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2.3 Meteorology

To ensure that a nuclear power plant can be designed, constructed, and operated on an applicant's proposed early site permit (ESP) site in compliance with NRC regulations, the staff evaluates regional and local climatological information, including climate extremes and severe weather occurrences that may influence the design and affect the siting of a nuclear plant. The staff reviews information on the atmospheric dispersion characteristics of a nuclear power plant site to determine if the radioactive effluents from postulated accidental releases, as well as routine operational releases, comply with NRC regulations. The staff prepared Sections 2.3.1 through 2.3.5 of this report in accordance with the review procedures described in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," using information presented in Section 2.3 of the PSEG Site ESP SSAR, responses to staff RAIs, and generally available reference materials, as described in applicable sections of NUREG-0800.

2.3.1 Regional Climatology

2.3.1.1 *Introduction*

In SSAR Section 2.3.1, "Regional Climatology," the applicant presented information on the climatic conditions and regional meteorological phenomena (both the averages and extremes thereof) that could influence the design and affect the operating bases of safety- and non-safety-related structures, systems, and components (SSCs) for the proposed nuclear power plant.

2.3.1.2 *Summary of Application*

In SSAR Section 2.3.1, 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 potential for restrictive air dispersion conditions and high air pollution levels at the proposed site

Based on the above information, the applicant provided in SSAR Table 2.0-1, "PSEG Site Characteristics," a representative list of characteristics that describe the PSEG Site. 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 applicant proposed these climatic site characteristics as minimum design and operating bases for the proposed PSEG 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, 1-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 (1-percent, and 0.4-percent annual exceedance; 100-year return period)

2.3.1.3 *Regulatory Basis*

The acceptance criteria for identifying regional climatological and meteorological information are based on meeting the relevant requirements of 10 CFR 52.17, "Contents of Applications; Technical Information," and 10 CFR Part 100, "Reactor Site Criteria." The staff considered the following regulatory requirements in reviewing the applicant's identification of regional climatological and meteorological information.

- 10 CFR 52.17(a), as it relates to the requirement that the application contain a description of the seismic, meteorological, hydrological, and geological characteristics of the proposed site

- 10 CFR 100.20(c), as it relates to the requirement that those meteorological characteristics of the site that are necessary for safety analysis or that might have an impact on plant design be identified and characterized as part of the NRC's review of the acceptability of the site

- 10 CFR 100.21(d), as it relates to the requirement that the physical characteristics of the site- including meteorology, geology, seismology, and hydrology- be evaluated and site characteristics 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 at the ESP stage 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," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities":

- GDC 2, "Design Bases for Protection Against Natural Phenomena," as it relates to the requirement that SSCs 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," as it relates to the requirement 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, including loss-of-coolant accidents

The following are the related acceptance criteria from NUREG-0800, Section 2.3.1, "Regional Climatology."

- The description of the general climate of the region should be based on standard climatic summaries compiled by the National Oceanic and Atmospheric Administration (NOAA).

- Data on severe weather phenomena should be based on standard meteorological records from nearby representative National Weather Service (NWS), military, or other stations recognized as standard installations that have long periods of data on record.

- The tornado parameters should be consistent with RG 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Revision 1. Alternatively, an applicant may specify any tornado parameters that are appropriately justified, provided that a technical evaluation of site-specific data is conducted.

- The basic (straight-line) 100-year return period, 3-second gust wind speed should be based on appropriate standards, with suitable corrections for local conditions.

- To be consistent with RG 1.27, "Ultimate Heat Sink for Nuclear Power Plants," Revision 2, the UHS meteorological data that would result in the maximum evaporation and drift loss of water and minimum water cooling should be based on long-period regional records that represent site conditions. (The guidance in this RG does not apply to passive reactor designs that utilize a passive containment cooling system at the UHS.)

- The weight of the 100-year return period snowpack should be based on data recorded at nearby representative climatic stations or obtained from appropriate standards with suitable corrections for local conditions. The weight of the 48-hour PMWP should be determined in accordance with reports published by NOAA's Hydrometeorological Design Studies Center.

- Ambient temperature and humidity statistics should be derived from data recorded at nearby representative climatic stations or obtained from appropriate standards with suitable corrections for local conditions.

- High air pollution potential information should be based on U.S. Environmental Protection Agency (EPA) studies.

- All other meteorological and air quality conditions identified by the applicant as design and operating bases should be documented and substantiated.

- Design Certification (DC)/COL Interim Staff Guidance (ISG)-007, "Interim Staff Guidance on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures," which clarifies the staff's position on identifying winter precipitation events as site characteristics and site parameters to determine normal and extreme winter precipitation loads on the roofs of Seismic Category I structures.

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

- RG 1.23, Revision 1, "Meteorological Monitoring Programs for Nuclear Power Plants," which provides criteria for an acceptable onsite meteorological measurements program.

- RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," which describes the type of regional meteorological data that should be presented in SSAR Section 2.3.1.

- RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," which provides criteria for selecting the design-basis hurricane parameters

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

2.3.1.4 *Technical Evaluation*

The staff reviewed SSAR Section 2.3.1 to ensure that the ESP application represents the complete scope of information relating to "Regional Climatology." The staff's review confirmed that the information contained in the application addresses the required information relating to regional climatology.

2.3.1.4.1 Landforms and Ground Surface Character of the Site's Region

In SSAR Section 2.3.1.1, the applicant stated that the climate of the proposed site is the combined result of several geographic factors. These factors include the synoptic weather patterns that are typical of the area, the type of approaching air masses, and the character of the regional ground surface.

The PSEG Site is located on the eastern bank of the Delaware River, at the southwest corner of New Jersey (NJ). SSAR Figure 2.3-1, "New Jersey Landform Areas," (reproduced in Figure 2.3-1 of this report) depicts the major landform areas surrounding the site. The proposed PSEG Site is located near the edge of three of the landform areas: the Delaware River, the Inner Coastal Plain, and the Outer Coastal Plain. SSAR Figure 2.3-2, "Local Topographic Map," (reproduced in Figure 2.3-2 of this report) presents a regional topographic map for the area surrounding the PSEG Site.

In SSAR Section 2.3.1.1, the applicant stated that within a distance of approximately 8 km (5 mi) surrounding the PSEG site, the ground surface is primarily marsh. At distances greater than 8 km (5 mi), the ground surface is a combination of cleared area, coastal dune vegetation, forest (including oak, beach, and pine), and urban centers.

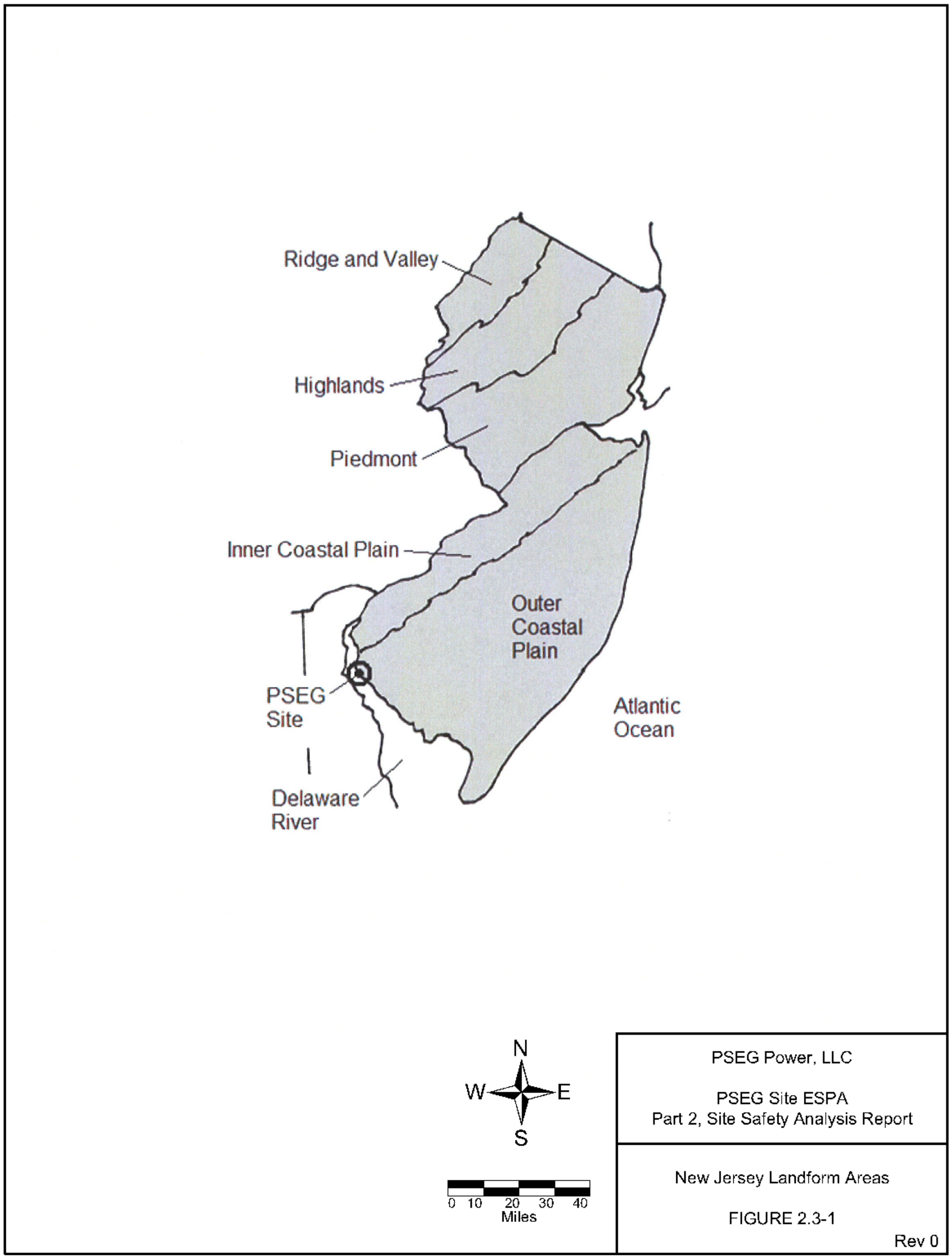

Figure 2.3-1 New Jersey Landform Areas (Reproduced from SSAR Figure 2.3-1)

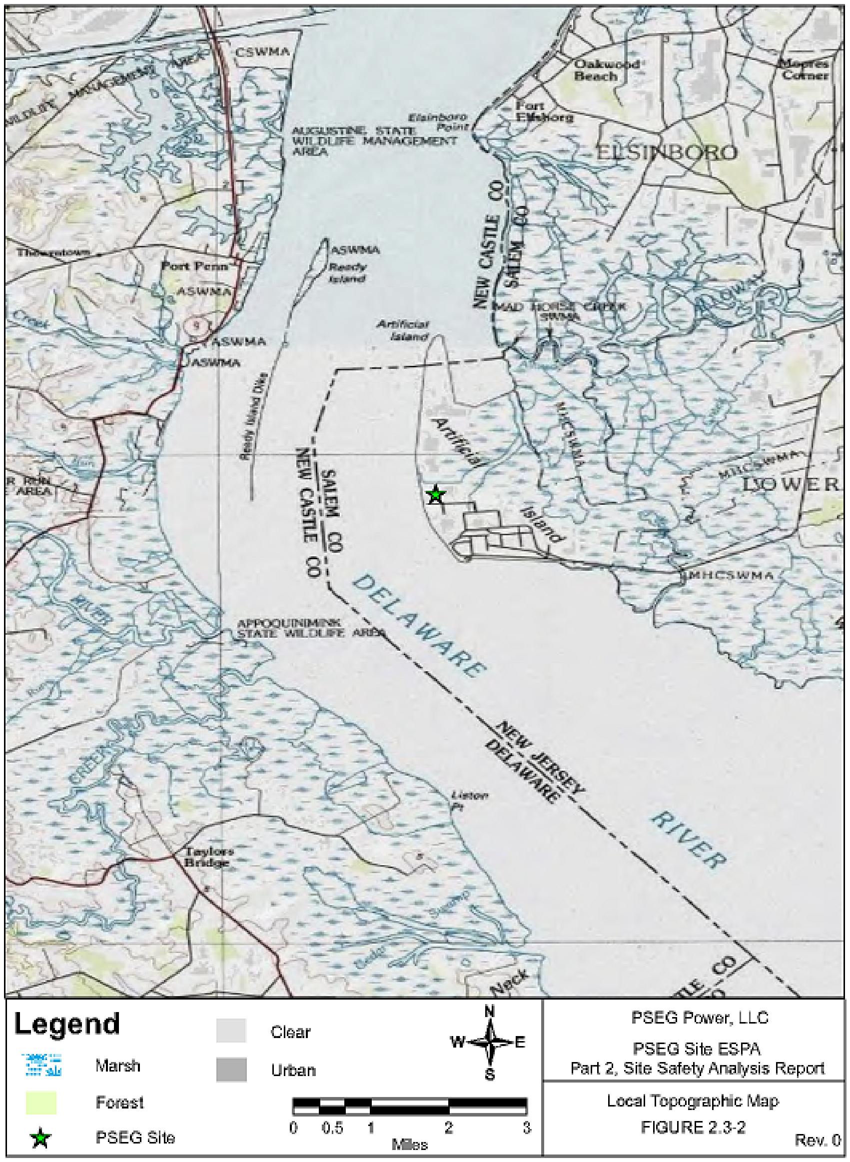

Figure 2.3-2 Local Topographic Map (Reproduced from SSAR Figure 2.3-2)

The staff finds this portion of the SSAR acceptable for information purposes only, as it does not result in any site characteristics.

2.3.1.4.2 General Climate of the Site's Region

The applicant described the proposed PSEG Site's general climate as a continental climate, with variations of that continental climate type on a regional basis. Elevations in the southwest portion of New Jersey are between sea level and 30.5 m (100 ft) above sea level. The proximity of Delaware Bay gives the PSEG Site a slightly maritime climate. The southwest region of New Jersey is shown to have the highest daytime temperatures and higher nighttime minimum temperatures in the state because it has a different soil type than the rest of New Jersey.

The prevailing winds in southwest NJ are from the southwest, except in winter when the west-to-northwest (rotating clockwise) winds dominate. High humidity is common in this portion of New Jersey, and moderate temperatures prevail when winds flow from the south or the east. The staff compared the applicant's general climate description to a similar National Climatic Data Center (NCDC) narrative description of the climate of New Jersey (NCDC, Climates of the States #60)[1] and confirms its accuracy and completeness; thus, the staff finds the applicant's description of the general climate acceptable.

2.3.1.4.3 Identification of Representative Regional Weather Monitoring Stations

The applicant explained the criteria that were used to determine the local weather reporting stations considered representative of the site area. The selection criteria that were presented included: (1) limiting the selected area to the inner and outer coastal plains, (2) excluding all stations within a distance of 16 km (10 mi) of the Atlantic Ocean, (3) excluding all stations located in the hills and mountains to the northwest in Delaware (DE), Maryland (MD), and Pennsylvania (PA), (4) excluding all stations in the vicinity of major water bodies other than the Delaware Bay, and (5) excluding all stations farther than 64 km (40 mi) from the PSEG Site.

