipitation onto outcrops of aquifer sediments creates a ground-water source. Locally, net infiltration from precipitation recharges the Water Table aquifer (SNC 2008b, Section 2.4.12.1.1). Net infiltration from precipitation recharges the locally confined Tertiary and Cretaceous aquifers at outcrops of these formations nearer the fall line (SNC 2008b, Section 2.4.12.1.1).

The applicant stated that the Water Table aquifer discharges to ground-water wells and local drainages, including springs and seeps that ultimately drain to the Savannah River (SNC 2008b, Section 2.4.12.1.2). Figure 2.4.12-7 of the SSAR (SNC 2008b) depicts the piezometric surface of the Water Table aquifer and implies that ground-water flow throughout the proposed powerblock area is moving to the north-northwest and Mallard Pond. Depictions of the piezometric surface from 1971 (see SNC 2003 drawing AX6DD329) and 1984 (see SNC 2003 drawing AX6DD330) reveal the evolution of decline in the piezometric surface of the Water Table aquifer.

The applicant stated that the Tertiary aquifer drains to the Savannah River (see Figure 2.4.12-14 in SNC 2008b) and discharges to wells, natural springs, and subaqueous outcrops presumed to exist offshore (SNC 2008b, Section 2.4.12.1.2). Discharge to the Savannah River occurs where the river has completely eroded the Blue Bluff Marl confining layer (SNC 2008b, Section 2.4.12.1.2). Depictions of the piezometric surface from 1971 (see SNC 2003 drawing AX6DD327) and 1984 (see SNC 2003 drawing AX6DD328) reveal the evolution of the piezometric surface of the Tertiary aquifer.

The applicant concluded that piezometric head data for observation wells OW-1001 and OW-1001A were invalid and removed the data from the ESP application (SNC 2008b, Section 2.4.12.1.3, pg. 2.4.12-12). The well screen for OW-1001A ranges in elevation from 146.13 to 136.13 feet MSL (SNC 2008b, Section 2.4.12.1.3). In the vicinity of the proposed VEGP Unit 4, which is close to these wells, the top of the Blue Bluff Marl is located between 121.9 feet and 138.2 feet MSL (SNC 2008a, Part 2, Section 2.5.1.2.3.2 and Figure 2.5.1-47), with the lower value in the vicinity of OW-1001A. Omission of these data and information led the applicant to interpolate other nearby measurements and assign a piezometric head value to this location of approximately 147 feet (SNC 2008b, Figure 2.4.12-7) when the information suggests a head value less than the screened interval.

The applicant reported hydraulic properties of the Barnwell Formation sediments and included the range of hydraulic conductivity measurements for the Utley Limestone from 3,250 to 125,400 feet/year (9 to 343 feet/day). The applicant derived a value for effective porosity of 0.34 (SNC 2008b, Section 2.4.12.1.4) from the median specific gravity and moisture content measurements for Barnwell sediments. Using ground-water data from June 2005 through July 2007, the applicant estimated a hydraulic gradient of 0.014 feet/feet to apply to the Water Table aquifer across the site (SNC 2008b, Section 2.4.12.1.3).

The applicant reported a range of 480 to 1220 feet/year (1.3 to 3.3 feet/day) for hydraulic conductivity values in the engineered backfill (SNC 2008b, Section 2.4.12.1.4). The applicant obtained this value from the prior postconstruction testing of backfill regions underlying VEGP Units 1 and 2, as reported in the updated final safety analysis report (UFSAR), Table 2.4.12-14 (SNC 2003). The applicant used a value of 0.34 for the porosity of the engineered backfill, as applied in the FSAR for VEGP Units 1 and 2 (SNC 2003, Sections 2.4.13.1.1 and 2.4.12.2.4.3, and Table 2.4.12-14).

The applicant reported hydraulic properties of the Tertiary aquifer sediments (SNC 2008b, Section 2.4.12.1.4, Table 2.4.12-3). These include a range of hydraulic conductivities from 0.35 to 2.1 feet/day with a geometric mean of 0.83 feet/day, an effective porosity of 0.31, and a storage coefficient of 1.0×10^{-4}. The applicant estimated a hydraulic gradient of 0.005 feet/feet to apply to a distance of 5600 feet between the center of the proposed powerblock area and the Savannah River.

In Section 2.4.12.1.4 of SNC 2008b and Appendix 2.4B of SNC 2008c, the applicant presents the development and application of a two-dimensional, single-layer, steady-state ground-water model of the Water Table aquifer underlying the VEGP site. The model domain includes the watersheds on either side of the ridge on which VEGP Units 3 and 4 are proposed to be sited and is bounded above by the land surface and below by the top of the Blue Bluff Marl. The model varied spatially the hydraulic conductivity assignments to represent the presence or absence of the possibly more conductive Utley Limestone unit. In addition, the model assigned engineered fill areas associated with existing and proposed VEGP units the maximum hydraulic conductivity of engineered backfill measured at VEGP Units 1 and 2. The aquifer recharge rate assignments accounted for variations in surface slopes, vegetative cover, and land use, including structures and paved areas.

The applicant executed a series of simulations for seven alternative models. The seven models involved different combinations of hydraulic conductivity and recharge to calibrate the model (SNC 2008b, Section 2.4.12.1.4, pg. 2.4.12-18). The applicant also considered the seven model simulations to represent alternative conceptual models of the site and aquifer. The seven models include the following:

1. uniform hydraulic conductivity and recharge (single values of each for the entire model domain)

2. uniform hydraulic conductivity, variable recharge (open and forested areas, buildings and pavement)

3. accounting for thickness of the Utley Limestone (variable hydraulic conductivity, model 2 recharge pattern and values)

4. simplified Utley Limestone (simplified version of model 3)

5. high conductivity zone upstream of Mallard Pond (acknowledges Utley cave and spring)

6. low conductivity zone in southwestern part of model domain (attempt to reduce bias in model results; in models 1 through 5 the predicted hydraulic head in Daniels Branch, Telfair Pond watershed, is lower than observed while predicted head in Mallard Pond watershed is higher than observed)

7. simplified version of model 6

The applicant stated that, while the solutions obtained with models 6 and 7 were very similar and close to the measured water levels, model 7 provided the best match with the observed data and was selected for analysis of the postconstruction setting (SNC 2008b). The applicant analyzed travel time by using model 7 to simulate the travel path from the VEGP Unit 4 auxiliary building to the upper reaches of Mallard Pond. Essentially, the ground water moved through three regions of the model—the saturated engineered backfill, the aquifer from the excavation (backfill) to the high conductivity zone above Mallard Pond, and the high conductivity zone to Mallard Pond. The applicant predicted travel times through the three zones to be 2.4 years, 3.2 years, and 1.1 years for a total ground-water travel time of 6.7 years (see Figure 78 in Appendix 2.4B, SNC 2008b).

The applicant provided data about regional and local ground-water use (SNC 2008b, Section 2.4.12.2, pg. 2.4.12-23). The application lists permits issued by the State of Georgia Environmental Protection Division for ground-water withdrawals that exceed 100,000 gallons per day during any single month for municipal, industrial, and agricultural users. In addition, users are listed as shown in the Safe Drinking Water Information System maintained by EPA. The applicant provided the locations of the nearest examples of each of these ground-water users. The application summarizes current well location and usage by VEGP Units 1 and 2.

The applicant also provided a forecast of water resource usage in Burke County and summarized the projected ground-water use for the proposed units. Part 3 of the application (i.e., the environmental report) includes additional information and data (SNC 2008a, Part 3, Section 2.3.2).

Regarding the reliability of ground-water resources and systems used for safety-related purposes, the applicant stated that a future plant that fits within the bounding parameters provided in the proposed permit application has a passive safety-related UHS. Consequently, no safety-related ground-water supplies are necessary except for initial fill up and occasional makeup water (SNC 2008b, Section 2.4.12, pg. 2.4.12-1).

The applicant stated that the plant grade for the proposed units is elevation 220 feet MSL, and the foundation embedment depth is 39.5 feet from plant grade (SNC 2008b, Section 2.4.12, pg. 2.4.12-1). The elevation of containment and auxiliary building foundations is approximately 180.5 feet MSL. The applicant stated that the maximum ground-water elevation of the Water Table aquifer underlying the proposed VEGP units is 165 feet MSL (SNC 2008a, Part 2, Table 1-1). Regarding the reliability of dewatering systems, the applicant stated that a future plant that fits within the bounding parameters provided in the proposed permit application will not require a permanent dewatering system to lower the design-basis ground-water level because all safety-related SSCs are well above the highest recorded water table elevation in the powerblock area (SNC 2008b, Section 2.4.12.4, pg. 2.4.12-25).

The applicant stated that the excavated natural materials will be replaced with compacted structural fill with properties that provide an adequate factor of safety against liquefaction (SNC 2008a, Part 2, Section 2.5.4.8.3.1). The applicant reported confirmatory liquefaction analyses in Section 2.5.4.8 (SNC 2008a, Part 2, Section 2.5.4.8). The applicant concluded that the liquefaction potential of the compacted structural fill was not a concern and materials comprising the Blue Bluff Marl had an adequate factor of safety against liquefaction (SNC 2008a, Part 2, Section 2.5.4.8.4).

The applicant committed to review and evaluate existing SNC ground-water monitoring programs and observation well locations for adequacy and to describe that evaluation and the resulting long-term ground-water monitoring program for the proposed units in the COL application (SNC 2008b, Section 2.4.12.3, pg. 2.4.12-24).

2.4.12.3.2 Technical Evaluation

The technical evaluation by NRC staff is presented below for each of the specific RS-002 acceptance criteria. As a result of a series of requests, beginning at the initial site audit conducted in January 2007, the applicant has revised Section 2.4.12 of the SSAR with each revision of the application. The applicant provided the latest version of this FSAR section to the NRC as a supplement to Revision 4 of the application (SNC 2008b).

In an initial request for additional information (RAI) the NRC staff asked the applicant for (1) an interpretation of field observations and the potential for an alternative conceptual model allowing communication between the Water Table aquifer and the Tertiary aquifer, (2) a description of the process to develop the conceptual model (i.e., alternatives considered and the methodology used by the model to account for transient behavior), and (3) all available location information on the sediments related to the Water Table aquifer (e.g., thickness and continuity of the Barnwell sands, silts and clays, the Utley Limestone, and the Lisbon Formation). Southern responded to these requests (SNC 2007c) and incorporated new material in Revision 2 of the SSAR.

The NRC staff issued the SER with Open Items and included Open Item 2.4-2, which requested that the applicant provide an improved and complete description of the local hydrological conditions, including alternative conceptual models, to demonstrate that the design basis related to ground-water-induced loadings would not be exceeded. Future projections were needed of the impact on the Water Table aquifer arising from potential changes in land use and aquifer recharge as a result of construction of the proposed facilities. The applicant developed a ground-water model of the Water Table aquifer and incorporated its description and results into Revision 3 of the SSAR.

The NRC staff's review of the ground-water model described in SSAR, Revision 3, as well as model input and output, revealed issues with model convergence, mass balance, and calibration bias. The NRC staff also realized that alternative conceptual models were not presented. Rather, the applicant presented a sequence of models used to achieve calibration of a single conceptual model. The staff raised these concerns with the applicant at a public meeting at the NRC in Rockville, Maryland, on April 8, 2008, at a site audit at the applicant's consultant's offices in Frederick, Maryland, on April 9, 2008, and through additional RAIs dated July 22, 2008. The applicant addressed these issues in the supplement to Revision 4 of the application (SNC 2008b) and in responses to the RAIs (SNC 2008c).

The applicant's analysis, which was initially based entirely on field data and the assumption that postconstruction ground-water levels would not exceed prior measured levels, evolved into an analysis based on field data, a model of the Water Table aquifer, and postconstruction projections of the water table. This final analysis provided reasonable assurance that the design basis related to ground-water-induced loadings would not be exceeded.

Local and Regional Ground-Water Characteristics and Use

Based on a review of USGS documents (Clarke and West 1997, 1998; Cherry 2006; Cherry and Clarke 2007), State of Georgia documents, Huddlestun and Summerour (1996), and Summerour et al. (1994, 1998), the NRC staff determined that the applicant's description of the regional and local hydrogeologic conditions is accurate with one potential exception-ground-water flow within the Water Table aquifer may not always be from the powerblock area to the north-northwest and Mallard Pond. The NRC staff's investigations of the site and review of topographic maps confirm that the proposed location is on a ridge perpendicular to the Savannah River and separating drainages to the north-northwest (e.g., Mallard Pond) and to the south-southeast (e.g., Daniels Branch, Telfair Pond, and Beaverdam Creek).

The NRC staff confirmed that the recorded piezometric surface contour plots, including seasonal and climatic fluctuations of the Water Table aquifer, indicate ground-water movement toward the north-northwest and Mallard Pond from release points within the powerblock area. However, a number of lines of reasoning, described below, led the NRC staff to question whether this would be the only ground-water flow and contaminant migration direction for future accidental effluent release events.

First, the applicant stated that the piezometric head level in the Water Table aquifer is a function of the topography and recharge, which both change in the vicinity of the proposed VEGP Units 3 and 4. Substantial areas of the proposed site will be leveled and made impervious by construction of buildings and paved surfaces. Other substantial areas of the proposed site will be leveled and might be made more transmissive (i.e., able to accept more recharge) by converting them to gravel surfaces that would be maintained essentially vegetation free. Stormwater management facilities that will be constructed to route runoff from significant storm events away from the site could reduce potential infiltration rates. Each of these actions implies a potentially substantial change in the net infiltration to the Water Table aquifer in the immediate vicinity of the proposed VEGP Units 3 and 4. The applicant's model of the Water Table aquifer (SNC 2008b, 2008c) includes an evaluation of current, spatially varying recharge patterns and postconstruction changes to recharge resulting from changes in land use and vegetation. In addition, the NRC staff has used the applicant's model and conservatively analyzed a higher postconstruction recharge with a lower hydraulic conductivity assigned to the engineered backfill in the excavated region.

Second, the NRC staff's review of the historical piezometric head contours in the Water Table aquifer for the years 1971 (see SNC 2003, drawing AX6DD329), 1984 (see SNC 2003, drawing AX6DD330), and 2005 (see SNC 2008b, SSAR Figure 2.4.12-7) revealed evidence of change that has occurred since 1971 in the piezometric head as a result of the construction and operation of VEGP Units 1 and 2. This suggests that the assumption that the current piezometric surface will exist after construction and during operation of the proposed units is not realistic. However, the NRC staff notes that the broad and essentially flat area created for construction of the proposed VEGP Units 3 and 4 does represent a current local topographic high, and it is likely that the highest postconstruction recharge rates within the region disturbed by construction would be in the vicinity of the cooling tower area and not near the powerblock area. Thus, while the same ground-water surface will not exist, the location of the ground-water high divide will remain in the vicinity of the proposed cooling towers.

Finally, the NRC staff used the applicant's model of the Water Table aquifer to evaluate the sensitivity of the model solution to drain boundary condition elevations, to the use of minimum light detection and ranging (LiDAR) data rather than average LiDAR data in drain cells, to the use of drain cells instead of constant head boundary conditions for the perennial reach of Daniels Branch, and to postconstruction conditions more extreme than those evaluated by the applicant. In the latter cases, the staff evaluated the origin of releases to the watershed that lies to the southeast of the proposed facilities. To do this, the staff first assigned drain boundary condition cells elevations consistent with the land surface and conductance consistent with neighboring cells. This did not result in a substantial change in the model solution. The NRC staff next used minimum rather than average LiDAR to set drain elevations in the Daniels Branch drainage to evaluate ground-water movement to that drainage. This modification in the model boundary condition did not substantially change the essential feature of the applicant's model in this regard (i.e., that ground water moved beneath and was not intercepted in the upper reach of the Daniels Branch). The staff then used a drain boundary condition in the perennial reach of the Daniels Branch which did cause the cell ground-water level prediction to increase (i.e., the predicted ground-water elevation in the drainage was higher than in the constant head boundary condition model). However, ground water continued to discharge to the perennial reach of the streambed, but at a lower rate. Next, the staff used a series of recharge rate cases to evaluate the sensitivity of the applicant's results. These post construction cases included the hydraulic conductivity of the engineered fill (3.3 feet/day) in the excavation and a suite of high expected value and low recharge rates applied to the powerblock area and the cooling tower area. None of the cases revealed discharge to the Daniels Branch drainage; however, one case exhibited ground-water flow under the streambed. In addition, the case in which a high recharge was applied to both the proposed powerblock and cooling tower areas resulted in movement of some pathways directly toward the Savannah River from the southeast corner of the powerblock. However, such a result is not plausible because the powerblock grounds are actually engineered (e.g., sloped, paved) to promote runoff rather than infiltration and recharge. If comparable recharge rates were applied to VEGP Units 1 and 2 then flow toward the river from the proposed VEGP Units 3 and 4 would not occur. Thus, the staff attempted to test the hypothesis that ground water from the powerblock could discharge to the other watersheds but did not do so. However, because a pathway from the powerblock into the Daniels Branch drainage was demonstrated, by the staff, the uncertainty in the aquifer structure and hydraulic properties compels the staff to view this pathway as plausible and to continue to examine the alternative conceptual model of ground-water flow from the powerblock being intercepted by the upper reaches of the Daniels Branch. SER Section 2.4.13 further discusses alternative conceptual models of the future ground-water pathway.

The NRC staff confirmed the applicant's hydraulic conductivity values for the Water Table aquifer. The NRC staff independently determined that the USGS-derived minimum and maximum range of transmissivity values based on field data (i.e., 500 feet2/day to 9500 $feet^2$/day or 3700 gallons/day/feet to 71,000 gallons/day/feet) (Clarke and West 1998, Table 3), when combined with the local thickness of the Water Table aquifer (i.e., approximately 30 feet), are indicative of the higher values of the Utley Limestone of the Barnwell Formation cited by the applicant.

The NRC staff's review of the SSAR (SNC 2008b, Section 2.4.12) and USGS documents (Clarke and West 1997, 1998; Cherry 2006; Cherry and Clarke 2007) supports the applicant's interpretation that the Tertiary aquifer drains toward the Savannah River. The sequence of piezometric head maps from 1971 (see SNC 2003 drawing AX6DD327), 1984 (see SNC 2003 drawing AX6DD328), and the seasonal fluctuations in the 2005 to 2006 time period (see SNC 2008b, SSAR Figures 2.4.12-14 through 2.4.12-18) indicate the direction that ground-water flow has been maintained. These piezometric head data reveal a pattern of decline in head values over time, but the change will not affect both the existing and future groundwater uses.

Regarding the applicant's reported values of hydraulic conductivity in the Tertiary aquifer, the NRC staff independently reviewed USGS minimum and maximum ranges of transmissivity estimates based on field data (1,346 to 91,200 gallons/day/foot) and on regional simulation (100 to 185,000 gallons/day/foot) (Clarke and West 1998, Table 12). When combined with the local thickness of the Tertiary aquifer (approximately 182 feet), the USGS data bracket the central value of hydraulic conductivity provided by the applicant (i.e., 0.83 feet/day), but are generally higher.

One purpose of using an alternative conceptual model is to acknowledge the uncertainty in the interpretation of field observations and data sets that are by their nature incomplete. An example lies in the interpretation of data available from observation wells OW-1001 and OW-1001A. A poorly constructed and slowly responding well (i.e., OW-1001) may still provide valid data, until the validity of the data are disproved by completion of a competent observation well at the location. Observations of hydraulic head below the screened interval elevation of a well (i.e., OW-1001A) are obviously not valid as head observations; however, they suggest that the hydraulic head at that location is below the bottom of the screen (i.e., 136.13 feet). Again, until they are replaced with a competent observation well and an unambiguous data set, OW-1001 and OW-1001A provide information that suggests an alternate interpretation of local communication between the Water Table and Tertiary aquifers. Data from Borehole B-1004 in the vicinity of these observation wells suggest that the Blue Bluff Marl is approximately 95 feet thick at this location (SNC 2008a, Part 2, Figure 2.5.1-51). The data and information from the two observation wells are consistent with ground-water movement from the Water Table aquifer into the Tertiary aquifer at this location; however, the thickness of the marl unit suggests the integrity of this confining unit. Section 2.4.13 of this SER further discusses this alternate conceptual model.