The applicant provided the locations of all of the stations in the site's region, regardless of the selection criteria listed above, in SSAR Table 2.3-4, "Available NOAA Regional Meteorological Monitoring Stations," and SSAR Figure 2.3-11, "Locations and Categories of Regional Weather Monitoring Stations" (reproduced in Figure 2.3-3 of this report).

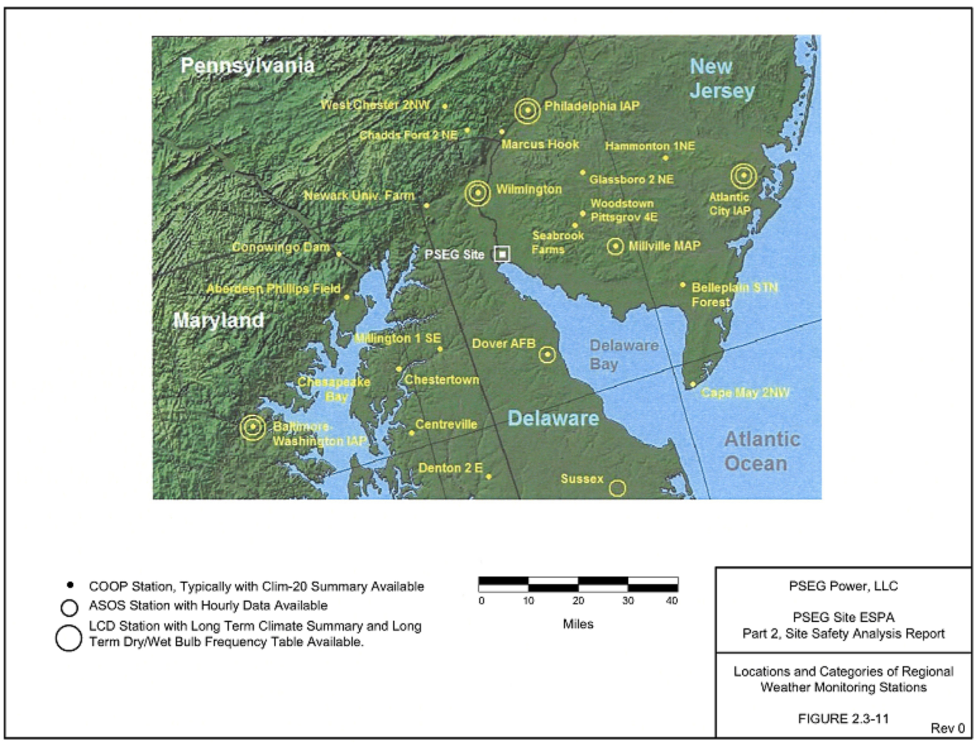

Figure 2.3-3 Locations and Categories of Regional Weather Monitoring Stations (Reproduced from SSAR Figure 2.3-11)

[1] http://cdo.ncdc.noaa.gov/climatenormals/clim60/states/Clim_NJ_01.pdf, accessed December 13, 2010.

In a discussion about the selection criteria, the applicant demonstrated that the regional data is representative of the site's area along the Delaware Bay. The staff reviewed the selection criteria presented by the applicant and considers them appropriate and reasonable.

2.3.1.4.4 Data Sources

The applicant characterized the regional climatology of the proposed PSEG Site area using data from the NCDC, including data from first-order reporting stations in Philadelphia, PA, and Wilmington, DE, and from eight other nearby cooperative observer stations. The cooperative observer stations are located in Kent County in Delaware; Gloucester, Atlantic, Cumberland, and Salem Counties in New Jersey; Delaware County in Pennsylvania; and Kent County in Maryland. The regional climatic observation stations used by the applicant are included in the list presented in SSAR Table 2.3-4 and depicted in SSAR Figure 2.3-11 (reproduced in Figure 2.3-3 of this report).

The applicant also obtained information on mean and extreme regional climatological phenomena from a variety of sources, such as publications by the NCDC, 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 American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). The staff reviewed these sources and finds them acceptable.

2.3.1.4.5 Severe Weather

2.3.1.4.5.1 *Extreme Wind*

Estimating wind loading on plant structures involves identifying the site's "basic" wind speed, which is defined by American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) 7-05, "Minimum Design Loads for Buildings and Other Structures," as the "3-second gust speed at 33 ft (10 m) above the ground in Exposure Category C." Exposure Category C relies on the surface roughness categories as defined in Chapter 6, "Wind Loads," of ASCE/SEI 7-05. Exposure Category C is acceptable at the PSEG Site because of scattered obstructions of various sizes in the immediate site area. Exposure Category B specifies that there must be "urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger" prevailing "in the upwind direction for a distance of at least 2,600 ft (792 m) or 20 times the height of the building, whichever is greater." Exposure Category D specifies that there must be "flat, unobstructed areas and water surfaces" prevailing "in the upwind direction for a distance greater than 5,000 ft (1,525 m) or 20 times the building height, whichever is greater." Based on the site description in SSAR Section 2.3.3.3, neither Exposure Category B nor Exposure Category D accurately describes the conditions at the PSEG meteorological tower. ASCE/SEI 7-05 states that Exposure Category C shall apply for all cases for which neither Exposure Category B nor D applies. SSAR Figure 2.3-12, "Annual Mean Wind Rose at S/HC Primary Meteorological Tower 33 ft. Level During Three Year Period 2006-2008," shows that the PSEG Site has two prevailing wind directions, northwesterly and southeasterly.

Using a plot of basic wind speeds presented in ASCE/SEI 7-05 (reproduced in Figure 2.3-4 of this report) for the portion of the United States (U.S.) that includes the proposed PSEG Site, the applicant determined a 50-year return period wind speed of 40.2 m/s (90 mph). The applicant also used data from the AFCCC Engineering Weather Data (EWD) compact disc (CD) (Air Force Combat Climatology Center (AFCCC), National Climatic Data Center (NCDC), "Engineering Weather Data, 2000 Interactive Edition," developed by the AFCCC and published in the NCDC, Ashville, NC, 1999). The applicant noted that the highest 50-year recurrent wind speed at any of the first order reporting stations in the site area is 49 m/s (110 mph), as reported at Philadelphia International Airport. The staff confirmed this value using the EWD. This value is associated with a mean recurrence interval of 50 years[2]. Using a conversion factor listed in ASCE/SEI 7-05, the applicant derived a 100-year return period 3-second gust wind speed site characteristic value of 52.6 m/s (117.7 mph), as presented in SSAR Table 2.0-1.

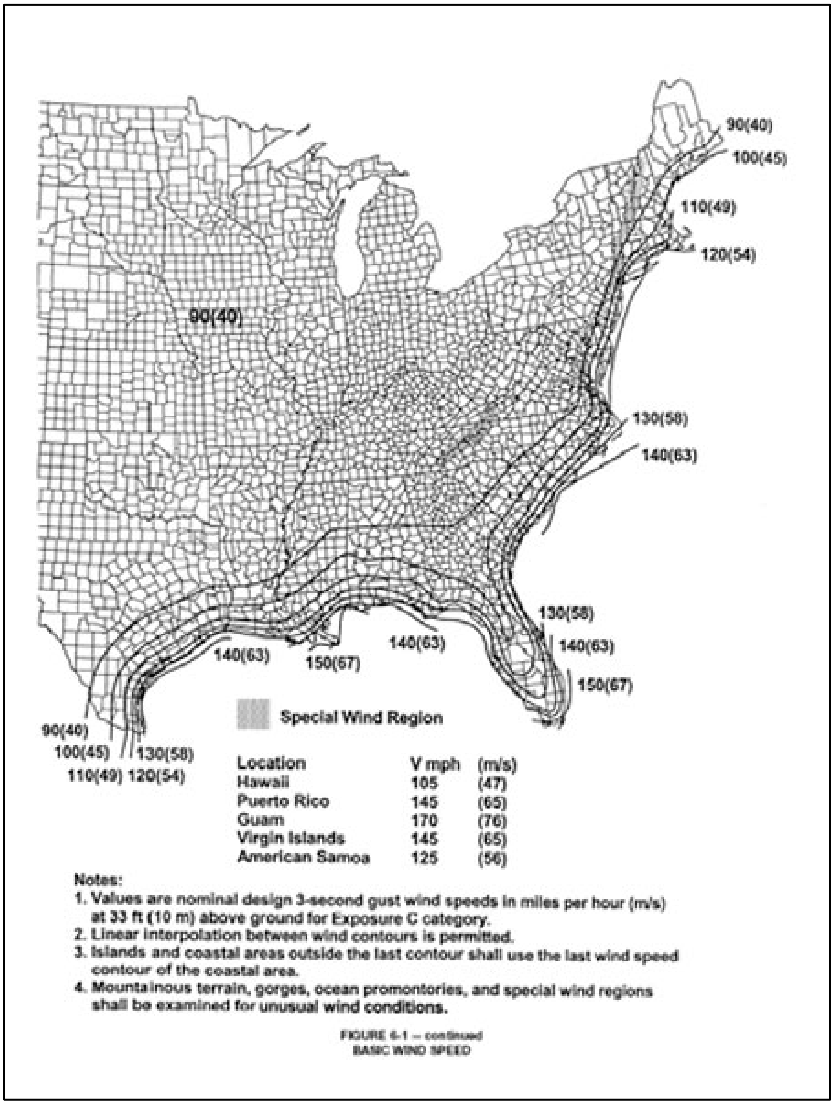

Figure 2.3-4 ASCE/SEI 7-05, Figure 6-1, "Basic Wind Speed"

[2] The staff noted that the 50-year recurrence, 3-second gust basic wind speed reported by the EWD is based on data from ASCE 7-95. The 50-year recurrence basic wind speeds were updated 3 years later in ASCE 7-98 and were subsequently lowered to the basic wind speeds found in ASCE 7-05. The basic wind speeds presented in ASCE 7-05 were updated "based on a new and more complete analysis of hurricane wind speeds." A complete discussion of the reasons for this change can be found in ASCE/SEI 7-05, Section C6.5.4, "Basic Wind Speed."

In October 2011, the NRC issued RG 1.221, which provides the design-basis hurricane wind speeds that correspond to an exceedance frequency of 10^{-7} per year. Based on the data in RG 1.221, it is possible that the potential winds associated with hurricanes may exceed the wind speeds associated with tornadoes at sites near the coasts. In accordance with the requirements of 10 CFR Part 52 and 10 CFR Part 100, and with the guidance of RG 1.221, in RAI 56, Question 02.03.01-8, the staff requested that the applicant update the site characteristic values in the SSAR to include a new site characteristic called "Hurricane Wind Speed." In a March 23, 2012, response to RAI 56, Question 02.03.01-8, the applicant provided information on a new site characteristic titled, "Hurricane Wind Speed," and committed to update SSAR Table 2.0-1 with this information. Using the guidance in RG 1.221, the applicant assigned this site characteristic a wind speed of 71.1 m/s (159 mph). This wind speed represents the maximum nominal 3-second gust wind speed at 10 m (33 ft) above ground over open terrain having a probability of exceedance of 10^{-7} per year. In the response to RAI 56, Question 02.03.01-8, the applicant added a new Table 2.3-38, "Hurricane Missile Site Characteristics for PSEG Site," which provides the Hurricane Missile Site Characteristics for the PSEG Site. Additionally, the applicant added a short description in SSAR Section 2.3.1.5.3, "Tropical Cyclones," of the development of the abovementioned site characteristic specific wind speed. The applicant committed to add the new table as well as the short description in the next revision of the application. The staff reviewed the response and the proposed changes, and finds them acceptable. In addition, the staff has verified that the applicant's committed changes have been incorporated into Revision 1 of the PSEG ESP application, dated May 21, 2012. Accordingly, the staff considers RAI 56, Question 02.03.01-8, resolved.

Since the applicant determined the site characteristic values in accordance with NUREG-0800, Section 2.3.1, and has chosen conservative values, the staff finds them adequate and acceptable.

2.3.1.4.5.2 *Tornadoes*

The applicant chose the tornado site characteristics based on RG 1.76, Revision 1, which provides design-basis tornado characteristics for three tornado-intensity regions throughout the U.S., each with a 10^{-7} probability of occurrence. The proposed PSEG Site is located within tornado intensity region II. The applicant proposed the following tornado site characteristics, which are listed in SSAR Table 2.0-1:

maximum wind speed	89.4 m/s (200 mph)
translational speed	17.9 m/s (40 mph)
maximum rotational speed	71.5 m/s (160 mph)
radius of maximum rotational speed	45.7 m (150 ft)
pressure drop	6.2 kilopascals (kPa) (0.9 psi)
rate of pressure drop	2.76 kPa (0.4 psi/sec)

In SSAR Table 2.3-7, "Regional Tornadoes and Water Spouts," the applicant presented statistics on tornadoes that have occurred in the eight counties surrounding the PSEG Site. Using the NCDC Storm Events database, the staff was able to confirm (within a reasonable amount) the number of storms that have been recorded near the PSEG Site, as presented in SSAR Section 2.3.1.5.2, "Tornadoes."

SSAR Section 2.3.1.5.2, "Tornadoes," stated that the site design basis tornado (DBT) characteristics (SSAR Table 2.3-5) are from RG 1.76, Revision 1, March 2007. The staff maintained that the wind speeds provided in Revision 1 of RG 1.76 are not DBT wind speeds. In RAI 14, Question 02.03.01-1, the staff requested that the applicant update SSAR Section 2.3.1.5.2 to correct this error, or provide justification to substantiate the statement in the ESP application. In a May 13, 2011, response to RAI 14 Question 02.03.01-1, the applicant provided updates to the SSAR in which the applicant removed language stating that the values presented in the SSAR are the DBT wind speeds. The applicant corrected this language by clarifying that the wind speeds presented are site characteristic values. The applicant provided SSAR markups and committed to incorporate them in the next revision of the application. The staff reviewed the applicant's response to RAI 14, Question 02.03.01-1, as well as the SSAR markups, and finds them acceptable. Subsequently, the staff verified that the applicant's committed changes have been incorporated in Revision 1 of the ESP application, dated May 21, 2012 and, therefore, the staff considers RAI 14, Question 02.03.01-1 resolved.

Since the applicant's tornado site characteristics are based on those presented in RG 1.76, Revision 1, the staff finds that the applicant has chosen acceptable tornado site characteristics.

2.3.1.4.5.3 *Tropical Cyclones*

In SSAR Section 2.3.1.5.3, "Tropical Cyclones," and in SSAR Table 2.3-8, "Regional Tropical Cyclones by Storm Category," the applicant provided information on tropical cyclones. During the period of time between 1851 and 2008, 109 tropical cyclone centers passed within an 185-km (115-mi) radius of the proposed PSEG Site. The applicant used the NOAA-Coastal Services Center (CSC)[3] historical tropical storm database to determine that of the 109 tropical cyclone centers, 31 were extra-tropical depressions, 9 were tropical depressions, 60 were tropical storms, 6 were Category 1 hurricanes, and 3 were Category 2 hurricanes.