The NRC staff reviewed aspects of the ground-water system that led to the applicant's statement that ground-water in South Carolina neither affects nor is affected by VEGP site operation. The NRC staff reviewed the USGS ground-water model of the region that included the VEGP site in Georgia as well as the SRS in South Carolina (Clarke and West 1998; Cherry 2006). This recent USGS work presents a current interpretation of ground-water data and provides insight into where the Savannah River has incised confining zones, allowing releases to occur from confined aquifers into the Savannah River alluvium and hence to the Savannah River. The deep confined aquifers of the Cretaceous aquifer system (i.e., described as the Dublin and Midville aquifer systems in USGS reports) are not incised by the river opposite the VEGP site, but are incised several miles upstream (Clarke and West 1998, Figure 5). Therefore, the confining zones are intact beneath the Savannah River opposite the VEGP site. This allows complete communication of ground water in the Cretaceous aquifer between the States of Georgia and South Carolina. Accordingly, at the request of NRC staff, the USGS analyzed alternate water use rates at the VEGP site using its regional model to predict impacts and ground-water origins (Cherry and Clarke 2007). For those scenarios that examined the anticipated pumping rate for the proposed VEGP Units 3 and 4, the ground water appeared to originate in the upland areas of Georgia, with none of the recharge originating in South Carolina.

Water use data for a period of 20 years ending in the year 2000 suggest that withdrawal rates for surface water and ground water remained nearly unchanged (Fanning 2003) in the vicinity of the VEGP site. Projected water demand in Burke County, Georgia, indicates an increase of 50 percent by 2035 (Rutherford 2000). In South Carolina, analysts project an increase of 50 percent by 2045 (SC DNR 2004). However, despite these projections, a recent USGS report assigned lower ground-water pumping rates for the region in the future (i.e., through 2020) than have occurred during the recent drought (Cherry 2006, Figure 34). This suggests that stress on the ground-water resource was highest during the recent drought and could now diminish. Future demand includes production from the Water Table aquifer; however, wells in the Water Table aquifer are relatively low-production wells providing ground water for domestic use. Such wells exhibit a relatively local drawdown and, when located on the VEGP property boundary, are so distant from the proposed powerblock area that they would not substantially influence the elevation of the water table or the pathway of accidental releases.

The aquifers of interest in the evaluation of safety-related issues are the unconfined or Water Table aquifer and the uppermost confined or Tertiary aquifer. The two aquifers are separated by the Blue Bluff Marl formation, which has a thickness of approximately 63 feet (SNC 2008b). An accidental release to ground water would contaminate the Water Table aquifer. It is possible, but perhaps unlikely, that hydraulic communication exists between the Water Table and Tertiary aquifers. However, such communication, if it exists, could lead to an accidental release reaching the Tertiary aquifer. The staff conducted a confirmatory analysis of this scenario and documented the results in Section 2.4.13 of this SER. Based on its review of available data on the piezometric levels of these aquifers, the NRC staff concludes that they are influenced by local changes in aquifer characteristics and water use and discharge locally to surface drainage systems that ultimately discharge to the Savannah River. Changes in ground-water use with a potential to affect regional ground-water characteristics (i.e., the deep confined or Cretaceous aquifer system) over the long term will not influence the safety-related analysis of the ground-water system, which focuses on the unconfined or Water Table aquifer.

Effects on Plant Foundations and Other Safety-Related Structures, Systems, and Components

The proposed VEGP Units 3 and 4 will have foundations for the containment and auxiliary buildings at elevation 180.5 feet MSL. The applicant's parameter for maximum water table elevation or design ground-water level is 165 feet MSL (SNC 2008a, Part 2, Table 1-1). The applicant based this ground-water level on monitoring of the unconfined aquifer over the past decade. The plant grade elevation is 220 feet MSL. Foundations of all safety-related structures will be on structural backfill that will be placed above the Blue Bluff Marl on an engineered fill. The excavated natural materials will be replaced with compacted structural fill with properties that provide an adequate factor of safety against liquefaction (SNC 2008a, Part 2, Section 2.5.4.8.3.1). The maximum ground-water level from the site parameter list for the plant fitting within the bounding parameters in the proposed permit application is 2 feet below the design grade elevation. Therefore, the safety-related structural requirement for a plant that fits within the bounding parameters in the proposed permit application located at the proposed VEGP site is a ground-water elevation less than 218 feet MSL.

Based on the maximum observed ground-water level of 165 feet MSL, the water table elevation of the unconfined aquifer will not contribute a buoyant force on the nuclear island structure, which will have a foundation elevation at or higher than 180.5 feet MSL. However, after construction activity and modification of surface condition of the area surrounding the safety-related plant structures, changes in land use and ground-water recharge will likely alter the elevation of the ground-water table.

As part of the SER with Open Items, the NRC staff wrote, "The applicant should provide an improved and complete description of the current and future local hydrological conditions, including alternate conceptual models, to demonstrate that the design bases related to groundwater-induced loadings on subsurface portions of safety-related SSCs would not be exceeded. Alternatively, the applicant can provide design parameters for buoyancy evaluation of the plant structures." This was Open Item 2.4-2.

In response, the applicant has provided additional data from COL borings, revised its interpretations of data sets, and developed a ground-water model of the Water Table aquifer. The applicant's model of the Water Table aquifer (SNC 2008b, 2008c) includes an evaluation of current, spatially varying recharge patterns and of post-construction changes to recharge resulting from changes in land use and vegetation. These additional data and analyses have allowed the NRC staff to evaluate alternative conceptual models, alternative directions of ground-water movement, and the effects of ground-water-induced loadings on subsurface portions of safety-related SSCs.

The NRC staff used the applicant's model and analyzed a higher post construction recharge assignment to the powerblock and cooling tower areas, along with a lower hydraulic conductivity assignment to the engineered backfill in the excavated region of the powerblock area. Using a hypothetical high recharge rate of half of the precipitation (i.e., 24 inches/year) and a low hydraulic conductivity in the engineered backfill (i.e., the minimum of observed values in engineered backfill for VEGP Units 1 and 2 or 1.3 feet/day), the predicted hydraulic head was still below the foundations of all proposed structures and well below the design requirement of a plant that fits within the bounding parameters in the proposed permit application (i.e., a maximum water table elevation of 218 feet MSL). Therefore, based on its independent analysis, the NRC staff finds the applicant's site characteristic value for the maximum ground-water elevation at the VEGP site to be acceptable. This elevation will be far enough below the site grade so as to not represent a safety concern for the plant fitting within the bounding parameters proposed in the application. This analysis by NRC staff enables closure of Open Item 2.4-2. Therefore, Open Item 2.4-2 is closed.

Reliability of Ground-Water Resources and Systems Used for Safety-Related Purposes

Any plant that fits within the bounding parameters provided in the proposed permit application will not need ground water for safety-related use. Therefore, the NRC staff did not evaluate the reliability of the ground-water source for safety-related use. The NRC staff determined that the proposed VEGP Units 3 and 4 will have no SSCs that rely on ground water for a safety-related use other than initial filling and occasional makeup to water storage tanks associated with the passive containment cooling system.

Reliability of Dewatering Systems

The applicant proposed no permanent dewatering systems as part of the operation of the proposed VEGP Units 3 and 4. On the basis of the field data and the applicant's ground-water model results, as well as its own modeling efforts, the NRC staff concludes that a permanent dewatering system will not be required for a future plant fitting within the bounding parameters provided in the proposed permit application.

2.4.12.4 Conclusion

As set forth above, the applicant has substantiated sufficient information pertaining to the identification and evaluation of the effects of ground water in the vicinity of the proposed site. Section 2.4.12, “Groundwater,” of RS-002 directs the applicant to address in the SSAR the requirements of 10 CFR Part 52 and 10 CFR Part 100 as they relate to identifying and evaluating the effects of ground water in the vicinity of the site and site regions. Furthermore, the applicant considered the most severe natural phenomena historically reported for the site and surrounding area while describing the hydrologic interface of the plant with the site with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in this site characteristic, as documented in the SERs for previous licensing actions. Accordingly, the NRC staff concludes that the use of these methodologies results in a site characteristic containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the NRC staff considers the identifed site characteristic for the highest ground water elevation to be acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

Therefore, the NRC staff concludes that the identification and consideration of the ground-water elevation characteristic set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.23(d)(4). In view of the above, the NRC staff finds the proposed hydrology-related site characteristic to be acceptable for inclusion in an ESP for the applicant’s site.

2.4.13 Accidental Releases of Radioactive Liquid Effluents in Ground and Surface Waters

2.4.13.1 Introduction

This section of the applicant’s SSAR evaluates the hydrogeological characteristics of the site in terms of the effects of accidental releases of radioactive liquid effluents in ground and surface waters on existing uses and known and likely future uses of ground and surface water resources. The NRC staff’s review of the applicant’s SSAR, described in this section, addresses only accidental releases of radioactive liquid effluent with regard to surface and subsurface site characteristics. The NRC staff’s review of the SSAR covers (1) alternate conceptual models, (2) characteristics that affect transport, (3) pathways, and (4) consideration of other site-related evaluation criteria.

This section of the SER reviews the applicant’s process to identify and quantify the accidental radioactive liquid effluent release, its pathway to the accessible environment, and its migration and attenuation in surface waters and ground waters.