Using the same database, the staff was able to verify the statistics presented by the applicant. Therefore, the staff finds the applicant's description of the number of tropical cyclones in the vicinity of Salem County, NJ, acceptable.

2.3.1.4.5.4 *Precipitation Extremes*

In SSAR Section 2.3.1.5.4, "Precipitation Extremes," the applicant stated that there is considerable variability of extreme rainfall and snowfall events across the site's climate region. The staff finds the applicant's statement consistent with the staff's understanding that extreme precipitation events are generally short-lived and confined to a small region. Due to this, one station may report extreme precipitation, whereas, a nearby station may report much less precipitation.

[3] http://www.csc.noaa.gov/ Accessed 12/15/2010

Table 2.3-1
Precipitation Extremes at the Salem/Hope Creek Site and at NOAA Regional Meteorological Monitoring Stations (Reproduced from SSAR Table 2.3-11)

Station Name	State	County	Maximum Recorded 24-Hour Rainfall (inches)	Maximum Recorded Monthly Rainfall (inches)	Maximum Recorded 24-Hour Snowfall (inches)	Maximum Recorded Monthly Snowfall (inches)
S/HC Site	NJ	Salem	10.03	13.51	not measured	not measured
Dover	DE	Kent	8.50	16.08	25.0	36.5
Glassboro 2 NE	NJ	Gloucester	6.67	15.37	14.0	27.0
Hammonton 1 NE	NJ	Atlantic	7.55	14.01	26.0	40.0
Marcus Hook	PA	Delaware	11.68	16.13	30.7	30.7
Millington 1 SE	MD	Kent	10.77	15.58	20.0	25.6
Millville MAP	NJ	Cumberland	9.06	12.90	14.8	26.2
Philadelphia IAP	PA	Philadelphia	6.63	13.07	27.6	33.8
Seabrook Farms	NJ	Cumberland	6.57	12.99	11.0	23.6
Wilmington New Castle R	DE	New Castle	8.29	12.68	22.0	31.6
Woodstown Pittsgrove 4E	NJ	Salem	7.24	12.53	19.0	38.3
Overall Maximum			11.68	16.13	30.7	40.0

Based on observations from 10 nearby NOAA meteorological monitoring stations and from the Salem and Hope Creek Site, the applicant presented historical precipitation extremes for the region in SSAR Table 2.3-11, “Precipitation Extremes at the Salem/Hope Creek Site and at NOAA Regional Meteorological Monitoring Stations” (reproduced in Table 2.3-1 of this report) The applicant stated that the highest 24-hour rainfall total in the area was 297 mm (11.68 in.) on September 16, 1999, about 42 km (26 mi) to the north-northeast of the PSEG Site at the Marcus Hook monitoring station. The highest monthly rainfall total in the site area was 410 mm (16.13 in.) recorded during September 1999 at the same monitoring station. Site characteristic values corresponding to the site parameter precipitation (rain) rates for 1-hour and 5-minute time periods are addressed in SSAR Section 2.4.2.3, “Effects of Local Intense Precipitation,” and are discussed in Section 2.4.2.2.3, “Effects of Local Intense Precipitation,” of this report.

On July 1, 2009, the staff issued Design Certification (DC)/COL Interim Staff Guidance (ISG)-007, “Interim Staff Guidance on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures,” which clarifies the staff’s position on identifying winter precipitation events as site characteristics and site parameters to determine normal and extreme winter precipitation loads on the roofs of Seismic Category I structures.

The ISG updates and revises the previously issued staff guidance provided in NUREG-0800, Section 2.3.1.

DC/COL-ISG-007 states that normal and extreme winter precipitation events should be identified in NUREG-0800, Section 2.3.1, as COL site characteristics for use with NUREG-0800, Section 3.8.4, “Other Seismic Category I Structures,” in determining the normal and extreme winter precipitation loads on the roofs of seismic Category I structures. The normal winter precipitation roof load is a function of the normal winter precipitation event, whereas the extreme winter precipitation roof loads are based on the weight of the antecedent snowpack resulting from the normal winter precipitation event plus the larger resultant weight from either: (1) An extreme frozen winter precipitation event or (2) an extreme liquid winter precipitation event. The snow and/or ice from the extreme frozen winter precipitation event is assumed to accumulate on the roof on top of the snow and/or ice from the earlier normal winter precipitation event. Whereas the water from the extreme liquid winter precipitation event may or may not accumulate on the roof, depending on the geometry of the roof and the type of drainage provided. The ISG further states:

- The normal winter precipitation event should be the highest ground-level weight (in pounds per square foot (lb/ft^2)) among: (1) The 100-year return period snowpack; (2) the historical maximum snowpack; (3) the 100-year return period two-day snowfall event; or (4) the historical maximum two-day snowfall event in the site region.

- The extreme frozen winter precipitation event should be the higher ground-level weight (in lb/ft^2) of: (1) The 100-year return period two-day snowfall event; and (2) the historical maximum two-day snowfall event in the site region.

- The extreme liquid winter precipitation event is defined as the theoretically greatest depth of precipitation (in inches of water) for a 48-hour period that is physically possible over a 25.9-km^2 (10-mi^2) area at a particular geographical location during those months with the historically highest snowpacks.

In a May 13, 2011, response to RAI 14, Question 02.03.01-2, the applicant committed to updating the SSAR to include a discussion in accordance with DC/COL-ISG-07. The staff reviewed the response and determined that the applicant’s response and associated SSAR markups did not include the normal and extreme winter precipitation load specified in the ISG. Therefore, in RAI 48, Question 02.03.01-7, the staff requested that the applicant expand the list of site characteristics in SSAR Table 2.0-1 to include site characteristic values that correspond to the normal and extreme winter precipitation site parameter values contained in the Design Control Documents (DCDs) for the reactor designs referenced in SSAR Section 1.2.2, “Site Development.” These winter precipitation loads should be determined in accordance with the guidance provided in DC/COL-ISG-07. In a February 16, 2012, response to RAI 48, Question 02.03.01-7, the applicant provided information consistent with the guidance in the ISG, and committed to update SSAR Table 2.0-1 to include two additional winter precipitation site characteristics (Normal Winter Precipitation Event and Extreme Frozen Winter Precipitation Event). The applicant also committed to update the text in SSAR Section 2.3.1.5.4, “Precipitation Extremes,” to include a discussion on how the additional site characteristics were determined. The applicant committed to including in SSAR Section 2.3.1.5.4, a description of the historical maximum snowpack and the normal winter precipitation load as defined by the ISG. The staff reviewed the applicant’s response with the proposed changes and confirmed the values presented by using verified NCDC sources. Since the applicant followed the methodology suggested DC/COL-ISG-07, the staff finds the applicant's proposed revisions acceptable.

Subsequently, the staff verified that the applicant's committed changes have been incorporated in Revision 1 of the ESP application, dated May 21, 2012. Accordingly, the staff considers RAI 48, Question 02.03.01-7 resolved.

FIGURE 7-1 (continued) GROUND SNOW LOADS, p_g, FOR THE UNITED STATES (LB/FT^2)

Figure 2.3-5
ASCE 7-05, "Figure 7-1: Ground Snow Loads, p_g, for the United States (lb/ft^2)"

In SSAR Section 2.3.1.5.4, “Precipitation Extremes,” the applicant identified the maximum 24-hour snowfall for the area surrounding the PSEG Site to be 780 mm (30.7 in.) on January 8, 1996. This snowfall was measured at the Marcus Hook observation station located approximately 42 km (26 mi) north-northeast of the PSEG Site. The applicant identified its extreme frozen winter precipitation event as 100.1 kg/m^2 (20.51 lb/ft^2), based on the 100-year return period two-day snowfall event. This snowfall measurement is consistent with the staff’s understanding that it is the highest recorded snowfall event in the region. The 50-year return period ground-level snowpack, as given in ASCE/SEI 7-05, Figure 7-1, “Ground Snow Loads, p_g for the United States (lb/ft^2),” (reproduced in Figure 2.3-5 of this report) is equal to 117.2 kg/m^2 (24 lb/ft^2) when converted to a 100-year weight. The applicant also presented its extreme liquid winter precipitation event as 533 mm (21.0 in.) liquid depth, which was identified as the 48-hour PMWP. Using ASCE/SEI 7-05 and NCDC Snow Climatology[4] the staff independently confirmed the winter precipitation data presented by the applicant and finds it complete and acceptable.

2.3.1.4.5.5 *Hail, Snowstorms and Ice Storms*

This section’s discussion on hail, freezing rain, and sleet is intended to provide a general climatic understanding of the severe weather phenomena in the site’s 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. In SSAR Section 2.3.1.5.5, “Hail, Snowstorms, and Ice Storms,” the applicant stated that the NOAA “Climate Atlas of the United States” (NCDC, “The Climate Atlas of the United States,” Version 2.0 CD, published by NCDC Ashville, NC, September 2002) was used to estimate that the annual mean number of days with hail 2.54 cm (1.0 in.) or greater in diameter is approximately 0.5 per year at the PSEG Site. The applicant also stated that large hail events (i.e., those with hail having a diameter greater than 4.45 cm (1.75 in.)) have been observed only six times within the two counties surrounding the PSEG Site during the 60-year period covered in the NOAA reference.

The staff confirmed the applicant’s statement that query results from the NCDC Storm Events Database for hail event(s) reported in Salem County, NJ, and New Castle County, DE, between January 1, 1950, and August 31, 2010, show that a total of six hail events with hail 4.45 cm (1.75 in.) or greater in diameter occurred in the PSEG Site area.

The staff notes that the number of reported hail events has increased significantly over time, primarily as a result of increased reporting efficiency and confirmation skill. This increase in hail reports is also likely caused by the increased number of targets because of urbanization. This is because there are more targets damaged by hail in urban areas than in a rural area. Estimates of hail size can range widely based on the surrounding area’s population density and the years considered. The applicant stated that Salem and New Castle Counties can expect, on average, hail with a diameter of 2.54 cm (1.0 in.) or greater approximately 0.5 days per year. The staff verified the hail frequencies presented by the applicant from “The Climate Atlas of the United States.” Based on the National Severe Storms Laboratory (NSSL) “Severe Thunderstorm Climatology, Total Threat,”[5] the staff finds that, when considering data from 1980

[4] http://www.ncdc.noaa.gov/ussc/index.jsp, accessed June 2, 2011.
[5] Severe Thunderstorm Climatology. Accessed 10/26/2010. https://www.nssl.noaa.gov/hazard/

through 1999, the total number of days per year with hail greater than 1.91 cm (0.75 in.) in diameter ranges from 1 to 2.

In SSAR Section 2.3.1.5.5, “Hail, Snowstorms, and Ice Storms,” the applicant stated that the annual snowfall is highly variable across the region and ranges from 2.54 centimeters (cm) to 127 cm (1 in. to 50 in.). Occasionally, these snow events are accompanied by, or alternate with, sleet and freezing rain as the weather system moves over the area. The Climate Atlas of the United States indicates that the occurrence of snowfall 2.54 cm (1.0 in.) or greater in the site area averages 2.5 to 5.4 days per year. Using the NCDC Climate Maps of the United States (CLIMAPS)[6] and Local Climatological Data (LCDs) from the nearby NWS reporting stations, the staff independently confirmed the hail and ice storm frequencies provided by the applicant.

2.3.1.4.5.6 *Thunderstorms*

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

In SSAR Section 2.3.1.5.6, “Thunderstorms,” the applicant stated that, on average, approximately 27 days with thunderstorm occurrences happen per year in the site area. This frequency was obtained from the 2010 NCDC LCD Annual Summary with Comparative Data for Wilmington, DE[7]. The majority of the storms recorded (73 percent) occurred between May and August.

In SSAR Section 2.3.1.5.6, the applicant estimated, based on a method attributed to the Electric Power Research Institute (EPRI) and the U.S. Department of Agriculture (USDA, “Rural Utilities Service Summary of Items of Engineering Interest,” August 1988), that approximately 3.3 flashes to earth per km^2 per year (8.6 flashes/mi^2-yr) occur at the PSEG Site. The staff independently evaluated this estimate based on NCDC LCDs from the same weather reporting station, the EPRI method (3.3 flashes/km^2-yr (8.6 flashes/mi^2-yr)), a 10-year flash-density map from Vaisala[8] (3 to 4 flashes/km^2-yr (7.7 to 10.4 flashes/mi^2-yr)), and a 1999 study by G. Huffines and R.E. Orville titled, “Lightning Ground Flash Density and Thunderstorm Duration in the Continental United States: 1989–96” (Journal of Applied Meteorology 38(7): 1013-1019, July 1999) (1 to 3 flashes/km^2–yr (2.6 to 7.7 flashes/mi^2-yr)). Based on these accepted sources, the staff finds that the applicant has provided a reasonable estimate of the frequency of lightning flashes.

2.3.1.4.6 Meteorological Data for Evaluating the Ultimate Heat Sink

RG 1.27, Revision 2, states that the UHS should be designed to provide sufficient cooling water to permit safe shutdown and cooling down of each unit and to keep each unit in a safe shutdown condition. In the event of an accident, the UHS is designed to provide sufficient cooling water to safely dissipate the heat for the accident. The UHS is sized so that makeup

[6] NCDC Climate Maps of the United States. http://cdo.ncdc.noaa.gov/cgi-bin/climaps/climaps.pl

[7] Quality Controlled Local Climatological Data. http://cdo.ncdc.noaa.gov/qclcd/QCLCD?prior=N

[8]http://www.lightningsafety.noaa.gov/stats/08_Vaisala_NLDN_Poster.pdf, accessed October 26, 2010

water is not required for at least 30 days following an accident and design-basis temperature and chemistry limits for safety-related equipment are not exceeded. The UHS is designed to perform its safety function during periods of adverse site conditions, resulting in maximum water consumption and minimum cooling capability.

RG 1.27 specifies that applicants should ensure that design-basis temperatures of safety-related equipment are not exceeded and that a 30-day cooling supply is available. Consequently, applicants should identify the meteorological conditions that result in minimum water cooling and maximum 30-day evaporation and drift loss.

To verify the applicant's site characteristic design conditions for the UHS, the staff examined hourly temperature and humidity observations from the same stations as the applicant (Wilmington, Dover, and Millville). The staff calculated 1-day, 5-day, and 30-day average wet-bulb and coincident dry bulb temperatures from the hourly data and selected the periods with the highest average wet-bulb temperatures as the worst periods. The resulting maximum 1-day, 5-day, and 30-day average wet-bulb temperature values were similar to the values presented by the applicant. Based on the results of this analysis, the staff finds the design-basis UHS meteorological site characteristics proposed by the applicant in SSAR Table 2.0-1 acceptable.