2.4.13.2 Regulatory Basis

The acceptance criteria for identifying potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the identification of potential hazards in the site vicinity:

- 10 CFR 52.17(a) requires the application to contain information regarding the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit.

- 10 CFR 100.20(c) requires that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit.

- 10 CFR 100.21(d) requires that the physical characteristics of the site (including seismology, meteorology, geology, and hydrology) must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility to be located at the site.

Section 2.4.13 of RS-002 provides the following criteria that the NRC staff used to evaluate this SSAR section:

- Compliance with 10 CFR Part 52 and 10 CFR Part 100 requires that the NRC consider the local geologic and hydrologic characteristics when determining the acceptability of a site to host a nuclear unit. The geologic and hydrologic characteristics of the site may have a bearing on the potential consequences of radioactive materials escaping from a nuclear unit of specified type that might be constructed on the proposed site. An applicant should plan special precautions if a reactor will be located at a site where a significant quantity of radioactive effluent could accidentally flow into nearby streams or rivers or find ready access to underground water tables.

- These criteria apply to RS-002, Section 2.4.13, because the reviewer evaluates a site's hydrologic characteristics with respect to the potential consequences of radioactive materials escaping from a nuclear unit of specified type that might be constructed on the proposed site. The review considers the radionuclide transport characteristics of ground water and surface water environments with respect to accidental releases to ensure that current and future users of ground water and surface water are not adversely affected by an accidental release from a nuclear unit of specified type that might be constructed on the proposed site. RG 1.113, Revision 1, "Estimating Aquatic Dispersions of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," issued April 1977, and RG 4.4, "Reporting Procedure for Mathematical Models Selected to Predict Heated Effluent Dispersion in Natural Water Bodies," issued May 1974, provide guidance in the selection and use of surface water models for analyzing the flow field and dispersion of contaminants in surface waters.

- Meeting the requirements of 10 CFR Part 52 and 10 CFR Part 100 provides reasonable assurance that accidental releases of liquid effluents to ground water and surface water, and their adverse impact on public health and safety, will be minimized.

- To judge whether the applicant has met the requirements of 10 CFR Part 52 and 10 CFR Part 100 with respect to accidental releases of liquid effluents, the NRC uses the following criteria:

  — The applicant should describe radionuclide transport characteristics of the ground-water environment with respect to existing and future users. In addition, the applicant should describe estimates and bases for coefficients of dispersion, adsorption, ground-water velocities, travel times, gradients, permeabilities, porosities, and ground-water or piezometric levels between the site and existing or known future surface water and ground-water users. These estimates and bases should be consistent with site characteristics. The application should identify potential pathways of contamination to ground-water users and describe and reference data sources.

  — The applicant should describe transport characteristics of the surface water environment with respect to existing and known future users for conditions which reflect worst-case release mechanisms and source terms to postulate the most pessimistic contamination from accidentally released liquid effluents. The applicant should also describe estimates of physical parameters necessary to calculate the transport of liquid effluent from the points of release to the site of existing or known future users. The application should identify potential pathways of contamination to surface water users and describe and reference sources of information and data. The NRC staff will base its acceptance on its evaluation of the applicant's computational methods and the apparent completeness of the set of parameters necessary to perform the analysis.

  — Mathematical models are acceptable to analyze the flow field and dispersion of contaminants in ground water and surface water, providing that the models have been verified by field data and use conservative site-specific hydrologic parameters. Furthermore, conservatism should guide the selection of the proper model to represent a specific physical situation. Radioactive decay and sediment adsorption may be considered, if applicable, providing that the adsorption factors are conservative and site specific. RG 1.113 guides in the selection and use of surface water models. RS-002 discusses the transport of fluids through porous media.

2.4.13.3 Technical Evaluation

This section consists of (1) a review of the information provided by the applicant and (2) the NRC staff's evaluation of the applicant's submittal.

2.4.13.3.1 Technical Information Presented by the Applicant

In Section 2.4.13 of the SSAR, Revision 4-S2 (SNC 2008b), Southern presented information and data describing a postulated accidental release of radioactive liquid effluents in ground water and surface water. Southern also described (1) the conceptual models of the site, (2) characteristics that affect radionuclide transport, (3) contamination pathways, and (4) other site-related evaluation criteria.

In SSAR Section 2.4.13.1.1, the applicant selected the accident scenario from the information provided by the reactor vendor for the future plant fitting within the bounding parameters provided in the SSAR. The accident scenario is an instantaneous release from an effluent holdup tank located at the lowest level of the auxiliary building within the powerblock area (SNC 2008b). The applicant stated that the effluent holdup tank has a volume of 28,000 gallons, and a postulated rupture leads to a loss of 80 percent of that volume or 22,400 gallons in accordance with Branch Technical Position (BTP) 11-6. In its analysis, the applicant assumed that the release instantaneously enters the backfilled region of the Water Table aquifer, which underlies the auxiliary building, and displaces all pore water in a space 21 feet wide, 21 feet long, and 20 feet deep.

The applicant presented field observations of the current Water Table aquifer and a model of the aquifer in a variety of post construction settings to conclude that ground water will flow north in the future from the proposed powerblock area toward Mallard Pond (SNC 2008b, Figure 2.4.13-1). Southern concluded that the most critical release pathway in the ground-water environment will be from the proposed VEGP Unit 4 auxiliary building northward to the south side of Mallard Pond. The travel distance scaled from the curvilinear pathway shown in Figure 78 of Appendix 2.4B (SNC 2008b) revealed an approximate distance of 2550 feet; 150 feet through backfill, 1200 feet through undisturbed aquifer to a point south of observation well OW-1005, and an additional 1200 feet to the south side of Mallard Pond through an undisturbed but higher conductivity segment of aquifer. Using a ground-water model of the Water Table aquifer to trace the pathway of contaminants, the applicant reported travel times through the three curvilinear aquifer segments of 2.4, 3.2, and 1.1 years, respectively, for a total travel time of 6.7 years from the release point below the auxiliary building to Mallard Pond.

In SSAR Section 2.4.12.1.4 (SNC 2008b), the applicant reported hydraulic properties of the Barnwell Formation sediments used in the safety analyses and included the range of hydraulic conductivity measurements for the Utley Limestone from 3,250 to 125,400 feet/year (9 to 343 feet/day). The applicant also derived a value for effective porosity of 0.34 (SNC 2008b, Section 2.4.12.1.4) from the median specific gravity and moisture content measurements. The applicant estimated a maximum hydraulic gradient of 0.014 feet/feet to apply to the Water Table aquifer in the vicinity of the proposed Units 3 and 4 (SNC 2008b, Section 2.4.12.1.3). A maximum gradient of 0.023 feet/feet can be derived from the hydraulic head data for the aquifer between OW-1005 and Mallard Pond. The applicant used the ground-water model and estimated the travel times for the last two segments in the aquifer as 3.2 and 1.1 years respectively, for a total of 4.3 years.

In SSAR Section 2.4.12.1.4 (SNC 2008b), the applicant reported the range of measured hydraulic conductivity values in the engineered backfill as 480 to 1220 feet/year (1.3 to 3.3 feet/day). As reported in UFSAR Table 2.4.12-14, the applicant obtained these values from the prior postconstruction testing of backfill regions underlying existing VEGP Units 1 and 2 (SNC 2003). The applicant also estimated the backfill porosity to be 0.34 based on information from the UFSAR (SNC 2003). An estimate of the hydraulic gradient in the engineered backfill is the same as in the surrounding Water Table aquifer, a maximum estimated value of 0.014 ft/ft. The applicant used the ground-water model and estimated the travel time to be 2.4 years.

The applicant also postulated an alternative release pathway from the powerblock area through the Tertiary aquifer to the Savannah River (SNC 2008b, Figure 2.4.13-2). In SSAR Section 2.4.12.1.4, Table 2.4.12-3, the applicant reported hydraulic properties of the Tertiary aquifer sediments (SNC 2008b) used in the safety analyses and included a range of hydraulic conductivities from 0.35 to 2.1 feet/day, with a geometric mean of 0.83 feet/day and an effective porosity of 0.31. The applicant estimated a maximum hydraulic gradient of 0.005 feet/feet to apply to a distance of 5600 feet between the center of the powerblock and the Savannah River (SNC 2008b, Section 2.4.12.1.4). Based on the geometric mean of the hydraulic conductivity, the maximum gradient, and the effective porosity, the applicant estimates the travel time to be 1142 years.

As the applicant described, Mallard Pond is controlled by a combination of standpipe and spillway with discharge to a stream that ultimately discharges to the Savannah River (SNC 2007c, 2008b). The applicant identified two companies as the nearest downstream industrial surface water users; both withdraw water from the Savannah River and are located near River Mile 45, about 106 miles downstream of VEGP (SNC 2008b, Section 2.4.13.1.2.1).

For the Mallard Pond drainage pathway, the applicant's analysis considered (1) radionuclide decay associated with travel times in the ground-water pathway, (2) adsorption and decay during a retarded travel time for sorbed radionuclides in the groundwater pathway and the dilution of the ground water released to Mallard Pond (i.e., 0.094 gallons/ per minute) in the stream below the pond (i.e., 1125 gallons/minute). The applicant performed analytical tests to estimate distribution coefficients for cobalt, strontium, and cesium. The minimum values of the distribution coefficient from 16 soil samples, identified by the applicant as being representative of backfill material, were 1.4 milliliters per gram (mL/g) for cobalt, 6.0 mL/g for strontium, and 3.5 mL/g for cesium. Minimum values from three samples of aquifer materials, identified by the applicant as being representative of Barnwell Group sediments, were 3.9 mL/g for cobalt, 14.4 mL/g for strontium, and 22.7 mL/g for cesium. Ground-water wells withdrawing aquifer water did not intercept either of the pathways analyzed by the applicant.