2.3.1.4.7 Design Basis Dry Bulb and Wet Bulb Temperatures

In SSAR Section 2.3.1.7, "Design Basis Dry Bulb and Wet Bulb Temperatures," the applicant based its ambient air temperature and humidity site characteristics on hourly databases recorded at first-order stations located in Wilmington and Dover, DE, and Millville, NJ. The applicant presented the site characteristic temperature and humidity values in SSAR Table 2.0-1 and in SSAR Section 2.3.1.5. The staff performed an independent analysis using hourly NCDC data from the same stations. The staff calculated dry-bulb and wet-bulb temperatures that are similar to those presented by the applicant. As a result of this confirmatory analysis, the staff finds the proposed site characteristics for ambient air temperature and humidity appropriate.

SSAR Section 2.3.1.7 describes the method used to calculate the 100-year return period maximum and minimum dry-bulb temperatures. The applicant used a linear regression technique from Chapter 14 of the 2009 ASHRAE Handbook (ASHRAE, "The Handbook CD 2009 Fundamentals," CDR, published by ASHRAE Atlanta, GA, 2009). The staff used data from the 2009 ASHRAE Weather Data Viewer, Version 4.0, to determine the 100-year return maximum and minimum dry-bulb temperature values for the PSEG Site. Through this method, the staff finds that the applicant's proposed 100-year return period maximum and minimum dry-bulb temperature site characteristic values of 41.1 °C (105.9 °F) and -28.2 °C (-18.7 °F) are correct and acceptable.

The applicant also presented the maximum and minimum (zero percent exceedance) site characteristic temperatures for the PSEG Site area. The applicant presented a zero percent exceedance maximum dry bulb temperature of 42.2 °C (108 °F). This maximum dry bulb temperature was recorded at the Marcus Hook reporting station. Using NCDC hourly data from reporting stations in Dover and Wilmington, DE, Millville, NJ, and Philadelphia, PA, the staff performed an independent confirmatory analysis to determine the 0-percent-exceedance dry bulb temperature. Using these NCDC observation station data, the staff confirmed the applicant's 0-percent-exceedance site characteristics dry bulb temperature value. The staff affirms that the 0 percent annual exceedance dry bulb temperature bounds the PSEG Site characteristic 100-year return period dry bulb temperature. The staff finds this acceptable because the observation of 42.2 °C (108 °F) bounds the staff's independent calculations for 100-year return period and maximum 0 percent exceedance dry bulb temperatures. Therefore, the staff considers the proposed site characteristic temperatures conservative.

The applicant also presented a 100% exceedance minimum dry bulb temperature of -26.1 °C (-15 °F) and a zero-percent-exceedance non-coincident wet bulb temperature of 30.1 °C (86.2 °F). Using hourly observation data from NCDC reporting stations in Dover and Wilmington, DE, Millville, NJ, and Philadelphia, PA, the staff performed an independent confirmatory analysis and determined that the applicant's site characteristic temperatures are correct and conservative. Therefore, the staff accepts the PSEG Site characteristic temperatures as provided in SSAR Table 2.0-1.

2.3.1.4.8 Restrictive Dispersion Conditions

This section's discussion on restrictive dispersion conditions is intended to provide a general understanding of the phenomena in the site's region but does not result in the generation of site characteristics for use as design or operating bases.

In SSAR Section 2.3.1.8, "Restrictive Dispersion Conditions," the applicant used estimates of air stagnation provided in Air Stagnation Climatology for the United States (Wang, J.X.L. and J.K. Angell, "Air Stagnation Climatology for the United States (1948-1998)," NOAA/Air Resources Laboratory Atlas No. 1, National Oceanic and Atmospheric Administration, Silver Spring, MD, April 1999). The applicant stated that, on average, the PSEG Site experiences 11 days per year with stagnation conditions, or 2 cases per year with the mean duration of each case lasting 5 days. Using a reference (Holzworth, G.C., "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United Stated," AP-101, U.S. Environmental Protection Agency, January 1972) consistent with NUREG-0800, Section 2.3.1, the staff verified that the information provided by the applicant is correct and adequate.

2.3.1.4.9 Air Quality

The following discussion on air quality is intended to provide a general understanding of the phenomena in the PSEG Site's region, but does not result in the generation of site characteristics for use as design or operating bases.

The EPA establishes national ambient air quality standards (NAAQS)[9] for ground-level ozone and other criteria pollutants (pollutants that can injure health, harm the environment and cause property damage). The EPA works with partners at State, local, and Tribal levels to meet these standards. Under the Clean Air Act (CAA), as amended in 1990, each State must develop a plan describing how it will attain and maintain the NAAQS. Ozone and particulate matter (PM)

[9] U.S. Environmental Protection Agency, "Ozone (O_3) Standards," http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_index.html, particularly "Ozone Implementation - Programs and Requirements for Reducing Ground Level Ozone," http://www.epa.gov/airquality/ozonepollution/implement.html.

(a complex mixture of extremely small particles and liquid droplets that can affect the heart and lungs and cause serious health effects) are criteria pollutants. These standards apply to the concentration of a pollutant in outdoor air. If the air quality in a geographic area meets or exceeds the national standard, it is called an attainment area; areas that do not meet the national standard are called non-attainment areas.

In SSAR Section 2.3.1.9, "Air Quality," the applicant explained that the proposed PSEG Site is located in the Metropolitan Philadelphia Interstate Air Quality Control Region (40 CFR 81.15, "Metropolitan Philadelphia Interstate Air Quality Control Region (Pennsylvania-New Jersey-Delaware)"). The counties within this region include Salem County, NJ and New Castle County, DE. Salem County, NJ is a non-attainment area for ozone under the 8-hour standard. New Castle County, DE is a non-attainment area for ozone under the 8-hour standard and for PM under the $PM_{2.5}$ standard. According to the EPA, $PM_{2.5}$ are fine particles such as those found in smoke and haze and are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air. Using data provided by the EPA, the staff has verified that the information provided by the applicant is correct and adequate.

2.3.1.4.10 Climate Changes

To be compliant with NRC regulations, nuclear power plants (NPPs) must be built in consideration of the most severe natural 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. NPPs are designed with these stipulations on the environmental conditions that are considered at the site. Climate change is a concern because of the potential for unforeseen changes in extreme conditions in the local and regional environment. In SSAR Section 2.3.1.10, "Climate Changes," the applicant provided a discussion on the climatology of the PSEG Site region with regards to the trends in meteorological phenomena.

NUREG-0800, Section 2.3.1, states that historical data used to characterize a site should extend over a significant time interval to capture cyclical extremes. The staff obtained datasets considered to be of sufficient duration to determine the adequacy of the applicant's proposed site characteristics. For example, snow load was based on a 100-year return period and ambient design temperatures were based on a minimum of 30 years of hourly data and an estimated 100-year return period value. Tornado statistics were based on a 35-year period and tornado wind speeds were based on a 10^{-7} per year return interval as stated in DG-1143. Extreme winds were based on a 100-year return period, including 158 years of historical hurricane data (1851–2008).

The U.S. Global Change Research Program (USGCRP) released a report to the President and Members of Congress in June 2009 titled, "Global Climate Change Impacts in the United States." (Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.) This report, produced by an advisory committee chartered under the Federal Advisory Committee Act, summarizes the science of climate change and the impacts of climate change on the United States.

The USGCRP report found that the average annual temperature of the Northeast (which includes southwest New Jersey where the proposed PSEG Site is located) did not change significantly over the past century as a whole, but the annual average temperature has risen approximately 1.1 °C (2 °F) since 1970 with the greatest seasonal increase in temperature occurring during the winter months. Climate models predict continued warming in all seasons across the Northeast and an increase in the rate of warming through the end of the 21st century. Average temperatures in the Northeast are projected to rise by 1.7 to 2.8 °C (3 to 5 °F) by the end of the 2050s, depending on assumptions regarding global greenhouse-gas emissions.

The USGCRP report also states that there has been a 10- to 15-percent increase in observed annual average precipitation from 1958 to 2008 in the region where the proposed PSEG Site is located. Future changes in total precipitation are more difficult to project than changes in temperature. Model projections of future precipitation generally indicated that northern areas of the U.S. will have more precipitation in the winter months and less in the summer months. Except for indications that the amount of rainfall from individual hurricanes will increase, climatic models provide divergent results for future precipitation for most of the northeast.

The USGCRP reports that the power and frequency of Atlantic hurricanes has increased substantially in recent decades, but the number of North American mainland land-falling hurricanes does not appear to have increased over the past century. The USGCRP reports that likely future changes for the United States and surrounding coastal waters include more intense hurricanes with related increases in wind and rain, but not necessarily an increase in the number of these storms that make landfall.

In SSAR Section 2.3.1.10, the applicant analyzed trends in temperature and rainfall normals over a 70-year period for successive 30-year intervals by decade beginning in 1931 (e.g., 1931 through 1960, 1941 through 1970, etc.) for the climate divisions NJ-02 and DE-01. The applicant stated that the normal (i.e., 30-year average) temperature showed no discernible trend over the 70-year period, with a slight increase of about 0.28 °C (0.5 °F) during the most recent normal period. The applicant also stated that the normal rainfall had increased by about 25 mm (1 in.) during the most recent normal period.

The USGCRP further states that there is no clear trend in the frequency or strength of tornadoes since the 1950s for the United States as a whole. In SSAR Section 2.3.1.10, the applicant stated that the number of recorded tornado events has generally increased since detailed records were routinely kept beginning around 1950. However, much of this increase is attributable to a growing population, greater public awareness and interest, and technological advances in detection. The USGCRP report reaches the same conclusion.

The USGCRP reports that the distribution by intensity for the strongest 10 percent of hail and wind reports is little changed, providing no evidence of an observed increase in the severity of such events. Climate models project future increases in the frequency of environmental conditions favorable to severe thunderstorms. But the inability to adequately model the small-scale conditions involved in thunderstorm development remains a limiting factor in projecting the future character of severe thunderstorms and other small-scale weather phenomena.

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 PSEG Site. However, no conclusive evidence or consensus of opinion is available on the rapidity or nature of such changes. There is a level of uncertainty in projecting future conditions because the assumptions regarding the future level of emissions of heat trapping gases depend on projections of population, economic activity, and choice of energy technologies. If it becomes evident that long-term climatic change is influencing the most severe natural phenomena reported at the site, the COL holders have a continuing obligation to ensure that their plants stay within the licensing basis.

2.3.1.5 *Conclusion*

As discussed above, the applicant presented and substantiated information to establish the regional meteorological characteristics. The staff reviewed the information provided and, for the reasons given above, concludes that the applicant has established site characteristics and design parameters acceptable to meet the requirements of 10 CFR 100.20(c)(2) and 10 CFR 100.21(d).

The staff finds that the applicant has considered the most severe phenomena historically reported for the site and surrounding area in establishing the above site characteristics. The staff, following the guidance provided in NUREG-0800, Section 2.3.1, has accepted the methodologies used to determine the severity of the phenomena reflected in these site characteristics. Accordingly, the 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 staff finds the site characteristics previously identified by the applicant and reviewed by the staff acceptable for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or construction permit (CP) application.

Therefore, the staff concludes that the identification and consideration of the climatic site characteristics discussed 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).

Early Site Permit applicants need not demonstrate compliance with the GDC listed in Section 2.3.1.3 of this report, "Regulatory Basis," however, the applicant chose to provide all necessary information with respect to regional climatology.

In view of the above, the staff finds the applicant's proposed site characteristics related to climatology for the proposed PSEG Site acceptable.

2.3.2 Local Meteorology

2.3.2.1 *Introduction*

In SSAR Section 2.3.2, "Local Meteorology," the applicant presented information on local (site) meteorological parameters, an assessment of the potential influence of the proposed plant and its facilities on local meteorological conditions and the impact of these modifications on plant design and operation, and a topographical description of the site and its environs.

2.3.2.2 *Summary of Application*

In SSAR Section 2.3.2, 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 how the construction and operation of the nuclear power plant and associated facilities that are planned to be built on the proposed site will influence the local meteorology, 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

In Section 2.3.2 of this report, the staff verifies that the applicant has identified and considered the meteorological and topographical characteristics of the site and the surrounding area, as well as changes to those characteristics that might be caused by the construction and operation of the proposed facility.

2.3.2.3 *Regulatory Basis*

The acceptance criteria, as identified in NUREG-0800, Section 2.3.2, "Local Meteorology," 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), as it relates to the requirement that the application contain a description of the seismic, meteorological, hydrological, and geological characteristics of the proposed site

- 10 CFR 100.20(c), as it relates to the requirement that that the meteorological characteristics of the site that might be necessary for safety analysis or that might have an impact on plant design be identified and characterized as part of the staff's review of the acceptability of a site

- 10 CFR 100.21(c), as it relates to the requirement that site atmospheric dispersion characteristics be evaluated and dispersion parameters established to ensure 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), as it relates to the requirement that the physical characteristics of the site, including meteorology, geology, seismology, and hydrology be evaluated and site characteristics established to ensure 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, at the ESP stage, in compliance with the above regulatory requirements would be necessary to determine, at the COL stage, a proposed facility's compliance with the requirement in 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants":

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.

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

- RG 1.23, Revision 1, which provides criteria for an acceptable onsite meteorological measurements program to be used to monitor site characteristics related to local (onsite) meteorology

- RG 1.206, 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 Section 2.3.2, the staff applied the same above-cited methodologies and techniques.

2.3.2.4 *Technical Evaluation*

The staff reviewed SSAR Section 2.3.2 to ensure that the ESP application represents the complete scope of information relating to this review topic. The staff's review confirmed that the applicant addresses the required information relating to local meteorology.

2.3.2.4.1 Local Meteorology

2.3.2.4.1.1 *Data Sources*

To describe the local meteorology, the applicant used data from the onsite meteorological monitoring system, first-order NWS stations, and other nearby cooperative network observing stations listed in SSAR Table 2.3-4, "Available NOAA Regional Meteorological Monitoring Stations," and presented in SSAR Figure 2.3-11 (reproduced in Figure 2.3-3 of this report). 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 also presented mean values for, and historical extremes of, temperature, rainfall, and snowfall data from the offsite observation stations listed in SSAR Tables 2.3-1, "NOAA Climate Summary for Wilmington, Delaware," 2.3-2, "NOAA Climate Summary for Atlantic City, New Jersey," and 2.3-3, "NOAA Climate Summary for Philadelphia, Pennsylvania."

The staff evaluated the information regarding local meteorological conditions submitted by the applicant using data from the PSEG onsite meteorological monitoring system, as well as climatic data reported from the NCDC sources "Monthly Station Climate Summaries," "U.S. Monthly Climate Normals," and "Daily Surface Data."

2.3.2.4.2 Normal, Mean, and Extreme Values of Meteorological Parameters

2.3.2.4.2.1 *Wind*

In this Section of this report, the staff discusses information provided by the applicant in SSAR Sections 2.3.2.2.1.1, "Scales of Air Motion," 2.3.2.2.1.2, "On-Site Wind Roses during Three Year Period," and 2.3.2.2.1.3, "On-Site Wind Roses during 32 Year Period."

In SSAR Section 2.3.2.2.1.1, "Scales of Air Motion," the applicant provided a brief description of the scales of air motion. The macroscale, mesoscale, and microscale airflow patterns are commonly used in meteorological literature when discussing air movement patterns of varying spatial and temporal scales. The staff accepts this portion of the SSAR for informational purposes only because it does not result in the generation of site characteristics for use as design or operating bases.

In SSAR Section 2.3.2.2.1.2, "On-Site Wind Roses during Three Year Period," the applicant presented hourly wind data from the PSEG onsite meteorological monitoring program, as described in SSAR Section 2.3.3, "On-Site Meteorological Measurements Program," from January 1, 2006, through December 31, 2008. The applicant also provided annual and seasonal wind roses measured at the 10-m (33-ft) observation height of the onsite meteorological measurement system. The 10-m (33-ft) observation height is the only height used for the atmospheric-dispersion modeling described in Sections 2.3.4 and 2.3.5 of this report. The prevailing annual wind direction for the site is generally from the north and northwest quadrants. There is also a secondary maximum from the southeast. Winds from the northwest predominate during the autumn and winter months; southeasterly winds predominate during the spring months and account for approximately nine percent of the total winds during the summer and autumn.

The applicant stated that no calm winds were recorded at the site because of the sensitivity of the on-site sonic wind sensor and the open exposure of the flat terrain and Delaware Bay. The staff confirmed this statement and accepts it as correct and adequate.

In SSAR Section 2.3.2.2.1.3, "On-Site Wind Roses during 32 Year Period," the applicant provided wind roses (SSAR Figure 2.3-29, "Annual Mean Wind Rose at S/HC Primary Meteorological Tower 33-ft Level During 32 Year Period 1977-2008") compiled from a 32-year period of record (1977–2008) at the proposed PSEG Site (reproduced in Figure 2.3-6). The staff agrees that the longer period of record shows similar wind speed and direction characteristics when compared with the 3-year period of record (2006–2008). The staff accepts the comparison between the two datasets as informational and has not verified its accuracy because the 32-year period of record is not used in the generation of site characteristics for use as design or operating bases.

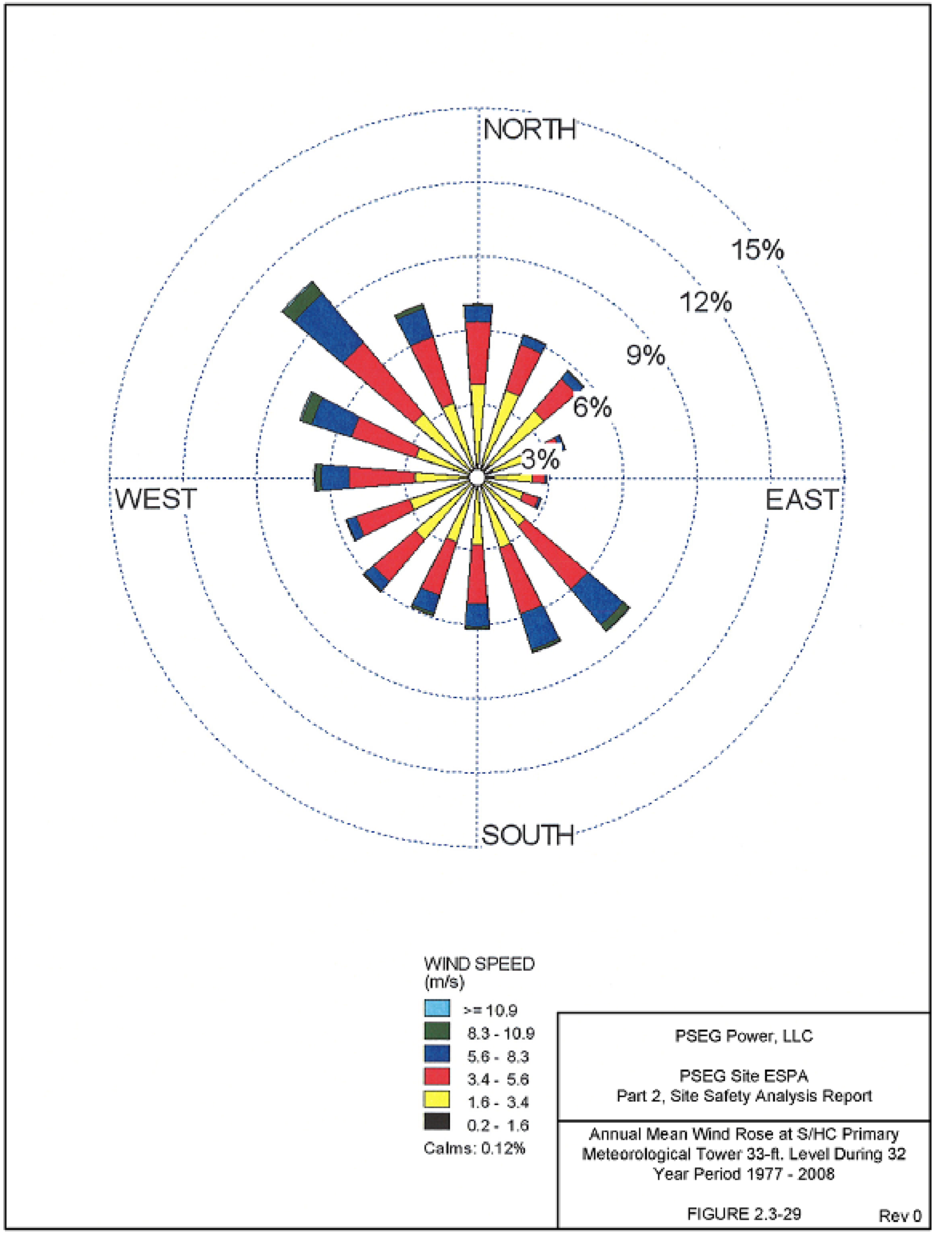

Figure 2.3-6 Annual Mean Wind Rose at S/HC Primary Meteorological Tower 33-ft Level During 32 Year Period 1977-2008 (Reproduced from SSAR Figure 2.3-29)

Using data from the onsite meteorological measurements program recorded between January 1, 2006, and December 31, 2008, the staff verified wind roses and joint frequency distributions (JFDs) provided by the applicant and accepts them as correct and adequate.

2.3.2.4.2.1.1 Comparison of Annual and Seasonal Three Year On-Site Wind Roses with Annual and Seasonal Station Wind Roses

The applicant compared the onsite wind summaries against wind speed and direction from the Wilmington, Millville, and Dover reporting stations in the following SSAR Figures:

- Figure 2.3-36, “Annual Mean Wind Roses at S/HC Primary Meteorological Tower 33 ft. Level During Three Year Period 2006–2008 and Long-Term at Wilmington, Millville, and Dover.”

- Figure 2.3-37, “Winter Mean Wind Roses at S/HC Primary Meteorological Tower 33 ft. Level During Three Year Period 2006–2008 and Long-Term at Wilmington, Millville, and Dover.”

- Figure 2.3-38, “Spring Mean Wind Roses at S/HC Primary Meteorological Tower 33 ft. Level During Three Year Period 2006–2008 and Long-Term at Wilmington, Millville, and Dover.”

- Figure 2.3-39, “Summer Mean Wind Roses at S/HC Primary Meteorological Tower 33 ft. Level During Three Year Period 2006-2008 and Long-Term at Wilmington, Millville, and Dover.”

- Figure 2.3-40, “Autumn Mean Wind Roses at S/HC Primary Meteorological Tower 33 ft. Level During Three Year Period 2006–2008 and Long-Term at Wilmington, Millville, and Dover.”

The annual PSEG Site 3-year wind rose shows two primary wind directions, northwest and southeast. The three stations in comparison all show an annual primary wind direction from the west through northwest directions (clockwise). Wilmington and Dover also show that winds blow from the south and surrounding sectors. The applicant states that the higher frequency of winds from the southeast at the PSEG Site, when compared with the surrounding stations, is because of the proximity and direction of the Delaware Bay coastline.

2.3.2.4.2.1.2 Wind Direction Persistence

The applicant presented wind persistence data from the PSEG onsite meteorological monitoring program, as described in SSAR Section 2.3.3, “On-Site Meteorological Measurements Program,” from January 1, 2006, through December 31, 2008. The applicant stated that wind persistence is an indicator of the duration of atmospheric transport from a specific sector to a corresponding downwind sector that is 180 degrees opposite. The applicant provided detailed information on the wind persistence that was observed by the onsite meteorological measurements in the following SSAR Tables:

- Table 2.3-21, “Wind Direction Persistence/Wind Speed Distributions at the Salem/Hope Creek Primary Meteorological Tower 33 ft. Level 2006-2008 Period Wind Speed Greater than or Equal to 2.24 m/sec”

- Table 2.3-22, “Wind Direction Persistence/Wind Speed Distributions at the Salem/Hope Creek Primary Meteorological Tower 33 ft. Level 2006-2008 Period Wind Speed Greater than or Equal to 4.47 m/sec”

- Table 2.3-23, “Wind Direction Persistence/Wind Speed Distributions at the Salem/Hope Creek Primary Meteorological Tower 33 ft. Level 2006-2008 Period Wind Speed Greater than or Equal to 6.71 m/sec”

- Table 2.3-24, “Wind Direction Persistence/Wind Speed Distributions at the Salem/Hope Creek Primary Meteorological Tower 33 ft. Level 2006-2008 Period Speed Greater than or Equal to 8.94 m/sec”

- Table 2.3-25, “Wind Direction Persistence/Wind Speed Distributions at the Salem/Hope Creek Primary Meteorological Tower 33 ft. Level 2006-2008 Period Speed Greater than or Equal to 11.18 m/sec”

Through analysis of data from the onsite meteorological measurements program, collected between January 1, 2006, and December 31, 2008, the staff independently confirmed the wind persistence measurements at the PSEG Site, and thus accepts the applicant’s data and discussion.

2.3.2.4.2.2 ***Atmospheric Stability***

The applicant classified atmospheric stability in accordance with the guidance provided in RG 1.23, Revision 1. Atmospheric stability is a critical parameter for estimating dispersion characteristics as applicable for SSAR Sections 2.3.4, “Short-Term (Accident) Diffusion Estimates,” and 2.3.5, “Long-Term (Routine) Diffusion Estimates.” Dispersion of effluents is greatest for extremely unstable conditions (i.e., Pasquill stability class A) and decreases progressively through extremely stable conditions (i.e., Pasquill stability class G) as discussed in RG 1.145, “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants.” The applicant primarily based its stability classification on temperature change with height (i.e., delta-temperature or $\Delta T/\Delta Z$) between the 45-m (150-ft) and 10-m (33-ft) heights, as measured by the PSEG onsite meteorological monitoring program between January 1, 2006 and December 31, 2008. In SSAR Section 2.3.2.2.2, “Atmospheric Stability,” the applicant explained that the use of the delta-temperature between the 45-m (150-ft) and 10-m (33-ft) heights is more appropriate than the use of the delta-temperature between the 91-m (300-ft) and 10-m (33-ft) levels. This is because short-term and long-term releases from each of the reactor technologies used to develop the plant parameter envelope (PPE) are considered to occur at ground level. Using this lower layer to determine the stability class is more representative of conditions that would affect a ground-level release.

In SSAR Tables 2.3-26 and 2.3-27, the applicant provided annual frequencies of atmospheric stability classes for the 3-year period of record from January 1, 2006, through December 31, 2008. The applicant stated that there is a predominance of slightly stable (Pasquill stability class E) and neutral (Pasquill stability class D) conditions at the proposed PSEG Site. Extremely unstable conditions (Pasquill stability class A) occur about 11 percent of the time and would be expected to occur most frequently during the spring and summer. Extremely stable conditions (Pasquill stability class G) occur about seven percent of the time and would be expected to occur most frequently during the autumn. 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 PSEG Site is generally consistent with expected meteorological conditions.

Through analysis of data from the onsite meteorological measurements program, collected from January 1, 2006, through December 31, 2008, the staff independently confirmed the atmospheric stability measurements at the proposed PSEG Site, and thus accepts the applicant’s data and discussion. The staff notes that these data are appropriate to use as input to the dispersion models discussed in Sections 2.3.4 and 2.3.5 of this report.

2.3.2.4.2.3 *Temperature*

In SSAR Section 2.3.2.2.3, “Temperature,” the applicant characterized normal and extreme temperatures for the site based on the ten representative surrounding observation stations listed in SSAR Section 2.3.1.3, “Identification of Representative Regional Weather Monitoring Stations.” The extreme maximum temperature recorded in the vicinity of the site is 42.2 °C (108 °F) at the Marcus Hook, PA cooperative recording station 42 km (26 mi) to the NNE of the proposed PSEG Site. The extreme minimum temperature recorded in the vicinity of the site is -26.1 °C (-15 °F) at the Millington 1 SE, MD station located 37 km (23 mi) to the SW of the proposed PSEG Site. Due to its location near the Delaware Bay, the proposed PSEG Site typically experiences temperatures that are more moderate than the cooperative reporting stations that are farther inland. Through the use of data from the surrounding NCDC recording stations, the staff confirmed the temperature discussion provided by the applicant.

2.3.2.4.2.4 *Water Vapor*

In SSAR Section 2.3.2.2.4, “Water Vapor,” the applicant provided wet-bulb temperature, dew point temperature, and relative humidity data summaries from the Wilmington, DE NWS observation station to characterize the typical atmospheric moisture conditions near the proposed PSEG Site.

In SSAR Table 2.3-1, “NOAA Climate Summary for Wilmington, Delaware,” the applicant showed that for a 25-year period of record, the mean annual wet-bulb temperature is 9.4 °C (48.9 °F) at the Wilmington, DE NWS site. The highest monthly mean wet-bulb temperature is 20.6 °C (69.0 °F) during July, and the lowest monthly mean wet-bulb temperature is -1.7 °C (29.0 °F) during January. The applicant stated that the mean annual dew point temperature at Wilmington is 7.0 °C (44.6 °F), which also reaches its maximum during summer and minimum during winter. The applicant gives the highest monthly mean dew point temperature as 18.9 °C (66.1 °F) during July, and the lowest monthly mean dew point temperature as -4.3 °C (24.1 °F) during January.

Based on a 30-year period of record from the data recorded at the Wilmington, DE NWS site, the applicant stated that relative humidity averages 68 percent on an annual basis. The average early morning relative humidity levels exceed 80 percent from June through October. Typically, the relative humidity values reach their diurnal maximum in the early morning and diurnal minimum during the early afternoon.

The staff verified and finds acceptable 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 “Wilmington, DE, 2009 Local Climatological Data, Annual Summary with Comparative Data.” Due to the proximity of Wilmington, DE, to the proposed PSEG Site and because of the similarity of topographic features at both locations (e.g., distance from the Delaware Bay), the PSEG atmospheric moisture data should be typical of the atmospheric moisture conditions in the proposed site’s region.