In RAI 2.4.13-2 (SNC 2007c), the NRC staff requested that the applicant evaluate the potential for chelation and complexation agents (e.g., organic acids) to mix with radiological liquid effluents and adversely impact sorption phenomena. The NRC staff requested that the applicant clearly state whether or not mixing with chelation agents was possible. In its RAI response (SNC 2007c), the applicant stated that the site does not prohibit the use of chelating agents, but does require a comprehensive evaluation before their use. The applicant stated that it will tightly control any future use of chelating agents at VEGP and that it does not anticipate using chelating agents if they could come in contact with radioactive materials. In summary, the applicant stated that it would be extremely unlikely for radioactive liquids to come into contact with chelating agents.

In RAI 2.4.13-3 (SNC 2007c), the NRC staff requested that the applicant more fully describe the basis for the estimated ground-water flow into Mallard Pond and provide all data supporting the dilution of the release in surface water flow within the Mallard Pond drainage. In SSAR Section 2.4.13.1.3.1, the applicant fully described the ground-water release (SNC 2008b) and provided a calculation package detailing the measurements made for Mallard Pond and its downstream drainage (SNC 2007c). This calculation package, dated September 27, 1985, documents field observations made during June and July of 1985. These measurements represent single moment-in-time measurements. The applicant's calculation package states that the discharge downstream of the confluence of the Mallard Pond drainage and West Branch drainage ranges from 800 to 1200 gallons/minute (SNC 2007c). The applicant used a discharge rate of 1125 gallons/minute in calculations of the release dilution (SNC 2008b, Section 2.4.13.1.3.1). After the NRC issued the SER with Open Items, the applicant developed a ground-water model of the Water Table aquifer and provided simulations of postconstruction events that better describe future ground-water flow in the vicinity of the proposed VEGP Units 3 and 4 (SNC 2008b, Appendix 2.4B)

Of the 56 radionuclides in the effluent holdup tank inventory (SNC 2008b, Table 2.4.13-1), the applicant only identified 10 that will require more than decay in the ground-water pathway to be reduced to less than 1 percent of their maximum effluent concentration limits (ECLs) (SNC 2008b). The 10 radionuclides were H-3, Mn-54, Fe-55, Co-60, Sr-90, Ag-110m, I-129, Cs-134, Cs-137, and Ce-144.

In SSAR Section 2.4.13.1.3.1, the applicant identified eight radionuclides that will require more than decay and adsorption in the ground-water pathway to be reduced to less than 1 percent of their ECLs (SNC 2008a). Distribution coefficients were only available for cobalt, strontium, and cesium. Following inclusion of adsorption and decay associated with retarded travel time, the applicant identified the remaining eight radionuclides requiring further analysis as H-3, Mn-54, Fe-55, Sr-90, Ag-110m, I-129, Cs-137, and Ce-144.

The applicant applied dilution downstream of Mallard Pond to the decayed radioisotope concentrations entering Mallard Pond from the Water Table aquifer. The applicant's estimated concentration of each radioisotope downstream of the dilution location is below its respective ECLs. The highest contributor to dose is H-3, which, according to the applicant, represents nearly 6 percent of its ECL (SNC 2008b, Section 2.4.13.1.3.1, Table 2.4.13-5). The applicant calculated the cumulative measure, (i.e., the sum of all ratios), and reported 0.058, which is less than one and meets the requirement in Note 4 in Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release Sewerage," to 10 CFR Part 20, "Standards for Protection against Radiation" (SNC 2008b, Section 2.4.13.1.4).

The applicant noted that it demonstrated compliance for a point along the stream within the restricted area which does not represent a potable water source. The applicant stated that the stream is a gaining stream (i.e., it does not discharge to ground water) which discharges to the Savannah River. The applicant identified the Savannah River as being the nearest potable water supply in an unrestricted area. The applicant indicated that a conservative representation of Savannah River flow is the 100-year drought flow of 3298 cubic feet/second (1,480,000 gallons/minute) while the tributary flow rate is 1125 gallons/minute, thus the additional dilution would further reduce radionuclide concentration by a factor of about a 1,000 (SNC 2008b, Section 2.4.13.1.4).

For the alternative Tertiary aquifer pathway mentioned above, the applicant stated that, using only the radioactive decay in the Tertiary aquifer pathway, the cumulative measure applied to ground-water quality before discharge to the Savannah River (i.e., the sum of all ratios) is 0.036. Therefore, this value is in compliance with 10 CFR Part 20 limits (SNC 2008b, Section 2.4.13.1.4).

In SSAR Section 2.4.13.2, the applicant stated that no outdoor tanks contain liquid radioactive waste in the reactor design under consideration; therefore, no accident scenario is projected to result in a liquid effluent release directly to the surface water environment (SNC 2008b).

2.4.13.3.2 Technical Evaluation

The NRC staff has divided its technical evaluation into four topics—alternate conceptual models, characteristics that affect radionuclide transport, contamination pathways, and contaminant transport analyses.

The applicant provided this section of the application to the NRC as a supplement to Revision 4 of the application (SNC 2008b). As a result of a series of requests, beginning at the initial site audit conducted in January 2007, the applicant has revised Section 2.4.13 of the SSAR with each revision of the application.

The staff issued an initial RAI on March 15, 2007, which asked the applicant to describe and discuss (1) the process followed to establish the conceptual model for the plausible transport pathways and travel times, (2) the process used to evaluate the potential of chelating agents (e.g., organic acids) that may combine with radionuclides and influence the movement of radionuclides in the environment, and (3) the process used to estimate the ground-water flux carrying an accidental release from the powerblock to Mallard Pond. Southern responded to these requests (SNC 2007c) and incorporated revisions into Revision 2 of the SSAR.

The NRC staff issued the SER with Open Items and included Open Item 2.4-3 asking that the applicant include an analysis providing assurance that it had considered an adequate number of combinations of release location and plausible alternative pathways. The NRC staff cited the inevitable change in site hydrology (e.g., changes in surface material and vegetation, slope, infiltration or recharge, runoff) as potentially significant in forecasts of aquifer response to construction of the proposed facility and potential future ground-water pathways. The NRC staff's analysis, which did not apply adsorption because of the potential impact of chelating agents, concluded that dilution in the Savannah River was required to meet the requirements of Table 2, Column 2, of Appendix B to 10 CFR Part 20. Accordingly, public access to ground water or surface water before its discharge to the river was an issue, and the staff included Open Item 2.4-4 requesting that the applicant specify the nearest point of public access along each potential pathway.

In response to these open items, the applicant developed a ground-water model of the Water Table aquifer and incorporated its description and results into Revision 3 of the SSAR. The applicant exercised the model using alternative combinations of the magnitude and distribution of recharge rates, the magnitude and distribution of hydraulic conductivity, and external and internal boundary conditions. In addition to revising the section to reflect the application of a ground-water model, the applicant better described the point of public exposure for each of the pathways analyzed.

The NRC staff's review of the ground-water model results in Revision 3 of the SSAR, as well as model input and output, revealed issues with model convergence, mass balance, and calibration bias. The NRC staff also noted that the applicant did not present alternative conceptual models. Instead, the applicant presented a sequence of models used to achieve calibration of a single conceptual model. The staff raised these concerns with the applicant at a public meeting at NRC in Rockville, Maryland, on April 8, 2008, at a site audit at the applicant's consultant's offices in Frederick, Maryland, on April 9, 2008, and in RAIs sent on July 22, 2008. The applicant addressed these concerns in its supplement to Revision 4 of the application (SNC 2008b) and in responses to the RAIs (SNC 2008c).

The applicant's analysis of radioactive liquid effluent pathways, which was originally based entirely on field data and the assumption that prior pathways would not be altered in the future, evolved into an analysis based on field data, as well as a model of the Water Table aquifer, enabling a more thorough analysis of plausible postconstruction conditions.

Alternate Conceptual Models

Transport of an accidental release of radioactive liquid effluent is viewed as a combinatorial problem with multiple possible environmental pathways. Among all plausible alternative conceptual models and pathways, the critical one results in the plausible yet conservative release consequence that is ultimately of interest for the site safety evaluation.

In general, the process of determining plausible pathways is uncertain because of spatially and temporally varying characteristics and because the release may occur in the future after substantial change has or may have occurred to the local landscape and near-field hydrology of the proposed site. This is even more important in the case of the VEGP site because it sits atop a ground-water divide and thus is very sensitive to changes in hydraulic conductivity and recharge. The existing hydrology of the site does not necessarily represent the future hydrology of the site. Construction of a large industrial facility such as the proposed nuclear power plants can lead to substantial change to the postconstruction landscape and hydrologic features of this site. These changes lead to alterations in the distribution of recharge in the vicinity of the proposed plants and in the water table of the aquifer underlying the proposed site.

The applicant developed a two-dimensional, single-layer, steady-state ground-water model of the Water Table aquifer underlying the VEGP site (SNC 2008b). Section 2.4.12 of this SER describes this model. Based on field data and the results of the simulation of seven alternative ground-water models, the applicant concluded that all contaminants released from the Nuclear Island area at the proposed VEGP Units 3 and 4 would move to the north and discharge to

Mallard Pond. Upon evaluation of the modeling results, the NRC staff concluded that this alternative pathway is perhaps the most plausible of alternative pathways. The applicant used model 7 to define, using tracer particles, plausible ground-water pathways and simulate the travel path from the proposed VEGP Unit 4 auxiliary building to the upper reach of Mallard Pond. Essentially, the ground water moved through three regions of the model—the saturated engineered backfill, the aquifer from the excavation (backfill) to the high conductivity zone above Mallard Pond, and through the aquifer's high conductivity zone to Mallard Pond. As described in Section 2.4.12, the applicant predicted travel times through the three zones to be 2.4 years, 3.2 years, and 1.1 years, respectively, for a total ground-water travel time of 6.7 years. Section 2.4.13.1.3.1 of the SSAR (SNC 2008b) further describes this pathway through the Water Table aquifer, which the NRC staff evaluates below.