2.3.2.4.2.5 *Precipitation*

Based on data from the surrounding observation stations listed in SSAR Table 2.3-18 and presented in SSAR Figure 2.3-11 (Section 2.3.1.4.3 of this report), the applicant stated that the average annual precipitation (water equivalent) totals generally range from 915 mm (36.04 in.) to 1176 mm (46.28 in.) The highest average annual precipitation is 1176 mm (46.28 in.), which occurs at the Dover, DE station (approximately 37 km (23 mi) to the south of the proposed PSEG site).

The applicant also stated that the mean annual snowfall recorded at the surrounding stations ranges from 19.1 cm (7.5 in.) to 49.0 cm (19.3 in.), as presented in SSAR Table 2.3-19, “Mean Monthly and Annual Snowfall (in.) at the NOAA Regional COOP Meteorological Monitoring Stations.” The highest annual average snowfall total of 49.0 cm (19.3 in.) is at the Philadelphia International Airport (IAP) located 48.3 km (30 mi) to the north-northeast of the proposed PSEG site, based on the 2009 LCD for Philadelphia, PA.

Using daily snowfall and rainfall data from NCDC, the staff independently verified the precipitation statistics presented in SSAR Section 2.3.2 and finds them acceptable and accurate.

2.3.2.4.2.6 *Fog*

Wilmington, DE is the closest station to the proposed PSEG Site that makes fog observations. In SSAR Section 2.3.2.2.6, “Fog,” the applicant stated that, based on a 45-year period of record, Wilmington averages about 26 days per year of heavy fog conditions (i.e., conditions in which visibility is reduced to one-quarter of a mile or less).

The applicant stated that the frequency of typical fog conditions at Wilmington, DE is expected to be similar to that at the proposed PSEG Site because of the proximity and similarity of topographic features between the two locations. Both sites are located in relatively flat terrain and are nearly equidistant from the Delaware River.

Using the 2009 NCDC LCD from Wilmington, DE, the staff confirmed the applicant’s assertion that the Wilmington, DE station reports approximately 26 days per year with heavy fog observations. The staff agrees that the frequency of fog conditions at Wilmington, DE is expected to be similar to that at the proposed PSEG Site because of the similarity of topographic features at both locations.

2.3.2.4.3 Potential Influence of the Plant and its Facilities on Local Meteorology

In SSAR Section 2.3.2.3, “Potential Influence of the Plant and Related Facilities 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 on 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. In Section 2.3.3 of this report, the staff discusses the effects of these larger structures on wind flow.

Although temperature may increase above altered surfaces at the proposed PSEG Site, the effects will be too limited in their vertical profile and horizontal extent to alter local- or regional-scale ambient temperature changes. Due to the limited and localized nature of the expected modifications associated with the proposed plant structures and the associated improved surfaces, the staff agrees that the proposed facility will not have significant impacts on local meteorological conditions.

2.3.2.4.4 Current and Projected Air Quality

As discussed in Section 2.3.1 of this report, the proposed PSEG Site is located in the Metropolitan Philadelphia Interstate Air Quality Control Region (40 CFR 81.15, "Metropolitan Philadelphia Interstate Air Quality Control Region (Pennsylvania-New Jersey-Delaware)"). The counties within this region include Salem County, NJ and New Castle County, DE. Salem County, NJ is a non-attainment area for ozone under the 8-hour standard. New Castle County, DE is a non-attainment area for ozone under the 8-hour standard and for PM under the $PM_{2.5}$ standard. The closest Federal Class I area in the surrounding area is the Brigantine Wilderness at the Edwin D. Forsythe National Wildlife Refuge, an area of 2672 hectares (6603 acres) on the Atlantic Ocean shoreline located 113 km (70 mi) from the proposed PSEG Site.

In SSAR Section 2.3.2.4, "Current and Proposed Site Air Quality," the applicant stated that the proposed nuclear steam supply system (NSSS) and other radiological systems related to the proposed facility will not be sources of criteria pollutants (as discussed in Section 2.3.1.4.9 of this report) 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.

In SSAR Section 2.3.2.4, the applicant stated that once a reactor technology is selected and detail design is completed for the cooling towers and combustion sources, PSEG will consult and work with the New Jersey Department of Environmental Protection to demonstrate compliance with the applicable air quality regulations. At the COL or CP stage, if the applicant chooses a plant design that requires the use of an UHS cooling tower, the applicant will need to identify the appropriate meteorological characteristics (i.e., maximum evaporation and drift loss and minimum water cooling conditions) used to evaluate the design of the chosen UHS cooling tower. In accordance with 10 CFR 52.17(a)(1)(iii), "Contents of applications; general information," at the time of the COL or CP application, the applicant will provide the design type and characteristics of the UHS.

2.3.2.4.5 Topographic Description

The proposed PSEG Site is located in Salem County, NJ, adjacent to the Delaware Bay. SSAR Figure 2.3-41, "PSEG Site Directional Elevation Profiles within 50 Miles of PSEG Site," displayed the elevation of the land within 80 km (50 mi) of the site. SSAR Figure 2.3-41 is reproduced in Figure 2.3-7.

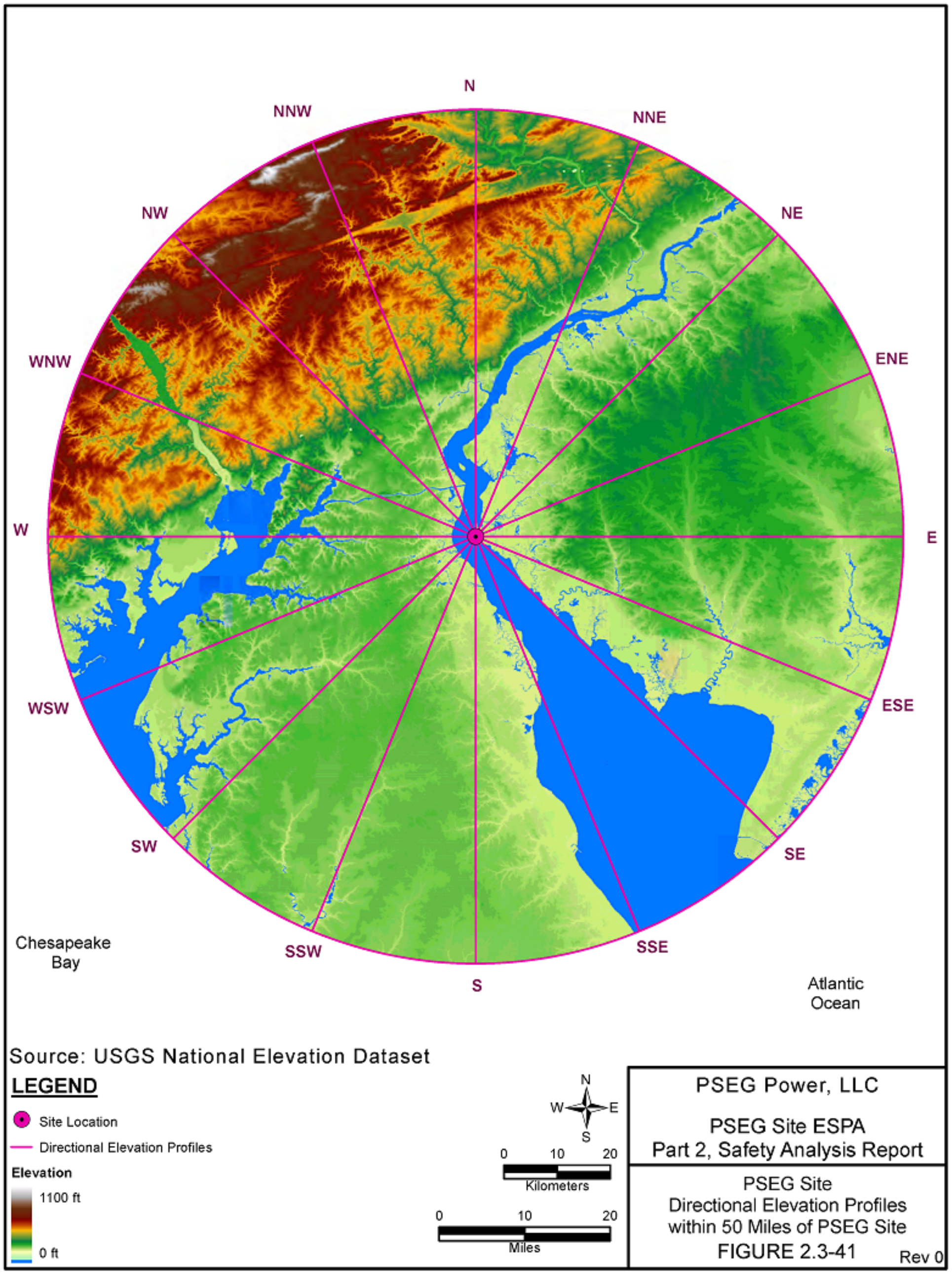

Figure 2.3-7 PSEG Site Directional Elevation Profiles within 50 Miles of the PSEG Site (Reproduced from SSAR Figure 2.3-41)

The applicant also provided terrain elevation profiles along each of the 16 standard 22.5-degree compass radials out to a distance of 80 km (50 mi) in the following SSAR figures:

- Figure 2.3-42, “Elevation Profiles to a 50-Mile Radius for N and NNE Direction Sectors”
- Figure 2.3-43, “Elevation Profiles to a 50-Mile Radius for NE and ENE Direction Sectors”

- Figure 2.3-44, “Elevation Profiles to a 50-Mile Radius for E and ESE Direction Sectors”
- Figure 2.3-45, “Elevation Profiles to a 50-Mile Radius for SE and SSE Direction Sectors”
- Figure 2.3-46, “Elevation Profiles to a 50-Mile Radius for S and SSW Direction Sectors”
- Figure 2.3-47, “Elevation Profiles to a 50-Mile Radius for SW and WSW Direction Sectors”
- Figure 2.3-48, “Elevation Profiles to a 50-Mile Radius for W and WNW Direction Sectors”
- Figure 2.3-49, “Elevation Profiles to a 50-Mile Radius for NW and NNW Direction Sectors”

Based on these profiles, the applicant characterized the site terrain as gently rolling with elevations increasing to the northwest clockwise through the north-northeast. The staff agrees with this terrain characterization based on topography data from the USGS. The staff finds that the applicant provided necessary and adequate topographic information.

2.3.2.5 *Conclusion*

As discussed above, the applicant presented and substantiated information on local meteorological, air quality, and topographic characteristics of importance to the safe design and operation of a nuclear power plant or plants, falling within the applicant’s PPE, that might be constructed on the proposed PSEG Site. The staff reviewed the information provided and, for the reasons given, concludes that the applicant’s identification and consideration of the meteorological, air quality, and topographical characteristics of the site and the surrounding area meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.21(d), and are sufficient to determine the acceptability of the site.

The staff also reviewed available information relative to severe local weather phenomena at the proposed PSEG Site and in the surrounding area. As discussed above, the staff concludes that the applicant has identified the most severe local weather phenomena at the proposed PSEG Site and surrounding area.

Early Site Permit applicants need not demonstrate the compliance with the GDC listed in Section 2.3.2.3, “Regulatory Basis,” of this report; however, the applicant chose to provide all necessary information with respect to local meteorology that can be provided for an ESP.

2.3.3 Onsite Meteorological Measurement Program

2.3.3.1 *Introduction*

The PSEG onsite meteorological measurements program addresses the need for onsite meteorological monitoring and the resulting data.

2.3.3.2 *Summary of Application*

In SSAR Section 2.3.3, 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

In Section 2.3.3 of this report, the staff 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 design-basis accidents (DBAs) and routine releases from a nuclear power plant of the type specified by the applicant.

2.3.3.3 *Regulatory Basis*

The acceptance criteria, as identified in NUREG-0800, Section 2.3.3, "Onsite Meteorological Measurements Programs," 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 100.20(c), as it relates to the requirement that the meteorological characteristics of the site that are necessary for safety analysis or that might have an impact on plant design be identified and characterized as part of the staff's review of the acceptability of a site

- 10 CFR 100.21(c), as it relates the requirements that the meteorological data used to evaluate site atmospheric dispersion characteristics and establish dispersion parameters such that: (1) radiological effluent release limits associated with normal operation can be met for any individual located off site; and (2) radiological dose consequences of postulated accidents meet prescribed dose limits at the EAB and the outer boundary of the LPZ

- 10 CFR 100.21(d), as it relates to the requirement that the physical characteristics of the site, including meteorology, geology, seismology, and hydrology, be evaluated and site characteristics established to ensure 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 Section 13.3 of this report, "Emergency Planning") 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 Part 50, Appendix E, as it relates to the requirement for emergency plans to have adequate provisions for equipment that will be used to determine the magnitude of, and continuously assess the impact of, the release of radioactive materials to the environment

- 10 CFR 50.47(b), as it relates to the requirement 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

The development and implementation of an onsite meteorological program is necessary for the collection of onsite meteorological information at the ESP stage, in order 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.”

The following Regulatory Guide applies to this section:

- RG 1.23, Revision 1, which provides criteria for an acceptable onsite meteorological measurements program that can be used to monitor local meteorology site characteristics.

The related acceptance criteria from NUREG-0800, Section 2.3.3 of are as follows:

- The preoperational and operational monitoring programs should be described, including: (1) A site map (drawn to scale) that shows the tower location and true north with respect to man-made structures, topographic features, and other features that may influence site meteorological measurements; (2) distances to nearby obstructions of flow in each downwind sector; (3) measurements made; (4) elevations of measurements; (5) exposure of instruments; (6) instrument descriptions; (7) instrument performance specifications; (8) calibration and maintenance procedures and frequencies; (9) data output and recording systems; and (10) data processing, archiving, and analysis procedures.

- Meteorological data should be presented in the form of Joint Frequency Distributions (JFD) of wind speed and wind direction by atmospheric stability class in the format described in RG 1.23, Revision 1. An hour-by-hour listing of the hourly averaged parameters should be provided in the format described in RG 1.23, Revision 1. If possible, evidence of how well these data represent long-term conditions at the site should also be presented, possibly through comparison with offsite data.

- At least two consecutive annual cycles (and preferably three or more whole years), including the most recent 1-year period, should be provided with the application. These data should be used by the applicant to calculate (1) the short-term atmospheric-dispersion estimates for accident releases discussed in Section 2.3.4 of this report and (2) the long-term atmospheric dispersion estimates for the routine releases discussed in Section 2.3.5 of this report.

- The applicant should identify and justify any deviations from the guidance provided in RG 1.23, Revision 1.

2.3.3.4 *Technical Evaluation*

The staff reviewed the applicant's information concerning the onsite meteorological measurements program. The applicant used the pre-application onsite meteorological measurements program at the PSEG Site to collect data 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 operational onsite meteorological measurements program at the time of the COL application in accordance with the guidance provided in Section C.III.2.2.3.3 of RG 1.206, "Combined License Applications for Nuclear Power Plants."