The applicant presented an alternative ground-water pathway involving the Tertiary aquifer in Section 2.4.13.1.3.2 of the SSAR (SNC 2008b). The Blue Bluff Marl appears to be of substantial thickness and low hydraulic conductivity in the vicinity of the proposed construction; however, based on an alternative interpretation of field data (i.e., the possibility that ground water could move from the Water Table aquifer into the Tertiary aquifer) that cannot be completely excluded, the applicant evaluated a Tertiary aquifer pathway. The NRC staff considers this pathway to be plausible but unlikely. This pathway requires that a release to the Water Table aquifer be transported through the underlying mud unit, ultimately releasing to and moving through the confined Tertiary aquifer and discharging into the Savannah River opposite the site.

As described in Section 2.4.12 of this SER, the NRC staff used the applicant's model of the Water Table aquifer to evaluate the sensitivity of the model's solution to drain boundary condition elevations, to the use of minimum LiDAR data to define drainages, and to a variety of postconstruction conditions more extreme than those evaluated by the applicant. The staff used a matrix of recharge rates applied to the powerblock area and cooling tower area to explore the potential for change in the water table to yield alternative pathways for releases from the powerblock area. In addition, the staff evaluated the sensitivity of the simulation to the hydraulic conductivity of the backfill by assuming a less permeable or less conductive material. Using the matrix of recharge rates, the staff analyzed combinations of the following—powerblock area recharge high (i.e., half precipitation, 24 inches/year), expected (i.e., one-eighth precipitation, 6 inches/year), or zero, and cooling tower area recharge high ((i.e., half precipitation, 24 inches/year), expected (i.e., quarter precipitation, 12 inches/year), or zero.

A review of surface treatments and slopes within the powerblock and cooling tower areas reveals that it is unlikely that recharge rates inside a powerblock area would ever be greater than those inside a cooling tower area. Slopes, surface materials, and surface water control structures within the powerblock area are designed to conduct water away, especially during high precipitation events. Lesser slopes, gravel-covered surfaces, and surfaces maintained free of vegetation are typical of cooling tower areas, and all substantially increase the potential for recharge, especially during normal precipitation events. Accordingly, cases involving high and expected, high and low, and expected and low recharge for the powerblock and cooling tower areas, respectively, are implausible.

Given the historical measurements of the Water Table aquifer, as well as the natural flow and discharge of the Water Table aquifer to surrounding ravines or drainages, at least four potential ground-water pathway directions could be evaluated relative to the plausible combinations of recharge and hydraulic conductivity that contribute to a calibrated model. These potential ground-water pathways include ground-water flow from the powerblock toward (1) the Mallard Pond drainage, (2) the Daniels Branch drainage, (3) the Savannah River, and (4) an unnamed drainage located south of the VEGP Units 1 and 2 cooling towers. The applicant-produced ground-water model (SNC 2008b, 2008c, Appendix 2.4B) served as the starting point for the analysis. This model reproduces the general magnitude and location of the present-day ground-water high and surrounding contours. The staff then made perturbations to recharge rates and hydraulic conductivity to evaluate alternative pathways.

For all plausible recharge rate cases, as well as in the case of a lower conductivity backfill material, no ground-water pathway beginning inside the proposed powerblock area resulted in a simulated discharge to the Daniels Branch drainage or to the drainage located south of the VEGP Units 1 and 2 cooling towers. The high recharge cases with both maximum- and minimum-field-measured backfill hydraulic conductivity values did yield pathways that flow under the upper reaches of the Daniels Branch; however, the ground water was simulated to be below the streambed and it did not discharge into the Daniels Branch. In these same two cases, Water Table aquifer pathways were simulated that discharged into the Savannah River; however, this is an artifact of the case and not necessarily realistic. The model assigned higher recharge rates to the VEGP Units 3 and 4 powerblock and cooling tower areas than to the comparable VEGP Units 1 and 2 areas. If the model treated all powerblock and cooling tower areas similarly, the resulting higher water table that would underlie VEGP Units 1 and 2 would preclude ground-water movement directly towards the Savannah River from the VEGP Units 3 and 4 powerblock. For all plausible recharge rate cases, the majority of pathway traces showed ground-water movement to the north and traces beginning inside the powerblock area released to Mallard Pond.

However, the NRC staff postulated plausible pathways by conservatively extending the release points outside the proposed power block area. Based on measured hydraulic heads, site topography, and model simulations, the NRC staff concludes that, of the four possible ground-water pathways in the Water Table aquifer leading to the receptor, the Mallard Pond drainage pathway is the most plausible, the Daniels Branch drainage pathway is plausible but perhaps unlikely, the Savannah River drainage pathway is implausible, and the drainage to the south of VEGP Units 1 and 2 cooling towers is implausible. The decision to categorize the Daniels Branch drainage as plausible but unlikely results from (1) the ability to configure a relatively simple model and create pathways from the proposed powerblock area to ground water underlying the upper reaches of the Daniels Branch drainage, (2) uncertainty in future recharge rates and their spatial distribution, and (3) uncertainty in the magnitude and spatial distribution of the hydraulic conductivity of the Barnwell Group sediments, including the Utley Limestone, in the vicinity of the proposed facility. Thus, the uncertainties that exist with regard to the existing hydrogeological setting and future conditions require the NRC staff to conclude that the Daniels Branch pathway is plausible but perhaps unlikely. The possible Water Table aquifer pathways toward the Savannah River and toward the drainage located south of the VEGP Units 1 and 2 cooling towers did not conform to known aspects of the field setting; therefore, the staff determined that they were implausible. The following sections on the characteristics that affect transport and pathways evaluate the pathways found to be plausible in terms of their compliance with 10 CFR Part 20, Appendix B, Table 2.

The applicant provided parameters for an accidental release, including the tank, its relative location in the facility, its volume, and its contents. The applicant specified a single possible location for the accidental release of radioactive liquid effluents. The NRC staff postulated that a release could occur anywhere within the powerblock area. This assumption allows the identification of all potential alternative pathways and the selection of the most critical ones to conservatively estimate accidental release consequences.

The NRC staff found that the applicant's analysis in the SSAR was sufficient with respect to data (e.g., both past and present) and with respect to the model developed, thus enabling the staff to perform its evaluation. However, the NRC staff concluded that the additional ground-water pathway it identified previously (i.e., the pathway from the proposed powerblock area to the Daniels Branch drainage) is plausible. In the SER with Open Items, the NRC wrote that the applicant's SSAR, Revision 2, was incomplete because it did not consider the inevitable change in hydrology, and, hence, the potential change in flow direction within the Water Table aquifer for some release locations within the powerblock area. The analysis provided no assurance that the applicant had considered an adequate number of combinations of release locations and feasible pathways. This was Open Item 2.4-3. The applicant did develop and apply a model of the Water Table aquifer and has included ground-water pathways in both the Water Table and Tertiary aquifer. Therefore, Open Item 2.4-3 is closed.

Characteristics that Affect Transport

The NRC staff independently determined that the USGS-derived minimum and maximum range of transmissivity values based on field data (i.e., 500 to 9500 $feet^2$/day) (Clarke and West 1998, Table 3), when combined with the local thickness of the Water Table aquifer (i.e., approximately 30 feet), provide hydraulic conductivities ranging from 16.5 to 316 feet/day that are indicative of the values for the Utley Limestone of the Barnwell Formation cited by the applicant (i.e., 3,250 to 125,400 feet/year or 9 to 343 feet/day based on aquifer tests (SNC 2008a, Section 2.4.12). In model 7, the applicant identified hydraulic conductivity values of 32, 100, and 8 feet/day applied to three zones of the Water Table aquifer. The applicant assigned the majority of the model domain a value of 32 feet/day; it assigned a zone immediately upgradient of Mallard Pond a value of 100 feet/day, and it assigned the southwestern quadrant of the model domain the low value of 8 feet/day. A sensitivity case based on model 7 used hydraulic conductivity values of 25, 65, and 5 feet/day and divided the center of the model into a low and high zone; the remainder of the model was assigned the middle value. In this case, the applicant assigned the majority of the model domain associated with Utley Limestone the highest value, 65 feet/day, and assigned a small zone between the proposed location of the VEGP Units 3 and 4 the lowest value, 5 feet/day. Overall, the NRC staff found the model values to be comparable to the applicant data and USGS values of hydraulic conductivity.

The NRC staff reviewed the applicant's prior estimates of the magnitude of the hydraulic gradient (i.e., 0.014 and 0.023 for the backfill to OW-1005 segment and the OW-1005 to Mallard Pond segments, respectively), effective porosity (i.e., 0.34 and 0.31), and ground-water flux (i.e., 0.094 gallons/minute into Mallard Pond) and found them appropriate for simple, conservative effluent transport analyses. Ultimately, the applicant used the model-based values of hydraulic conductivity and hydraulic gradient to derive travel time along a pathway. The beginning of this section and the entirety of Section 2.4.12 summarize the NRC staff's review of the applicant's ground-water model. On the basis of its review, the staff concludes that the ground-water model exhibits mass balance and convergence.

The NRC staff reviewed the hydraulic properties assigned by the applicant to the engineered backfill. The applicant's analysis of transport characteristics in the engineered backfill relies on the observed maximum hydraulic conductivity of the existing units' engineered backfill (1220 feet/year, 3.3 feet/day) and the estimated values of effective porosity (0.34) and hydraulic gradient taken from the Water Table model. The NRC staff also used the minimum measured hydraulic conductivity (480 feet/year or 1.3 feet/day) in sensitivity analyses. The staff notes that the entire range of hydraulic conductivity for the backfill is below the range applied in the model to the natural sediments of the Water Table aquifer. This is not unexpected given the relatively high compaction and well-graded sediments of the backfill material, especially compared to portions of the Barnwell Group sediments, including the Utley Limestone, which are known to be more conductive.

Regarding the applicant's reported values of hydraulic conductivity in the Tertiary aquifer, the NRC staff independently reviewed the USGS minimum and maximum ranges of transmissivity estimates based on field data (180 to 12,200 feet2/day) and regional simulation (13 to 24,700 feet2/day) (Clarke and West 1998, Table 12). When combined with the local thickness of the Tertiary aquifer (approximately 182 feet), the USGS data, while being generally higher, do bracket the central value of hydraulic conductivity provided by the applicant (i.e., 0.83 feet/day). The NRC staff reviewed the applicant's estimates of the magnitude of the hydraulic gradient (i.e., 0.005) and effective porosity (i.e., 0.309). Ultimately, the NRC staff's use of the highest observed transmissivity value attributed to the Tertiary aquifer (i.e., 2.1 feet/day) ensures a conservative estimate of pore-water velocity and travel time (i.e., 450 years). The NRC staff notes that the applicant employed the geometric mean of the hydraulic conductivity values (i.e., 0.83 feet/day) and an effective porosity of 0.309 and calculated a travel time of 1142 years. Such a value represents the central tendency of the travel time and should not be viewed as overly conservative.

The applicant has not stated that it will avoid the use of complexants or chelating agents at the proposed VEGP Units 3 and 4. In response to RAI 2.4.13-2 (SNC 2007c), Southern indicated that it does not prohibit the use of chelating agents; rather it requires a comprehensive evaluation prior to use. Southern's statements suggest that, while it stopped routine use of chelating agents a number of years ago, circumstances could result in a mixture of chelating agents and radioactive liquid effluent. Accordingly, the NRC staff's analysis assumed that complexants or chelating agents may be present.

The NRC staff reviewed the applicant's estimate of streamflow necessary to dilute the radiological effluent released through the Water Table aquifer into Mallard Pond after an accident. For the streamflow dilution, the applicant used a measured streamflow of 1125 gallons/minute at a point just downstream of the confluence of the stream discharging from Mallard Pond and its west branch, which is a single moment-in-time measurement made in June and July 1985. The NRC staff determined that a lower streamflow than that measured by the applicant is feasible. Because the data were not gathered during the most severe drought of record (USACE 2006), the NRC staff concludes that it is reasonable to assume that the discharge from Mallard Pond could cease entirely for a period of time. It should also be noted that the stream downstream of Mallard Pond crosses the VEGP property boundary and then reenters the VEGP property before discharging to the Savannah River (SNC 2008b, Section 2.4.13.1.4). Thus, the discharge from Mallard Pond enters the public domain before its discharge to the Savannah River.

The applicant stated that the magnitude of the 100-year drought flow of the Savannah River was 3298 cubic feet per second (cfps) (1.48x106 gallons/minute). The minimum release from Thurmond Dam is currently set at 3600 cfps (1.616x106 gallons/minute) by the U.S. Army Corps of Engineers. A USGS streamflow gauge near the VEGP site shows higher flows, suggesting that at low flows the Savannah River actually picks up some additional flow between Thurmond Dam and the VEGP site. These additional flows are contributed by and consistent with tributary and ground-water discharges flowing into the Savannah River. The staff determined that, based on the above, 3600 cfps is a conservative estimate of monthly and annual flows.

The applicant believes that the drainage below Mallard Pond, when it enters the Hancock Landing property, does not represent a potable water supply and that 10 CFR Part 20 requirements do not apply. The applicant identified the Savannah River as the potential water supply to which 10 CFR Part 20 compliance applies and identified the closest surface water withdrawal downstream of the release as two industrial surface water users, both located about 106 miles downstream of the VEGP site. However, the NRC staff does not concur with this selection and instead determined based on the information provided by the applicant that the intersection between the Creek below Mallard Pond and the Hancock Landing property is the point of compliance. The staff evaluated both points of compliance and determined that for both points, 10 CFR Part 20 limits can be met. In addition, although the staff disagrees with the applicant's point of compliance for 10 CFR Part 20 limits, the staff concurs that the applicant adequately demonstrated that 10 CFR Part 20 limits can be met downstream of Mallard Pond, inside the exclusion area boundary (i.e. before reaching an unrestrictred area).

Contamination Pathways

To bound the most severe radiological consequences of radioactive liquid effluent release, the NRC staff postulated plausible alternative pathways to the accessible environment. The NRC staff concludes that the Mallard Pond drainage would likely intercept most accidental release pathways originating inside the powerblock area of the proposed VEGP Units 3 and 4. However, the future direction of ground-water flow within the Water Table aquifer may change, and it is not unreasonable to expect that some accidental release locations within the powerblock area could result in releases moving to the west and south. Such releases could flow into the upper reaches of the Daniels Branch drainage and ultimately to the Savannah River. Another feasible accidental release pathway would involve transport from the Water Table aquifer into the Tertiary aquifer, with subsequent migration toward and discharge into the Savannah River from the Tertiary aquifer. The NRC staff concludes that these three pathways represent plausible alternate pathways for the transport of an accidental release of radioactive liquid effluents and analyzed all three.

The NRC staff reviewed the Mallard Pond drainage accidental release pathway postulated by the applicant, and, assuming no credit for adsorption because of the potential presence of chelating agents, concludes that such a release and pathway analysis would require inclusion of release and dilution into the Savannah River to ensure that radionuclide concentrations meet site suitability requirements (10 CFR Part 20, Appendix B, Table 2).
The postulated release posed by the applicant is conservative because it ignores the leak containment and detection systems associated with the effluent holdup tank; the integrity of the engineered system, including the foundation of the auxiliary building; the time required to move through the vadose zone; the dispersal of contaminants in the vadose zone and aquifer; and the opportunity to remediate contaminant plumes in the ground-water environment.

Contaminant Transport Analysis

The NRC staff reviewed the applicant's calculations regarding the inventory, its accidental release, and its decay, adsorption, and dilution during transport through the environment. The NRC staff concludes that the applicant's use of adsorption to allow additional decay of cobalt, strontium, and cesium isotopes during retarded travel times was not warranted given the potential for chelating agents to be present. The NRC staff also concludes that neither the analysis nor the data adequately support the flow measurements and dilution calculations performed by the applicant for the Mallard Pond drainage north of the proposed VEGP Units 3 and 4. Consequently, it is reasonable to assume that flow from Mallard Pond ceased in the past and could cease in the future during times of extreme drought because of the standpipe discharge control structure. Neglecting adsorption and onsite dilution, the NRC staff determined that release from the drainage to the Savannah River will require mixing with approximately 10 percent of the Savannah River low flow (i.e., 160,000 gallons/minute) to achieve concentrations meeting the site suitability requirements (i.e., a sum of fractions less than one).

The NRC staff considered alternate subsurface conceptual models and release locations, with the release moving in another direction (e.g., towards the southwest), and determined that a pathway leading to the upper reaches of the Daniels Branch drainage was plausible but unlikely. As in the case of the Mallard Pond drainage analysis, the potential presence of chelating agents precludes the application of adsorption phenomena, and the release could not meet the 10 CFR Part 20 requirements before reaching the site boundary. Such a pathway (i.e., the Daniels Branch drainage) could pose a greater threat than the Mallard Pond drainage pathway quantified by the applicant in SSAR Section 2.4.13 (SNC 2008b).

The NRC staff concludes that, in addition to alternate conceptual models involving the direction of ground-water flow in the Water Table aquifer, an alternate conceptual model exists that suggests possible local communication between the unconfined Water Table aquifer and the confined Tertiary aquifer. The NRC staff determined that limited evidence indicates the possibility of a local hydraulic flaw in the aquitard separating these two aquifers. If an accidental release from the proposed VEGP Units 3 and 4 were to be intercepted by such a local communication region of the Water Table aquifer, then the staff concludes that the release could move into the Tertiary aquifer and move toward and discharge into the Savannah River. Using the maximum hydraulic conductivity cited by the applicant for the Tertiary aquifer, the shortest travel time to the river would be approximately 450 years. After accounting for decay during this travel time, of all radionuclides listed (SNC 2008b, Table 2.4.13-1), only I-129 and

Cs-137 would require future concentration reduction by mixing or dilution in the Savannah River. The NRC staff determined that dilution in only 76 gallons/minute of flow in the Savannah River (i.e., less than 0.005 percent of the 3600 cfps low flow) would be required to achieve the level of less than 1 percent of their ECLs. In this instance, the hierarchical process followed by the NRC staff to evaluate alternate conceptual models yields a release that is of less consequence than either a release through Mallard Pond or to the Daniels Branch drainage.

When the SER with Open Items was released, the NRC staff's review of the release location, migration, attenuation, and dilution of the radioactive liquid effluent release was incomplete. As stated in Open Item 2.4-3, the applicant had not considered a sufficient number of alternate conceptual models to identify potential release points and pathways. In addition, the analysis of the Mallard Pond drainage pathway raised an issue concerning the point of compliance, and the staff required the applicant to specify the nearest point along each potential pathway that was accessible to the public. This was Open Item 2.4-4. Later, the applicant provided the analysis of pathways and radionuclide transport through Revision 4 (2008b) and the response to RAIs (2008c). Also, the applicant provided a map of the site boundary and noted that the stream draining the Mallard Pond drainage does leave the site and reenters it before discharging to the Savannah River. It is also clear from the applicant's map that the stream draining to the upper reaches of the Daniels Branch leaves the site just before entering Lower Debris Basin 2. Therefore, Open Item 2.4-4 is closed.

The NRC Staff conducted a further analysis of the Mallard Pond and upper Daniels Branch drainages. The staff determined the catchment areas for both watersheds and applied monitored runoff rates from unregulated watersheds in the region to estimate the minimum monthly runoff rate for the Mallard Pond and upper Daniels Branch drainages. The catchment areas were based on standard 10-meter resolution USGS digital elevation models (DEMs) acquired from the U.S. Department of Agriculture Geospatial Gateway. The DEM for each catchment was checked for anomalous sinks or peaks and processed to produce flow direction and flow accumulation data. The staff identified a drainage outlet location at the intersection of the drainage channel and site boundary. Using these inputs, the staff used the ArcGIS "watershed" function to trace the catchment boundary and determine the catchment area. The area of the Mallard Pond catchment was 3.266 square kilometers, and the upper Daniels Branch catchment was 3.122 square kilometers. The staff used stream gauge data from six unregulated watersheds in Georgia and South Carolina to quantify the runoff from the VEGP watersheds. One gauge had a duration of record from 1929 to present, another from 1949 to present, and all others were of relatively short duration. The staff determined streamflow or runoff as a function of watershed area for these watersheds and defined the minimum watershed flow as the average of the lowest 12-month period. In other words, the staff used a 12-month floating window to search the data and define the 12-month period with the lowest annual flow of record. The average flow for that year was considered to be the minimum watershed flow. The minimum watershed flow for the Mallard Pond drainage was 279 gallons/minute, and for the upper reaches of the Daniels Branch drainage it was 267 gallons/minute.