2.3.3.4.1 Onsite Meteorological Measurements Program

2.3.3.4.1.1 *General Program Description*

The applicant provided a narrative of the onsite meteorological monitoring system in SSAR Section 2.3.3.2, "General Program Description." The onsite meteorological monitoring program at the PSEG Site is a continuation of the current program that supports the operating Salem and Hope Creek (S/HC) power plants. Instruments for measuring pertinent meteorological parameters are mounted on a 90-m (300-ft) guyed, open-lattice tower. The meteorology tower is located about 1667 m (5470 ft) southeast of the proposed power block area.

The applicant provided a summary of the instrumentation on the primary and backup towers in SSAR Table 2.3-28, "Meteorological Instrumentation Descriptions and Accuracies for the On-Site Meteorological Monitoring System." The meteorological monitoring tower has observation equipment mounted at heights of 10, 45, and 90 m (33, 150, and 300 ft) above ground level. Measured data include wind speed and direction at 10, 45 and 90 m (33, 150, and 300 ft), temperature at 10, 45 and 90 m, (33, 150, and 300 ft) differential temperature between 90 and 10 m (300 and 33 ft) and 45 and 10 m (150 and 33 ft), dew point temperature (calculated based on the coincident ambient temperature and relative humidity measurements) at 10 m (33 ft), precipitation, barometric pressure, and solar radiation at the tower base, and sigma theta (standard deviation of the wind direction) at 90, 45, and 10 m (300, 150, and 33 ft). In SSAR Section 2.3.3.2, the applicant described the backup meteorological tower as being a 10-m (33-ft) utility pole located 118 m (386 ft) south of the primary tower. The backup tower is used only in the event that the instrumentation on the primary tower is unavailable. The measurements taken at the backup tower include wind speed, wind direction, and sigma-theta at the 10-m (33-ft) level only.

2.3.3.4.1.2 *Location, Elevation, and Exposure of Instruments*

In SSAR Section 2.3.3.3, "Location, Elevation, and Exposure of Instruments," the applicant explained that the base of the meteorological 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 low native vegetation. The applicant stated that it had evaluated minor structures in the vicinity of the primary meteorological tower. These structures were determined to have no adverse effect on the measurements taken at the meteorological measurement tower. The applicant stated that the closest major structures to the meteorological measurement tower will be the existing S/HC reactor buildings and proposed natural draft cooling towers for the PSEG Site. 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 S/HC cooling tower is located 1432 m (4700 ft) northwest of the meteorological tower and has a height of 156 m (512 ft). The new reactor cooling towers are to be located 2072 m (6800 ft) northwest of the meteorological tower and have a maximum potential height of 180 m (590 ft), based on the PPE.

RG 1.23, Revision 1 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. However, 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. The current S/HC cooling tower does not meet the 10-building-height distance criterion, but because of its conical shape, it is not expected to have any adverse aerodynamic effects on the meteorological tower wind measurements. The staff agrees with the applicant's discussion in SSAR Section 2.3.3.3 regarding the 10-building-height distance criterion and, therefore, concludes that building wake from the existing S/HC reactors and cooling towers and the proposed PSEG structures will not cause any adverse aerodynamic effects. For the proposed cooling tower with its potential height of 180 m (590 ft), being 2072 m (6800 ft) away thus clearly satisfies the above rule.

The primary meteorological equipment is mounted on a 90-m (300-ft) guyed, triangular open-lattice tower with solid legs and a 0.45-m (18-in.) face. Wind sensors are mounted on the northwest side of the tower (upwind when the wind is blowing from its most prevalent direction) to reduce the turbulent effects of the tower on the measurements. In SSAR Section 2.3.3.2, the applicant stated that the sensors are mounted on booms at distances that are equal to more than twice the horizontal width of the tower to further minimize the turbulent effects of the tower on the measurements.

2.3.3.4.1.3 *Instrument Maintenance*

In SSAR Section 2.3.3.4, "Instrument Maintenance," the applicant provided a description of how often the meteorological equipment is inspected and serviced. The meteorological data is reviewed daily by a meteorologist and sensor and system repairs are performed as needed. The applicant stated that full system calibrations are done on a quarterly basis. Also, the wind sensors are swapped out and returned to the manufacturer for wind tunnel calibrations on an annual basis, or every fourth calibration. The guyed wires are inspected annually and anchors are inspected every 3 years. The staff concludes that the instrument maintenance practices, as described in SSAR Section 2.3.3.4 conform to the guidance provided in RG 1.23, Revision 1. Accordingly, the staff finds these descriptions acceptable.

2.3.3.4.1.4 *Data Collection and Analysis*

In SSAR Section 2.3.3.5, "Data Collection and Analysis," the applicant explained that data from the meteorological tower is collected, processed, displayed, and transmitted by equipment in the meteorological building at the base of the primary meteorological tower. The measurements are recorded once per second and are then stored in separate 15-minute and hourly average files. Real-time measurements are available for display in the meteorological building at the tower base. Fifteen minute averages are available to the operators in the S/HC Control Rooms and the Technical Support Centers (TSC) over fiber optic cable or modem. Meteorological data are downloaded and reviewed daily using software and manual checks for reasonableness.

For the 2006–2008 data set, the average data recovery rates were well above the 90-percent threshold established in Revision 1 of RG 1.23 for all variables except the 10-m (33-ft) dew point temperature during 2006 and 2008. The applicant stated that the 10-m (33-ft) dew point temperature failed to meet the 90-percent recovery rate threshold because of recurring instrument failure. The applicant also stated that they have installed redundant instruments so that the 90-percent threshold will now be met. The applicant presented a table summary of the meteorological monitoring systems' recovery rates in SSAR Table 2.3-29, "Annual Data Recovery Statistics for the On-Site Meteorological Monitoring System."

2.3.3.5 *COL Action Items Related to the On-Site Meteorological Measurements Program*

PSEG ESP application, Part 5 describes the proposed Emergency Plan, including inspection, tests, analyses, and acceptance criteria (ITAAC). Attachment 10, "Emergency Planning – Inspections, Tests, Analyses, and Acceptance Criteria (EP-ITAAC)" in Part 5 of the ESP application includes the emergency planning (EP) ITAAC. The following EP-ITAAC involve demonstrating that the operational onsite meteorological monitoring program appropriately supports the PSEG emergency plan.

- EP Program Element 6.3: Demonstrated through training or drills that EPIPs provide direction to continuously assess the impact of the release of radioactive materials to the environment, accounting for the relationship between effluent monitor readings, and on-site and off-site exposures and contamination for various meteorological conditions (Acceptance Criteria 6.3).

- EP Program Element 6.4: Demonstrated that meteorological data necessary to implement the EPIPs is retrievable in the Control Room, TSC and EOF (Acceptance Criteria 6.4).

These items will be addressed by the COL applicant at the COL stage, and the requirements will be met by way of fulfilling EP-ITAAC 6.3 and 6.4 and Acceptance Criteria 6.3 and 6.4. EP, including EP ITAAC, is addressed in Section 13.3, "Emergency Planning," of this report.

2.3.3.6 *Conclusion*

As discussed above, the applicant presented and substantiated information to establish the onsite meteorological monitoring program and the resulting database. The staff reviewed the information provided and, for the reasons given above, concludes that the onsite meteorological monitoring system provides adequate data to represent onsite meteorological conditions as required by 10 CFR 100.20 and 10 CFR 100.21. The onsite data also provide an acceptable basis for (1) making estimates of atmospheric dispersion for design-basis accident releases and routine releases from a nuclear power plant or plants that might be constructed on the proposed site and (2) meeting the requirements of 10 CFR Part 20, 10 CFR Part 100, and 10 CFR Part 50, Appendix I.

2.3.4 Short-Term Diffusion (Accident) Estimates

2.3.4.1 *Introduction*

The short-term diffusion estimates are used to determine the amount of airborne radioactive materials expected to reach a specific location during an accident situation. The diffusion estimates address the requirement for conservative atmospheric dispersion (relative concentration) factor (χ/Q value) estimates at the exclusion-area boundary (EAB), at the outer boundary of the low-population zone (LPZ), and at the control room for postulated design-basis accidental radioactive airborne releases.

2.3.4.2 *Summary of Application*

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

- 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

In Section 2.3.4 of this report, the staff verified that the applicant 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.

2.3.4.3 *Regulatory Basis*

The acceptance criteria (as identified in NUREG-0800, Section 2.3.4, “Short-Term Dispersion Estimates for Accident Releases”) 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), as it relates to the requirement that the meteorological characteristics of the site that are necessary for safety analysis or that might 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), as it relates to the requirement that site atmospheric-dispersion characteristics be evaluated and dispersion parameters established to ensure 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 related acceptance criteria from NUREG-0800, Section 2.3.4 are as follows:

- a description of the atmospheric dispersion models used to calculate χ/Q values for accidental releases of radioactive and hazardous materials to the atmosphere

- 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

- a discussion of atmospheric diffusion parameters, such as lateral and vertical plume spread (σ_y and σ_z) as a function of distance, topography, and atmospheric conditions, should be related to measured meteorological data

- hourly cumulative frequency distributions of χ/Q values from the effluent release point(s) to the EAB and LPZ should be constructed to describe the probabilities of these χ/Q values being exceeded

The following Regulatory Guide applies to this section:

- RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," Revision 1, as it relates to the use of dispersion models.

2.3.4.4 *Technical Evaluation*

The staff reviewed SSAR Section 2.3.4, "Short-Term (Accident) Diffusion Estimates," to ensure that the ESP application represents the complete scope of information relating to this review topic. The staff's review confirmed that the application addresses the required information relating to the short-term diffusion estimates.

To evaluate atmospheric dispersion characteristics with respect to radiological releases to the control room, detailed design information (e.g., vent heights, intake heights, and distance and direction from release vents to the room) is necessary. Since the ESP application uses a plant parameter envelope, and therefore little detailed and specific design information is available at this stage for the nuclear power plant or plants that might be constructed on the proposed site, a COL or CP applicant citing this ESP will need to assess the dispersion of airborne radioactive materials to the control room at the COL or CP stage.

2.3.4.4.1 Atmospheric Dispersion Model

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, Revision 1, as described in SSAR Section 2.3.4.1, "Basis."

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 of hourly values of wind speed and wind direction by atmospheric stability class. 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 (e.g., 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-to-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-to-2-hour “5-percent overall site χ/Q value.”

The larger of the two χ/Q values, either the 0.5-percent maximum sector-dependent value or the 5-percent overall site value, is selected to represent the χ/Q value for the 0-to-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 to 8 hours, 8 to 24 hours, 1 to 4 days, and 4 to 30 days), PAVAN performs a logarithmic interpolation between the 0-to-2-hour χ/Q values and the annual average (8760-hour) χ/Q values for each of the 16 sectors and the overall site. For each time period, the highest χ/Q value from among the 16 sectors and the overall site is identified and becomes the short-term site characteristic χ/Q value for that time period.

2.3.4.4.2 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 1, 2006, through December 31, 2008, as described in SSAR Section 2.3.4.1. The wind data were obtained from the 10-m (33-ft) level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-temperature) measurements taken at the 45-m (150-ft) and 10-m (33-ft) levels of the onsite meteorological tower.

In RAI 34, Question 02.03.04-2, the staff requested that the applicant justify why the SSAR did not include χ/Q values that accounted for the potential effects of land-water boundaries on the airflow of the site area. In a September 8, 2011, response to RAI 34, Question 02.03.04-2, the applicant provided the requested information, with a commitment to update SSAR

Sections 2.3.2.2.1.2 and 2.3.4.1 to include an expanded discussion on the airflow patterns at the PSEG Site. The applicant stated that closed sea-breeze mesoscale circulations do not occur at the PSEG Site, and recirculation of airflow during periods of prolonged atmospheric stagnation seldom occurs. The staff reviewed the applicant's September 8, 2011, response to RAI 34, Question 02.03.04-2; verified that the committed changes have been made in the ESP application, Revision 1 dated May 21, 2012; and finds the response acceptable. Accordingly, the staff considers RAI 34, Question 02.03.04-2 resolved.

The staff developed an annual wind rose for each level of the meteorological tower. The wind roses developed by the staff and provided by the applicant in SSAR Figures 2.3-12 through 2.3-28 show higher frequencies of winds from the southeast and northwest. As stated in Sections 2.3.2 of this report, this is generally consistent with the wind patterns recorded in the site's region. As discussed in Sections 2.3.2 and 2.3.3 of this report, the staff considers the 2006–2008 onsite meteorological database suitable for input to the PAVAN model.

2.3.4.4.3 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, as described in SSAR Section 2.3.4.1. 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 PSEG Site. Therefore, the staff finds the applicant's use of diffusion parameter assumptions, as outlined in RG 1.145, acceptable.

2.3.4.4.4 Conservative Short-Term Atmospheric Dispersion Estimates for EAB and LPZ

The applicant modeled one ground-level release point and did not take credit for building wake effects, as described in SSAR Section 2.3.4.1. 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 the EAB to be a circular region that surrounds the expected power block area, as described in SSAR Section 2.3.4.1. The power block area is used to conservatively enclose all possible release points for the selected reactor technologies. The shortest distance from the outer edge of the power block area to the EAB is 600 m (1968 ft), as shown in SSAR Table 2.3-31, "PAVAN 0-2 Hour 0.5% Exclusion Area Boundary χ/Q Values," and SSAR Figure 1.2-3, "Site Utilization Plan." SSAR Figure 1.2-3 is reproduced in Figure 2.3-8. This distance was used as the distance in each direction and is considered a conservative assumption. The outer boundary of the LPZ for the PSEG Site is a circle surrounding the power block area with a radius of 8045 m (5 mi). The distance from the power block area to the LPZ is shown in SSAR Table 2.3-32, "PAVAN 0-30 Day Low Population Zone χ/Q Values," and SSAR Figure 2.1-21, "PSEG Site 2010 Resident Population Within the Low Population Zone."

SSAR Tables 2.3-31 and 2.3-32 list the short-term atmospheric-dispersion estimates for the 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 2.0-1. The staff finds these χ/Q values acceptable for use as site characteristics because they are a conservative estimate of the atmospheric dispersion at the proposed PSEG Site. These atmospheric dispersion site characteristics are used by the applicant to demonstrate compliance with the requirements of 10 CFR 100.21(c)(2) for the radiological dose consequences of postulated accidents.

Figure 2.3-8 Site Utilization Plan (Reproduced from SSAR Figure 1.2-3)

Using the information presented by the applicant in SSAR Table 2.3-27, including the JFD of wind speed, wind direction, and atmospheric stability measured at the 10-m (33-ft) level, the staff confirmed the applicant's χ/Q values by running the PAVAN computer code and obtaining consistent results (within 1 percent). The applicant's JFD used eleven wind speed categories based on RG 1.23, Revision 1. The staff accepts the short-term χ/Q values presented by the applicant.

2.3.4.5 *Conclusion*

As discussed above, the applicant presented and substantiated information to establish short-term (post-accident) atmospheric dispersion site characteristics. The staff reviewed the information provided and, for the reasons given above, concludes that the applicant has established site characteristics and design parameters acceptable to meet the requirements of 10 CFR 52.17(a)(1)(ix), 10 CFR 100.21(c)(2), and 10 CFR 100.20(c).

2.3.5 Long-Term Atmospheric Dispersion Estimates for Routine Releases

2.3.5.1 *Introduction*

The long-term dispersion estimates are used to determine the amount of airborne radioactive materials expected to reach a specific location during normal operations. The diffusion estimates address the requirement concerning atmospheric dispersion and dry deposition estimates for routine releases of radiological effluents to the atmosphere.

2.3.5.2 *Summary of Application*

In SSAR Section 2.3.5, the applicant provides details on the following specific areas:

- atmospheric dispersion and deposition 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
- meteorological data and other assumptions used as input to the atmospheric dispersion models
- derivation of diffusion parameters (e.g., σ_z)
- atmospheric-dispersion (relative concentration) factors (χ/Q values) and deposition factors (D/Q values) used for assessment of consequences of routine airborne radioactive releases
- the characteristics of each release mode
- the location of potential receptors for dose computations
- any additional information requirements prescribed in the “Contents of Application” sections of the applicable chapters of 10 CFR Part 52, Subpart A, “Early Site Permits”

2.3.5.3 *Regulatory Basis*

The acceptance criteria (as identified in NUREG-0800, Section 2.3.5, “Long-Term Atmospheric Dispersion Estimates for Routine Releases”) 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), as it relates to the requirement that the meteorological characteristics of the site that are necessary for safety analysis or that might 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), as it relates to the requirement that site atmospheric-dispersion characteristics be evaluated and dispersion parameters established to ensure 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 in order 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 following Regulatory Guides apply to this section:

- RG 1.23, Revision 1, as it relates to an acceptable onsite meteorological measurements program, which can be used to monitor site characteristics related to local meteorology

- 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," Revision 1, as it relates to calculating offsite doses

- RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1, as it relates to calculating offsite doses

The related acceptance criteria from NUREG-0800, Section 2.3.5 are as follows:

- a detailed description of the atmospheric dispersion and deposition models used by the applicant to calculate annual average concentrations in the air and the amount of material deposited as a result of routine releases of radioactive materials to the atmosphere

- a discussion of atmospheric diffusion parameters, such as vertical plume spread (σ_z) as a function of distance, topography, and atmospheric conditions

- meteorological data summaries (onsite and regional) used as input to the dispersion and deposition models

- points of routine release of radioactive material to the atmosphere, including the characteristics (e.g., location and release mode) of each release point

- the specific location of potential receptors of interest (e.g., the nearest vegetable garden, nearest resident, nearest milk animal, and nearest meat cow in each 22½-degree direction sector within a 5-mi (8-km) radius of the site)

- the χ/Q and D/Q values to be used for assessment of the consequences of routine airborne radiological releases as described in RG 1.206, Section 2.3.5.2: (1) Maximum annual average χ/Q values and D/Q values at or beyond the site boundary and at specified locations of potential receptors of interest using appropriate meteorological data for each routine venting location, and (2) estimates of annual average χ/Q values and D/Q values for 16 radial sectors to a distance of 50 mi (80 km) from the plant using appropriate meteorological data

2.3.5.4 *Technical Evaluation*

The staff reviewed SSAR Section 2.3.5, "Long-Term (Routine) Diffusion Estimates," to ensure that the ESP application represents the complete scope of information relating to this review topic. The staff's review confirmed that the application addresses the required information relating to long-term atmospheric dispersion estimates.

2.3.5.4.1 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 Releases at Nuclear Power Stations") to estimate χ/Q and D/Q values resulting from routine releases, as described in SSAR Section 2.3.5.1, "Basis." The XOQDOQ model implements the constant mean wind direction methodology outlined in RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1.

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 (e.g., annual averages), the plume's horizontal distribution is assumed to be evenly distributed within the downwind direction sector (i.e., "sector averaging"). A straight-line trajectory is assumed between the release point and all receptors.

2.3.5.4.2 Release Characteristics and Receptors

The applicant modeled one ground-level release point, setting the minimum building cross-sectional area and building height to zero, as described in SSAR Section 2.3.5.1. The applicant assumed a ground-level release to model routine releases. A ground-level release is a conservative assumption at a relatively flat terrain site, such as the PSEG Site, resulting in higher χ/Q and D/Q values when compared to a mixed-mode (i.e., part-time ground, part-time elevated) release or a 100-percent elevated release, as discussed in RG 1.111, Revision 1. Therefore, the staff finds a ground-level release assumption acceptable.

The distance to the receptors of interest (i.e., the nearest meat animal, residence, and vegetable garden) were presented in SSAR Table 2.3-34, "XOQDOQ Predicted Maximum χ/Q and D/Q Values at Receptors of Interest for Routine Releases." The distances to each of these receptors have been derived from a land use census table provided by the applicant in SSAR Reference 2.3.5-1, "2008 Annual Radioactive Effluent Release Report for the Salem and Hope Creek Generating Stations." The distances were adjusted to reflect the source originating at Unit 2, because the original land use evaluation was centered on Unit 1. The staff finds these assumptions acceptable.

NUREG-0800, Section 2.3.5 states that the ESP site characteristics should include the maximum χ/Q and D/Q values calculated at the specific locations of potential receptors of interest. SSAR Section 2.3.5.2, "XOQDOQ Modeling Results," stated that the site boundary's χ/Q values were disregarded for sectors SE to NW (in the clockwise direction) because the site boundary is bordered by the Delaware River. In RAI 35, Question 02.03.05-4, the staff requested that the applicant update the SSAR to include the χ/Q and D/Q values at the site boundary for all 16 radial directions. In a September 9, 2011, response to RAI 35, Question 02.03.05-04, the applicant provided the requested information, including a draft revision of SSAR Section 2.3.5.2 and a new SSAR Table 2.3-37, "XOQDOQ Predicted Annual Average χ /Q and D/Q Values at the Site Boundary for Routine Releases." The staff evaluated the χ/Q and D/Q values provided in the RAI response and finds the response acceptable. However, the applicant also explained that the χ/Q and D/Q values at the portion of the site boundary adjacent to the Delaware River (sectors SE to NW in the clockwise direction) are not considered in the analyses for radiological exposure because of routine gaseous effluents in that area. The applicant states in the RAI response that this is acceptable "because of the negligible time any individual is expected to spend in this area during any one year period." The directions that are being excluded contain 7 of the 10 highest site boundary χ/Q and D/Q values. The staff agrees that at the time this ESP is issued, it is unlikely that there is a limiting exposure pathway for routine releases for these site boundary sectors adjacent to the Delaware River. The staff finds this conclusion acceptable for this ESP application based on the assumption presented by the applicant that the time any individual is expected to spend in the excluded areas is negligible. Therefore, the staff considers RAI 35, Question 02.03.05-4 resolved.

The staff's conclusion of acceptability regarding RAI 35, Question 02.03.05-4, and SSAR Section 2.3.5 is based on assumptions presented by the applicant as to the types of exposure pathways and locations of dose receptors described in the ESP application. However, the COL applicant should consider whether different exposure pathways and dose receptors exist that would not fall within the ESP long-term release atmospheric dispersion site characteristic values, including for those sectors adjacent to the Delaware River that the applicant screened from its analysis, and confirm that associated doses are in compliance with applicable NRC requirements. 10 CFR 20.1302(b)(1) states that a licensee shall show compliance with the annual dose limit in 10 CFR 20.1301 by (1) demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit. A COL applicant referencing this ESP can comply with 10 CFR 20.1302, in part, by ensuring that the decision made in the ESP application to disregard the sectors adjacent to the Delaware River is still valid.

> **COL Action Item 2.3-1:** A COL applicant referencing this early site permit should verify specific release point characteristics and specific locations of receptors of interest used to generate the long-term (routine release) atmospheric dispersion site characteristics. Any different exposure pathways and dose receptor locations, including those in sectors adjacent to the Delaware River, should be identified and discussed in order to demonstrate that long-term release atmospheric dispersion estimates fall within the site characteristic values in the ESP and to provide assurance of compliance with NRC dose requirements.

2.3.5.4.3 Meteorological Data Input

The meteorological input to XOQDOQ used by the applicant consisted of a JFD of wind speed, wind direction, and atmospheric stability based on hourly onsite data from a 3-year period from January 1, 2006, through December 31, 2008, as stated in SSAR Section 2.3.5.1. The wind data were obtained from the 10-m (33-ft) level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-temperature) measurements taken between the 45-m (150-ft) and 10-m (33-ft) levels on the onsite meteorological tower. Following the discussion provided in Section 2.3.2 of this report, the staff considers the 2006–2008 onsite meteorological database suitable for input to the XOQDOQ model.

RG 1.111, Revision 1, states that spatial and temporal variations of airflow should be considered at sites along and near coasts with significant land-water boundary layer effects on airflow and sea-land breeze circulations. SSAR Section 2.3.2.2.1.2 describes the complex wind patterns at the PSEG Site that are caused in part by Delaware Bay breezes and local shoreline breezes. The staff noted that in the XOQDOQ input/output files that were provided to the staff in an April 6, 2011, response to RAI 16, Question 02.03.05-1, adjustments for the potential effects of land-water boundaries on airflow had not been addressed. In RAI 35, Question 02.03.05-03, the staff requested that the applicant update SSAR Section 2.3.5 to include the χ/Q and D/Q values that consider and account for the potential effects of land-water boundaries, or provide justification as to why this is not necessary for the PSEG Site. In a September 9, 2011, response to RAI 35, Question 02.03.05-03, the applicant provided the requested information along with a commitment to update SSAR Sections 2.3.2.2.1.2 and 2.3.5.1 to include an expanded discussion on the airflow patterns at the PSEG Site. For ease of review, the revisions to SSAR Subsection 2.3.2.2.1.2 were applied from PSEG's response to RAI 34, Question 02.03.04-2. The applicant stated that closed sea-breeze mesoscale circulations do not occur at the PSEG Site, and recirculation of airflow during periods of prolonged atmospheric stagnation seldom occurs.

The staff developed an annual wind rose for each level of the meteorological tower. The wind roses developed by the staff and those provided by the applicant in SSAR Figures 2.3-12 through 2.3-28 show increased winds from the southeast and northwest. As stated in Section 2.3.2 of this report, this is generally consistent with the wind patterns recorded in the site region.

10 CFR 100.21(c)(1) requires that site atmospheric dispersion characteristics must be evaluated and dispersion parameters established such that radiological effluent release limits associated with normal operation from the type of facility proposed to be located at the site can be met for any individual located offsite. SSAR Section 2.3.5.1 stated that the downwind distances used to determine the χ/Q and D/Q values at each of the receptors of interest were calculated from the center of the power block area. In RAI 35, Question 02.03.05-5, the staff requested that the applicant justify why the SSAR used the center point of the power block, rather than the outer edge, to determine the distances to the receptors. In a September 9, 2011, response to RAI 35, Question 02.03.05-05, the applicant stated that the reactor technologies that are being considered typically have vent stacks near the center of the power block. The applicant also stated that the building wake effects are conservatively not credited in the χ/Q and D/Q calculations. The staff reviewed the applicant's response to RAI 35, Question 02.03.05-5 and finds it acceptable as correct and adequate. Accordingly, the staff considers RAI 35, Question 02.03.05-5 resolved.

2.3.5.4.4 Diffusion Parameters

The applicant chose to implement the diffusion parameter assumptions outlined in RG 1.111, Revision 1, as a function of atmospheric stability, for its XOQDOQ model runs as stated in SSAR Section 2.3.5.1. The staff evaluated the applicability of the XOQDOQ diffusion parameters and concluded that no unique topographic features preclude the use of the XOQDOQ model for the PSEG Site. Therefore, the staff finds the applicant's use of diffusion parameter assumptions (as outlined in RG 1.111, Revision 1) acceptable. As discussed in Section 2.3.5.4.3 of this report, the applicant determined that it was not necessary to model and include the effects of land-water boundaries on the χ/Q and D/Q values. Since the site is not subject to the frequent sea-breeze circulations commonly observed at coastal locations, the staff agrees with this assessment.

2.3.5.4.5 Resulting Relative Concentration and Relative Deposition Factors

SSAR Table 2.3-34 lists the maximum long-term atmospheric dispersion and deposition estimates for the receptors of interest that the applicant derived from their XOQDOQ modeling results. SSAR Tables 2.3-35, "XOQDOQ Predicted Annual Average χ/Q Values at the Standard Radial Distances and Distance-Segment Boundaries for Routine Releases," and 2.3-36, "XOQDOQ Predicted Annual Average D/Q Values at the Standard Radial Distances and Distance-Segment Boundaries for Routine Releases," also contain the applicant's long-term atmospheric dispersion and deposition estimates for the 16 radial sectors from the site boundary to a distance of 80 km (50 mi) from the proposed PSEG Site.

The χ/Q values presented in SSAR Tables 2.3-34 and 2.3-35 reflect several plume radioactive decay and deposition scenarios. RG 1.111, Revision 1, Section C.3 states that radioactive decay and dry deposition should be considered in radiological impact evaluations of potential annual radiation doses to the public that result from routine releases of radioactive materials in gaseous effluents. RG 1.111, Revision 1, Section C.3.a 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 are as follows:

- Undepleted/No Decay χ/Q values are χ/Q values 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 of radioactive decay.

- Undepleted/2.26-Day Decay χ/Q values are χ/Q values 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-133.

- Depleted/8.00-Day Decay χ/Q values are χ/Q values 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.

Using the information provided by the applicant, including the 10-m (33-ft) level JFDs of wind speed, wind direction, and atmospheric stability, in SSAR Tables 2.3-34 through 2.3-36, the staff confirmed the applicant's χ/Q and D/Q values by running the XOQDOQ computer code and obtaining similar results (i.e., values on average within about 1-percent). The applicant's JFDs used 11 wind speed categories based on RG 1.23, Revision 1. Based on the discussion above, the staff finds the long-term χ/Q and D/Q values provided by the applicant acceptable.

2.3.5.5 *Conclusion*

As discussed above, the applicant provided meteorological data and an atmospheric dispersion model that is appropriate for the characteristics of the PSEG Site and release points. The staff's review confirmed that the applicant addressed the required information relating to long-term diffusion estimates, and there is no outstanding information to be addressed in the SSAR related to this section. Therefore, the staff concludes that representative atmospheric dispersion and deposition conditions have been calculated for specific locations of potential receptors of interest. The characterization of atmospheric dispersion and deposition conditions satisfies the criteria described in RG 1.111 and 10 CFR Part 100 and are appropriate for the evaluation to demonstrate compliance with the numerical guides for doses for any individual located offsite contained in 10 CFR Part 50, Appendix I.