The migration and fate of an accidental release of a radioactive liquid effluent can be estimated by assuming that (1) migration from the engineered backfill is the same or nearly the same for both pathways, (2) chelating agents are not present, and therefore, the minimum measured distribution coefficients are assumed to conservatively represent cobalt, strontium, and cesium movement, and (3) the runoff measured at other nearby unregulated watersheds is an appropriate surrogate for minimum annual runoff at watersheds on and adjacent to the VEGP site. For the analysis of the Mallard Pond drainage, key data include the travel times through the backfill and aquifer (i.e., 2.4 and 4.3 years (SNC 2008b)), the ground-water flux from the engineered backfill carrying the radioactive contamination, (i.e., 0.094 gallons/minute (SNC 2008b)), and the minimum distribution coefficients for backfill and aquifer materials (see FSAR Table 2.4.13-3 (SNC 2008b)). The resulting sum of fractions, where the fraction is the ratio of radionuclide concentration to its effluent concentration limit, is 0.235, which is below the requirement of one (10 CFR Part 20, Appendix B, Table 2).

For the analysis of the upper reach of the Daniels Branch drainage, key data include the travel times through the backfill and aquifer, the ground-water flux from the backfill, and the minimum distribution coefficients. The staff assumed the travel time through the backfill to be the same in both cases (i.e., 2.4 years). The staff also assumed that travel through the aquifer occurs from the engineered backfill to the nearest reach of Daniels Branch drainage, approximately 1500 feet away, and occurs at a ground-water velocity comparable to that currently observed. This results in a travel time estimate of 2.6 years. The resulting sum of fractions for this pathway is 0.336, which is also below the requirement of one (10 CFR Part 20, Appendix B, Table 2).

The NRC staff's analysis demonstrates that a release to the ground-water environment of a radioactive liquid effluent will meet the requirements of 10 CFR Part 20, Appendix B, Table 2. However, use of the minimum distribution coefficients in the analysis implies that no chelating agents can be comingled with the radioactive liquid effluents. Therefore, COL Action Item 2.4-1 requires that the COL or CP applicant confirm that no chelating agents will be comingled with radioactive waste liquids and that such agents will not be used to mitigate an accidental release. Alternatively, the COL or CP applicant may repeat experiments that include chelating agents to produce the distribution coefficients, and incorporate these newly determined distribution coefficients into the analysis to demonstrate that the requirements of 10 CFR Part 20, Appendix B, Table 2, are satisfied.

2.4.13.4 Conclusion

As set forth above, the applicant has substantiated sufficient information pertaining to the identification and evaluation of the effects of accidental releases of radioactive liquid effluents in ground and surface waters on existing users and known and likely future users of ground and surface water resources in the vicinity of the proposed site. Section 2.4.13 of RS-002 indicates that the SSAR should address the requirements of 10 CFR Part 100 as they relate to identifying and evaluating the effects of accidental releases of radioactive liquid effluents in ground and surface waters on existing users and known and likely future users in the vicinity of the site. Furthermore, the applicant considered the most severe natural phenomena historically reported for the site and surrounding area while describing the hydrologic interface of the plant with the site with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena reflected in this analysis, as documented in the SERs for previous licensing actions. Accordingly, the NRC staff concludes that the use of these methodologies results in an analysis containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the staff considers the applicant's analysis to be acceptable for use in establishing the design bases for those SSCs important to safety as may be proposed in a COL or CP application.

The NRC staff concludes that the identification and consideration of accidental releases of radioactive liquid effluents in ground and surface waters set forth above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d).

2.4.14 Site Characteristics

This section of the SER lists site characteristics and bounding parameters recommended by the NRC staff for inclusion in the ESP that may be granted for the VEGP site as given in table below.

Table 2.4.14-1 - Proposed Site Characteristics Related to Hydrology

SITE CHARACTERISTIC	VALUE	DEFINITION
Proposed Facility Boundaries	Figure 2.4.14-1	The site boundary within which all safety-related SSC will be located.
Highest Ground Water Elevation	165 feet MSL at the Water Table Aquifer	The highest elevation of the water table within the site boundaries.
Maximum Flood Elevation (maximum hydrostatic water surface elevation due to a postulated upstream dam breach scenario)	166.79 feet MSL	The stillwater elevation, without accounting for wind-induced waves that the water surface reaches during a flood event.
Wind run-up (to add to the maximum flood elevation)	11.31 feet	The water surface elevation reached by wind-induced waves running up on the shore.
Combined Effects Maximum Flood Elevation	178.10 feet MSL;	The water surface elevation obtained by adding wind run-up to the highest flood level.
Local Intense Precipitation	19.2 inches during 1 hour 6.2 inches during 5 minutes	The depth of PMP for duration of one hour on a one square-mile drainage area. The surface water drainage system should be designed for a flood produced by the local intense precipitation. The local intense precipitation is specified by SSAR Table 2.4.2-3 (see Table 2.4.2-1 of this SER).
Frazil Ice	The ESP site does not have the potential for the formation of frazil and anchor ice	Ice crystals that form in turbulent, open waters in presence of supercooling. Frazil ice is very sticky and may lead to blockages of intake screens and trash racks.

Table 2.4.14-2 Bounding Parameters

Bounding Parameters	Value	Definition
Plant Grade Elevation	220 feet MSL	The elevation of the finished ground surface that prevents the flood produced by the local intense precipitation from affecting the safety-related SSCs.

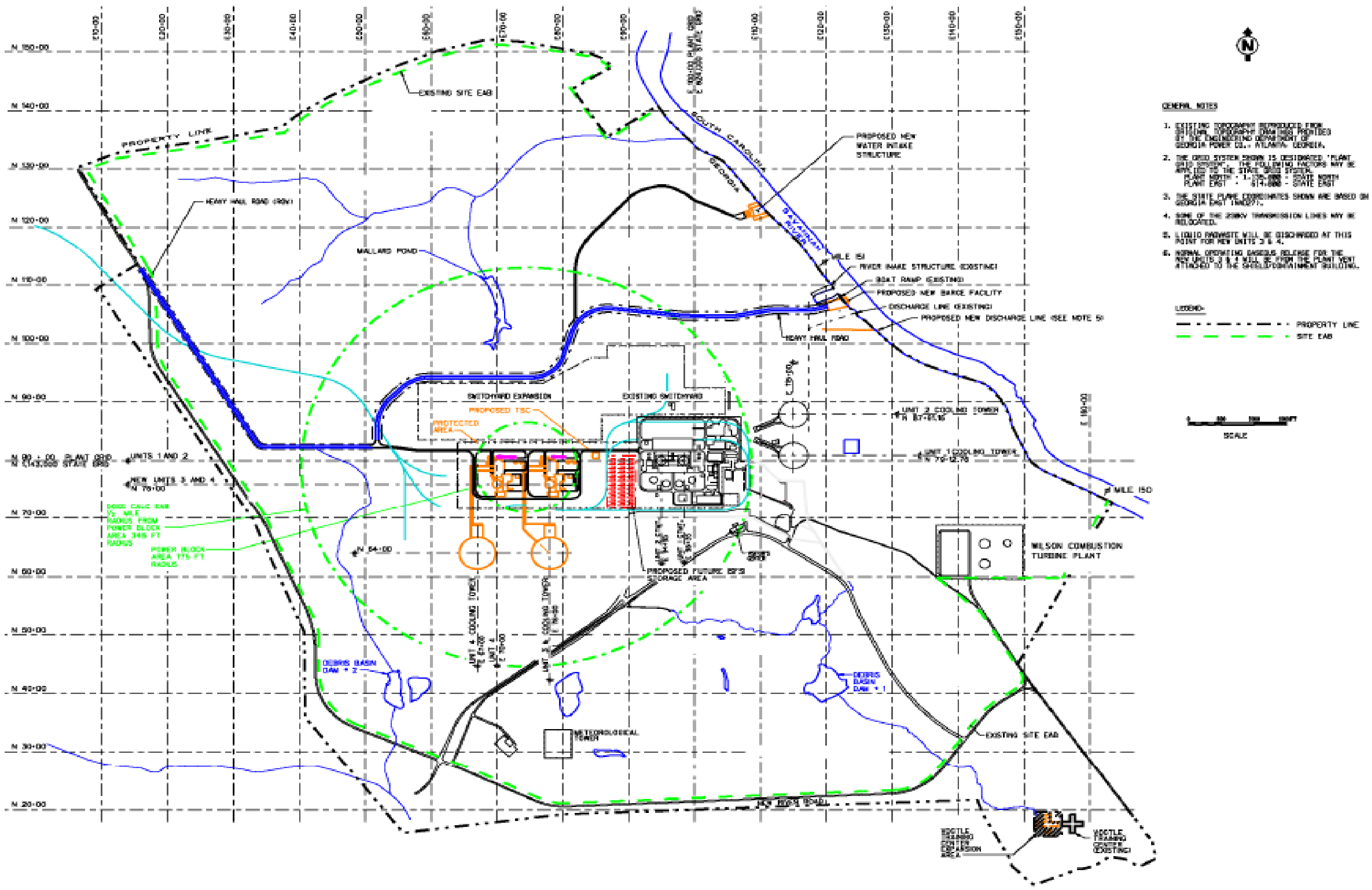


Figure 2.4.14-1 - The Proposed facility boundary for the VEGP site (Taken from SSAR Figure 1-4).